

TESTING TIMES

The vital role of ship fuel oil assessment
and quantity verification in an uncertain era

Nic Gardner

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Based on new research by Thetius, this report examines the contemporary issues in the bunker supply chain and unpacks some of the strategies available to combat them and protect ship fleets from the dangers of off-spec and poor quality fuel.

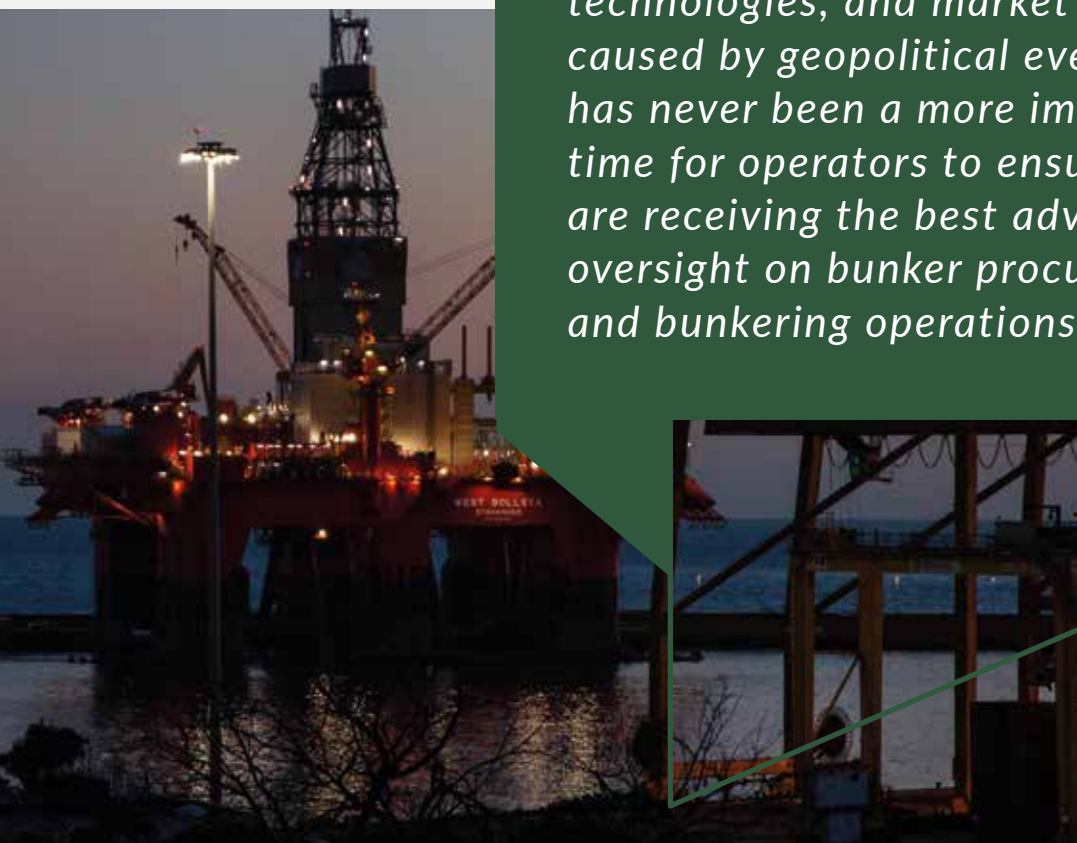
FOREWORD

ANDREW SHAW

MANAGING DIRECTOR,
LLOYD'S REGISTER
FUEL TESTING
SERVICES

We are delighted to work in collaboration with Thetius on this report to look at the issues surrounding fuel quality and the importance of testing in an era of contamination and new blended products that put at risk the safety of crew, the environment and the protection of the vessel as an asset.

Due to changing regulations, technologies, and market movements caused by geopolitical events, there has never been a more important time for operators to ensure they are receiving the best advice and oversight on bunker procurement and bunkering operations.



In an era of new fuels and the advance of biofuels we will continuously work with industry and regulators as a trusted advisor to ensure that fuel testing standards are developed and used to ensure transparency and fairness to all parties in the fuel buying process.

As this report discovers every year fuel suppliers globally deliver between 1 and 1.5 million MT of off-spec fuel to vessels engaged in international trade with the cost of average cost of a fuel quality dispute around \$54,000 highlighting the vital role of independent fuel testing.

At Lloyd's Register, we understand that speed and depth of a fuel testing service is essential and we continue to invest in our logistics team alongside our leading team of chemists and engineers to ensure that tests are carried out as efficiently and effectively as possible.

Due to changing regulations, technologies, and market movements caused by geopolitical events, there has never been a more important time for operators to ensure they are receiving the best advice and oversight on bunker procurement and bunkering operations.

In an era of new fuels and the advance of biofuels we will continuously work with industry and regulators as a trusted advisor to ensure that fuel testing standards are developed and used to ensure transparency and fairness to all parties in the fuel buying process.

I hope you enjoy reading the findings of this unique report into bunker testing and myself and my team are happy to discuss the issues and solutions in further detail.

Andrew Shaw, Managing Director, Lloyd's Register Fuel testing services.



INTRODUCTION

Despite the quickening pace of decarbonisation in the merchant shipping industry, fossil fuels remain central to powering global trade and the ocean economy in the years ahead. As manufacturers search for increasingly hard-to-obtain efficiencies from distillate and residual fuels, engines become increasingly susceptible to damage from poor quality or off-spec fuels.

To meet growing local demand, Europe will need to increase imports from North America, South America, and the Middle East and this will increase ton-mile costs for crude and refined stocks

Variations in bunker fuel quality have been a pressing issue for some time and lobbying for tighter bunker licensing and chain of custody schemes aimed at improving supply chain transparency have increased in recent years. But as operators and insurers are witnessing, the problem of off-spec and poor quality bunker fuel is at constant risk of resurgence.

Changes to the geographic orientations of global bunker fuel markets are another influential factor. To meet growing local demand, Europe will need to increase imports from North America, South America, and the Middle East and this will increase ton-mile costs for crude

and refined stocks, and put further price pressure on fuel supplies. As fraud and corruption in bunker supply continues to impact operator margins, this increased pressure may provide more oxygen to less scrupulous suppliers in the bunker supply chain, leading to even more variability in quality and quantity.

Based on new research by Thetius, this report examines the contemporary issues in the bunker supply chain and unpacks some of the strategies available to combat them and protect ship fleets from the dangers of off-spec and poor quality fuel. This report examines three key questions:

- ▶ What are the current key issues in bunkering?
- ▶ What trends and developments will affect bunkering over the coming decade?
- ▶ How can fleets protect themselves from the costs and risks of contaminated or off-spec fuel?





The monetary and environmental cost of maritime accidents has steadily increased over the last decade, despite the continuation of a general trend of improvement in safety across the global fleet.

CONTEMPORARY ISSUES IN FUEL OIL QUALITY AND QUANTITY

MACRO INFLUENCES

The monetary and environmental cost of maritime accidents has steadily increased over the last decade, despite the continuation of a general trend of improvement in safety across the global fleet. Major hull and machinery insurers Allianz Global Corporate and Speciality (AGCS) reported in May 2022 that 1 in 3 of these incidents are caused by machinery failure.¹ The report reflects an uncertain picture in bunker related incidents as cost, availability, and quality vary as a result of many different factors.

The report also points to the significant influence of the Russia-Ukraine war. While this conflict was certain to cause shockwaves in Europe and worldwide, the effects on shipping have not been limited to the economic cost of sanctions and severed trade links with the oil and grain markets. Aside from a significant crew welfare crisis at the outset of the conflict, the residue of which is still affecting some seafarers, disruptions to major oil supplies and infrastructure have impacted on the bunker markets in more subtle ways. Pre- and post-2020, Russian oil has been the dominant feed stock for global bunker markets and the disruption has caused shifts in market dynamics. Prices have fluctuated significantly, while availability has declined, but as AGCS points out, the disruptions have also resulted in an erosion of fuel quality for many vessels. Justus Heinrich, Global Product Leader and Head of Marine at AGCS said “We have already seen requests from ship owners who are considering

¹ Allianz (2022). Safety and Shipping Review 2022 - an annual review of trends and developments in shipping losses and safety. Retrieved from <https://www.agcs.allianz.com/>

using non-compliant bunker fuel that has a [lower flash point]. Longer term, we may see a shortage of bunker fuel with more and more vessels having to turn to non-compliant or substandard fuels.”

According to Thetius research, every year fuel suppliers globally deliver between 1 and 1.5 million MT of off-spec fuel to vessels over 5,000GT engaged in foreign trade. Of the off-spec or contaminated fuels that are detected, over 6,200 MT is de-bunkered at significant cost. Data from BIMCO and the IBIA published in May 2022 indicates that an average fuel oil quantity dispute costs \$27,790, while fuel quality disputes average just over \$54,000.²

The same source pointed to an initial spike in off-spec fuel detections immediately after January 2020, which gradually stabilised as the supply chain adjusted. However, the severity of the off-spec issues continued to increase, particularly in relation to fuel stability, sludging, and cold-flow issues.³ 55% of respondents had experienced off-spec fuel, 62% had experienced increased sludge deposits, and 32% had experienced wax appearance in the fuel system as a result.

Some unscrupulous bunker suppliers could take advantage of time-pressed operators who cut corners while stemming bunkers.

COMMERCIAL PRESSURE

Most vessels face considerable commercial pressure, including financial and time constraints. Time in port costs money; unforeseen delays can lead to missed tides, contractual breaches, and lost cargoes. When it comes to bunkers, this pressure forces ship managers to choose between potentially losing time and money due to short-delivery or substandard bunkers, or losing money due to delays in checking for and resolving problems.⁴ Some unscrupulous bunker suppliers could take advantage of time-pressed operators who cut corners while stemming bunkers.

Bunker suppliers also face challenges including low margins, changing regulations, fluctuating fuel costs, and payment defaults.⁵ Dealing with these issues may tempt some suppliers into unethical or illegal acts, from cutting corners to outright fraud. In these cases, the acts of the minority impact the majority, as it forces ship managers to distrust all suppliers.

² BIMCO & IBIA. (2022, May). BIMCO-IBIA BL & MFM Survey Analysis. <https://ibia.net/wp-content/uploads/2022/07/IBIA-BIMCO-BL-MFM-Survey-Analysis.pdf>

³ Gomersall, I. (2021b, March 23). IMO 2020: Marine fuel trends, quality, and issues. Seatrade Maritime. Retrieved August 17, 2022, from <https://www.seatrade-maritime.com/bunkering/imo-2020-marine-fuel-trends-quality-and-issues>

⁴ Sahu, S. (2022, January). S&P Global Commodity Insights. S&P Global Commodity Insights. Retrieved August 23, 2022, from <https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/oil/011422-mass-flow-meters-deliver-clear-benefits-for-bunker-industry-exxonmobil>

⁵ Clipper Oil. (2018, February). Real Issues Impacting Shipping Operators and Bunker Oil Suppliers. Retrieved August 19, 2022, from <https://www.clipperoil.com/real-issues-impacting-shipping-operators-bunker-oil-suppliers/>





Fraud and corruption remain risk factors in global trade and the scale and decentralised nature of the global fuel oils market can be both a strength and a weakness when it comes to recognising dishonest actors.

FRAUD AND CORRUPTION

Fraud and corruption remain risk factors in global trade and the scale and decentralised nature of the global fuel oils market can be both a strength and a weakness when it comes to recognising dishonest actors. The growth of accessible laboratory testing services and independent bunker quantity surveyors has made a measurable impact on this. The Maritime Anti-Corruption Network (MACN) recently reported corruption incidents have been decreasing since 2017,⁶ and over 75% of respondents in a recent Thetius survey of maritime bunkering stakeholders⁷ also believed bunker quantity fraud had decreased in the last decade. However, in the same survey, more than 90% reported knowledge of or experience with bunker quantity fraud suggesting that while the general trend has been improving, malpractice is still an issue.

This idea is supported by the 2022 BIMCO/IBIA survey⁸ that showed that 3 out of 5 respondents had experienced a bunker quantity dispute in the previous 12 months, and just under half had experienced a quality dispute in the same period.

The drivers of fraud and corruption are complex. Motivations can include cultural influences, fear, survival, and commercial pressure. Seafarers, bunker suppliers, and ship managers have little hope of addressing the underlying causes, so the industry as a whole must improve on the *management* of fraud and corruption: tackling the symptoms of the disease and minimising their effect.

6 Maritime Anti-Corruption Network. (2022, February). A Decade of Reporting. <https://macn.dk/wp-content/uploads/2022/02/MACN-ten-years-anonymous-reporting.pdf>

7 Thetius private research extracted under licence

8 Ibid 2 (BIMCO IBIA 2022)

LACK OF SUPPLY CHAIN TRANSPARENCY

Supply chain ‘transparency’ describes the openness and availability of supply chain and sourcing information to customers and other stakeholders. For the bunker markets, supply chain transparency would allow ship managers to map the bunker supply chain, trace the provenance of purchased fuel, and verify that it matches supplier claims about quality and specification.

Whether intentional or otherwise, the lack of traceability in the supply chain allows delivery of off-spec very-low-sulphur fuel oil (VLSFO) and poor-quality cutter stocks derived from aviation, automotive fuels, oil sands, and other untraceable and undesirable sources. Many common fuel adulterants do not just damage the environment, but can also damage engines and machinery.⁹ Further, this lack of transparency facilitates fraud and corruption, and hampers detection and evidence collection. Some startups are attempting to address this in different ways, including adding traceable chemical markers to fuel,¹⁰ and blockchain and molecular tagging.¹¹

Many common fuel adulterants do not just damage the environment, but can also damage engines and machinery.

UNEQUAL ENFORCEMENT OF FUEL STANDARDS

After the Baltic sulphur emissions control area (SECA) was introduced, researchers found compliance was higher at Great Belt Bridge than in the rest of the Baltic, perhaps because ships know that Great Belt Bridge is monitored and so steps are taken to prepare. Similarly, researchers found that outbound vessels are more likely than inbound vessels to breach the rules, as they are less likely to be inspected.^{12 13} This demonstrates that, to some extent, enforcement drives compliance.

There is some variability across regions, states, and even ports on the level of diligence in enforcing compliance with international standards, including fuel standards.¹⁴ Singapore is a leading example.

To tackle bunker malpractice, Singapore moved to a mandatory licensing model for bunker suppliers in 2017. Every bunker supplier in Singapore must hold a licence issued by the Maritime and Port Authority of Singapore (MPA) in



9 Traill, L. (2020, October). Fuel Authentication & Traceability through the Supply Chain: Advancing Quality & Sustainability. Authentix. Retrieved August 20, 2022, from <https://authentix.com/fuel-authentication-traceability-through-the-supply-chain-advancing-quality-sustainability/>

10 Dow. (n.d.). Accutrace. Retrieved August 20, 2022, from <https://www.dow.com/en-us/brand/accutrace.html>

11 BunkerTrace. (n.d.). BunkerTrace. Retrieved August 20, 2022, from <https://bunkertrace.co/>

12 Mellqvist, J., Beecken, J., Jacobo, A., & Ekholm, J. (2017). Surveillance of Sulfur Emissions from Ships in Danish Waters. Chalmers University of Technology. <https://doi.org/10.17196/DEPA.001>

13 Mellqvist, J., Beecken, J., Jacobo, A., & Ekholm, J. (2017). Fixed remote surveillance of fuel sulphur content in ships from fixed sites in the Göteborg ship channel and Öresund bridge. Chalmers University of Technology. <https://doi.org/10.17196/CompMon.001>

14 Saul, J. (2019, December 19). New clean shipping fuel rules, but who polices the polluters? Reuters. Retrieved August 23, 2022, from <https://www.reuters.com/article/us-shipping-imo-enforcement-idUSKBN1YN1UD>



For a ship operating in cold regions, the cold flow property of pour point in particular will require special attention.

order to operate. This gives MPA the power to monitor and enforce standards, including fuel standards. Serious or frequent breaches result in a licence being revoked, or renewal denied. One high profile example of this was recently demonstrated by MPA after High Sulphur Fuel Oil (HSFO) being sold at the port was contaminated with high concentrations of Chlorinated Organic Compounds (COCs). While the authority found no evidence that the suppliers in question had intentionally contaminated the fuel, they had failed to act on test results they had received and a further 24 vessels had been supplied with the affected stock. As a result, MPA suspended the supplier licence for two months and the company was asked to provide MPA with evidence of an improvement in procedures before resuming operations. Commenting on the incident, an MPA statement reads, '*MPA takes a serious view of contraventions of the bunker supplier licence terms and conditions, and will not hesitate to suspend or cancel the relevant licences, where necessary*'.¹⁵

CLIMATE CHANGE

As global warming opens up Arctic regions, the lower temperatures of the polar regions add yet another problem to the well-known list: low-temperature pour points. In a 2022 BIMCO/IBIA survey¹⁶ of fuel oil quality and safety, pour point was in the top four most common off-spec characteristics, only falling below sulphur, sediment, and aluminium plus silicon. For a ship operating in cold regions, the cold flow property of pour point in particular will require special attention to ensure that the temperature of the fuel is retained at at least 10° above the tested pour point to avoid solidification in the storage tanks and in the transfer fuel lines. Operationally, provided that the ship has sufficient fuel heating capacity and trace heating on the transfer pipe lines, then cold flow is purely a fuel management matter.

As with many VLSFOs, where the fuel viscosity is low and the pour point is found to be high (this can be as much as +40°), then attention needs to be given to ensure that the viscosity of the fuel at the engine is kept above the OEM recommended viscosity; normally stated as min. 2cSt at the engine fuel rail. Allowing the viscosity to drop can result in a drop in engine performance and increased fuel leakage.

¹⁵ MPA Singapore. (3rd August 2022). MPA Completes its investigations into bunker fuel contamination in Singapore port. Retrieved from <https://www.mpa.gov.sg/media-centre>

¹⁶ Ibid 2.

MARKET, TECHNOLOGY, AND REGULATORY TRENDS IN FUEL OIL BUNKERING AND QUALITY VERIFICATION

What follows is a brief summary of some of the key influencers on the fuel oil bunkering markets. These influences span a range of source types, from chemical developments, to technology, standards, and changes to the regulatory landscape.

With the barriers down, more ships may see a switch to compatible biofuels as an easy way to reduce carbon emissions, environmental impact, and reliance on fossil fuels.

BIOFUEL

The IMO's 2022 Unified Interpretation on the application of MARPOL Annex VI, Regulation 18.3¹⁷ defines "biofuel" as, "...a fuel oil which is derived from biomass and hence includes, but is not limited to, processed used cooking oils, fatty-acid-methyl-esters (FAME) or fatty-acid-ethyl-esters (FAEE), straight vegetable oils (SVO), hydrotreated vegetable oils (HVO), glycerol or other biomass to liquid (BTL) type products". The interpretation removes the main barriers to use of biofuels and biofuel blends on ships. Many biofuels have similar energy

density to fossil fuels, and can be a "drop in" replacement.¹⁸ With the barriers down, more ships may see a switch to compatible biofuels as an easy way to reduce carbon emissions, environmental impact, and reliance on fossil fuels.

First-generation biofuels are made from food crops such as sugarcane, corn and soybeans. This leads to an obvious trade-off between using such crops for food, or for biofuel.¹⁹ However, the real-world impact of this trade-off varies significantly between regions.²⁰

17 International Maritime Organization (IMO) Unified Interpretations to MARPOL Annex VI (MEPC.1/Circ.795/Rev.6). (2022, June). <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/MEPC.1-Circ.795-Rev.6.pdf>

18 Sustainable Shipping Initiative (SSI). (2021, June). Availability of sustainable biofuels. <https://www.sustainableshipping.org/wp-content/uploads/2022/01/Availability-of-Sustainable-Biofuels-Report-updated-final.pdf>

19 Chakraborty, D., Efthi, J. H., Khanom, M., & Mahbul, I. M. (2020). Prospective and Challenging Issues of Biofuels. *EDU Journal of Computer and Electrical Engineering*, 1(1), 4–10. <https://doi.org/10.46603/ejcee.v1i1.5>

20 Knápek, J., Králík, T., Vávrová, K., Valentová, M., Horák, M., & Outrata, D. (2021). Policy implications of competition between conventional and energy crops. *Renewable and Sustainable Energy Reviews*, 151, 111618. <https://doi.org/10.1016/j.rser.2021.111618>



second-generation biofuels can be produced from marginal land, which is unsuitable for food crops, and third-generation biofuels have higher yields and do not require any agricultural land use at all.

In most regions, even for first generation biofuels, research only points to a weak relationship between food prices, food shortages, and biofuel production.^{21 22} However, for a biofuel to be sustainable, it should not compete with people's basic needs, such as food and water.²³

Fortunately, second-generation or cellulosic biofuels are made from cellulose, such as non-food crops and waste biomass; third-generation biofuels, while not yet in commercial production, are produced with or from algae.²⁴

Because of this, second-generation biofuels can be produced from marginal land, which is unsuitable for food crops,²⁵ and third-generation biofuels have higher yields and do not require any agricultural land use at all.²⁶

As second- and third-generation biofuel production scales up, the trade-off between food and fuel will become less of a problem. Instead, biofuel production may one day create jobs and industries in regions where the land is unsuitable for agriculture. The question for industry is what influence biofuels will have on the ship fuels market.

21 Filip, O., Janda, K., Kristoufek, L., & Zilberman, D. J. (2017). Food Versus Fuel: An Updated and Expanded Evidence. SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.3070704>

22 Ahmed, J. (2020). The effect of biofuel crops cultivation on food prices stability and food security-A Review. EurAsian Journal of BioSciences, 14, 613–621.

23 Lloyd's Register; UMAS. (2018). Zero Emission Vessels, what needs to be done? Report prepared for Sustainable Shipping Initiative. Retrieved from https://sustainablesipping.org/wpcontent/uploads/2018/05/SSI_ZEV_Report_Final-May-2018.pdf

24 United States Environmental Protection Agency. (2022, April 14). Economics of Biofuels. US EPA. Retrieved August 18, 2022, from <https://www.epa.gov/environmental-economics/economics-biofuels>

25 Ibid 23

26 Ibid 20

Bunker licences give authorities the power to enforce standards and compliance and prevent negligent, corrupt, or sub-standard operators from conducting business.

BUNKER LICENSING SCHEMES

Bunker licensing schemes, in various forms, have been around for decades. Simply, a bunker licence specifies the minimum conditions for bunker suppliers to operate in a particular jurisdiction. Bunker licences give authorities the power to enforce standards and compliance and prevent negligent, corrupt, or sub-standard operators from conducting business. After introducing bunker licensing schemes in Singapore and Gibraltar, the number of quantity and quality disputes in those ports has decreased.²⁷

In the previously mentioned BIMCO/IBIA survey,²⁸ 80.85% of respondents would prefer to bunker at a port with a bunker licensing program, despite 48.9% believing it would increase fuel prices at the port. When bunker licensing schemes were first proposed to the IMO at MEPC 74 in 2019, the committee decided that the administrative burden of mandatory licensing would outweigh its benefits.²⁹

However, the committee did agree to draft a template for a voluntary licensing scheme. This template³⁰ was adopted at MEPC 76 in June 2021.³¹

Despite early friction at the IMO, a growing number of ports and countries, including several major ports at key locations, have implemented bunker supplier licensing schemes, with more considering doing so in the near future. After first discussing the idea in 1994, Port of Rotterdam finally introduced a provisional bunker licensing scheme in 2021, covering the Port of Rotterdam, Schiedam, Vlaardingen, Dordrecht, Zwijndrecht, and Papendrecht. The scheme will be reassessed and updated in 2023. The goal is to address an increasing number of bunker quality and quantity disputes, promote the transparency and traceability of the bunkering process, and improve the area's reputation for bunkering ports.³²



²⁷ Port of Rotterdam. (2022, June). Explanatory Notes to the Bunker Licence for Bunker Fuel Transporter. <https://www.portofrotterdam.com/sites/default/files/2022-06/bunker-license-fuel-transporter.pdf>

²⁸ Ibid 2

²⁹ Mfame. (2019, May). IMO To Discuss Bunker Licensing Scheme in April: IBIA. Retrieved August 22, 2022, from <https://mfame.guru/imo-to-discuss-bunker-licensing-scheme-in-april-ibia/>

³⁰ ICS, BIMCO, INTERTANKO, & WSC. (2019, December). Bunker Supplier Licensing Schemes (MEPC 75/5/2). IMO.

³¹ International Maritime Organization (IMO). (2021, June). Marine Environment Protection Committee (MEPC 76), 10 to 17 June 2021 (remote session). IMO. Retrieved August 22, 2022, from <https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MEPC76meetingsummary.aspx>

³² Ibid 28

MASS FLOW METERS

Also known as an inertial flow meter, a mass flow meter measures the mass of fluid flowing past a fixed point per unit time. When bunkering, a properly calibrated mass flow metre can monitor the mass flow, density and temperature throughout the bunker fuel delivery process. This has several advantages, including:

- ▶ lower workload;
- ▶ increased integrity, transparency and traceability;
- ▶ time savings;³³
- ▶ measurement independent of density and viscosity; and
- ▶ providing evidence in bunker disputes.

Despite this, mass flow meters are not perfect. They have several disadvantages and restrictions that affect their performance or viability, particularly on board ships. These can be divided into practical constraints, and dishonest operational practices by barge operators. Practical constraints include:

- ▶ high initial cost, particularly for large lines;
- ▶ errors at flow rates outside the rated limits (Q_{max} and Q_{min}) of the mass flow meter;
- ▶ limited temperature range; and
- ▶ signal noise that can affect accuracy.

Mass flow meters reduce the opportunities for dishonest barge operators, however some still try to work around them. Recently, authorities have identified the following dishonest practices:

- ▶ errors in the presence of strong magnets;^{34 35} and
- ▶ determined criminals who syphon off bunkers after the fuel has passed through the meter.³⁶

Mass flow meters reduce the opportunities for dishonest barge operators, however some still try to work around them.

33 ExxonMobil. (n.d.). Mass flow metering system (MFMS). Retrieved August 18, 2022, from <https://www.exxonmobil.com/en/marine/technicalresource/marine-resources/marine-fuels-mass-flow-metering-system>

34 Ship & Bunker. (2019, March). Singapore: Evidence Emerges of Attempts to Use Magnets to Influence MFM Bunker Volume Readings. Retrieved August 18, 2022, from <https://shipandbunker.com/news/apac/823021-singapore-evidence-emerges-of-attempts-to-use-magnets-to-influence-mfm-bunker-volume-readings>

35 Bunkerworld. (2021, September). Bunkerworld Blogs - Nine convicted for mass flow meters-related bunker fuel tamper in Singapore. Retrieved August 18, 2022, from <https://www.bunkerworld.com/news/insight/162591/Surabhi-Sahu-Nicholson-Lim/Nine-convicted-for-mass-flow-meters-related-bunker-fuel-tamper-in-Singapore>

36 Chinoy, K. H. (2017, May). Mass Flow Meter Malpractice? This is What We've Seen in Singapore and What You Can Do to Protect Yourself [Pictures]. Ship & Bunker. Retrieved August 18, 2022, from <https://shipandbunker.com/news/features/bunker-quality-quantity/289677-mass-flow-meter-malpractice-this-is-what-weve-seen-in-singapore-and-what-you-can-do-to-protect-yourself-pictures>

Despite these constraints, 94.15% of respondents in the 2022 BIMCO/IBIA survey,³⁷ would prefer to bunker from a supplier that has a mass flow meter installed and 79.79% would accept the supplier's figures from a properly installed, certified and used mass flow meter. This positive response is despite 59.57% believing that it would increase fuel prices. This suggests that many customers are willing to pay extra for the protection and assurance afforded by a mass flow meter, which may offset suppliers' high initial installation and purchase costs. When it comes to criminals deliberately bypassing or inducing errors in mass flow meters, proper inspection and enforcement within a bunker licensing scheme such as Singapore's will address this. Crucially, a mass flow meter working in tandem with an independent bunker quantity surveyor offers a robust approach to levelling the playing field.

In Singapore, mass flow meters have been mandatory for fuel oil deliveries since 2017, and for distillate bunkers since 2019. Because they are regulated within Singapore's bunker licensing framework, the MPA can enforce appropriate inspection, installation, calibration and maintenance regimes. This reduces ambiguity, and makes them a reliable means of measuring fuel quantity. In the BIMCO/IBIA Survey, 76.1% of respondents believed that the mandatory use of mass flow meters has had a positive impact on bunkering in Singapore.



As mass flow meters benefit bunker suppliers as well as shipowners, a growing number of bunker suppliers are voluntarily installing mass flow meters, examples of which can be found, among other locations, in China,³⁸ Gibraltar,³⁹ Turkey,⁴⁰ and Rotterdam.^{41 42}

In 2019, following Singapore's successful implementation of mandatory mass flow meters, Rotterdam considered following suit.⁴³ Although several shipowners had complained about widespread problems with bunker quantity, the port decided that there were insufficient complaints to justify mandating mass flow meters, and were concerned about litigation.⁴⁴

³⁷ Ibid 2.

³⁸ Liang, L. H. (2019, June). Chimbusco starts bunker deliveries using mass flow meters. Seatrade Maritime. Retrieved August 23, 2022, from <https://www.seatrade-maritime.com/asia/chimbusco-starts-bunker-deliveries-using-mass-flow-meters>

³⁹ CEPESA. (n.d.). Cepesa, the only bunker supplier to use mass flow meters - Cepesa. Retrieved August 23, 2022, from <https://www.cepsa.com/en/press/Cepesa,-the-only-bunker-supplier-in-the-Port-of-Gibraltar-to-use-mass-flow-meters>

⁴⁰ CYE. (n.d.). About Us - CYE Petrol. Retrieved August 23, 2022, from <https://www.cyepetrol.com.tr/about-us>

⁴¹ Ubmemea. (2014, February). OW Bunker brings mass flow meters to Rotterdam. Seatrade Maritime. Retrieved August 23, 2022, from <https://www.seatrade-maritime.com/europe/ow-bunker-brings-mass-flow-meters-rotterdam>

⁴² Ship & Bunker. (2022, January). Trefoil Installs Mass Flow Meter on ARA Bunker Barge. Retrieved August 23, 2022, from <https://shipandbunker.com/news/emea/432426-trefoil-installs-mass-flow-meter-on-ara-bunker-barge>

⁴³ Kristiansen, T., & Krigslund, N. (2019, April). Rotterdam is concerned about reports of bunker problems. Shippingwatch. Retrieved August 23, 2022, from <https://shippingwatch.com/Ports/article11311878.ece>

⁴⁴ Ship & Bunker. (2020, November). No Mass Flow Meter Mandate for Rotterdam Before 2023. Retrieved August 23, 2022, from <https://shipandbunker.com/news/emea/179817-no-mass-flow-meter-mandate-for-rotterdam-before-2023>

Hafnia has agreed to pay a higher price for bunker fuel in return for the supplier fitting and using mass flow meters, providing fully digitalised documentation, offering complete visibility into all loadings and deliveries.

Despite the lack of action from the port, the Oslo-listed tanker manager Hafnia offered to reward their suppliers with long contracts in return for voluntarily installing mass flow meters on their bunker barges.⁴⁵ In 2021, they entered an agreement with a bunker supplier in Amsterdam, Rotterdam and Antwerp (ARA).⁴⁶ Hafnia has agreed to pay a higher price for bunker fuel in return for the supplier fitting and using mass flow meters, providing fully digitalised documentation, offering complete visibility into all loadings and deliveries, and complying with Singapore's standards regarding the use of mass flow meters in bunkering. This agreement is a positive model to encourage wider use of mass flow devices.



UPCOMING CHANGES TO THE ISO 8217 STANDARD: SPECIFICATIONS OF MARINE FUELS

After IMO 2020 entered into force, BIMCO, ICS, INTERCARGO and INTERTANKO conducted an industry survey in order to, “...get a greater understanding of the quality of the new fuel oils and possible safety implications of the IMO 2020 sulphur regulation.”⁴⁷ This survey found that:

- ▶ 62% of respondents had experienced increased sludge in the fuel oil system and separators;
- ▶ 32% had experienced wax in the fuel oil system; and
- ▶ 31% had experienced operational issues related to increased catalytic fines (cat fines).

⁴⁵ Ibid 44.

⁴⁶ Carlsen, C. (2021, October). Hafnia and bunker supplier introduce mass flow meters and digital bunkering in ARA. Shippingwatch. Retrieved August 23, 2022, from <https://shippingwatch.com/carriers/Tanker/article12786032.ece>

⁴⁷ BIMCO, International Chamber of Shipping (ICS), INTERCARGO, & INTERTANKO. (2020). 2020 Fuel Oil Quality and Safety Survey Report. BIMCO. <https://www.bimco.org/-/media/bimco/news-and-trends/news/priority-news/2020/2020-fuel-oil-quality-and-safety-survey---report.ashx>



A specific fuel, contaminant, chemical or additive may cause problems for one ship, but not for another.

Ships' bunkers must comply with certain standards, namely ISO 8217, which details the specifications for compliant marine fuels, and ISO 4259, which covers sulphur limits. However, the most recent version of ISO 8217⁴⁸ was published in 2017, before IMO 2020 entered into force and before the problems it created were fully understood.

ISO TC 28/SC4/WG6 overseeing the revision of the marine fuel standard ISO 8217, was satisfied that jointly with the ISO/PAS 23263:2019, ISO 8217:2017 would address all of the raised concerns anticipated in way of stability, compatibility between different fuels, flash point, cold flow properties and the wide divergence of viscosity between bunkers that ships would likely have to contend with.

It also should not be forgotten that the initiative by IMO to require ships to have a Ship Implementation Plan (SIP), effectively helped to mitigate some of the risks of the anticipated challenges of the VLSFO RM (Residual Marine) grades during the switch over in January 2020. This resulted in a better informed and prepared industry for the impact that this overnight change to 0.50% m/m sulphur fuel was going to have.



48 International Organization for Standardization (ISO). (2017). ISO 8217:2017(en) Petroleum products – Fuels (class F) – Specifications of marine fuels (ISO 8217:2017). <https://www.iso.org/obp/ui/#iso:std:iso:8217:ed-6:v1:en>

All crude oil contains asphaltenes. In practical terms, asphaltenes cause sludge. Sludge creates waste, and takes extra time and money to manage and dispose of.

ASPHALTENES, COMPATIBILITY AND STABILITY

For ships, most bunkers are residual fuels: the fuels that are left at the bottom of the tower once the lighter fuel oils and products are removed. Generally, heavy fuel oil consists of cracked residua, reduced crude, or cracking coil heavy product which is mixed or 'cut back' to a specific viscosity with cracked gas oils and fractionator bottoms. These 'cutter stocks' vary widely, resulting in a range of possible blend recipes, and all the stability and compatibility problems that go with them.⁴⁹

All bunkers supplied under the RM category will contain asphaltenes. To avoid these asphaltenes dropping out to form sludge, it is important that the fuels meet the required sediment limits. Note that having a maximum asphaltene limit will serve no benefit, but rather the fuel has a suitable stability reserve built in by the supplier when blending and suppliers should ensure that sufficient reserve is built into the final blended product to be supplied. A range of tests for compatibility and stability are available, including toluene or xylene equivalence, P-value, or the ASTM D4740 spot test. However, these also aren't yet required under ISO 8217:2017.⁵⁰

WAX POINT, CLOUD POINT, AND PARAFFINS

ISO 8217:2017 specifies several parameters that affect a fuel's cold flow properties.

For distillate fuels, this includes pour point, cloud point, and cold filter plugging point.

However, of these only the pour point is specified for VLSFO or ultra-low-sulphur fuel oil (ULSFO). Operationally, providing the temperature of the residual fuel is above the pour point then the fuel with higher temperature wax appearance temperatures will remain transferrable to the higher temperature settling tank and separator pre-heating fuel system control. As these very low sulphur fuel oil have shown to be more paraffinic in nature, some level of increased wax deposition might be expected from the lower viscosity fuels and require more specific thermal management when passing through the separator fuel cleaning process. Asphaltenes will remain in suspension if the stability reserve is sufficient.^{51 52}

The wax appearance temperature for VLSFO is equivalent to the cloud point of a distillate fuel: it is the temperature below which wax forms. Wax appearance temperature is not specified in ISO 8217:2017, but it should be considered by buyers. Lloyd's Register-GMT offers their clients a test for sediment and wax precipitation point (SWPP) for low viscosity VLSFO.

49 Barsamian, A. (2019, January). ISO 8217 Specs Inadequate for IMO2020 Compatibility Issues. Ship & Bunker. Retrieved August 23, 2022, from <https://shipandbunker.com/news/features/industry-insight/459514-iso-8217-specs-inadequate-for-imo2020-compatibility-issues>

50 Ibid 49.

51 Breneol, A. (2015). Marine Fuel Stability and Compatibility – Issues, Tests and Management. ExxonMobil. https://www.exxonmobil.com/en/marine/~/_media/files/global/us/marine/news-and-resources/marine-fuel-stability-and-compatibility

52 Manifold Times. (2020, October). Infineum explains: ISO 8217:2017 should be viewed as a 'minimum performance benchmark' for VLSFOs. Retrieved August 24, 2022, from <https://www.manifoldtimes.com/news/infineum-explains-iso-82172017-should-be-viewed-as-a-minimum-performance-benchmark-for-vlsfos/>



Around 200 ships received fuel oil contaminated with chlorinated hydrocarbons in Singapore; of these, around 80 reported engine damage.

PROGRESS

In 2019, ISO published a 'Publicly Available Specification' (ISO/PAS 23263:2019) covering general requirements for all 0.5% sulphur fuels. This PAS briefly explains how ISO 8217:2017 applies to VLSFO, and includes specific considerations for:

- ▶ kinematic viscosity;
- ▶ cold flow properties;
- ▶ stability;
- ▶ ignition characteristics;
- ▶ cat fines; and
- ▶ compatibility.

It is likely that the next version of ISO 8217 will cover these areas in greater detail.

GAS CHROMATOGRAPHY-MASS SPECTROMETRY AND INVESTIGATION TECHNOLOGY

As mentioned earlier in this report, around 200 ships received fuel oil contaminated with chlorinated hydrocarbons in Singapore; of these, around 80 reported engine damage.⁵³ This contamination was not detectable through routine testing in line with ISO 8217:2017.⁵⁴

Performance varies among laboratories, but generally, good quality GC-MS testing offers a faster, more accurate and more cost-effective way to identify components of volatile and semi-volatile substances, such as bunker samples, by analysing the vapour above the sample. Because the analysis focuses on the vapour, not the fluid, residual fuels have many components that GC-MS will miss.⁵⁵



53 Ship & Bunker. (2022b, April). Singapore's MPA Names Glencore as Original Supplier of Contaminated HSFO. Retrieved August 25, 2022, from <https://shipandbunker.com/news/apac/675797-singapores-mpa-names-glencore-as-original-supplier-of-contaminated-hsfo>

54 Ship & Bunker. (2022c, April). SURVEY: Support Grows for Mandatory GCMS Testing After Singapore Bunker Contamination. Retrieved August 25, 2022, from <https://shipandbunker.com/news/world/141582-survey-support-grows-for-mandatory-gcms-testing-after-singapore-bunker-contamination>

55 Simmons, M. (2020, November 13). GC-MS Analysis of Bunkers. SMS Analytical. Retrieved August 25, 2022, from <https://www.smsanalytical.com/blog/gc-ms-analysis-of-bunkers>



Bunker claims are costly, but most claims and disputes centre around questions of fact: was the correct quantity of fuel oil delivered? And did the supplier meet the contractual and legal specifications?

When used to assess bunker samples, GC-MS can lead to a long list of contaminants. Unfortunately, for many of these, acceptable limits have not yet been established, and GC-MS is not an approved testing method under ISO 8217:2017.

PROGRESS

In light of several high-profile fuel contamination cases in recent years, shipping companies, P&I Clubs, and industry bodies are in favour of routine GC-MS testing, and are pushing for harmonised standards and test methods.

Larger labs offer GC-MS fuel sample testing in addition to standard testing in order to identify fuel contamination problems not yet covered by ISO 8217. Note that some labs can become oversubscribed, leading to significant waiting times for results, so again, there are advantages to using more established and better-resourced services.

LAB ON SHIP TEST KITS

Bunker claims are costly,⁵⁶ but most claims and disputes centre around questions of fact: was the correct quantity of fuel oil delivered? And did the supplier meet the contractual and legal specifications? Resolving these questions requires high-quality evidence to support answering those questions. Often, clauses in bunker suppliers' terms and conditions seek to limit admissible evidence, place a time-bar on claims, or otherwise make it difficult for shipowners to successfully claim in the case of a dispute.

One major difference between quantity and quality disputes is that, in most cases, it has always been possible for surveyors or crew to carry out accurate bunker quantity surveys to establish quantity on board; recently, mass flow meters have provided more accurate measurements during fuel transfer. For quality disputes, however, samples must be sent to labs ashore for analysis.

56 Ibid 2.



The accuracy of a test can be broken into two factors:

1. repeatability; and
2. reproducibility

If a test carried out on the same sample by the same operator, with the same equipment, and under the same conditions yields the same or very similar results, the test has high repeatability (r). If a test of the same sample yields the same or similar results under different test conditions, with different operators, and different equipment, then the test has high reproducibility (R). ISO 17025 sets the standards for testing and calibration laboratories.⁵⁷ Among other things, the standard requires full traceability of the testing of every sample; certain standards and records of equipment checks, maintenance and calibration; and staff qualifications.

Some on-board tests are more well-established, including tests of water content, kinematic viscosity, density, stability/compatibility, and microbial content. More recently, test kits have become available for on-board tests of cat fines and sulphur content.

P&I clubs warn that on-board testing, particularly of cat fines and sulphur, is not a full substitute for laboratory analysis, even though it is useful for providing ships' engineers with an early warning of problems.

Despite this, P&I clubs warn that on-board testing, particularly of cat fines and sulphur, is not a full substitute for laboratory analysis, even though it is useful for providing ships' engineers with an early warning of problems.^{58 59} West P&I Club explains that it can be difficult to prove that bunkers did not meet contractual specifications if, "...the laboratory analysing the bunkers did not keep proper records," as the defending party may be able to throw doubt on the analysis.⁶⁰ Therefore, regardless of the accuracy of on-board tests, when dealing with claims and disputes, tests should be carried out by a recognised laboratory to avoid questions as to the validity of the samples.⁶¹

⁵⁷ ISO. (n.d.). ISO/IEC 17025 Testing and Calibration Laboratories. Retrieved August 28, 2022, from <https://www.iso.org/ISO-IEC-17025-testing-and-calibration-laboratories.html>

⁵⁸ The North of England P&I Association. (2018). Marine Fuels: Preventing Claims and Disputes. The North of England P&I Association.

⁵⁹ North P&I. (2016, September). Testing Time for Bunkers. Retrieved August 28, 2022, from <https://www.nepia.com/articles/testing-time-for-bunkers/>

⁶⁰ West P&I Club. (2019). Bunker Quality Disputes Part 2: Legal and Claims Handling Considerations. https://www.westpandi.com/getattachment/cf85bdab-1b86-46a2-ad62-c67277c59f40/p-i_guide_bunker_quality_disputes-part2_12pp_v3_lr.pdf

⁶¹ idem

REGULATORY CHANGES

The regulations affecting ship bunker fuel are updated regularly. Significant recent and upcoming changes include the MARPOL fuel oil sampling amendment that entered into force in April 2022,⁶² and the SOLAS flashpoint amendments that are likely to be adopted at MSC 106 in October 2022.⁶³

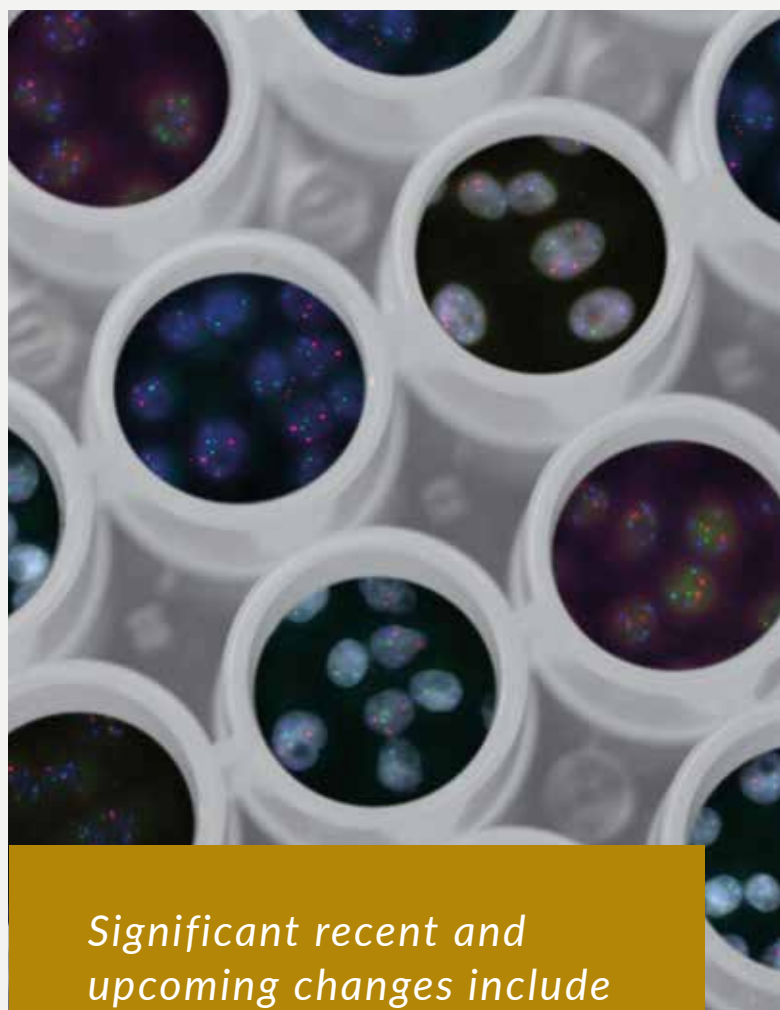
MARPOL AMENDMENTS TO FUEL OIL SAMPLING AND TESTING

For ships, the MARPOL amendments on fuel oil sampling that entered into force in April 2022, are straightforward. The key amendments are:

- ▶ definitions of three types of fuel oil samples:
 - in-use sample;
 - onboard sample; and
 - MARPOL delivered sample;
- ▶ requirement for designated sampling points for taking samples of in-use fuel oil;
- ▶ new procedures for in-use and onboard fuel oil sampling;
- ▶ procedures for verification and analysis of in-use samples and onboard samples; and
- ▶ amended procedures for verification and analysis of MARPOL delivered samples.

Sample types

As the names suggest, an in-use sample is a sample of the fuel oil actively in use; an onboard sample is a sample of fuel carried on board; and a MARPOL delivered sample is a sample of the fuel oil delivered during bunkering.



Significant recent and upcoming changes include the MARPOL fuel oil sampling amendment that entered into force in April 2022.

62 IMO. (2020, November). Amendments to MARPOL Annex VI (Procedures for sampling and verification of the sulphur content of fuel oil and the Energy Efficiency Design Index (EEDI)) (MEPC 75/18/Add.1). [https://www.wcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/MEPC.324\(75\).pdf](https://www.wcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/MEPC.324(75).pdf)

63 IMO. (2022, April). Maritime Safety Committee (MSC 105), 20–29 April 2022. IMO. Retrieved August 29, 2022, from <https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MSC-105th-session.aspx>

In-use fuel oil sampling points

To enforce the IMO 2020 rules on fuel sulphur content, competent authorities must be able to take samples of the fuel in use. To enable this, ships (other than those using low-flashpoint fuels) must be fitted with a sampling point or points for in-use fuel, and issued with an updated supplement to the International Air Pollution Certificate (IAPP).

The new rules apply to fixed and floating drilling rigs, and ships of 400gt or over. New ships with the keel laid on or after 1 April 2022 must comply on delivery; existing ships must comply by the first IAPP renewal survey on or after 1 April 2023.

As with most IMO requirements, the amendment is goal-based, and the pipework modifications must comply with the relevant guidelines,⁶⁴ be in-line with Classification Societies' rules,⁶⁵ be clearly marked for easy identification, and included in the piping diagram or other documentation. If no existing sampling point is suitable, designers should consider possible fuel oil cross-contamination and service tank arrangements when designing new sampling points.

Fuel oil sampling procedures

As with traditional MARPOL fuel oil samples, samples drawn by inspectors:

- ▶ should be taken when there is a steady flow through the fuel system;
- ▶ must be taken after the sampling connection has been thoroughly flushed through;
- ▶ must be sealed and labelled in the presence of the crew; and
- ▶ the ship should be given the option of retaining a sample.



To enforce the IMO 2020 rules on fuel sulphur content, competent authorities must be able to take samples of the fuel in use.

⁶⁴ IMO. (2019, May). 2019 Guidelines for On Board Sampling for the Verification of the Sulphur Content of the Fuel Oil Used on Board Ships (MEPC.1/Circ.864/Rev.1). https://info.lr.org/l/12702/2021-12-09/ccz5bj/12702/1639062437mCl3JbzQ/MEPC.1_Circ.864_Rev.1.pdf

⁶⁵ Lloyd's Register (LR). (2022, February). MARPOL Annex VI – Fuel Oil Sampling Points. Retrieved August 28, 2022, from <https://maritime.lr.org/classnews2022-02>



Fuel oil sample verification and analysis

All samples, whether they are MARPOL delivered, onboard or in use, must be tested by a lab accredited for that particular test. Accredited labs will reject any sample received with a broken seal. Once the lab breaks the seal, they will take two sub-samples, reseal the original sample, and test the two sub-samples. If the tests of the two samples fall within the repeatability range for that test, the lab will average the two and provide an aggregate result. At this point, the procedures for the MARPOL delivered and onboard/in use samples diverge.

MARPOL delivered samples are compliant if the sulphur content is below the applicable regulatory limit (i.e. 0.1% or 0.5%). Onboard and in use samples have some leeway, and are still compliant even if they are 59% of the reproducibility limit above the regulatory limit. That is, if the sulphur content is below 0.11% or 0.53%, as appropriate.

SOLAS AMENDMENTS ON FLASHPOINT

An ISO comparative study found that in the first half of 2020, there was a small increase in marine distillate fuel samples with a flashpoint below the 60°C required by SOLAS.⁶⁶ Despite evidence that VLSFO is no more prone to low flashpoint than HSFO,⁶⁷ low-flashpoint fuel does pose dangers when carried unknowingly. Therefore, IMO MSC 105 approved draft amendments to SOLAS chapter II-2 in relation to flashpoint.

These amendments are expected to be adopted at MSC 106, and enter into force on 1 May 2024. Under the draft amendments, which will be supported by matching amendments to MARPOL Annex VI, Appendix V, bunker delivery notes must be provided before bunkering. In addition to the existing content, these delivery notes must include:

- ▶ a signed declaration that the fuel supplied complies with regulation SOLAS II.2/4.2.1;
- ▶ a description of the test method used for measuring the flashpoint;

and either:

- ▶ the measured flashpoint (if below 70°C); or
- ▶ a statement that the flashpoint has been measured at or above 70°C.
- ▶ Flashpoint measurements above 70°C may be included, but it is not required.

⁶⁶ IBIA. (2019, November). IMO meeting considers flashpoint and other safety implications of 0.50% bunker fuel sulphur limit. Retrieved August 27, 2022, from <https://ibia.net/2017/06/20/imo-meeting-considers-flashpoint-and-other-safety-implications-of-0-50-bunker-fuel-sulphur-limit/>

⁶⁷ idem

GUIDANCE ON CURRENT BEST PRACTICE IN FUEL OIL ANALYSIS AND QUANTITY VERIFICATION

Bunker fuel represents a significant proportion of the running costs for merchant vessels and many experienced captains, crew, and shorebased staff view bunkering operations as a routine part of daily operations.

But the risks associated with bunkering off-spec or off-quantity fuel remain a significant and costly issue. Many suppliers offer a robust bunker supply service supplying good quality, on-spec fuels in the correct quantities, but even well known suppliers can themselves be the victims of upstream contamination or mistakes from trade partners like barge operators.

Below are three core recommendations to help keep fuel oil consumers protected:

...even well known suppliers can themselves be the victims of upstream contamination or mistakes from trade partners like barge operators.



3

STRATEGIC RECOMMENDATIONS FOR MANAGING FLEET FUEL OIL IN THE FUTURE

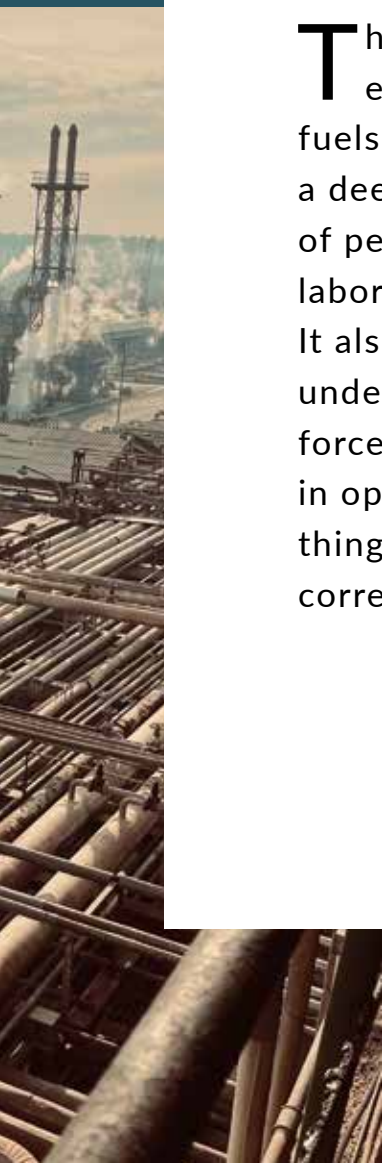
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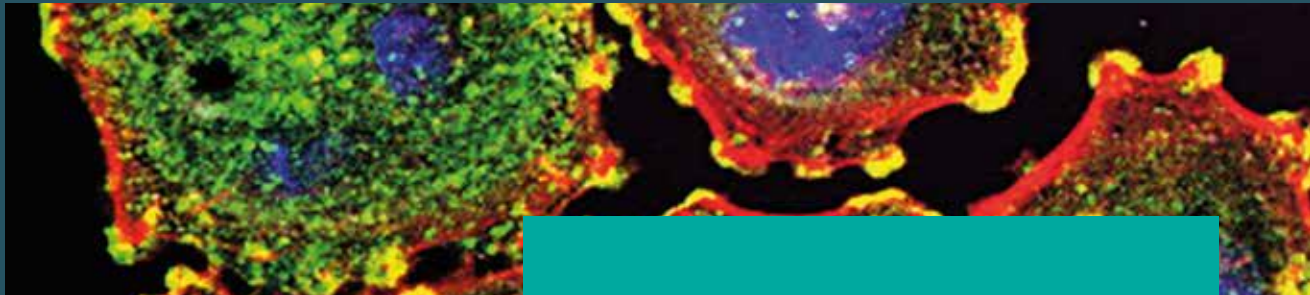
EXPERTISE MATTERS.

The testing, analysis, and evaluation of bunker fuels requires more than a deep understanding of petro-chemistry and laboratory techniques. It also requires a deep understanding of market forces, regional differences in operation, and when things are found amiss; corrective actions.

Earlier this year, Thetius conducted a series of interviews with a cross-section of demand-side operators with experience and responsibility for bunkering their vessels. 9 in 10 of them wanted to speak to a trusted expert in the event of an off-spec or contamination detection. Not only are corrective measures potentially complex and dependent on the unique circumstances and equipment fit of a particular vessel, but where disputes arose with suppliers, ship operators need an independent expert witness who is trusted by both parties. The overwhelming feeling among respondents was that presenting test results from a trusted testing service like LR's FOBAS/BQS was pivotal to the timely resolution of such disputes.

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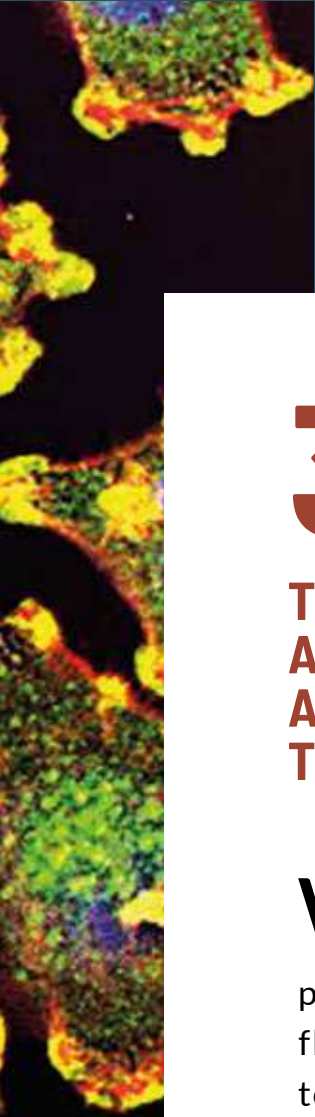
2.

WORK WITH SUPPLIERS TO SET CLEAR EXPECTATIONS.

One example of this could be to agree to longer contracts with trusted suppliers in exchange for installing mass flow metres similar to those set out in the Singapore requirements.

High profile incidents of fuel contamination provide a focal point for the shipping industry to have a wider discussion around the causes and effects of off-spec fuel.

High profile incidents of fuel contamination provide a focal point for the shipping industry to have a wider discussion around the causes and effects of off-spec fuel. But less widespread or lower impact incidents are more common than the high profile incident rate suggests. Demanding that suppliers adhere to certain standards of transparency and disclosure would go some way to rebuilding trust between both sides of the market and testing and verification services are well placed to consult with both parties on such arrangements.



3.

TAKE A BELT AND BRACES APPROACH TO NEW TECHNOLOGY.

Where time-to-result is critical, providing test kits and flow monitoring equipment to crew, training them to use them effectively, and backing up results with laboratory analysis offers a well thought-out approach to reducing fuel risks.

Results from flow meters fitted to the ships receptacle pipework is not only accepted by many suppliers, but helps build a complete picture, aiding the bunker surveyor and crew in their duty to ensure an equitable transaction takes place.

As discussed, lab-on-ship test kits cannot be considered a replacement for professional testing and verification services, but detecting potential issues in real time can support decision making. If the bunkers being stemmed are anticipated for use on the next leg of the voyage, self-test kits might make the difference whether the vessel sails before a full laboratory analysis is completed. Similarly, results from flow meters fitted to the ships receptacle pipework is not only accepted by many suppliers, but helps build a complete picture, aiding the bunker surveyor and crew in their duty to ensure an equitable transaction takes place.

CONCLUSION

The bunkering industry has a lot to be proud of when looking back over the last few decades. What was once thought of as 'bandit country' for operators has evolved through the creation of standards, the development of new technologies, supplier consolidation, and changed attitudes to refuelling from both sides into a higher-functioning industry. However, significant gaps remain where opportunities for poor fuel quality and off-quantity deliveries can gain and maintain a foothold. →

Macroeconomic and geopolitical influences such as Russian military aggression in Ukraine, the commercial pressures felt by a shipping industry that is obliged to adapt to a disorientating period of change and development, the ever-present spectre of fraud and corruption, lack of supply chain transparency, the unequal enforcement of emerging fuel standards, and of course - climate change, conspire to make the market prone to serious issues. When evidence shows that in excess of one million metric tons of off-spec or non-compliant fuels are detected each year, the cost to industry is considerable, with the bill to the unwary ship operator estimated at \$27 - 50,000 USD per event. By comparison, the cost of testing and verification

When evidence shows that in excess of one million metric tons of off-spec or non-compliant fuels are detected each year, the cost to industry is considerable, with the bill to the unwary ship operator estimated at \$27k - 50k USD per event.

services is attractive, but the benefits are not just financial. Strong evidence suggests that operators need reliable support in bunkering disputes and independent testing and verification is the only way of being truly supported.



Shipping cannot hope that supply side controls will eventually eliminate the problems from their risk registers without also making sound basic investments into protecting their own assets and interests.

The issues that operators face need to be considered alongside some of the more positive, but no less influential developments. Some examples covered here include the introduction of biofuel oils, the increasing prevalence of bunker licensing schemes, the increased commonality of mass flow meters, upcoming changes to ISO standards for marine grade fuels, and the rise of more standardised test methods using GCMS, FTIR and other techniques, along with the development of more imaginative performance based testing standards, some of which are under development at this time. and 'lab-on-ship' technologies. Together, they form a picture of the constantly shifting patterns, parameters, and problems that ship operators face in their bunkering operations whether fully aware of the risks or not. As regulations, technologies, and market movements conspire, there has never been a more important time for operators

to ensure they are receiving the best advice and oversight on bunker procurement and refuelling operations.

The outlook is generally optimistic in the bunker markets during the long transition to alternative fuels. But as recent events in Singapore (one of the most scrutinised bunkering locations in the world) have shown is that one thing remains true regardless of the macro trends; professional testing and verification services are the only reliable way to protect seafarers, assets, and financial transactions from harm. Shipping cannot hope that supply side controls will eventually eliminate the problems from their risk registers without also making sound basic investments into protecting their own assets and interests. New standards and regulations will help those who also chose to help themselves.

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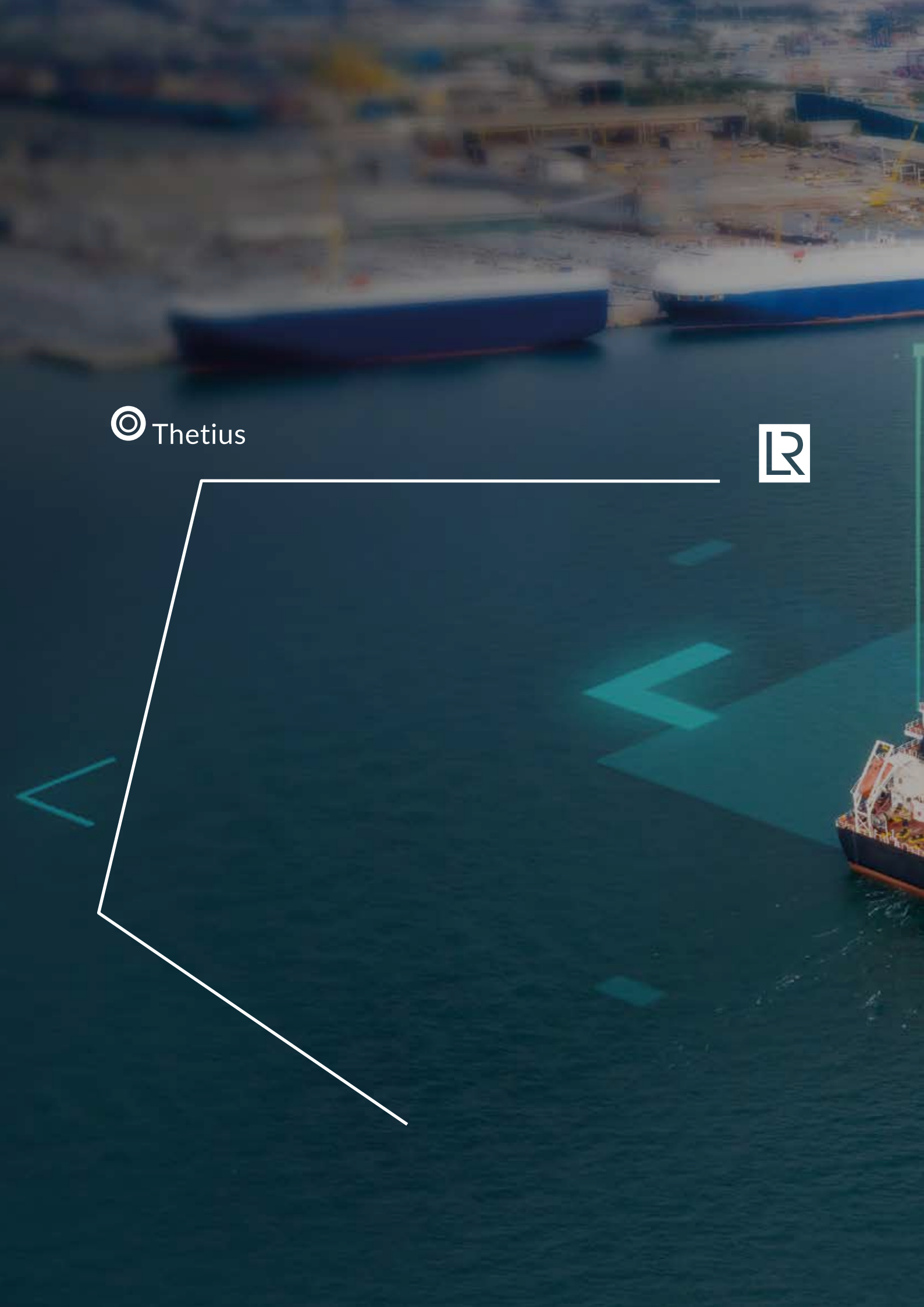
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