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Worldwide Winter Diesel Fuel Quality Survey 2014

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Infineum Worldwide Winter Diesel Fuel Quality Survey 2014

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Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 - Contents

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 - Introduction

The Infineum Worldwide Winter Diesel Fuel Quality Survey aims to provide the petroleum refining and distribution industry with an overview of the quality of automotive diesel in the marketplace, allowing tracking of international trends. To achieve this purpose, the Survey needs to cover as much of the globe as possible. For the winter 2014 Survey, some 350 samples were collected in 51 countries around the world. The majority of samples were collected during January and February, deep winter months in the northern hemisphere. In southern hemisphere countries, sampling was undertaken in mid-2013, when true winter grade samples could be obtained, enabling the Survey to be released earlier than usual.

Samples need to be representative of the diesel purchased by the average consumer. As a general principle, Infineum tries to get one sample that represents the production from each refinery or region in a given country. To minimise the possibility of taking multiple samples from a single refinery, knowledge of local exchange agreements and distribution systems is used to select where each sample is collected. For the larger diesel consuming countries, this procedure results in samples that represent a reasonable average of the overall quality. However, for smaller countries or specific producers, spot sampling over a short period of time will effectively only provide a snapshot of production quality, with data derived from only one or two samples.

Analysis

The analyses applied to each sample are those we consider to be of most interest to the diesel producers, marketers, distributors and consumers. They cover areas of national specification, exchange specification and performance parameters.

A degree of standardisation has been applied to enable diesel from all countries to be compared and the data analysed as a single set. Standardisation, however, means that not all national specifications are reported. Wherever possible, industry standard test methods have been applied and in-house test methods avoided. This has been done so that the data published here most accurately reflect the results which could or would be generated by organisations within the petroleum industry.

When considering our data, in particular when comparing the various test results with the national specifications, it should be noted that a number of the tests have quite wide reproducibility bands, and very little repeat testing has been conducted to determine compliance or otherwise with specifications.

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 - Introduction

Test methods

The majority of testing was carried out at quality accredited laboratories in the UK, China and Japan using the test methods below.

Density	IP365 / JIS K 2249
Kinematic Viscosity	ASTM D445 / JIS K 2283
Sulphur Content	ASTM D2622 / JIS K 2541-6
Cetane Number	IP498
Cetane Index	ASTM D4737 / ASTM D976 / JIS K 2280 -5
Pour Point	ASTM D5950 / JIS K 2269
Distillation	ASTM D86 / JIS K 2254
Cloud Point	ASTM D5772 / JIS K 2269
CFPP	IP309 / JIS K 2288
HFRR	ISO 12156-1 / JPI-5S-50-98
Wax Content	Differential Scanning Calorimetry
LTFT	ASTM D4539
FAME Content	EN 14078
Rancimat	EN 15751 (mod)

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – Fast facts

The data contained in the 2014 Infineum Winter Diesel Fuel Quality Survey (WDFQS) is a snapshot of the quality of diesel fuel collected from retail stations from around the world in the deep winter months. Infineum has been tracking the trends in diesel fuel quality in this biennial Survey since 1985*, giving Infineum a comprehensive picture of the global changes in fuel quality.

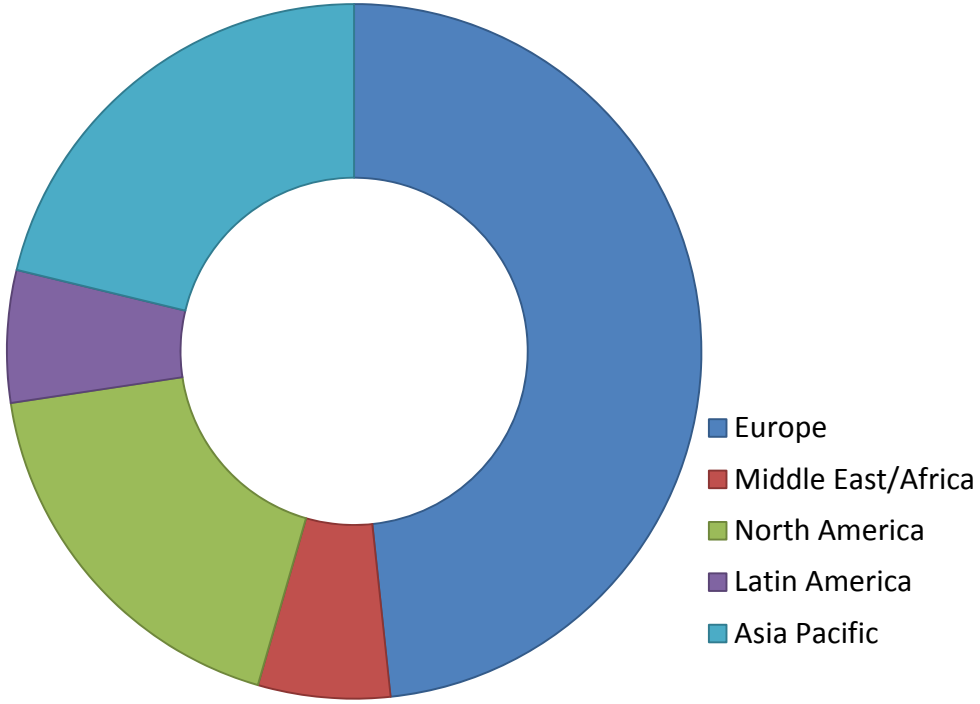
350 Samples collected

51 Countries

66 Parameters measured

10,116 Data points analysed

Regional sample collection

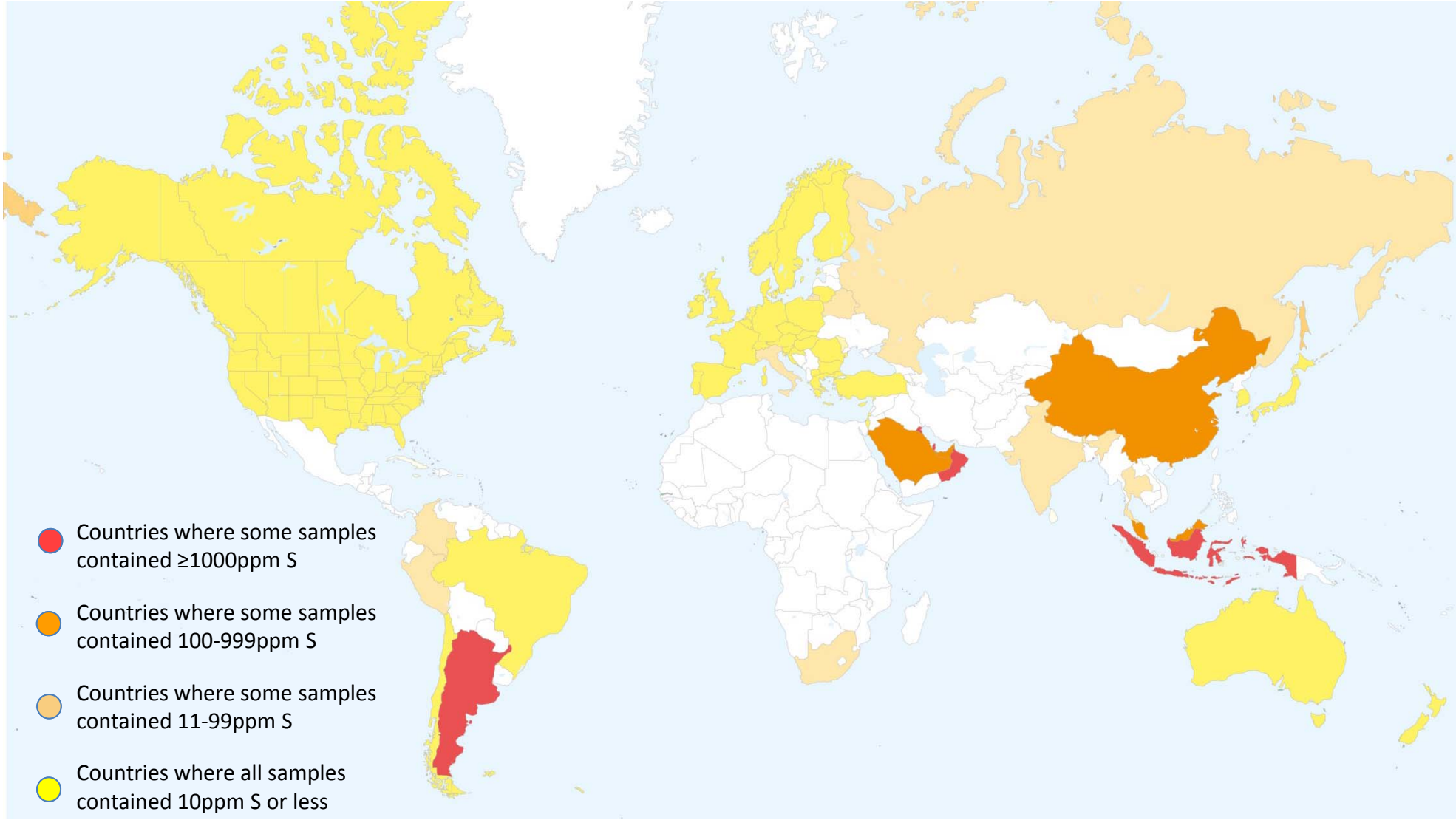


* Prior to 1999, work was undertaken by Paramins (the additives division of Exxon Chemical Company), which together with Shell Additives (a division of The Shell Petroleum Company Ltd and Shell Oil Company) formed the Infineum joint venture.

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – Key findings

Sulphur

Significant drop in sulphur in some Latin American countries, Saudi Arabia and South Africa. Some countries still have fuels containing well over 1,000 ppm S.

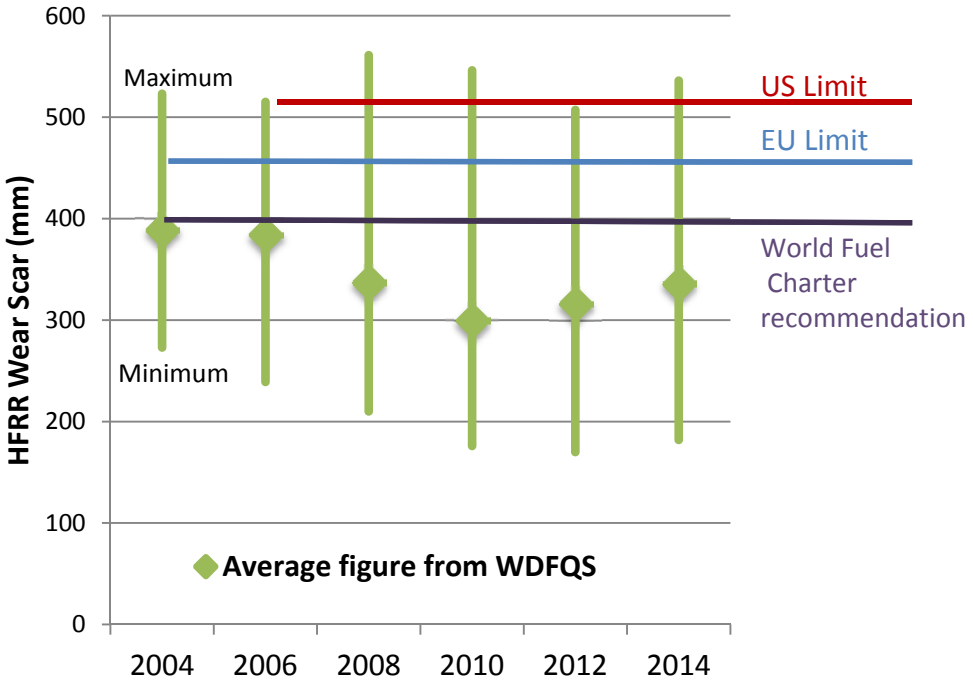


Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – Key findings

Lubricity

The downward trend in global average wear scar diameter observed in previous Surveys has levelled off.

World trends in diesel fuel lubricity

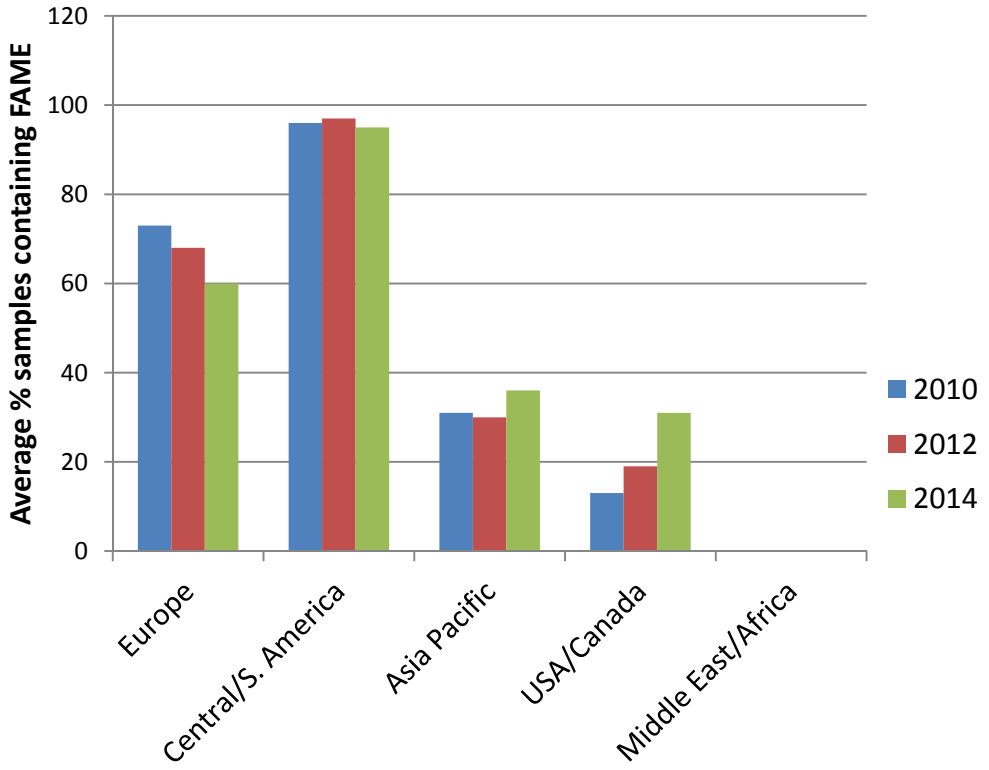


FAME

2014 marks our first ever sighting of fatty acid methyl ester (FAME) containing diesel fuel blends in Australia.

We are seeing the backing off of FAME use in Europe in winter, but an increase in FAME use in US/Canada and Asia Pacific.

Samples containing FAME



Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – Key findings

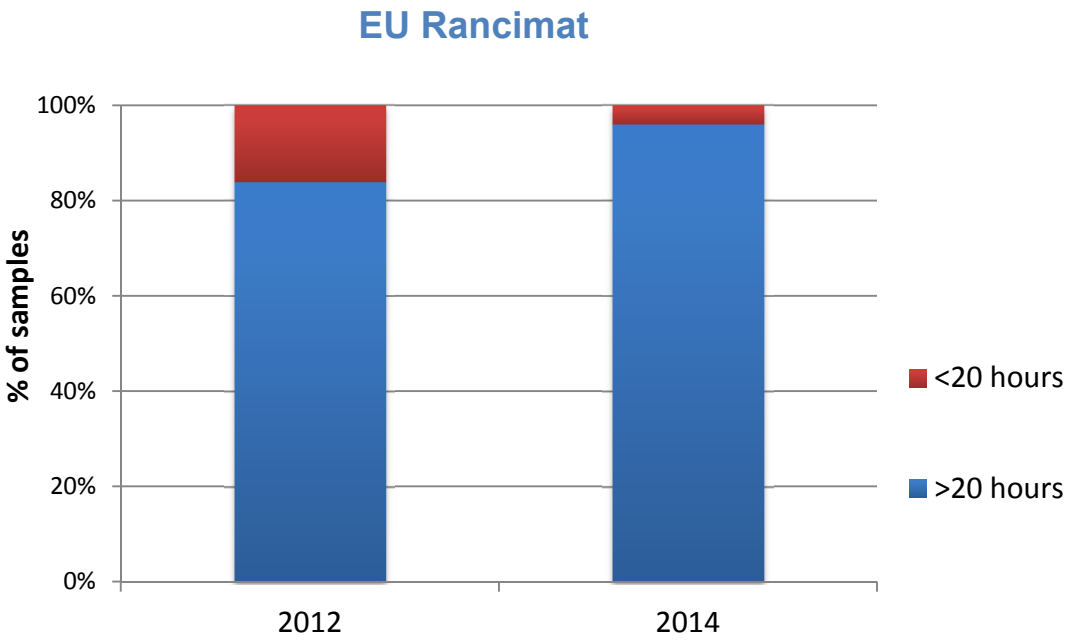
Oxidation

There has been an improvement in oxidation stability in Europe, with fewer samples than in 2012 failing to meet the specification requirement in the Rancimat test at the time of testing.

Test correlation

New for 2014 we have run both Rancimat EN 15751 and PetroOxy EN 16091 oxidation tests. The data confirm that a correlation exists between the two tests, as already demonstrated in studies carried out by the EU Industry.

Read on for the Infineum interpretation of the 2014 Winter Diesel Fuel Quality Survey.



Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

Right now, global fuels producers and marketers have three key issues to address: how best to satisfy widely varying global demand patterns for fuels; how to ensure the fuels they produce meet regional specifications so that they do not cause vehicle operability issues; and how to maximise return on investment.

As the demand for diesel surpasses that of other fuels, the global movement of diesel fuel is increasing. We expect to see an increase in the transfers of middle distillate and 10 ppm sulphur diesel fuels across the various regions, with Europe being the biggest net importer of diesel from the US, Middle East, Russia and Asia.

With this drive to maximize diesel production for export markets, refiners must work to ensure their fuel is fit for purpose. This means they must meet the specifications in their own local market, plus any pipeline specifications throughout the fuels transit and the 'at the pump' standards of their final destination market.

However, national standards vary the world over for almost every parameter including: sulphur content, FAME %, cold filter plugging point (CFPP), cetane, aromatics and lubricity. And, as the data from our Survey show, there is a huge variation in fuel quality from country to country and even from filling station to filling station within the same country.

In recent years, with the discovery and exploitation of new streams, (for example shale reserves) crudes are more difficult for refiners to treat, which, presents them with a long "how do I" list:

- Balance the barrel to meet the fuel product demands of wider markets.
- Meet tightening environmental regulations that put pressure on fuel composition.
- Incorporate more renewables into fuels without compromising fuel quality.
- Ensure fuels perform in the harsh conditions presented by today's vehicles.
- Provide trouble free operation in any environmental conditions.
- Protect fuel products during transportation and storage, in light of the increased volume.
- Do all the above while providing a reasonable return on investments.

The 2014 WDFQS gives a broad picture of how refiners are managing to address these challenges.

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

FAME use

On a global level in the 2014 WDFQS slightly more samples contained FAME than in 2012. This high level picture shows that, where FAME is used, levels are generally moving from B5 and 6 to B7 and above. However, the trends in FAME use vary on a regional basis.

FAME in North America

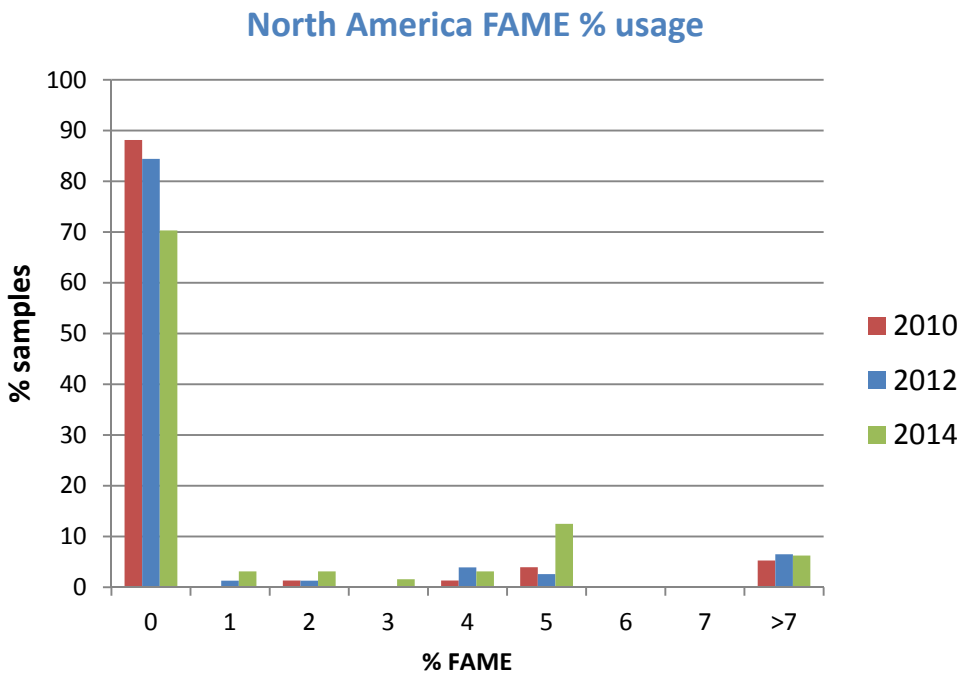
Over the past four years the percentage of samples in North America containing FAME has increased from 12% in 2010 to 30% in 2014. The average % FAME content over the same period has risen from 1% to 3% with a significant increase in the number of samples containing 5% FAME.

The National Renewable Fuels Standard Program (RFS2) is steadily increasing the total amount of biofuel that must be blended into transport fuels. However, the US Environmental Protection Agency (EPA) is proposing to maintain the biomass-based diesel standard for 2014 and 2015 at the 2013 level of 1.28 billion gallons. However, we can expect biodiesel use to increase as EPA has also indicated that biomass-based diesel can be used to help meet the volume requirements for advanced biofuel of 2.20 billion gallons.

Several states have introduced incentives/mandates to regulate the amount of biodiesel used in fuel: Minnesota being the first to introduce a B10 requirement in certain months. While the Minnesota samples we collected this winter contained 4-5% FAME, we did detect 9-11% FAME in samples from Iowa and Illinois, but believe that these high levels are being driven by local tax incentives. However, no FAME was detected in the samples from other states with biodiesel incentives/mandates such as Kansas, Louisiana or Michigan, while Oregon, Pennsylvania and Washington, were not sampled. Biodiesel was also detected in some of the fuel samples from Texas, California, Colorado, Massachusetts and New Jersey, which do not currently have incentives/mandates.

Our expectation is that at a federal level the mandates will continue to evolve, but at the state level the standards will, with the exception of California, continue to be less stringent.

Canadian Renewable Fuels Regulations require an average 2% renewable content in diesel fuel. However, biodiesel is not blended during the deep winter months so, as expected, none of the 13 samples collected contained FAME.



The percentage of samples in North America containing FAME has increased

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

FAME in Europe

The overall picture of increased FAME use in the US is quite a contrast to the one that is emerging in Europe. Here the percentage of samples containing FAME is steadily falling from 72% of samples in 2010, 68% in 2012 to just 60% of samples today. And, at the same time the average FAME content has fallen from just over 4% to 3.4%.

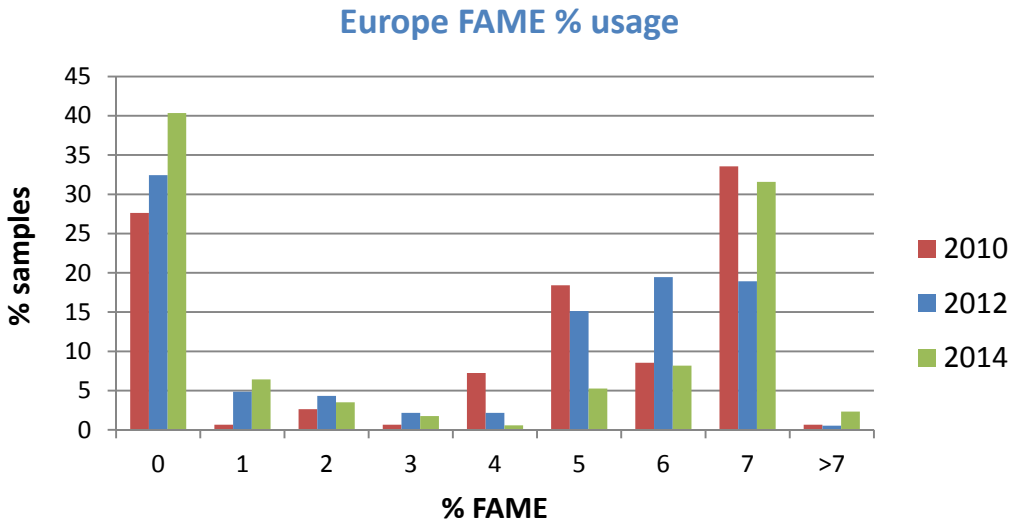
It must be said that the decrease in FAME use in Europe is not uniform, with countries including Greece, Italy the Czech Republic and Ireland adding significantly more FAME than in previous years. Although some of this 'observed' increase could be down to sampling variations.

But, in Spain, Austria, Germany and the UK not only did fewer samples contain FAME, but also the average percentage of FAME was down. Spain and Germany show the biggest drop in FAME use. Most surprising is Spain, which had been at the forefront of FAME use, moving from 100% of samples containing FAME in 2012 to only 55% in 2014 and FAME content falling from an average of 6% to 1%.

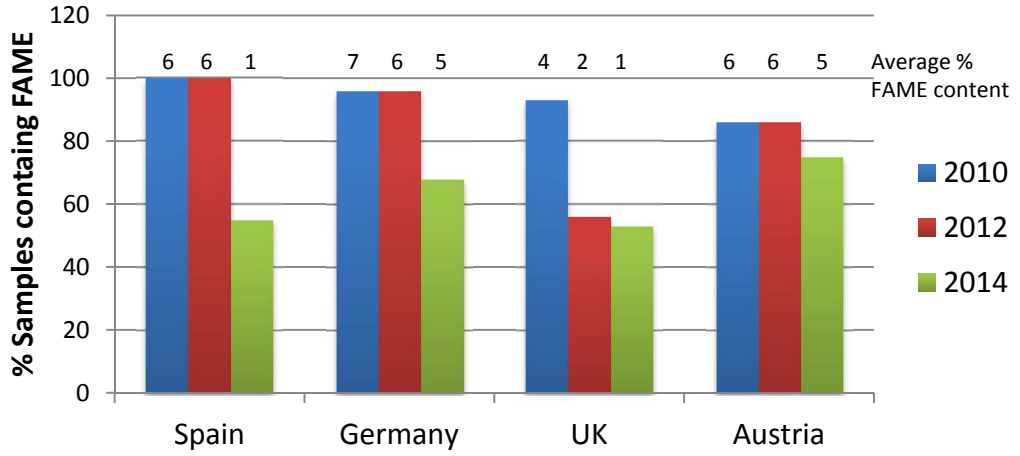
We can see a number of potential reasons for this backing off in FAME use:

- An increase in the use of used cooking oil in countries where it counts double towards renewable targets.
- The high cost of FAME could be driving refiners to use a less expensive alternative to meet renewable targets.
- An increase in the use (and availability) of next generation biofuels.
- Adverse reaction to the filterability issues observed in Europe recently, which some have attributed to FAME use.
- Seasonal use variations – more FAME use in summer and less in winter – a trend that is likely to increase owing to filterability issues.

Looking ahead, the new European Commission will shape the next course of biofuel policies with a 2030 strategy that will be substantially different. While no major changes are expected to fuel quality, fluctuations in biodiesel quality and quantity are highly likely to continue.



The percentage of samples in Europe containing FAME is steadily falling



In some European countries the average percentage of FAME was down

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

FAME in Asia Pacific

Biodiesel was detected in samples in South Korea, Malaysia, Thailand and Indonesia. However, while the levels in the first three countries were at or above the local mandates, samples from Indonesia contained 1-2% FAME, well below the 10% biodiesel blending in all gasoil the Government had mandated from September 2013 onwards.

For the first time since we began looking for FAME in our samples we have found evidence of its use in Australia, with one sample registering 4% FAME. The volume of FAME blended into Australian diesel fuels is set at a state level, and currently only New South Wales has a mandatory blending level of 5%. But, in the future we expect biodiesel use to increase as the Australian Government increases its commitment to renewable fuels through the Clean Energy Future Plan.

FAME in Latin America

Levels of FAME ranged from 0% in Chile to 11% in Argentina. This wide variation is not surprising because FAME use is driven by various local mandates and Chile is the only country sampled in the region with no mandated blending levels. In the future we expect biodiesel use to increase as more countries raise their blending ratios to 10% and possibly beyond.

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

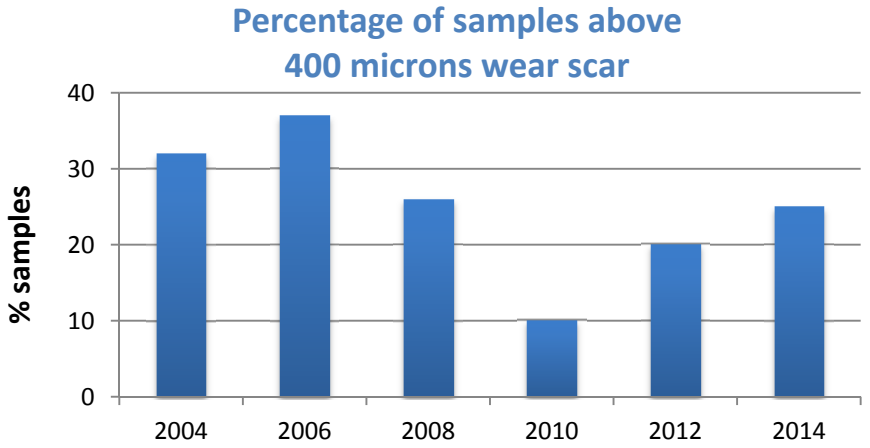
Lubricity

In 2012 we reported a worsening picture for global average diesel fuel lubricity, which we attributed to a combination of the backing off of FAME use, the tough economic climate and variations in sampling (e.g. inclusion of an increased number of Middle Eastern countries compared to 2010).

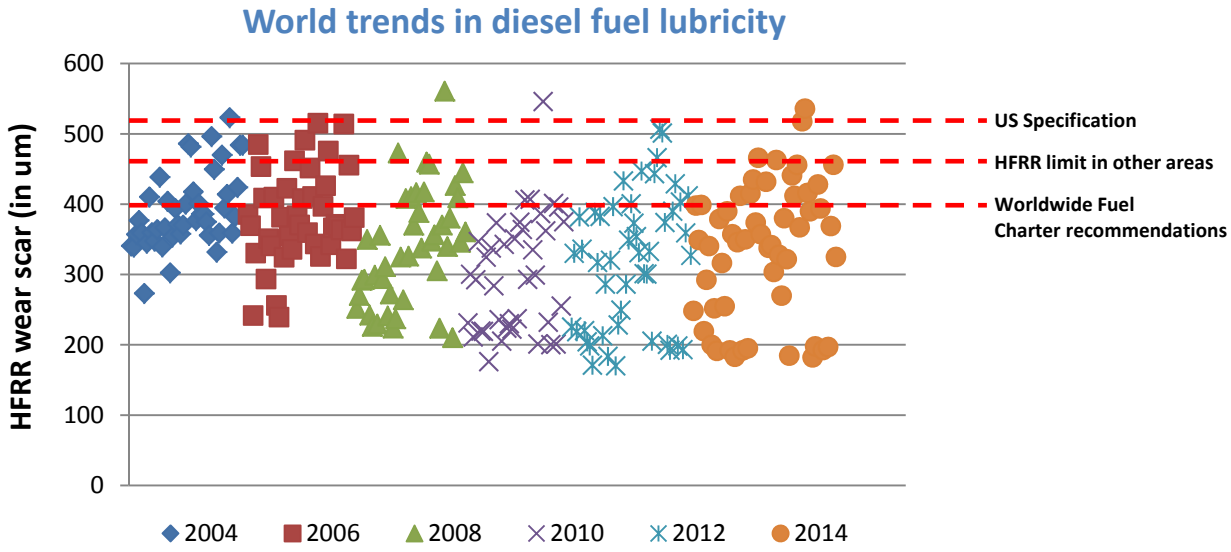
In 2014 we have seen a continuation of this global average trend, and from a situation in 2010 where most samples were below the Worldwide Fuel Charter recommendation of 400 microns (for category 4 and 5) we now find 25% of samples are above this target.

More European countries are above 400 microns than in 2012, an effect that may be owing to the reduction of FAME use in the region. In North America there seems to be some adjustment for the 2014 data, as there is clearly an increase in FAME use but this is not replicated in the high frequency reciprocating rig (HFRR) lubricity results. In Canada for example, 5 of the 13 samples had HFRR well above the 460 micron limit.

However, the majority of samples lie below the North American and European specification limits.



Worsening picture for global average diesel fuel lubricity continues in 2014



Most average lubricity results lie under the specification limits

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

Oxidation in Europe

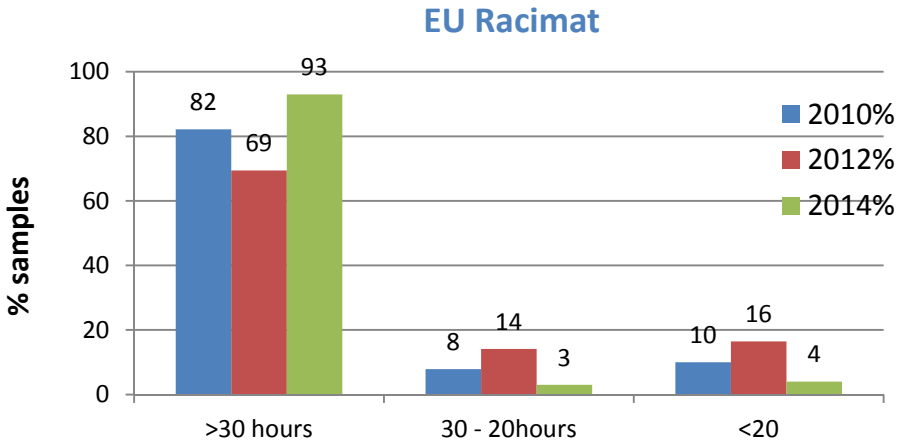
As FAME concentrations have increased, the European EN 590 diesel fuel quality standard has been adjusted to ensure fuel quality is maintained. The EN 15751 Rancimat test is an oxidation stability test that analyses the formation of volatile organic acids in diesel fuel. Organic acids result from a degradation reaction of FAME with oxygen upon heating. The time taken for these acids to reach the control chamber and cause a rapid increase in conductivity in the control sample is called the induction time. The EN 590 diesel fuel specification states a pass limit of a minimum of a 20 hour induction period for any diesel blend containing more than 2% FAME (on a volume basis).

In 2010 10% of European fuels failed to meet this minimum Rancimat requirement at the time of testing. This figure rose to 16% in 2012 - although there was some uncertainty about the root cause of the finding.

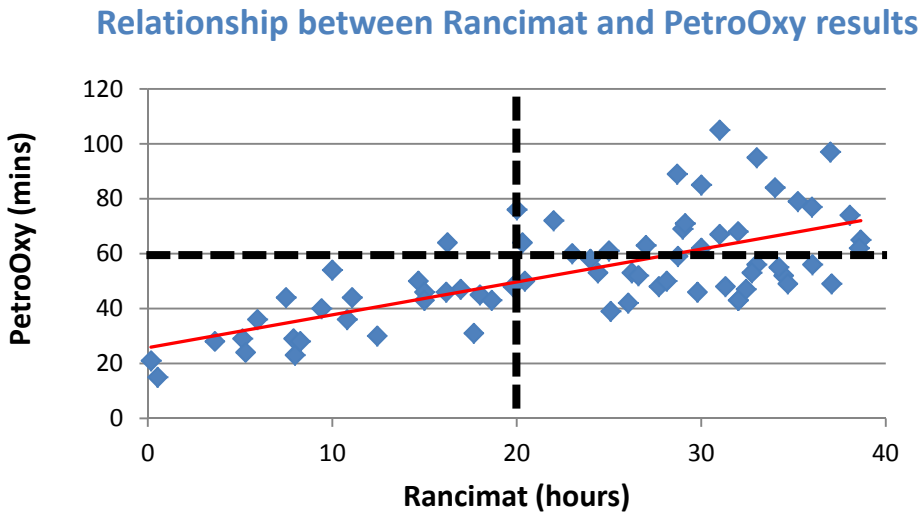
In the 2014 Survey the number of European samples failing to meet the minimum Rancimat limit fell to 4%. However, it should be noted that oxidation stability performance is influenced by the age of the fuel and storage conditions. Hence the results obtained for our samples may not represent fully the performance of the fuel at the moment of sampling.

New for this year is a look at the relationship between oxidation results obtained in the Rancimat test and the PetroOxy test – the latter of which is quicker to perform.

The data show a correlation between the two tests, and suggest that a test sample achieving a result of around 60 minutes in the PetroOxy test would reach the minimum of 20 hours required to pass the Rancimat test in the EN 590 specification.



The number of European samples failing to meet the minimum Rancimat limit has fallen



The PetroOxy test can be seen as an alternative means of predicting diesel fuel oxidative performance

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

Sulphur

In Europe and North America very low sulphur limits for diesel fuels have been in place for some years, and in the samples we collected sulphur levels ranged from <3 ppm to 30 ppm sulphur. Apart from Belarus and Italy, where one sample from each was above the countries' 10 ppm limit, fuels generally meet the minimum sulphur levels, which means in these areas there are no discernible trends to report.

The main area of interest in our Survey is the data from those countries that are still working towards the 'ultra low sulphur diesel' benchmark.

This year's sulphur-related headline is the significant drop in South Africa, Brazil, Argentina and Saudi Arabia compared to 2012 – with average sulphur levels in the samples collected falling from hundreds to just tens of ppm in 2014.

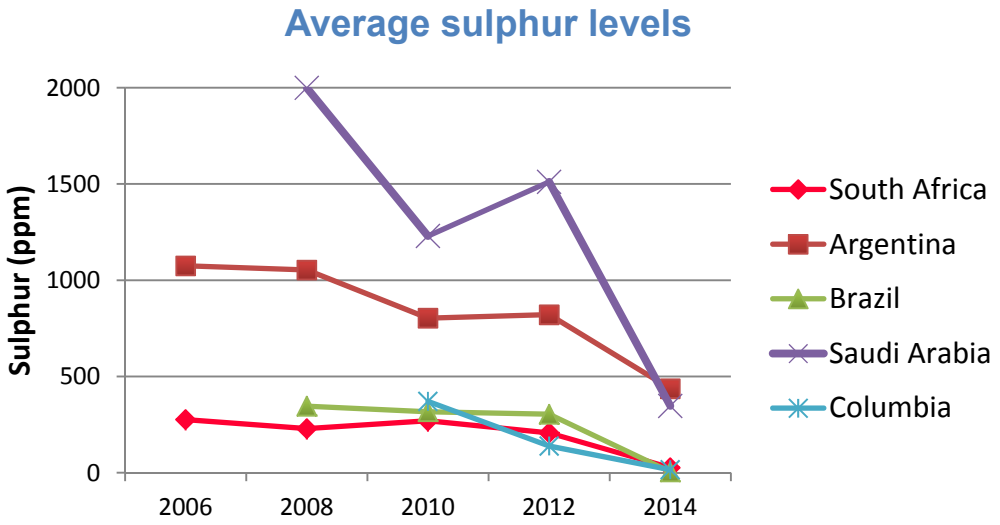
Care must be taken in assuming that in all cases this is representative of the countries' entire diesel pool, because city diesel tends to be lower in sulphur than rural diesel, and sampling may have a significant influence.

Despite this dramatic reduction in Latin America and South Africa, the chart below reveals that high sulphur containing fuels are still present in some regions of the world.

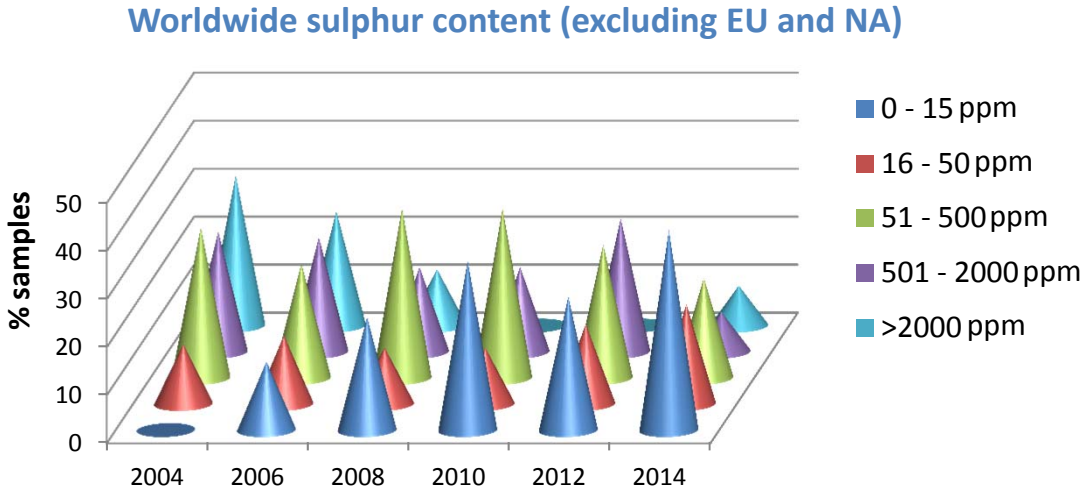
While the general trend is downwards, some of the samples collected still contained more than 1,000 ppm sulphur.

One area with high sulphur fuels is the Middle East where some fuels still contain several thousand ppm sulphur. But there are signs of improvement here, especially in Saudi Arabia, where average fuel sulphur levels fell from just over 1,500 ppm in 2012 to 347 ppm this year.

As emissions legislation drives the use of more advanced vehicle technology in all regions of the world, we expect diesel fuel sulphur levels will continue to fall. In our view, proven lubricity additives will be required to ensure that vehicle performance is not adversely affected.



Sulphur levels in some countries have fallen significantly



Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

Cold flow

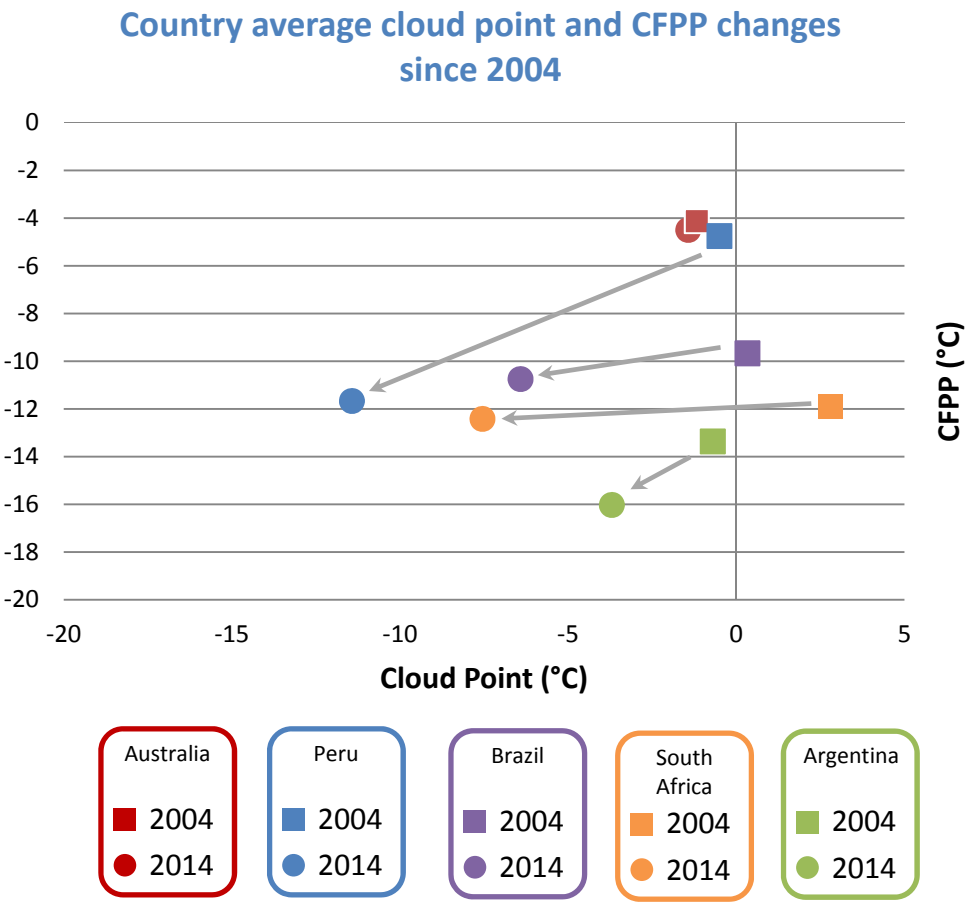
The cloud point and CFPP results obtained for the northern hemisphere samples show the situation is stable, and give us nothing to report on the cold flow performance of diesel fuels in this area.

However, in the southern hemisphere samples we have seen a progressive reduction in cloud point. Comparing the 2014 data with that obtained in 2004, this phenomenon is clearly visible in South Africa, Brazil, Peru and to some extent Argentina.

Potential causes of this reduction in cloud point include:

- The need to reduce back-end distillation to facilitate sulphur reduction
- Increased use of imported diesel in some locations
- Specification changes

Regardless of the cause, this trend will provide natural cold flow benefits, particularly where cold flow additives are not employed. Where cold flow additives are used we have not detected any significant change in CFPP, despite sulphur reduction and lower cloud points. This indicates that refiners have managed to maintain consistent fuel quality.



A progressive reduction in cloud point has been observed in some samples

Infineum Worldwide Winter Diesel Fuel Quality Survey 2014 – The trends

Looking to the future

We expect to see an increase in demand for diesel fuel, especially in developing economies which comes at a time when they are imposing more stringent emissions legislation – for example tightening sulphur limits and increasing the use of renewable fuels.

Across the globe, product flows are also likely to increase, not only in response to changing demand patterns, but also as new crude streams come online, especially in North America.

One of the key challenges for refiners to overcome is how to maximise diesel production to meet increased demand while remaining profitable.

These trends, combined with continued vehicle enhancements that OEMs are introducing to gain emissions reductions and fuel economy improvements, mean the use of proven, harms free additive technology is becoming increasingly important to help address the growing list of challenges the fuels industry is facing.

The samples from China have been collected and the analysis has been released separately as part of an *Insight* article.