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THE NAVAL ARCHITECT
International Journal of The Royal
Institution of Naval Architects

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Published by:
The Royal Institution of Naval Architects

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Printed in Wales by:
Stephens & George Magazines
Merthyr Tydfil

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A one-year subscription in 2005 to *The Naval Architect* costs £100 (UK), £105 (Europe), and £115 (Rest of the world).

Audited Circulation 10,167
JAN - DEC 2004
ISSN 0306 0209



THE NAVAL ARCHITECT



Work on Japan's national project to develop a next-generation fleet of efficient and 'green' coastal vessels - the Super Eco-Ship programme - is approaching its zenith. Seen here is the prototype integrated propulsion pod being tested on a special rig in a drydock at Aioi. It will feature contra-rotating propellers. Plans are that primary electrical current will be generated using a new power source: a specially designed Super Marine gas turbine. More details appear on page 44 as part of our special Japanese report.

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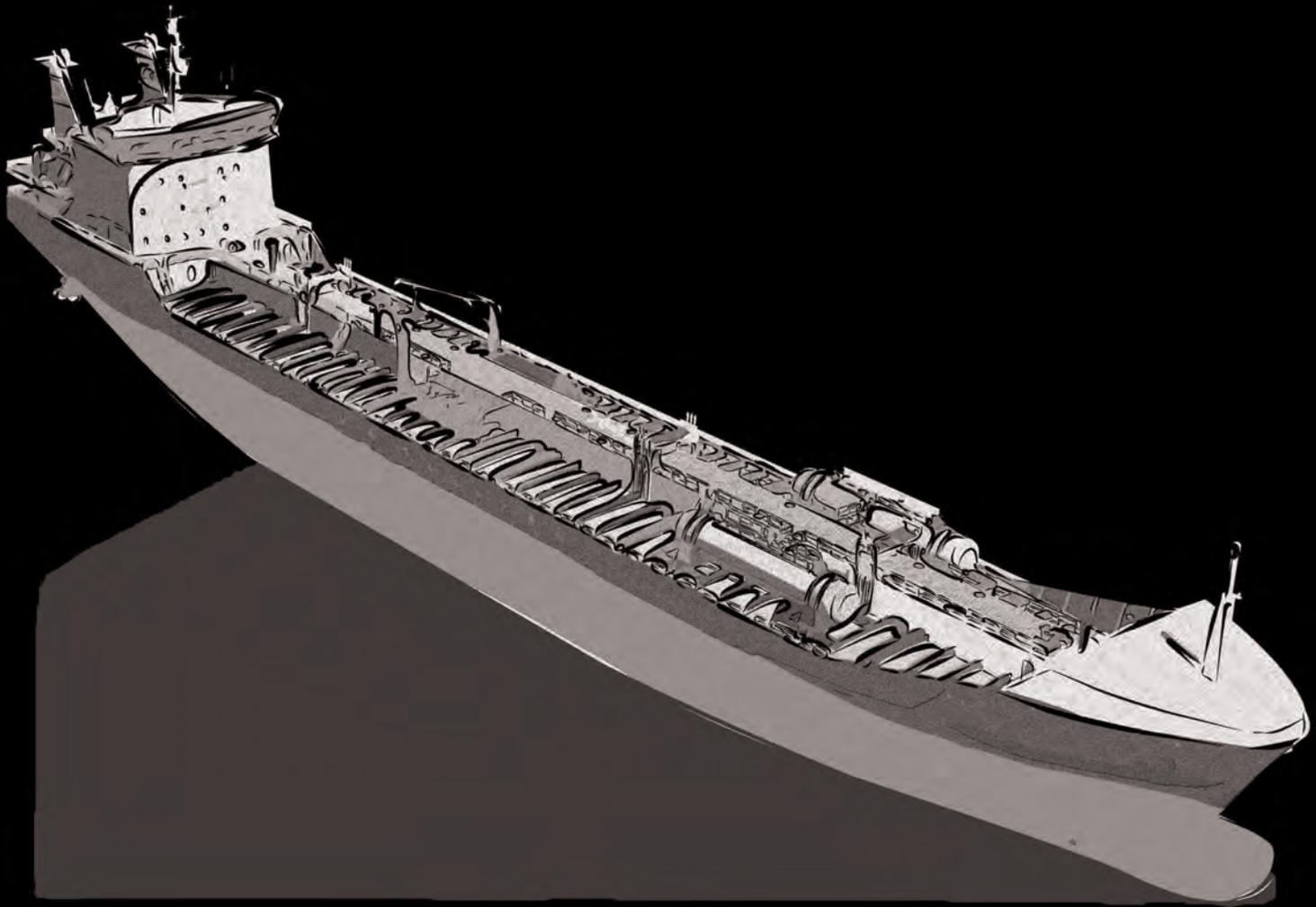
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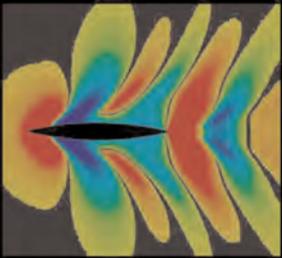
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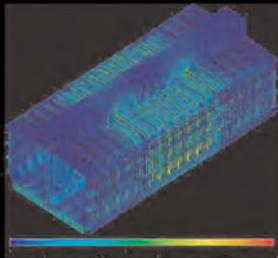
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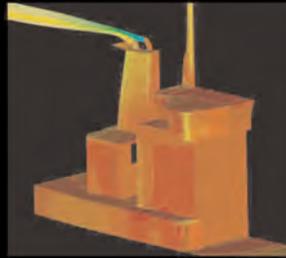
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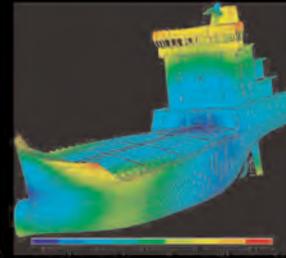
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Radical new approaches to lifesaving

HOW many naval architects can claim to have taken part in a lifeboat evacuation? We know that there is at least one out there who emerged ashen-faced from the experience of banging and crashing against the hull - and it was only a practice drop with a conventional boat. To his credit, that person was influenced enough to re-design the launch and descent mechanism on that particular ship, which he duly did.

This is, of course, another reason why all naval architects should spend some time at sea: a policy which The Royal Institution of Naval Architects and *The Naval Architect* have advocated on several occasions, but which is still largely ignored by the industry. This journal knows from our own experience in Norway of a training station launch in a free-fall lifeboat (certificate obtained to prove that we did it) what a difficult and slow operation it is - and those which back or neck problems were advised not to take part!

From discussions with those at the sharp end of inspecting lifeboats and their davit systems, there is clearly still much work still to be done to improve the design and operation of such equipment - disregarding the practical difficulties of persuading grandmothers and children to climb in. Some consolation can be gained from IMO's revised SOLAS regulations for the

A revolution in lifesaving: this vertically stowed Rescubec proposal, today being re-examined in earnest by its creator, the Norwegian lifeboat manufacturer Norsafe, aims to allow people to walk straight into the boat from a fire-safe citadel zone on a ship. Thus, orderly evacuations should be possible in most scenarios.



inspection and maintenance of lifesaving apparatus that are due to come into force in July 2006 but the fact remains that new thinking is needed on the design front.

We are pleased to report that brains have been at work, and a discussion on new davit ideas from a retired Norwegian sea captain, Egil Stag, appears on page 6 of this issue. Last month's Cruise & Ferry exhibition in London also enabled this journal to catch up on the newest advances in something much larger: the Rescubec project, also from Norway. We reported on this design briefly in the past (June 2003, page 3), as part of an earlier discussion on this topic.

The Rescubec - it has been on a back-burner for the last two years or so at the factory of its creator, Norsafe, based at Faervik, while more concentration took place in the offshore and cargo-ship sectors - is totally radical and includes something unique amongst its design attributes. This is that the designers believe - along with others - that the safest place in many emergencies is to remain onboard the ship itself: the citadel concept. Norsafe has also been seeking a solution beyond prescriptive regulations, which generally appear to be superseded today.

A Rescubec is planned to be stowed in a large hull recess, inboard of which would a fire-safe cofferdam stretching across the hull to a similar recess on the opposite side of the hull. This feature would allow mustering to take place in an orderly and smooth fashion - the Evi simulation software developed by Safety at Sea at Glasgow/Strathclyde University (*The Naval Architect* June 2002, page 20) has been used by Norsafe to model evacuation scenarios.

One of the principal catalysts for the idea has been the large numbers of passengers and crew being loaded onto mega cruise liners such as Royal Caribbean's Voyager and Ultra-Voyager classes, also Cunard's *Queen Mary 2*. For example, passenger and crew capacities are approximately 3840/1180 for the Voyager class), and 4400 total on *Queen Mary 2*. At a slightly lower level, up 2700 passengers and 250 crew can sail on the brand-new cruise-ferry *Color Fantasy*. These are all very large numbers to muster in an emergency. In view of IMO's equal concerns over ships with large numbers of people onboard, it was appropriate that Norsafe took the trouble to present its latest ideas at IMO in February this year.

Rescubecs are planned to be very large: each enclosed unit can load up to 330 people in three rotating modules (110 people in each), and entry is at up to six levels. Plenty of space would be available for standing as there is 1700mm of clear height above, and a number of pre-agreed seats could be removed so that there would be space for disabled passengers.

Norsafe is considering aircraft-type doors to seal the entrances after everyone is on board. Craft would be manufactured from GRP composites and mounted to comply with the maximum drop distance of 15m - a 1:4 scale model is currently being fabricated, and drop tests will be carried out. A propulsion plant able to automatically guide a launched Rescubec 100m from an abandoned ship would be fitted.

An interesting innovation - hopefully to be thoroughly tested and proved foolproof - is the planned rotating mechanism of each module. Each of the three cylinders will rotate automatically through 90deg prior to a 35deg launch so that occupants will be in upright seating positions in the water. It is proposed that shipyards would simply provide the hull slot, and Norsafe would supply the boat and launch mechanism as a package. A hydraulic power pack would probably be needed to launch such a large weight.

Clearly, some naval architectural issues would be raised by the proposed recesses and the safe citadel zones, but these can be considered positive, not negative, aspects, and it is good to hear that the Norwegian Maritime Directorate has been most encouraging in its comments. An aim now is to find a shipyard and a shipowner bold enough to take this fascinating project forward - Norsafe says it is already talking to two leading passenger-ship companies, Alstom Marine and Carnival. Norsafe acknowledges that some extra cost will certainly be involved, up to 30%, depending on a ship design, but if a safer and more passenger- and crew-friendly ship results, then we should all be welcoming such an advance with open arms. 

More illustrations of the Rescubec appear in our Cruise & Ferry report on page 59.

Special submersible carrier for superyachts

AN order to supply a 19.7MW power plant for a yacht carrier contracted by the heavy transport specialist **Dockwise Shipping BV**, based in Breda in the Netherlands, has been awarded to **Wärtsilä Corp.**

The yacht carrier has been ordered from **Yantai Raffles Shipyard**, in China, with delivery due in autumn 2006. The vessel is 205.34m in length, has a 32.2m beam, and an operational draught of 5.80m. The cargoes of yachts will be loaded by floating them over the stern - the cargo deck measures 165m long by 31m wide - while the vessel is ballasted down. To protect yachts, the cargo area is equipped with high bulwarks.

This vessel is the first to be designed and built for carrying luxury yachts. Dockwise has built up its yacht transport business since 1987 and already owns four converted semisubmersible vessels dedicated to this business. The new vessel will be employed in carrying yachts primarily across the North Atlantic, with monthly sailings between Florida/Caribbean and the Mediterranean. The vessel will have a service speed of 18knots. This will reduce the current Transatlantic transit time of 15 days to eight days.

The new yacht carrier will be equipped with a 19,680kW diesel-electric plant for propulsion, ancillary electrical power, and all shipboard electrical services. This will be centred on two Wärtsilä 12V38B main diesel generating sets, two Wärtsilä 6L20 auxiliary generating sets, and a 300kW emergency/harbour generating set. Current will be supplied to twin Lips CS3500 pull thrusters for propulsion.

Manoeuvrability will be enhanced by a 1.64MW Lips CT225 transverse bow thruster. The two 5.1MW azimuthing pull thrusters will each be equipped with a 4.0m-diameter Lips skewed, CP propeller and Sternguard MK2M shaft seals.

This is one of the first vessels to be equipped with Lips pull-type thrusters. The propeller is arranged ahead of the pod to achieve the best overall hydrodynamic efficiency and steering at high ship speeds.

The complete power plant will be delivered by a consortium formed by Wärtsilä and the Dutch company Imtech NV, a specialist in electrical installations and integrated bridge systems. The consortium is responsible for the initial design of the power plant, the supply of the complete generating sets, thrusters, all ancillary systems, electrical switchboards, and the integrated bridge system, including controls for the whole power plant. Furthermore, Imtech will deliver components and controls for the ballast system.

The choice and design of the power plant has certain beneficial features that well suit the ship's trade. For example, the choice of a diesel-electric plant gives flexibility in matching engines in operation to the service speed for good operating economy, while also providing for the high ballast-pumping capacity required when loading and unloading the ship.

In addition, the combination of a diesel-electric plant, azimuthing main thrusters and the transverse bow thruster provides good



The yacht-carrying dockship of Dockwise Shipping BV will be equipped with a Wärtsilä diesel-electric power plant, Lips pull thrusters, and a Lips transverse thruster.

manoeuvrability when approaching and leaving the yacht loading and unloading points. Additionally the common-rail engines should reduce smoke to zero. This is a mandatory requirement for transporting luxury yachts.

FUEL SAVINGS NEW WITH NEW HULL APPENDAGE - Deltamarin, the Finnish design consultancy, has recently announced the Interceptor configuration. Interceptor is a plate, which can be designed and installed easily, even to existing ships. It is an immersed plate located under the transom which is faired into the hull forward, normally for a short distance. As a simple construction piece it is relatively easy to manufacture and the weight is only a few tonnes.

The payback time is said to be short. The optimum design for the fairing for the first test cases was carried out and verified with the Ranset-type CFD code by Safety at Sea in Glasgow. Fuel savings of 10%-18% have been reached with the best combinations of bulbous bow, ducktail, Interceptor/trim wedge and optimised recesses.

In model tests at MARIN, in Wageningen, a passenger cruise vessel showed an improvement of up to 10% in propulsion power. The reference level was reached with a ducktail included and the Interceptor installed under this. The performance level with the reference hull shape without Interceptor was already considered good in comparison with present industry standards.

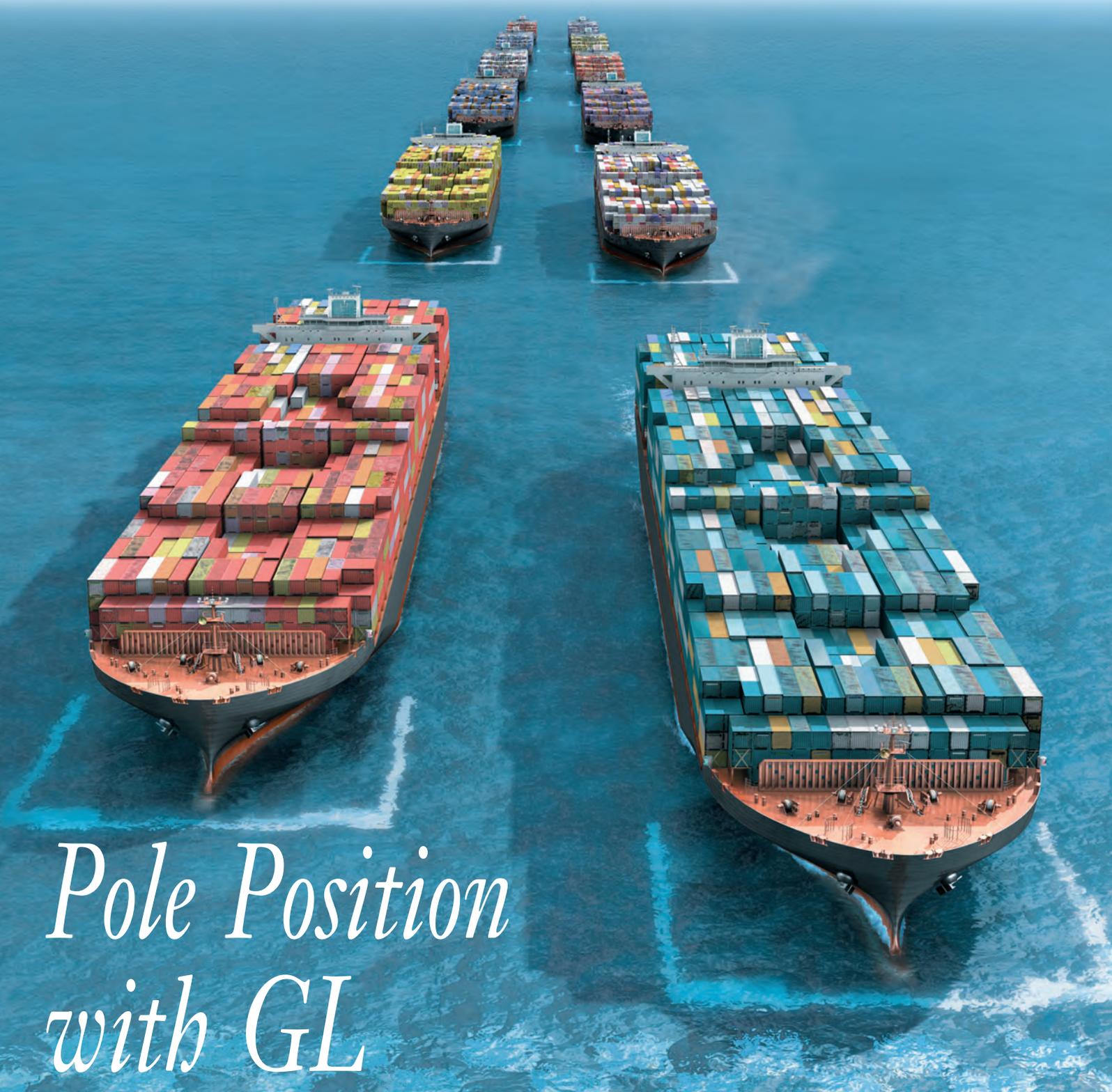
GAS-FUELLED FERRY FLEET TO HAVE BERGEN ENGINES - A fleet of passenger/vehicle ferries fuelled with LNG are to be built to serve two routes on the Norwegian coast, as reported in *The Naval Architect* January

2005, page 18. Now, Bergen lean-burn spark-ignition gas engine generator sets from Rolls-Royce have been selected as prime movers for all five 129m vessels, in a gas/electric propulsion system. The ships will be built at Aker Yards for Fjord 1, and are set to go into operation at the start of 2007.

Three of the double-ended vessels will sail between Halkjem and Sandvikvåg, joining sections of the E39 road along the south coast of Bergen, and the other two ships will operate between Arsevågen and Mortavika, in the Stavanger area. These routes are the second and third most used links in Norway in terms of passenger and vehicle number use.

All five vessels will carry a mixture of vehicles within a 198 car-equivalent limit, and up to 530 passengers, but will be powered for different service speeds. Three are to have a total of 12,370kW of engine power, provided by two Bergen KVGs-16G4 engines, each of 3535kW and two KVGs-12G4 units rated at 2650kW, to give a service speed of 21knots. Only 17knots is required on the two vessels on the Arsevågen-Mortavika route, so they will be equipped with two of the same model of 12-cylinder engine.

MORE LNG CARRIERS ORDERED - ChevronTexaco has ordered two liquefied natural gas (LNG) carriers from Samsung Heavy Industries, of South Korea, to support the planned growth in the company's LNG business. The vessels will have a capacity of 154,800m³ each. Both carriers will be of membrane-type design and equipped with dual-fuel diesel-electric propulsion. The two carriers are planned for delivery in 2009. 



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Alternative angle on lifeboat davits

Capt Dennis Barber, FNI, ARINA, considers an innovative approach from Norway to the problems of launching lifeboats safely.

CAPTAIN Egil Stag, a retired Norwegian sea captain, has put forward an alternative to the traditional approach to launching lifeboats. His solution does not re-design the lifeboat so much as the launching device. The considerable experience of this master should be examined carefully before any of his ideas are dismissed, particularly as they may not involve any great re-assessment of the launching process.

The Lifesafe II davit concept proposed by Capt Stag has identified one area that is consistently neglected by many manufacturers of davits. The initial swinging-out of the boat from its stowed position to the point at which it begins its vertical descent to the water is, too often, the most difficult phase of launching to control. The problems associated with the speed of this phase are - for many existing designs - what give seafarers their main concerns regarding the safety of that manoeuvre. As a result, they can become reticent to carry out the procedure too frequently.

The Stag concept is slightly reminiscent of the Miranda davit developed by Schat in the late mid-20th century and still in use. Like the Miranda, the Lifesafe II is a moving cradle in which the boat is suspended, the cradle itself moving bodily from stowed to a water's edge position. The difference with the Lifesafe II davit, however, is in its clever geometry.

When stowed, the angle of the inverted L-shaped frame lifts the boat clear of the deck and deck edge. As the assembly is lowered down the ramps to the hull's side, one leg of the L passes over the sheerstrake and rolls down the ship's side. The other leg continues in the ramp, projecting the apex outboard of the sheerstrake, such that there is no sudden transition between horizontal to vertical motion - as tends to be the case with conventional pivoting davits. Clearances are also calculated to preclude the possibility of contacts between boat and ship's side - a regular problem with conventional pivot davits.

Once outboard, the whole rig is lowered with the boat to the water, thus ensuring that the boat itself is kept clear of the ship's side and any accompanying potential for serious damage to the boat or injury to personnel. Because the falls are led over a fairlead at the deck edge and not held outboard by davit arms - a concept also used in the Miranda design - except in an extreme heel, they will nearly always result in a compressive force on the cradle against the ship's side.

Uncontrolled swings and ship's side impacts are therefore much less likely than with conventional davits, which deliberately plumb well clear of the side, ignoring the inevitable swings with even the slightest of ship movement.

The design of the ramps involves a slight rise on the inboard extreme. This is to raise the boat from a stowed position to a suitable height for clearing the sheerstrake. It also occurs to this commentator that a design that stows the boat in a cradle on deck lends itself to float-free capability in the event of rapid sinking, as with cargo ships and



A Harding MCF 28 conventional enclosed lifeboat weighing 5.5tonnes, showing the Stag set-free arrangement rigged. Note the central 'power lever' for simultaneous release of both forward and after strops.

bulk carriers laden with dense cargoes or lacking sufficient subdivision. It might also be noted however, that the rise in the ramp might prevent the totally gravity-driven launch so much loved by SOLAS.

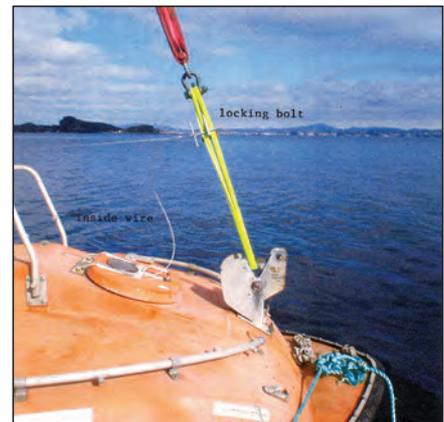
Captain Stag has thought of this and insists that the arrangement can be fitted with an outhaul, which can be operated by hand to propel the arrangement to the peak of the rise where gravity can then take charge. This commentator also observes, however, that it cannot be beyond the wit of designers to produce some stored energy device such as a hydraulic ram and accumulator to achieve the same result. It is, after all, achieved with starters on emergency generators.

Put into context, it can be observed that in the event of an adverse heel, most pivoting designs cannot launch from the stowed position (as required by SOLAS) due to the position of the craft's centre of gravity relative to the pivot fulcrum, so the Stag design should not be unilaterally penalised in this respect.

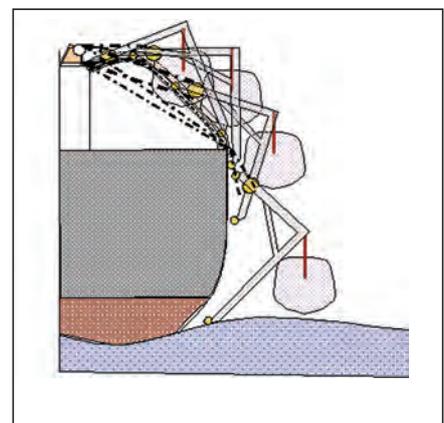
Together with the promise of a smoother transition to the outboard lowering position and elimination of sudden impacts that stress both the equipment and occupants, seafarers might have their trust in launching systems restored. Davit manufacturers would be well advised, first to recognise that many existing designs can be most unsatisfactory in service, and secondly, to acknowledge the wisdom of a sea captain's experience and look towards putting the idea into production. In that way, seafarers should benefit in improved safety and designers, and builders should benefit in their profits. Safety does not have to be diametrically opposed to prosperity. A win-win situation can be achieved!

Novel Lifesafe release system

Together with the launching system, Captain Stag has also advocated a suspension and release system that is based on a 'soft' connecting principle. His proposal advocates webbing straps rather than what have latterly become 'traditional' steel links, chains, and other rigid, hard and unyielding linking devices. He also advocates a system of release that operates from the outside



The attachment to the hook. Further development of safety precautions to prevent inadvertent premature release should be possible; also, duplication of the suspension strop without release gear until just above the water would be prudent.



Operation of a Lifesafe II cradle. The boat is suspended within the cradle on short suspension strops.

where the moving parts are visible, rather than within complex equipment hidden from view within the suspension hooks. *continued*

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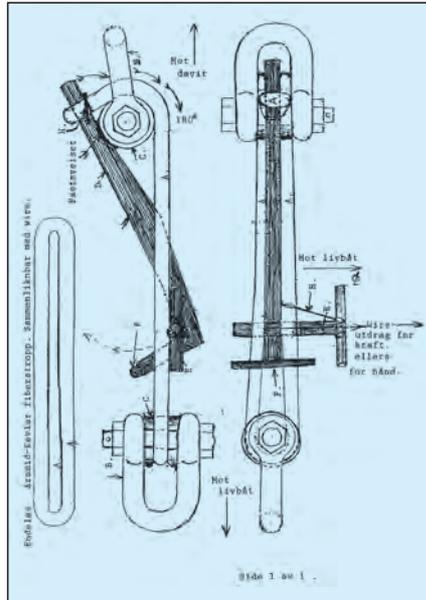
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The system envisages a pin that is withdrawn simultaneously at each end of the boat. This simultaneous withdrawal is assured by wire connections to a central lever designed to provide extra purchase to overcome the resistance of the pin when loaded. It is possible that this lever could be operated by a simple line to the cockpit but it should be rigged for 'pull' rather than 'push' activation.

In terms of a safety override, the pin could have a profiled shape that resists inadvertent withdrawal, but it would also be advisable, in the light of many accidents, to duplicate the suspension strop to a permanently shackled and easily accessible hanging-off position. The shackle would obviously require releasing before reaching the water but trained lifeboatmen are still required in boats, according to SOLAS. They should be credited with some skill, otherwise the survival course is a waste of time and money.

The reasons for rigid links are understood, but they are based on engineering considerations, made more necessary by the need for precision positioning in the davits on conventional 'suspended' arrangements. Most seamen regard 'precision' at sea with a measure of disdain, as they know from experience that the more finely engineered the equipment, the quicker it degenerates to an unworkable condition.

Before blaming seafarers for lack of maintenance, manufacturers should take stock of what they are dealing with. Steel, plus salt water, plus air, always did equal corrosion - and now crews are a fraction of the size they were in earlier days! Is it reasonable for the maintenance to continue in an upward trend?



Operation of the release arrangement.

More importantly however, the rigid links ignore the considerable danger they pose to operatives within the boats, whereas with soft links the danger is minimal, hence the need to consider Capt Stag's proposals seriously. The safeguards against inadvertent release definitely need further development but this should not be impossible to devise.

The positioning of the boat is less critical with the Lifesafe II cradle, since the length of the straps is short, and inboard cradling arrangements, with the boat being inserted from above, should be

within the tolerances of any stretch. Webbing straps are also more readily manipulated by crew members, with less danger to hands and upper body and in an emergency, a handy cutting device is an option.

By comparison, jammed release hooks and rigid links are impossible to clear in an emergency. Like the Lifesafe II launching proposal, the Lifesafe suspension and release system is designed around sound principles of seamanship. Development of further safeguards should be a minor problem. 

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Innovative product/chemical tanker from Turkish yard

MORE information has now been received on the interesting 15,000dwt product/chemical tankers ordered from Cicek Shipyard, in Turkey, by KS Tankers, the design of which was featured in our January 2004 edition, page 6. This ship, *Puli*, will be most notable for the specification of Ulstein Aquamaster azimuth propulsion thrusters. An identical sister is also currently under construction, and a contract has been signed for a third vessel but this will have major modifications to the cargo parts of the hull. *Puli* has recently been sold to a Danish owner, prior to completion, and her name has been changed.

Puli's design was created by the Turkish consultancy Delta Marine Engineering Co, based in Istanbul, and is representative of a number of advanced designs now being built in that country. The ship is planned for IMO Type II cargoes, with densities up to 1.99tonnes/m³. The tanks and piping are arranged so that dangerous cargoes can be loaded in adjacent tanks. Double aft cargo lines and two slop tanks provide good flexibility in loading, discharge, and cleaning, while the engineroom and fuel tanks, as well as the cargo spaces, are protected by a double skin. Both hull and machinery are strengthened to comply with Bureau Veritas 1A ice class, and the mooring deck forward is protected by a whaleback.

Finite-element analysis software ANSYS was used by the consultancy Mesh Engineering Co to ensure an optimum hull structure while minimising the volume of steel. In particular, the area at the stern between the thrusters and the hull



The advanced product/chemical tanker *Puli* has been designed by Delta Marine Engineering to provide a flexible cargo service as well as a high level of propulsion redundancy. An important innovation is the specification of azimuthing propulsion thrusters. Since launching, the tanker has been sold to a Danish owner and her name has been changed.

TECHNICAL PARTICULARS 15,000DWT PRODUCT/CHEMICAL TANKER

Length, oa.....	148.00m
Length, bp.....	139.50m
Breadth, moulded.....	21.60m
Depth, moulded.....	11.30m
Draught, design.....	8.50m
Deadweight, design draught...	15,000dwt
Cargo capacity.....	18,422m ³
Water ballast.....	6574m ³
Heavy fuel.....	738m ³
Diesel oil.....	13m ³
Lubricating oil.....	57m ³
Grey water.....	3.3m ³
Fresh water.....	96m ³
Cleaning water.....	294m ³
Main engines.....	2 x Bergen B32:40L8P
Output.....	2 x 3600kW
Speed, service, 90% MCR,	
10% sea margin.....	15.50knots
Accommodation.....	(18 single berth, 2 twin berth)
Classification.....	Bureau Veritas +Hull, + Machinery, Chemical Tanker, Oil Tanker, ESP, Unrestricted Navigation, SYS NEQ 1, AUT-IMS, Ice Class 1A, Clean Sea, AVM-DPS, IG, VCS, Inwater Survey, MANOVR

was evaluated with special care. Free and forced vibration analyses were also carried out by making a finite-element model of the engineroom and superstructure. Thus, it was possible to remove natural frequencies from resonance areas by making structural changes.

To optimise the hull further, various potential flow and viscous flow solvers were used, while resistance, manoeuvring, and propulsion experiments were carried out at the Bulgarian Ship Hydrodynamics Centre, in Varna. The latter tests confirmed that the hull form had very low resistance and other values. With an improved aft form and inclusion of a central skeg, perfect linear stability is provided. Periodic coercive forces, which might cause vibration, are minimised by allowing the propellers to work in uniform flow.

Mild steel is utilised throughout the vessel (66%), except for the cargo tanks where high-tensile AH grade (24%) is employed. A further 10% is of DH type, used on the shell expansion instead of 20mm A-grade.

Cargo is carried in 18 hold tanks separated by corrugated transverse and longitudinal bulkheads, plus two cylindrical cargo/slop tanks on deck, and all precautions have been taken to minimise tank residues. Up to 20 segregations are possible, and loading stability can be monitored by a Deltaload computer designed by Delta Marine.

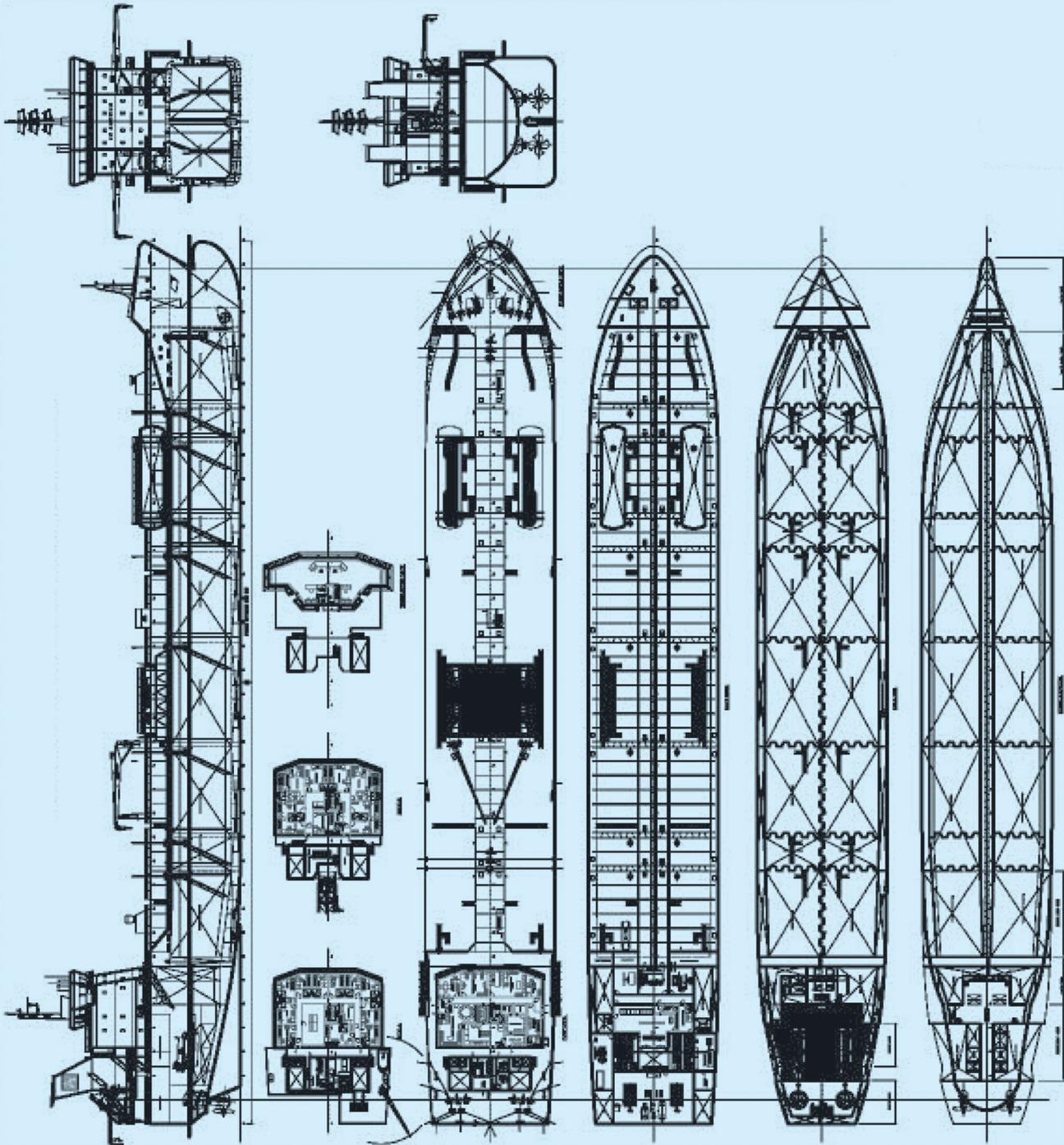
All tanks are coated with Advanced Polymer Coatings' MarineLine Siloxirane-based system,

and each tank has its own Frank Mohn hydraulic cargo pump (18 x 335m³/h and 2 x 80m³/h). With six pumps running simultaneously, a discharge rate of 2100m³/h is possible. Heating is provided by a thermal oil plant circulating liquid through coils, and each tank is fitted with two Scanjet tankcleaning guns. Tank ventilation is through PresVac valves. Two Gürdesan 5tonne jib cranes are fitted for hose-handling.

The special propulsion plant is designed around the principle of redundancy, while taking into account that tankers require a large amount of power during loading and discharge. The chosen solution to combine these two needs was to specify two main engines, two azimuthing propellers, and an A van Kaick 1500kVA alternator driven off the free end of each engine. Additional electrical supplies can be supplied by a 540kVA Nordavn Scania auxiliary diesel-alternator. This arrangement gives a service speed of 15.50knots, but in case of a breakdown in one line, *Puli* can still continue at a speed of 13knots. This layout allows the ship to achieve a Bureau Veritas AVM-DPS notation.

The engines are of the Rolls-Royce Bergen B32:40L8P type, each developing 3600kW at 720rev/min, and the thrusters are also products of the same group, being Aquamaster CP types running at 182.3rev/min and with nickel-aluminium-bronze blades. In addition to the azimuthing main propellers, a Kamewa Ulstein 600kW bow thruster is also installed. ⚓

General arrangement plans of the 15,000dwt IMO Type II product/chemical tanker *Puli*, built by Cicek Shipyard for KS Tankering and Shipping Co.



LINDENAU Safety Tanker Class 2010

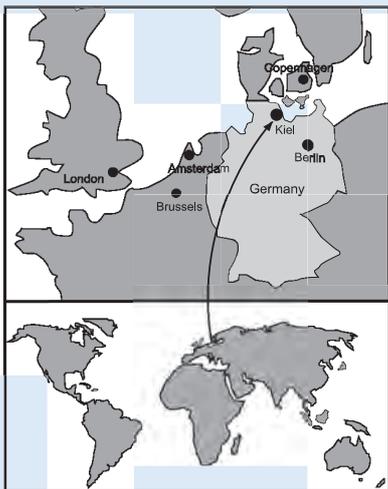


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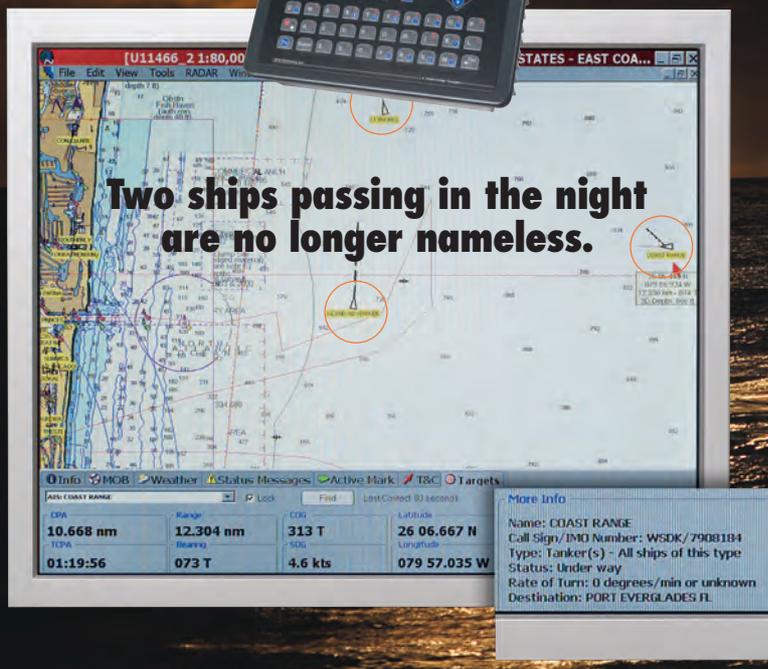
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Seychelles Pioneer: another efficient 'green' tanker from Lindenau

FOR several years now, the Lindenau shipyard at Kiel, in Germany, has been a successful builder of high-quality advanced product tankers, particularly those of the Class 2000 series - first launched in 1990, which can range from 3000dwt to 13,000dwt (*Jian She 51*, built in 1995) to 32,250dwt (*Seadevil*, completed in 1996), *Silver River*, of 13,300dwt (1999), and the 32,230dwt *Seaturbot*, delivered in 2000 (a modified design, Class 2004). These four vessels were presented respectively in the 1995, 1996, 1999, and 2000 editions of our annual *Significant Ships* series.

Now, Lindenau has delivered (in April) an even larger vessel, the 37,500dwt *Seychelles Pioneer*, to the Seychelles Petroleum Co, and one the same day launched a sister; they are of another variant, known as Class 2010. These are IMO Type II vessels for transporting oil, products, and chemicals, and apart from the normal advanced specification for this type of tanker, the new pair will be notable for their additional Germanischer class notations BWM-S (ballast water management-sequential) and EP (environmental passport). Managing the new problem of ballast water discharge in foreign waters was discussed by Lloyd's Register in *The Naval Architect* January 2001, page 24.

By issuing the additional class notation EP to a double-hull tanker, improved 'green' performance should be assured. In addition to ballast-water implications, the criteria include compliance with MARPOL Annex VI (emissions of NOx and SOx), efficient vapour return system, good sewage treatment facilities, environment-friendly waste handling and firefighting equipment, and compliance with minimum bilge-water oily residues, as well as the specification of TBT-free antifouling paints.



The 37,500dwt *Seychelles Pioneer* is the latest in an extensive family of advanced and environment-friendly chemical/product tankers from Lindenau GmbH.

TECHNICAL PARTICULARS SEYCHELLES PIONEER

Length, oa.....	184.96m
Length, bp.....	175.20m
Breadth.....	28.00m
Depth, to main deck.....	16.80m
Draught, scantling.....	11.70m
Deadweight, scantling.....	37,500dwt
Cargo capacity, 100%.....	42,327m ³
Slop capacity.....	944m ³
Cargo specific gravity,	
max.....	1.10tonne/m ³
Gross.....	22,346gt
Water ballast, segregated.....	16,754m ³
Main engine.....	MAN B&W 6L58/64
Output.....	8340kW at 428rev/min
Speed, trial, 8430kW,	
11.00m draught.....	15.80knots
Accommodation.....	21 cabins
	for 27 persons
Classification.....	Germanischer Lloyd
	+100 A5 Chemical Tanker,
	Type II, Oil Product Tanker,
	ESP, COLL3, BWM-S, EP,
	+MC, AUT, INERT

Seychelles Pioneer and her sister (the latter varies slightly on some of her details but is otherwise identical) have a double-skin in the area of the engineroom fuel tanks, as well as for the now-mandatory cargo spaces. These features also qualify for a Germanischer Lloyd COLL3 collision notation - the hull is believed to give a four-times-higher resistance to collision than a single-skin construction; this notation has already been included on earlier Lindenau tankers.

Over the years, the shipyard's design team has thoroughly refined the hull lines, with a special yard-created bulbous bow, to give a very favourable speed/power ratio, while manoeuvrability is aided by a semi-spade rudder with an efficient profile and turning angle (2 x 44deg), plus an electrically driven CP bow thruster of 1050kW. At the same time, a high cargo tank volume/deadweight ratio is claimed.

On both tankers, the cargo arrangement comprises two pairs of five tanks, plus three slop tanks, all coated with epoxy, which are separated from each other by corrugated longitudinal and transverse bulkheads mounted on stools. The resulting smooth surfaces give short discharge times (approximately 10 hours), minimum cargo residues, and a short tank-cleaning period. The list of cargoes that can be carried under the IMO

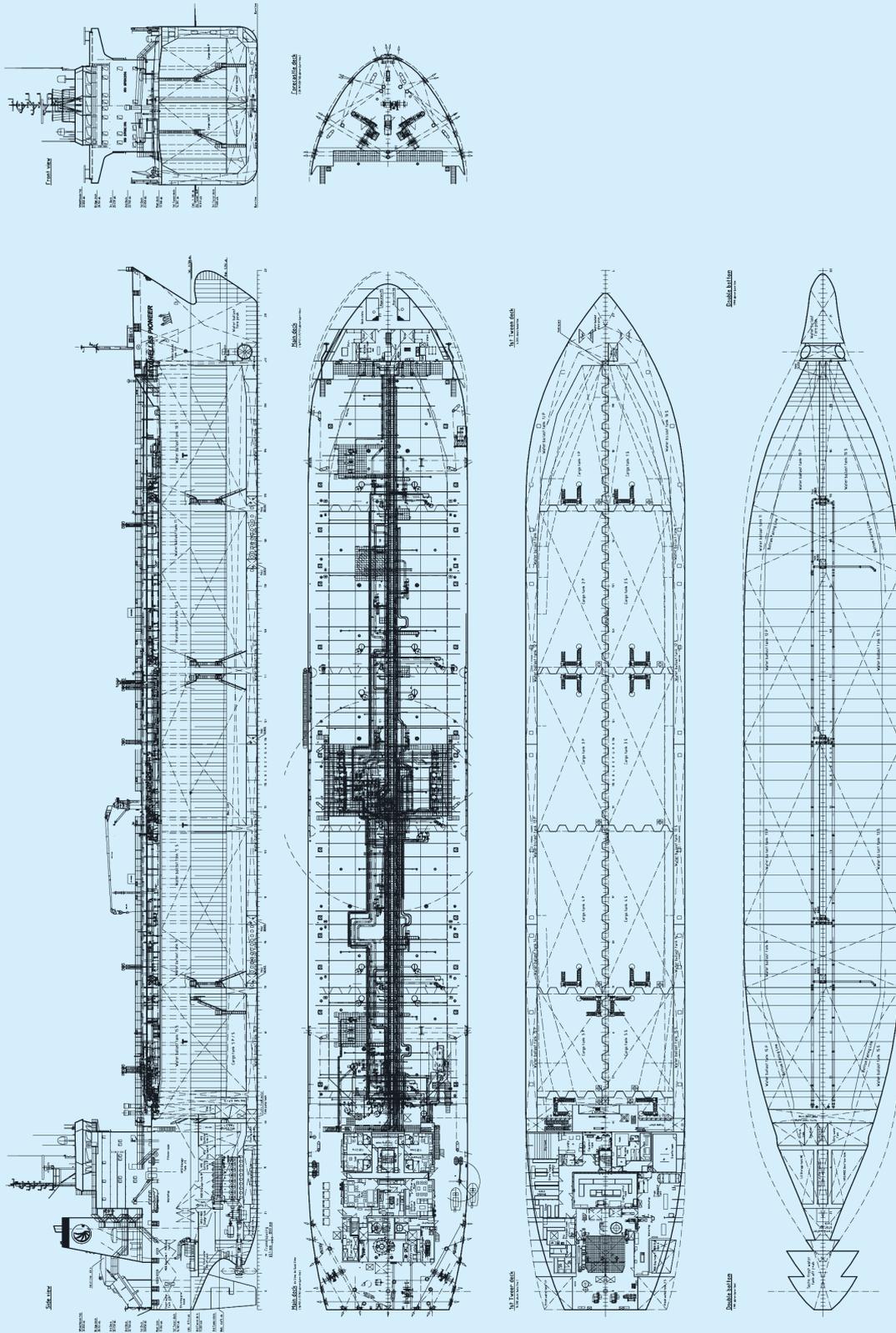
Type II class (IBC code and MARPOL Annex II) will include the transport, as from 2007, of vegetable oils.

In the machinery spaces, the layout has been designed according to ergonomic principles, and an economic layout has been adopted for pipelines, cable trays, and air ducts. An integrated control system with power management helps to ensure optimum operation of the 1400kVA alternator driven off the gearbox and the three 1200kVA diesel-driven sets.

On the bridge is a workstation from where the crew can choose the most economic form of power supply according to demand, by using the most appropriate of five programmed modes. A programmable logic controller (PLC) automatically executes the required functions.

A computer-based cargo monitoring and indicating package (radar type for the cargo tanks and pneumatic elsewhere) is included, as is a secondary steam heating system and deck heat exchangers with temperature indication. All the electro-hydraulic valves (for five segregations) are masterminded from a remote console, and the actual pumping system is based on individual submerged hydraulic pumps (10 x 500m³/h, 2 x 200m³/h, and 1 x 100m³/h). These are combined with a super stripping arrangement. ⚙️

General arrangement plans of the 37,500dwt IMO Type II chemical/product tanker *Seychelles Pioneer*, built by the Lindenau shipyard for the Seychelles Petroleum Co.



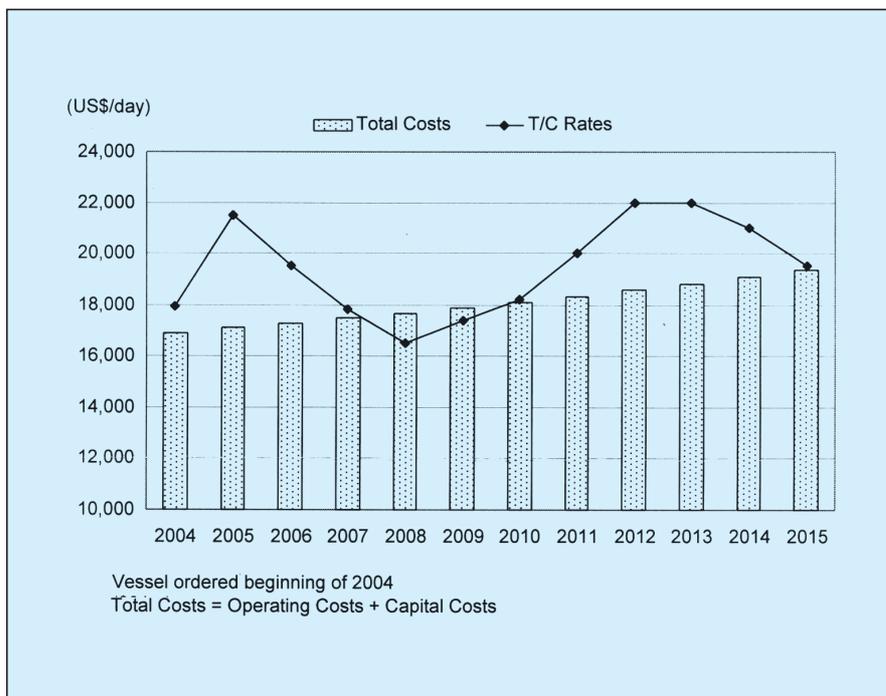
Changes ahead for product tankers

ACCORDING to a new report from the UK Analyst, Ocean Shipping Consultants, major changes can be expected in the product tanker trades; at the same time, the world fleet is expected to expand from 40.50 million dwt to 65 million dwt by 2015. Important factors include an Asian crude distillation capacity standing at 26% (the highest anywhere), followed by North America (24%), with important new refining capacity expected to come on stream in Asia, the Middle East, and Africa.

Last year, average one-year time-charter rates for 30,000dwt product types rose to US\$14,700dwt/day from US\$11,500/day in 2002, while spot rates for the same size of ship fluctuated from US\$14,000/day in 2002 to more than US\$36,000/day last year. Newbuilding prices have been strongly influenced by a bulging order book, strong price competition, and China's expanding capacity; these factors have been offset by huge steel-price increases and limited berth availability. A reflection of these considerations has been that prices for a 40,000dwt-50,000dwt product tanker rose from US\$29 million in 2003 to more than US\$40 million in early 2005.

Global product trade volumes are forecast to grow by around 4% annually, from 633 million tonnes in 2004 to 740 million tonnes in 2010. After that date, they will rise even further, by 5.5%, to more than 920 million tonnes by 2015. The boost in Middle East and Asian exports is expected to hoist demand for larger product designs of more than 45,000dwt.

The recent revisions to MARPOL 73/78 (Annex I regulation 13G) accelerated the phase-out schedule for Category 1 tankers (pre-MARPOL) to April this year, rather than 2007, as originally planned. In addition, the phasing-out date for Category 2 and 3 tankers has been brought forward to 2010, from 2015 (*The Naval Architect* May 2005, page 4). The phase-out of pre-MARPOL tonnage is expected to impact most strongly on tankers smaller than 30,000dwt, since this sector has a



Product tanker profitability to 2015 (base case). Source: Ocean Shipping Consultants.

large concentration of single hulls. Phase-out of Category 2 and 3 tankers means that by 2010 more than half the existing fleet will have to be scrapped or replaced.

An alarming forecast by Ocean Shipping Consultants is that typical product-tanker operating costs will rise by 45% of the next decade, taking the annual aggregate for a typical 30,000dwt-50,000dwt design to US\$2.37 million in 2010 and US\$2.81 million

in 2015. Profitability is anticipated to strengthen in 2005 before weakening in 2008, and rising again in 2010, then weakening yet again.

Product Tankers: Market Prospects to 2015 is published by Ocean Shipping Consultants at £675.00, €975, or US\$1300, inclusive of airmail delivery and packing. Electronic versions are also available. E-mail address: info@osclimited.com, www.osclimited.com

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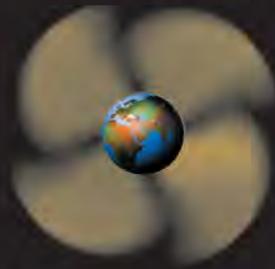
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Pressurised LNG: an alternative way to transport gas

In recent months, this journal has published several articles about various alternative techniques for hauling LNG to market. Here, a group of experts from ExxonMobil* consider a new possible technique that could be especially useful for remote or stranded gas. Cargoes are carried at a higher temperature and pressure than conventional LNG but need a new low-temperature steel (already developed by ExxonMobil) to make projects viable.

APPROXIMATELY 85 trillion m³ of natural gas reserves worldwide (Ref 1) are stranded due to economical, technical, or political issues, and transport is often the primary limitation to economic development of these resources. However, ExxonMobil's proposed new proprietary gas transportation technology - pressurised LNG (PLNG) - could change this.

By transporting the gas at moderate pressures, the liquefaction temperature for PLNG is higher than LNG. Since less cooling is required to liquefy the gas, refrigeration and processing systems are reduced, making PLNG facilities less expensive than those for LNG. The elevated pressure of PLNG requires a new ship and a pressurised cargo containment system consisting of multiple pressure vessels contained in an insulated 'coldbox'.

While the ship and cargo containment costs for PLNG are higher than traditional LNG, the reduction in gas treatment and refrigeration facilities, along with a new cryogenic steel for

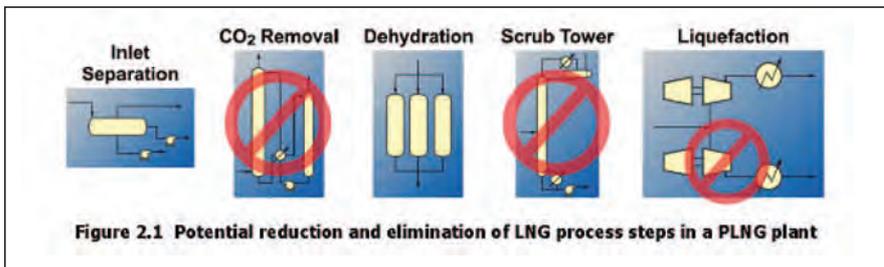


Figure 2.1. Potential reduction and elimination of LNG process steps in a PLNG plant.

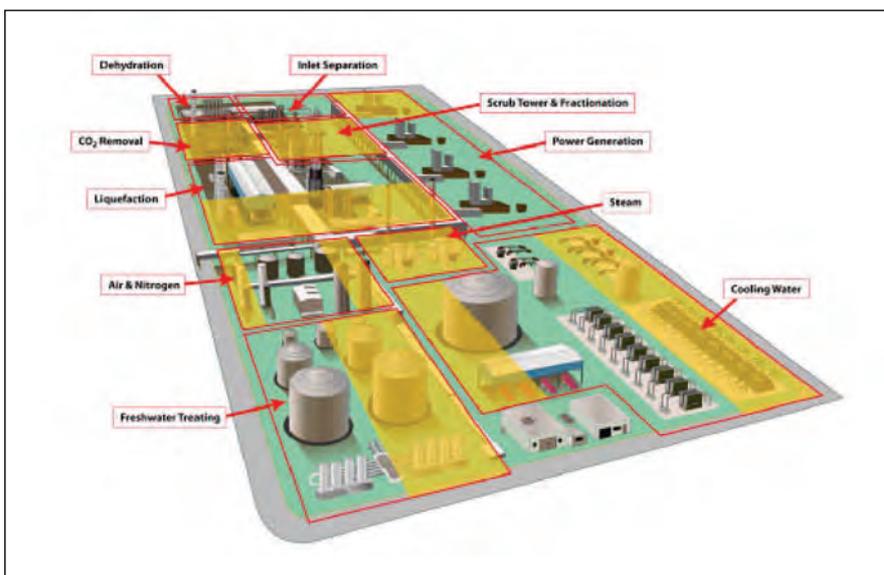


Figure 2.2. Reduction of area and facilities in an LNG plant that could be achieved with a PLNG facility of comparable capacity.

TECHNICAL PARTICULARS PROPOSED PLNG CARRIER	
Length, overall.....	350.00m
Breadth, moulded.....	55.00m
Depth, moulded to upper deck at side.....	30.00m
Draught, full load, moulded.....	11.40m
Deadweight, full load draught.....	78,000dwt
Displacement, full load draught:.....	154,000tonnes
Cargo capacity.....	200,000m ³
Main engine.....	slow-speed diesel engine
Fuel.....	Heavy oil
Output.....	45,570kW
Speed, service, full load draught, 90% MCR, 15% sea margin.....	22.00knots

*Extracts from the paper 'Pressurised liquefied natural gas (PLNG): a new gas transportation technology', presented by Ronald R Bowen, Mark C Gentry, Eric D Nelson, Scott D Papka, and Ann T Leger, all from ExxonMobil Upstream Research Co, Houston, Texas, USA, at the Gastech 2005 conference, held in Bilbao, Spain, from March 14-17, 2005.

cargo containment, offers the potential for cost-savings to enable new opportunities for development of stranded gas.

PLNG benefits

The benefits of PLNG are associated with the reduction in facilities relative to an LNG project. In cases where infrastructure for gas production and import limit economic feasibility, PLNG has the potential to enable development of the resources. For similar facilities output, only around one-half of conventional LNG facilities are required for PLNG. While this cost reduction is an obvious advantage, the weight and footprint of the facilities are also reduced by approximately 50%. Reduced weight and footprint may enable less expensive development of offshore fields.

Furthermore, this reduction may enable integration of offshore production with the liquefaction facility on one hull thereby reducing infrastructure and pipeline costs for offshore developments. PLNG is also attractive in difficult onshore construction environments. In this case, facilities could be constructed in a more cost-effective location and imported as a barge-mounted unit.

In addition to the potential reduction in infrastructure costs, the PLNG liquefaction process uses less fuel than LNG because of the higher liquefaction temperature. Therefore, more gas is available for delivery to market. In addition, the reduced facilities also improve plant reliability.

Finally, PLNG could provide a cost-effective development option for smaller resources. Since facility costs are a smaller fraction of overall project costs, PLNG is less dependent upon high capacities and large resources required for LNG, to achieve efficient economies of scale. For similar reasons, PLNG is suitable for a staged development of a resource, providing multiple options for marketing flexibility and earlier revenue generation.

Comparison with LNG

PLNG can be shipped at a variety of conditions ranging from 1.0MPa to 7.6MPa, corresponding to temperatures between -123°C and -62°C; however, for typical applications, a 1.7MPa and -115°C case is optimal. These conditions provide reductions in both PLNG liquefaction and gas treating facilities. At -115°C, the refrigeration



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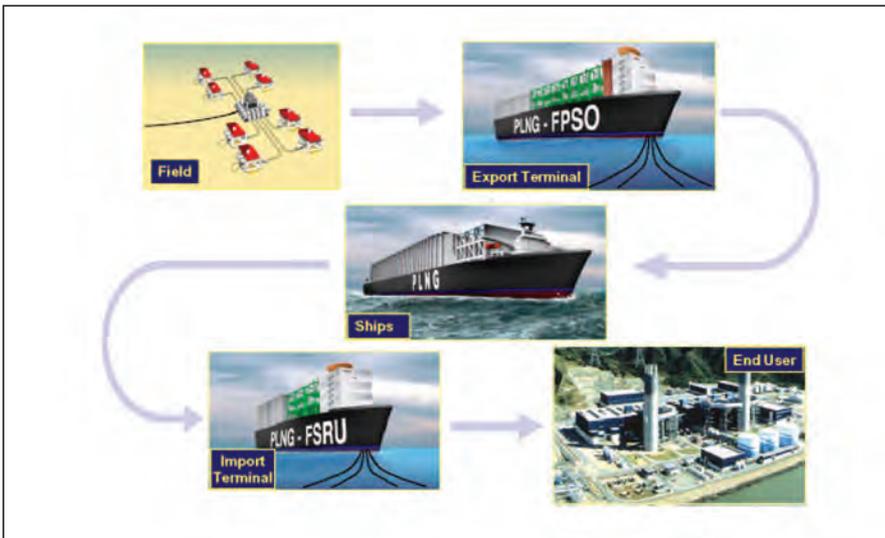


Fig 3.1. PLNG delivery chain.

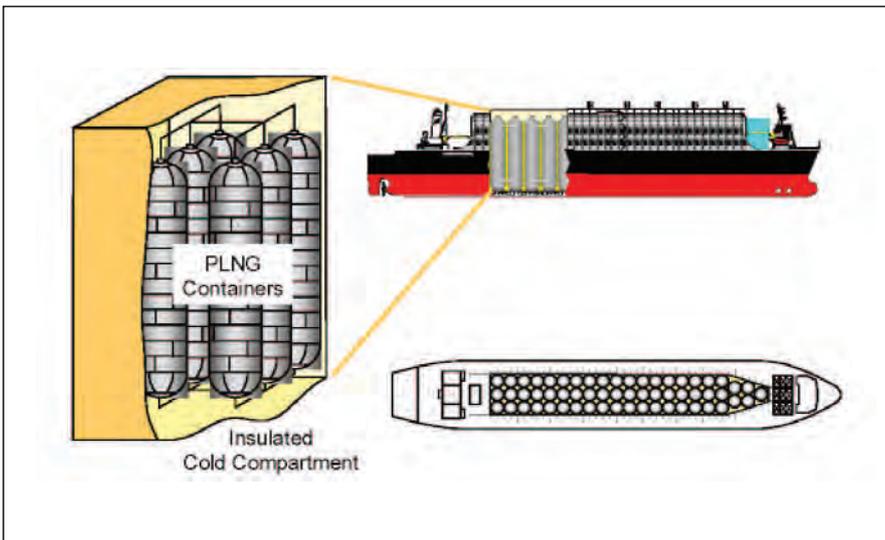


Fig 3.3. Arrangement of a PLNG ship and its containment system.

power required to liquefy natural gas is roughly one-half of the comparable LNG liquefaction requirement.

This lower power requirement allows direct reductions in the most expensive components of the LNG chain - liquefaction refrigerant compressors, associated gas turbine drivers, and liquefaction heat exchangers. Improved processing reliability should also result.

PLNG at -115°C can retain some 2% CO_2 in solution without solids formation. The increased liquefaction pressure and temperature of PLNG increases the CO_2 solubility thereby removing the need for amine treating in many applications.

Although water solubility is also slightly increased at the warmer temperatures, PLNG production, like LNG, still requires dehydration using molecular sieves. Similar to the CO_2 solubility, the higher PLNG temperature increases the solubility for aromatic and paraffin hydrocarbons. LNG traditionally uses a scrub tower to separate these components from the gas before liquefaction. Depending upon the inlet gas composition, the need for this scrub tower may

also be eliminated for PLNG. A scrub tower normally feeds a fractionation system to separate LPG for refrigerant make-up. By eliminating the scrub tower, a PLNG liquefaction plant will not have this fractionation system, but instead must import LPG for refrigerant make-up.

If both the amine system and scrub tower/fractionation system are eliminated at a PLNG production facility, the two largest heat inputs are removed. The only remaining system requiring a large heat input is the molecular sieve regeneration; this heat can be recovered directly from a waste heat recovery unit on the power or liquefaction gas turbine. With the reduced heat requirements, a large distributed steam system is not required in a PLNG facility. Elimination of 50% of the gas turbine drivers, as well as the heating system, has a substantial impact on fuel consumption. Generally, only half of the fuel required for an LNG facility would be required to operate a PLNG plant at a similar capacity.

Fig 2.1 shows the major LNG process steps that could be potentially reduced or eliminated for PLNG. Because of the reduction of these, the

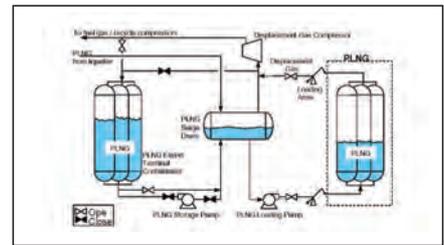


Fig 3.2. Export terminal loading processes.

utilities and infrastructure required to support them are also significantly reduced. The overall equipment reduction for a typical LNG facility is shown in Fig 2.2.

Although substantial savings can be realized in the plant cost of the PLNG facilities, the elevated temperature and pressure of PLNG compared with LNG results in a reduced product density. At -115°C , the PLNG product density is approximately 80% of the LNG product density at -160°C . This reduction in product density increases the storage and shipping volumes by 25% to move an equivalent energy content of natural gas over LNG.

In addition, the PLNG storage vessels need to contain the pressures associated with PLNG cargo conditions. This can be costly with conventional steels. The higher weight of the PLNG containment compared with LNG also adds to the cost of a hull and supporting systems. Nevertheless, a new high-strength, low-temperature steel specially developed for PLNG pressure vessels should be able to reduce the amount of steel needed for a containment system, thereby lowering overall weight and cost of a ship.

PLNG delivery chain

The PLNG delivery chain shown in Fig 3.1 has the same components as an LNG delivery chain. It starts with gas production from the resource. The gas is delivered to an export terminal, which treats, liquefies, and then stores the gas as PLNG. The export terminal may also have integrated production facilities as depicted. Cargo is then offloaded into special PLNG carriers; these travel to the market location where the PLNG is offloaded onto an import terminal. The import terminal may have storage followed by pumping and vaporisation. Finally, the import terminal delivers the gas into a commercial pipeline system.

Export terminals

The advantages of PLNG facilities make it well suited for offshore applications. The reduced footprints require less space on a floating vessel than corresponding LNG facilities. As a result, combining PLNG with production facilities to produce, liquefy, store, and offload a cargo on a single vessel (similar to existing FPSO concepts) is potentially feasible. The FPSO concept can be a spread-moored barge for calm environments or a ship that weathervanes around a turret in more severe environments. If required, a disconnectable turret can be utilised to avoid hazards such as hurricanes or icebergs. In the FPSO concept, the liquefaction facilities can be configured in multi-level modules at the one end of the vessel while the cargo containment would be located at the other end.



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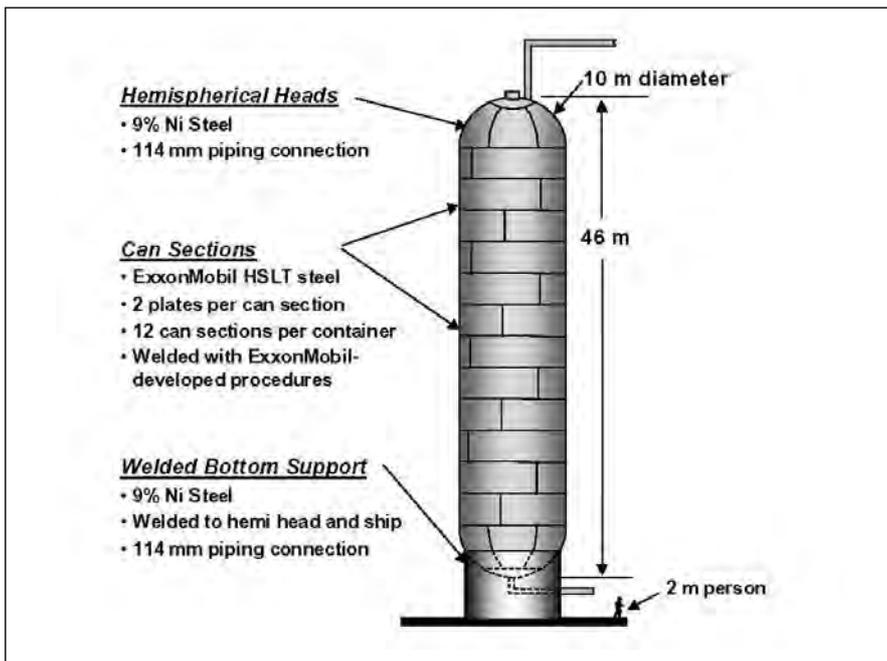


Fig 3.4. Schematic of 10m PLNG container.

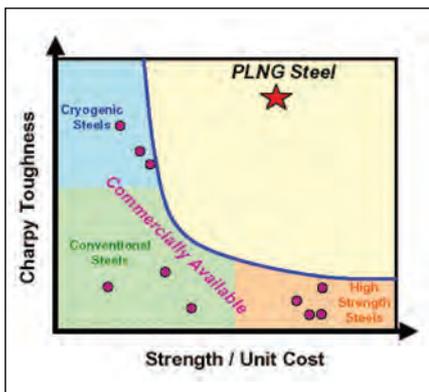


Fig 4.1. Comparison of Charpy toughness, strength, and cost for various steels at PLNG temperatures.

Both export terminal designs would employ a similar process and facility design. PLNG can be efficiently produced with a single mixed refrigerant with no pre-cooling. With the modular nature of the construction, the refrigeration system would likely be driven by large aero-derivative gas turbines and utilize brazed aluminum plate-fin heat exchangers to reduce weight. Similar to LNG, the PLNG process also requires inlet separation, molecular sieve dehydration, mercury removal, and utility systems.

For on-shore or near-shore production, a near-shore PLNG export barge may be a preferred concept. Such a barge, including the required storage, can be built in a lower cost construction environment and floated to the plant location. As with the FPSO, the facilities can be modular to take advantage of the lower cost construction environment. The completed production and storage barge can be moored in shallow water or grounded on location if the soil and shipping conditions are acceptable.

The displacement gas-system concept for loading a ship at the export terminal is shown in Fig 3.2. Using this, displacement gas is

compressed and injected into terminal storage containers during transfer from the export terminal to the ship. PLNG liquid is driven from the containers and directed to the surge drum where it is mixed with PLNG coming directly from the liquefiers. The combined stream is then loaded onto the ship through a single set of loading pumps.

The size of the displacement gas compression system and piping can be optimised as part of the entire transportation chain to minimise overall costs. This optimisation leads to slower loading and unloading rate, typically adding an extra ship to a transport chain and effectively exchanging storage at the terminals for storage on the extra ship.

Ship design

The pressurised storage requirement of a PLNG system calls for a unique ship design for transporting the cargo. A conceptual design has been developed to carry 200,000m³ of PLNG when filled to 98% capacity. The nominal technical particulars of this vessel are shown in the table at the beginning of this article.

The ship would a single insulated compartment (220m long x 33m wide x 49m high), or coldbox, which contains the large cylindrical pressurised cargo containers. The hull is approximately the same size as a VLCC and larger than conventional LNG carriers. With an onboard reliquefaction facility designed for a 0.3% daily boil-off rate, the ship is able to use less expensive bunker fuel for propulsion and deliver a larger percentage of the more valuable PLNG to market. The insulated coldbox is designed to limit the boil-off rate to match the capabilities of the reliquefaction plant.

Shipboard containment using coldboxes

A PLNG containment system consists of a collection of large pressure vessels constructed from ExxonMobil patented high-strength, low-temperature (HSLT) steel. The current base design has 59 of these, each of 10m diameter and 46m tall. They would be contained in a 33m x



Fig 5.1. The prototype PLNG container, following manufacture at Kawasaki's Harima works.

49m x 220m externally reinforced, N₂ purged single coldbox. The containers are connected by piping into groups of 12 to create five tanks. Each tank is connected via headers to the piping systems for offloading and reliquefaction.

The inner surfaces of the coldbox are insulated to protect the ship steel from the cryogenic temperatures, and PLNG that boils off due to heat transfer into the coldbox is reliquefied and injected back into the container using an on-board reliquefaction plant. The containers, designed according to AMSE Section 8, Division 2, are constructed out of the ExxonMobil HSLT steel and welded using patented welding techniques and consumables.

The HSLT steel and the associated welding process were developed by ExxonMobil researchers to meet the challenging high-strength, high-toughness requirements of the PLNG containers. The can sections of the containers are built from HSLT steel while the hemispherical heads are made of 9% nickel steel. The containers are supported by a traditional pressure vessel skirt made out of 9% nickel steel welded to the inner bottom hull.

Finite-element analysis indicates that the bottom skirt limits container deflections sufficiently without the need for a top support; however, piping systems at the container tops can accommodate deflections of the bottom-supported containers during worst-case sea states. While a top support can be implemented, a single-bottom support is expected to reduce the complexity and expense associated with container installation.

The single-coldbox concept was selected to simplify containment system design and construction. The amount of insulation is much less than that required if each individual container were insulated. In addition, the flat surfaces of the coldbox are simpler and less costly to insulate than the curved surfaces of the container heads. By designing the ship with no transverse bulkheads penetrating the coldbox, the total insulation requirement is minimised and the overall design is simplified by eliminating heating systems that would otherwise be required to keep the bulkhead steel at an acceptable temperature. Additionally, the single-coldbox design simplifies ship construction by enabling the use of large, repeated blocks. It also provides easier access for container and piping installation during ship construction.

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To achieve the required torsional stiffness and racking resistance, the top exterior of the coldbox is reinforced with structural members. In addition, the double hull is robustly designed to minimise container deflection and provide structural integrity of the ship. Since the entire cargo hold is a single volume, a damage-extent zone along the ship's perimeter is included to minimise the risk of breaching the coldbox in the event of a collision. This proposed PLNG ship is designed to meet the International Gas Carrier (IGC) code requirements for both side and bottom damage.

Unloading a PLNG carrier

A PLNG discharge operation differs from LNG because of the increased number of containers. Instead of inserting a pump in each of the PLNG containers, a simple displacement gas system is used to force cargo out of the containers. This system is designed to allow several or all of the containers to be unloaded simultaneously. Compressed gas from the import terminal could be used to increase pressure in the containers on the ship. Cargo from the ship is then allowed to flow back to the import terminal surge tank and from there into import terminal storage.

Evolution of a new steel to contain PLNG

Controlling the cost of containment is critical to realizing the benefits of PLNG. This cost, coupled with the pressure and temperature requirements of the cargo, motivated the development of a new high-strength, low-temperature (HSLT) material. Commercially available materials either cannot meet the required combination of mechanical properties or they are too expensive to be employed economically.

Past studies on concepts similar to PLNG indicated that the barrier to successful commercialisation was the high containment costs (Ref 2). Although it is possible to make the PLNG containers from a variety of materials, most commercial facilities typically use steel to fabricate such large pressure vessels. In addition, basic fundamental metallurgy, coupled with advances in plate manufacturing, suggested that the required properties were attainable in steel. As a result, a programme was initiated to develop a steel, a welding consumable, and welding procedures to construct PLNG containers.

Several high-strength steels are commercially available, but these do not possess the necessary low-temperature fracture performance for this application. A number of cryogenic steels are also available, but their limited strength requires either a large wall thickness that contributes greatly to the cost of a ship or an operating stress above that normally accepted in pressure vessel designs. In addition, these low-temperature steels are generally too expensive due to the high amount of alloy content and complex heat treatment required to achieve the desired fracture performance.

Therefore, a new steel was developed to achieve the combination of high strength and cryogenic toughness at a cost-effective price (Fig 4.1). ExxonMobil researchers designed thermo-mechanical control process (TMCP) schedules that optimise plate processing to minimise alloy content and reduce cost. Successful combinations



Fig 5.2. Fabrication, welding and hydrotesting of the prototype PLNG container. Satisfactory testing was carried out to 150% pressure, as required by the IGC code.

of chemistry and processing were generated with nickel contents between approximately 1wt% and 5wt%. These TMCP treatments, in combination with careful chemistry control, generate a microstructure that provides an ideal combination of high-strength, low-temperature toughness, plus low cost.

After successfully producing laboratory-sized heats that met required properties, a commercial mill manufactured full-scale heats of the steel. Extensive strength and fracture toughness testing was conducted to establish the final target chemistry and processing parameters for commercial production. The HSLT steel has received approval from the American Society for Testing of Materials (ASTM) and is listed as ASTM A841 Grade D in the ASTM standards.

Overcoming welding problems

In order to utilise the HSLT steel in a pressure vessel, new welding procedures and consumables were required. The primary challenge was to develop a welding technique that (1) produces the required toughness in both the weld metal and the heat-affected zone (HAZ), and (2) produces a joint strength that is even or over-matching compared with the targeted plate strength. ExxonMobil researchers developed an automated welding technique that utilises a purpose-designed ferritic weld wire and the gas tungsten arc welding (GTAW) process.

In the GTAW process, two weld torches are used in series. The first weld torch deposits the weld consumable, while the second torch applies an autogeneous pass to reheat the weld metal, thereby refining the grain size in the HAZ and reducing the likelihood of weld defects. This technique is referred to as thermally enhanced HAZ (TEHAZ). Extensive testing demonstrated that welds possessed a superior combination of low-temperature toughness and joint strength required for PLNG containers.

Prototype container demonstrator

In order to verify the design and fabrication methods for a PLNG container, a prototype was constructed using the HSLT steel and welding process. Kawasaki Heavy Industries' Harima Works fabricated the 5m diameter by 17m tall PLNG prototype container (Fig 5.1).

The success of this confirmed many aspects of PLNG containment technology. The HSLT plate was successfully formed into cylindrical can sections using equipment suitable for mass

production. Mechanical testing confirmed that the formed plate retained the required properties. Another important aspect of the prototype was the transfer and application of the welding technology in a commercial facility.

Prior to the prototype construction, HSLT welding processes had only been demonstrated in a laboratory environment. An ability to transfer this technology from the laboratory to commercial welders, who could in turn apply the welding processes with commercially-available welding equipment in a production facility, further confirmed the ability to produce PLNG containers on a production scale. Confirming the ability to form and weld the HSLT plate with production equipment (Fig 5.2), was critical, since the large number of containers required for PLNG must be mass-produced to satisfy project timelines and economics.

After construction of the prototype, the vessel was hydrotested to 150% of its working pressure (also shown in Fig 5.2). According to Section 8, Division 2 of the AMSE boiler and pressure vessel code, a test to only 125% of working pressure is required, but the International Gas Carriers (IGC) code required the more stringent 150% hydrotest. With completion of the hydrotest, the fabricator confirmed the viability of constructing containers in a commercial facility.

Cost studies

PLNG ship design and cost estimates are also being addressed while progressing the technology development. ExxonMobil has completed a conceptual design of a PLNG ship in conjunction with contracted naval architects and engineers. World-class shipyards from both Europe and Asia have reviewed the ship designs and have provided cost estimates. In addition, several fabrication companies with experience in building large pressure vessels have provided fabrication plans and cost estimates for the PLNG containers.

Since the export plant and import plant use conventional equipment, the components for this part of the PLNG delivery chain are estimated based on available data. All the cost data is being utilised to evaluate the economic incentives for the PLNG technology.

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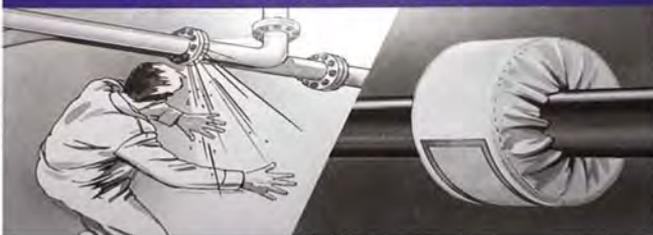
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impact of increased shipping costs. These conditions are more likely satisfied for gas resources located between 1000nm and 4000nm from market. While there are several different development scenarios that demonstrate the strengths of PLNG, an offshore gas development provides an example to discuss the advantages of PLNG in greater detail.

Example offshore application

In this example of an offshore PLNG development, a medium-capacity PLNG FPSO of approximately 3 million tonnes to 5 million tonnes annual capacity supports a shipping chain spanning 3000nm to an offshore import terminal. As previously described, for PLNG to be attractive, savings from the reduced PLNG facilities and other associated infrastructure are needed to offset the higher PLNG shipping costs.

Utilising an FPSO as an export terminal offers several advantages over conventional alternatives. In contrast to an onshore development, the production facilities can be integrated with the PLNG facilities onto an FPSO. No offshore LNG concept has been advanced into a project, primarily because of the high cost of placing the large amount of facilities offshore. The smaller footprint and weight of the PLNG facilities compared with LNG has the potential to reduce the size of an export vessel so that it becomes economically feasible. Since the loading terminal is located with the production operations, the pipeline, associated transmission compression, and

dehydration or hydrate control facilities for an onshore development are eliminated. Furthermore, much of the harbour infrastructure (jetties, breakwaters, and dredging) would not be required for a PLNG floating production facility.

In this example application, the small size of the resource makes it difficult for an onshore LNG project to achieve the economies of scale of currently planned world-class projects (Ref 3). Because PLNG export facilities are a smaller percentage of the overall value-chain cost than LNG, PLNG is less sensitive to economies of scale

Shipping

This example PLNG project would require three 200,000m³ PLNG carriers to deliver 4million tonnes annually over 3000 nautical miles to market. Storage requirements for the overall delivery chain would be minimised with a loading rate of around 6000m³/h. Conversely, the LNG application requires two 200,000m³ ships loading at 10,000m³/h to deliver 3.8million tonnes annually. As previously mentioned, for a specified gas production rate, the increase in fuel efficiency for PLNG makes more liquefied product available for delivery to market.

Conclusions

Pressurised liquefied natural gas is a new ExxonMobil proprietary technology that has the potential to reduce the costs of delivering viable commercial gas. By transporting the liquefied gas under pressure and at a higher

temperature than by conventional LNG methods, processing facilities can be significantly reduced. Therefore, in projects where the economics cannot support the costs associated with conventional export plants and import terminals, PLNG technology may provide a means of transportation that enables resource development.

ExxonMobil has developed materials technologies to meet the demands of PLNG application while reducing the transportation costs for pressurised cryogenic cargo. The materials technology has been demonstrated on a commercial scale through the construction of a prototype container. Leading shipyards and fabricators have evaluated the PLNG ship design and provided cost estimates for project evaluations. In addition, several terminal and loading system concepts have been developed to maximise flexibility in application. The resulting technology system has several potential advantages for gas resources, particularly for offshore or Arctic locations. 

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Optimism for a new breed of coastal LNG carrier

Kawasaki Shipbuilding believes that its pressure build-up technique for feeder-type ships offers interesting potential in distributing smaller parcels of cargo in today's gas-focussed economies. It is a simple idea, with all boil-off gas contained within the tanks, thus a traditional propulsion machinery layout can be adopted.

TODAY's exciting times in the LNG and associated sectors has, as readers of this journal will know, already generated contracts for ships of sizes and with propulsion plant largely undreamed of a few years ago, with ever larger carriers of up to 250,000m³ expected in the near future. In parallel with these advances has come a requirement to distribute gas cargoes from reception terminals to smaller users. Already, in Norway, Knutsen is operating the 1100m³ *Pioneer Knutsen* (*The Naval Architect* March 2004, page 11), and not long after, in Japan, Shinwa Chemical Tanker Co took delivery of the 2500m³ *Shinju Maru No 1* (presented in *Significant Ships of 2003*). The latter vessel, designed by Kawasaki Shipbuilding Corp, employs a pioneering new cargo containment method, the pressure build-up concept, specially conceived by Kawasaki for smaller vessels running on short routes.

Although initially developed as an experiment, *Shinju Maru No 1* has proved to be a huge success, and great interest is now being shown by many smaller utility companies in Japan (with ports too small to handle large LNG vessels), who are now following the example of the country's major concerns, such as Tokyo Gas and Osaka Gas, in converting their operations totally to natural gas. Prospects for further 'distributor' ships look very bright, especially as pipelines are not considered to be economically viable or are non-existent in certain areas, and transport by lorry or rail tanker is not particularly efficient.



The 2500m³ mini LNG carrier *Shinju Maru No 1*, built under subcontract by Higaki Shipbuilding, is the prototype of what is expected to be a new breed of coastal distribution ship employing Kawasaki's pressure build-up technique.

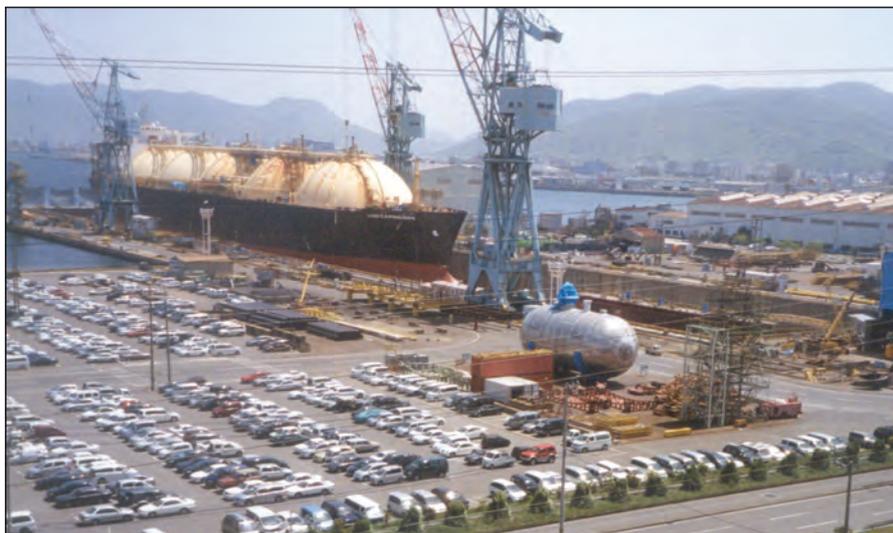
Indeed, a second ship has already been ordered in Japan for completion in December this year; this will be operated by Hikari Marine and owned by Iino Kaiun - both companies have much experience in LPG transport.

At the time of writing, negotiations were in hand for a third example, which might possibly operate with slightly higher cargo temperatures and could be used for a longer route from Tokyo Bay to Hokkaido Island. Most significantly,

Kawasaki believes that its pressure build-up concept is additionally suitable for other parts of the world, including China, South-Eastern Asian archipelagoes, Mediterranean countries, and northern Europe.

Kawasaki is, of course, a practised hand at construction of large LNG carriers, all so far of the Moss spherical-tank type with steam turbine propulsion and built at its large Sakaide yard on Shikoku Island; a total of 14 have been delivered (including Japan's first, *Golar Spirit*, in 1981), with a further nine are on order. The company does also hold a GTT licence for the French originator's NO 96 and Mk III membrane systems but no orders have been secured yet, although a tank mock-up has been built.

One of the two aluminium cargo tanks for the second mini LNG carrier, seen here at Kawasaki's Sakaide yard. The ship itself will be built at Shin-Kurushima.



All cargo boil-off gas contained

The most important feature of the pressure build-up concept for small ships is that all cargo is contained within the cylindrical cargo tanks (fabricated from the same 5083-grade aluminium as used by Kawasaki in large Moss tanks), and the propulsion engine (Hanshin LH36LA for *Shinju Maru No 1*) runs entirely on oil fuel. This makes for a simpler machinery arrangement compared with that on *Pioneer Knutsen*, whose two Mitsubishi GS16R-MPTK engines are primarily running on cargo boil-off gas and require special equipment for dual-fuel burning.

Experience with *Shinju Maru No 1* has proved to be simpler than expected, largely due to the fact that the ship's crew was well versed in hauling LPG cargoes on other ships and were therefore more relaxed about a relatively minor

change to LNG. The new ship has been loading Indonesian gas at the Kita-Kyushu terminal in northern Kyushu Island and from a new terminal at Himeji on Honshu Island further east. Destinations have principally been Matsuyama on Shikoku Island (a distance of 180km from Kita-Kyushu), Okayama, and Takamatsu (the latter is 290km from Himeji). The international discharge terminals have partly been sited in this area because of the location nearby of large industrial and city gas consumers, such as Nippon Steel and Osaka Gas.

The idea of the pressure build-up containment is based on IMO's Type C tank configuration, with a minimum design pressure, no secondary barrier, and containment of all boil-off in the tank. Heat leakage during a voyage accumulates in the cargo, resulting in a gradual rise in pressure and temperature. During a ballast voyage, heat leakage is absorbed in the tank and warm-up vapour, again causing a pressure rise. In-coming heat accumulated in the tank during a voyage is released during loading and discharge.

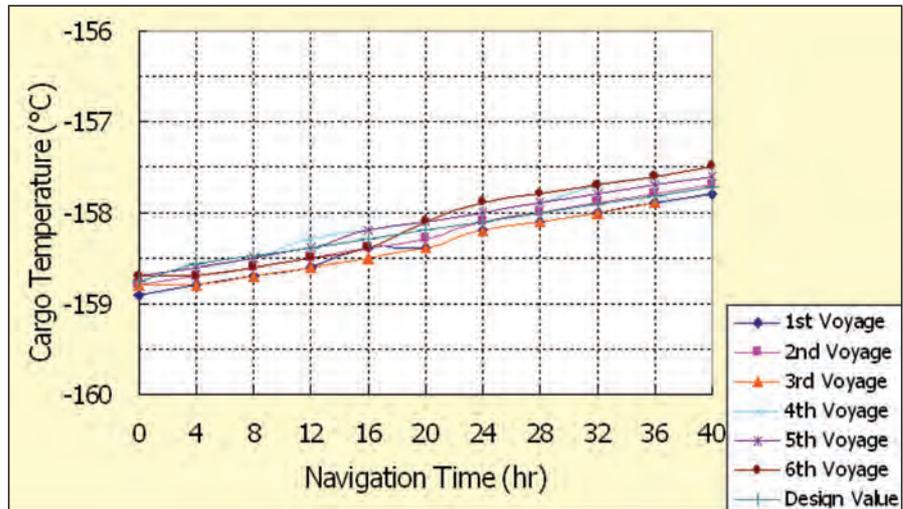
These features make the concept ideal for short voyages. Actual tank size would be dictated by the service, but the pressure-build-up concept can, says Kawasaki, be expanded in size up to around 10,000m³ or 15,000m³ cargo capacity, and the pressure increased. Above 15,000m³ the cargo tanks would start to become rather heavy and the system uncompetitive.

Studies and experience have shown that after seven days, the pressure will reach approximately 280kPa g, which is below the design pressure of 300kPa g. When maintaining uniformity of LNG within the tanks with the shower system used (to extend the pressure build-up period by maintaining uniformity of temperature), the pressure rise after a build-up period of 21 days in an emergency situation will be approximately 170kPa g, which is still less than the design pressure. Likewise, after seven days the tank inner temperature and the surface temperature of LNG will be around -140°C.

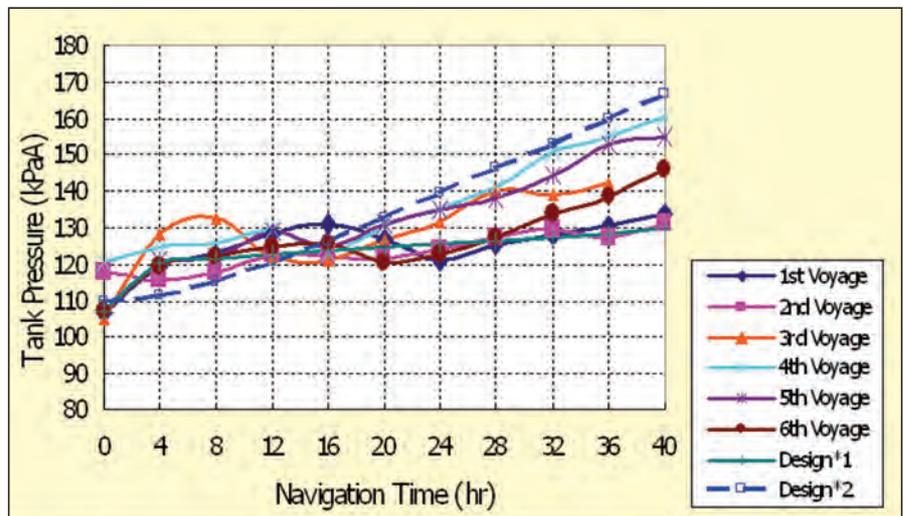
As a result of these criteria, two days' margin has to be built into any voyage to counter any problems. For *Shinju Maru No 1*, her 3.0bar g pressure tanks (compared with 18bar for a typical LPG operation) are planned for five days plus two days margin, in a fully loaded condition. The two identical aluminium tanks are each 22.70m long and 9.06m diameter, and are supported by two semi-circular belts of laminated phenolic resin liners. A Kawasaki panel insulation system is employed (330mm thick) to withstand the common LNG temperature of -163°C.

A swash bulkhead, normally installed for horizontal LPG cylindrical tanks, is not used here, to avoid damage to connecting parts between tanks and bulkheads, neither are there any pipe towers. It was therefore necessary to study sloshing and load effects on internal components, and this was carried out by Kawasaki's technical institute.

In 2003, the prototype vessel carried 22,000tonnes on 22 voyages; the total has now risen to 90, but this still reflects a relaxed schedule. It is estimated that with a second ship, these figures will rise in 2011 to 170,000tonnes and 170 voyages, and by 2017 to 200,000tonnes and 200 voyages - these figures do not take into account an anticipated third LNG carrier.



Actual cargo temperatures recorded over several voyages of *Shinju Maru No 1*, plotted against the design value.



Vapour pressures recorded on actual voyages of *Shinju Maru No 1*, with LNG agitation and high-temperature thermal-layer generation.

Because the short voyages result in frequent arrivals and departures, *Shinju Maru No 1* is fitted with a CP main propeller, bow thruster, and a high-lift rudder for maximum manoeuvring efficiency.

Prospects for pressurised LNG

Aside from the exciting possibilities that have arisen from the successful design and operational experience with the pressure build-up concept, Kawasaki has also been taking part in a feasibility study with ExxonMobil into the merits of the pressurised LNG concept. This aims to reduce the costs of cargo reliquefaction, energy, and plant size associated with the extraction and transport of gas from small or remote fields (so-called stranded gas) on voyages between 2000nm and 4000nm.

The highly interesting technology proposed, using VLCC-class carriers fitted with up to 250 special cylindrical tanks, was presented at the recent Gastech 2005 conference in Bilbao,

Spain, and extracts from this interesting paper appear elsewhere in this issue. Although overall costs are expected to be lower, the ship costs could be higher since a special low-temperature high-tensile steel for the cargo tanks is involved; a prototype tank fabricated from this patented material has already been built by Kawasaki Heavy Industries.

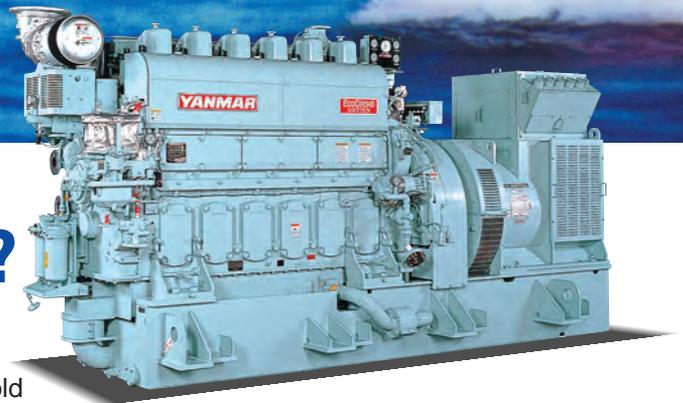
A Californian naval architectural consultancy has drawn up an outline ship design, which has been checked by Kawasaki Shipbuilding, and ExxonMobil is impressed enough to continue further studies into this novel alternative, which could carry more cargo, loaded in less time, than competing compressed natural gas (CNG) proposals, and it is possible that a small prototype could be built. Such a vessel would probably fall outside the International Gas Code, but the US class society ABS is believed to be working on this problem. US Coast Guard approval would, of course, have to be obtained if such a ship was to trade into US ports.

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Model	Generating Capacity	Model	Generating Capacity
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6N21(A)L	560 - 960kW	8N280L	2000 - 2200kW
8N21(A)L	800 - 1270kW	6N330L	2200 - 2500kW
6EY26L	1300 - 1720kW	8N330L	2600 - 3300kW

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Perfecting a method for calculating pressures in membrane LNG tanks

MORE than 300 gas ships of all types, including 34 LNG carriers, are currently in class with ClassNK, and the society continues to be at the forefront of R&D into LNG carrier design. In line with the new trend towards spot-market trading and part-load cargoes, the society has been investigating the phenomenon of cargo sloshing. This is, of course, not normally a problem with Moss spherical designs or IHI SPB tanks, but those ships featuring membrane tanks need careful analysis - especially the new generation of very large ships with capacities of 200,000m³ and upwards.

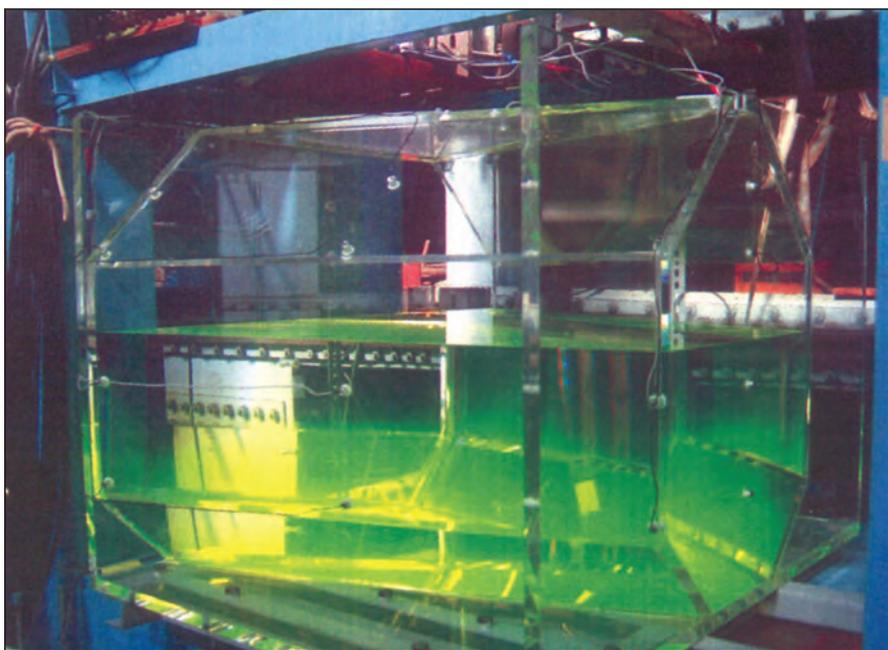
CFD techniques have been employed by the society's research centre to analyse motions, and to confirm their accuracy, tank tests have additionally been carried out. Results showed that the CFD technique can be used to estimate accurately liquid motion but is not perfect for calculating sloshing pressure everywhere, particularly at the tank ceiling.

In this part of a membrane tank, the impact pressure has many fine thread pulses. This pulse occurs due to the change of the boundary condition from a free-surface one to a rigid-wall condition, and is difficult to estimate by numerical analysis. As a result, Dr Makoto Arai, a professor at Yokohama National University, revised the sloshing program, and with this revision, a new concept has been introduced relating to boundary conditions, and the problems have been solved. New calculations show that with the revised method it is now possible to reproduce impact pressure exactly and steadily.

A design load should usually be the maximum that a LNG carrier will face; in the case of normal loads where there is no significant non-linearity effect, frequency response and short-term distribution can be calculated by linear analysis. By using joint statistics of wave heights and periods (usually taking the North Atlantic for the worst case), long-term distribution of the load can be calculated. Based on the results of such long-term distribution, the maximum load can be calculated against a probability exceeding 10⁻⁶.

However, in the case of sloshing loads (where there is a significant non-linearity effect), the above method cannot be used. In the case of linear response, it is possible to calculate the response for a short-term sea state, consisting of several wave components, by the summation of frequency response against each wave component. In the case of non-linearity, the summation cannot be produced, and it is impossible to calculate the short-term sea-state response by the summation of frequency responses.

To overcome these problems, ClassNK has now developed an analysis system to calculate the maximum sloshing load. In this, the software program noted above has been included as the core. The system selects various sea states, consisting of the most severe wave frequency and the most severe heights from the statistical wave data. Random waves under the conditions of the



A model of a membrane-type cargo tank built as part of the ClassNK project to perfect a method of calculating the maximum sloshing load, particularly at the tank ceiling.

above sea state will be produced on the computer, and random ship motion will be calculated by frequency response.

Then, a sloshing simulation analysis of the ship motion will be carried out, and fluctuations of liquid and maximum pressure calculated. By using such simulation analysis, in the case of the sloshing phenomenon with its non-linearity, the maximum load that a ship will face in her life can be calculated, and from that the design load can be deduced. ClassNK believes that this new method - perfected in association with Yokohama National University and Mitsui Engineering & Shipbuilding - will be a major support tool in the design of future membrane-type LNG cargo tanks.

On other gas matters, ClassNK is closely following the success of the first pressure-build-up LNG carrier *Shinju Maru No 1* (discussed in more detail elsewhere in this feature). The society notes that a second vessel has been ordered, which like the first, will be classed with Class NK. It is also cooperating with Mitsui Engineering & Shipbuilding on the development of offloading systems for a special FPSO designed to handle natural gas hydrates (see separate article in this feature), and has recently dealt with its first ice-classed LNG carrier, the 145,000m³ Kawasaki-built *Energy Frontier*, which will haul LNG from Sakhalin to Tokyo.

Continuing role in bulk carrier safety

ClassNK continues to be very active in all aspects relating to ship safety and is playing an 'all-

consuming' role in the development of new-generation bulk carriers. At the present time, the second draft of proposed new IACS regulations has been released and is currently being reviewed by the industry. IACS has already adopted regulation S31 on renewal criteria for side-shell frames, and ClassNK has completed a database of requirements for all its bulk carriers, numbering more than 1100. The society considers that this new rule will certainly reduce the chances of further serious casualties.

At the same time, the IACS hull panel (part of the recently re-modelled IACS organisation) very recently started to examine reports (not concerning ClassNK ships) of unsatisfactory grades of steel for some bulkers which have suffered brittle fracture at low temperatures. The society takes the view that increasing regulations generally equal more steelweight and therefore a more robust and safer ship.

ClassNK to handle *Asuka 2*

In another interesting move, ClassNK will re-class the cruise liner *Crystal Harmony* (built in 1990 by Mitsubishi) when she replaces the IHI-built *Asuka* next year (the latter ship will be sold). *Crystal Harmony*, which will transfer from Lloyd's Register, will be refitted to suit the Japanese market, and such features as hot baths and facilities for Japanese-style food will be installed. More older people in Japan are becoming keen on cruising but they like to maintain their domestic way of life onboard. The ship will be renamed *Asuka 2*. 



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Two environment-friendly bulk carrier models from Sanoyas

NEW requirements, including those anticipated for next year, from both IMO and IACS, plus a positive shift in our industry towards environment-friendly features in 21st century ship designs, have been the catalyst for a pair of advanced super-Panamax bulk carrier models from Sanoyas Hishino Meisho. The Mizushima works of this leading Japanese exponent of bulk carrier construction, as reported in our October 1998 issue, page 24, has finely tuned its facilities to make the yard an exceptionally efficient builder of mainly Handymax and Panamax sizes, but also tankers.

A measure of the company's success can be judged from the fact that Sanoyas has already delivered 26 examples of its current 75,000dwt bulk carrier model and has a further 21 on order. Now it is looking towards the next generation, and *The Naval Architect* was told during our recent visit that a sales team consulted 20 European owners to establish the criteria for such vessels. Unfortunately, two different overall hull lengths emerged from this exercise: some wanted the traditional 225m while others requested a longer 229m. Since it was unable to reconcile the two, Sanoyas evolved two models of these Eco-Ships, one of 78,000dwt and the other of 83,000dwt.

Although some shipyards around the world are leaning towards the now non-mandatory feature of double side-skins, Sanoyas maintains its belief in a well-designed single-skin construction, mainly in the interests of economy and avoidance of access problems, but also because most owners stated that they also preferred single skins. At the same time, the yard is including a number of highly interesting environment-friendly features, introduced by its design team.

Most importantly, these include the shifting of the main heavy fuel tanks to protected locations at the sides and forward end of the machinery space, four tanks in total. In addition, a dedicated tank is now provided for grey water retention, together with another one in the saddle spaces for dirty fresh hold-cleaning water (the clean water for this purpose is stored in a hopper tank below).



Both new Panamax Eco-Ship designs from Sanoyas will be fitted with a set of these Sanoyas Tandem Fins (STF), not previously used by the yard on Panamax-class bulkers; those seen here are on a tanker built by the yard. Fuel savings of around 4% can be expected, depending on a ship's draught.

To reduce the load on current incinerator models, these Eco-Ships will have their incinerator capacity increased by 1.7 times, while another innovation is the provision of two separate tanks for bilge liquids - one for oil and one for water, together with a large separator; previously, the mixture was held in one tank only. Fuel heating arrangements have also been modified, after some owners noted that cargoes such as grain have occasionally been damaged by heat transmitted through the aft bulkhead. To avoid this, the new ships will have only a small compartment heated and controlled automatically, rather than the complete tank.

Other modifications include a free-fall lifeboat as standard, special locks on certain doors to meet the new ISPS security legislation, specification of

R-404A refrigerants onboard, and light-coloured ballast-tank coatings. Larger hatches (600mm each side, making the opening half the hull breadth), have been introduced for improved cargo-handling, and side-rolling covers have been retained.

CFD techniques were utilised in developing the new hull form, and model tests were carried out at the Shipbuilding Research Centre of Japan, in Tokyo. Although a conventional bulbous bow will be used, at the stern Sanoyas has decided to include a set of its own fins, known as the Sanoyas Tandem Fin (STF). These have already been fitted on some tankers and Handymax bulkers built at the yard but until now have not been used for Panamax-class ships.

The arrangement comprises a forward fin on each side, slightly angled and roughly in line with the propeller shaft, with a further fin at a higher level, wrapped around the hull forward of the propeller, as shown in the accompanying illustration. This patent-pending design should save around 4% on fuel, depending on the hull draught.

At the time of writing, Sanoyas had secured orders for one 78,000dwt vessel and one of 83,000dwt, with further orders for the larger model being negotiated. Owners have not yet been disclosed. Meanwhile, this efficient yard continues to make maximum use of its single construction dock, in which a whole hull and parts of two further ships can be assembled in tandem by judicious positioning of an internal gate. Speedier production is today possible by the introduction of a so-called *Tanban* method of hull fabrication, using smaller sections for certain panels and longitudinal stiffeners. ⚓

TECHNICAL PARTICULARS 78,000DWT BULK CARRIER

Length, oa.....	225.00m
Length, bp.....	219.00m
Breadth, moulded.....	32.24m
Depth, moulded.....	19.90m
Draught, scantling moulded.....	14.35m
Deadweight.....	78,000dwt
Cargo capacity.....	91,000m ³
Main engine.....	MAN B&W 7S50MC-C
Output, MCR.....	9555kW at 110rev/min
Output, CSR.....	8121kW at 104.2rev/min
Speed, service, design draught.....	14.50knots
Speed, service, scantling draught.....	13.90knots

TECHNICAL PARTICULARS 83,000DWT BULK CARRIER

Length, oa.....	229.00m
Length, bp.....	223.00m
Breadth, moulded.....	32.24m
Depth, moulded.....	20.20m
Draught, scantling moulded.....	14.50m
Deadweight.....	83,000dwt
Cargo capacity.....	96,000m ³
Main engine.....	MAN B&W 6S60MC-C
Output, MCR.....	10,731kW at 95rev/min
Output, CSR.....	9121kW at 90rev/min
Speed, service, design draught.....	14.70knots
Speed, service, scantling draught.....	14.00knots

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Members who are aware of recent work by a university, company or organisation which has or could lead to an improvement in safety at sea are invited to nominate them for one of the Awards, giving brief details of the achievement. The nominated university, company or organisation will then be invited to submit an entry.

There are separate categories for universities and industry. An Award of £1500 is made in each of the categories and will be presented at the 2006 RINA Annual Dinner.

Requests for further information and expressions of interest should be forwarded to:



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Active times and new engine model for Daihatsu

A VERY busy period is currently being enjoyed by Daihatsu Diesel Manufacturing Co, primarily because the huge boom in new ship orders in Japan, Korea, and China. Approximately 600 engines were completed between April 2004 and March 2005, some 70% of which were for marine duties. As a result, it has been necessary to introduce two working shifts at company machine shops. Despite this happy situation, the increased price of key components such as crankshafts is causing concern.

This leading company builds both propulsion engines (the DKM series) with outputs up to 4413kW and several series of auxiliary engine, the most significant of which are the DK and DC types. The most recent model is the eight-cylinder DC-32, sales of which started this year. So far, around 40 examples of this heavy-fuel-burning design have been sold, including engines for installation in K-Line 8000TEU container liners at IHI, for Hapag-Lloyd new container liners at Hyundai, and for OOCL container ships at Samsung. Most of these ships require four diesel-driven alternators. Daihatsu is also working hard to break into the LNG sector - a new market for the company.

Today, some of the company's engines are being built in China by two licensees there, Anqing and Sanxi; the former builds the DK20 models and the latter the larger DK28. The latter is mainly being ordered in propulsion versions by Chinese owners while the DK20 models are often specified for generator drive by European companies.

Among DK20 contracts are three six-cylinder engines driving 680kW Nishishiba alternators on board each of Graig Shipping's new Diamond 53 double-side-skin bulk carriers being built at Chengxi Shipyard and elsewhere (*Spar Lyra, Significant Ships of 2004*). Similar sets are also to be exported to Vietnam (Ha Long and Nam Trieu yards) for Graig's extended series building in that country.

The new DC-32, in eight-cylinder format, can offer owners outputs up to 3600kW output - a figure which could be attractive not only to container-liner operators with their high number of refrigerated containers but also to LNG carrier operators specifying reliquefaction plants, with equally high requirements, for their new-generation tonnage. The design is aimed at being environment-friendly, with low NOx and SOx emissions, and can be fitted with conventional controls or the latest electronic fully flexible systems in conjunction with common-rail fuel injection.

Daihatsu has also been working on a 1000kW gas-fired engine burning LNG, in association with Mitsui Engineering & Shipbuilding, using the DK20 engine as a base. However, this DKMD20G model, with its high thermal efficiency, is mainly aimed at land-based urban co-generation power plants, in situations where exhaust pollution can be a problem, although LNG carriers could be a future market, too. Such gas-fired engines emit no SOx at all. Tests have also recently been completed on an engine

running on the new DME fuel. These have proved satisfactory although the fuel removes some of the piston-ring sealing effect.

Campaign against fake spare parts

At the present time, Daihatsu is acting as chairman of a joint Japanese initiative formed by 15 internationally known names in the marine engineering field. In association with the Japan Ship Machinery and Equipment Association (JSMEA), this consortium is running a high-profile campaign against fake engine parts originating in China and often sold on the Internet. The sale of non-authorized spares is a problem that has been around for many years and which for some unfortunate owners has resulted - as a consequence of substandard machining - in extensive damage to diesel engines and other key equipment.

Daihatsu and its colleagues are, however, raising the campaign several notches and even sent a delegation to meet the Chinese government last November. Some success has been achieved, and both the CSSC and CSIC shipbuilding organisations are cooperating. More positive action has been taken by a few of the Japanese companies by registering some of their trademarks in China, also by issuing only numbered and certified components, with a class mark if necessary, which can be traced back to their Japanese source. Nevertheless, this remains a difficult topic, which says Daihatsu, also needs action to link in European manufacturers. ⚓



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The changing face of naval warfare means that the role of the submarine has altered in recent years. Their use is increasingly moving away from the open ocean into shallower waters and the littoral.

Most navies are currently facing a reduction in resources, which will also affect the design of future submarines and size of complement. Lower complements are becoming more attractive with advances such as total integration of combat systems, machinery controls and data presentation. However, lower complements mean improved support infrastructures are required. Much can be done in making the submarine more 'support friendly' with more efficient supply chains both in production and for support.



The issue of safety aboard submarines is becoming increasingly important. Effective evacuation and fire fighting are complicated by the enclosed atmosphere and deep operation. A further issue is the resolution of minor incidents, such as onboard fires, while still retaining covert operations.

This will be the twenty-fifth in the Institution's successful WARSHIP symposia. The symposium will cover developments since 'Naval Submarines 7' in 2002. The Institution invites papers on the following subjects:



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Full order books - but not yet at a profit

Despite excellent volumes, a two-year lean period awaits many shipyards before contracts secured at current higher prices can boost profits. At the same time, the Shipbuilders Association of Japan urges companies not to neglect their R&D.

OVER the last two years, Japan's shipbuilding situation has changed dramatically. Today, yards are bursting with orders and are fully occupied up to 2008 or 2009. Both Japanese shipowners and Japanese steelmakers are enjoying historically high profits, but the financial state of yards is not good, principally because of the time lag from order to delivery.

According to Nobutaka Nambu, executive managing director of The Shipbuilders Association of Japan (SAJ) - speaking to *The Naval Architect* in a special interview, a VLCC contract two years ago would have been valued at less than US\$70 million, whereas today the same ship would cost closer to US\$120 million (a similar situation also exists, of course, in Korea). So in spite of the huge backlog on order, current profits are not so healthy, while shipyards are also suffering badly from the massive increase in steel prices.

Nevertheless, traditionally efficient Japanese yards are doing their utmost to limit losses and to improve efficiency even further. There is, however, a limitation to what can physically be achieved, and thus most builders will have to endure approximately two years of difficulties until the new prices kick in to the system. This scenario does have a few exceptions: Japan's active medium-size shipyards, for example, are - because of their size and situation - generally more competitive, and therefore profits levels are higher. The SAJ reckons that by 2007 all the country's yards, large and small, should be on a safer financial footing.

As always, a few caveats exist, such as the way steel prices move and any significant changes in the Yen exchange rate with the



At the beginning of this year, what is believed to be the largest ferry ever built in Japan, the 35,000gt *Kiso*, was delivered by Mitsubishi's Shimonoseki yard to Taiheiyo Ferry. She is operating between Nagoya, and Sendai, on Honshu, to Tomakomai, on Hokkaido. Despite the long-haul route, service speed is only 23.00knots, provided by a pair of 11,840kW MAN B&W 9L58/64 medium-speed engines. Up to 800 passengers can be carried in luxury amenities, along with 183 x 12m lorries and 47 cars. Both bow and stern ro-ro access is provided.

Dollar - it is hoped that the former will not appreciate. Steel prices in April this year were around the Yen70,000/tonne mark (Yen40,000/tonne a year ago), but because of shortages largely brought on by China's galloping economy, yards have to accept the situation. Contracts negotiated in Yen can offer some amelioration, and in a seller's market when owners want to order ships (partly to offset tax) this can be possible. The three Japanese leading owners, NYK, MOL, and K-Line, fall in this category and are expected to place orders worth Yen3 trillion over the next three to four years.

In such a scene, when yards are worrying about today's performance, the SAJ is urging them not to neglect their R&D for tomorrow - especially as Japan is a high-cost nation. Small steps are being taken by the SAJ, especially to develop the concept of life-cycle value to generate higher-quality vessels. It is consulting with leading owners over offering ships automatic equipment (such as weather routing information) to ensure that the optimum route can be selected on the important services to the US West Coast. It is hoped that the project will be complete next year. A second unspecified project is also being considered.

It is interesting to note that many owners and yards are, according to the SAJ, focussing on propulsion advances because of the current high fuel prices. Unfortunately for engineers, this often equates to burning cheaper low-grade

oil with its sometimes attendant problems, but another angle of attack is a new Japanese investigation into sail assistance, which was last taken quite seriously around 20 years ago.

One interesting success story in Japan today is a focus on advanced bulk carriers, a class of ship that one might have thought would have been passed over to China. Nevertheless, canny Japanese yards feel that such vessels offer better chances of profit; one that thinks so is medium-size Sanoyas, whose two latest super-Panamax designs are reviewed on page 34. This may partly be the reason why the country's yards have not yet homed in to any great extent on the newest generation of large labour-intensive membrane-type LNG carriers.

The SAJ reports that the recent operation to re-organise the major shipbuilders into new groupings has generally been a success. It particularly quotes the tie-up between Hitachi and NKK to form Universal Shipbuilding, which is today turning in much better profits. As already reported in this journal, some companies associated with shipbuilding have transferred part of their activities to China to shrink costs. Examples are Tsuji Heavy Industries, now fabricating hull sections and superstructures (*The Naval Architect* February 2005, page 94) for export back to Japan, and medium-size Tsuneishi, which is also building blocks there; others are said by the SAJ to be considering such moves. 

Modern-generation engine control systems

SINCE October last year, the Japanese control specialist Nabco has been renamed Nabtesco, following its merger with the TS Corp, a company whose expertise lies in hydraulic motors and reduction gears for control systems; the goal is to become a global leader in precision control, not only for marine engines but also for industrial, rail, and air equipment. Marine controls will mainly be assembled at Nabtesco's Seishin plant, located west of Kobe.

The company's newest marine engine control package is the M-800III, which has been specified for a number of recent engines, including the new generation of Sulzer and MAN B&W two-stroke models with no camshafts and electronic controls. The M-800III system is centred on serial binary

communication cables, which offers several attractions for shipyard installation engineers, including reduced cable volumes, smaller control panels, and less cost.

Since 2002, when the M-800III version was launched, more than 1000 orders have been secured, including a few for four-stroke machinery and at least 29 for electronically-controlled two-stroke engines (included in the latter are a number of sets for new-generation diesel-powered large LNG carriers). In 2004 alone, 230 sets were delivered, including those for export to engine builders in Korea, China, and Poland.

Apart from equipment for main engines, Nabtesco manufactures integrated packages for additionally controlling CP propellers, bow

thrusters, and rudders, also special systems modified for dynamic positioning. CP propeller equipment has recently been supplied to the new fast ferry *Hamanasu* and her sister (the first ships to feature the contra-rotating propeller Azipod concept), also equipment for the new Japanese deepsea research drill ship *Chikyū*. Several sets for training simulators have also been delivered, for colleges in Singapore and Rotterdam, and for leading ship operators such as NYK and Evergreen. For the future, Nabtesco engineers are working to perfect a system to control water injection into diesel engines - one of the latest technologies to make engines more environment-friendly. An experimental system is working on a Japanese government training ship. 

Switching to Eco-engines at Mitsubishi

LIKE its two-stroke engine competitors in Europe, Mitsubishi has advanced to the era of electronic controls and the elimination of camshafts for its well-established UEC series of two-stroke engines. These two features offer the attractive benefits of NOx emission reduction - down to IMO's 'second' level between 14g/kWh and 12g/kWh, without the need for water injection - and smokeless operation, along with lower fuel consumption and maintenance costs, optimised combustion at any load, also stable and continuous low-load operation. Water injection is likely to enable such Eco-engines to achieve considerably lower NOx values down to around 6g/kWh.

Mitsubishi engineers at the Kobe works have achieved all this through the adoption of hydraulic controls with solenoid valves, rather than a common-rail fuel system. Crankshaft angle and top-dead-centre detection are detected by proximity switches close to the flywheel, and both a low-emission mode and an economy mode are possible.

Work first started in 1988, and both performance and reliability have been confirmed during extensive testing up to 1997 on a single-cylinder NC33 engine at Nagasaki. The first commercial engine, an 8UEC60LSII-Eco model developing 15,540kW at 104rev/min, finished its shop tests at Kobe last November, and is scheduled to enter service on a 6400-unit car carrier built by Toyohashi Zosen for NYK this month - an appropriate time for Mitsubishi, since 2005 is the centenary of the Kobe engine works.

At the time of writing, no further orders had been secured, although many enquiries have been received. It is possible that some of these might have come from LNG carrier operators, particularly as Mitsubishi is in favour of the heavy-fuel-burning-plus-reliquefaction option for next-generation ships. Since all owners will eventually have to comply with IMO regulations, Eco-engines seem certain to come into their own in due course.

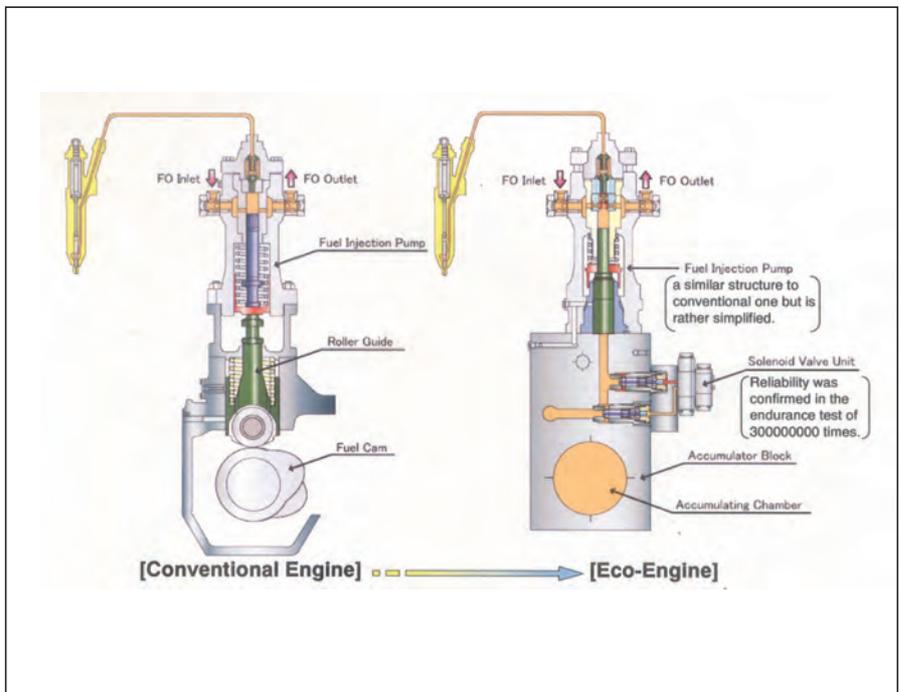
Good export progress with UEC engines

Meanwhile, on the conventional technology front, Mitsubishi has been doing quite well with orders. Particularly satisfying are recent export contracts for a number of ships being built in European yards; these include six 7UEC68LSE engines for 2500TEU container ships building at the two Aker Ostsee yards, and a 6UEC50LSII engine for a 25,000dwt chemical tanker at the Celik Tekne yard in Turkey. The latter engine is particularly notable since it was the first to be built by Mitsubishi's new European licensee, Manises, in Spain (no engines were ever built under the earlier licence at DMR, Germany). Mitsubishi is keen to expand its operation again in Europe and sees good prospects, especially in Turkey.

On the Asian front, 11 engines have been exported to China - four 7UEC37LA models to Hangzhou Dongfeng to power 5000dwt general cargo ships, and seven 6UEC50LSII engines for 25,000dwt multipurpose ships at the Kouan



Mitsubishi's first production UEC Eco-engine, an 8UEC60LSII model, on the testbed last November at Kobe. It is scheduled to go to sea this month in a 6400-unit car carrier built by Toyohashi Zosen for NYK.



Switching to new-generation controls on two-stroke engines: principal components of a conventional fuel injection system with a mechanical camshaft (left) and the hydraulic arrangement with solenoid valves as used on the Mitsubishi Eco-engine (right).

yard. Of special interest are nine orders for ships on order in Vietnam yards: five 7UEC33LSII models to power 12,500dwt bulk carriers at the Ha Long yard, three six-cylinder

units of the same model for cargo ships at Bach Dang, and one 6UEC37LA engine to be installed in an 8500dwt bulker at the Ben Kien yard.

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Update on natural gas hydrates

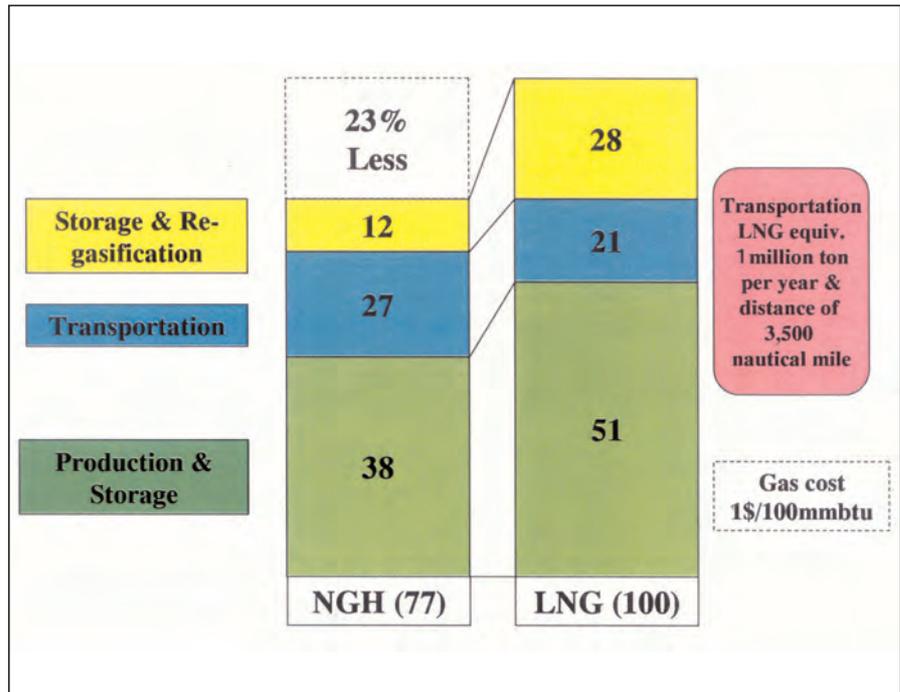
THERE is no doubt that one of the most impressive sights during *The Naval Architect's* recent visit to Japan was a demonstration of the burning of a natural gas hydrate (NGH) pellet. We have seen this previously at the National Maritime Research Institute (as reported in our special article in October 2003) but the cold pellets (somewhat similar to small golf balls) and the spectacle this year at Mitsui's Chiba shipyard - where a demonstration NGH processing plant is set up - remains fascinating.

Each pellet contains 170 times the volume of the original gas and therefore offers an attractive alternative to existing fuel, at a time of increasing energy demand and when many more utilities in Japan are switching to gas for their principal fuel. NGH is seen as especially important for smaller fields or those where the distance to market is with 3500nm; it will therefore be competing with other technologies such as CNG (such as the CETECH concept, discussed in our March 2005 issue, page 32) and pressurised LNG (see our article elsewhere in this issue).

In addition to manufacturing pellets from LNG and water, large natural NGH deposits are known to exist around the coast of Japan; these could be exploited one day (perhaps with the help of the new Japanese research drill ship *Chikyu*). Interesting possible routes for manufactured pellets include Qatar to Singapore, Indonesia to Japan, and Sakhalin to Japan.

NGH encompasses the phenomenon of self-preservation, ie, once generated in a special plant (as a snow-like powder) by a bubbling/mixing technique and when moved away, its water content begins to freeze again in a membrane state after a certain amount of solution with heat absorption; rapid solution and gasification are prevented naturally. For shipowners and builders, there is another attractive feature - it can be transported at much higher temperatures than LNG around -20°C, while the pellet form gives good fluidity for loading and unloading. A mixture of pellet sizes will probably give better hold filling efficiency.

Mitsui has already made an outline design of a special 100,000dwt ship, similar to a bulk carrier,



Bar charts comparing capital costs for a natural gas hydrate (NGH) train and one based on conventional LNG. These figures are for transporting 1 million tonnes annually over a 3500nm route.

to carry pellets (160,000m³ cargo capacity) in insulated hold; this could be ready to build by 2008. It has been estimated that an NGH train for a 3500mile route to carry 1 million tonnes annually - comprising production plant, ship, regasification plant, and storage tanks (at atmospheric pressure) - would cost 23% less to build than that for a similar LNG transport chain; this figure reduces to 18% if transport is included because the pellets are slightly less efficient in volume terms. Within the 3500mile transport radius, CO₂ emission for two plants and a ship are estimated to be less than that for a small LNG carrier (between 2% and 14% depending on production capacity) while overall energy consumption is between 6% and 14% less.

By the end of 2005, Mitsui plans to have completed the outline design of a floating NGH production plant (similar to a FPSO). In association with this, a pilot practical production plant will be needed, with realistic loading and discharge facilities. The company estimates that, if all goes well, a first project could be under way by 2010. Studies are being carried out in association with the Japanese government, and Mitsui has recently signed a technical and business agreement with Aker Kvaerner, partly because the Japanese company recognises the need for international cooperation over any resulting project. More news may be available at this month's hydrate conference in Trondheim. 

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Construction of first Super Eco-Ship draws nearer

WORK is continuing apace in Japan with the aim of ensuring that the country's prototype Super Eco-Ship - a cargo vessel designed to revolutionise coastal shipping under the Ministry of Land, Infrastructure, and Transport's national research project - is in service sometime next year. Nevertheless, this demonstrator vessel (possibly a 749gt cement carrier or a ferry) will, as Phase 1 of the project, not feature the specially developed Super Marine Gas Turbine originally proposed, nor the electric contra-rotating podded propeller; the proposed operator of the ship has requested that a diesel-electric plant (1000kW) with mechanical contra-rotating azimuthing propeller be installed.

Nevertheless, considerable R&D work has taken place in perfecting the Super Eco-Ship concept, and more studies continue. It is expected that in Phase 2 a second vessel, a 4999dwt light-product tanker, complete with full gas turbo-electric package and an integrated CRP podded propeller, will be built for possible delivery in 2007 to Eiyu Kaiun.

Of course, a Super Eco-Ship will feature much other advanced technology, and the concept is expected to be eventually suitable for ships up to 10,000gt, particularly tankers but also including ro-ro ferries. Amongst the Super Eco-Ship's expected attractions are a 20% increase in cargo capacity, 25% reduction in CO₂ emissions for each tonne kilometre, and a 90% reducing in NO_x emissions. The choice of contra-rotating propellers should also give excellent propulsive efficiency - up to 10%.

Full-scale tests of a contra-rotating podded propeller (2 x 1250kW) were conducted last August in a drydock at IHI's Aioi shipyard, using a special rig set up to support the unit. Attention was particularly paid to endurance (1 million revolutions were achieved satisfactorily), vibration, and the sealing system for the two propellers. The target efficiency for the unit, which was designed by the National Maritime Research Institute to a modular concept and cast by Nakashima, was 93%, but these trials revealed a pleasing average attained efficiency of 94%.

The two Toshiba Mitsubishi-Electric motors inside the pod (one for each propeller) are of the permanent-magnet synchronous type, whose principal spin-off attributes are a smaller casing size and the employment of forced-convection seawater cooling (instead of more complicated air cooling on other types of pod). Difficulties associated with sealing against escape of lubricating oil on the two shafts were overcome by the ingenious employment of air pressure. The pod can be applied to both pusher and tractor-type layouts. A report on the full-scale tests at Aioi was presented on June 2 to the Society of Naval Architects of Japan by authors from the NMRI, Nakashima Propeller Co, and Toshiba Mitsubishi-Electric Industrial Systems.

The totally new 2500kW Super Marine Gas Turbine (whose layout was illustrated on page 16 of our March 2005 issue) was developed over two phases - 1997-2002, and 2002-2005,



An impression of the new contra-rotating propulsion pod to power the Super Eco-Ship. Selection of permanent-magnet drive motors will result in a smaller casing and elimination of air cooling systems - the motors can be satisfactorily cooled by surrounding sea water.



The prototype propulsion pod mounted on its special rig in a drydock at IHI's Aioi shipyard for testing. Successful trials were completed, but more refinement work is needed on the fluid dynamic characteristics when fitted on a real hull; this will be carried out very soon.

with the aim of achieving a thermal efficiency of at least 38% and very low NO_x values below 1g/kWh - considerably below those figures for any diesel engine. Actual tests on

the site at Kawasaki's Akashi plant showed results of 0.97g/kWh for NO_x and 38.2% thermal efficiency. Although the ideal plant would feature a combined cycle, with steam

being generated from waste heat, such a unit will not be included in the first ship to be powered by the gas turbine.

Throughout the whole project, the emphasis has been on 'green' features and labour-saving devices - the latter especially important since finding crews for coastal vessels in Japan is an on-going problem. Therefore, the prototype Super Eco-Ships will feature innovations in navigation, mooring, and cargo-handling; these will include a highly automated wheelhouse capable of being operated by one man with the assistance of various 'human-like' features, including voice control, which have been developed by the National Maritime Research Institute, Mitsubishi Heavy Industries, and the domestic tanker owners' association.

For mooring operations, lightweight ropes, easy-to-operate winches, and simple human-to-machine interfaces will be used, while for cargo-handling, crew members will keep in close contact with the cargo control station in the wheelhouse, from where sequential process control can be masterminded.

Noise and vibration problems are unlikely to be a problem on these new ships, especially as vibration will be very low with a gas turbine plant, and noise can be handled by placing machinery in enclosures.

CRP propellers cast by Nakashima

Work to develop the contra-rotating propeller plant for the Super Eco-Ship was carried out by the leading Japanese propeller manufacturer Nakashima, based at Okayama, in association

with the National Maritime Research Institute, in Tokyo. Blade section profiles are NACA66 (TMB mod) with a 0.8 (mod) mean line, and the blade outline is that of a MAU-series propeller. The diameter ratio D_{in}/D_{out} is 0.906, which is quite small when compared with a normal CRP set; this is due to a heavily loaded bollard condition. The FP blades have diameters of 3400mm for the inboard unit (four blades) and 3080mm for the outboard set (five blades), and the whole unit can turn through 360degrees at a speed of 1.5rev/min. Rated propeller speed is 200rev/min. Roller bearings are used throughout.

Should either of the permanent-magnet motors (using 660V current, converted from the 6.6kV generated current) fail for any reason, the second can continue to supply its full power. The smaller motor diameter means the motors turn at a slower speed, thus less heat is generated and therefore exterior sea water is quite satisfactory for cooling the machinery. The pod is turned by two hydraulic motors with two pumps and duplicated circuits for redundancy.

A combination of lip-type and spring-loaded air-pressure seals, designed by Kobelco Eagle, solves the difficult problem of sealing contra-rotating shafts against water leakage in or oil leakage out, and a drain system (pumped out by the bilge pump) is included in case of emergency need.

Now that full-scale tests have been completed, as described above, Nakaskima is working on a new design of mechanical CRP

New factory for Nakashima

LATER this year, Nakashima Propeller Co, which celebrates its 80th anniversary in 2006, plans to have a second, new, factory in operation. This is specially designed to cast very large FP propellers up to 12m diameters and 150tonnes weight for next-generation ships (CP models may be built later), and will relieve pressure on the existing Okayama site. The latter is exceptionally busy at present with shipyard orders - especially exports to Korea and China; maximum capacity here is propellers up to 10m diameter.

The new factory is being constructed on a 57,000m² site and will employ 100 people. It is approximately one hour's travelling distance from Okayama. Propellers will easily be able to be transported to a nearby quay for shipment.

propulsion unit, which the company believes, will be used for the prototype Super Eco-Ship.

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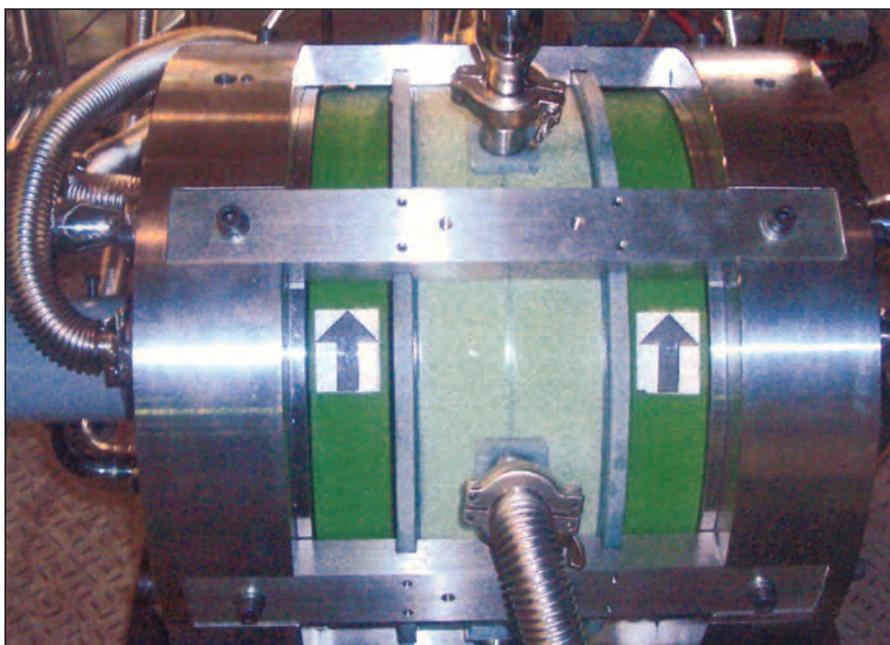
AT the Yokohama Engineering Centre of IHI, a most interesting project for future ships is almost complete. This is the development of a practical liquid-nitrogen-cooled commercial superconducting electric motor for ship propulsion, believed to be the first of its type; a sales campaign is expected to start in August. Great expectations are forecast for this revolutionary technology. IHI is working in association with other industrial companies, including Sumitomo, (whose superconducting motor was illustrated more than 10 years in *The Naval Architect*, November 1991, page E509), and the University of Fukui. The actual propeller has been cast by Nakashima, and Niigata Power Systems built the integrated pod and slewing gear for the motor. Although the prototype is fitted in a pod, and this type seems likely to be attractive for owners, the concept is equally suitable for conventional shaft arrangements.

The prototype pod that *The Naval Architect* witnessed in action is quite small but a 5000kW is expected to be on test soon, and a 10,000kW motor - considered the probable practical maximum - next year. A contra-rotating version is also expected to be tested soon. Perhaps the most significant feature of a 5000kW motor, for example, is its size - approximately one-tenth of the volume of a conventional synchronous unit and one-fifth of the weight.

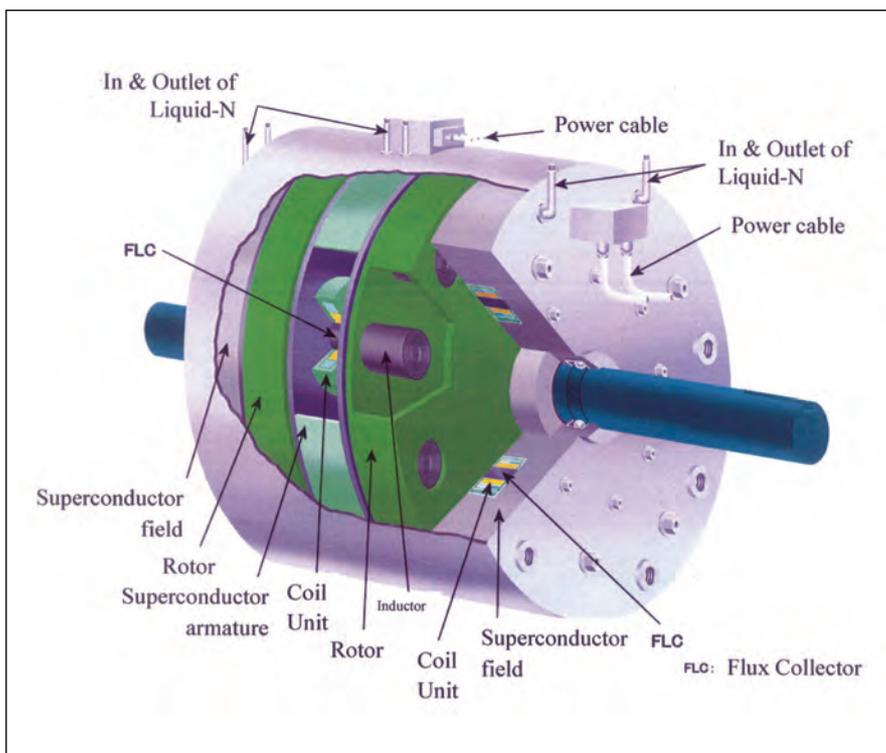
Manufacture has been possible through the development of mass-produced high-temperature superconductor wire cooled by liquid nitrogen. Previously, it had been proved difficult to use this economical coolant - when using nitrogen, conventional technology could not generate high-density magnetic flux of the field system for a large motor, and with helium or neon, a system has a greater volume and becomes more complicated, as well as needing a lower temperature of around -270°C .

Electric current applied to high-temperature bismuth-based superconductor wire is greatly influenced by magnetic flux and temperature interlinking with the wire. Development by the IHI team of a so-called flux collector (or FLC as the patented name is known) intensifies the magnetic flux density, in which the flux interlinked with the superconductor wire has been greatly reduced. High-temperature superconductivity results in electric resistance of a conductive material becoming zero at -200°C or higher, which means that nearly 200 times the amount of conventional electric current can be passed through it.

The FLC has a highly magnetism-transmittable material in the core of the field system, which allows intensive transmission of the flux. This enables the large current flow at the low temperature; as a result, very intense density of the magnetic flux could be obtained. It is this feature which permits a very small motor size. Such technology could therefore perhaps be of great interest to companies such as ABB and Siemens-Schottel in obtaining higher powers not only within reasonable pod sizes for their azimuthing systems, but for conventional shaft layouts.



The actual prototype 12.5kW motor used in the demonstration at Yokohama.



A cutaway diagram of IHI's new high-temperature superconducting electric motor, showing the various components. Many attractions are claimed, and output powers up to 10,000kW can be obtained.

The outer diameter is expected to be half that of a pod with a conventional motor, while propulsion efficiency should increase by between 3% and 5%. If required, tandem motors could be fitted. Less noise should be produced, and the exterior temperature of the motor should be normal, so servicing should not be too great a problem.

Although principally planned for ships, these new motors could also find homes in trains, in wind-power generators, and for industrial drives in factories.

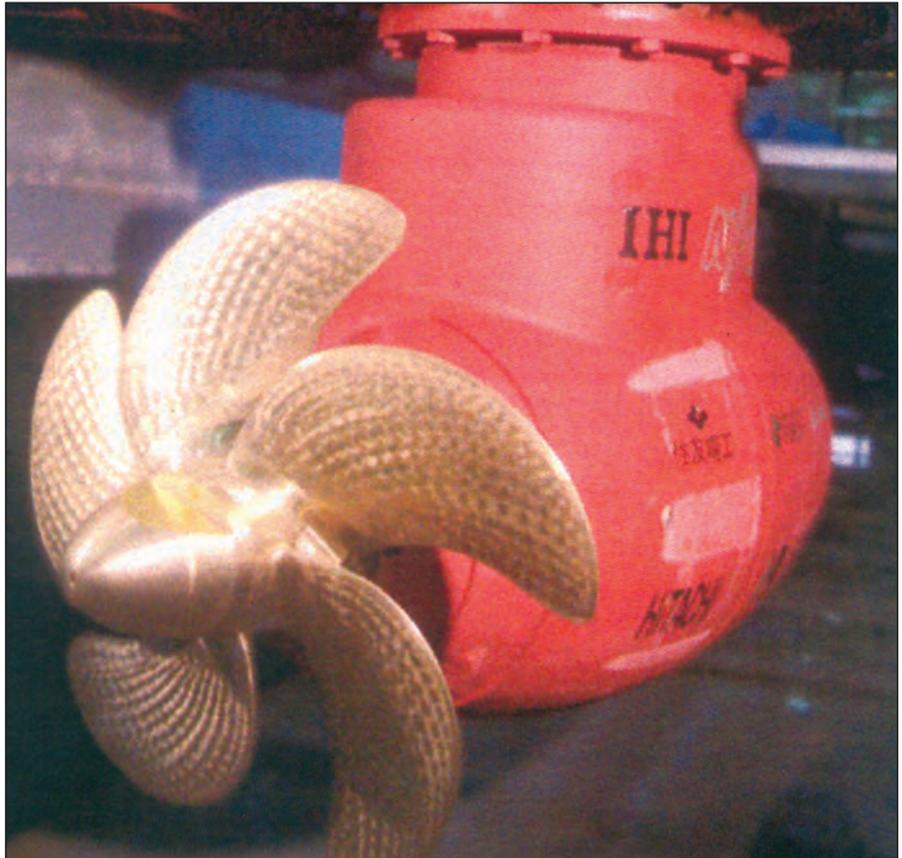
The actual unit on test at Yokohama is 2m long and 0.8m wide, and is fitted with a 1m diameter five-bladed FP propeller. The next motor size to

be tested will probably be fitted into the same pod, while the 5000kW future motor is expected to have a diameter of approximately 2m.

The motor can run in both directions freely at speeds up to 100rev/min (all the superconductor components are fixed, which makes refrigerant supply easy). Design values for the prototype are 12.5kW for the rated output, or 62.5kW for a short time, at a liquid-nitrogen temperature of 66K. Torque developed is the same as that for a 973kW conventional motor running at 1500rev/min. Cooling requirements on a ship are anticipated 3.5kW for a 500kW motor and 30kW for a 10,000kW unit.

A production unit is expected to be slightly different in that the armature as well as the field system will be superconducting (this is not the case with the prototype); thus superconducting wire will be used throughout. The most important benefit of this is that heat generation will be almost zero, but other spin-offs will be an annual 11% reduction in CO₂.

It seems likely that a naval ship (Japan Self-Defence Force) will test the first practical unit. Although this article has concentrated on motors inside azimuthing pods, the concept is, as mentioned, equally adaptable to traditional propeller-shaft arrangements, and it is possible that the navy installation may be one of these. Not surprisingly for such revolutionary technology, estimated capital costs for initial production units are anticipated to be +15% extra for a 500kW motor but lower, +5%, for a 10,000kW motor. Wide adoption could well shrink these figures to make this technology competitive with existing systems.

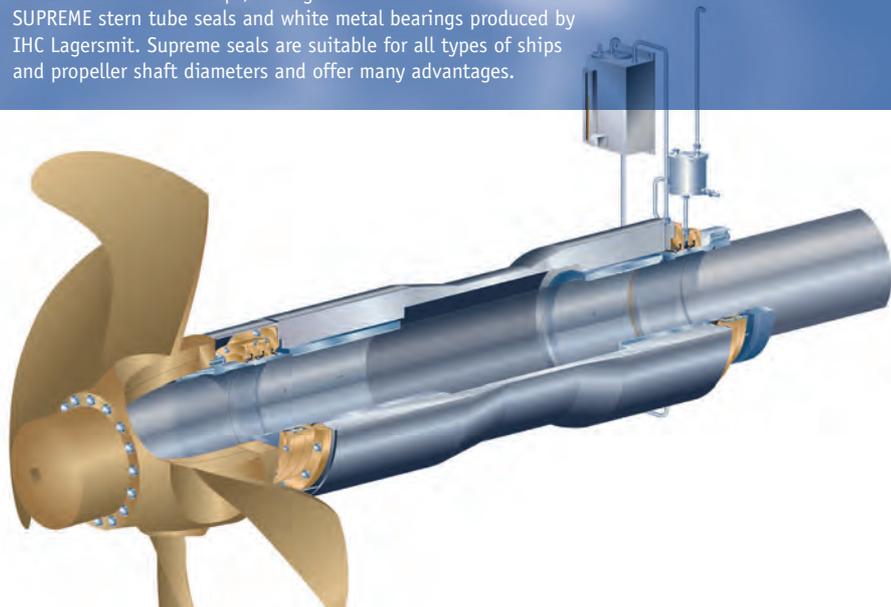


The azimuthing pod in which the prototype motor is fitted. The rated output of this test unit is 12.5kW but a larger motor is expected to be fitted inside for following tests, while production pods will be more hydrodynamically faired. The pod itself, with its steering gear, was supplied by Niigata Power Systems, and the propeller was cast by Nakashima.



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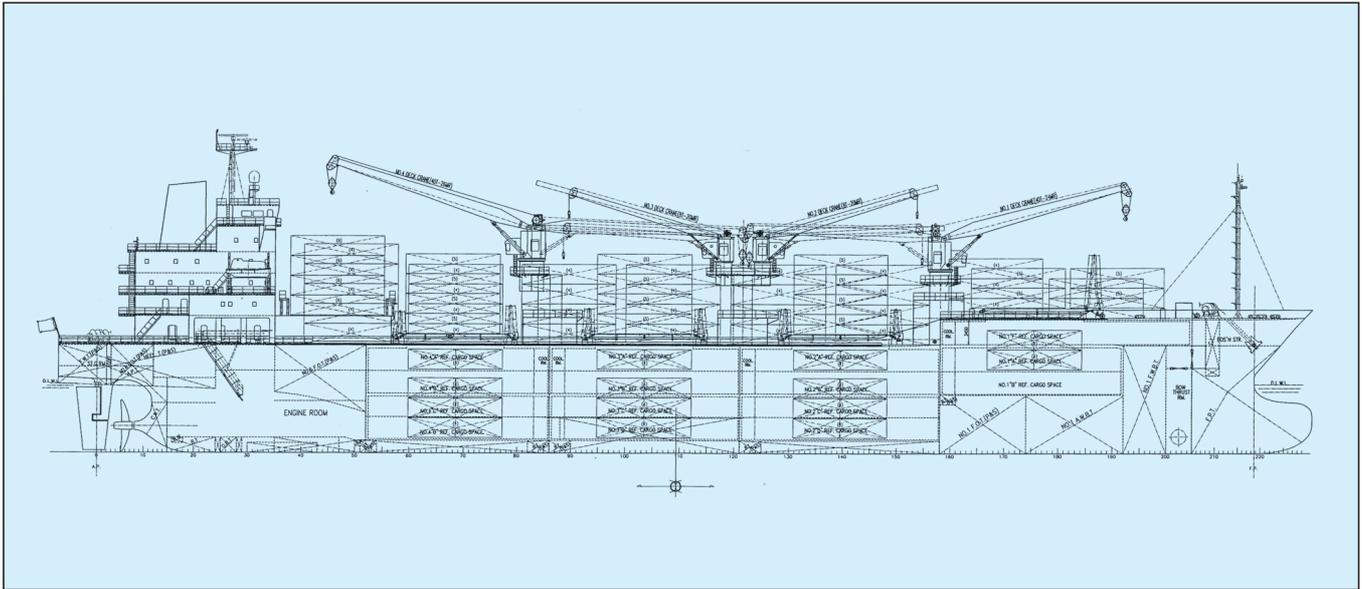
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Profile of the new-generation 585,000ft³ pallet-friendly refrigerated cargo ships on order at Shikoku Dockyard for Nissen Kaiun. They will feature a number of innovations.

New-generation pallet-friendly reefer ships at Shikoku Dockyard

THE Japanese shipbuilder Shikoku Dockyard, based at Takamatsu, has a well-earned global reputation as a constructor of refrigerated cargo ships; by 1998, it had completed more than 50 vessels - the 50th example being the 565,000ft³ *Costa Rican Star*, featured in *Significant Ships of 1998*. Unfortunately, not long after that, the fortunes of the reefer trades declined seriously, and they have been in the doldrums ever since.

Today at last, there are small signs of a possible revival, which have been particularly marked by the recent ordering at Shikoku, by Japanese owner Nissen Kaiun, of four large pallet-friendly designs of the most modern type with a capacity of 585,000ft³; they are believed to be for charter to Star Reefers. The series has been designed by Shikoku's own team, based on its considerable experience in this sector.

Despite the optimism engendered by this new contract, Shikoku Dockyard emphasises that in the near-future, refrigerated ships are likely to represent only a fraction of its order book, in view of a small number of players and an uncertain global situation in this niche sector. Construction of the first reefer ship is expected to begin in September this year.

Cargo-handling innovations

Although there is a shift in some reefer trades towards containers, Shikoku believes that it is more cost-effective to load some cargoes, particularly bananas, on pallets; the new ships for Nissen Kaiun do, although traditional in many ways, feature a number of significant innovations on the cargo-handling front. At the same time, a new hull form has been developed for a higher service speed of 22knots/23knots - approximately 1knot faster than previous ships, as requested by the owner. At the same time, the hull is 5m longer and 1m wider, to give optimum stability at the

new speed plus increased overall capacity and more rooms for deck containers. Model tests were carried out at Mitsui's Akishima tank (Mitsui is a majority shareholder in Shikoku) to ensure good stability and wake distribution at the propeller.

Four holds will be installed, each with four compartments, except for No 1 hold divided into three compartments, and in new departure, each compartment will have its own cooling system to promote higher quality control over cargo. Overall, there will be eight cooling zones.

Height in each compartment has been increased to 2.3m to accommodate new deeper carton sizes, while all hatches (with MacGregor-Kayaba covers) have been increased in size to allow 40ft containers to be loaded in all holds (although loaded reefer units will normally be carried on deck only). Containers will be handled by each ship's four IHI jib cranes. Two of these (the fore and aft units) will each have a 40tonne capacity and are positioned to plumb each hold, while between are two 8tonne units mounted on one pedestal. To assist with efficient cargo handling, the new class will be fitted with automatic heel compensation, using a 600m³/h pump and a pair of dedicated tanks.

Special ventilation arrangements are to be fitted to allow export cars to be carried on backhaul voyages. Fans will be controlled by five-step frequency converters, considered to be superior to traditional pole-change-type motors, and CO₂ monitors will be fitted so that fresh air can be injected should the oxygen level rise.

Nissen Kaiun's new class will be Shikoku Dockyard's first experience with the new environment-friendly refrigeration gas ammonia. An NH₃/CaCl₂ brine system with three brine chillers (one normally on standby) will be installed, with cooled air circulated in a ductless

arrangement through wooden gratings constructed of Warkaus, or similar, plywood. Temperatures can be varied from -25°C to +15°C, with insulation maintained by prefabricated fitted panels (all vertical for efficient pallet stowage).

The complete layout has been engineered by Maekawa Marine, who will also install, possibly for the first time on a reefer ship, one of its own humidification systems to help stop fruit drying out. Two humidifiers in each compartment will maintain relative humidity between 90% and 95% at temperatures between +5°C and +12°C. Cooling-down times prior to cargo loading will be approximately 24hours for bananas (to +28°C), 36hours for other fruit (to +15°C), and 48hours for frozen food (to -20°C). Fixed piping for future installation of controlled-atmosphere equipment (charterer's supply) will be provided in all eight cargo zones.

Fixed gas distribution piping and connecting manifolds will be fitted on the weather deck for maintaining a modified atmosphere, if required, by continuously flushing N₂ gas through the 200 reefer containers that can be stowed here, without monitoring or active control. Portable generators will be supplied by the charterer. For normal monitoring of containers, a wide/narrow broadband power cable transmission system has been specified.

To supply the high electrical power for all this key equipment, each of the new ships will be fitted with four 1500kVA diesel-alternator sets. Propulsion power for a service speed of 23.00knots at the banana draught (7.5m draught) or 22.00knots at the design load draught (9.05m draught) will be provided by a Mitsui-built MAN B&W 7S60MC-C low-speed engine developing 14,240kW CSR at 101.4rev/min and driving a FP propeller. To aid manoeuvring and avoid too

**TECHNICAL PARTICULARS
585,000FT³ REEFER SHIPS**

Length, oa.....	162.50m
Length, bp.....	150.00m
Breadth, moulded.....	26.00m
Depth, moulded.....	14.10m
Draught, design, moulded.....	9.05m
Draught, scantling, summer.....	9.70m
Cargo capacity.....	585,000ft ³
Holds.....	4
Cooling zones.....	8
Compartments.....	15
Clear height.....	2.30m
Pallets.....	5270 (1.00m x 1.20m)
Cars.....	550
Containers	
On deck.....	150FEU
On hatch covers.....	70FEU
In holds.....	56FEU
Total.....	276FEU (or 436TEU+58FEU)
Expected load to comply with IMO requirements.....	192 units (summer draught)
Reefer plugs.....	200 (on deck and hatch covers only)
Gross.....	13,800gt
Deadweight, summer draught.....	13,250dwt

much reliance on tugs, a new feature for this type of vessel will be an electrically driven CP bow thruster (12tonnes thrust).

Maintaining emphasis on bulk carriers

Shikoku's staple diet in recent years has been 29,000dwt and 35,000dwt bulkers, a market in which it has competed - and continues to compete - most successfully. This is primarily the result of efficient design and production facilities (the latter recently remodelled to allow

blocks up to 70tonnes to be assembled) on a modest and constricted site, aided by continuing strong demand from both domestic and overseas owners (many from Asia), and, apart from the new reefer ships, the order book for bulkers now stretches through to 2008. As is common (unfortunate, if viewed from a safety angle) in the marine world, a significant proportion of the new contracts are for owners rushing to order before new IMO and IACS legislation becomes mandatory.

It is interesting to note that some bulk carrier owners at Shikoku have been specifying the MO Tech propeller boss cap fin (PBCF) for their new ships, such as on the new 35,000dwt *New Blessing*, which was nearing completion at the time of our visit. By concentration on its efficient production techniques (the yard as no room for expansion), Shikoku is able to complete five 29,000dwt ships annually. Even more improved working should soon be possible soon when the single building berth is lengthened at the seaward end by 7m; this will allow better conditions for fitting rudders and propellers.

As in many yards worldwide, steel shortages are major headache at present - especially when larger yards with more bargaining power are able to negotiate extra supplies, and there is pressure on Shikoku (and others) to reduce consumption; however, this is difficult when new rules, such as those from IACS, actually call for more.

Main engine.....	Mitsui-MAN B&W 7S60MC-C
Output, MCR.....	15,820kW at 105rev/min
Output, CSR.....	14,240kW at 101.4rev/min
Speed, service, design draught.....	22.00knots
Speed, service, banana draught.....	23.00knots
Complement.....	25
Classification.....	Class NK NS* (Equipped for Carriage of Containers and Vehicles), MNS*, RMC* (-25°C/32°C), Equipped for the Carriage of Fruit in all Cargo Chambers), CA (Equipped for all Cargo Chambers, 8 Zones)

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Techno Superliner nears completion

JAPAN'S first large example of the long-running government-sponsored Techno Superliner project is expected to be complete at the end of October this year at Mitsui's Tamano yard. Named *Super Liner Ogasawara*, this 39knot high-speed hybrid ferry (a mixture of catamaran and surface-effect ship) will run between Tokyo and Chichi Jima on the Ogasawara Islands - a distance of 1000km. She follows the earlier 70m-long *Hisho*, subsequently converted to an emergency rescue ship. Her owner is Techno-Seaways Inc and the operator will be Ogasawara Kaiun.

The date of the first voyage has not yet been decided, and the ship will only carry passengers and a number of cargo containers - there will be no space for vehicles, since the islands are small and the number of inhabitants is only 2500. The original plan had been to sail on a route to the northern island of Hokkaido but financial problems of the shipowner involved prevented that proposal proceeding.

Her design has been conceived to handle 5m significant wave heights, while passengers will only sit in the midships section, because of the accelerations; however, stabiliser fins plus automatic fore-and-aft venting of air-cushion air should ensure a comfortable ride. However, since the main part of the voyage is expected to be at night, most passengers will probably be asleep. In any case, the size of the hull (140.00m length overall and 29.80m breadth) should allow reasonable passenger movement without any need to be seated, under normal circumstances.

Accommodation space for up to 362 passengers sleeping on futons will be provided, with the remaining 378 in one-, two-, or three-berth cabins. A restaurant for 100 people will also be included.

Super Liner Ogasawara fulfils the requirements of the HSC Code (the first time for a domestic-service vessel). As we reported last October, parts of the aluminium hull (those requiring plate up to 4mm thickness) are assembled using friction-stir welding - believed to be for the first time on a ship. This



Super Liner Ogasawara at the outfitting quay of Mitsui's Tamano yard. She is expected to be complete by October, but extensive trials will probably follow prior to entry into regular service.



Apart from passengers, an important part of the load on the route to and from the Ogasawara Islands will be 10ft containers - up to 40 can be stowed in two tiers in this dedicated forward area.



Part of the restaurant for 100 persons.

The new fast ferry will be powered by two of these Kamewa VLWJ235 waterjets, which will provide a speed of 39knots.



method's lower working temperature gives fewer distortions. TIG welding is employed for thicker plate up to 15mm.

An important feature of the new ferry will be the ability to load up to 40 x 10ft containers (similar to those carried on Japanese railways) in two tiers in a forward recessed and open compartment. These will be secured on conventional fittings (aluminium with steel bases).

Lifesaving will be based on six vertical escape chutes - three on each side of the hull; each can deal with 160 people. Evacuation simulations have been carried out by the National Maritime Research Institute.

The principal machinery lines - including two LM2500+ General Electric gas turbines, each

developing 25,180kW - are mounted on anti-vibration supports, and noise-damping treatment has been applied to the exhaust lines of the four Niigata 16V20FX engines driving the eight lift fans. The gas turbines drive two of the largest-ever Kamewa waterjets, the VLWJ235 type.

Many people in Japan and elsewhere will be scrutinising closely the first voyages of the *Super Liner Ogasawara*, especially regarding passenger comfort. Accelerations and distortions will be monitored onboard and transmitted back to Tokyo for analysis. If she performs well, maybe commercially-minded operators will be tempted to order a ship - most likely a ro-ro version. Other routes are already under consideration, such as one carrying containers to Shanghai, China. 

The Royal Institution of Naval Architects

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Since they were developed in the 1950s, bulk carriers have provided a crucial service to world commodities' transportation. Some 5,000 bulk carriers trade around the world.



Following a spate of losses of bulk carriers in the early 1990s, IMO in November 1997 adopted new regulations in SOLAS containing specific safety requirements for bulk carriers. In December 2004, the Maritime Safety Committee adopted a new text for SOLAS chapter XII, incorporating revisions to some regulations and new requirements relating to double-side skin bulk carriers. The International Association of Classification Societies are also developing a set of unified requirements for the classification of bulk carriers. This conference will bring together designers, regulators, class societies and operators to discuss these, and other, aspects of bulk carrier design and operation.



Papers are invited on all subjects related to bulk carriers, including the following topics:

- Pros & Cons of Double Skin Tankers
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Many uses for innovative insulation blanket

As readers will be aware, aluminium is now commonly used in the construction of cruise ships, superyachts, and work/service boats, as well as on the more traditional fast ferry. Savings in weight bring benefits in fuel economy and in increased payload, and the use of aluminium as a superstructure material allows taller, rather than wider, cruise ships to be built.

The employment of aluminium, and other lightweight materials such as GRP composites, also has some disadvantages, not least of which is its resistance to fire. Unlike steel load-bearing decks and bulkheads, under IMO codes the core temperature of aluminium structures must not rise more than 200°C above ambient temperature in the case of a fire. This leads to the use of increased volume

and weight of fireproofing materials. On the other hand, Insulfrax Blanket products, manufactured by Unifrax Corp, are said to be ideal materials for providing passive fire protection to structures based both on lightweight materials and also traditional steel.

Insulfrax Blanket is a totally inorganic, flexible, high-temperature insulation blanket suited to marine passive fire protection applications. The calcium, magnesium, and silicate chemistry is designed to enhance bio-solubility, and the proprietary fibre spinning technology of Unifrax combined with the mechanical needling of the fibres eliminates the need for binders in the product. This results in a material with high-tensile strength, also good thermal and acoustic properties.

The system comes with Marine Equipment Directorate approval for steel and aluminium structures, is approved by the US Coast Guard for steel and aluminium structures, and it also complies with SOLAS Safety Objectives and IMO FTP Code fire test requirements.

This fire protection system for bulkheads and decks is claimed to be easy to cut and install, and has no requirement for wire mesh. This should ensure simplified logistical management with no pre-cutting, and installation is from standard stock rolls. The blanket is available with aluminium foil (SF), reinforced aluminium foil (SFR), and glass cloth (SG) covering to provide enhanced durability.

Insulfrax Blanket products are already widely used for passive fire protection in a variety of vessel types. Recent projects include installation on Royal Caribbean Line's *Jewel of the Seas*, in which 50,000m² of Insulfrax SF Blanket was supplied for A60 steel and aluminium decks, bulkheads and ducts; this gave a weight saving of 160tonnes. In addition, Brittany Ferries' *Pont-Aven* was installed with 5000m² of Insulfrax SF Blanket used for aluminium A60 decks and bulkheads, and the weight saving here was 5tonnes. Finally, *Kemba*, a fast supply and intervention vessel, has its A60-rated engine rooms and accommodation areas protected with 1500m² of Insulfrax SFR Blanket. The weight saving here was 1.5tonnes. 

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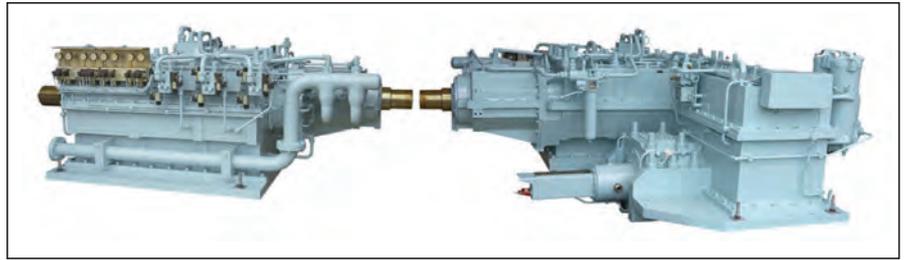
IN March this year, the Remontowa yard in Poland delivered the double-ended ferry *Bastø III* - the largest such vessel to be built there - to her Norwegian owner Bastø Fosen, for operation on the well-established route across the Oslo Fjord, between Moss and Horten. Although outwardly she represents the classic Norwegian double-ended profile, inboard is a novel propulsion and transmission arrangement, which has allowed the ferry to be awarded Det Norske Veritas' highest notation for propulsion redundancy. A comparison can perhaps be made with the slightly smaller and diesel-electric-powered *Finnøy*, built by the same yard in 1999 for Rogaland Trafikkselskap (*Significant Ships of 1999*).

Bastø III's arrangement is based on a complete propulsion package supplied by the Wärtsilä group. This comprises two Wärtsilä Vasa 6R32LN diesel engines, each rated at 2460kW at 750rev/min, which drive - through a complex gearing and clutch arrangement - a four-bladed, highly skewed, stainless-steel Lips CPS100 feathering CP propeller of 3400mm diameter at both the bow and stern. To provide a large measure of redundancy, a cross-over shaft connects the aft engineroom plant with that in the forward engineroom, so that either propeller can be driven from one or the other engine - or by both.

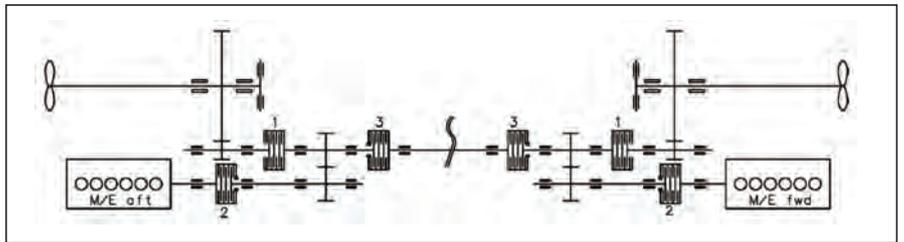
Multiple clutches

Each Wärtsilä TCH125H50V57 reduction gear is fitted with three hydraulically-operated multiple disc clutches - a propeller clutch, an engine clutch, and a 'cross-over' clutch. The combination of these allows the following modes of operation:

- forward engine can drive forward, aft, or both propellers
- aft engine can drive forward, aft, or both propellers
- both engines can drive forward, aft, or both propellers at the same time.



The two special Wärtsilä gearboxes built for *Bastø III*, which feature cross-over shafts so that either of the two propulsion engines can drive either, or both, of the two feathering CP propellers (one at each end of the ferry).



Layout of the complex transmission plant on the new double-ended ferry *Bastø III*. It offers a high level of redundancy (50% of power always available) at reduced capital cost. As a result of this system, the ferry is able to achieve a Det Norske Veritas RPS redundancy notation.

The twin input power of each gear is 2 x 2460kW at 750rev/min, while the single output can be 4920kW at 192rev/min propeller speed.

High level of redundancy

Due to the high level of redundancy that this arrangement affords, together with the five watertight bulkheads between each gearbox and the stern tubes, Det Norske Veritas was able to award *Bastø III* the class +1A1, Rv, Ice C, Car Ferry A, Clean, E0, RPS. The notation RPS is applicable for vessels where the propulsion system is redundant, such that at least 50% of propulsion power can be restored after any single failure in the propulsion train.

This diesel-mechanical propulsion solution with feathering CP propellers was chosen over

a more conventional diesel-electric system with steerable thrusters (as on the earlier *Finnøy*) because the latter option would have increased the investment by 10%. Additionally, fuel consumption at a service speed of 14knots is said to be some 20% higher with a diesel-electric/steerable thruster arrangement. This increase is claimed to be due to electrical losses, higher ship resistance, and lower efficiency of the thrusters.

Concept based on that used in Chinese-built tanker

Wärtsilä based its special TCH125H50V57 gearboxes on the proven design concept of a transmission system installed in *Sten Idun*, a

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16,400dwt chemical/product tanker built by Jiangnan Shipyard in China and delivered in 2003.

On this latter vessel, the propulsion arrangement centres on a six-cylinder in-line Wärtsilä 46 engine driving a Lips CPS130 CP propeller via Wärtsilä SCV116-SDCT65 reduction gearing, whereby electric power from auxiliary engines can feed a dual-role shaft generator/electric motor driven by a power-take-off/power-take-in shaft on the gearbox, to turn the propeller.

In order to increase total propulsion power, this power take-in (PTI) facility can also be used as a 'booster', which means that the diesel-electric propulsion system is operated in parallel with the main engine, with a total propulsion power of 7000kW.

The arrangement has a two-speed PTO/PTI feature to reduce propulsion power in a PTI mode (operation only as diesel-electric propulsion). Reduced propeller speed in this mode increases propeller efficiency significantly at low vessel speed.

Currently, more than 60 Wärtsilä gears are either in operation or on order with different type of PTI solutions. Approximately 20 gears of the same type as *Sten Idun* are in operation/on order, and based on the experience with *Sten Idun* (first of an order of five) seven more vessels of the Norwegian Skipskonsulent design SK 4056 have been ordered from the same yard

All of Wärtsilä's gear systems, available in three standard models - single reduction gears with vertical or horizontal offsets, and twin input/single

output gears in the power range 1500kW-35,000kW - can be supplied with one or more power take-off shafts for driving any rotating device such as shaft alternator, pump, or compressor. 

Centa-Joint - a new link for propulsion and auxiliary use

A BRAND-NEW link coupling, principally designed for marine drive lines in both propulsion and auxiliary situations, was launched at the recent Hannover Fair by Centa Antriebe Kirsche, the German specialist in this field. The simple and flexible Centa-Joint covers a wide performance range from 1.10kNm to 42kNm and is said to offer very quiet and vibration-free performance. Both noise and vibration are dampened by two sets of rubber bushes, and the unit is free from float, torsion, and radial movement. Both wear and maintenance needs are claimed to be low.

This Centa-Joint coupling consists of two joints plus a connecting steel or carbon tube, with special bushes designed to withstand tension and pressure, and able to handle every articulation; these are screwed axially with both the drive and connection flanges. 

Seen here under test is a special gearbox built by Renk for installation in a new class of national security cutters for the US Coast Guard. It is designed for combined diesel and gas turbine operation (CODAG) and has now been delivered to Northrop Grumman Ship Systems. The gearbox is quite heavy (110tonnes) and combines the gear types AS 2/250 and AS 198F; it handles the output of one central gas turbine and two diesel engines, transmitting a total of 37,000kW to twin CP propellers.

The arrangement is said to excel in the part-load range when one diesel engine drives both propellers; such a mode covers 70% of all operations. Thus diesel engine maintenance is considerably extended. All gear stages feature double-helical teeth. 



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Buoyant year for Registro Italiano Navale

LAST year was an exceptional one for the Italian classification society Registro Italiano Navale (RINA). The fleet grew by 10%, profits before tax were up 12%, and the number of personnel increased by 10%. At the same time, a satisfactory proportion of cruise liners on order are being built to RINa class (12 out of 23 ships), while 14 of the 114 ferries on order are also to be handled by the society. In the high-speed ferry sector, 12 of the 31 hulls are being classed by RINA.

Although not a special subject for this journal, readers may be highly interested to know that the Italian society holds 25% of the megayacht order book and has recently issued a new set of rules for classification of charter yachts (many are often planned for some kind of commercial service). These new rules, which apply to craft carrying less than 12 passengers and with lengths above 24m, cover class and survey, hull, materials, welding, and

Some of the highlights of the recent Cruise & Ferry Exhibition and Conference, held at Earls Court, London, from May 3-5.

other aspects. A voluntary anti-pollution notation Green Star, based on the society's extensive cruise liner experience, has also recently been launched for yachts. The Italian Maritime Administration and the UK Maritime & Coastguard Agency have both recently issued a code of safety for charter yachts.

Award for TNF Magic

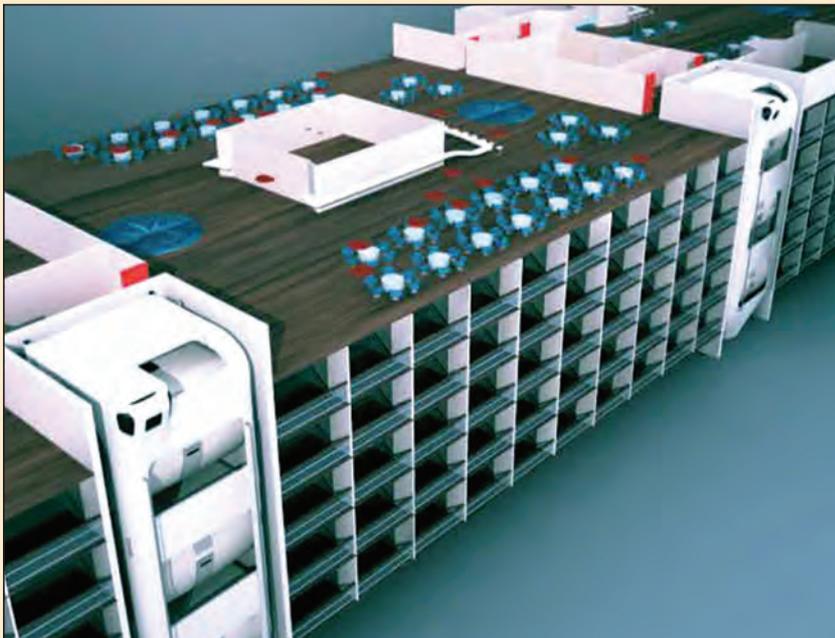
The winner of the 2004 Ship Safety competition, organised by The Royal Institution of Naval Architects and sponsored by Lloyd's Register, is

TNF Interiors (Inexa Panel), manufacturer of the PVC-free TNF Magic. This is a new-generation halogen-free, non-toxic fire-retardant marine wall finishing is, the company believes, the first to come in a wide range of patterns. Up to now, most coverings for cabin and corridor walls have been very plain. The elimination of the PVC content is a major step forward, since no noxious fumes will be emitted in the event of fire. At the end of 2005, Inexa will start manufacturing the finishes in China as well as in Denmark.

Spray-on insulation

A Swedish company using an idea created in France is making inroads into shipbuilding in Korea. Ovacon AB's SpreFix spray-on insulation for ships' bulkheads is an alternative to traditional mineral wool secured by wire netting; the product is still based on mineral wool but this is mixed with water-soluble binding agents to produce a sprayable product. A number of important benefits include fire protection, elimination of condensation as the material has no potential for air gaps, and good insulation against both heat and sound. This year, the company expects to work on 40 ships, using its SpreFix S version approved for marine use, with 100 planned for 2006. Although most work has been at major Korean yards, others in Norway have used the technique, and Ovacon has appointed a SpreFix partner in China, who is already applying the insulation in yards there.

These three computer-generated images represent features of the new Rescubelifeboat proposal from the Norwegian company Norsafe, which aims to overcome the difficulties of loading passengers and launching traditional lifeboats, mainly on cruise liners and ferries. Such Rescubes would be stowed vertically so that passengers can walk directly in from special fire-safe zones; each of the three modules inside would rotate for launch and when afloat. More details of this interesting concept are discussed in our Editorial Comment on page 3.



UK-built modular cabins

A British company making modular cabins is beginning to make a name for itself. The McGill division of Vinci Services, based at Billingham, has mainly been producing fully outfitted prefabricated units, complete with wet units, for naval ships but versions for cruise liners and ferries are also designed and made. McGill is working in association with another UK company, Strongbox, which is manufacturing all the internal furniture such as beds, desks, and wardrobes. Service ducts for piping and wiring are in-built for exterior connection after the cabin has been positioned. If required, cabins can be supplied as flat-packs for shipyard assembly.

A typical example of a ferry or cruise liner cabin designed and built by the McGill division of Vinci Services.



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Success for *Hamanasu*

In a joint presentation to the Cruise and Ferry Conference, Kiyoshi Takaoka, from Shin Nihonkai Ferry, Naoki Ueda, from Mitsubishi Heavy Industries, and Thomas Hackman, from ABB, outlined the project that led to the construction of two 30.5knot ferries *Hamanasu* and *Akashia*, the first ships to be installed with the contra-rotating Azipod propulsion plant (*Hamanasu* was presented in *Significant Ships of 2004*). The speakers reported that after several months of operation and based on bunkering records, the two older ships (the 1996-built *Suzuran* and *Suisen*), with conventional mechanical twin-screw plants, burned more than 20% more fuel for approximately the same speed - 29.4knots. The power to achieve these figures is based on 47,660kW for the older pair and 42,800kW for the new ships. At the same time, turnround time was reduced by 25% on the new pair.

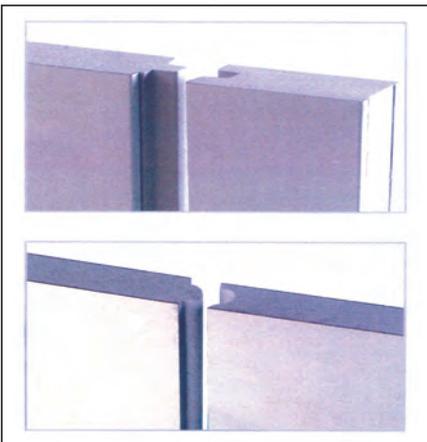
The new ferries are also able to manoeuvre without tug assistance in wind speeds up to 18m/sec, compared with 13m/sec in the previous ships. At slow speeds, steering is said to be 'remarkable' and acceleration superior, while the stern wake is small. Performance during a typhoon on the route between Maizuru (Honshu) and Otaru (Hokkaido), when wave heights were above 8m, was still said to be good, and the ferry remained fully manoeuvrable.

Lightweight doors

Danish manufacturer NCM Core A/S, headquartered at Vodskov, is producing a range of lightweight building panels for the marine industry under the brand names LiteCore panels also Skamodoor wooden fire doors and insulation products. Naval architects will be interested to know that some doors can be supplied with a weight of only 19kg instead of a more traditional 39kg.

LiteCore panels come with four fire ratings: B-15, B-30, A-60 and H-120, with respective weights of 8.1kg/m², 10.2kg/m², 25.4kg/m², and 38.3kg/m², with either laminated or steel outer surfaces. All panels have US Coast Guard approval and are also approved by Lloyd's Register and Det Norske Veritas.

Joint details for typical H-120 (top) and B-15 (bottom) fire-rated LiteCore lightweight panels produced in Denmark by NCM Core A/S.



Contra-rotating Azipod at work: the Shin Nihonkai ferry *Akashia* at full speed. The single-shaft installation, with a CRP Azipod unit behind, is reported to have been eminently successful.



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Challenges ahead for paints and coatings

Some of the critical issues (including IMO's proposed new performance standards), currently facing not only the global paints and coating industry but equally owners and shipbuilders, are discussed by Raouf Kattan, FRINA, managing director of UK coatings consultancy Safinah Ltd. An objective review of some of the newest technologies is also offered.

THE surge in China's shipbuilding growth has had a real impact on the marine coatings market. A positive repercussion of the rapid growth in GDP in that country is however - as highlighted in the Hempel article in this feature and recent information from Jotun - a well-documented boom year for shipowners and levels of output from shipyards. Consequently, with the exception of a poor start to the drydocking market (owners held ships back from repairs to maximise earnings), all paint companies are reporting increased/record sales volumes.

One negative impact of this growth, as highlighted by International Paint, is that despite increased volumes, very high oil price rises have resulted in increased raw material costs. This, together with some unfavourable exchange rate movements, is making margins tight for all companies. Yards and owners, having been used to paying low prices for coatings, are now fighting against much-needed cost rises.

The big topic at present, however, is still regulations. At the time of writing, there is considerable concern in the industry about the IMO DE48/12 Performance Standard for Protective Coatings, due to be discussed last month (May 11 2005).

This draft performance standard is raising a few eyebrows in the industry, since it lays out shipowners' requirements for a 15-year life for ballast tank coating schemes. The selected scheme, which is based on the TSCF15 (Tanker Structures Construction Forum) format and IMO resolution A789 (18), means that in the last 15 years some 12-15 new standards, regulations, and guidelines have been introduced relating to the coating of ballast tanks.

The issue raised is that some TSCF15 requirements are more stringent than paint company requirements and are extremely onerous for shipyards. However, the corrosion problem in ballast tanks is critical, and this will be a very important standard to monitor for all parties.

The document has been submitted by BIMCO, IACS, Intercargo, and Intertanko as a response to the requirements of the draft SOLAS regulations XII/6.4 dealing with performance standards for double-side-skin bulk carriers. The submission has raised some concerns for shipyards, which focus on a number of areas:

- applicability to all vessel types - the ballast tanks of each ship type are subjected to



Completion of work on the 100th ship to be coated with Intersleek 700, International Paint's non-biocidal, foul-release product, took place recently at the Subic Bay Shipyard, in the Philippines. The 5512TEU container liner *YM Green*, owned by Yang Ming, of Taiwan, is one of nine ships in this owner's fleet to use Intersleek. More details appear on page 67.

Technology award for Ameron

THE Frost & Sullivan Award for Technology Leadership is bestowed each year upon the company that has demonstrated excellence in technology leadership within its industry. The recipient company has to demonstrate technology leadership by excelling in all stages of the technology lifecycle - incubation, adaptation, take-up, and maturity to ensure a continuous flow of improvements. By innovating leading-edge concepts, the company has to have pioneered client applications.

Ameron International is the recipient of the 2005 Frost & Sullivan Technology Leadership Award in the US protective coatings market. This award has been presented to Ameron International for its long and successful track record as an innovator and leading supplier of polysiloxane (PSX) technology.

This patented technology, seen as a new generic class of high-performance coatings, combines the performance of a polysiloxane with an organic resin. Traditional coating types have inherent

strengths and weaknesses, but through combining siloxane chemistry with traditional coating resins, significant improvements can be obtained for such features as long-term gloss retention, durability, chemical resistance, and so forth. Besides coatings, Ameron has also developed a PSX composite pipe and PSX epoxy adhesives sold by Ameron's glassfibre pipe division.

In other news, Ameron has opened a new branch in Busan, Korea, as the company sees the Far East as one of the most important and fastest growing markets for marine and offshore coatings. Ameron Korea has been opened to directly sell into and service this strategically important marine marketplace, with the company's coatings range for both new ships and for maintenance. Han Jin, Ameron's existing Korean licensee, will manufacture for Ameron under a toll manufacturing agreement. Han Jin will also continue as Ameron's licensee to sell into Korean offshore and industrial markets. 

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varying conditions through life, and this standard may be too high for some ship classes

- the recommended salt limits before secondary surface preparation is set at $\leq 30\text{mg/m}^2$. This will create problems for yards using fresh water washing, as some fresh water supplies may be unable to achieve this
- the grading of coatings as 'Good, Fair, or Poor' lacks an industry-wide consistency and also varies between classification societies
- many of the newer high-volume solids products do not yet have a 15-year track record.

This standard will pose challenges for yards and paint suppliers alike. Many yards are also concerned about the changes, which this will mean alterations to their well-established working practices plus associated implications on build costs and production time. This could have the effect of significantly increasing the work content.

The product types featured in the articles presented in this feature focus on the following areas:

- top-coats - for external superstructure and house colours
- antifouling and foul-release coatings - for drag reduction and fuel savings
- universal primers - to reduce the number of products used to coat a ship.

Topcoats are critical for the appearance of a vessel or offshore structure and often create a very important first impression for third parties. The ranges of most leading marine coatings companies include products based on a variety of chemistries including: alkyds, polyurethanes, epoxies, vinyls, acrylics, and, more recently, polysiloxanes. In this area, Jotun has introduced its Hardtop Flexi, while Ameron has had its PSX technology (introduced in the mid-1990s) recognised in the USA.

Antifouling solutions have gone through tremendous changes in the last few years with the demise of TBT SPC products which have been the mainstay of the industry for several decades. The solution envelope has broadly focussed down to two technologies (although there are some novel and alternative technologies out there at various stages of testing).

These two technologies are copper-based SPC antifouling products that broadly reflect the banned TBT SPC products and match them in technology and performance, and foul-release technology (low-surface-energy coatings).

The demise of TBT-based products left gaps in the product ranges of all paint companies, and the recent product launches by Hempel (Olympic) and Jotun (SeaForce) are aimed at ensuring all vessel type requirements can be catered for, based on speed, level of activity, and trade patterns. For many years, foul-release technology has been led by International Paint, but as that leading company celebrates its 100th

application, the choice in the market place is increasing, with offerings from Hempel (Hempasil) and Sigma (Sigmaglide).

These products do not polish or contain booster biocides, instead they offer a very smooth, low-surface-energy surface, to which it is difficult for fouling to adhere. Consequently, when the vessel is stationary, some fouling may occur, but as the ship builds up to its required critical speed, the fouling is released. These products offer a potential of a long service life well in excess of five years, but can suffer from mechanical damage.

They are proving very popular on large container vessels and are being specified on some of the new LNG carrier orders. The use of silicone does present some challenges for shipyards to control the potential for contamination of other surfaces by silicone, and to date, the majority of applications have been in repair drydocks.

Finally, universal primers are playing an increasingly important role in simplifying the coating process, both at newbuilding stage and during maintenance and repair, by reducing the total number of products required to coat any given ship. These products are designed to be applicable to most vessel areas as a first-coat anti-corrosive and to be over-coated by a variety of products.

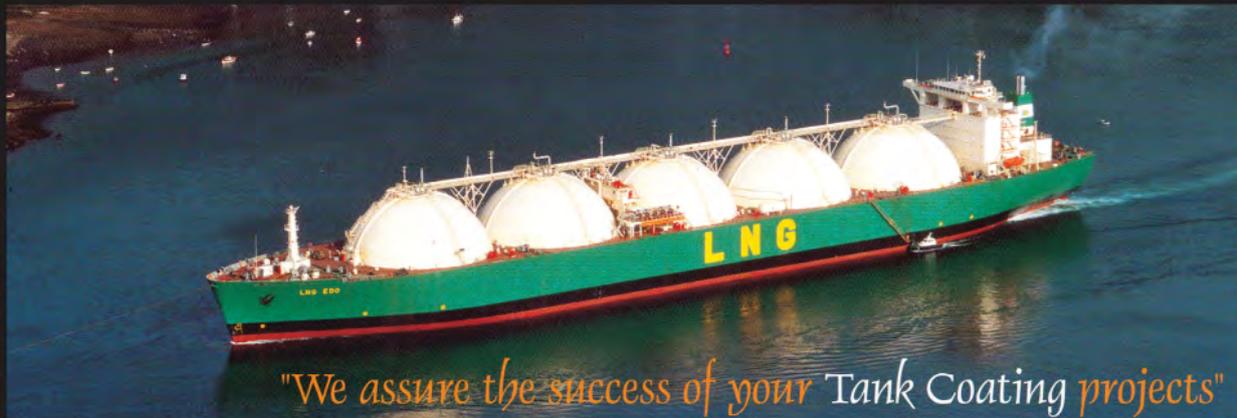
They afford through life protection for a variety of environments. A welcome addition to the products on offer from many of the leading paint companies is Hempadur Uniq (from Hempel), as a solution to this problem that is faced by both owners and yards alike. 



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Global introduction of a new flexible topcoat

A NEW impact-resistant polyurethane formulation, that matches the highest levels of colour and gloss retention expected of polyurethane topcoats, named Hardtop Flexi, has recently been launched by Jotun. Based on new technology, Hardtop Flexi can, claims the company, survive rough conditions, without cracking, as proved when used on hatch covers which were 'hit' by a loaded transport container.

With a high solids content of 64% by volume, the new product boasts low VOC emission levels, and can be applied in single-coat thickness of up to 150microns to minimise downtime and application costs. Hardtop Flexi can be applied directly to metal, over any two-pack primer, or as a topcoat where it is effective in hiding imperfections due to the lower gloss level.

Flexibility of the product has been ascertained using the ASTM 522-93a conical-mandrel test. In this, coated sheet-metal panels are bent over conical mandrels and the flexibility of the coating determined from the diameters of the mandrels at the points at which any cracking starts.

Further testing was carried out under normal working conditions where often, says Jotun, paint is applied without first carrying out correct pre-treatment. Even under these testing conditions, Hardtop Flexi is claimed to have shown exceptional adhesion to its substrate. It is quick drying and does not stick to other painted surfaces, so is ideal for use on production lines where parts may be stacked in a yard after being coated.

More than 1 million litres of Hardtop Flexi have already been successfully used in a wide range of applications. Suitable for application at

temperatures down to 5°C, it also has good water resistance, and should not be damaged by an unexpected rain shower on a newly painted surface.

Novel plasticiser technology for new TBT-free antifoulings

In other news, Jotun Coatings has introduced three new TBT-free antifoulings, named SeaForce 30, SeaForce 60, and SeaForce 90. Complementing SeaQuantum, the SeaForce range is targeting the cost-sensitive sector of the market, offering what is said to be a cost-effective high-solids self-polishing antifouling with a lifespan between 36 months for SeaForce 30, and 60 months for SeaForce 60 and SeaForce 90.

The high-performance SeaForce 90 is even said to have superior qualities to hydrating/CDP products, which usually are characterised as hybrid antifoulings. The new range offers features normally only achieved by hydrolysing antifoulings, such as SeaQuantum. Main benefits include a linear polishing rate, high antifouling performance predictability, reduced leached layer thickness, as well as high volume solids (58%).

These features of SeaForce are due to a new patent-pending technology called polymer plasticiser technology (PPT). Since SeaQuantum is based on a silyl polymer, incorporating environmentally acceptable active ingredients with flexible hydrolysing acrylic polymers, the product does not require a film modifier. Most other types of antifoulings, however will eventually become hard and brittle, and are thus in need of a film modifier.

Traditionally, a film modifier consists of either extremely large fibres to reinforce the paint film, resulting in a 3D network, or, more often, uses flexible polymers and low molecular weight plasticisers, to allow for optimal mechanical properties. Many of these solutions cause concern, however, since they may effect the environment or human health.

Low-molecular-weight plasticisers, for example, are so small that they have a tendency to migrate, resulting not only in losing the intended effects, but also becoming harmful when migrating from the paint. These plasticisers have, for instance, been identified as 'hormone analogues', thus copying the structure of hormones so closely that they can be harmful for human health. Another threat is that they may contain large levels of chlorine and thus be harmful to the environment.

However, Jotun's new PPT consists of a combination of unique polymeric plasticisers. Being polymeric (ie, large) in nature, they cannot migrate and thus remain fixed within the film. At the same time, their structure is specially designed to remain stable throughout the lifetime of the coating and thus continue to function as intended throughout the entire life span of the antifouling.

An important additional feature for the new polymers is the fact that they can be tailor-made, allowing other properties to be built into the structure. One benefit, for example, is the ability to select building blocks (monomers) in a combination that assists in reducing the thickness of leached layers. ☺

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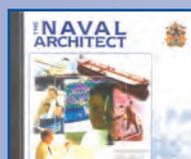
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Record commodity prices still driving up paint costs

MARINE coatings are set to initiate further product price rises in response to the unprecedented rise in raw material costs. 'By the end of 2004, prices of all raw materials key to the manufacture of our marine coatings increased significantly', reports Mr Brian Smith, International Paint's marine coatings commercial director. 'In 2005, we continue to see record highs in the prices of raw materials used throughout our business, and this leaves us with little choice but to regrettably raise the prices of our products'.

Record oil prices continue to drive the increase in raw material costs. This year has seen a record high for crude oil at more than US\$55/barrel. OPEC production has almost reached its capacity of 28.5 million barrels/day. China's and indeed India's continued appetite for oil and a decline in Russian oil production have added to market pressures. A key concern now is also the shortfall in global refining capacity, with demand forecast to continue outstripping supply. Key raw materials used in marine coatings that have experienced significant price increases include zinc, epoxy resins, and titanium dioxide.

Copper prices have hit a recent high of US\$3308/tonne and are expected to rise still further this year. Continuing Chinese demand has resulted in a sustained supply deficit, which is expected to remain for at least 12 months. The broker Morgan Stanley has raised price forecasts for 2005 and 2006 by 8%.

Zinc, which is used extensively in anti-corrosive products, has reached its highest price for five years. It has increased by 15% already in the first three months of 2005 and analysts forecast further increases during the year. Zinc prices are being hit by decreasing inventories and supply shortages due to unprecedented demand from China. No new mine production is planned until late 2006 at the earliest.

Epoxy resin manufacturers continue to launch frequent price increases to counter the

impact of high energy and feedstock costs. Epoxy bulk liquid production remains 'sold out' globally, with producers preferring to supply the healthy and more lucrative polycarbonate market. The price of liquid epoxy resin has increased by 14% so far this year.

Titanium dioxide producers have announced another global US\$150/tonne (7%) price rise effective from April 1 2005. There has been no investment in new titanium dioxide production plants since the 1980s and with global demand expected to increase by 5% in 2005, rutile producers are expected to increase prices still further this year.

Paint can packaging costs have also risen by 11% this year as a result of last year's 72% increase in the price of iron ore. Steel producers have passed this on to metal packaging manufacturers. The situation is further exacerbated for steel producers by the shortfall in coking coal that is used to stoke blast furnaces, which saw prices move up by 120% last year. 'In such a volatile climate of incessant price rises, International Marine Coatings has little choice but to reluctantly pass some of these increases onto our customers', said Mr Smith.

In other news, Akzo Nobel (International Paint's parent company) has reported high results for the first quarter 2005. For coatings, revenues were flat despite price increases; and raw material pressures. Revenues were €1.2 billion, up slightly on 2004, with autonomous growth of 1% (prices up 4%, volumes down 3%). EBIT fell 26% to €62 million with EBIT margin at 5.0% (2004: 6.8%). As expected, on average raw materials costs increased by 10%. The company noted that the first quarter is low season and that revenues will pick up in the second and third quarter. In terms of raw materials, Akzo Nobel is working with its customers to address the issue.

For industrial activities, margins were affected by an unprecedented surge in the cost of petrochemical derivatives. While volume

growth in Asia continued, results in the region were impacted by higher raw material prices and competition.

The marine and protective coatings division (International Paint) continues to deliver excellent performance. This business is benefiting from record levels of new shipbuilding, particularly in Korea. Coatings restructuring programmes continued, resulting in a workforce reduction.

100th Intersleek application

International Paint recently completed the 100th ship coated with the non-biocidal, foul-release product Intersleek 700. Working in partnership with the Yang Ming group, the 5512TEU, 24knot container ship *YM Green* was successfully coated at Subic Bay Shipyard in the Philippines. A ceremony to mark the occasion of the 100th ship application will be held jointly, with Yang Ming, in Taiwan in this month.

Intersleek 700 is a patented, foul-release coatings technology that controls marine fouling without the use of biocides. Especially designed for deep-sea high-activity liner-type ships, Intersleek 700 provides a very smooth and slippery, low-friction surface onto which fouling organisms have difficulty settling. Any that do settle, normally do so only weakly and can usually be easily removed by simple wiping or washing or by the vessel moving through the water at speed. The environmental benefits of Intersleek 700 include no leaching of biocides into the sea and reduced wash water treatment costs at drydocking.

The smooth surface of Intersleek 700 provides a reduction in average hull roughness through careful application and a potential increase in vessel operating efficiency with reduced fuel consumption. Of the 100 ships coated with Intersleek 700, 24 have now returned to drydock in excellent condition (slime only). Five of these vessels have been in service for over 60 months. 

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Marine coatings maker responds to environmental challenge

ALTHOUGH Danish paint manufacturer Hempel has reported record sales levels, actual turnover and profit figures have been affected by the fall of the Dollar against the Euro and other European currencies. However, all indications are that the good sales levels have been maintained, and restructuring to reduce costs should pay off, according to chief executive Pierre-Yves Jullien. Mr Jullien, a Frenchman who formerly ran Hempel's subsidiary in France and has been based in Denmark since 1994 and a board member since 2000, was appointed to the post earlier this year.

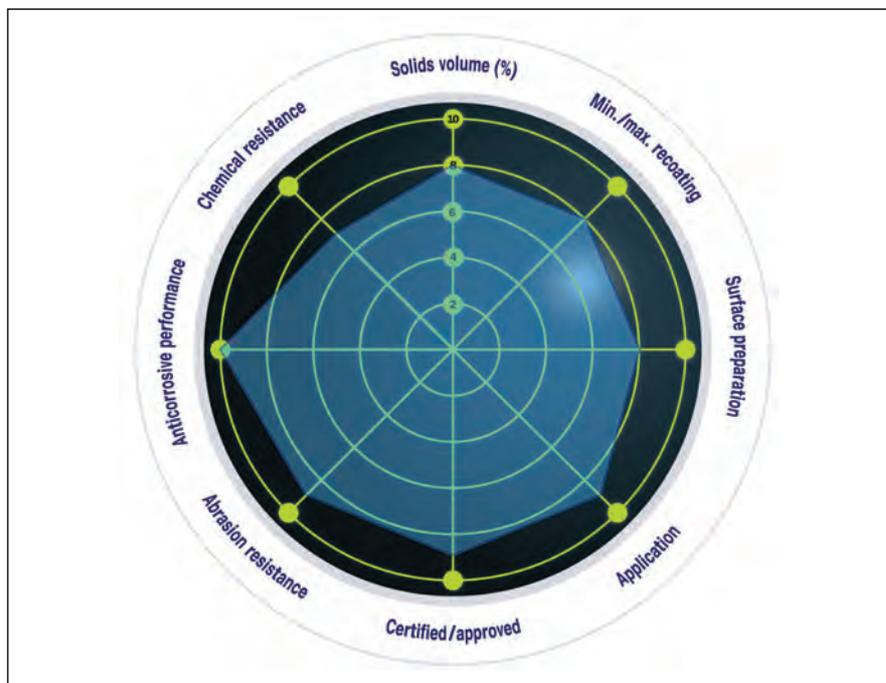
Changes in environmental legislation have been good for the company. Phasing-out of organo-tin compounds (tributyltin - TBT) in antifouling has seen a number of tin-free products launched, employing various technologies. Olympic is a Hempel low-cost self-polishing coating designed to last up to 36 months in normal fouling conditions. It contains fibres to maintain mechanical strength while offering polishing control. One advantage of Olympic is that it can, says the company, be applied to most types of finish without having to use a tie coat. Hempel claims that many TBT-free products from other manufacturers require such an intermediate tie coat in order to avoid absorption of binder and active ingredients into the old antifouling system, but with Olympic it is possible to apply repeated coatings without having to use a tie coat. The Olympic range is compatible with most brands of TBT-based paint as well as Hempel's other TBT-free coating systems.

Globic is a range of high-performance organic TBT-free antifouling designed for various different vessel speeds and types of operation. It too uses microfibre technology, but in this case the fibres are incorporated into a synthetic rosin substitute as a binder, which goes through an ion exchange process when immersed in seawater to provide enhanced polishing control and increased mechanical strength.

The company says that Globic has a particularly high solids level, resulting in a low VOC content. It also means that up to 35% less antifouling paint is required in many applications, while its self-smoothing properties can result in significantly lower fuel consumption. Globic, too, can be used for repeated recoating without the need for a tie coat, and can be applied in relatively high film thicknesses, resulting in low overall cost to a user for a high-performance product.

Oceanic is a similar fibre-reinforced TBT-free antifouling which also offers a high-volume solids level, meaning a 30% reduction in quantity of paint required compared with an equivalent lower-volume product. It is designed for application without a tie coat, and can be specified for 36 months on vertical sides and 60 months on flat bottoms.

All these solutions operate on the principle of destroying organisms which attempt to attach themselves to the vessel. However, Hempasil is a silicone foul-release coating that, due to its non-stick properties, does not permit organisms to gain a hold in the first place. The major problem



A Radargram for Hempel's new Hempadur Uniq 4774 universal primer, showing performance on a scale of 1-10 for eight parameters, presented in 'radar screen' format.

with such products is that its non-stick formulation, by definition, makes it very difficult to apply successfully and firmly to vessel bottoms as it will not adhere to epoxy paints used on steel.

A tie coat is obviously essential with such coatings, but those previously available have had a very narrow recoating window, making them impractical for use on large vessels. Hempel believes it has found a solution to this difficulty in a new product, Nexus, which is scheduled for release this coming summer. The company claims that after application of Nexus, a large vessel can be overcoated with Hempasil in most climatic conditions, including those encountered in areas such as the Middle East.

Two products are available, to suit high speed or high activity. Hempasil/Nexus offers at least a five-year life, and in normal circumstances the company believes that it can be regarded as a 10-year system. The actual system life and duration of antifouling performance varies according to speed and activity profiles, and the basic product carries a price premium, with up to five times extra cost per litre. However, Hempel's calculations show that this will be recouped within three to four years for large, high-activity vessels, and after four years for most other ships, due to the long system life and the savings in fuel consumption offered by the exceptionally smooth coating. The system has been successfully trialled on the research trimaran *Triton*.

Hempel produces a wide range of epoxy paints and to assist shipyards, owners and designers, it has recently issued its *Epoxy Encyclopaedia*, aimed at providing users with guidance and advice on which epoxy type to choose for a

specific application. This is supplemented by another recent introduction, known as the Radargram. This pictorial tool, based on eight performance values, provides a performance snapshot, based on the familiar appearance of a radar screen, for each Hempel product. The eight parameters are grouped according to their importance to the user (on the left of the screen) or the shipyard (to the right) - ease of application may not be of importance to the end user, but it is vital to the yard, for example - in order to provide a comparison in terms of application and protective performance.

Hempel's latest epoxy product is Hempadur Uniq 4474, designed to cover virtually all areas of a ship. Previously, says the company, up to 30 different coatings could be used on one newbuilding. The market has, however, begun to demand standardised, universal coatings, and in order to accommodate this new philosophy, Hempel developed Uniq, which can be applied to all exterior and interior surfaces of a newbuilding. The only exception is freshwater, chemical, and sewage water tanks.

It is designed to provide a universal primer system combining good application properties with high-performance capabilities. The company claims that the applicator is ensured high productivity all-year-round, resulting in lower consumption due to less cleaning and waste, while the end-user benefits from long-term protective performance with minimum subsequent maintenance. Because less stock handling, cleaning and wastage is involved, Hempel says that the use of Uniq could provide significantly cost savings for shipbuilders. ☺



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Ref: BP20

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Ref: BP21

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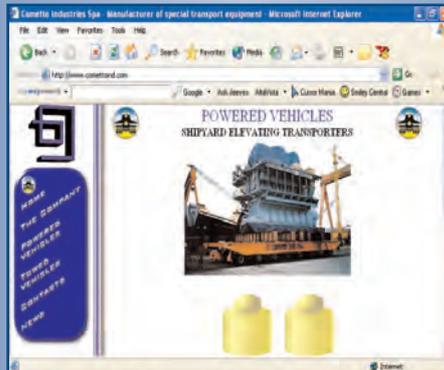
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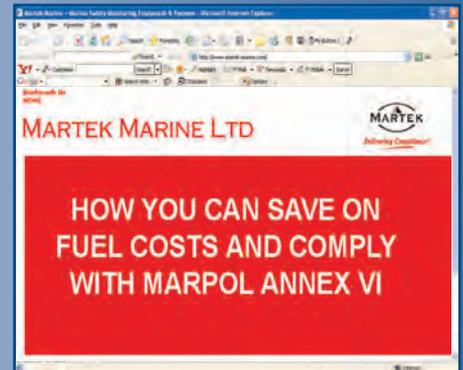
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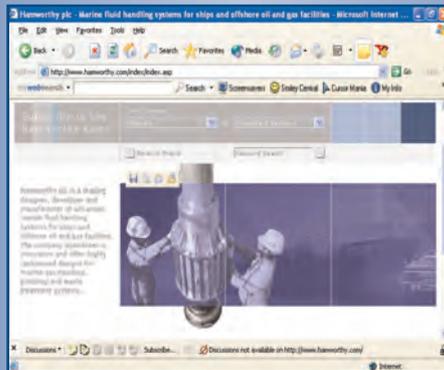
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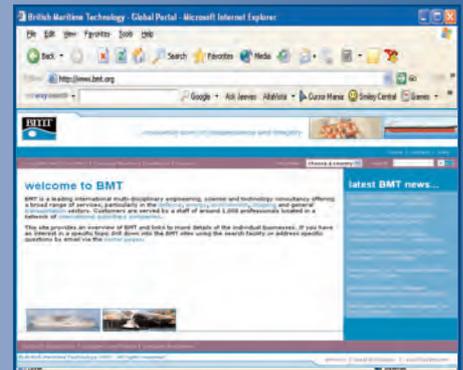
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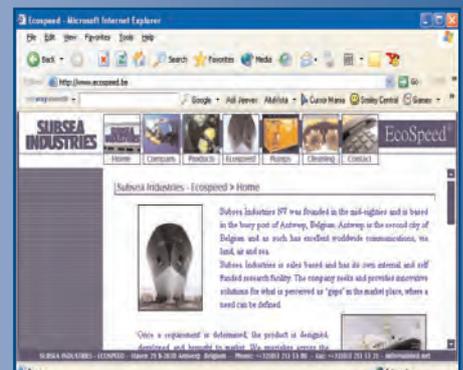
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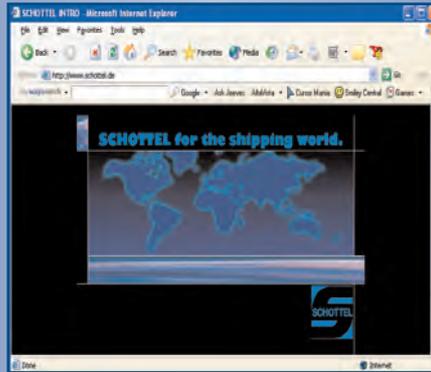
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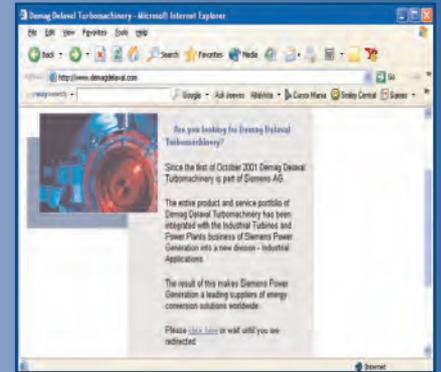
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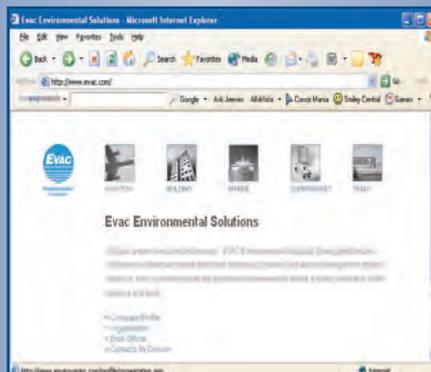
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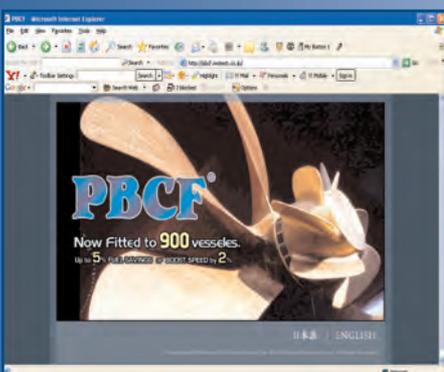
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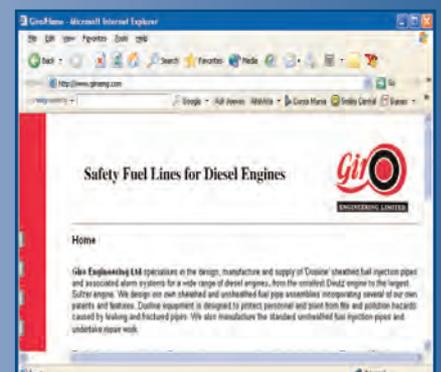
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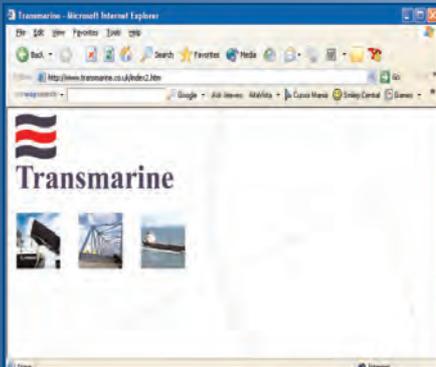
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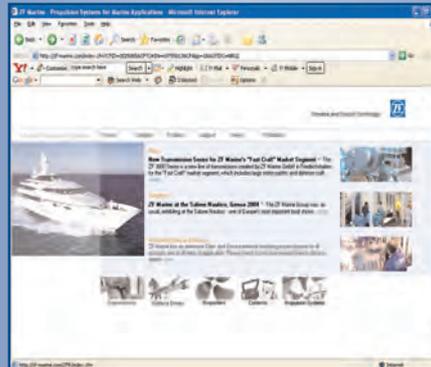
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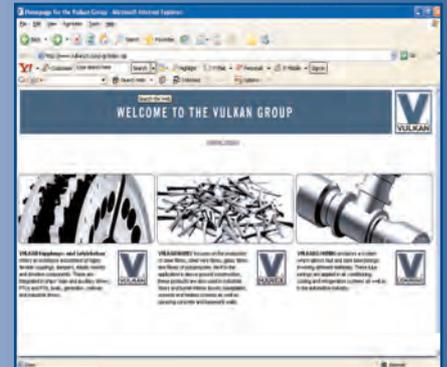
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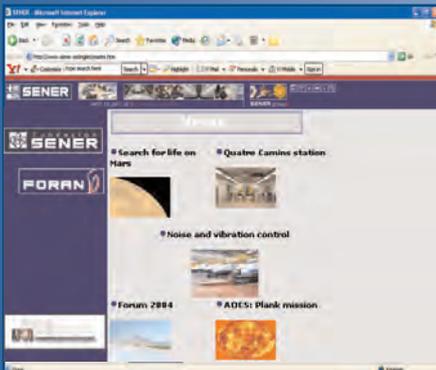
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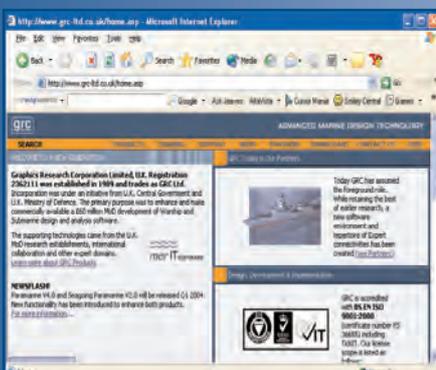
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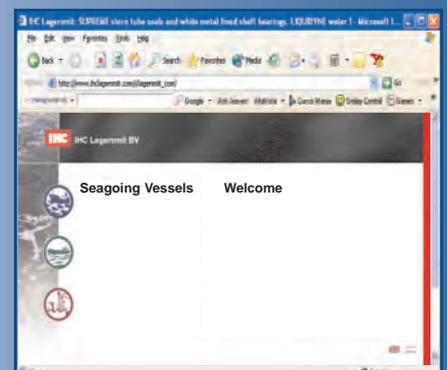
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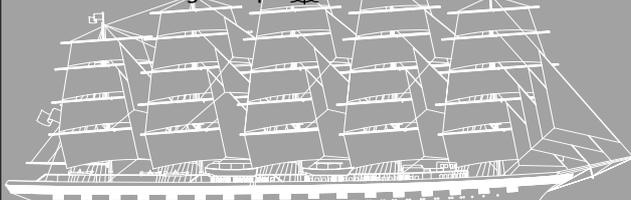
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