Response to spills of alternative fuels and energy products

Very low and ultra low sulphur fuel oils

KEY MESSAGES

- Very low sulphur fuel oil and ultra low sulphur fuel oil vary widely in their physicochemical characteristics
- Knowledge of their characteristics - particularly viscosity and pour point, but also other parameters - is essential to understand their behaviour and potential impacts, and to ensure appropriate spill response options are deployed

INTRODUCTION

Low sulphur marine fuels are increasingly being adopted globally; therefore it is important for oil spill contingency planners and responders to understand their potential fate, behaviour and impact if accidentally released to the environment. This fact sheet examines their properties and characteristics and suggests appropriate response strategies for two classes of fuels:

VERY LOW SULPHUR FUEL OIL (VLSFO)	• Mandated under the International Maritime Organization's MARPOL Annex VI since 2020, VLSFOs contain a maximum of 0.5% sulphur
ULTRA LOW SULPHUR FUEL OIL (ULSFO)	• MARPOL Annex VI also allows the designation of Sulphur Emission Control Areas, where use of ULSFOs with a maximum of 0.1% sulphur content is mandated

References and links to further reading are provided at the end of this fact sheet. Information common to all the fact sheets in this series is provided here.

0.5% S CAP

VERY LOW SULPHUR FUEL OIL

Refiners and suppliers formulate VLSFO in a variety of ways to encourage widespread availability whilst meeting the mandated requirements.

The formulations' highly variable nature means a knowledge of key properties concerning the fuel oil on board is crucial to ensure that appropriate spill response options are deployed.

PHYSICOCHEMICAL PROPERTIES

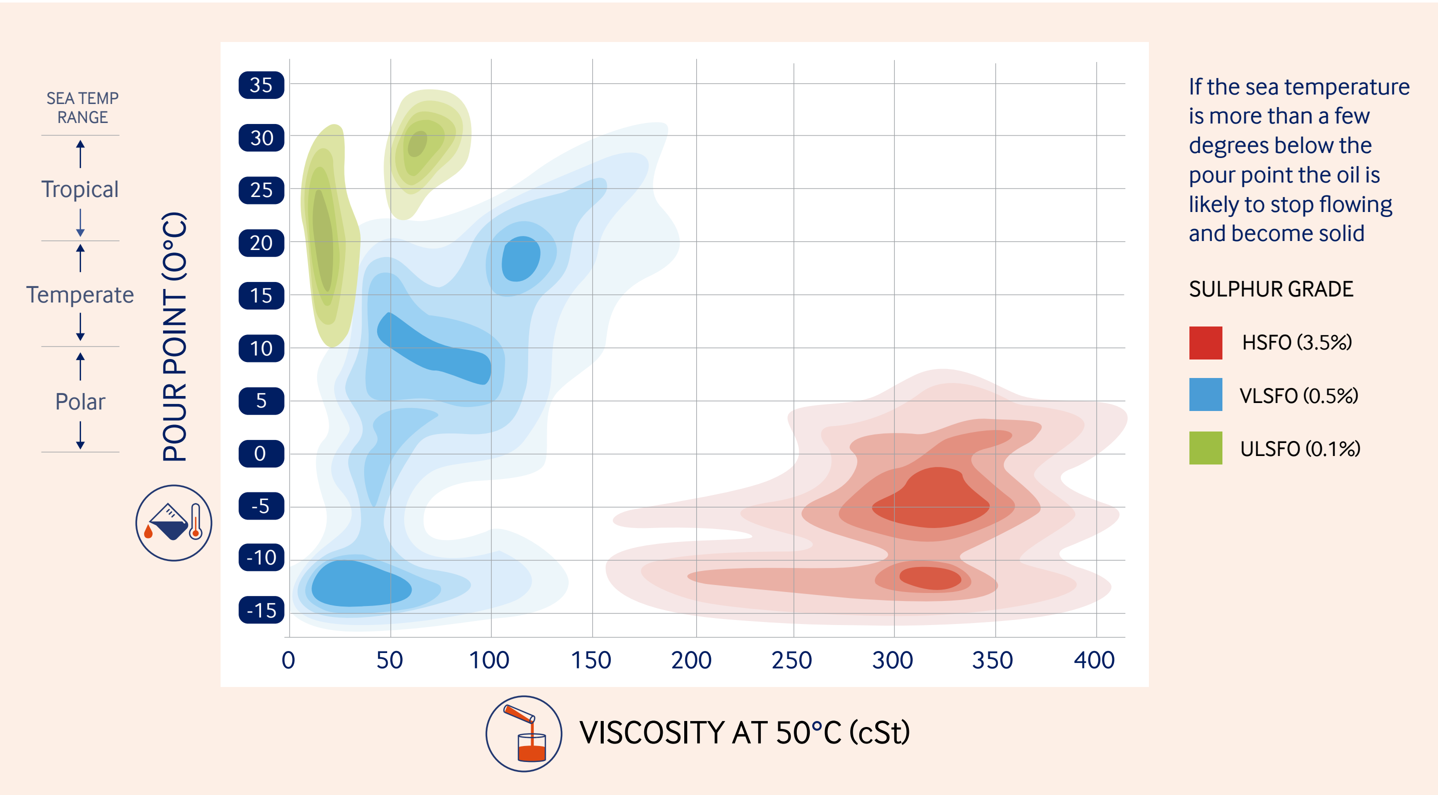
VLSFOs can vary widely in density, viscosity, pour point and stability, due to the wide variation in their composition. Spilled VLSFO may spread very quickly and flow freely or have a thicker consistency and even form waxy lumps.

Its behaviour depends on the oil properties and ambient sea temperature, and it will change over time through weathering processes. Figure 1 illustrates the variation in pour point and viscosity of low sulphur fuel oils. Viscosity at 50°C is shown; it will be higher at ambient sea temperatures. Both parameters will increase as an oil weathers.

The formation of water-in-oil emulsions has been demonstrated in various studies; this contributes to the viscosity increase and adds volume to the pollutant. The likelihood, extent and stability of emulsion formation will vary in relation to an oil's characteristics and the prevailing sea state. Viscosity can increase to over 100,000 centistokes (cSt) at ambient temperatures, primarily through evaporation and emulsification processes.

Knowing the characteristics of the fuel onboard may be complicated by one bunker fuel being loaded 'on top' of another fuel sourced at a different port and possessing significantly different characteristics. Good practice recommends limiting the mixing of fuels where possible. In the event of a spill, reference to the safety data sheet and bunker delivery note for the fuel(s) loaded and a discussion with the ship's chief engineer will help to clarify this. Whilst this knowledge will provide pointers to behaviour, the uncertainties and variations in ambient environmental conditions, such as sea state and temperature, emphasise the need for initial and on-going field sampling and assessment during a spill response.

Figure 1: Variation in pour point and viscosity of low sulphur fuel oils compared to high sulphur fuel oil (HSFO)

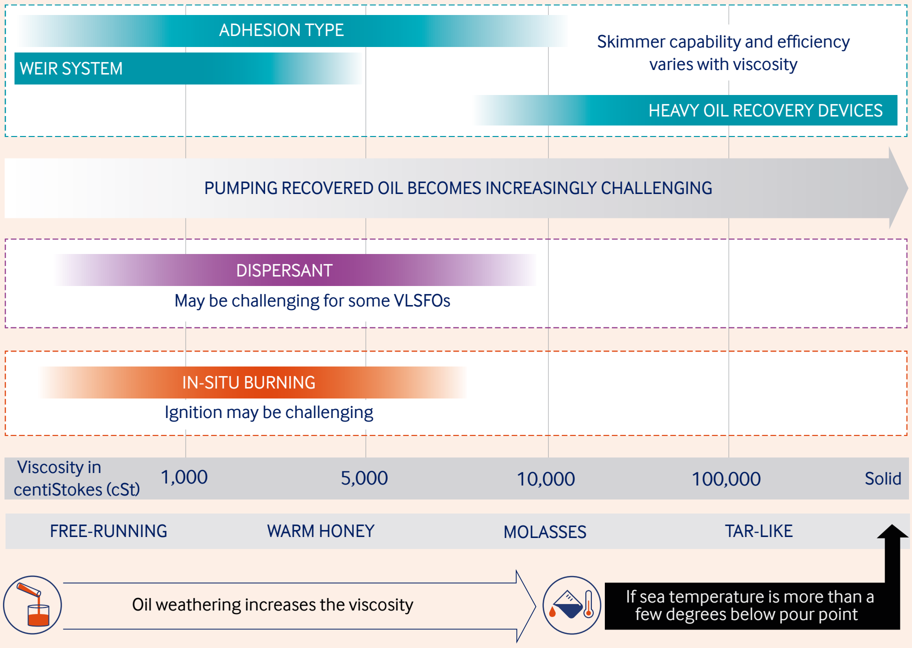


RESPONSE AND CLEAN-UP

Response tactics for spills of VLSFO are difficult to generalise due to the variability of their properties. However, in principle, persistence of some fraction of the oil should be anticipated. Viscosity, pour point and ambient temperature will have a major influence on which response options may be viable (Figure 2). Responders should endeavour to have the full response toolkit available and to be ready to adapt as the oil weathers.

Figure 2 illustrates the challenges spilled VLSFO may present, highlighted in the following key points:

Figure 2: Graphic illustrating the typical operating ranges for various response options in relation to VLSFO viscosity



CONTAINMENT AND RECOVERY

It is good practice to have a range of skimmer types available within an equipment stockpile. Depending on the ambient temperature and weathering states of the oil, the efficiency of skimmers can vary widely. Very high viscosity product, particularly encountered when the water temperature is more than a few degrees below the VLSFO's pour point, may require recovery devices that can grab, net, or capture non-flowing material. High viscosity recovered oil also poses challenges for pumps and may need positive displacement or screw pumps with options for water annular injection and wide diameter hoses. Consider storage and onward transfer of recovered material, possibly using heating to reduce oil viscosity.

DISPERSANTS

There is currently no real-world experience of dispersant application to spilled VLSFO. Laboratory studies indicate effective dispersion of some VLSFOs if viscosity remains within the range indicated in Figure 2. Higher pour points and oil weathering may result in poor or ineffective dispersion, a factor more prevalent in colder climates. Governmental authorisation should be received prior to dispersant application.

IN-SITU BURNING

There is currently no in-situ burning (ISB) field experience with VLSFOs, but most are predominantly paraffinic and once ignited they are likely to burn reasonably well. However, laboratory studies have concluded that the low volatile content of VLSFO may make ignition challenging. Emulsification of the product would further reduce ignitability.

SHORELINE CLEAN-UP

The behaviour of VLSFO on shorelines and subsequent choice of clean-up techniques will depend on the VLSFO's initial composition, weathering and type of shoreline. There is potential for VLSFO to penetrate porous beach types. Field experience and controlled studies indicate that the range of techniques currently used on many oil spills (including manual methods and flushing/collection) may be viable. Assess each scenario using existing guidance on a case-by-case basis.

OILED WILDLIFE

If the VLSFO retains a free-running low viscosity it will be easier to clean captured wildlife compared to more viscous fuels such as heavy fuel oil. However, preening animals can easily ingest low viscosity oil leading to internal health issues. No changes to standard wildlife procedures are suggested due to the low sulphur content.

RESPONDER AND PUBLIC HEALTH CONCERNS

The properties of VLSFOs do not pose any new challenges beyond those already managed by established good practice in oil spill responder and public safety guidance. The products tend to have low volatile content, indicating reduced risks relating to fire, explosion or inhalation, particularly following a short weathering period. Responders should wear suitable personal protective equipment to avoid skin contact when involved in clean-up.

POTENTIAL IMPACTS ON MARINE LIFE

Laboratory studies using the water-accommodated fraction of VLSFOs indicate their acute toxicity is like other marine fuels, including distillate fuels and residual heavy fuels. Generally, the products are lower in aromatic components compared to many crudes or other oil products. Therefore, there are no unique factors relating to sulphur content when looking at sensitive resource impacts. If the product is chemically dispersible, a spill impact mitigation assessment (SIMA) should be considered.

DETECTION, MONITORING AND SAMPLING

VLSFO spills result in surface slicks that can be detected and monitored like other floating oils. This includes aerial observation using visual or infra-red sensors along with satellite, aircraft or vessel detection using radar. The quality and reliability of detection will depend on the volume of oil spilled, its weathering characteristics and the prevailing sea and environmental conditions. Some VLSFOs may approach the water density and become neutrally buoyant or over-washed by waves. This can compromise the detection process.

Standard oil sampling methodologies are applicable to VLSFOs. Due to the VLSFOs' variable characteristics and lack of field information from spills, taking samples for laboratory analyses throughout an incident is encouraged to verify and build the knowledge base. Field kits can be used to test the dispersibility of spilled oils, when considering dispersant use.

MODELLING SPILLS

Where the VLSFO's characteristics are known, its fate and behaviour when spilled can be predicted by oil spill computer models. These models provide estimations of slick movement and oil weathering under forecast or modelled environmental conditions (temperature, wind velocity, sea state and currents). The model outputs can guide oil spill contingency planners or incident management teams when responding to a spill. Laboratory and mesoscale (flume or test tanks) studies can be used to verify or improve modelling for a specific oil as part of a contingency planning process.

ULTRA LOW SULPHUR FUEL OIL

In most cases these fuels are distillate blends of marine gas oil (MGO) and are therefore 'clean and bright'. They may also be marine diesel oil (MDO) or various blends of distillate marine (DM) fuel and residual marine (RM) fuel which have residual (black) product blended into them. These are described in ISO 8217:2017 which also contains a dispensation for fuel to contain up to 7% fatty acid methyl ester (FAME) which is biodiesel derived from renewable sources. This is becoming more common as electric vehicle use expands and diesel vehicle use diminishes. Automotive diesel is also a useful blend component as it is extremely low in sulphur.

RESPONSE AND CLEAN-UP

Three general types of ULSFO can be considered having significant bearing on oil spill response considerations:

(1) MGO (clear and bright DM grades).

(2) Fuel sourced from the automotive diesel fuel supply chain which, although extremely low in sulphur, may increasingly contain FAME/biodiesel.

(3) Hybrid RM fuels, such as low (0.1%) sulphur MDO blended with residual product. An example hybrid RM fuel is the low-viscosity RMD 80, favoured in the commercial industry by fishing vessels and cruise ships for its convenience of not requiring heating.

Response considerations for ULSFO spills of type (1) and (2) are similar in most respects to those historically used for diesel. This may not be the case with hybrid RM/DM fuel spills (3), due to the incorporation of residual product. These products are likely to display properties within the range already discussed for VLSFO. Response considerations will be similar and determined by a product's specific characteristics. ULSFOs can have relatively high pour points, leading to high viscosities in colder temperatures and resultant response challenges.

RELEVANT RESOURCES

Coelho, G., Slaughter, A., Liu, R., Boufadel, M., Broje, V. (2021). 'Development of a dispersibility assessment kit for use on oil spill response vessels.' *Marine Pollution Bulletin,* Vol. 170. https://doi.org/10.1016/j.marpolbul.2021.112665

Norwegian Coastal Administration (2021). *IMAROS.* www.kystverket.no/en/preparedness-and-emergency-response-against-acute-pollution/research-and-development/imaros_eng/
NOTE: the EU-funded project IMAROS gathers knowledge and experience from several countries to make recommendations on how best to implement oil spill response in the event of an oil spill of low sulphur fuel oil on water.

Oil Spill Response Limited (2020). *Weathering behaviour and oil spill response options for low sulphur fuel oil (LSFO).* www.oilspillresponse.com/knowledge-hub/response/weathering-behaviour-and-oil-spill-response-options-for-low-sulphur-fuel-oil/

SINTEF (2017). *Weathering properties and toxicity of marine fuel oils summary report.* www.kystverket.no/globalassets/oljevern-og-miljoberedskap/forskning-og-utvikling/diesel--og-hybridoljer/weathering-properties-and-toxicity-of-marine-fuel-oils.pdf/download

SINTEF (2020). *Characterization of low sulfur fuel oils (LSFO) – a new generation of marine fuel oils report.* https://sintef.brage.unit.no/sintef-xmlui/handle/11250/2655946

SINTEF (2021). *Ultra low sulphur fuel oils (ULSFOs) interactions with shoreline report.* www.kystverket.no/globalassets/oljevern-og-miljoberedskap/forskning-og-utvikling/diesel--og-hybridoljer/ultra-low-sulphur-fuel-oils-ulsfos-interactions-with-shoreline.pdf/download

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Ipieca is the global oil and gas association dedicated to advancing environmental and social performance across the energy transition. It brings together members and stakeholders to lead in integrating sustainability by advancing climate action, environmental responsibility and social performance across oil, gas and renewables activities.

Ipieca was founded at the request of the United Nations Environment Programme in 1974. Through its non-lobby and collaborative approach Ipieca remains the industry's principal channel of engagement with the UN.

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