DNV·GL

TANKER UPDATE

2018

Eco-friendly shuttle tanker

Alternative fuels

TMSA3 & cybersecurity

Tail shaft alignment

CONTENT

Cover photo: Teekay

Catrine Vestereng
DNV GL Business Director Tankers
catrine.vestereng@dnvgl.com

DEAR READER,

The manoeuvring space for tanker owners is full of challenges these days. Rates are low, competition is tough, and constantly changing regulations must be accommodated. There isn't much DNV GL can do about tanker rates, but we are dedicated to supporting our customers with the two latter items. Read our environmental review about the forthcoming sulphur cap, the increasing areas with NO_x Tier III limits, and not to forget, CO_2 – the next big challenge ahead!

In today's competitive environment, the choice of fuel is clearly an important factor. Read in "The fuel challenge" what your options are and how ships might be propelled in a few decades. Apart from scrubbers, LNG definitely remains an attractive option.

Efficiency enhancements and hybridization are another way to make ships more competitive and eco-friendly: smaller tankers in particular can benefit from battery-assisted auxiliary power plants, as our report about a JIP with several major players shows. Tackling emissions from another side, the Teekay Offshore Group's new shuttle tanker concept recovers volatile organic compounds from the cargo and uses them for propulsion.

A wish for increased cargo capacity and simplification of the building process drove DNV GL experts and partners to develop a new bulkhead structure for smaller tankers. The basic thought, not entirely new, is to make the bulkheads hinged and flexible instead of having a traditional stool with supporting elements.

The cyberrisks associated with digitalization are the subject of our thorough look at the new update of the Tanker Management Self-Assessment (TMSA) programme. DNV GL's advisory services help operators implement these crucial but challenging requirements.

As a classification society, DNV GL listens to its customers and embraces change. Stern tube bearing failures have over the years caused the industry unnecessary off-hire and costly repairs, hence our new class rules address this complex issue.

Finally, it is both the quality of our services and the breadth of topics our solutions cover that customers such as shipowner Sonangol appreciate about DNV GL.

Enjoy reading!

TANKER UPDATE

Published by DNV GL
Maritime Communications

DNV GL – Maritime
20457 Hamburg, Germany

DNV GL – Maritime
1322 Høvik, Norway

Managing Editor:
Jeannette Schäfer

Additional authors:
Andreas Kühner (AK),
Myra Shannon-Fuller (MF),
Jeannette Schäfer (JS),
Kevin Tester (KT)

Design and production:
printprojekt, Hamburg

Layout: Lohrengel Mediendesign, Hamburg

EVEN MORE NEW ORDERS?

Even with relatively healthy demand for tankers, a wave of new tonnage coming out of shipyards puts pressure on rates. We still observe substantial ordering, particularly in the VLCC segment. Is this just another counter-cyclical wave of ordering – or the perfect moment to enter this market?

In the last edition of TANKER UPDATE, we argued that increased ordering of crude oil tankers does not necessarily mean a prolonged period of subdued earnings. In light of continued oil demand growth, global inventories falling to their five-year mean level or US exports rapidly increasing their pace, the expected demand for tankers seemed quite robust anyway.

On the flip side, we still have the OPEC's painful measures and, so far, all members have exemplified themselves with meticulous compliance to their oil production limits. Elsewhere, the problems in Venezuela are only getting worse. The country's oil production, their main source of revenue, fell to just 1.5 million barrels per day (mbd), representing an almost 25 per cent decline year-on-year. At the time of writing this article, we still do not know the result of the elections. However, a change of president seems unlikely, which will most likely deepen the ongoing crisis and certainly increase tensions with the US. Speaking of the latter, we also need to mention the US withdrawal from the Iranian nuclear deal and the repeal of the sanctions relief. It may be argued whether it is good or bad news for tanker demand, but undoubtedly it means less oil in the international markets until somebody else picks up the slack.

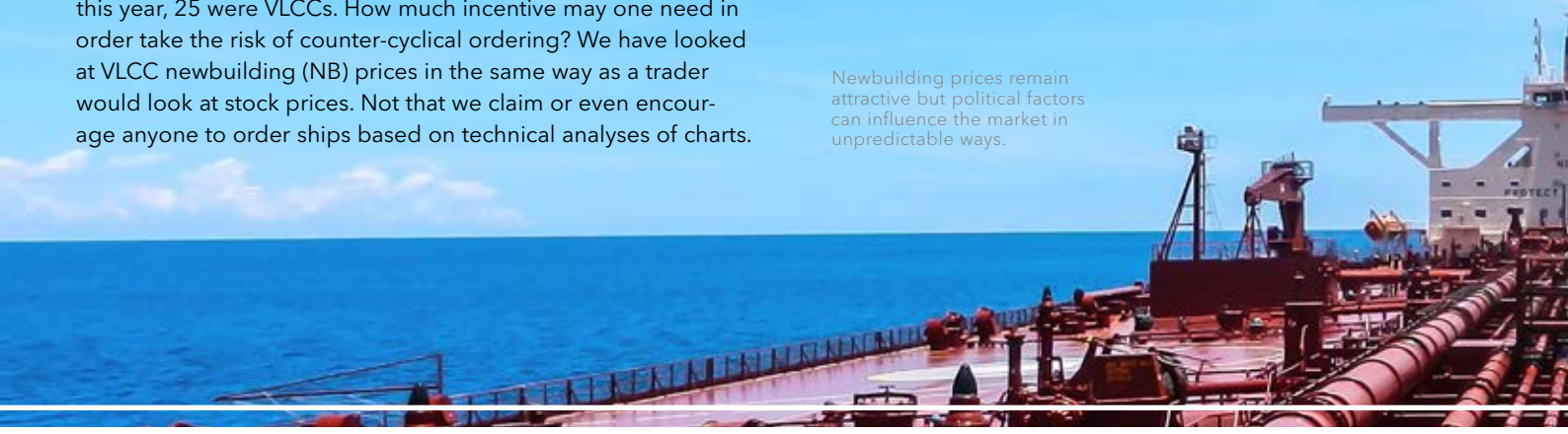
Order book continues to grow

With such mixed signals from the market, one could argue that ordering more ships may not be such a great idea. Yet, we observe quite the opposite behaviour. According to IHS Markit, there were 61 tankers (crude and products over 10k dwt) representing 9.8 million dwt ordered in the first four months of the year. Compared to the same period of 2017, it represents a growth of eleven per cent and 20 per cent respectively. It is worth noting that contracting of tankers in 2017 was already quite high, so increased activity during substantially weaker markets may come as little surprise. However, once again the price of new ships is the main factor behind ordering. Out of 61 tanker contracts this year, 25 were VLCCs. How much incentive may one need in order take the risk of counter-cyclical ordering? We have looked at VLCC newbuilding (NB) prices in the same way as a trader would look at stock prices. Not that we claim or even encourage anyone to order ships based on technical analyses of charts.

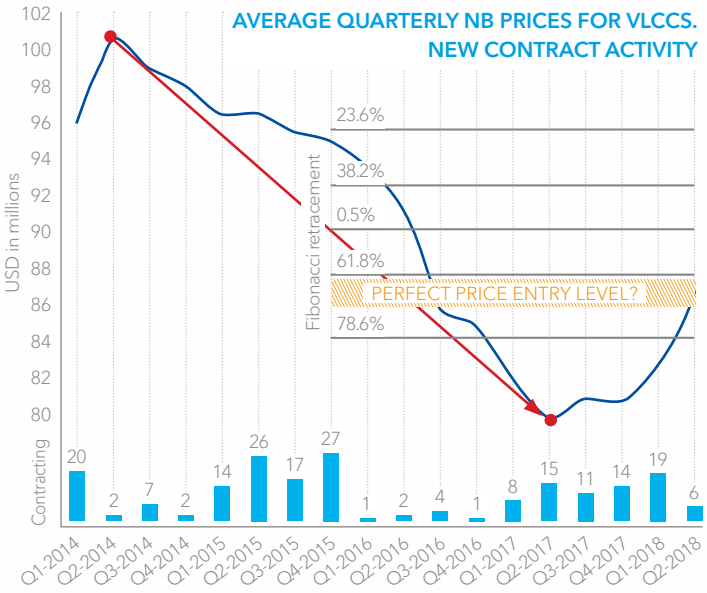
Nevertheless, we looked into the latest downtrend between Q2 2014 when the average NB price was at USD 100.5 million to Q2 2017 when prices reached the bottom at USD 80 million, and the trend reversed upwards. If you plot the Fibonacci retracement (a popular technical analysis technique to predict how far the prices are likely to fall or grow), a typical price entry point for the stock would be somewhere between 60 to 70 per cent below the peak price at the beginning of the trend. In our case, it is somewhere in the range of USD 88 to 85 million. If prices go even lower, the "buy" signal gets even stronger. As we can see not only did they go lower, they also remained there for more than two years. Even though technical analysis should not be used as a real buy/sell indicator for VLCCs, the above picture shows what kind of bargains oil tanker owners can get these days.

The low-prices period pushed the order book of crude and product tankers (over 10k dwt) to 627 ships, which represent ten per cent in number and 13 per cent in dwt of the existing fleet. This ratio is the highest in the VLCC sector, with 16 per cent and 17 per cent respectively. None of these numbers, however, represent an alarming level. The only problem we may see is an elevated number of ships that need to be absorbed by the market in a relatively short period of time. If we look at the larger ships, ever since 2016 we have had a growing number of deliveries, and in 2018 we should expect 56 new VLCCs, 45 Suezmaxes and 72 Aframax tankers. Bearing in mind that neither of the segments currently earn more than just a mere USD 9,000/day in the spot market, such high deliveries sound like more trouble ahead.

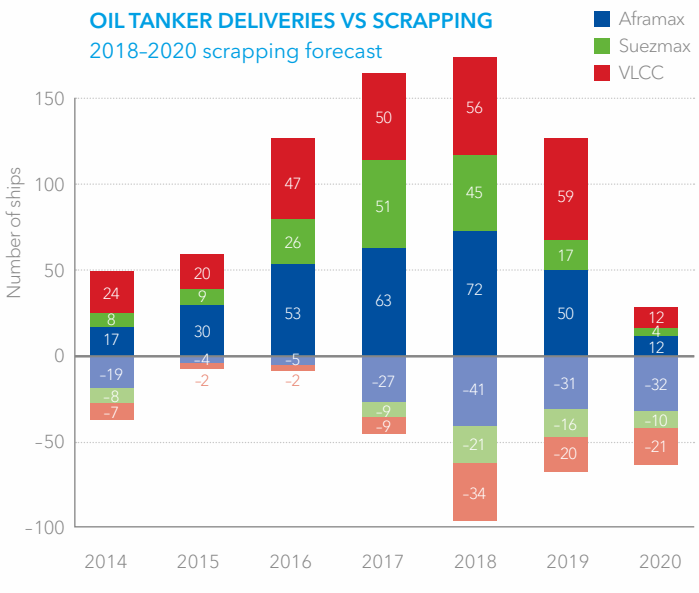
However, this may not necessarily be so. First of all, we will definitely see some slippage. According to Clarksons Research figures, the non-delivery ratio for tankers is currently 19 per cent, which means that some 35 ships will most likely be delayed until 2019. In addition, with scrap prices reaching USD 450/ltd, we are observing accelerated removals, which ultimately will ease the



Newbuilding prices remain attractive but political factors can influence the market in unpredictable ways.



After hitting rock bottom in mid-2017, newbuilding prices are now increasing.



2018 will be the peak year in terms of both deliveries and scrapping.

pressure on earnings. Our forecast indicates 88 VLCCs, 72 Suezmaxes and 146 Aframaxes will qualify for scrapping in the next four years. In 2018 we expect nearly 100 ships from the larger segments to be removed from the market.

Mixed picture

In light of the coming regulations, from ballast water management and sulphur cap to upcoming CO_2 regulations, there are a lot of incentives to renew elderly ships with new, more efficient and fully compliant ships. Even with the recent pullback in newbuilding prices, historically, they are still at competitive levels, particularly if they include the cost of extra equipment, e.g. scrubber and ballast water treatment installations.

Last, but certainly not least, we should also look into second-hand prices and the residual value of assets. A five-year-old VLCC is currently valued at just over USD 60 million. The same age Suezmax trades at USD 43 million, whereas an Aframax costs USD 32 million. All of these prices should be regarded as relatively low and should the earnings bounce back in a few years, there would be at least a 20 per cent upside potential, which will offer a substantial relief in the balance sheets, particularly for the ships ordered recently.

The near future does not paint a rosy picture for oil tankers, particularly on the crude side. The market will have to absorb a lot of new tonnage. The demand side of the equation does not look bad, however, much depends on OPEC and its future oil supply strategy. Higher oil prices don't serve oil transportation well. We can expect a further reduction in Venezuelan cargoes, and most likely we will experience a disruption in cargo flows from Iran, particularly for their European customers. An ongoing debate between the US and the rest of the world concerning import tariffs may also result in negative developments.

On the other hand, we should appreciate a continued, healthy growth of seaborne trade, substantially reduced inventories (which at some point will have to be replenished) and rapidly growing US oil exports, allowing us to be cautiously optimistic for the mid-term future of oil tankers. The ships we are building these days appear to be quite robust in terms of their financial, environmental and efficiency aspects. So, are we pushing our luck? Perhaps quite the opposite – and we are building one of the most future-proof ships ever. **JW**

Photos: DNV GL, ©haris - stock.adobe.com

DNV GL Expert
Jakub Walenkiewicz (JW), Principal Market Analyst
Phone: +47 67 57 81 93
E-Mail: jakub.walenkiewicz@dnvgl.com

ECO-FRIENDLY SHUTTLE TANKERS FOR NORWAY

With its new "E-Shuttle" concept, developed in cooperation with Wärtsilä, Teekay opens up a new chapter in setting ambitious environmental standards for shuttle tankers.

As a major player in the shuttle tanker sector, the Teekay Group with its affiliated company Teekay Offshore has always embraced forward-thinking ideas and concepts. Ever since the Norwegian authorities imposed restrictions on environmentally damaging volatile organic compound (VOC) emissions in 2003, Teekay has explored many options for reducing emissions from its shuttle tankers.

The development of their latest innovative, eco-friendly shuttle tanker concept "E-Shuttle" started in 2016. Amongst other new features, the design concept incorporates several of Wärtsilä's new technologies. Its annual emission reduction potential is estimated at up to 42 per cent, with fuel consumption reduced by up to 22 per cent compared to traditional shuttle tankers.

With its new all-encompassing energy concept, the shuttle tanker design will fully comply with Norway's future emission restrictions.

An initial order for two Suezmax-size, DP2 shuttle tankers based on the new concept was placed at Samsung Heavy Industries (SHI) in July 2017, followed by two more in November 2017. SHI will supply the fully compliant, DNV GL classed vessels in 2019 and 2020, respectively. The 130,000 dwt shuttle tankers are destined for service in the North Sea under Teekay's existing agreement with Statoil and many other customers.

"This is another important milestone for Teekay Offshore's shuttle tanker franchise since it further strengthens our position as the leading provider of shuttle tanker services in the North Sea," commented Ingvild Sæther, President and CEO of Teekay Offshore Group. "Our customers require a reliable, long-term solution for securing offtake services from over 15 oil fields in the North Sea and, therefore, these state-of-the-art newbuilds demonstrate our ongoing commitment to our customers," Sæther continued. "What makes me particularly proud is that these newbuilds will set new standards for both fuel consumption and CO_2 emissions."

The new shuttle tankers will operate on both liquefied natural gas (LNG) as the primary fuel, and a mixture of LNG and recovered volatile organic compounds (VOCs) as secondary fuel. Environmentally harmful VOCs are produced in a gaseous state from evaporation occurring in the oil cargo tanks. That new mixture enables shuttle tankers to travel from the oil fields on their own waste gas rather than releasing it into the atmosphere. This will reduce both emissions and bunkering requirements considerably.

The fuel mixture will cut NO_x emissions from engine exhaust gases by more than 80 per cent to a level below IMO Tier III limits. Since LNG contains almost no sulphur, SO_x emissions will be eliminated almost entirely, and particulate emissions will be reduced by more than 95 per cent.

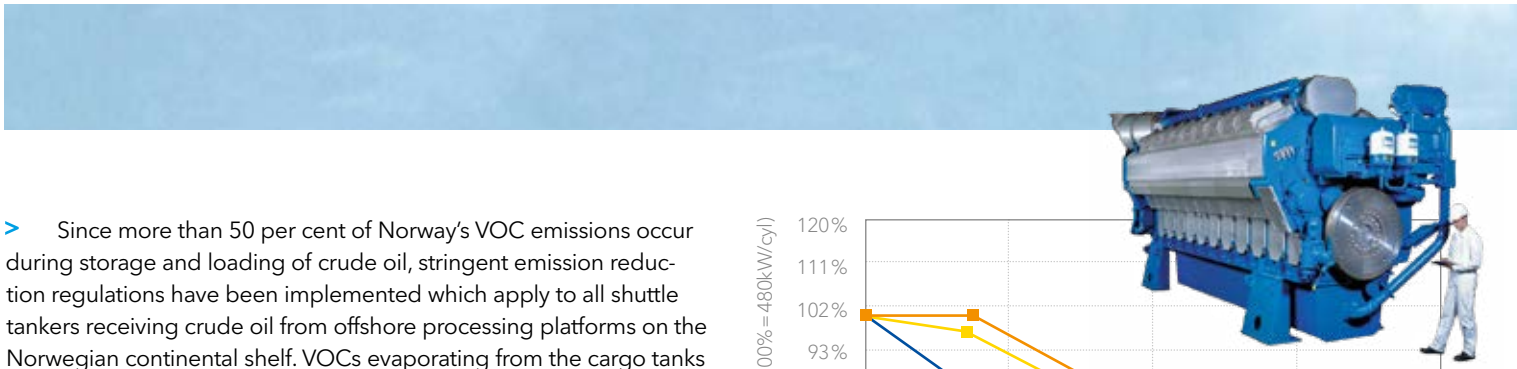
Utilization of waste VOCs

During operation, traditionally designed shuttle tankers produce high levels of emissions, in particular VOCs which are typically released during loading, storage, and transport of crude oil. >

"This is another important milestone for Teekay Offshore's shuttle tanker franchise since it further strengthens our position as the leading provider of shuttle tanker services in the North Sea."

Ingvild Sæther, President and CEO of the Teekay Offshore Group

Photos: Teekay, Wärtsilä

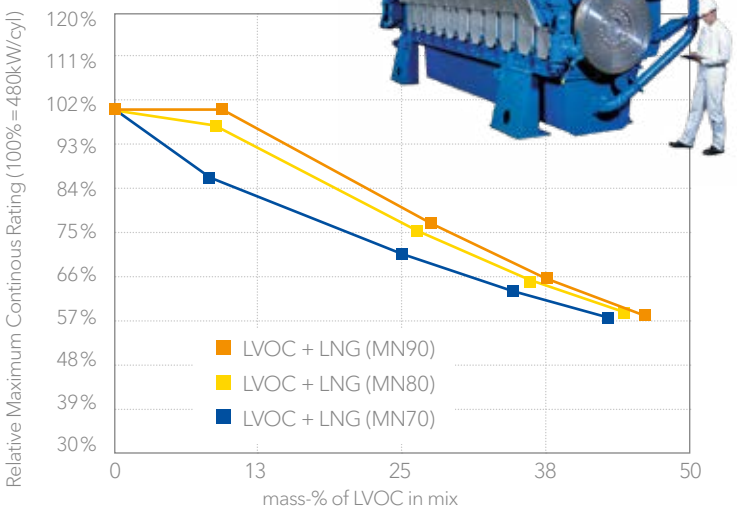


> Since more than 50 per cent of Norway's VOC emissions occur during storage and loading of crude oil, stringent emission reduction regulations have been implemented which apply to all shuttle tankers receiving crude oil from offshore processing platforms on the Norwegian continental shelf. VOCs evaporating from the cargo tanks during loading must be captured by a VOC recovery plant.

"Teekay has long experience operating VOC recovery modules in the North Sea," explains Sæther. "With more stringent requirements to reduce VOC emissions and the use of LNG as a primary fuel, we are now able to burn the liquefied VOCs, previously seen as a byproduct with limited value, as fuel in our vessels. This solution creates value for our customers as well as potential environmental benefits. Our experts have spent significant amounts of time developing this new technology together with Wärtsilä and believe the additional enhancement will provide future value."

The new generation of VOC recovery plants will comply with the more stringent government requirements expected to take effect from 2030. The heavier hydrocarbons are converted into liquid VOCs (LVOC) using several compression and cooling phases, and stored in a tank on deck. The lighter hydrocarbons, referred to as surplus VOCs (SVOC), are not liquefied. The main component of SVOC is methane gas that will be burnt in a gas turbine for electricity generation, delivering twice the efficiency of a traditional boiler and steam generator arrangement.

From a typical 850,000 bbl crude oil load from a North Sea platform, the plant will recover 100 tonnes of LVOC and 10 tonnes of SVOC. By reusing those VOCs as a fuel, the annual emissions can be reduced by 42 per cent. Assuming approximately 32 loads per year, this means cutting the CO_2 discharge from 43,000 down to 25,000 tonnes. An average 100 tonnes of recovered LVOC per load could provide up to 30 per cent of the total fuel consumed by the new shuttle tankers. The new concept allows 100 per cent of the recovered LVOC to be used as fuel for electric power generation. Teekay has therefore replaced the conventional two- and four stroke engine configuration with a fully electric main propulsion system and four stroke dual-fuel (DF) generator sets that also increase flexibility and avoid functionality overlap. To achieve full SECA and NECA compliance, the new shuttle tanker will be equipped with Wärtsilä's fuel gas handling system that includes a bunkering station for gas mode operation.

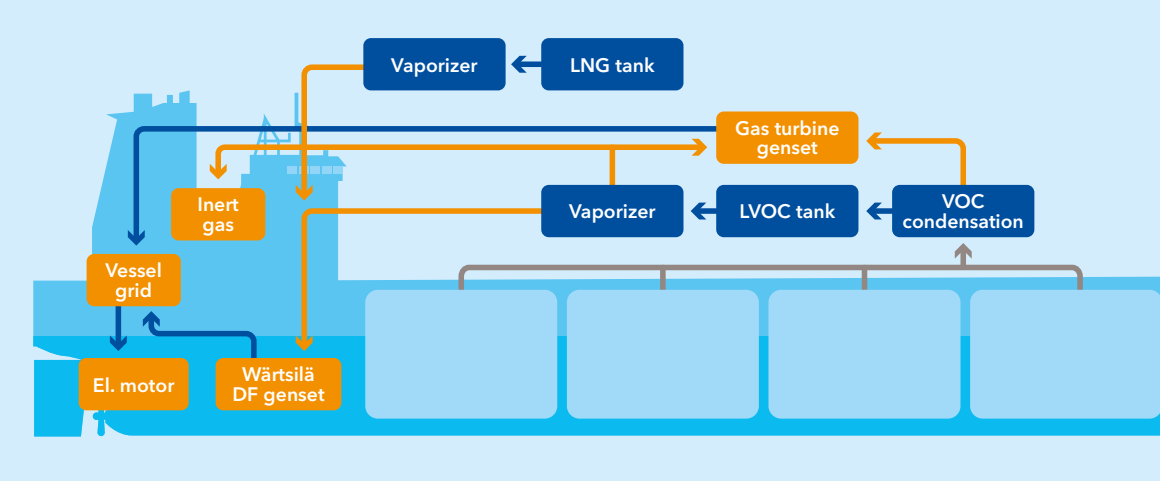


Relative maximum continuous rating in relation to LVOC mass ratio in per cent in LNG mixes.

Operational flexibility

The new power distribution system is part of Wärtsilä's low-loss hybrid (LLH) system, which uses batteries to store excess energy

With an average fuel consumption of 8,750 tonnes per year, the vessels will reclaim 3,200 tonnes of LVOC for use in the fuel mix.



Wärtsilä's low loss hybrid (LLH) system uses batteries to shave peak loads and balance energy consumption.

generated and enables more fuel savings through peak load shaving and added overall system redundancy while minimizing the impact of a failure during DP operation.

The battery storage system will handle dynamic load variations when the gensets are operating at optimum load, eliminating the need to start further gensets to buffer transient load variations. The new shuttle tankers are the first ships of their size to be equipped with a battery storage system for improved efficiency during transit operation.

Highly dependent on their DP capabilities, shuttle tankers can benefit from a hybrid power system in more ways than most other cargo ship types, and while the DP system of a traditional shuttle tanker consumes 60 per cent of thruster power, these new ships will require only 40 per cent. This further improves their fuel efficiency and enhances their manoeuvring capabilities. Built-in system redundancies will ensure resilience when unexpected incidents occur that might otherwise have severe consequences in the harsh environments where these vessels will operate.

The new hybrid system also has a direct positive impact on main machinery operation, resulting in fewer running hours and consequently lower maintenance time and costs. The total installed power on board was reduced from 26 to 23 MW. Apart from the required trial speed of the vessel, the size and functionality of the power plant is determined by the power requirement during DP operations. While a traditional electrical distribution system could lose more than 50 per cent of installed power and several thrusters, the low-loss hybrid system can lose only 25 per cent of the installed power and no more than one thruster. Together with the electric propulsion system, it reduces the required total mechanical installed power by 14 per cent, increasing the overall fuel performance compared to traditional power distribution concepts.

As a total result of the new concept, the total energy consumption will decrease from 110 GWh to 75 GWh per year compared to a traditional shuttle tanker.

"Working together with the world's most experienced yard and suppliers in the shuttle tanker segment is one of the key success factors in this project. SHI has integrated all systems into a very efficient hull. Brunvoll supplies all propulsion systems and reduction gears which need to be integrated effectively into the rest of the vessel systems," Sæther describes the collaboration of the project partners. "As our classification partner, DNV GL supports us in achieving compliance in important aspects such as the LNG/VOC mixing and battery solutions, which are the main environmental drivers of this project." **JS**

DNV GL Experts
Catrine Vestereng
Business Director Tankers
Phone: +47 97067390
E-Mail: catrine.vestereng@dnvgl.com

Eirik Jacobsen
Area Manager Norway South-West
Phone: +47 97712720
E-Mail: eirik.jacobsen@dnvgl.com

Photos: DNV GL, Teekay, Wärtsilä

TOWARDS ZERO EMISSIONS: ENVIRONMENTAL OUTLOOK

While the world is struggling to live up to its commitment to limit climate emissions, new data indicate that climate change may be more severe and occur more rapidly than anticipated earlier. The IMO is looking for ways to make shipping climate-neutral over the next decades. DNV GL gives an overview of the status of the discussion and potential future measures.

When the Paris Agreement was adopted in 2015 in response to the increasing signs of global climate change, shipping and aviation were not included. Instead, the IMO and ICAO were asked to come up with greenhouse gas (GHG) emission reduction schemes of their own. At MEPC 72 the IMO has now adopted a strategy to reduce emissions from shipping. This aims to reduce total emissions from shipping by at least 50 per cent by 2050, and to reduce the average carbon intensity by at least 40 per cent by 2030 while aiming for 70 per cent in 2050, all figures compared to 2008. The ultimate vision of the IMO is to phase out greenhouse gas emissions entirely at the earliest time possible within this century. This initial strategy will be reviewed in 2023 based on information gathered from the IMO Data Collection System (DCS) as well as a fourth IMO GHG study to be undertaken in 2019.

As it must be assumed that the global shipping activity will continue to grow towards 2050, the 50 per cent emission reduction target is quite ambitious and will most likely require widespread uptake of zero-carbon fuels in addition to other energy efficiency measures. However, there are no zero-carbon fuels available today. A concerted research and development effort is needed not only to develop such fuels but also to make them available in the required volumes.

The IMO is looking for strategies to eliminate greenhouse gas emissions from ships by 2100.

To implement its ambitious strategy the IMO must develop new policy measures and regulations. The strategy contains a long list of options, such as

strengthening the EEDI, applying operational indicators, reducing speeds, rolling out market-based measures, or developing zero-carbon fuels. Work on an action plan to kick-start the development of appropriate measures will start this fall.

While limited immediate impact on ships is to be expected, the efforts required to reach the long-term goals will have to build over the coming years, with a real impact starting to materialize in the 2020s. In a long-term perspective, DNV GL expects this strategy to fundamentally change the way ships are designed and operated.

More information on low-carbon shipping and alternative fuels is available at **www.dnvgl.com/low-carbon-shipping** and **www.dnvgl.com/alternative-fuel**

The EU's CO_2 monitoring, reporting and verification (MRV) scheme is in effect as of 2018.

CO_2 data collection in the EU and at the IMO

In the EU, regulations for monitoring, reporting and verification (MRV) of CO_2 emissions have entered into force, requiring all ships above 5,000 GT sailing to or from European ports to report CO_2 emissions, cargo data and average energy efficiency. 2018 is the first year of reporting, with data being published annually by the EU as of mid-2019.

One purpose behind the EU MRV regulations was to encourage the IMO to work on a similar mechanism with global coverage. The EU regulation itself contains a provision for a review aimed at alignment with a future international system, if in place. It is therefore significant that the IMO has adopted a global mechanism for mandatory monitoring, reporting and verification of fuel consumption data for all ships 5,000 GT and above. The scheme, known as the IMO Data Collection System (DCS) on fuel consumption, will have 2019 as its first year of operation.

The IMO DCS differs from the EU MRV in several important aspects, including the confidentiality of data, the calculation of efficiency metrics, and the requirements for data verification. While these are all issues where the EU has a strong preference for the requirements of its own system, the European Commission has nevertheless initiated a formal review process aimed at aligning the EU MRV with the IMO DCS. There are encouraging signs of a legislative proposal to be published in May 2018, though it is expected to be challenging and likely time-consuming for the commission, the parliament and the council to come to an agreement. DNV GL believes that full alignment is unlikely, and that the industry may have to cater to both reporting regimes for the foreseeable future.

More information on EU MRV and IMO DCS is available at **www.dnvgl.com/mrv** and **www.dnvgl.com/dcs**

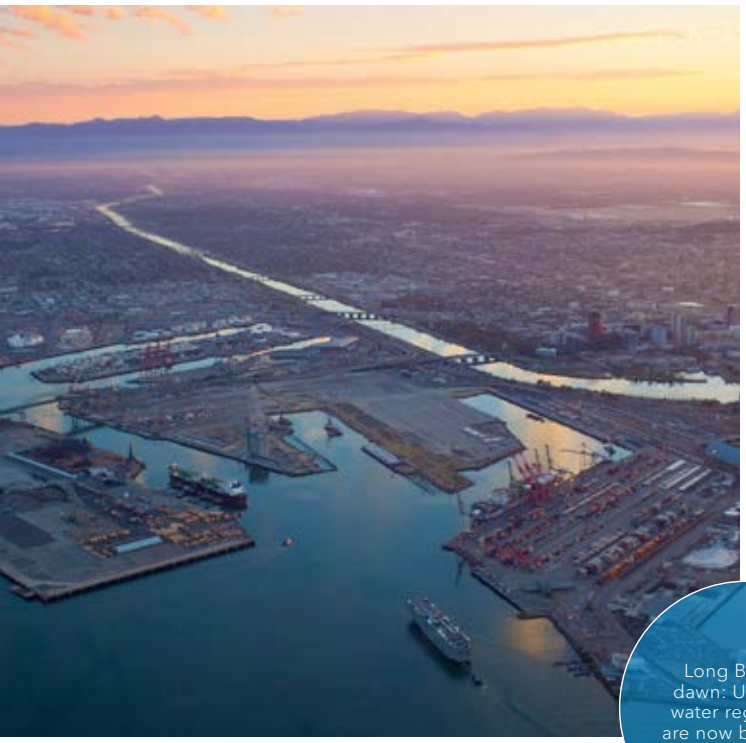
SO_x regulations

IMO has agreed that the 0.5% global sulphur cap will be implemented from 1 January 2020. The decision is final and will not be subject to renegotiation, which gives certainty to the maritime and bunker industries. There were intense discussions on both the practicalities of implementation and on how to ensure robust enforcement and a level playing field. IMO is continuing to discuss implementation and supporting measures on a priority basis and is holding an intersessional meeting dedicated to the topic in July. The meeting is expected to provide robust guidelines for industry and authorities; these will be finalized at MEPC 73 in October and then circulated.

Ship operators will have to choose their preferred compliance strategy, a decision with far-reaching operational and financial implications. There is no one-size-fits-all solution on the table; scrubbers, LNG, and "hybrid" fuels are all realistic options, but most vessels are expected to default to using 0.5% marine gas oil (MGO) and blends, at least initially. Local availability issues and price volatility are expected to result from the dramatic change of the fuel demand situation as of 1 January 2020, and the number of non-compliance cases, especially because of insufficient tank cleaning at bunker facilities and on board ships, is likely to be rather high during a transitional period.

Enforcement remains a critical concern, especially on the high seas. Contrary to emission control areas (ECAs), where enforcement is up to the respective port state, monitoring of operations on the high seas is the responsibility of the flag state. Legitimate questions are being asked about the readiness of all flag states to provide uniform and robust enforcement to ensure a level playing field around the globe. To alleviate the enforcement issue to some extent, the IMO at MEPC 72 agreed to establish a ban on carriage of non-compliant fuels for all ships without scrubbers. This ban is likely to be adopted at MEPC 73 and will then take effect in March 2020. Ships without scrubbers will still be allowed to carry non-compliant fuel as cargo.

Moving to regional and domestic matters, it should be noted that in the EU the Water Framework Directive is imposing restrictions on the discharge of scrubber water. Belgium and >



Long Beach at dawn: US ballast water regulations are now being fully enforced.

> Germany have prohibited the discharge of scrubber water in most areas, thereby limiting the operability of open-loop scrubbers. Similar restrictions apply in some US coastal waters, e.g. off Connecticut.

In Asia China's regulations for domestic SECA-like requirements are being rolled out in the sea areas outside Hong Kong/Guangzhou and Shanghai as well as in the Bohai Sea. China is taking a staged approach, initially requiring a 0.5% maximum sulphur content in fuel burned in key ports in these areas, gradually expanding the coverage to finally apply fully to all fuels used in these sea areas from 2019 onwards. Conceivably the allowable sulphur content will be tightened to 0.1% by 2020, and China may eventually submit a formal ECA application to the IMO. In our view there is a real possibility of these zones being extended to include further Chinese sea areas.

More information is available at **dnvgl.com/maritime/publications/global-sulphur-cap-2020.html**

NO_x regulations

The NO_x tier III requirements have entered into force in the North American ECAs for ships constructed on or after 1 January 2016. Anyone constructing a ship today needs to consider whether operation in the North American ECAs will be part of the operational pattern, whether upon delivery or at any time in the future. If so, NO_x control technology will be required on board. When choosing an NO_x control technology operators should consider how they intend to ensure compliance with the 2020 sulphur cap to avoid system integration issues.

With respect to upcoming regulations, IMO has agreed to apply NO_x Tier III requirements to ships constructed on or after 1 January 2021 when operating in the North Sea and Baltic Sea ECAs. There are presently no indications of plans for additional NO_x Tier III areas.

Ballast water management

The Ballast Water Management (BWM) Convention entered into force on 8 September 2017, more than 27 years after the start of negotiations, and 13 years after its adoption in 2004. The implementation schedules was revised at MEPC 71 in July 2017. Briefly put, every ship in international trade will be obliged to comply at some point between 8 September 2017 and 8 September 2024. For ships from 400 GT upwards, the compliance date is linked to the renewal of the International Oil Pollution Prevention certificate, while ships below 400 GT must comply by 8 September 2024. By that date the entire world fleet must be in compliance.

In the US, the domestic ballast water management regulations entered into force in 2013. New ships must comply upon delivery, while existing ships must comply by the first scheduled dry-docking after 1 January 2014 or 2016, depending on ballast water capacity. USCG type approval is required for ballast water treatment systems; six such approvals have been granted so far, with eleven more in the approval pipeline. The USCG's previously liberal extension policy granting deferred installation dates to more than 12,500 ships due to the unavailability of approved systems has changed since the first type approvals were issued. Presently the USCG is very restrictive on granting extensions and this policy is likely to tighten further. In practical terms, operators should now plan their installation dates based on the compliance dates in the regulation and not gamble on receiving an extension.

For more information on ballast water-related topics please visit **dnvgl.com/bwm**

Emerging issues

There are a number of new environmental regulations under consideration at the IMO as well as in various countries. They cover a broad range of topics, such as plastic pollution from ships, the impact of noise on cetaceans, particle emissions, hull biofouling, and a ban on heavy fuel oil in the Arctic. The discussions are at various stages; New Zealand, for example, has introduced biofouling regulations in May this year. The noise issue is primarily a concern of a few isolated stakeholders, while plastics and an Arctic HFO ban are under consideration at the IMO. Nevertheless, most if not all of these topics are likely to be the subject of further domestic or international regulations sooner or later during the next decade. ■ **EN**

DNV GL Expert
Eirik Nyhus (EN), Director Environment
Phone: +47 926 23 818
E-Mail: eirik.nyhus@dnvgl.com

Photos: DNV GL, Courtesy of the Port of Long Beach

HYBRIDIZATION PAYS

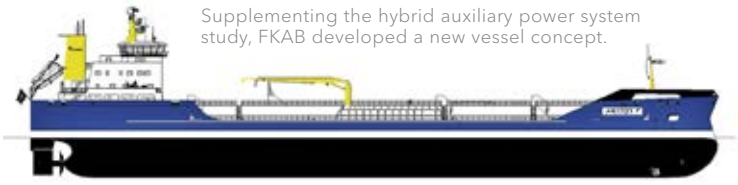
There is no simple way to overcome all the environmental challenges facing the shipping industry. Hybridization is considered a key strategy. DNV GL and Total joined forces with several industry partners to look at a specific scenario: auxiliary engines on small tankers.

Hybrid scenarios, most experts agree, are the best approach to optimizing the energy household on board while ensuring compliance with emission regulations.

To better understand how specific battery configurations can reduce operational costs while improving the emission profile, build a solid business case for such scenarios, and provide decision support for newbuilding projects, DNV GL initiated a joint industry project (JIP) with oil major Total, the ship designer FKAB Marine Design, the battery manufacturer SAFT Batteries, the shipowner Viken Shipping, and the ship operator Wallem Shipmanagement.

Balancing energy needs

The JIP focused on the long-term benefits of lithium-ion battery systems for auxiliary power management on board smaller-sized oil or product tankers in the 17,000 dwt range. Reference data, such as trading patterns, typical modes of operation, and power loads were aggregated from conventional sister vessels. On one of these ships, live power load recording equipment was installed to obtain realistic data. The deployment area considered in the JIP included typical routes in northern and western European waters.



Supplementing the hybrid auxiliary power system study, FKAB developed a new vessel concept.

All this information also served as input for the development of a new ship design concept. Four possible hybrid auxiliary power system configurations were identified, while the main engine and the shaft generator configurations were identical.

The project looked at potential benefits of batteries when used for various purposes: to boost the available supply of power at times of maximum demand or in case of machinery failure ("spinning reserve"); to avoid loading down the generator sets excessively, which causes high fuel consumption ("peak shaving"); to achieve a more even loading of the generators ("load levelling"); to allow the generators to run at the most economical load levels and reduce the number of generator sets required on board; to feed on-demand power to equipment as needed (such as discharge pumps, tank cleaning equipment, thrusters during port navigation); and to provide propulsion power at very low transit speeds (in port) as well as in high-sea emergency operation. Based on the power needs of the reference ships, the required battery size when eliminating one generator set was calculated to be 400 kWh.

Building the business case

These areas of battery use were subjected to comprehensive cost-versus-benefit and return-on-investment (ROI) analyses and environmental evaluations. Safety considerations, operational requirements, dependence on third parties, and specific technical requirements were likewise considered.

For the capital expenditure (CAPEX) calculations, the study assumed a battery life cycle of ten years and a ship lifetime of 20 years. The operating expenditures (OPEX), composed of fuel and maintenance costs, depend on the engine running hours. A battery system should reduce both the installed engine power and the hours of operation to lower the total cost of ownership. The fuel bill for the auxiliary engines was cut by about ten to eleven per cent compared to the base case. The payback period was less than two years, and net savings in the range of 800,000 US dollars. The auxiliary engine running hours were reduced by 50 to 62 per cent.

While the effects on the EEDI remain below the tolerance threshold, CO_2, SO_x and particulate matter (PM) emissions are reduced by about ten per cent, and NO_x emissions by roughly five per cent for all hybrid configurations reviewed for the study.

Besides the economic and environmental benefits, the JDP once more proofed that batteries offer other means of energy saving, making them a favourable solution for small tankers, such as to store surplus and regenerative energy on board for peak demand situations, providing instant back-up power and act as load optimizer. Further the generators sets can run at their most energy-efficient levels, yet provide enough reserve capacity for peak loads and emergencies.

Over a 20-year operating period, all hybrid configurations investigated perform better than the conventional base scenario. It is thus safe to say that hybridization of the auxiliary machinery is beneficial, at least for smaller tankers, and should be considered in all newbuilding projects. The required battery package size should be determined based on the ship's power needs. **OVN**

DNV GL Expert
Ole Vidar Nilsen (OVN)
Business Development Manager
Phone: +47 95838650
E-Mail: ole.vidar.nilsen@dnvgl.com

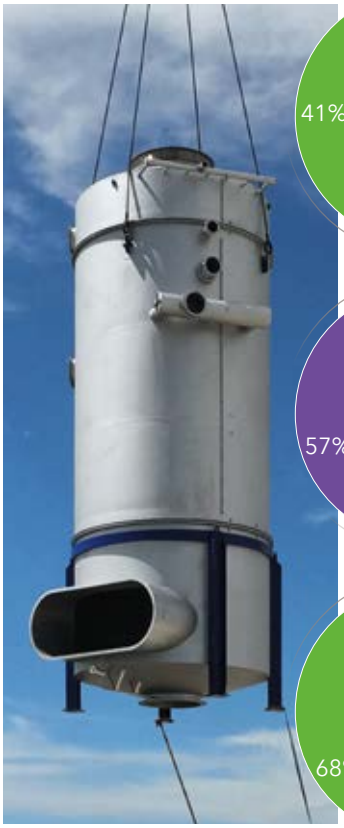
THE FUEL CHALLENGE IN SHIPPING

Choosing the most effective, sustainable and economically feasible strategy to comply with the new emission limits is not an easy task. The decision must be based in part on assumptions that may or may not prove to have merit. TANKER UPDATE summarizes the options and prospects.

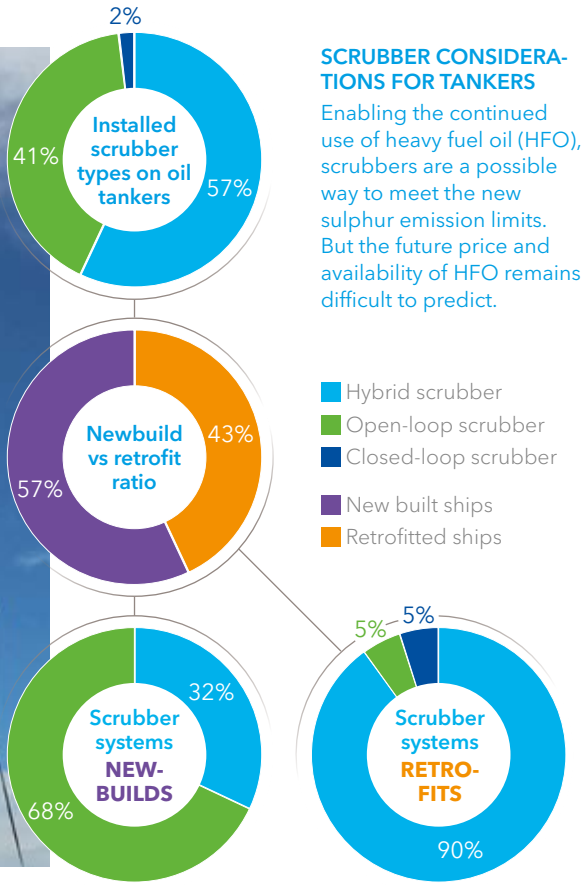
Amid the international environmental and climate-protection efforts, an impressive number of emission restrictions for shipping have come into force recently or will do so within the next few years. They are driving the search for low-emission alternatives to oil-based fuels. In particular, the decision of the International Maritime Organization (IMO) to limit the sulphur content of ship fuel from 1 January 2020 to 0.5 per cent worldwide and the recently adopted ambition to reduce GHG emissions by 50 per cent within 2050 have the potential to become game changers and have shipowners, operators and shipbuilders wondering which way to go.

Currently up to 48 million tonnes of fuel with a sulphur content of 0.1 per cent or less will be then needed annually. Once the IMO sulphur cap is in force, most of the fuel consumed (70 to 88 per cent) will have a low sulphur content of 0.1 to 0.5 per cent and will take the role of the high-sulphur fuel used today. In 2016 an installed base of roughly 4,000 scrubber systems by 2020 was assumed, with no more than eleven per cent of the fuel consumed

Ship-to-ship bunkering: a variety of fuel options are available to ensure compliance with new emission regulations.



Open-loop scrubber systems are currently the preferred type for newbuilds.



SCRUBBER CONSIDERATIONS FOR TANKERS

Enabling the continued use of heavy fuel oil (HFO), scrubbers are a possible way to meet the new sulphur emission limits. But the future price and availability of HFO remains difficult to predict.

globally would be high-sulphur fuel (HFO). Latest estimates assume only 1,000 to 2,000 scrubber installations, which leads to a high-sulphur fuel consumption well below 10 per cent in 2020. This raises the question whether HFO will be available in many ports due to low demand, and if so, at what price. To support the Port State Control and flag states with the enforcement, the IMO at MEPC 72 agreed to establish a ban on carriage of non-compliant fuels for all ships without scrubbers. This ban is likely to be adopted at MEPC 73 and will then take effect in March 2020. Ships without scrubbers will still be allowed to carry non-compliant fuel as cargo.

Open-loop or closed-loop scrubbers?

As per March 2018 most oil tankers fitted with a scrubber chose a hybrid option that provides the flexibility to operate in both open- and closed-loop mode. When at sea the switch can be made to open loop using only seawater. The sulphur oxides in the exhaust react with the water to form sulphuric acid. Chemicals are not required since the natural alkalinity of seawater neutralizes the acid. When required to switch to closed loop, for instance whilst entering a port in a low-alkalinity area, the natural alkalinity of seawater is boosted by an alkali which uses caustic soda (NaOH) as a buffer.

41 per cent of oil tankers using a scrubber preferred the open-loop option. Open loop scrubbers comply with the IMO's 2020 regulations regarding SO_x emissions while being simpler, cheaper and quicker to install and as such requiring less time off-hire. An open-loop scrubber has less equipment for a crew to monitor and maintain. The shipowner also does not have to worry about the purchase of sodium hydroxide (caustic soda) or more crucially, waste disposal in port.

New low-sulphur fuels

New, low-sulphur-compliant blended fuels (0.5% S) will be available in the market in 2020. It is expected that a varying range of products will be available in different parts of the world, depending on local refinery technology and crude oil quality. These fuels may prove to have a different composition than currently available HFO, hence predicting their compatibility with other fuel batches may be a challenge. It is expected that precautions with regards to fuel storage and mixing will be necessary. The ISO 8217 Fuel Standard working group is currently putting effort into selecting testing methods for fuel stability and compatibility. A draft standard should be available in autumn 2019, with the updated standard publication expected in 2022. First samples of blended fuels are expected to become available later this year, and this will allow all stakeholders to gain experience in using them.

These are some of the practical challenges resulting from sulphur reduction. At the same time the accelerating worldwide trend towards restricting NO_x, CO_2 and particle emissions is reason enough to intensify the search for fuels and technologies that can help meet the challenges ahead.

Feasible alternative options

Among the alternative ship fuels being discussed to substitute conventional fuels, DNV GL has identified LNG, LPG, methanol, biofuels and hydrogen as the most promising options.

In 2016 the first dual-fuel engine with a low-flashpoint liquid (LFL) fuel system was installed on an ocean-going tanker, using methanol as a fuel. Methanol reduces sulphur emissions (SO_x) by about 95 per cent and nitrogen oxide emissions (NO_x) by about 30 per cent compared to conventional marine diesel oil. The DNV GL-classed vessels have been assigned the additional notation LFL FUELLED to demonstrate compliance with the DNV GL rules for low-flashpoint liquid fuels (LFL). DNV GL was the first classification society to publish rules covering LFL marine fuels in July 2013, to ensure that the arrangement and installation of these systems have an equivalent integrity level in terms of safety and availability as a conventional system. Methanol today is produced mainly from natural gas but can also be produced by renewable sources, such as biomass, recycled CO_2 and hydrogen, or agricultural and timber waste. Its energy content is roughly half that of standard heavy fuel oil, but as it is liquid, methanol can be >

Photos: DNV GL, Igor Groshev – stock.adobe.com

Bunkering LNG, this crude oil tanker exemplifies an increasingly popular approach to meeting strict emission limits.

> handled using relatively simple bunkering and storage solutions without having to make extensive modifications.

The first LNG-powered Aframax crude oil tankers will be delivered this year. The new Aframax ships will be equipped with low-pressure X-DF dual-fuel engines meeting Tier III requirements in all operational modes. The first four units will be LNG-fuelled or LNG-ready and capable of running either on LNG or on standard marine fuels. The tankers will receive the DNV GL Clean (Design, Tier III) class notation. When not running on LNG fuel, selective catalytic reduction (SCR) technology on board will ensure compliance with the Tier III regulations governing NO_x emissions.

As DNV GL's PERFECt ship concept study has demonstrated, the well-known combined cycle gas and steam turbine technology might be a viable solution for ships in the power range above 30 megawatts once low-sulphur fuels are widely in use. Other new technologies with reasonable potential for application in certain ship types include battery systems, fuel cell systems and wind-assisted propulsion. The biggest hurdles for other alternative ship fuels and propulsion technologies are unrelated to whatever it takes to apply current engine and gas turbine technology. In conjunction with the low-emission fuels named above they are readily available or can be developed without substantial effort. Fuel cell technology in combination with various fuels can achieve efficiencies equal to or better than those of current propulsion systems. However, fuel cell applications for ships are still in their infancy. The most advanced developments are those related to the DNV GL-supported e4ships lighthouse project in Germany, with Meyer Werft and Thyssen Krupp Marine Systems

VLCC BETS ON SCRUBBER TECHNOLOGY

The crude oil carrier *Almi Atlas* is an early reference ship of her size category for IMO Tier III-compatible diesel propulsion machinery, featuring an exhaust gas scrubber system.

The new VLCC, delivered in March 2018, was designed in accordance with the latest regulations and industry requirements. Special emphasis was placed on an environmentally friendly design. To comply with the IMO sulphur cap, the vessel is equipped with a scrubber using an open-loop arrangement and configured with a U-design. Seawater is used to scrub the exhaust gas and reduce the sulphur oxides, providing the wherewithal to satisfy the IMO's 2020 mandatory global sulphur cap while operating on heavy fuel oil. The scrubber plant is 11 m high and 8.3 m wide, and its U-shape forms a natural water trap, preventing water backflow to the engine without requiring any additional equipment.

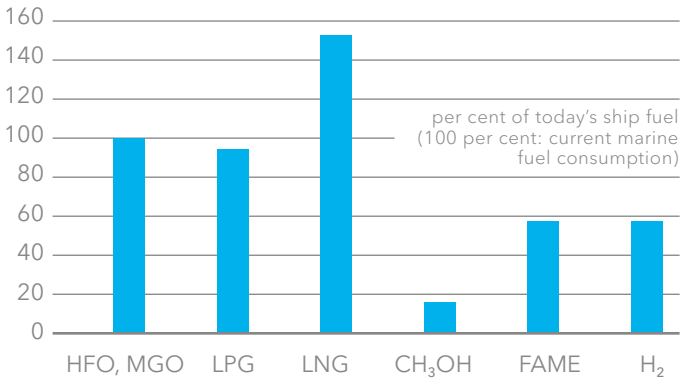
"We are proud that two 315k state-of-the-art VLCC newbuilds came under our management, built by Hyundai Samho Heavy Industries and classified by DNV GL. These VLCC vessels are the first in the water worldwide to have been fitted with SO_x scrubbers and are also NO_x Tier III-compliant. Safety and environmental protection were our top priorities for the design and construction of the vessels while innovative technology was applied to all their systems and equipment," Captain Stylianos Dimouleas, CEO, Almi Tankers, states.

For TIER III compliance, the *Almi Atlas* is equipped with the HYUNDAI-B&W 7G80ME - C9.5 - EGRTC (Tier III) Green-type engine. The vessel is one of the first vessels of her size with a Tier III engine. The G-type is an ultra-long-stroke engine, which, in conjunction with a larger propeller diameter, offers significant fuel savings and produces lower emissions than other engine designs with the same output.

FIGURE 1: ANNUAL PRODUCTION OF ALTERNATIVE FUELS COMPARED TO CURRENT MARINE FUEL CONSUMPTION (2016)

relative energy content

All fuel alternatives can meet possible shipping requirements for the next ten years when a small growth in shipping applications is assumed. If the market share of any ship fuel except LNG increases rapidly, its production capacity will have to be increased accordingly.



The e4ships project focuses on fuel cell technology to improve the on-board energy infrastructure and the ecological footprint of shipping.

leading the initiatives for seagoing vessels. Wind-assisted propulsion likewise has a certain potential to reduce fuel consumption, especially on slow ships, but the business case remains challenging.

Batteries used for energy storage, while not a primary energy source, have major potential for ships running on short distances, or as supplementary energy sources on board any ship if used to increase the efficiency of the propulsion system. In deep-sea shipping, current battery technology cannot substitute liquid or gaseous fuels.

Where to go from here

The primary challenges associated with alternative fuels in shipping result from environmental considerations, availability of sufficient fuel quantities, fuel costs, and the rules of the IGF Code. Environmental and price challenges continue to drive the interest in alternative ship fuels, but the number of realistic candidates remains small. After LNG has overcome the hurdles of international legislation, methanol and biofuels will follow suit very soon; the development of rules for LPG and hydrogen within the scope of the IMO IGF Code will take considerably longer. Yet, the foreseeable volume requirements for shipping could in principle be met by all fuel alternatives mentioned above over the coming years. But a major rise in demand would without doubt require massive investments in production capacity, except LNG, which can also be available in higher quantities than the currently forecasted demand (comp. Fig. 1 for production capacities. Note that LNG includes increase in production until 2020).

Without government action in the form of tax breaks or subsidies, renewable fuels will find it difficult to compete with the prices of conventional fossil fuels. LNG and LPG are the only fossil fuels capable of achieving a reasonable CO_2 reduction in the next five to ten years. "CO_2-neutral" shipping seems possible only with fuels produced from renewable sources. If the shipping sector resorts to synthetic fuels produced from hydrogen and CO_2 using renewable energy, the available alternatives will be liquefied methane (which is very similar to LNG) and diesel-like fuels. **GW/CC**

Download the complete guidance paper on alternative fuels at: **dnvgl.com/alternative-fuel**

Almi Atlas was designed as an eco-friendly VLCC using leading-edge technology for all systems and equipment.

ALMI ATLAS PARTICULARS

- Length overall: 336.1 m
- Length b.p.: 330.0 m
- Breadth: 60.0 m
- Depth: 30.3 m
- Draught: 22.6 m
- Deadweight: 315,221 t(m)
- Gross tonnage: 162,306 t
- Cargo capacity (98%): 350,622 m^3
- Cargo pump capacity, total: 15,000 m^3/h
- Ballast capacity: 93,901 m^3
- Main engine power(MCR): 26,000 kW
- Class: DNV GL
- Class notations: ✠1A1 Tanker for oil, BIS, BWM(T, E<S>), CLEAN, COAT-PSPC(B,C), CSA(FLS1), CSR, E0, ESP, NAUT(OC), Recyclable, SPM, TMON(oil lubricated), VCS(2, B)
- Flag: Liberia

Photos: Almi Tankers, DNV GL, e4ships, Kalyakan – stock.adobe.com

DNV GL Experts
Dr.-Ing. Gerd Würsig (GW)
Business Director Alternative Fuels
Phone: +49 40 36149-6757
E-Mail: gerd.wuersig@dnvgl.com

Dr Christos Chryssakis (CC)
Business Development Manager
Phone: +47 915 54 678
E-Mail: christos.chryssakis@dnvgl.com

CYBERSECURITY GIVEN PRIORITY IN TMSA3

Demonstrating that cyberrisks have been assessed and that mitigating procedures have been put in place is integral to TMSA3.

Tanker management self-assessment (TMSA) may be voluntary in principle but for tanker operators seeking regular charters from oil majors meeting its requirements is a fundamental commercial imperative.

Whereas traditional class requirements give a snapshot of a vessel's quality at a given moment in time, TMSA was devised to gauge quality of a company's operations over time. The second edition of the programme, which was introduced in 2008, comprised twelve elements covering a range of safety and performance metrics. In April last year, OCIMF, the industry body that devised and maintains the assessment programme, released a highly anticipated update, that took effect from 1 January 2018.

The update from TMSA2 to TMSA3 was a radical overhaul. The biggest change was the introduction of a completely new element on maritime security that zeroed in on cyberrisk management. "While there was a growing awareness of cyberrisk in the shipping industry, until that point it was nearly always framed in the future tense. It was raised as a hypothetical issue, one that would have to be addressed in the years to come," observes Jason Stefanatos, Senior Research Engineer in DNV GL's Maritime R&D and Advisory team. "Offering operators less than a year to prepare or risk losing business, TMSA3 brought it solidly into the present."

Assessing all major risks for IT and OT systems is a major challenge for tanker operators on their way to meeting TMSA3 requirements.

Holistic approach

Effective cybersecurity is built on three pillars: people, processes and technology. "There's still a common misconception that it's a matter for the company IT department and that as long as I remember my password, it doesn't affect me. But that's no longer today's reality," Stefanatos stresses.

IT departments do play an important role in implementing technical mitigations such as firewalls and intrusion detection systems and so forth, and it is true these defences successfully prevent many attempted attacks. However, processes are also essential. "End-users – both crews at sea and staff ashore – need to know how to react to the attack or system failure that wasn't prevented or anticipated by technical safeguards," he warns. More importantly, he adds: "You need people to be aware of the risks and to take them seriously."

TMSA3's new maritime security section – Element 13 – is intended to instil these behaviours and encourage operators to adopt such a holistic approach. To attain the lowest score (Level 1), procedures for identifying threats applicable to the vessel and shore sites must be demonstrated. Reaching Level 2 requires guidance and mitigation measures in all procedures, as well as the promotion of cybersecurity good-practice among vessel personnel.

Satisfying Level 3 calls for security procedures to be regularly updated. The highest grade, Level 4, demands that novel or innovative methods for minimizing cyberrisk are evidenced.

Leadership and change

Although cyberrisk management is addressed in greatest depth in Element 13, it exerts a gravitational pull on other elements covered by TMSA. Providing an effective response to cyberrisk, for instance, will require good leadership (Element 1). Meanwhile, management of change (MoC, Element 7) will have to incorporate software and system configuration management. The latter aspect is particularly important.

Satisfying Level 1 of MoC requires that documented procedures are in place for implementing change and for assessing its impact, as well as specifying the framework for granting approval. Level 2 demands that all documentation and records affected by the change are identified and amended or annotated.

Reaching Level 3 calls for a comprehensive software management procedure covering both shipboard and shore systems. Crucially this goes beyond items typically associated with standard business IT infrastructure and should include operational technology (OT), such as the PLCs (Programmable Logic Controllers) and related interfaces for controlling onboard machinery.

Threat evolution

The threat landscape is evolving faster than ever, says Stefanatos. Hackers have grown up and become professional. They are more organized and have more resources at their disposal. Consequently, techniques and tactics have grown in sophistication.

In the 2000s, office IT systems were the predominant target. In other words, the PC on your desk. But these days, attacks directed at OT – the embedded systems and PLCs – are growing increasingly frequent. "It's a worrying trend. Whereas before it was mostly a company's finances and reputation at risk, now that has escalated to safety of life, property and the environment. The stakes are much higher," Stefanatos observes.

> "Because the procedures and documentation are new, they must be created from scratch. Tanker owners are familiar with how TMSA works, but few quite anticipated the scale of the task facing them."
>
> **Jason Stefanatos,** Senior Research Engineer Maritime R&D and Advisory at DNV GL

One of the first obstacles facing any operator implementing the new TMSA requirements is to decipher and establish a common interpretation of what they mean, a task which, according to Stefanatos, isn't as straightforward as it sounds: "Some are open to interpretation depending on what perspective you're approaching them from. Senior managers, for example, may arrive at different conclusions to those working in the IT department or working as an ETO on a ship. It is essential everyone agrees before getting started."

Demanding work

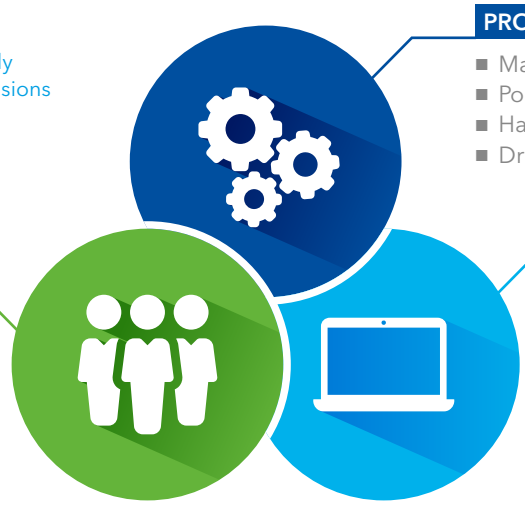
Another challenge is the sheer amount of work involved in performing the necessary risk assessments for all IT and OT systems. "Because the procedures and documentation are new, they must be created from scratch. Tanker owners are familiar with how TMSA works, but few quite anticipated the scale of the task facing them," explains Stefanatos recalling conversations with clients.

Operators can purchase pro forma procedures off the shelf, but he emphatically cautions against taking such shortcuts: "A cookie-cutter approach defeats the object. Unless you properly investigate and drill down into >

Photo: Devrimb-Thinkstock

COUNTERING CYBERRISKS

The ship management industry already addresses risks throughout the dimensions of people, process and technology. Cybersecurity risks are also managed through these:



PROCESSES
- Management systems
- Policies, procedures
- Handling of vendor/third parties
- Drills & audit regimes

PEOPLE
- Cyberhygiene
- Training & awareness
- Professional skills & qualifications
- Written procedures
- Authorization control
- Physical security

TECHNOLOGY
- Antivirus
- Firewalls
- Intrusion detection systems
- SW updates, patches
- Test
  - Functional testing
  - Vulnerability scanning
  - Penetration test

> the potential security gaps particular to your company, you won't be able to find the vulnerabilities specific to your operations. In turn, you won't be able to devise effective remedial actions or countermeasures."

While the workload might be daunting, ultimately managing cyberrisk is no different to managing any other risk. The equipment and terminology may be unfamiliar but the approach is fundamentally the same as, say, managing any hot work that modifies a vessel's structure. Software changes, for example, should not be done ad hoc. They should be planned, approved, and recorded. They should be categorized as minor or major to ensure personnel with appropriate authority can approve. This is very similar to the process for gaining approval prior to carrying out welding.

Close collaboration

In 2016, DNV GL compiled and published a set of recommended practice (RP), which details the principles and processes that underpin effective cyberrisk management. It provides an authoritative resource for operators of tankers – or any ship type – intending to build a cyberrisk management system under their own steam.

However, feedback from and conversations with tanker operators using the RP highlighted a clear need for a more collaborative approach. "Operators understood the guidance as it was written down on paper but translating that into action was proving harder than expected," notes Stefanatos. This realization prompted DNV GL to start providing dedicated advisory services to assist operators meet TMSA3 requirements.

DNV GL experts work alongside the operator to familiarize themselves with the existing management system and then carry out a gap analysis. This reveals what safeguards are already in place, what requires attention and what's missing. These outcomes facilitate a highly methodical approach to developing procedures that are effective at reducing risk and that mesh neatly with the specific nuances of an operator's structure and working practices.

The final stage is for the procedures to be tested to ensure that all the identified gaps have been addressed and that they would stand up under the scrutiny of a TMSA vetting inspection. Depending on the level of customer

> "DNV GL's training resources proved effective in communicating the criticality of cybersecurity to staff at all levels and across company operations, on shore and at sea."
>
> **Frantzeskos Kontos,** Technical Manager at Prime Marine Management

engagement, the whole process can take between six and eight weeks to complete.

Positive feedback

With only a short window of opportunity between TMSA3 being announced and it taking effect, DNV GL has experienced strong uptake for its advisory services from across the tanker segment, including a number of reputed Greek operators.

Frantzeskos Kontos, Technical Manager at Prime Marine Management, says cybersecurity is no longer a paperwork exercise. "In recent times, we've identified many minor threats – and a handful of more serious ones – on our vessels, so it was urgent we took action to prevent further escalation. The inclusion of cybersecurity in TMSA gave us an additional commercial impetus."

Collaborating with DNV GL enabled the Greek operator to detect gaps existing in its management system and address them swiftly and systematically. Procedures were enhanced and new control measures were introduced as a direct result of DNV GL's proposals and recommendations. "There were some challenging discussions along the way, but, on reflection, they produced tangible results," reports Kontos.

Initially educating and bringing employees on board was challenging, Kontos admits. "DNV GL's training resources proved effective in communicating the criticality of cybersecurity to staff at all levels and across company operations, on shore and at sea."

Minerva Marine also turned to DNV GL to help it develop a cyberresilience strategy that both complies with TMSA3 and aligns with forthcoming IMO requirements. Part of the project was to carry out a vulnerability assessment on board a Minerva vessel. Company IT manager Eftihia Benaki says: "In addition to the potential financial and reputational damage, cyberrisk now carries significant safety and environmental implications. The assessment was invaluable in revealing the technical gaps we faced and identifying the areas we needed to focus on." She adds: "DNV GL provided a depth of resource and level of specialism that we didn't have internally."

The Massachusetts Institute of Technology (MIT) calls cybersecurity a negative target: it is impossible to ever be 100 per cent secure. This is for two reasons. Firstly, it's highly dynamic with new threats and risks emerging on a daily basis and, secondly, there is a large attack surface for hackers to exploit. This latter aspect is especially true in a complex supply chain environment, such as shipping, characterized by interactions with and between numerous and diverse stakeholders. However, as we have seen, it is possible to take steps and minimize exposure to these risks and plan a response for when the unexpected happens. This is what TMSA3 essentially seeks to achieve by incentivizing preparedness.

While TMSA3 has made cyberrisk management a priority for tanker operators, it is only a matter of time before similar requirements arrive in other market segments. The advisory services developed by DNV GL for TMSA3 sit alongside with associated cybersecurity offerings including gap analysis for various global standards; a growing range of practical services including penetration testing and incident response drills; and training courses for raising awareness and tackling phishing and social engineering. These can be deployed in various configurations to manage risk on bulk carriers – should RightShip evolve in this direction – and across the global fleet when IMO requirements to incorporate cyberrisk within ISM take effect in 2020.

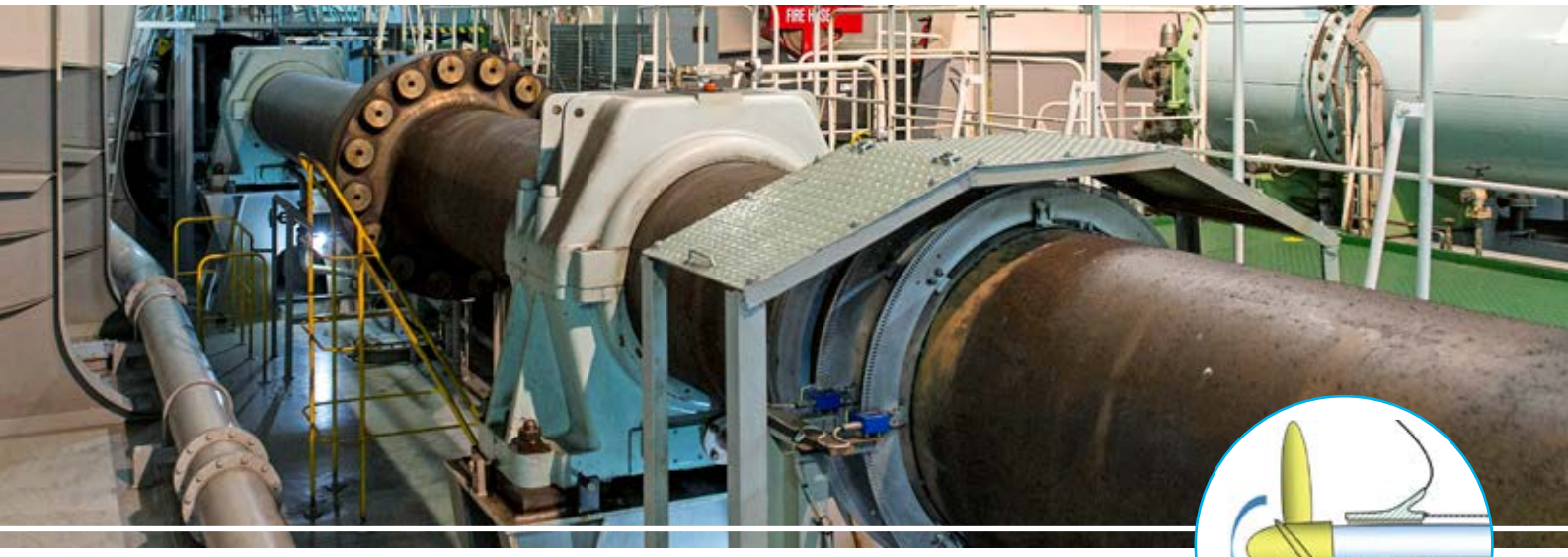
Reflecting on the maritime industry's response to cyberrisk has evolved, Stefanatos observes: "Misha Glenny, a British computer journalist specializing in cybersecurity, famously quipped that there are two types of companies in the world: those that know they've been hacked and those that don't. Maybe the day has come to add a third type: those that have prepared and are confident they can respond." **KT**

To learn about the cybersecurity aspects of TMSA3 in greater detail, watch a webinar at: www.dnvgl.com/tmsa3webinar

To find out more about DNV GL's full range of maritime cybersecurity services and solutions visit: www.dnvgl.com/cs

DNV GL Expert
Jason Stefanatos, Senior Research Engineer
Maritime R&D and Advisory
Phone: +30 2104100200
E-Mail: jason.stefanatos@dnvgl.com

DNV GL TACKLES SHAFT BEARING CHALLENGES



Downward bending moment induced during a starboard turn on a single-screw right-handed propeller.

DNV GL has revised the main class rules for single stern tube bearing installations and now offers new optional shaft alignment class notations.

In the wake of a reported upsurge in stern tube bearing failures, DNV GL has revised main class rules for single shaft bearing installations and introduced two optional shaft alignment class notations: Shaft align(1) and Shaft align(2). The revised rules for single-bearing installations, included in Part 4, Chapter 2, Section 4 of the DNV GL Rules, mitigate the impact of potential influencing factors behind the failures, while a recently announced joint research project into environmentally acceptable lubricants (EALs) will investigate the performance of biodegradable lubricants compared to traditionally used mineral oils.

Both notations can be assigned to newbuilds as well as vessels in operation (in conjunction with a propeller shaft withdrawal). Design and in-service follow-up rules for the notations are included in DNV GL's January 2018 rules for ships, Part 6, Chapter 2, Section 10, and Part 7, Chapter 1, Section 6 (38) respectively.

DNV GL observes keen interest from the industry in the new class notations and is currently engaged in many live projects.

Reliability challenge

Oddvar Deinboll, head of the machinery approval section, DNV GL, explains: "The industry has faced challenges with some of the more recent single stern tube bearing installations with respect to the reliability of the propeller shaft bearings. Extreme turns in the upper speed range have been observed as one of the predominant scenarios in which many of the failures have been reported."

Most of the reported damages have been observed on the aft-most part of the aft bearing and were accompanied by high bearing temperatures with an abrupt rate of rise. Expensive and time-consuming repairs were the consequences.

"We hope that ships complying with the revised main class rules for single bearing installations and Shaft Align(1) or (2) will have substantially reduced risk for stern tube bearing failure. Hence DNV GL will meet the industry needs for more reliable stern tube bearing installations," Deinboll adds.

Monaco-based Scorpio Shipping, a frontrunner with DNV GL in many evolving trends in classification, is the first operator to opt for the Shaft align(1) notation. Dean Mihalic, Technical Director at Scorpio, notes: "We are looking forward to deriving early benefits from this DNV GL class notation by being the first to bring it to the market. Our immediate plan is to use it on an 82,000 dwt bulk carrier being built under DNV GL class."

DNV GL is currently the only classification society requiring verification of the hydrodynamic lubrication of the aft bearing in continuous operation. Larger propellers with lower rpm in combination with hydrodynamic propeller loads make it challenging to maintain an effective shaft-to-bearing contact area and keep the aft bearing well lubricated, DNV GL's internal research has shown. This realization has benefitted many applications and helped resolve issues in ships both in and out of class.

Extra focus

The new rules put additional focus on the impact of transient hydrodynamic propeller forces and moments on the aft-most propeller shaft bearing during turns, specifically at hard-over steering angles at maximum continuous rated (MCR) speed.

The Shaft Align class notations and revised requirements for single stern tube bearing installations call for a multi-sloped aft bearing design. This is supplemented by an additional evaluation of the aft bearing lubrication under an increased propeller-induced hydrodynamic downward bending moment on the aft bearing (corresponding to 30 per cent of MCR torque).

The requirements are formulated to improve bearing performance during turning conditions. The additional design and installation criteria will also increase operating margins and enhance bearing performance and lifetime under normal continuous running conditions.

Shaft align(1) is a cost-effective option for vessels with conventional hull forms, improving aft bearing performance in normal operation and in turns. Shaft align(2) is intended for propulsion systems requiring additional calculations to predict hydrodynamic propeller loads during extreme turning conditions, typically on vessels with unconventional hull forms such as asymmetric sterns or twin-skeg configurations.

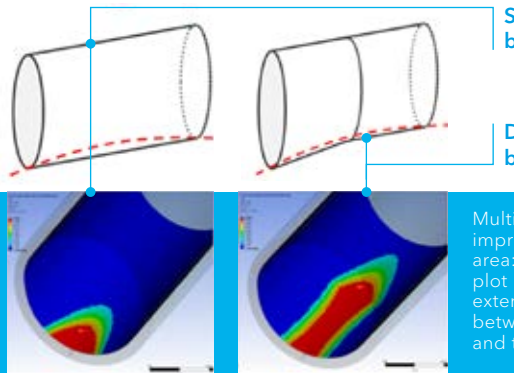
The main benefits of the notations include prescriptive design criteria beyond generic class requirements; increased operating margins for continuous and transient (turning) operation; potentially more accurate installation by enhanced sighting methods (laser-aided or equivalent); and the owner's benefit of having an additional notation in the vessel's certificate.

Bearing interaction

This shaft alignment philosophy aims to achieve an acceptable load distribution on shaft bearings while accounting for the hydrodynamic loads induced by the running propeller. The propeller weight as well as hydrodynamic forces and bending moments influence the angular misalignment of the shaft inside the aft bearing (relative slope) and, subsequently, the shaft-to-bearing contact area. The hydrodynamic lubrication – the formation of an adequate oil film – is mainly influenced by rpm, the shaft diameter, the oil viscosity, the net effective shaft-to-aft bearing contact area, and the bearing load and clearance.

The aft bearing design geometry must ensure a satisfactory shaft-to-bearing contact area in relevant operating conditions.

Photos: DNV GL



Multi-sloped bearing improves the contact area: the coloured plot reflects the extent of the gap between the shaft and the bearing.

This will also mitigate extreme localized loads (edge loading), the surface pressure on the aft bearing and associated thermal loads.

The most predominant hydrodynamic propeller loads are typically caused by continuous ahead operation under hydrodynamic lubrication conditions (typically a lifting bending moment induced by the propeller) or extreme transient manoeuvre (typically, hard over turning at MCR speeds with exaggerated hydrodynamic propeller loads acting downwards on a reduced area of the aft bearing).

Transient extreme turning conditions at the maximum speed can lead to mixed or boundary lubrication condition, which is not calculated under the main class criteria but is deemed satisfactory based on experience, provided that the installation complies with the applicable rule criteria for continuous running and incorporates the relevant range of bending moments.

A hot static starting condition, i.e. starting the prime mover to the minimum continuous propeller shaft speed, is also of interest with respect to hydrodynamic lubrication under the relevant rule criteria.

"A multi-sloped bearing design helps better optimize the shaft-to-bearing contact area in all operating conditions with regard to hydrodynamically induced propeller loads," observes Arun Sethumadhavan, Senior Principal Engineer, fleet in service for hull, materials and machinery, DNV GL. In the case of a single-sloped bearing, improving the contact area for one operating condition may reduce the contact area in another operating condition.

CFD calculations and finite element analysis – Shaft align(2)

On some installations, such as vessels with asymmetric sterns and twin skegs, propeller water inflow conditions during a turning manoeuvre may be altered beyond what is normally seen on more conventional designs. For such vessels there is a risk of excessive propeller loads and an empirical approach to stern tube bearing performance assessment may be insufficient. Rather, an additional evaluation of hydrodynamically induced bending moments and forces from the propeller on the aft stern tube bearing is mandatory for the Shaft align(2) class notation. Similar requirements may also apply upon evaluation under main class criteria.

Based on DNV GL's experience, this evaluation is essential to ensure satisfactory shaft-and-bearing interaction during extreme turning conditions at maximum speed. Computational fluid dynamic (CFD) propeller load calculations combined with finite element analysis (FEA) of aft bearing contact pressure/area are best suited to support aft bearing evaluation and design.

CFD predicts the bending moments and forces induced by the propeller during continuous straight-forward operation and under hard-over MCR turning conditions as input to the aft bearing contact area and contact pressure estimation. A class guideline, CG-0283, will be published in 2018 to provide easy reference on the expected process and results in this regard. ∎

Edited version of an article originally published in The Motorship.

DNV GL Expert
Arun Sethumadhavan, Senior Principal Engineer
Hull, Materials and Machinery section
Phone: +47 48000735
E-Mail: arun.sethumadhavan@dnvgl.com

THE RIGHT PARTNER FOR THE FUTURE

At a time of proliferating complexity of systems, rules and regulations, being able to rely on a partner who sees the big picture can make a big difference. Shipowner Sonangol turned to DNV GL to benefit from the company's expertise covering the full spectrum of technical and business questions.

When Sonangol EP, the national oil company of Angola, put down roots in Houston with a crude marketing subsidiary in late 1997, the new US-based firm quickly began placing orders for Suezmax tankers. As the business continued to expand, it became apparent by 2009 that the shipping activity of the company was best suited to operating under its own leadership, resulting in the creation of Sonangol Marine Services (Sonangol) in April of 2010.

Structured as a traditional shipowner and benefiting from strategic partnerships, the company enjoys more financial stability than its competitors, which ensures it can maintain a long-term focus on sustaining its top-quality deliverable. It is that deliverable which has secured Sonangol a position chartering to the oil majors. But even the most reputable, well-positioned, and well-equipped operators face challenges. While Sonangol continues to focus on maintaining its leading position, the company relies on DNV GL to support it in areas beyond its centre of expertise.

Sonangol Maiombe at her launch from the Daewoo Shipbuilding and Marine Engineering (DSME) shipyard in South Korea in 2017.

A new class partnership

Mark Heater, President of Sonangol, has been at the helm since the beginning. "This business came into existence out of necessity, and here we are eight years later with ten internationally trading Suezmax tankers and three LNG carriers," he says. From its Houston headquarters, Sonangol provides administrative oversight and management of the performance of their ships, technical managers, commercial solutions, and class relationships.

Sonangol's relationship with DNV GL reached a new milestone in 2015, with a contract signed for two DNV GL class 156,290 dwt crude oil tankers to be built at South Korean shipbuilder Daewoo Shipbuilding and Marine Engineering. Mark Heater praised Sonangol's newbuilding experience with DNV GL, calling it: "Seamless. During the newbuilding process DNV GL is working for the shipbuilder, of course, but what we managed to do this time, which had been unsuccessfully attempted in the past, was achieving an enhanced level of transparency by being included on DNV GL's correspondence with the shipyard. The tripartite agreement brought a whole new level of efficiency and value to the project which we lacked before."

Completed in 2017, this was the first newbuilding project between DNV GL and Sonangol, opening the door for a broader relationship. "Ten years ago the scope of what class was able to help us with was much narrower than what we can expect today. There is a great variety of issues. We not only rely on class to help us understand scrubber technologies and their implications; we can count on class to tell us what type of system will work best for us."

Mitigating future risk

On the chartering front, the approach Sonangol takes to contracting its vessels is unique. In 2005 the company partnered with tanker owner Stena Bulk to create the joint venture Stena Sonangol Suezmax Pool. This provides chartering services to the shipowners who wish to leverage their position through spot market fluctuations and provides insulation from market volatility risk by spreading it over the pool of vessels.

The market forecast for the Suezmax ship class is not good. "The outlook for 2018 is somewhere between miserable and terrible." Heater says, adding that from "2019 and beyond we think it looks healthier, but we are more of a traditional shipowner, and we're in it for the long haul." With its long-term vision and the absence of unreasonable pressure on the company to reduce operating expenditures, Sonangol's business has proven attractive to the oil majors.

To maintain that reputation among the oil majors, it is critical for the company to uphold a high level of quality. With DNV GL's class-independent advisory services, Sonangol benefits from the

"We rely on class to take a proactive role in pushing vendors to agree to certification that shows they have done their due diligence on software tracking and revisioning."

Mark Heater, President of Sonangol

global team of DNV GL advisory experts who help address the ever-increasing spectrum of business challenges, ranging from regulatory and compliance questions to fleet management and performance issues.

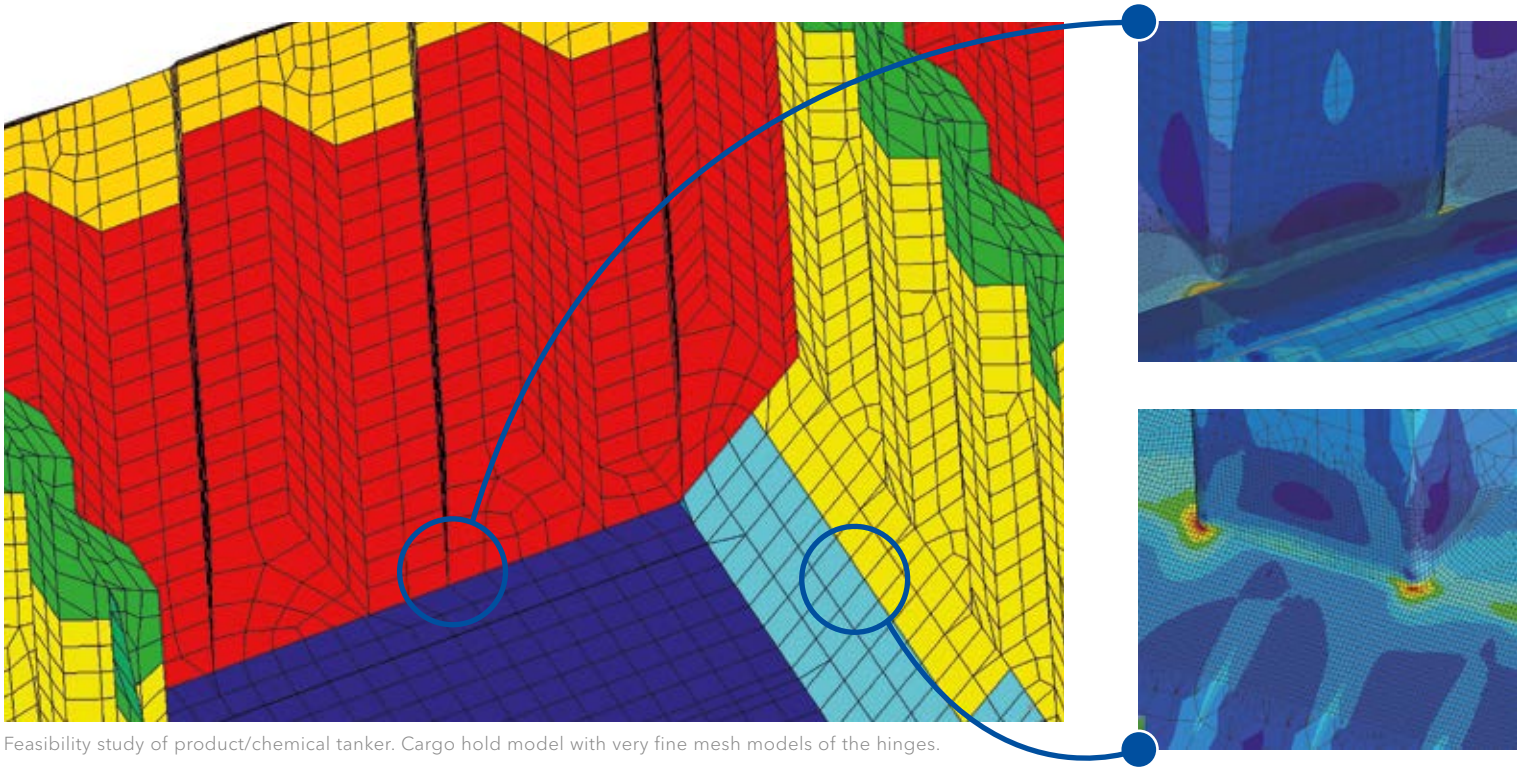
Solutions for complex issues

In an industry that is shifting to automation and becoming increasingly digital, Sonangol has come to rely upon the expertise of DNV GL. "Vessel systems are so integrated now, that if one component fails, four or five others in front or behind will follow. Suddenly, your ship is dead in the water because there is a failure in the steering component. We're finding that more often it's not the machinery itself that has failed, but some software component and that's something that our crew is not equipped to handle." Mark Heater says SIRE inspections capture and assess risk in these instances. In the oversaturated tanker market, where there is an abundance of available tonnage, rather than charter a vessel with continual software-related component failures, the charterer will simply opt for a vessel that doesn't have a problem. "We rely on class to take a proactive role in pushing vendors to agree to certification that shows they have done their due diligence on software tracking and revisioning. We interact with class a lot more on many component-related issues than we did in the past. Although we have people in-house with all the right credentials, the level of complexity has increased to the point where it is not feasible to deal with these issues internally. We look to DNV GL because DNV GL sees the full picture and can leverage its class relationships to bring about solutions to these complex industry problems." **MF**

Photos: DNV GL, Sonangol

DNV GL Expert
Yuvraj Lall
Manager Region North America
Phone: +1 281 396 1093
E-Mail: yuvraj.lall@dnvgl.com

Sonangol Cazenga and her sister ship *Maiombe* are the first newbuilding projects between Sonangol and DNV GL.



Feasibility study of product/chemical tanker. Cargo hold model with very fine mesh models of the hinges.

SIMPLIFYING BULKHEAD CONSTRUCTION

Taking unnecessary complexity out of the shipbuilding process while improving functionality and structural stability is a never-ending endeavour. DNV GL and several partners have looked at ways to simplify bulkhead corrugation joints.

Cargo holds in chemical tankers typically have corrugated bulkheads to achieve adequate structural stability without requiring excessive material thickness. The production of these corrugations naturally involves much more material and labour than building straight bulkheads, and corrugated bulkheads with all their recessed edges are harder to clean. It is therefore in the best interest of both owners and shipbuilders to develop design approaches which reduce manufacturing costs while facilitating tank cleaning. This can be achieved in particular by reducing the length of welded seams and avoiding complex structural features wherever possible.

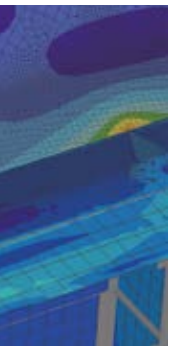
Rethinking a proven concept

A new feasibility study by DNV GL and several industry partners has investigated simplified structural tank bulkhead arrangements involving corrugations with "hinged" ends with the aim of avoiding an excessive number of parts and the associated welding work. The common feature of all variations of this arrangement was a 45-degree inclined plate at the end of each corrugation which carries the lateral forces into the surrounding structure via a single, straight welded seam or "hinge". Corrugations with hinged ends have been used in outer tank bulkheads of independent tanks for hot cargo and in deck panels of a product tanker from the 1980s and have performed satisfactorily. Building upon this experience, the new research project investigated the feasibility of applying this engineering principle on a broader basis, with a focus on tank bulkheads.

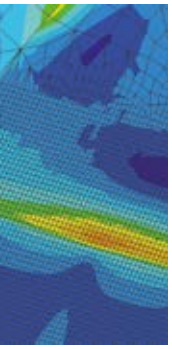
Key objectives of the project were to simplify bulkhead geometry so as to achieve clean surfaces, reduce shadow areas, facilitate assembly as well as drainage, and reduce complexity by maximizing the number of repetitive geometries and parts while decreasing the number of steel pieces; to boost the available tank volume by removing or minimizing voids behind angular plates; and to keep surface stresses and potential paint cracks to a minimum while avoiding deformation of structural elements surrounding the corrugation ends.

Promising results

DNV GL's comprehensive strength assessments, including finite-element computations of the yielding, buckling and

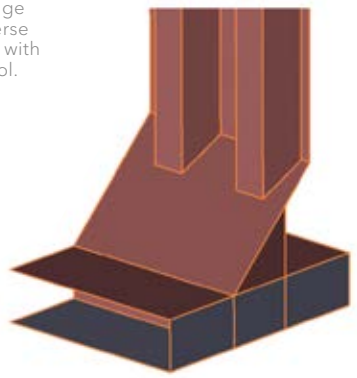


Lower hinge of CL bulkhead.



Lower hinge of transverse bulkhead with lower stool.

Vertical corrugation with lower stool.



HINGED BULKHEAD CORRUGATION JOINTS: POTENTIAL BENEFITS AND REMAINING CHALLENGES

Operational benefits

- Simple geometry with clean surfaces
- Easy drainage
- Reduction in shadow areas
- Low surface stresses/strains reduce the probability of paint cracks
- Removal of void spaces (stool tanks) reduces risk of leakage into them
- Increased cargo tank volume
- Reduced volume of voids increases available cargo tank volume
- Avoidance of deformation in surrounding structures (e.g. in upper deck) caused by rotation at ends of corrugations

Benefits for design and construction

- Simple geometry with easier assembly and reduced complexity
- Reduced number of steel pieces
- More repetitive geometries/ parts

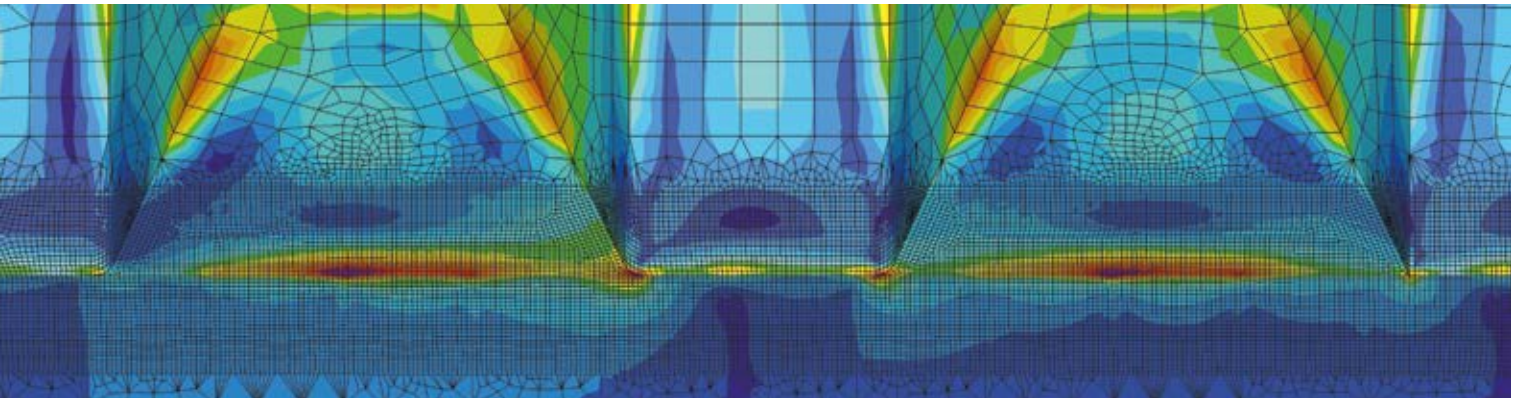
Challenges for further development and application

- In case of long bending span between hinges, corrugation scantlings may become high
- Alignment and welding of hinges
- Vibration issues: hinged ends result in different overall stiffness compared to conventional design

fatigue behaviour of various hinged end arrangements of centre line– and transverse bulkhead corrugations in a typical product and chemical tanker design showed that the proposed hinge joints generally show low to moderate stresses, with few exceptions where improvements to the structural arrangements would be advisable. In any such scenario, however, it would be crucial to pay close attention to precise alignment of the hinge welds at the end supports and generally to high welding quality. Points of stress concentration, such as where stiffeners or webs meet the corners of an inclined plate, require special diligence by the design engineer. In addition, the influence of vibration on overall system stiffness should be accounted for. DNV GL is currently discussing the application of hinged bulkhead corrugation ends with various shipowners, shipbuilders and designers, all of whom have shown great interest. Various joint development projects are in the planning stages. **ÅB**

DNV GL Experts
Åge Bøe (ÅB)
Vice President Technical Support Hull Approval
Phone: +47 90812492
E-Mail: age.boe@dnvgl.com

Bartosz Maciolowski
Principal Surveyor Hull – Cargo Ships
Phone: +47 91765102
E-Mail: bartosz.maciolowski@dnvgl.com



Photos: DNV GL

Feasibility study of product/chemical tanker. Maximum surface stresses (for hotspot stress assessment) at lower hinge of transverse bulkhead (see high stress concentration in way of inclined plate corner located close to a diaphragm web plate in lower stool).

SAFER, SMARTER, GREENER

Regional Maritime offices

Americas
1400 Ravello Drive
Katy, TX 77449
USA
Phone: +1 2813961000
houston.maritime@dnvgl.com

Greater China
1591 Hong Qiao Road
House No.9
200336 Shanghai, China
Phone: +86 21 3208 4518
marketing.rgc@dnvgl.com

North Europe
Johan Berentsens vei 109-111
Postbox 7400
5020 Bergen, Norway
Phone: +47 55943600
bergen.maritime@dnvgl.com

South East Europe & Middle East
5, Aitolikou Street
18545 Piraeus, Greece
Phone: +30 210 4100200
piraeus@dnvgl.com

West Europe incl. Germany
Brooktorkai 18
20457 Hamburg
Germany
Phone: +49 40 361495609
region.west-europe@dnvgl.com

Korea & Japan
7th/8th Floor, Haeundae I-Park C1 Unit,
38, Marine city 2-ro, Haeundae-Gu
48120 Busan, Republic of Korea
Phone : + 82 51 6107700
busan.maritime.region@dnvgl.com

South East Asia & India
16 Science Park Drive
118227 Singapore
Singapore
Phone: +65 65 083750
sng.fis@dnvgl.com

DNV GL – Maritime
Brooktorkai 18
20457 Hamburg, Germany
Phone: +49 40 361490
www.dnvgl.com/maritime

DNV GL AS
NO-1322 Høvik, Norway
Phone: +47 67 579900
www.dnvgl.com

DNV GL
DNV GL is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. Operating in more than 100 countries, our professionals are dedicated to helping customers in the maritime, oil & gas, power and renewables and other industries to make the world safer, smarter and greener.

DNV GL is the world's leading classification society and a recognized advisor for the maritime industry. We enhance safety, quality, energy efficiency and environmental performance of the global shipping industry – across all vessel types and offshore structures. We invest heavily in research and development to find solutions, together with the industry, that address strategic, operational or regulatory challenges.

Disclaimer: All information is correct to the best of our knowledge. Contributions by external authors do not necessarily reflect the views of the editors and DNV GL.