SHELL MARINE TECHNOLOGY INSIGHTS

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Improved methods of resolving filtration issues in marine fuels

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Shell Marine Products

Fuel oil filterability remains high on the agenda of the bunkering industry, and is one of the factors that may have a significant impact on shipping operations. To ensure marine fuels are reliable and safe, Shell has developed new test methods to evaluate filtration performance in heavy fuel oils and to provide insights into the factors that may influence or cause filter blocking.

Improved methods of resolving filtration issues in marine fuels

Residual fuel oil is a cost-effective energy source for mobile transport and has been an important enabler for growth in the shipping industry for decades. Even as alternative fuels such as middle distillates and natural gas are starting to gain traction, residual fuel oil is still expected to be the most widely used fuel in the marine industry.

At the same time, fuel quality requirements are evolving and new specifications are being adopted. A good illustration of how fuel suppliers and ship owners need to adapt to evolving fuel quality requirements is the release of the latest edition of ISO 8217:2010 in July last year, which contained additional steps to specifically help address ship and crew safety, for instance, through new requirements on ignition quality and hydrogen sulphide (H_2S).

The new ISO 8217 edition is aimed at tightening existing limits as well as adding new parameters to match the evolution of technology in the sector and increased stakeholder expectations[1]. As such, the marine fuel supply chain has to ensure that ships can continue using residual fuel oils safely and reliably whilst meeting the revised quality standards.

Shell has always been at the forefront of understanding fuel chemistry and generating new insights into fuel quality assurance, for example, by introducing the CCAI, a widely accepted indicator for ignition quality, and the total sediments methods that have been a part of the ISO 8217 standard for some years now. To better understand filter blocking incidents in the fuel oil system, Shell has developed an unique fuel oil filtration test rig to study filtration performance.

Fuel oil filterability remains high on the agenda of the bunkering industry. To ensure marine fuels are reliable and safe, Shell has developed new test methods to evaluate filtration performance in heavy fuel oils. This article aims to provide insights into potential causes of filter blocking, effective operational procedures and proper maintenance of relevant equipment that can help reduce filter blocking issues. These measures will result in minimising the impact on business operations, by preventing severe delays in shipping schedules.

Raising awareness on filtration

Filterability in residual fuel oil has been identified by Shell marine technologists as one of the factors that may have a significant impact on operations onboard vessels. Whilst the incidence rate of filtration problems is not high, it is important to fully understand the causes of filter blocking in order to determine how these issues can be prevented to safeguard these operations.

The current research and onboard investigations into fuel oil filterability that have been conducted across the marine industry are aimed at not only raising awareness about the significance of filtration performance, but also to provide guidance and practical advice to ship owners, operators, managers and refiners, and fuel suppliers on how to detect and resolve filtration issues. In this respect, Shell's bench filtration test rig is a major step forward as it offers a new method of identifying and assessing the root causes of filter blocking. What makes this unique is the fact that the filtration test rig is designed to operate with exactly the same conditions as the filters on board a ship, using similar pressures, fuel flow and temperatures, whilst remaining easy to operate. The filter material used in this bench test is also identical to those found in filter systems on board of ships.

The bench filtration test rig (shown in Figure 1) was developed by Shell in its fuel research facilities in Amsterdam, the Netherlands. A variety of commercially available residual fuels with and without reported filtration issues were used in the research. The first set of results from this study was presented at the IASH Conference in August 2006, and subsequent findings were shared at a CIMAC-ISO Fuel Oil seminar in June 2008.

Understanding filtration performance

Filtration performance can be highly complex, and filterability issues may result from many different factors that are operational, hardware and fuel related; or most likely a combination of these factors. The research conducted using the Shell filtration test rig provided several useful insights into the factors that may influence or cause the occurrence of filter blocking.

As a standard means of measuring filtration performance, filterability index (FI) can be interpreted as follows:

Filterability Index (FI)	Filtration Performance
< 20	No problem expected
20 to 50	No problem when used occasionally
> 50	Serious problems expected

Table 1: The use of filterability index in the Shell filtration test rig to measure filtration performance

All ships using fuel oil have onboard fuel treatment to ensure that the fuel is free of particles that harm the engine and endanger ship operation. Fuel purification starts in the settling tanks, followed by purifiers, centrifuges, strainers and filters; the larger and heavier particles, such as water and asphaltenic sludge, are removed in this first part of the fuel treatment system. The last filter before the fuel pumps and engine normally has a very fine mesh (around 10 micron) – whilst this really acts as the last barrier of engine protection, the fuel should already be clean before it reaches this filter.

Dirty filters can be removed and cleaned manually but more often this is done by automatic back flush. Filters are designed to block and take out particles to protect the engine but under certain circumstances, filter blocking happens so rapidly and so excessively that it limits fuel flow to the engines, reducing engine power or even leading to a full engine stop.

Common causes of filter blocking

A variety of contaminant materials have been found blocking filters on board of ships, ranging from catalyst fines, chemical wastes, polymers and fibres, rust from tanks, sand and coke particles. Some of these materials (cat fines, coke particles, water) are 'naturally' found in very low levels in fuel oil and restricted by the international ISO 8217:2005 fuel standard. It should be noted that in most cases, based on the filtration test rig experiments, the investigated fuels comply with ISO 8217:2005 specifications, which seem to imply that fuel quality is typically not the main cause of severe filter blocking.

Indeed, common causes of filter blocking may range from general housekeeping to the inadequate capacity of fuel purifiers and centrifuges to handle large amount of sediments. The below case studies further substantiate this.

Case study 1

A ship experienced filtration problems in the auto-filter just before the injection pumps. Filterability studies were performed with a sample of the fuel oil used on board of the ship at the time these filtration problems were reported, and these confirmed the poor filterability (FI of 69) in the fuel oil.

Extended chemical analyses of the filter blocking material revealed the presence of rust, coke and cat fine particles. The rust had originated from tank walls, whereas catalyst and coke particles originated from the fuel. Analysis of the fuel confirmed the presence of these materials, however, at normal and acceptable levels.

It was concluded that under normal circumstances, a properly functioning centrifuge would have been able to remove these materials from the fuel.

Case study 2

A vessel encountered serious problems immediately after it had started using newly bunkered fuel. Excessive water was discharged from the purifiers, overfilling the sludge tank, and hard solid sludge built up in the purifier, which needed to be cleaned after just over three days.

A sample taken between the barge and the vessel contained large amounts of seawater (5 percent by weight), which must have entered the fuel during transfer to the ship – analysis showed that the fuel was free of seawater when it was in the shore tank.

Interestingly, the amount of dry sludge was well below specification. Nevertheless, this fuel caused severe filter blocking problems. A sample of the fuel was investigated using the filtration test rig method and reflected poor filterability performance (Figure 2), with a FI of 821 kPa/kg.

Analysis of the filter blocking material showed mainly metals, carbon and sulphur (Al, Si, C, Fe, S, Ca), the majority being carbon, which indicates the presence of coke. The other constituents are made up of components related to cat fines and rust. It was most likely that the purifiers were not able to handle the excessive amounts of seawater and sludge, and some of the sludge and water simply passed through the centrifuge and clogged the filter.

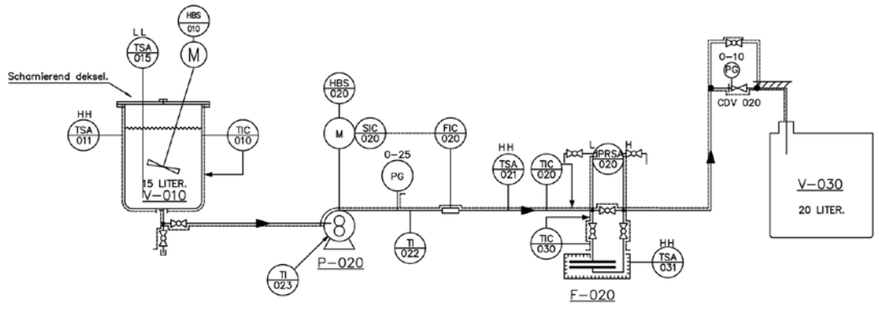

Figure 1: Schematic representation of the Shell filtration test rig

[1] "ISO standards expected to improve quality of marine fuels", International Organization for Standardization

Findings

These filtration test rig cases illustrate that in some instances, filter blocking occurred with 'normal' fuel constituents or sediments that are either present in the fuel or may have originated from the fuel system, such as sludge in tank bottoms.

Under normal operations, the fuel treatment system on board of a vessel should be able to remove these contaminants. However, when centrifuge capacity is too low, improperly adjusted or malfunctioning, sludge and water may slip through and reach the fine filters, resulting in filter blockage.

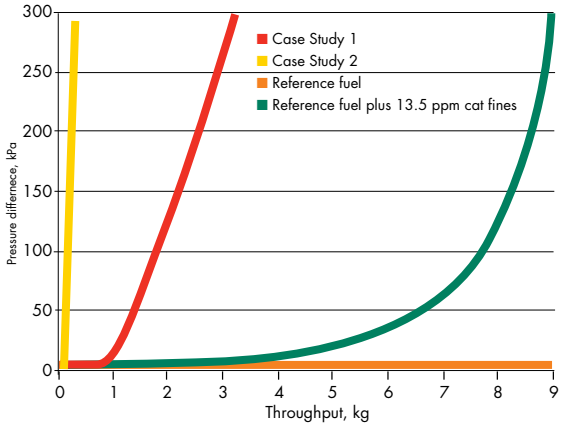

Figure 2: Examples of pressure curves recorded with the filtration test rig. According to the test, the filterability index of case study 1, 2, reference fuel, and reference fuel plus 13.5 ppm cat fines are respectively 69, 821, 0 and 17.

The case studies also showed that only small amounts of insoluble particles are sufficient to fully block a filter. This is further illustrated in Figure 2, showing the effect of the addition of 13.5 mg/kg cat fines to a reference fuel – the filterability index of the fuel increases from 0 to 17.

Conclusion

To ensure efficient business operations, marine operators have to be aware of the potential impact of severe filtration problems on their vessels. Shell understands the importance of meeting end-user requirements and delivering quality marine fuels.

The Shell filtration test rig, leveraging Shell's experience and strong technical expertise, is a significant development in providing a deeper understanding of the potential causes of filterability issues, and these perspectives are critical to maintaining the safety and reliability of bunkering operations.

Effective operational procedures and proper maintenance of filter and centrifuge equipment can help reduce filter blocking issues and allow shipping operators to avoid lengthy downtime. Two of the critical considerations for maintaining good filterability of fuel oils are to adopt correct sizing and maintenance of onboard fuel cleaning systems and to follow OEM recommendations on operation temperatures of centrifuges. Ultimately, shipping operators should always bunker with reliable fuel suppliers that can provide strong technical support to assess and address fuel filtration issues.

This research project by Shell has brought forth new and clear insights in the area of fuel oil filterability. Following the above recommendations will allow smooth, trouble-free operations for shipping operators across the globe.

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