2020 Fuels and beyond

Compliance now and the road to 2050

TECHNICAL AND OPERATIONAL REALITIES

— New fuel oils, their properties
— Scrubbers
— LNG
— Beyond 2020 to 2050

A technology report from Bureau Veritas Marine & Offshore

From January 1st 2020 the vast majority of ships will be burning compliant very low Sulphur fuel oils (VLSFOs) or gas oils

Technology Report #04 - Summer 2019

BUREAU VERITAS

TECHNOLOGY REPORT

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INTRODUCTION

January 1st 2020 is the effective implementation date for a new global regime controlling sulphur emissions from ships.

Shipping's greatest regulatory and operational challenge has provoked a wide variety of opinions, often highly polarized – as with the debate about scrubbers.

Many questions still require answers.

Fundamentally, for most, the issues are of pricing and timing:

- How much will new fuels cost?
- Who will pay?
- Will it be cost effective to install a scrubber?
- When do I need to act and start preparing my ships?

LNG is only really a potential option for newbuildings.

The future pricing of fuel will inevitably be uncertain. And, of course, the context of targets for a decarbonized industry is in play. But the main issues for most shipowners are operational: managing and burning the new very low sulphur fuel oils (VLSFOs).

For those who may decide to choose, or have already chosen, scrubbers, they need to justify the investment decision and go through the design approval and installation process, as well as manage the operational issues related to ongoing maintenance.

There are no easy answers. The much-vaunted goal of a level playing field will seem a steep slope to many, but others see opportunity.

COMPLIANCE OPTIONS

Very low sulphur fuel oil

Compliant fuels – preparing to use VLSFOs and gasoils

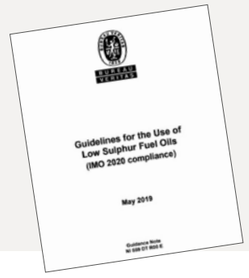
Most existing ships and most new ships at present will be using compliant fuels by the start of 2020. The questions are principally of availability, quality and management. The former is being addressed by the oil majors and significant information is now available and being presented by fuel marketers in global road shows.

Bureau Veritas is able to support owners and managers with the switch over process and help them to address issues. VeriFuel, the Bureau Veritas fuel specialists, are actively supporting the transition globally, and NI 559, recently released guidance, provides a clear route to effective compliance.

VeriFuel's global network of labs test fuel quality.

A Bureau Veritas VeriFuel inspector on his way to board a ship in Amsterdam.

New Guidance from Bureau Veritas - NI 559 R00 E, published May 2019



The recently released NI 559 from Bureau Veritas provides technical and operational guidance for shipowners and shipmanagers, including fuel definitions and guidance on meeting specific challenges, including:

- low viscosity,
- cold flow properties – pour point and cold filter plugging point,
- stability,
- incompatability,
- cat fines.

It provides detailed mitigation measures including:

- configuration of fuel tanks,
- measures to avoid viscosity issues,
- measures to avoid wax deposits.

And it details the required onboard tests, documents and procedures as well as test methods.

TERMINOLOGY: a new lexicon for marine fuels

Regulatory developments have changed the naming of marine fuels. New names, such as hybrid fuels and new ECA fuels, are being used referring to the non-distillate 0.10% sulphur fuels which were introduced to the market from late 2014 onwards. However, these terms are confusing and open to misunderstanding.

In order to agree on a common terminology, the **International Council on Combustion Engines** (CIMAC) Working Group (WG7) Fuels, has suggested that the industry uses the following terms for marine fuels:

- **Ultra-Low Sulphur Fuel Oil (ULSFO),** max 0.10% sulphur content in fuels,
- **Very Low Sulphur Fuel Oil (VLSFO),** 0.10% - 0.50% sulphur content in fuels,
- **Low Sulphur Fuel Oil (LSFO),** 0.50% - 1.00% sulphur content in fuels,
- **High Sulphur Fuel Oil (HSFO),** above 1.00% sulphur content in fuels.

THE AVAILABILITY AND CHARACTERISTICS OF COMPLIANT FUELS


© Courtesy TradeWinds

Andreas Johansen from VeriFuel sharing the results of Bureau Veritas lab analysis at the February 2019 TradeWinds 2020 Disruption Forum held in New York.

As the industry prepares for 2020 the question of availability of VLSFOs post 2020 has been the cause of much speculation. Major oil companies have issued statements specifying availability of VLSFO product in specific ports – the list is growing but may not be considered exhaustive. And there remains the question of pricing.

While there is uncertainty about the availability of VLSFO, marine gas oil (MGO), with sulphur below 0.50%, is widely available. MGO is expected to be more expensive than VLSFO, but the industry should note that MGO is a compliant alternative if VLSFO is not available in all ports.


© TradeWinds

The shipowners' panel at TradeWinds 2020 Disruption Forum debating 2020 impacts and solutions.

In February 2020, the Bureau Veritas fuel testing company, VeriFuel, called for greater cooperation and transparency across the marine fuel supply chain ahead of 2020

Bureau Veritas' Global Technical Manager for Marine Fuels, Charlotte Røjgaard, said: *"With under a year to go until the 2020 sulphur cap regulation comes into force, the marine fuel supply chain must band together and use this as an opportunity to help dispel increasingly outdated bunker fuel delivery processes and procedures. A lack of transparency does not adequately serve the interests of shipowners, ship managers, operators, or charterers. Instead of pulling in different directions, we need to work collaboratively for the greater good of the industry."*

This call to action comes, in part, as a result of recent events relating to fuel quality. While there have been a series of marine bunker fuel contamination cases around the world during 2018, the reality is that nothing conclusive has yet been identified in terms of the cause. This has been confirmed by the International Council on Combustion Engines (CIMAC), which found that no single chemical could be blamed for the engine failures caused by off-specification fuel.

While testing has previously been conducted in isolation, VeriFuel warns that this approach is not helping to solve the underlying problem. According to VeriFuel, without industry-wide cause-and-effect analysis on a global scale, testing will remain limited to advising owners afterwards what "might" have caused their problem.

HSFO - AVAILABILITY CONSIDERATIONS

The global sulphur cap will have a massive impact. HSFO is currently 75% of the current demand for marine fuel. Not only will vessels have to be prepared for the change, but refineries, shore terminals, tank farms and barges will also need to prepare by cleaning out the un-pumpables and deposits which have formed and settled during storage of high sulphur HFO.

Given that HSFO is a by-product after a refiner has captured more valuable products from the crude oil stock, refiners cannot simply cease the production of HFO – unless the refinery has the coking capability to complete further conversion of residuals into lower sulphur products.

However, cokers are billion dollar investments and the lead time from the investment decision to operational status may be five years. Some cokers are being, and have been, installed in refineries in Europe and USA. But not all will ever have coking capacity – and certainly many will not in time for 2020. Modern, large capacity refineries, e.g. in India and China, do have coking capability.

Refiners will now be looking for other markets for HFO, including power plants and refineries with deep conversion units (cokers) installed. Logically, there must be a question mark over the willingness of suppliers to maintain supplies of HFO for the modest remaining demand from scrubber-installed ships, particularly given the requisite separated storage and barging capacity in ports where there may be little or only sporadic demand.

This means that some marine fuels may very well become a niche fuel only available in larger ports after 2020, with consequent implications for the price differential between HFO and MGO.

AN INTRODUCTION TO VLSFOs

While the properties of 0.50% sulphur fuels were almost unknown a year ago, Bureau Veritas VeriFuel is now seeing samples of these fuels in labs. Of all the tested samples, only one was found to be unstable. All other samples tested so far are stable. Some contain cat fines as high as 50 ppm and a few samples have high wax content (as indicated through the pour point). Based on the analysis results of the samples received and tested to date, the properties of VLSFOs meet the requirements of ISO 8217: 2017, and to date there are no alarming trends or indications of concern.

VeriFuel is also in the process of testing the compatibility of these fuels. So far, the results indicate a much better compatibility performance than expected by the industry and in media reports.

STABILITY & COMPATIBILITY

Technical considerations: fuel composition, compatibility, stability, fuel segregation, supply lines, tank cleaning and switch-over timing and processes.

VLSFO Composition

The reduced sulphur content of VLSFOs requires a change in blend components and the variability between fuels will increase. Also, more paraffinic blend components will be used which has led to concern in the industry about, for example: cold flow properties, stability and compatibility.

Cold flow properties

Paraffinic fuel components - or waxy components - have excellent ignition and combustion properties but require temperature management to avoid solidification in tanks or filter blocking. Three standardised test methods to evaluate the cold flow properties are available:

- **cloud point (CP).** This is the temperature at which wax crystals form in the fuel. A clear and bright distillate will go cloudy at the CP – hence the name. This method only applies to clear and bright distillates,
- **cold filter plugging point (CFPP).** The temperature at which a fuel - under controlled conditions in a lab - will no longer flow through a filter. This method only applies to distillates,
- **pour point (PP).** The temperature at which the fuel will no longer flow, i.e., the temperature where it will become a solid.

So, while the PP is important from a storage perspective, the CP and CFPP are important from a filtration point of view. Provided that the cold flow properties of the fuel are known, and proper heating capabilities are available on board, vessels will be able to manage paraffinic blends by maintaining storage and filter temperatures in appropriate ranges.

Charlotte Røjgaard,
VeriFuel - Bureau Veritas' global technical manager for marine fuels

Stability

Stability (in this context) refers to the risk of asphaltenes coming out of suspension, resulting in the formation of sludge in separators and filters. Fuel suppliers need to ensure that asphaltenes are kept in colloidal suspension, i.e., that the fuel is stable.

Compatibility

While stability is the parameter used for a fuel as supplied, compatibility is the term used when two or more fuels are mixed together. Two completely stable fuels can form an unstable mixture if co-mingled. The consequences of an incompatible mix are similar to those when a fuel by itself is unstable: the asphaltenes come out of solution, resulting in sediment deposition, separator sludging and filter blocking.

It is a known operational issue that some incompatibility can be experienced in the fuel systems on board when switching between two different fuels. During this change-over period, the crew needs to manage additional filter cleaning and deal with separator sludging. But on completion of the change-over, things will run as normal again.

Accordingly, although linked, stability and compatibility are two different parameters. Stability is a supply issue, and an unstable fuel (as indicated through the ISO 8217, Table 2 requirements on TSA and TSP) will be the responsibility of the supplier. Compatibility, on the other hand, is an onboard fuel handling issue and no supplier will guarantee compatibility with a previously bunkered fuel.

ON BOARD IMPLEMENTATION AND THE IMPORTANCE OF TANK CLEANING

"A well thought-out ship-specific implementation plan is therefore of utmost importance in ensuring that the change to 0.50% m/m sulphur fuel is achieved as smoothly as possible." IMO Circular, MEPC.1/Circ.878

Preparing a ship for compliant operations from 2020 onwards requires preparation. Much of that preparation is ship specific and a ship specific plan will need to be prepared. IMO has provided a useful template in Circular, MEPC.1/Circ.878 useful guidance to help operators with their readiness and ability to demonstrate compliance to port state control.

Tank cleaning

Tank cleaning is a particular area of focus in the circular.

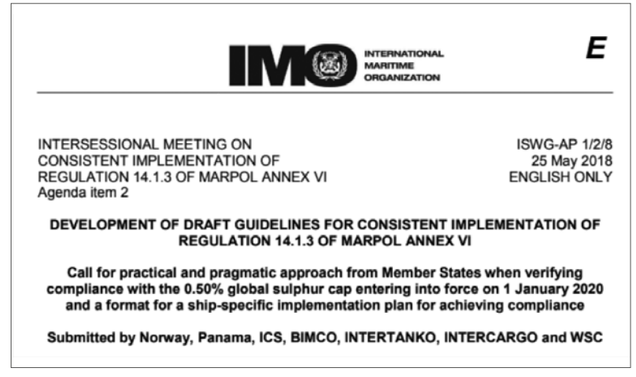
Marine residual fuels deposit impurities such as sediments, cat fines and water over time. It is either not always possible or regular operational practice to drain storage tanks, so years of accumulated sludge will form significant deposits in bunker tanks. The sulphur content of this sludge will reflect that of the previous fuels. Fuel tanks require cleaning before taking on board compliant 2020 fuels in order to avoid the fuel in use after January 1st 2020 being contaminated by high sulphur sludge on board. Each operator needs to carefully evaluate options for cleaning the individual tanks.

Settling and service tanks can (and should) be drained regularly to make the task easier, but it is important that cleaning these tanks is considered during the transition period.

There are various options for tank cleaning. Some operators will manually clean tanks during dry-docking. A further option or subsequent step is to use the dissolving effect of the lighter ULSFO or MGO fuels to remove the accumulated residues on tank bottoms, in frames and on tank walls, and to consume the mixture in advance of the implementation date. Still others consider taking one tank out of operation at a time and requiring the crew or riding gangs to clean them during ship operations.

There is not going to be one solution that fits all and each operator needs to decide on which approach will be more suitable for the specific fleet or vessel, while making sure crew safety is the first priority. The combination of tank arrangements, which may vary considerably, and the length of time those tanks have been in use and uncleaned, will be major factors determining the potential success of different options.

Depending on which strategy is applied for cleaning the fuel tanks, there is a likelihood that the residues from tank bottoms will enter the fuel system. Given that tank bottoms may have high levels of sediment, water and abrasive cat fines, the focus must be on optimising separation as well as filtration in order to


IMO INTERNATIONAL MARITIME ORGANIZATION

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INTERSESSIONAL MEETING ON CONSISTENT IMPLEMENTATION OF REGULATION 14.1.3 OF MARPOL ANNEX VI
Agenda item 2

ISWG-AP 1/2/8
25 May 2018
ENGLISH ONLY

DEVELOPMENT OF DRAFT GUIDELINES FOR CONSISTENT IMPLEMENTATION OF REGULATION 14.1.3 OF MARPOL ANNEX VI

Call for practical and pragmatic approach from Member States when verifying compliance with the 0.50% global sulphur cap entering into force on 1 January 2020 and a format for a ship-specific implementation plan for achieving compliance

Submitted by Norway, Panama, ICS, BIMCO, INTERTANKO, INTERCARGO and WSC

IMO has provided a useful template in Circular, MEPC.1/Circ.878 useful guidance to help operators with their readiness and ability to demonstrate compliance to port state control.

protect the engine against their impacts. Generally, the crew should expect extra work on cleaning filters/separators during this cleaning period.

The time required for the cleaning process will depend on the chosen tank cleaning option, as well as on the volume of the fuel system and tanks. The process should be completed before 1st January 2020, so the time required to complete cleaning must be considered in any transition planning.

It is recommended that the cleaning process is validated by taking samples at the engine inlet point when 0.50% max sulphur fuel has been bunkered, to verify that the sulphur content does not exceed the limit.

Further useful reading on tank cleaning can be found in Appendix 3 of IMO Circular, MEPC.1/Circ.878 – Guidance on the Development of a Ship Implementation Plan for the Consistent Implementation of the 0.50% Sulphur Limit under Marpol Annex VI.

Fuel segregation

Good fuel management processes should always be ensured on board and, as ever it is good practice not to mix fuels unless their compatibility has been verified.

However, considering the expected wide variability of VLSFOs, what is more important than ever in avoiding incompatibility issues is segregation. For example, tanks should be emptied to the greatest extent possible before loading a new bunker stem.

Although it is impossible to avoid a degree of mixing in the fuel system, such as during a change-over between fuels, the impact can be minimised by reducing the amount of fuel in the settling tank and the service tank to the greatest extent possible, within safety limits, before changing from one fuel to the other.

Heating of fuels

Considering that VLSFOs will in general be more paraffinic, it is important to consider heating capacities of storage tanks, as well as fuel lines and filters, for any ship. Existing HFO tanks should already have the required heating capacity available – but distillate tanks may not. While the heating capacity of storage tanks is not easily changed, it is relatively easy to heat trace filters and fuel supply lines when necessary.

If a vessel has insufficient heating capacity available, the fuel purchaser should ensure that the required cold flow properties are stated in the purchase specification. This is especially important if the vessel is heading for colder regions.

Crew training

In order to ensure a smooth a transition to 2020, each operator should ensure that their crews are prepared to handle all potential fuel challenges. The focus for such training should include how to avoid and manage compatibility issues and how to handle fuels with inferior cold flow properties.

Post January 1st 2020 – fuel testing and sampling

The current ISO 8217 versions will cover the new VLSFOs as they also cover the ULSFOs introduced in 2014-2015.

ISO 8217 takes the various aspects of fuel properties into consideration, commercially (e.g. density and water), statutorily (sulphur and flash point) and technically (e.g. viscosity, cold flow properties, stability and 'cat' fines).

It was impossible to prepare a new ISO 8217 revision before 2020 due to the timeframe. However, acknowledging the industry need and demand for a new specification, the ISO 8217 committee agreed to prepare and release a Publicly Available Specification (PAS) within the short time frame between the release of ISO 8217:2017 and 1 January 2020. The PAS is expected to be released some time during the second half of 2019 and is intended to be an information document addressing, "Considerations for fuel suppliers and users regarding marine fuel quality in view of the implementation of maximum 0.50% Sulphur in 2020".

Proper sampling and testing of marine fuels before consumption should always be performed in order to manage commercial issues, and compliance and technical considerations.

EXHAUST GAS CLEANING SYSTEMS (SCRUBBERS)

© Courtesy Alfa Laval

The broad experience of class can be vital when considering installation of exhaust gas cleaning systems.

Applicability to vessel type

Deciding which scrubber technology and process configuration to select depends mostly on a vessel's typical operating routes, and less on the type of vessel. Open loop scrubbers are best suited to vessels operating mostly on open sea, closed loop scrubbers are best for vessels operating in waters with low alkalinity, and hybrid scrubbers are the best choice for vessels operating within, or frequently visiting, Emission Control Areas (ECAs).

The choice of scrubber technology and configuration is also influenced by the number of engines and their power, and the space available on board the ship (including within the engine room, funnel and deck areas). In general, it is less influenced by specific vessel type. On tankers, use of scrubbers is already well established for cleaning gas from inert gas generators, and there may be some synergies in installation.

Upgrading the scrubber layout from open loop to closed loop or hybrid system is technically possible, but may pose significant difficulties, mostly due to the space required for installing equipment, ducts and piping.

One of the options when installing an open loop scrubber is to design it as 'hybrid ready', installing tie-in points for a hybrid system and leaving enough space for equipment to be installed, such as a water cleaning unit, pumps and tanks.

Emissions to air

The main purpose of a scrubber on board a ship is to remove sulphur oxides from flue gas but scrubbers also remove large amounts of particulates from the exhaust gas, especially larger particles. Some removal of nitrogen oxides and carbon dioxide can also occur in scrubbers.

Efficiency is monitored by a flue gas monitoring system, which must be certified. The main parameters to be monitored are the Sulphur dioxide (SO_2) and carbon dioxide (CO_2) content, in order to calculate the SO_2/CO_2 ratio, which must comply with IMO requirements.

Exhaust gas from wet scrubbers is cold and saturated with water. Because of this, a plume may be visible at the funnel outlet, which, although not harmful to the environment, is visible. In order to eliminate the visible plume, scrubber systems include de-plume equipment (demisters) which remove water droplets and reheat the exhaust stream.

Emissions to water

In wet scrubbers, sulphur oxides from the flue gas are converted to sulphates and discharged overboard. Sulphates occur naturally in sea water but their effect is still under debate and there are opposing views.

Due to the nature of wet scrubbing, the wash water has a low pH value. For discharge, the wash water is buffered to the acceptable pH value of 6.5 at 4 meters from the overboard discharge point. The pH value at discharge can be demonstrated or calculated using numerical simulation tools such as computational fluid dynamics (CFD).

Wet scrubbers also remove particulate matter from exhaust gas. There are limitations on the discharge of particulates, and wash water has to be treated to remove them before discharge. The quality of particulate removal is indicated by turbidity and polycyclic aromatic hydrocarbon (PAH) content in discharge water, for which limits are also set. Discharge water turbidity and PAH are compared to their value at the point of sea suction.

Nitrogen oxides may be removed to some extent and will be converted to nitrates. The content of nitrates in wash water is limited by IMO regulations.

Turbidity, PAH and pH of discharge water from scrubber systems must be continuously monitored using a certified monitoring system. Turbidity and PAH are to be monitored at sea suction and wash water discharge before any dilution, while the pH value of discharged wash water is measured in front of the discharge point.

Nitrates are not required to be continuously monitored, but samples must be taken periodically and the nitrate content must be recorded.

Waste disposal (sea, port)

Scrubber liquid effluent – wash water and bleed-off water – is allowed to be discharged to the open sea, but there are limitations on discharge in some ECAs and ports, depending on national regulations.

There are an increasing number of countries that have banned or limited the discharge of scrubber wash water in their waters or ports; the list currently includes Belgium, Germany, Ireland, Latvia, Lithuania, the United States, the United Arab Emirates, Singapore, China, India and Norway.

Sludge produced by wash water treatment has to be discharged to on-shore facilities. The number of ports able to receive scrubber sludge is increasing but checking in advance is advised.

Regulation impact

The number of installed scrubber systems is relatively low and with their effect on the environment still being assessed there remains the possibility that international and national regulations will be further developed in order to control scrubber use, particularly in the case of open loop scrubber discharge to sea water.

Operational realities

Any scrubber system is an important installation with a significant impact on the vessel. Equipment must be continuously operated and maintained in a proper condition to maintain compliance.

Exhaust gases and discharged wash water have to be continuously monitored, and monitoring equipment must be properly maintained and calibrated.

The increased complexity may require crew members and crew skills.

Issues to be addressed, considered and managed include:

- exhaust gas pressure drop,
- economy,
- risks and hazards,
- maintenance and materials,
- life of systems: expectations.

© Courtesy Star Bulk

Bureau Veritas has successfully supported the plan approval, installation and issuance of relevant statutory documentation for scrubber installation projects.

The increased complexity that installing a scrubber system creates may also increase requirements for operational, regular and unplanned maintenance. It is important to select a well proven system, with high levels of reliability.

The crew skills and knowledge have to be upgraded with training for proper operation, regular checks, operational and regular maintenance, as well as for troubleshooting.

The wet scrubbing process forms a very corrosive environment, especially when using sea water. Care must be taken with choice of materials.

Plastic materials, such as glass-reinforced plastic, have been successfully used as scrubber materials. But due to fire hazards, plastic materials are only allowed to be used for off-line scrubbers.

Care should also to be taken in selecting material for other elements of the scrubber system during design, including wash water piping and wash water treatment equipment.

Scrubber installation decisions are based on a calculation of the scrubber's lifetime, and the current installed scrubber pool of experience is not yet sufficient to establish estimates of scrubber lifetime expectancy or material life, both of which may be affected by the corrosive nature of scrubber operations, the type of system and onboard management.

Accordingly, it is important to ensure with the scrubber vendor that scrubber lifetime is as claimed or expected, since replacement of main scrubber parts may lead to high costs, including costs for equipment, works, lost revenue and possible non-compliance.

LNG as fuel: increasing availability world-wide.

LNG AS FUEL

LNG as fuel: going mainstream?

The decision by CMA CGM in 2017 to order nine BV-classed gas-fueled 22,000 TEU vessels has been seen as a turning point in industry adoption of LNG as a marine fuel. Previously, LNG had been perceived as a niche market choice, best suited to vessels such as ferries, offshore service vessels or tugs operating exclusively in emission control areas. The technology was well known. After all, gas carriers have been using LNG as part or most of their fuel source for many years. But until the landmark decision by CMA CGM, no major ocean-going merchant ship operator had chosen gas.

Additionally, more than 20 cruise ships on order for delivery over the next decade will be LNG fueled in a move that will enhance air quality in cruise destination ports and for passengers and crews on board. Operators such as Ponant and MSC Cruises have ordered LNG fueled ships.

Tightening environmental regulations that set limits on shipping emissions, have increased the attractiveness of gas as a marine fuel, and LNG has emerged as the principal gas option being adopted today.

LNG enables owners to comply with IMO's global 2020 0.50% sulphur cap and with the requirements in Emission Control Areas of 0.10% sulphur. Additionally, with the right propulsion system, LNG can meet new NO_x emissions requirements as well.

Consequently, demand for LNG fueled ships is growing. But as a proportion of the world orderbook and fleet, demand for LNG and gas fueled ships is still modest – can gas go mainstream?

Expanding infrastructure

Bureau Veritas is taking the lead in supporting the introduction of dedicated LNG bunker vessels.

While bunkering infrastructure is expanding, LNG is not yet available everywhere – many key bunkering ports do not yet have a solution in place and bespoke solutions to secure LNG as a marine fuel are still necessary.

A crucial development is the introduction of dedicated LNG bunker vessels able to provide ship-to-ship bunkering, providing the requisite flexibility. Bureau Veritas has classed a number of these new LNG bunker vessels (LNGBVs), including the first ever built, the ENGIE Zeebrugge.

The CMA CGM vessels under construction will have their needs met by an 18,600 m^3 bunkering vessel chartered by TOTAL and operated by MOL. Like the container ships themselves, the vessel is classed Bureau Veritas.

Ports around the world are now developing small-scale LNG facilities and working to understand what is required to enable LNG as a fuel to be available in their ports – to refuel the growing fleet of ships needing gas bunkers. Bureau Veritas is working with many of these ports and potential suppliers to help them understand and manage the risks involved.

LNG fuelled leadership

With its large portfolio of LNG fuelled ships ranging from tugs to tankers and from passenger ships to ultra-large container ships, Bureau Veritas has a vast amount of knowledge and experience which has been fed back into our class rules and approach to managing risk.

"The two major obstacles to widespread adoption of LNG as fuel have traditionally been the uncertainty over cost, in particular regarding the relative price of LNG versus both heavy fuel oil (HFO) and low sulphur fuel oil (LSFO) options, and a lack of LNG bunkering infrastructure."

Panos Koutsourakis
Global Technology Leader,
Sustainable Ships,
Bureau Veritas


© Baptiste Lignel

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Bureau Veritas classed Megastar bunkering LNG at Pori.

STEERING INTO ALTERNATIVE FUEL

Key issues for LNG as a fuel are safe bunkering, fuel quality and gas containment systems

Bureau Veritas is the leading classification society for dual-fuel vessels. Our experts are supporting the design, construction and classification of a wide-range of LNG fuelled ship projects all around the world including CMA CGM's project for the world's biggest initiative to date: the nine 22,000 TEU ships being built in China with GTT membrane containment systems

LNG is one of the fuel choices to meet the global Sulphur cap when it is introduced in 2020. The others are VLSFOs, distillates or to use exhaust gas cleaning systems (scrubbers). Until November 2017 uptake of LNG as a marine fuel by boxships had been limited to a number of relatively small containerships ordered in the USA for Jones Act trades and four HFO to LNG conversions (WES Amelie, conversion completed in 2017, and three others announced).

An LNG-fueled future for ULCSs

The largest Containerships in operation today trade between Asia and Europe. Heavy fuel oil (HFO) and marine gas oil (MGO) bunkering options are available at most or all ports used. The maximum bunker capacity of these ships is around 15,000 cubic meters (cbm).

However, a fully optimized, modern ULCS with a cargo capacity of 22,000 TEU, designed to run on LNG, will likely need the option of bunker capacity for a full west-to-east and east-to-west rotation. This covers a range of about 27,000 nautical miles and a voyage duration of about 80 days. For such a range and voyage duration, a ULCS will need an LNG bunker tank capacity of 18,000 to 20,000 cbm. The ability to complete a full round trip will be dependent on the current and future availability of LNG bunkering infrastructure to provide the required quantities of LNG. While supply of bunker stems up to 7,000 cbm has been developing fast, a step up in scale will now be required to meet demand for stems up to 20,000 cbm.

As a ship burns its fuel, LNG tank volumes will decline, potentially through the full spectrum from a full to an almost empty tank. This requires attention to ensure that tank arrangements, design and construction are able to withstand sloshing loads. It also requires optimized management of boil-off gas.

Supplying large gas-fueled Containerships with LNG bunkers –safely

To minimize operational disruption, large Containerships need to be able to take on board bunkers while alongside and while loading and discharging cargo. Taking on board 15,000-20,000 cbm of LNG will take at least 12 to 15 hours* from start to finish including: connection, inerting, testing, LNG transfer, purging, inerting again, and disconnection as well as delivery of a bunker delivery note with all requirements of the IGF code. So, a major port call requiring up to 40 hours for cargo operations is more than adequate for bunkering operations.

CASE STUDY

© CMA CGM

** 1,200 cbm/h using two lines for LNG and one for vapor return.*

The main challenge to be addressed for the ship-to-ship transfer of LNG is to identify and allow for a reasonable safety zone while minimizing the impact on loading operations as much as possible.

Risk assessment will determine the necessary size of the safety zone and, if deemed necessary, will be supplemented by a gas cloud dispersion model analysis (using a deterministic approach) as per ISO 20519 and SGMF Safety Guidelines for LNG bunkering.

However, simultaneous cargo and bunkering operations do not necessarily increase levels of risk. Moreover, a safety zone is not necessarily the same as an exclusion zone. But within the safety zone it is necessary to control, monitor, detect, protect against, and mitigate any consequences of potential LNG leakage, according to certain scenarios. This must take into account operational experience, appropriate crew training, terminal operator information, safety procedures, and the reliability of cryogenic transfer equipment allowing for the possibility of using entire vacuum insulated double wall transfer lines as have been developed for passenger ship LNG bunkering operations.

In summary, with proper care, appropriate precautions, trained personnel, and established procedures, regular LNG bunkering is not significantly more complicated than conventional HFO bunkering. Furthermore, conventional pollution prevention is not a risk, and oil spill prevention measures are not required.

Fuel quality

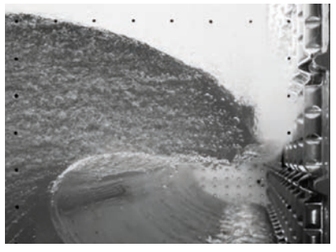
One key factor in establishing the quality of LNG as fuel is the methane number (MN). But it is not the only factor. Temperature is also important, as well other parameters such as, to a certain extent, the Wobbe index, where dual fuel (DF) boilers are used.

Custody transfer from the LNG bunker vessel to the receiving ship is also part of this, as it must quantify the energy transferred and deduct the vapor return quantity. The use of Coriolis flowmeters and spectrographs on board LNG bunker vessels eases transfer of commercial data and will help eliminate potential disputes. An ISO standard for LNG fuel quality is currently being developed to select a comprehensive method for MN calculation. Bureau Veritas is involved in this work.

Abroad group of stakeholders is involved in LNG bunkering safety: ISO, EMSA, IACS, IAPH, CSA, USCG, SGMF and SEA/LNG are all working - together where appropriate - in order to secure a strict application of safety guidelines and international standards and, where possible, ensure the harmonization of rules and standards. Bureau Veritas is playing a major role sharing its experience and supporting the industry in developing safe LNG bunkering arrangements, technology, standards and operations.

LNG as fuel bunker containment systems for Ultra-Large Containerships

60 years of LNG experience have enabled Bureau Veritas to develop the assessment tools to understand design requirements for large-capacity LNG bunker tanks.



Full scale impact wave at a low partial filling in a membrane tank (SlosHel Project).

The significant quantities of LNG required for ultra-large ships require large storage capacities, and one major decision is whether a design should be based on either one large bunker tank or two (or more) smaller tanks.

Sloshing

The requirements of trading Containerships will be that the tanks will have to be designed to withstand sloshing impacts in all partially filled conditions.

What is sloshing?

Sloshing of LNG is a hydrodynamic phenomenon that can lead to high magnitude impacts on walls with potential consequences on the containment system response. Sloshing is primarily an issue when LNG tanks are void of internal structure, and it occurs in partially filled conditions.

Bureau Veritas has been researching and responding to the challenge of creating containment systems in LNG carriers, FLNGs, FSRUs and, more recently, for bunker tank designs.

Sloshing is a critical safety issue to be addressed

On ULCSs, with their large beams, a tank spanning the breadth of the ship is potentially subject to heavy sloshing impact in beam seas when in partial fill condition.

However, proper assessment, calculation and, if required, adjustments to the design of the tank can address the risks of sloshing. Bureau Veritas has a methodology to assess loads and determine appropriate design responses requiring a strengthened containment system.

Seakeeping Analysis

Initially, the entire range of the ship's operational loading conditions is ordered in different groups reflecting different operational conditions, such as variations in draft. For example, at a given draft, the worst loading condition regarding sloshing is that associated with the greatest metacentric height (GM) and the lowest natural roll period.

Next, coupling effects between liquid motions inside the LNG tank(s) and the ship's motions need to be taken into account.

For one-row tank arrangements (i.e., one tank spanning the full beam of the ship), coupling must be taken into account (using HydroSTAR®), which is not the case for a double-row tank arrangement. A double-row tank arrangement will also be less sensitive to sloshing than a one-row tank as the tank's natural periods (for all filling levels) are out of the range of the ship's roll periods. So, a one-row tank will require a strengthened cargo containment system.

Sloshing Analysis

In addition to sloshing model tests to be submitted by the designer, Bureau Veritas carries out its own CFD calculations for sloshing model test verification and to derive the loads for the inner hull and pump-mast strength assessments. These CFD calculations are complementary to model tests. CFD calculations, by recording all data at each time step, in all cells, provide a total representation of the sloshing impacts on all the tank walls.

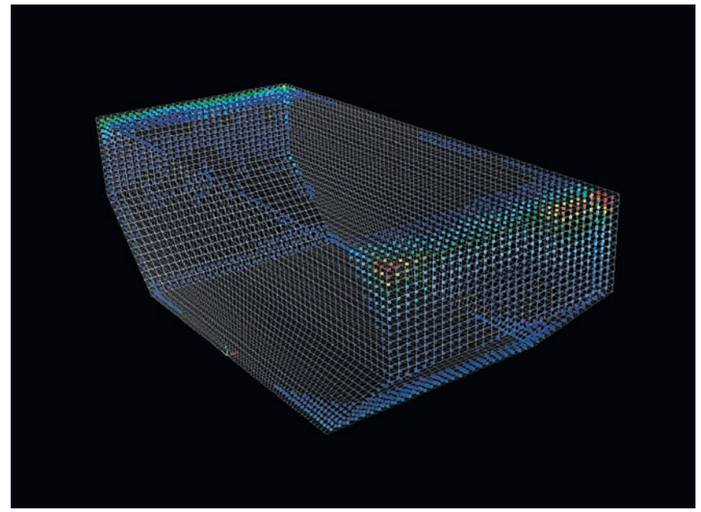
Sloshing loads applied

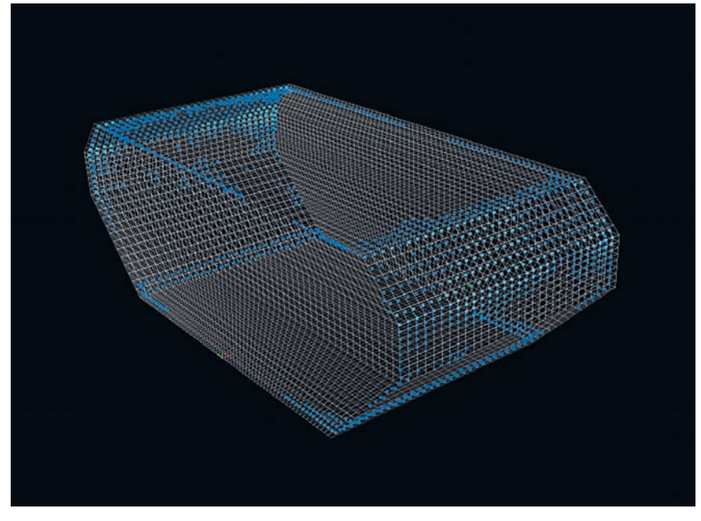
The final step is to apply sloshing loads to the entire containment system, including the inner hull and the pump mast inside the tank, for strength assessment against Bureau Veritas's Rules.

For further insight into the design and operation of ultra-large containers ships (ULCSs), incuding lashing and structural aspects, as well as the LNG as fuel, please refer to Bureau Veritas Marine & Offshore Technology Report #01 Winter 2017.

3-step sloshing assessment and calculation process

1. Seakeeping analysis - to calculate the motions of the ship and, consequently, tank motions.
2. Sloshing model tests (carried out by the designer) and computational fluid dynamics (CFD) calculations by Bureau Veritas (both using calculated tank motions) are carried out in order to determine sloshing loads.
3. Sloshing loads applied to entire containment system.





Reducing sloshing impact: membrane containment tank without upper chamfer (above); and with chamfer to reduce impact loads (below).

BEYOND 2020

Gijs de Jong
Sales & Marketing Director,
Bureau Veritas

CO_2 emissions per transport work
are to fall by at least
40% by 2030
and by
70% by 2050
compared to 2008

Overall greenhouse gas emissions
are to be at least
50% lower by 2050

Ambition

While the IMO 2020 Sulphur cap is part of a package of regulations designed to reduce harmful local emissions from shipping, moving beyond 2020 the regulatory focus shifts to global greenhouse gas (GHG) emissions.

In April 2018, IMO's Marine Environmental Protection Committee (MEPC 72) adopted an initial strategy for the reduction of GHGs from shipping, setting ambitious targets for reducing overall GHG emissions as well as for carbon intensity. CO_2 emissions per transport work are to fall by at least 40% by 2030, compared to 2008, and efforts are to be made to reach 70% by 2050. Ideally, GHG emissions should peak as soon as possible and then be reduced by at least 50% by 2050, compared to 2008. Furthermore, efforts are to be made to decarbonize shipping in order to align with the temperature goals of the Paris Agreement.

Some regulations have already been put in place for newbuildings, notably the Energy Efficiency Design Index (EEDI): EEDI phase 2 – requiring a 20% reduction compared to the reference line – will enter into force in 2020, followed by phase 3 – requiring new designs to be 30% below the reference line – in 2025.

Finally, the strategy calls for additional phases of the EEDI to strengthen the energy efficiency design requirements for new ships. MEPC 74 is considering recommendations to bring phase 3 forward for some ships to 2022/23.

Hybrid and electric ships represented a growing trend in 2018, with particular bright spots in coastal shipping, passenger ships and offshore support vessels. In addition to classing Canada's first all-electric ferries, Bureau Veritas classed the Wind of Change, Louis Dreyfus Armateurs' award winning SOV. The ship is powered by an innovative hybrid-electric configuration - managed on a DC grid, to increase efficiency. This significantly reduces both fuel consumption and air emissions. As environmental regulations become stricter, our experts will continue to offer a range of services and notations for hybrid and electric vessels through 2019 and beyond.

The next decade is critical

While the initial strategy reflects an ambition and is not a mandatory regulation, it is now expected that IMO will develop regulations consistent with the strategy. Note that IMO will review the initial strategy, and adopt a revised strategy in 2023, by which time more clarity regarding mandatory regulations may have emerged. The key point, however, is that in order to realize the targeted GHG emission reduction, work must start today to develop realistic and practical pathways towards higher levels of energy efficiency and reduced carbon intensity of fuels. The next decade will be critical for making the necessary research and development investment. Bureau Veritas believes the industry needs to work collaboratively to develop unified approaches and competitive, sustainable and scalable solutions.

This will not be easy.

History shows that transitions take time – it took about 50 years for the motor ship (approximately 1910s-1960s) to make the steamship obsolete. But while past transitions were driven by market forces, the transition of our time will be kick-started by new regulations defining a new playing field. How level that field is remains to be seen. Timing will be vital.

Multiple pathways and choosing 'the right horse for the right course'

There is no silver bullet when it comes to reducing GHG emissions. The best propulsion solution for a ship will depend on its type, size and operational profile – speed, cargo, area and range of operation – amongst other factors.

Bureau Veritas supporting innovation: PONANT's order for an ice breaking expedition class ship incorporates LNG as fuel for a hybrid electric propulsion system as well as an icebreaking hull.

The industry has a two-hundred-year history of ship propulsion innovation, evolving from wind power via coal fired steam to fuel oil and, now, gas. The transition from one phase to the next is never sequential, as old and new propulsion technologies have co-existed for lengthy periods. Bureau Veritas believes this pattern will continue going forward to 2030 and beyond, with the industry relying upon multi-pathway propulsion solutions encompassing co-existence of traditional fuel oils (residual, distillate), liquid natural gas (LNG), alternative fuels – including biofuels, liquid petroleum gas (LPG), methanol, hydrogen, ammonia and synthetic fuels – and batteries.

We also anticipate that different propulsion systems will co-exist on individual ships. The hybrid concept is nothing new – combined steam and sail powered ships, with sail increasingly becoming an auxiliary power source, were common in the 19th century. We foresee that this hybridized approach can be an enabler for reducing both EEDI and carbon intensity in our time. Recently designed ferries and offshore vessels are equipped with electric-hybrid power systems – they use batteries alongside oil or gas fueled engines. Furthermore, there is growing interest in revisiting the past to harness wind power in the form of kites, sails or Flettner rotors, as assisted propulsion sources on merchant ships.

Perhaps the key question to address is what to do TODAY? What options are available to a ship owner right now? The lack of clarity here is one of the reasons for the current low level of newbuilding activity. Additionally some of the technology signals are misleading. What may be suitable for a small ferry under local regulatory oversight in relatively sheltered waters, with rescue close at hand, may have no relevance for large ships designed for the deep sea and a world-wide range, trading under the requirements of international conventions.

Although alternative fuels – such as hydrogen and ammonia – and power systems – such as fuel cells and batteries – may prove to be long-term, zero-emission-technology solutions for shipping, today they are not ready for large scale deployment and will require huge investment over the coming

decades to realise their full potential, both in terms of onboard technology and fuel distribution networks.

Moving forward with pragmatism

LNG is available today and can be, at the very least, a stepping-stone to developing alternative carbon-free and carbon-neutral fuels. While it is a fossil fuel and there are concerns related to methane slip, LNG is a clean marine fuel with a well proven track record and expanding distribution network, which offers a step in the right direction towards lower GHG emissions in general and CO_2 emissions in particular. And as methane-based biogas or synthetic (or substitute) gas becomes available in the future, LNG fuelled ships could easily switch to new 'drop-in fuels' that are carbon neutral.

Batteries

For certain ship types, an avenue that can be pursued today is electrification using energy storage systems, predominantly batteries. Local ferries, which have moderate power requirements and operate on short duration fixed routes are suitable for fully electric powering. For other ships with either high power demand fluctuations – such as offshore service vessels – or temporary electric power (backup) requirements, electric-hybrid propulsion systems can significantly reduce fuel consumption and consequently emissions. The basic idea is to generate electricity at optimum efficiency and use energy storage to adapt to the power demand fluctuations. The technology is suitable for ultra-slow steaming and can be a solution of choice for multiple sources of power. A dedicated set of class notations and technical rules for electric-hybrid ships has been developed by Bureau Veritas to ensure safe and reliable operation and power management. The rules consider three different operating modes: power management, power backup and zero emissions. Bureau Veritas is involved in the classification of various electric-hybrid ships as well as fully electric ferries.

Wind power

Wind assisted propulsion (WAP) is currently gaining traction, with several initiatives underway to install Flettner rotors, sails or kites on ships. Although performance obviously depends on weather conditions – wind power is unlikely to become the main source of power – the energy saving potential is significant and WAP can contribute to meeting future EEDI reduction factors and reducing carbon intensity. Bureau Veritas is currently updating the class rules and is engaged in a number of forward-looking projects, through which we are assessing both safety and operational performance.

Debating the future of shipping: David Barrow, Vice President, South Asia - Bureau Veritas, Bjorn Højgaard, CEO Anglo-Eastern Univan and Charlotte Højgaard discussing the road to 2050 at the Bureau Veritas Asia and Australia Committee in April 2019.

An operational response

Fuel and power system choices aside, it should be acknowledged that there are operational means available to reduce energy demand, whereby (further) slowing down ships is the obvious candidate – a path taken by container ship operators in the wake of the 2008 financial crisis. In all likelihood slow steaming will be necessary to meet the 2030 carbon intensity reduction ambition of 40%. A number of issues need to be addressed though. Firstly, ships need a minimum amount of propulsion power for safe manoeuvring in heavy weather. This is addressed in IMO guidelines supplementing the EEDI requirements. Secondly, although speed reduction leads to a rapid decline in fuel consumption and emissions – the speed-power relationship is approximately cubic – for existing ships designed to operate at higher speeds the associated reduced engine load is likely to increase the specific fuel oil consumption (SFOC) of the engine, while the propeller and auxiliary systems may also no longer operate at their design point. Furthermore, the hull form will not be optimized from a resistance point of view. For existing ships this means that technical modifications to the propulsion train or even the hull – for example, replacement of the bulbous bow or fitting of energy saving devices – may be necessary to meet the savings objectives. Bureau Veritas has a proven track record in retrofitting existing container ships for (ultra) slow steaming operations.

Designed to go slow

At the same time, slow steaming provides opportunities for newbuildings, as both the hull form and the propulsion train can be fully optimized. Over the past decade, ships have become much more energy efficient. Combining slow steaming with hybridization would enable the development of optimized designs with more than one single

Oak Maritime Managing Director Jack Hsu taking part in the Environmental Panel during Bureau Veritas' Asia & Australia Committee meeting.

design point, and this could open the door to further future energy efficiency improvements.

Any consideration of slow steaming has to be made in the context of the bigger picture of shipping logistics. Slower ships mean that additional ships would be needed to maintain the same cargo throughput. Logistics chains will need to adapt. And this is an important point to consider, especially as international shipping contributes less than 3 percent to global CO_2 emissions, as reported in IMO's 3rd GHG study. It is important to acknowledge that we have to consider the entire supply chain when it comes to effectively addressing GHG emissions related to transportation. The Global Industry Alliance to Support Low Carbon Shipping (GIA), a public-private partnership initiative of the IMO under the GloMEEP Project, and of which Bureau Veritas is a member, has started discussing how "Just In Time" (JIT) operation can contribute to cutting emissions of shipping. This ties in with slow steaming initiatives. Another option to slash carbon intensity that strongly impacts on logistics is scale enlargement, as increasing the ship size will lead to lower emissions per tonne-mile-sailed. Although this has already happened in container shipping, and to a limited extend in bulk shipping, global trade patterns, port and navigational restrictions and the increased (insurance) risk associated with ultra-large ships are placing practical limitations on the idea.

Preparing for decarbonization

To prepare for a decarbonized future, the industry needs to invest in research and development to develop the technical means and fuel distribution networks. Collective action is needed. On the fuel side the development of new fuels is the key. Biofuels, hydrogen, ammonia and synthetic fuels produced with renewable energy – "power-to-gas" – are the apparent options to take us into a lower-carbon future. While on the power system side work needs to be done on fuel cells and batteries. All these alternative fuels and propulsion solutions need to be considered and explored, which is why Bureau Veritas is working together with industry partners on ambitious pilot projects in order to develop the regulatory framework necessary to support a sustainable future for shipping. There will be difficulties and obstacles to overcome with any of the new technologies.

The key issue is incentives. As shipping can only be a reflection of society, shipping's ability to evolve will depend on a commercial and regulatory environment that makes the necessary market and structural changes in support of a newer, cleaner world.

BUREAU VERITAS WAS FOUNDED IN 1828 TO ADDRESS MARINE RISKS

Our priority is safety – for our clients and for society. Today we are multi-sector Testing Inspection and Certification (TIC) organization with more than 75,000 people world-wide and about 1,400 laboratory and testing facilities.

My Fuel Consumption Monitoring emissions

In 2018, Bureau Veritas launched My Fuel Consumption, a digital application that helps clients manage new environmental regulations. In 2019, the app will allow users to submit their annual declaration of consumption online, and fully comply with EU MRV and IMO DCS reporting requirements.

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