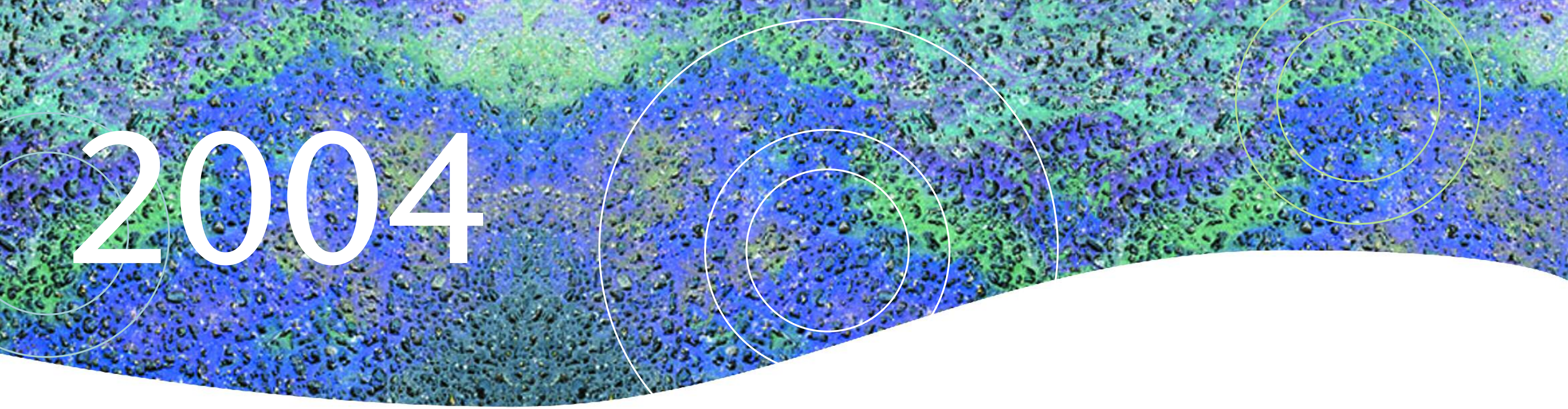



# Infineum Worldwide Winter Diesel Fuel Quality Survey 2004

 E200501

# 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 diesel in the marketplace, allowing international trends to be followed. To achieve its purpose, the Survey needs to cover as much of the globe as possible. For the winter 2004 survey, some 307 samples were collected in 42 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 delayed until later in the year when true winter grade samples could be obtained.

Samples need to be representative of the diesel purchased by the average consumer so they are gathered from service stations by Infineum colleagues at local area offices. 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. This can make it more difficult to evaluate trends with any accuracy.

**Analysis**

The analyses applied to each sample are those we consider will be of most interest to the diesel producers, 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 and space restrictions however, mean 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 the specifications.

**Test Methods**

The majority of testing was carried out at quality accredited laboratories in the USA, Japan and the UK using the following test methods:

| | |
|---|---|
| Density | ASTM D4052 |
| Kinematic Viscosity | ASTM D445 |
| Sulphur Content | ASTM D2622 / ASTM D4294 |
| Cetane Number | ASTM D613 |
| Cetane Index | ASTM D4737 / ASTM D976 |
| Pour Point | ASTM D97 / ASTM D5950 |
| Distillation | ASTM D86 |
| Cloud Point | ASTM D2500 / ASTM D5772 / ASTM D5771 |
| CFPP | IP309 / ASTM D6371 |
| HFRR | ISO 12156-1 / ASTM D6079 |
| Wax Content | Differential Scanning Calorimetry |
| LTFT | ASTM D4539 |

Samples collected in the Middle East were tested at a local laboratory, using the same or similar test methods.

Data on Korean and Chinese diesels were provided directly by the local authorities so information on test methods used is not available.

# The Trends

**Background**
This year's winter diesel fuel survey has been conducted against a backdrop of growing complexity in both the fuel and automotive manufacturing areas. Legislation aimed at reducing atmospheric pollution has driven, and continues to drive, changes to vehicle hardware and fuel composition that affect everyone from the largest fuel or vehicle producer to the general consumer.

To meet the demands of both improved engine performance and environmental legislation, vehicle manufacturers are increasingly employing more complex hardware. Common rail fuel systems, diesel particulate filters, NOx control devices, higher injection pressures, staged injection and smaller injection nozzles are the main features that come to mind. A number of these have a direct impact on fuel quality and put a demand on the fuel producers to improve fuel attributes such as stability and deposit control. However, the main influence on fuel composition probably remains sulphur reduction. This is driven partially by the direct negative impact of sulphur in the environment and partially by the need for vehicle producers to use sulphur intolerant after treatment devices. Additionally fuel composition is increasingly affected by the use of bio-diesel both as an extender to crude derived diesel, or as a fuel in itself.

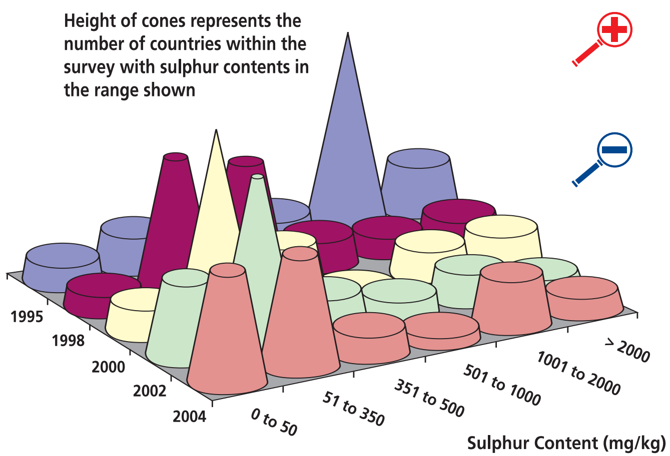
All these changes also have a direct impact on the fuel additive requirement; lubricity additive treat rates are increasing to counter the effects of more severe desulphurisation, performance packages are being rebalanced to provide the fuel stability and deposit control needed for the new hardware, and more specialised cold flow additives are being deployed to maintain the required performance in fuels of increasing severity.

Infineum diesel fuel surveys can be used to track the changes in fuel composition brought about by the factors discussed above. The 2004 survey is the most recent in a sequence extending back to 1985 and provides an up-to-date snapshot of diesel fuel quality that can be compared with those obtained in previous years to provide an insight into quality trends.

**Sulphur Reduction**
Sulphur reduction is a worldwide theme that is clearly visible within the survey samples collected over the past 10 years. Within Europe and North America there are consolidated programmes of sulphur reduction with the next major steps due to occur in 2005 and 2006 respectively. Specifications in other regions are less homogenous so the pace of sulphur reduction is not uniform, but similar trends are observed.

Sulphur reduction observed in this year's survey is limited to countries either from outside of Europe and North America or from within Europe that are changing ahead of the wider specifications to take advantage of tax incentives. This latter trend is clearly reflected within the chart below. Growth in the <50ppm peak as the 50 - 350ppm peak declines is predominantly driven by European tax incentives.

The chart would also appear to indicate that little change has occurred at the higher sulphur levels. However, this does not fit well with the analysis of individual countries which shows that almost all countries are reducing sulphur. This suggests that the chart trend in this area is probably a reflection of the number and mix of countries included in each survey.



# The Trends

To provide more detail: in the two year period since the previous survey was conducted we have witnessed sulphur levels reduce to; <10ppm in Austria and Germany, <50ppm in Japan and Ireland, <350ppm in Hungary and <500ppm in Australia. Additionally the Santiago area of Chile has reduced to <50ppm.

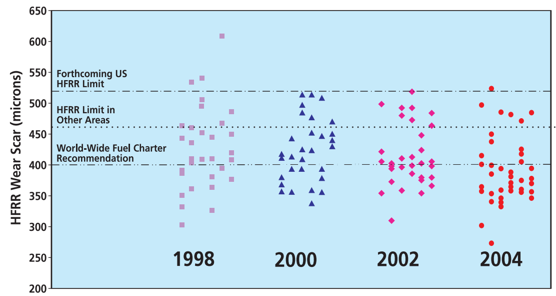
## Lubricity

Lubricity additives and high frequency reciprocating rig (HFRR) specifications have been used to protect the fuel systems of light duty vehicles in Europe and the low sulphur diesel producing countries in Asia Pacific for some time. However, in the absence of a lubricity requirement in the ASTM D975 diesel fuel specification, use of lubricity additives was not widespread in the predominantly heavy duty US region at the time of this survey. In June 2004 a 520µm maximum HFRR wear scar was added to ASTM D975 for implementation from 1st January 2005, but a ballot to delay the effective date is still pending at the time of publication of this survey.

The chart below compares average HFRR wear scars on a country by country basis since 1998 and clearly shows that lubricity standards are being maintained as results are very similar to those obtained during the 2002 survey.

However, it is worth noting that the World-Wide Fuel Charter, published jointly by ACEA, Alliance, EMA and JAMA, continues to advocate a 400µm HFFR wear scar limit.

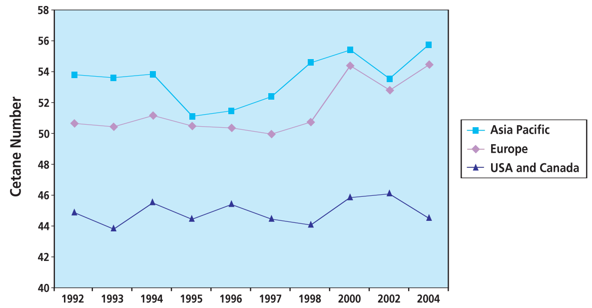
**Worldwide Lubricity Performance**




## Cetane

Again, worldwide cetane is very similar to that measured during the 2002 survey. The chart below compares average regional cetane values for the US and Canada, Asia Pacific and Europe since 1992. South and Central America has not been included in the chart as the list of countries included in the survey tends to change from year to year causing the average data to be inconsistent.

**Regional Average Cetane Number**




The shift of cetane in Europe from an average around 51 to an average around 53 is now confirmed. This shift is fully expected as it coincides with the changes to the EN590 specification in 2000 when the minimum cetane number was raised from 49 to 51.

## Cold Flow

The use of cold flow additives to ease diesel supply/demand issues and aid refinery economics is a long established principle. However, analysis of the diesel fuel survey samples clearly indicates that the principle is not employed by all refiners and fuel distributors. To provide an indication of worldwide cold flow additive use at a regional level, the 2004 survey data have been studied in detail.



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# The Trends

It is a phenomenon of most cold flow additives used in commercial applications that addition of the additive to the fuel will have no effect on fuel cloud point, but the cold filter plugging point (CFPP) will be reduced. In principle, it is therefore possible to identify survey fuels treated with cold flow additive as the difference between cloud point and CFPP will be extended compared to an untreated fuel. In practice this is an inexact science as the natural difference between cloud point and CFPP can vary significantly and the degree of CFPP depression provided by cold flow additives can vary from fuel to fuel. In the most extreme case, fuels treated with pour point depressant additives that are not active enough to depress the CFPP will appear in the analysis as untreated. However, in an average case the difference between cloud point and CFPP in an untreated fuel will be around 4 to 8°C and in a treated fuel it will be greater.

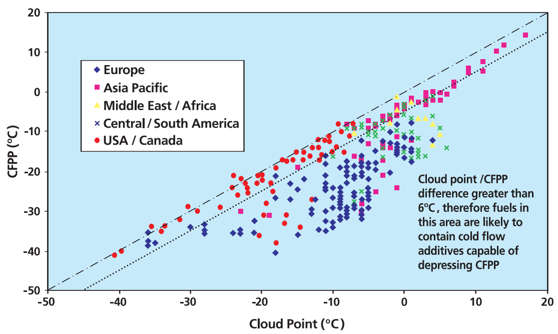
For the analysis of the survey data it has been assumed that fuels exhibiting cloud point/CFPP differences of 6°C or less are unlikely to be treated with cold flow additive, and fuels with cloud point/CFPP differences of 7°C or greater are likely to be treated.

The chart below is a plot of CFPP against cloud point covering all samples collected for the 2004 survey.

The lower diagonal line represents a cloud point/CFPP difference of 6°C. Based on the principle explained above, points occurring below this line are considered to represent fuels that have been treated with cold flow additive capable of depressing the CFPP. This provides an interesting regional breakdown:-

| Region | % of Samples Containing Cold Flow Additive Capable of Depressing CFPP |
|---|---|
| Europe | 90 |
| Central / South America | 48 |
| Asia Pacific | 33 |
| USA / Canada | 20 |

**Worldwide Cold Flow Evaluation**




It must be stressed that this analysis is only valid for the survey samples and may not represent a true picture within all of the regions used. Percentage figures for the Middle East Africa region are not included in the table as the number of samples tested is small. Figures obtained for Asia Pacific and Central / South America regions may also be misleading as coverage of these regions is somewhat limited. Sample coverage in the USA / Canada and Europe regions, however, is considerably better so the percentage figures here are likely to be more indicative of cold flow additive application within these regions.

**Looking Forward**

Shifting emphasis from analysing current trends to considering the future it is clear that a number of the themes already noted will continue in the forthcoming years. Fuel sulphur levels will continue to be reduced, biodiesel will increasingly be used as an extender to fossil fuel and the complexity of both fuel and vehicle production will increase. These changes will continue to apply pressure to refinery operations and as a consequence diesel fuel characteristics are likely to evolve. Today, the speed and direction of any evolution is a matter of speculation and is probably better dealt with as a trend in the next survey, currently planned for 2006.



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