PETROBRAS

MARINE FUEL OIL VLS B24

Technical Information

Assistência Técnica

Petrobras Technical Assistance aims to provide technical support to customers, focusing on the proper use, handling, conditioning, and storage of the products marketed by the Company.

Petrobras customers have service hubs throughout Brazil where technicians are prepared to meet various demands.

Additionally, the service is enhanced by the dissemination of technical information regarding Petrobras products at both local and institutional levels.

The publication of technical manuals is part of this initiative.

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1 - DEFINITION AND COMPOSITION

VLS B24 is a marine fuel oil with renewable content aimed at reducing sulfur emissions and greenhouse gases in the maritime sector. It can be used in the main engines of medium and large vessels that operate on the Diesel cycle and, therefore, have quality requirements different from those needed for industrial fuel oils. The product can also be used in auxiliary power generation or emergency systems as well as in the boilers of these vessels.

The basic raw material to produce bunker oils is the petroleum vacuum distillation residue, to which diluents must be added to adjust the sulfur content and viscosity, depending on the desired type of oil. After the production of the bunker oil, aimed at formulating the VLS B24, 24% by volume of ester-based biodiesel (FAME – Fatty Acid Methyl Ester) is added and mixed in a tank, where it remains stored until it is loaded onto a barge that will supply the customer's vessel or transferred via pipeline to the customer's ship.

Regarding sulfur content, VLS B24 meets the maximum limit of 0.50% by mass and can be used without restrictions by vessels with propulsion systems that do not have sulfur emission reduction systems (scrubbers).

VLS B24 has international sustainability certification ISCC EU RED, which is a system used for certifying fuels with a lower carbon footprint, in accordance with sustainability requirements and greenhouse gas (GHG) emission reduction criteria defined by the European Renewable Energy Directive.

2 - MAIN QUALITY REQUIREMENTS AND SPECIFICATION

VLS B24 marine fuel oil is produced in accordance with the international specification ISO 8217:2017 [1], which is voluntary, where the product is classified based on kinematic viscosity at 50 °C, except for compliance with item 5.1 regarding the presence of biodiesel. The National Agency of Petroleum, Natural Gas and Biofuels (ANP), through authorization N° 402, dated July 12, 2024 [2], allows the commercialization of VLS B24 in Brazilian territory, produced in accordance with ANP Resolution N° 903 of November 18, 2022 [3], except for the presence of biodiesel.

Viscosity is an important characteristic for the acquisition and use of marine fuel oils, as its choice depends on restrictions regarding storage, handling, as well as the availability of a heating system to achieve the necessary viscosity for injection into the engine. The more viscous the oil, the higher the temperature it must be heated to meet the required value for engine injection. In addition to the differences in viscosity values,

specific mass, sulfur content, water, vanadium, sodium, aluminum + silicon, carbon residue, and ash content also distinguish marine fuel oils.

The main quality requirements for marine fuels, based on their use, are highlighted in the following items.

2.1. Flammability

Since it is stored on board in a confined environment, VLS B24 must meet specific safety requirements for storage. Regarding product quality, it is important to determine the flash point, which is defined as the lowest temperature at which a quantity of vapors is generated that will support instantaneous combustion (flash) when a test flame is applied under controlled conditions.

This characteristic is an important indicator of the explosion and fire risks associated with fuels and allows for the assessment of the contamination of VLS B24 with lighter products (with a flash point below 60 °C).

2.2. Flow and atomization

VLS B24 must flow at the temperature of its use, without crystallization and deposition of paraffins in the pipes and filters. This is controlled through the pour point test, which is defined as the lowest temperature at which the fuel oil still can flow through pipes, valves, and tanks. Only oils with pour points lower than ambient temperatures can be transported through pipelines and stored in tanks without heating.

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2.3. Stability and compatibility

Fuels formulated from different components, such as bunker oils, can exhibit varying degrees of stability or incompatibility depending on the predominant chemical nature of their components, which can be paraffinic, naphthenic, or aromatic, indicating a greater or lesser tendency for asphaltene deposition.

In storage tanks on land or in vessels that mix fuels from different sources, there is a risk of incompatibility, that is, the tendency for asphaltene precipitation, which can be affected by the predominant chemical nature of the oils being mixed. Considering this, there is a need to conduct certain tests, such as the spot test, hot filtration sediment test, or total potential sediment test, which aim to indicate the risk of incompatibility between fuels from different sources. A good practice on ships is to segregate fuels from different sources in separate tanks to avoid the potential risk of incompatibility.

The importance of evaluating these characteristics lies in the fact that the products resulting from this instability or incompatibility can, for

example, deposit in tanks, clog lines and filters, or impact the operation of centrifuges on board the vessel.

Scientific studies have indicated that when mixed with bunker oil, biodiesel can help stabilize asphaltenes, providing greater stability to the fuel [4]

2.4. Ignition quality

Ignition quality is an important characteristic for marine fuels used in larger and slower engines (with lower RPM) that operate on the Diesel cycle, compared to automotive engines. In these types of engines, there is a longer delay between the start of fuel injection and the onset of ignition. Due to the variety of types of marine fuels and engines, the evaluation of this characteristic is conducted through empirical correlations established in the maritime sector, which are part of national and international specifications, as well as the manuals of marine engine manufacturers.

In VLS B24 case, this characteristic is assessed indirectly through the CCAI (Calculated Carbon Aromaticity Index), calculated from viscosity and density, properties that are controlled and are part of the product specification. Comparatively, marine fuels with higher density values will exhibit higher CCAI values and, consequently, poorer ignition quality.

In some cases, the FCA/FIA (Fuel Combustion Analyzer), which is an alternative test that determines the ignition delay in a constant volume combustion chamber, can be used as a complementary criterion to the CCAI for assessing the ignition quality of bunker oil. Although the equipment manufacturer has discontinued its sale, the FCA is available in some laboratories around the world, including at Petrobras.

Due to its chemical nature, biodiesel has a high cetane number, and its addition to bunker oil tends to improve the ignition quality of the product.

2.5. Sulfur content and other contaminants

Sulfur present in fuels is directly associated with the emission of SO2 and is also one of the main components of particulate matter emitted by Diesel cycle engines. In view of this, its content in the maritime sector has been subjected to increasingly stringent limits. In accordance with the IMO (International Maritime Organization), the ANP specified in its Resolution ANP N° 903 of November 18, 2022 [3], a maximum sulfur content of 0.50% by mass for marine fuel oils used in vessels that do not have emission reduction systems (scrubbers). VLS B24 supplied by Petrobras has the same limit for sulfur content.

The presence of contaminants in marine fuels can lead to the formation of deposits in fuel lines and injector nozzles, obstructing their passage, causing erosion, and impairing combustion. The reduction of these risks is achieved through the control of ash, residue, water, and

sediment levels in the fuel specification. Insoluble sediments, whether organic or inorganic, arise from various processes inherent to the production, storage, and transportation of the fuel. Although sediments are allowed in small quantities, even with product specification controls, accumulation in the tank can occur over time due to successive refueling, without periodic removal measures through treatment systems provided by the user, aiming for the use of the product according to the equipment manufacturer's guidelines.

The metallic elements present in the fuel do not burn, forming oxides that concentrate in the ash. Among these elements, aluminum, silicon, sodium, and vanadium stand out, which can lead to the following inconveniences if they are outside the specification limits:

- These oxides, when deposited on the inner walls of pipes, cause overheating, which can lead to the weakening of parts of the engine operating on the Diesel cycle.
- Aluminum-silicate compounds, when present in high quantities, have an abrasive action on pumps and engines, potentially causing erosion in injector valves and nozzles.

For this reason, the product must be treated in centrifuges before use. Water, when present in amounts exceeding the specification, reduces the calorific value of bunker oil, can cause the formation of emulsions, and leads to corrosion of metal parts in conjunction with other contaminants. For this reason, it should be eliminated during the centrifugation stage; however, in bunker oils with higher density, there may be greater difficulty in the processes of water decantation and centrifugation.

2.6. Calorific value

The lower calorific value (LCV) is a measure of the energy content of the fuel per unit of mass or volume. This value is used to calculate the energy efficiency of an engine and is necessary as an input for the electronic combustion control systems in more modern vessels. For fuels without the presence of biodiesel, ISO 8217 provides a formula for calculating this property based on specific mass and the levels of water, ash, and sulfur in its annex.

For blends of bunker oil with biodiesel, which has an LCV of approximately 37 MJ/kg [5], the 2024 version of the ISO 8217 standard indicates the experimental determination of the calorific value of the mixture [6].

2.7. Biodiesel

Biodiesel used in VLS B24 can be sourced by Petrobras from different national producers, in accordance with ANP Resolution N° 920 of 2023 [7]. The Brazilian specification for biodiesel has similar characteristics, or, in some respects, may be more stringent than ASTM D6751 (Specification for biodiesel fuel

blendstock – B100 – for middle distillate fuels) [8].

Biodiesel used in VLS B24 has ISCC EU RED certification, one of the most established in the market. It is applicable for traceability and calculation of greenhouse gas (GHG) emissions from more sustainable raw materials and bioproducts with lower GHG emissions, according to criteria defined by the European Renewable Energy Directive

3 - PRECAUTIONS FOR MAINTAINING QUALITY

To maintain the final quality of VLS B24, the following precautions should be taken:

- Ensure cleanliness and the absence of water, sediments, and sludge in the storage and transport of the product. Water and solid materials should be drained from the tanks, as they can alter the quality of VLS B24.
- Implement a routine of inspection and cleaning in the product storage systems, checking, among other items, the condition of the interior of the tanks.
- Thermal and oxidation stability should be considered when handling products containing biodiesel. Excessive heating should be avoided. Thermal and oxidation reactions can lead to increased acidity and the formation of sediments and gum-like materials, causing filter clogging. To prevent this, prolonged storage should be avoided, consuming the fuel using the "first in, first out" method. Retesting the fuel should be considered when the fuel is stored for more than six months [5].

When starting to use VLS B24 for the first time, dirt that has accumulated over time in the tank and lines can be dispersed in the fuel and cause additional load in the separation process and/or filter blockage. Therefore, it is good practice to monitor this closely and have the necessary resources for intervention in these systems. Biodiesel may tend to disperse dirt due to its higher solvency power. This can lead to more frequent cleaning of the separator and filter, especially at the beginning of the fuel's use. It should be ensured that the tanks do not contain large portions of residues from previous batches of mineral fuel. No negative impacts have been reported in the tests conducted so far, except for a higher frequency of filter cleaning at the beginning of use, which will diminish over time [5].

Stability and compatibility are characteristics that, although not present in the specifications, are important for the production and use of bunker oil. An oil is considered stable if asphaltenes and/or paraffins remain suspended over time under transport, storage, or processing conditions. Two or more streams or oils are considered

compatible when the resulting product from the mixture remains stable, without the deposition of asphaltenes, which can clog injector nozzles and cause flow issues and incomplete combustion. It is worth noting that even two stable oils can produce an incompatible mixture due to differences in their chemical nature. VLS B24 tends to have a lower viscosity than 100% mineral VLSFO. For this reason, careful temperature control should be adopted throughout the fuel treatment system, including the separation process. It is recommended to consult the manufacturer's manual for the purification system to verify the appropriate operating temperature based on the fuel's viscosity.

4 - SAFETY, ENVIRONMENT AND HEALTH

The recommendations for the safe storage, handling, and use of VLS B24 are contained in the corresponding Safety Data Sheet (SDS) of the Chemical Product. For transportation purposes, VLS B24 falls under risk class 9 and has the identification number 3082 (SUBSTANCE HAZARDOUS TO THE ENVIRONMENT, LIQUID, N.E. (Residual fuel oil), with a flash point above 60 ºC, according to UN classification adopted by the Ministry of Transport. Being considered a hazardous cargo, individuals involved in its transportation must be properly trained and qualified to carry out such operations.

5 - ADDITIONAL INFORMATION

The proper use of VLS B24 will help users avoid excessive fuel costs and maintenance expenses for combustion equipment and systems, while also meeting safety requirements. To make the most of this fuel, it is recommended to adopt the following precautions:

- Carry out the periodic maintenance specified by the engine manufacturer.
- If it is necessary to use VLS B24 that has been stored for more than six months, perform product specification tests to certify the quality of the product. The storage tank should be drained to eliminate any water and sediments that may have settled.
- Conduct periodic inspection and cleaning of the storage tanks to ensure the maintenance of fuel quality.
- Check the need to heat the transfer lines of VLS B24 based on its viscosity and ambient temperature to avoid line obstruction.
- In the storage of VLS B24, temperatures above 100 °C should be avoided, as the presence of water can lead to the phenomenon known as boil-over due to the rapid vaporization of water, potentially causing

accidents and environmental damage.

More information about marine fuels containing biodiesel can be found in the following documents:

- CIMAC Guideline - Marine-fuels containing FAME; A guideline for shipowners & operators [4]. Available at: https://www.cimac.com/cms/upload/workinggroups/WG7/CIMAC_Guideline_Marine-fuels_containing_FAME_04-2024.pdf
- CIMAC Guideline - ISO 8217:2024 - FAQ [9]. Available at: https://www.cimac.com/cms/upload/workinggroups/WG7/CIMAC_Guideline_ISO_8217_2024_FAQ_02-2024_Rev4.pdf
- MAN Energy Solutions – Service Letter SL2023-741 – Biofuel Operation [10]. Available at: https://www.man-es.com/docs/default-source/service-letters/sl2023-741.pdf

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[10]. MAN Energy Solutions – Service Letter SL2023-741 – Biofuel Operation. Available at: https://www.man-es.com/docs/default-source/service-letters/sl2023-741.pdf

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