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Marine Fuel Quality Survey 2016

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Infineum Marine Fuel Quality Survey 2016 – Introduction

Introduction

This first Infineum Marine Fuel Quality Survey provides an overview of the quality of marine fuels in the European marketplace.

Marine bunker fuels cover a range of products including middle distillates, residual (heavy) fuel oil (HFO) and hybrid fuels. However, they all follow one global specification: ISO 8217, but with different limits for the various grades.

The most commonly used marine distillates are DMA grades, also know as marine gas oils (MGO), and DMB grades, also known as marine diesel oils (MDO).

From the various HFOs, the most commonly used grade is RMG 380, which is also referred to as intermediate fuel oil (IFO) 380.

Until recently the specification for distillate fuels only included cloud point (CP), however in the near future the cold filter plugging point (CFPP) will also have to be stated. This could be taken as an indication of a step towards its inclusion in the specification.

Marine distillate fuel quality specifications

Limit	Parameter	DMX	DMA	DMZ	DMB
Max.	Viscosity at 40°C (mm^2/s)	5.500	6.000	6.000	11.00
Min.	Viscosity at 40°C (mm^2/s)	1.400	2.000	3.000	2.000
Max.	Micro Carbon Residue at 10% Residue (% m/m)	0.30	0.30	0.30	–
Max.	Density at 15°C (kg/m^3)	–	890.0	890.0	900.0
Max.	Micro Carbon Residue (% m/m)	–	–	–	0.30
Max.	Sulphur (% m/m)	1.00	1.50	1.50	2.00
Max.	Water (% V/V)	–	–	–	0.30
Max.	Total sediment by hot filtration (% m/m)	–	–	–	0.10
Max.	Ash (% m/m)	0.010	0.010	0.010	0.010
Min.	Flash point (°C)	43.0	60.0	60.0	60.0
Max.	Pour point in Summer (°C)	–	0	0	6
Max.	Pour point in Winter (°C)	–	-6	-6	0
Max.	Cloud point (°C)	-16	–	–	–
Min.	Calculated Cetane Index	45	40	40	35
Max.	Acid Number (mgKOH/g)	0.5	0.5	0.5	0.5
Max.	Oxidation stability (g/m^3)	25	25	25	25
Max.	Lubricity, corrected wear scar diameter (wsd 1.4 at 60°C) (µm)	520	520	520	520
Max.	Hydrogen sulphide (mg/kg)	2.00	2.00	2.00	2.00
	Appearance	Clear & bright			–

Marine HFO fuel quality specifications

Limit	Parameter	RMA	RMB	RMD	RME	RMG				RMK		
		10	30	80	180	180	380	500	700	380	500	700
Max.	Viscosity at 50°C (mm^2/S)	10.00	30.00	80.00	180.0	180.0	380.0	500.0	700.0	380.0	500.0	700.0
Max.	Density at 15°C (kg/m^3)	920.0	960.0	975.0	991.0	991.0				1010.0		
Max.	Micro Carbon Residue (% m/m)	2.50	10.00	14.00	15.00	18.00				20.00		
Max.	Aluminium + Silicon (mg/kg)	25	40		50	60						
Max.	Sodium (mg/kg)	50	100		50	100						
Max.	Ash (% m/m)	0.040	0.070			0.100				0.150		
Max.	Vanadium (mg/kg)	50	150			350				450		
Max.	CCAI	850	860			870						
Max.	Water (% V/V)	0.30	0.50									
Max.	Pour point (upper) in Summer (°C)	6	30									
Max.	Pour point (upper) in Winter (°C)	0	30									
Min	Flash point (°C)	60.0										
Max.	Sulphur (% m/m)	Statutory requirements										
Max.	Total Sediment, aged (% m/m)	0.10										
Max.	Acid Number (mgKOH/g)	2.5										
	Used lubricating oils (ULO): Calcium and Zinc; or Calcium and Phosphorus (mg/kg)	The fuels shall be free from ULO, and shall be considered to contain ULO when either one of the following conditions is met: Calcium >30 and zinc >15; or Calcium >30 and phosphorus > 15.										
Max.	Hydrogen sulphide (mg/kg)	2.00										

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There are two basic types of marine fuels – distillate and residual. Distillate fuel, also known as MGO, is composed of petroleum fractions that are separated from crude oil in a refinery with a 'distillation' process.

Hybrid marine fuels have surfaced to meet the increased demand for low sulphur marine fuels. These may be non-distillate and non-residual, typically lying halfway between the two. Because they are blended products of different refinery streams, these fuels present specific challenges in terms of pour point, viscosity and lubricity.

To be representative of the fuel purchased by ship operators in Europe, the samples were collected from the three main bunkering ports – Rotterdam, Antwerp and Amsterdam. For this first Survey, 16 fuel samples, a mix of residual, hybrid and distillates, were collected.

Analysis

The analyses applied to each sample are those Infineum considers to be of most interest to bunker fuel producers, marketers, distributors and consumers. They include parameters covered by specifications and those needed to deliver the required level of performance.

Using industry standard test methods ensures that the data published accurately reflect the results that could, or would, be generated by organisations within the petroleum industry. However, it should be noted that very little repeat testing has been conducted to determine compliance, or otherwise, with specifications.

Test methods

The testing was carried out at a quality accredited laboratory using the test methods opposite.

Distillate fuels

Density @15°C	ISO 12185
Kinematic Viscosity @50°C	ISO 3104
Flash Point	ISO 2719
Sulphur Content	ISO 8754
Pour Point	ISO 3016
Cloud Point	ISO 3015
Lubricity	ISO 12156-1
Oxidation Stability	EN 15751
CFPP	ASTM D6371 - 05(2010)

Residual fuels

Density @15°C	ISO 12185
Kinematic Viscosity @50°C	ISO 3104
Flash Point	ISO 2719
Sulphur Content	ISO 8754
Pour Point	ISO 3016

Infineum Marine Fuel Quality Survey 2016 – Key facts

Infineum has been monitoring the quality of and reporting the trends in worldwide winter grade automotive diesel fuel quality for over 30 years*. Now, with so much change expected in the marine world in the next few years, this activity has been extended to cover European bunker fuels.

This first set of samples includes distillate/ultra low sulphur fuel oil (ULSFO), residual and hybrid fuels to give a broad picture of the quality of fuel available on the European market.

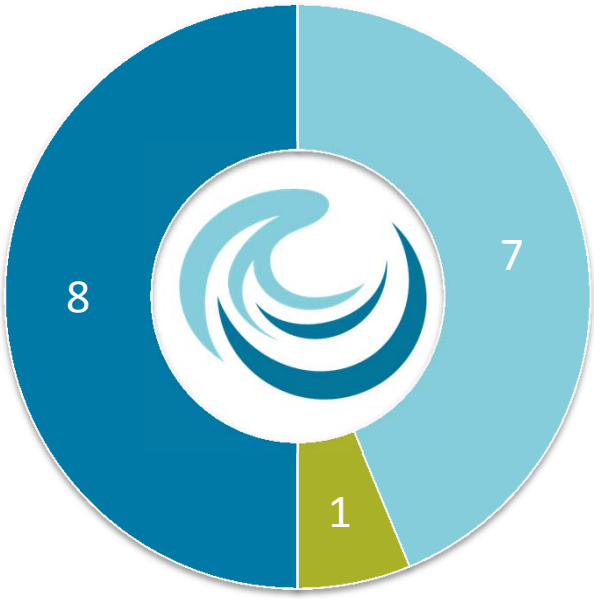
16 Samples collected

3 European bunkering ports

7 Bunker fuel suppliers

9 Parameters measured

Samples collected



In this first Survey samples were collected from bunkering ports in Rotterdam, Amsterdam and Antwerp in August and September 2016. The samples were analysed for a variety of parameters, including density, sulphur, cold flow properties and flash point, using industry standard tests.

Clearly, because this is the first year of sampling, no trend data can be drawn.

Read on to explore the 2016 data analysis.

* Prior to 1999, work was undertaken by Paramins (the additives division of Exxon Chemical Company), which together with Shell Additives (a division of The Shell Petroleum Company Ltd and Shell Oil Company) formed the Infineum joint venture.

Currently, the biggest driver for change in the marine industry is emissions reduction and, in the world of bunker fuels, the reduction of sulphur is of most interest.

Sulphur dioxide emissions from ships are being cut because they are thought to not only impact the environment, but also human health. Particularly the case for people living in port cities and coastal communities, beyond the existing emission control areas.

The current 3.5% global sulphur limit for the shipping industry is 3,500 times greater than the 10 ppm* sulphur level allowed for on-road diesel vehicles in Europe. While the International Maritime Organization (IMO) has already cut sulphur limit inside Emission Control Areas to 0.1%, it had also pledged to cut the global sulphur cap from 3.5% to 0.5%. However, until recently, it has been uncertain if the implementation date would be in 2020 or 2025.

This indecision on timing was associated with a lack of clarity on the availability of suitable fuels. However, the results of an IMO study published in 2016 revealed, under all scenarios and sensitivity options considered, that sufficient compliant fuel oil would be available to meet requirements.

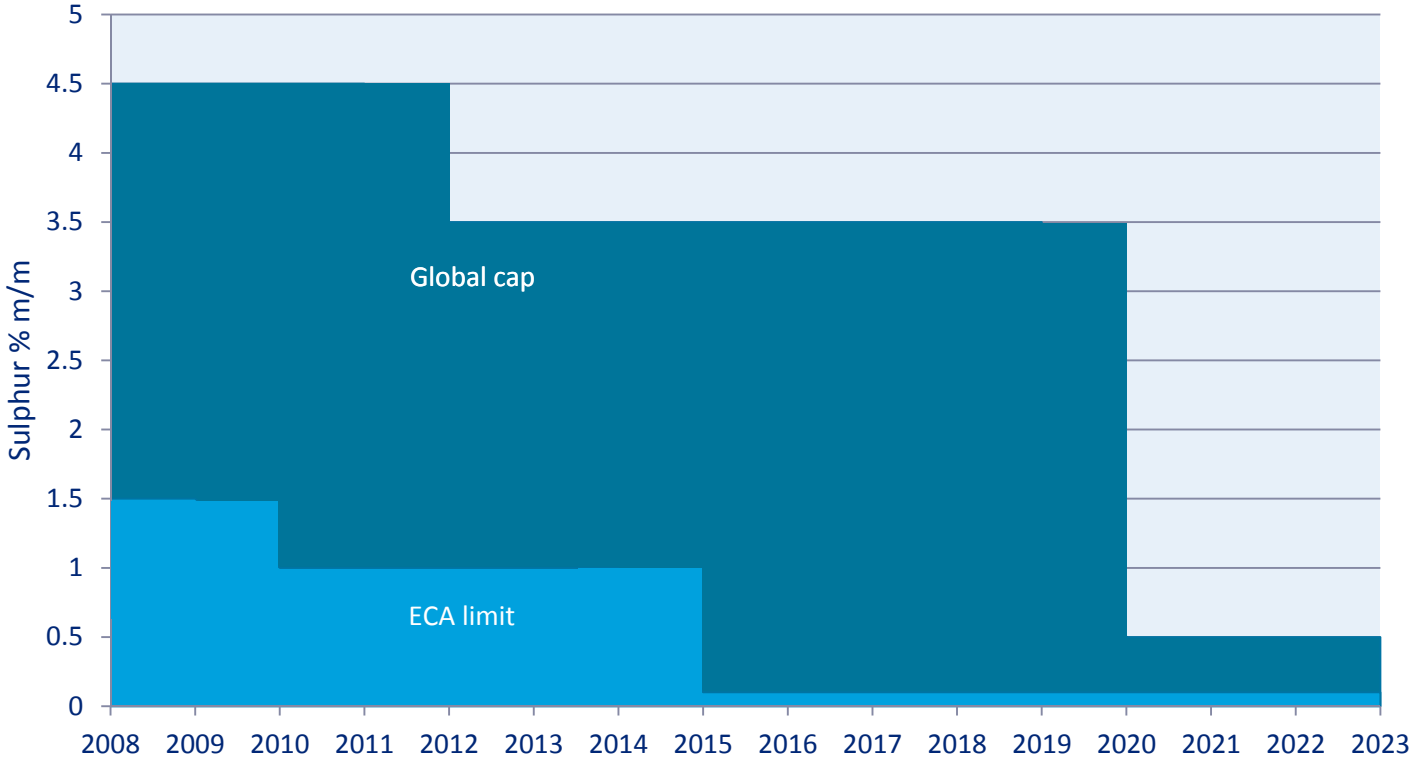
In October 2016 IMO set the implementation date of the global 0.5% sulphur cap to January 1 2020.

This timing will please campaigners who had been urging the IMO to make the cut early following the results of another study. This study estimated that implementation in 2020 rather than 2025 would prevent some 200,000 premature deaths due to less toxic fumes, mainly in coastal communities in the developing world.

The impact of IMO's regulatory change is far reaching; affecting shippers, refiners, crude producers and bunker suppliers. The cost of implementation is as yet unknown, although it is expected to be high. But, it is not only the marine world that will be affected, the impact is expected to be felt across all transport sectors and world markets.

* Multiply the sulphur % m/m values by 10,000 to convert to ppm

Sulphur emission limits



Global and ECA sulphur limits have been reduced significantly

Low sulphur options

The use of low sulphur distillate or hybrid fuels to meet the new sulphur limits is one option available to shippers. However, some may decide to meet the target by installing exhaust gas scrubbers and burning conventional bunker fuel. The latter option can be expensive – not only in up front installation costs, but also in ship downtime.

The decision on moving to low sulphur fuel or installing scrubbers will be a tough one to make, and one which involves some level of guesswork. If, for example, most ship owners opt to use low sulphur fuels, then demand for HFO could fall, which could make the investment in scrubbing equipment sensible. On the other hand, if most ship owners fit scrubbers, HFO demand will be maintained and the price difference between the two fuels would be expected to narrow. This is an interesting dilemma, and one that ship owners must resolve relatively quickly.

Impact on fuel demand

Bunker fuel demand at European ports was estimated to be in the region of 35 million metric tons in 2015, with Rotterdam and Antwerp being the two main bunkering ports. In our view, when the volume of fuel is taken into account, this tightening of sulphur limits represents a huge challenge for the refining industry.

If demand shifts to lower sulphur fuel, Europe's heavy fuel oil (HFO) surplus and middle distillate shortfall is likely to be further impacted. While some refineries are already upgrading to increase the production of middle distillate fuels, there are only three years remaining until the low sulphur implementation date. This is a very short period of time when it comes to deciding on and making major refinery investments, one that some refiners may struggle to meet.

On the flip side, refineries in the Middle East and Asia Pacific could benefit from the fast introduction of the new cap, potentially finding new customers for their middle distillate exports at European ports.

Refiners hoping to export fuels into the European bunker market will need to not only meet the ISO 8217 standard for fuel quality, but will also need to be aware of the specific local requirements of individual countries.

Looking beyond sulphur

A number of hardware design and operational changes are required to meet all of the expected emissions mandates. This makes fuel performance an increasingly important factor in ensuring the industry does not experience any operability issues in the field.

In our view, maintaining or improving the cold flow, lubricity and fuel compatibility performance of future fuels will be of utmost importance to ensure ships continue to stay reliably in operation for longer.

The 2016 Infineum Marine Fuel Survey highlights the variation in fuel quality that can be found from port to port and from bunker to bunker within the same port in Europe. In addition, it gives a broad picture of how refiners may address some of the key industry challenges.

Shippers and refiners have only three years to resolve the challenges presented by the new sulphur limits.

Sulphur

With the reduction in the global sulphur cap from 3.5 to 0.5 % m/m now scheduled for 2020, the sulphur content of bunker fuels is of increasing interest to the shipping industry.

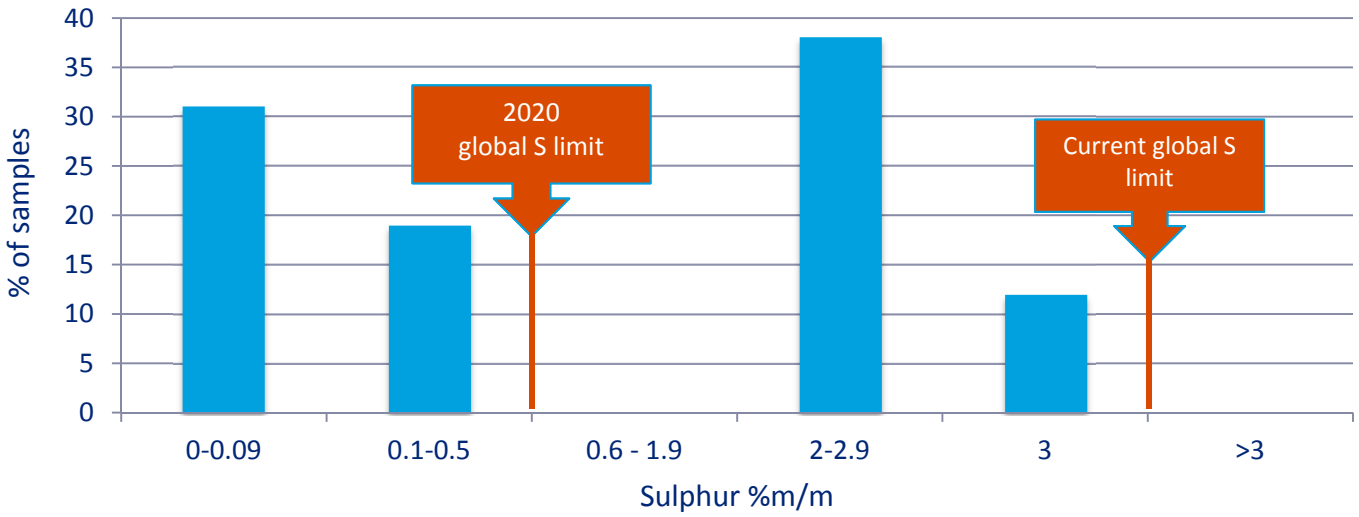
All of the fuels sampled in this year's Survey met today's 3.5% m/m maximum global sulphur limit.

However, 50% were above the 2020 0.5% m/m limit. Unsurprisingly, all of the samples above the future limit were residual fuels.

These results indicate that a number of refiners need to make considerable investments, in a relatively short time, for their fuels to meet the new sulphur limits. Beyond 2020, fuels containing more than 0.5% S can only be used in vessels fitted with exhaust gas scrubbers, which could limit the market for these fuels.

Infineum has reported on the challenges associated with the reduction of sulphur in automotive diesel fuel including lubricity and fuel stability. We can expect similar challenges in bunker fuels and it is essential to anticipate them so that risk of operational issues can be minimised.

Sulphur levels of European bunker fuels sampled



All of the 2016 samples met the current global sulphur cap

Flash point

Fuel flash point is defined as the temperature at which the vapours of a fuel ignite (under specified conditions), when a test flame is applied.

For marine users, Safety Of Life At Sea (SOLAS II- 2, regulation 4) sets out the limits that apply to fuel oil to prevent the ignition of combustible materials or flammable liquids during normal storage and handling. The regulation states that the flash point for fuels to be used in bulk on board vessels must not be less than 60°C – there are limited exceptions, for example in emergency generators, where fuel with a flashpoint of not less than 43°C may be used. Testing agencies frequently quote the flash point of a fuel sample as >70°C. But, if the flash point temperature is below this value an actual figure is quoted.

In the Infineum 2016 Survey, all but one of the samples were reported as >70°C. However, one residual fuel had a flash point of 58°C, which is below the minimum specified for these fuels. While it is not possible to be certain of the cause, the result could be indicative of fuel contamination by a more volatile product.

In the future, as the low sulphur regulations are introduced, the trends in flash point will be interesting to watch. If, for example, demand for low sulphur fuel is higher than expected in 2020, there could be an increased use of naphtha/kerosene in fuel oil blending. As these fuels often have a lower flash point than the 60°C minimum specified in the ISO 8217 standard, refineries will need to take care to ensure that the flash point of their final bunker fuels meets this requirement.

Density

Density measured at 15°C is used to calculate the quantity of fuel delivered and, for residual fuels, can be used to give an indication of other fuel characteristics such as ignition quality and specific energy.

Density is also important because fuels are cleaned by centrifugal separation before use to remove water and other impurities. To be successful, the density of the oil must be sufficiently different from water. Conventional separators have a maximum density limit of 991 kg/m^3 @15°C, while modern high density separators can clean fuel oils with a maximum density of 1010 kg/m^3 @15°C.

In the 2016 Survey, density in the residual/hybrid fuel samples @15°C ranged from 900.6 to 1011.5 kg/m^3, with three fuels being just above the max 1010 kg/m^3 specification limit. For fuels with higher densities certain centrifuges may be ineffective.

For the distillate results ranged from 885 to 887.9 kg/m^3, all meeting the specification limit.

Kinematic viscosity

Kinematic viscosity is a measure of the fluidity of the fuel at a certain temperature. It is well understood that fuel viscosity decreases with increasing temperature. The samples in 2016 ranged from 5.31 to 764 cSt, all within the limit of the specification.

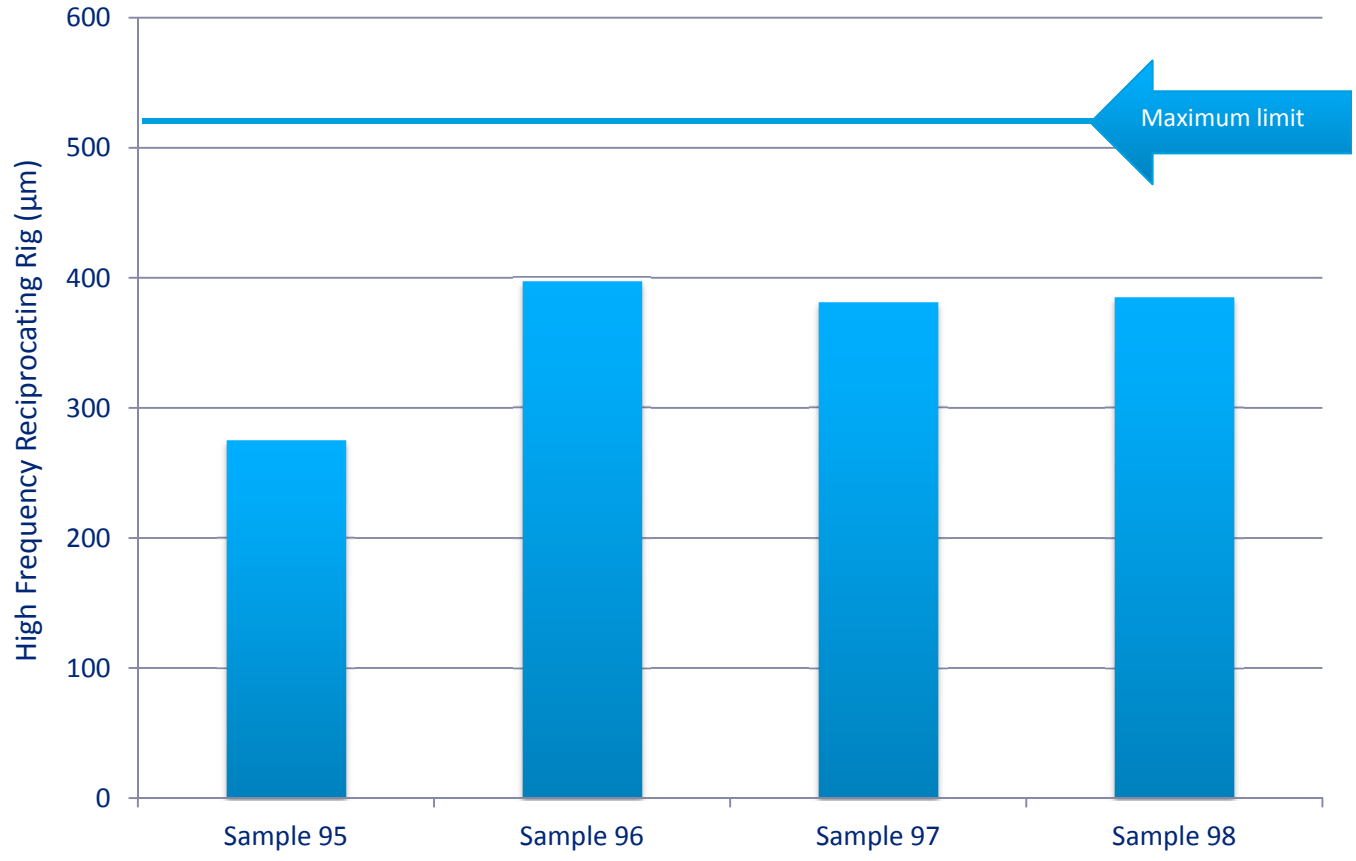
Lubricity

Lubricity is the ability to reduce friction between solid surfaces in relative motion. The use of fuels with poor lubricity can increase fuel pump and injector wear. To ensure fuels provide sufficient protection the marine fuel specification sets a lubricity limit of maximum 520 µm for distillate marine fuels with sulphur of less than 0.05%.

In the 2016 Survey, all the distillate fuels were well below the ISO limit.

Low sulphur fuels can have a lower natural lubricity than conventional fuels. As they are increasingly used in marine applications additives may be needed to maintain lubricity performance.

Lubricity of distillate fuels sampled



All of the 2016 samples were well below the specification limit

Oxidation stability

Oxidation stability is the resistance to change when exposed to air and can be used as a measure of the expected life of a fuel. Oxidative degradation can result in the plugging of filters and the formation of sludge throughout the fuel system and is an important quality parameter for consideration in the storage of large quantities of fuel.

All distillate fuels sampled returned an oxidation stability of >16 hours.

Distillate fuel cold flow

The four distillate / ULSFO fuels sampled were very similar in terms of sulphur, KV, density, flash point and oxidation stability. Where they differed most was in their cold flow properties.

Pour point

Pour point (PP) is the lowest temperature at which a fuel will continue to flow when it is cooled under specified standard conditions (ISO 3016). If a fuel is stored below its PP wax can solidify in the fuel, which can cause significant operational issues. The specification limit varies with grade and with time of year.

The pour point of the distillate fuel samples ranged from <-12 to -3°C. Since the test error is +/- 3°C all samples should be considered to be on specification.

However, given that wax crystals form at temperatures above the PP, fuels that meet the specification in terms of PP can still be challenging to operations in colder regions.

Cloud point

The cloud point (CP) is the temperature at which wax crystals start to visibly form in the fuel and a transparent fuel becomes cloudy (ISO 3015).

This is an important parameter because wax present in the fuel causes rapid filter blocking, which can lead to fuel starvation and possible engine shut down.

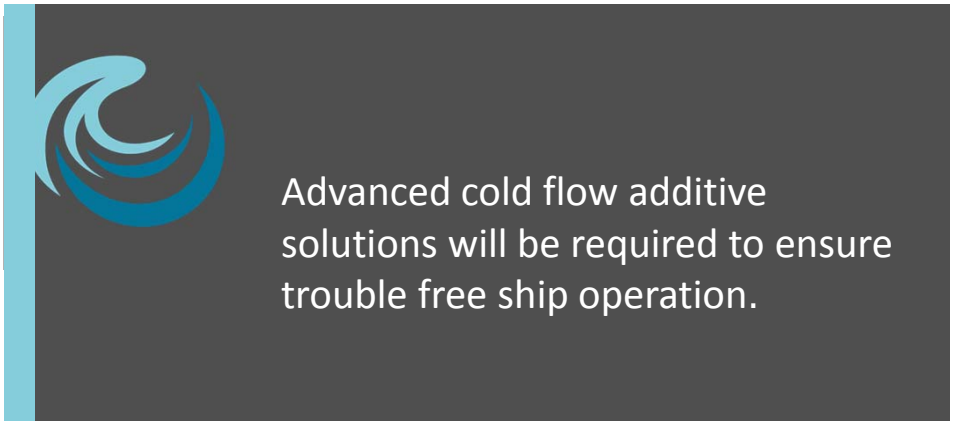
The samples in 2016 ranged from 9 to 24°C, all within the limit of the specification.

CFPP

CFPP is the lowest temperature where the fuel of a set volume, drawn, by vacuum, through a standardised filter within a specified time still continues to flow (ASTM D6371).

Until recently the specification for distillate fuels only included CP, however in the near future the CFPP will also have to be stated. This could be taken as an indication of a step towards its inclusion in the specification.

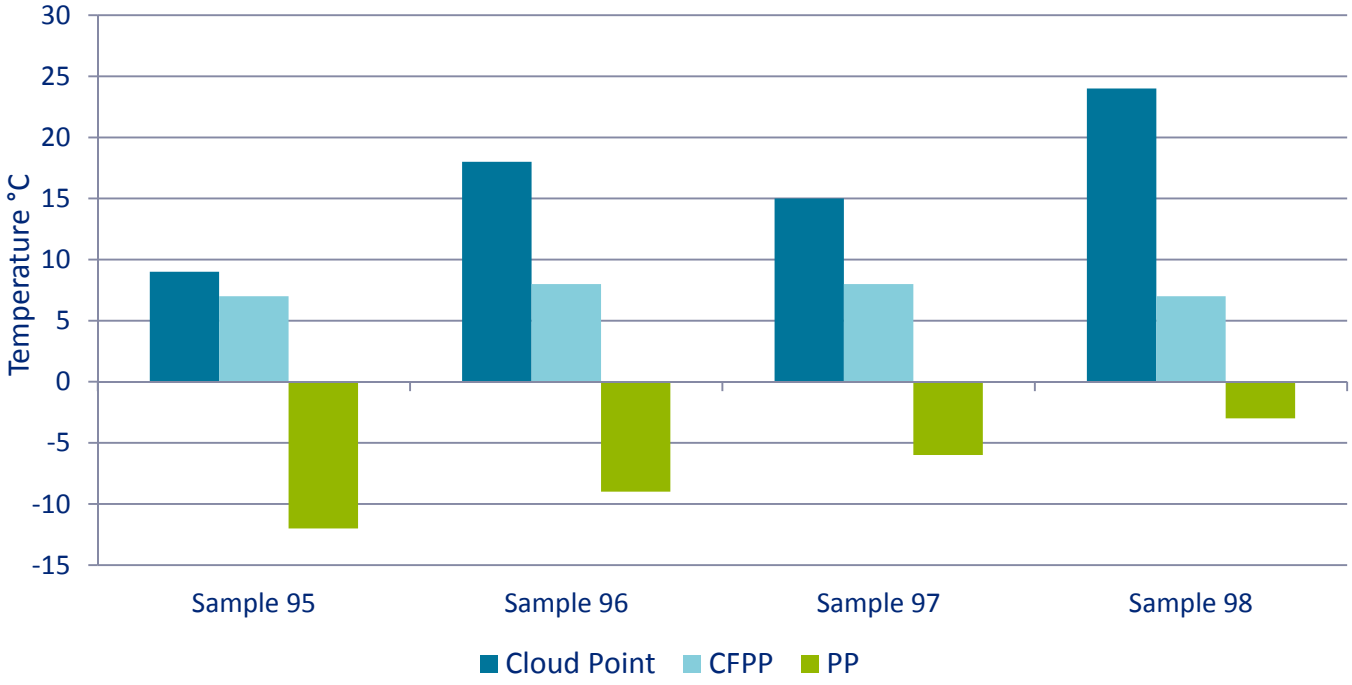
The 2016 distillate samples ranged from 7 to 8°C. High cloud point fuels may need more advanced additive solutions including middle distillate flow improvers and wax anti settling additives to ensure trouble free ship operation.



Wide differences

Typically the differences between the three cold flow properties in untreated fuels could be expected to be about 2-5°C, with the CP having the highest temperature and the PP the lowest. However, the 2016 Survey results show larger differences of 21 to 27°C.

Comparison of CP, CFPP and PP



Large differences between CP and PP were observed in the 2016 samples

While additives cannot influence the CP they can be used to depress the CFPP and PP. These large differences in temperature of the three parameters could be an indication of cold flow additive use.

As global sulphur levels for shipping fall, distillate fuels will be increasingly used in these applications. The low viscosity of these fuels means heating is not recommended, which suggests cold flow performance will require more attention if the ship is moving into cold climates.

The operational issues encountered to date by the industry have mainly been associated with high cloud point distillate fuels that have low pour points. This suggests that in some cases pour point is not providing enough protection. A CFPP specification may help to prevent operational issues in the future.

Future Surveys

In the future, as the introduction of low sulphur fuels increases, this Survey will be extended to cover bunker fuels from the rest of the world. As the data set grows, Infineum will be able to provide a more in-depth analysis and track the global and regional trends in bunker fuel quality.

Residual/hybrid fuels

Rotterdam

	Spec.	Max	Mean	Min	Sample 83	Sample 84	Sample 85	Sample 86
Density kg/m³		1011.5	1010.6	1009.3	1011.3	1011.5	1010.5	1009.3
KV cSt		764	710.4	679.6	716	681.9	679.6	764
Sulphur % m/m		3	2.79	2.56	2.59	3	3	2.56
Upper pour point °C	30 (max)	9	9	9	9	9	9	9
Flash point °C	60 (min)	>70	>70	>70	>70	>70	>70	>70

Antwerp

	Spec.	Max	Mean	Min	Sample 87	Sample 88	Sample 89	Sample 90	Sample 91	Sample 92	Sample 93	Sample 94
Density kg/m³		991	946.1	900.6	991	989.9	990.3	988.4	900.8	900.6	903.9	903.7
KV cSt		392.7	206.27	29.83	389.9	392.7	359.1	368.4	39.3	41	29.9	29.83
Sulphur % m/m		2.56	1.197	0.038	2.27	2.56	2.3	2.17	0.1	0.1	0.038	0.038
Upper pour point °C	30 (max)	30	10	0	0	0	0	0	30	30	9	9
Flash point °C	60 (min)	>70	-	58	>70	58	>70	>70	>70	>70	>70	>70

Ultra low sulphur fuel oil/distillates

Amsterdam

	Specification	Max
Density kg/m³		886.7
KV cSt		5.5756
Sulphur % m/m		0.1
Upper pour point °C		<-12
Flash point °C	60 (min)	>70
CP °C		9
CFPP °C		7
Oxidation stability h		>16
HFRR microns	520 (max)	275

Rotterdam

	Specification	Max	Mean	Min	Sample 96	Sample 97	Sample 98
Density kg/m³		887.9	886.8	885	887.5	885	887.9
KV cSt		5.539	5.459	5.31	5.539	5.31	5.527
Sulphur % m/m		0.091	0.089	0.087	0.091	0.088	0.087
Upper pour point °C		-3	-6	-9	-9	-6	-3
Flash point °C	60 (min)	>70	>70	>70	>70	>70	>70
CP °C		24	19	15	18	15	24
CFPP °C		8	8	7	8	8	7
Oxidation stability h		>16	>16	>16	>16	>16	>16
HFRR microns	520 (max)	397	388	381	397	381	385

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