GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE

TECHNICAL SUMMARY

EFFECTIVE FUEL DETERGENCY

All diesel fuels have a tendency to form small amounts of hard, carbonaceous deposits on the fuel injector nozzles of both direct injection and indirect injection diesel engines. This process is known to occur during the first few hours of operation, and then, generally to persist throughout the lifetime of the nozzles. The build up of excessive amounts of these deposits will disrupt the spray pattern of the fuel through the nozzle, which can lead to serious driveability problems. Increased fuel consumption, high noise levels and increased emissions are some of the problems attributed to excessive nozzle coking.

The Peugeot XUD-9 Nozzle Coking Test is the engine test most commonly used in Europe to assess the effectiveness of an additive in reducing nozzle coking in an indirect injection engine. Briefly, this test consists of operating the engine for 6 hours under steady state conditions and calculating the % flow loss through each of the injectors at the end of the test.

A fuel is generally deemed to have satisfactory detergency performance if the % flow loss averaged across the 4 injectors is 85% or lower (i.e. an average residual flow of 15% or higher) at a needle lift of 0.1mm.

Needle Lift (mm)	% Average Residual Flow Base Fuel	% Average Residual Flow 500 parts Base Fuel + 1 part GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE
0	0	0
0.10	4.25	24.5
0.20	6.5	37.5
0.30	11	50.75
0.40	21.75	66
0.50	56.5	77

The above results show that fuel treated with GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE at 1 litre to 500 litres gives very good detergency keep clean performance.

IMPROVED CETANE NUMBER

The cetane number of a diesel fuel is a measure of its readiness to ignite. Fuels with higher cetane numbers will burn more efficiently, releasing lower levels of emissions and giving better fuel economy than fuels with lower cetane numbers.

The standard method for determining the ignition quality (cetane number) of a diesel fuel is the ASTM D613 CFR engine technique. In this procedure, a single cylinder engine is used to measure the compression ratio for a fixed ignition delay. The cetane number of the test fuel is calculated by comparing its compression ratio with those of two reference fuels of known cetane numbers.

Cetane number improvers are routinely used as a cost effective way to boost the ignition quality (cetane number) of diesel fuel. The response of a particular diesel fuel to the addition of cetane number improver is dependent upon the characteristics of the base fuel, in particular the proportion of paraffins to aromatic constituents and the natural cetane number of the fuel. Most European diesel fuels having natural cetane numbers of between 45 and 55 will respond well to the addition of specially selected cetane number improvers.

The response of a UK diesel fuel to the addition of various concentrations of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE was measured by ASTM D613 method at Saybolt, an independent test house. The results of the tests are shown in tabular form below:

Test No	1	2	3	4	5	6
No of litres of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE added to 500 litres of base fuel	0	0.5	0.75	**1**	1.25	1.5
Cetane Number	52.6	53.0	54.4	**54.9**	55.2	55.5

The above results show that fuel treated with GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE at 1 litre to 500 litres increases the cetane number of the test fuel by 2.3.

IMPROVED LUBRICITY

Diesel fuel lubricity has become a very important issue in recent years, due to the introduction of low sulphur (<500 ppm wt) diesel fuels. The hydro-treating processes used at refineries to reduce the sulphur content of diesel fuel also reduce the concentration of polar molecules believed to give diesel fuel its inherent lubricity.

When low sulphur diesel fuels were introduced into the Swedish market in 1991, there was a major outbreak of fuel system failures in vehicles. Excessive wear was found in the rotary fuel pumps. An investigation by a major pump manufacturer attributed the excessive wear to the lack of lubricity in the low sulphur fuels.

The only cost-effective way of improving the lubricity of diesel fuel is to add a small amount of a lubricity additive to the fuel. GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE contains a very effective, non-acidic, lubricity additive.

The High Frequency Reciprocating Rig (HFRR) test method has been widely adopted across the industry as a means of evaluating whether a diesel fuel has sufficient lubricity performance. Both the CEN and ISO have accepted that fuels giving a mean scar diameter value of 460 µm and below are of satisfactory lubricity. Some pump manufacturers propose a more severe pass limit of 400 µm. The effectiveness of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE in improving the lubricity of a fuel has been demonstrated in a range of low sulphur European diesel fuels using the HFRR test. The results are shown in the table below:

Fuel	Base Fuel	Base fuel treated with GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE at 1 litre to 500 litres
Fuel 1	544	442
Fuel 2	380	345
Fuel 3	503	371

FOAM CONTROL

All diesel fuels have a natural tendency to produce foam when pumped into the tank of a diesel vehicle. Excessive foaming can cause motorists problems by "splashing-back" on them and by increasing re-fuelling times by prematurely activating the automatic fuel cut-off in service pump nozzles. Fuel spilling onto the service station forecourt also gives rise to environmental concerns.

A small amount of anti-foam added to the fuel can significantly reduce the above problems. In addition, fuel marketers have seen the commercial advantages of using anti-foam additives in terms of the greater volume of fuel that can be added to the vehicle tank before the pump cuts-off.

GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE contains a powerful anti-foam, which is very effective in reducing fuel foaming.

There are various methods for evaluating the performance of an anti-foam. Methods range from simple handshake tests to vehicle tank filling tests. A key supplier of GB Lubricants Ltd has recently developed an in-house rig method based on that used by a major oil company. The method correlates well with vehicle tank filling tests.

The effectiveness of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE in reducing fuel foaming was assessed using the aforementioned Foam Rig Test. This test involves the ejection of 425 ml of diesel fuel in 6 seconds under a pressure of 2.0 bar of N_2 from a metal vessel through a thin metal tube into a glass measuring cylinder. The initial height of the foam and the time taken for the foam to collapse are measured. The fuels used for the tests were typical European EN590 type fuels.

DRY FOAM

Test No	1	2
Additive	None	GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE
Treat-rate	0	1 litre to 500 litres
Foam Height (mm)	110	49
Foam Decay Time (sec)	53	1 sec

In addition to the above testing, GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE has been evaluated for antifoam durability testing to ensure that there is no loss of performance with time.

WET FOAM

Testing has also been conducted with the addition of 500ppm of water to simulate performance of the additive under conditions where water contamination may occur. In this case the CEC-RF93 reference diesel fuel was used.

Test No	1	2
Additive	None	GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE
Treat-rate	0	1 litre to 500 litres
Foam Height (mm)	68	60
Foam Decay Time (sec)	53	7

CORROSION CONTROL

The problems associated with fuel system corrosion are readily understood by today's diesel consumer.

GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE is very effective in imparting anti-corrosion properties to diesel fuels. The effectiveness of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE is readily demonstrated in a typical EN590 diesel fuel. This test involves immersing a polished steel pin in a mixture of diesel fuel and distilled water kept at 60ºC for 24 hours. At the end of this period, the extent of corrosion on the steel rod is assessed, using the NACE TM-01-72 rating scale. This scale runs from a rating of "E" denoting 75-100% rust, to a rating of "A" denoting 0% rust. A rating of "B+" or better is generally considered to be a pass. The results of the ASTM D665A tests are as follows:

Fuel	European fuel 1	European fuel 1
Additive	None	GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE
Treat-rate	0	1 litre to 500 litres
NACE rating	C	A

The above results show that GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE is very effective in preventing rust.

WATER DEMULSIFICATION

Some multifunctional diesel additive packages containing detergents can cause the formation of undesirable fuel-water emulsions if they are not correctly formulated.

GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE contains a demulsifier, which counters any detergent side-effects and improves the separation of fuel from water.

The water demulsification properties of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE were assessed using the ASTM D1094 test, in which 80 ml of diesel fuel and 20 ml of water are shaken for 2 minutes in a 100 ml stoppered measuring cylinder. The appearance of the interface and the degree of separation are rated after 5 minutes standing. The amount of emulsion formed and any change in volume of the water layer are recorded.

The fuel used for the following tests was a European EN590 fuel:

Test No	1	2
Additive	None	GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE
Treat-rate	-	1 litre to 500 litres
Interface Rating	4	4
Separation Rating	3	3
Δ Vol. of aqueous layer (ml)	15	20
Vol. of emulsion (ml)	5	0
Aqueous haze	NONE	NONE
Fuel haze	SLIGHT	SLIGHT

The results show that GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE is effective in improving the separation of diesel fuel from water.

WATER HAZE

Due to the fact that these premium diesel fuel additives contain surface active detergent chemistry, they do have the capacity to stabilise water haze in distillate fuels, if not correctly formulated. GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE has been evaluated for water haze stabilisation, according to an internationally recognised water retention test procedure. This procedure involves circulating the test fuel through a glass reservoir via a centrifugal pump in the presence of a fixed volume of water. The degree of haze is defined by transferring the fuel to a 500 ml wide necked jar and comparing the appearance with a set of standard photographs which are rated from 1 to 6 in order of increasing haze content.

A generally accepted pass for this test is that the additive treated fuel should achieve a rating of maximum 1 after 2-3 days.

GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE has been evaluated in this test and meets the requirement of <1 after 3 days.

OXIDATION STABILITY

The increased demand for diesel fuel has led refiners to use cracked components in diesel blending. Cracked components contain high levels of olefins, nitrogen and aromatics, and can be significantly more unstable than straight run diesel components. This instability manifests itself as a precipitation of insoluble gums, which can lead to the blockage of diesel fuel filters.

GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE contains additives that improve the oxidative stability of diesel fuels. The effect of GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE on the stability of CEC RF90-A-92 diesel fuel was evaluated using method IP 388 (ASTM D-2774), in which a sample of diesel fuel is aged at 95ºC for 16 hours while oxygen is bubbled through it. The higher the concentration of insolubles removed from the fuel after the test, the poorer the oxidation stability of the fuel. The test results are shown in the table below:

Additive	None	GB MULTIFUNCTIONAL DIESEL

		FUEL ADDITIVE
Treat-rate	-	1 litre to 500 litres
Filterable insolubles (mg/100 ml)	0.47	0.02
Adherent insolubles (mg/100 ml)	0.38	0.7
Total insolubles (mg/100 ml)	0.85	0.9

The results show that GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE improves the oxidation stability of diesel fuel.

LUBRICANT INTERACTIONS

Since there is the possibility of treated diesel fuel coming into contact with crankcase lubricant, and certain diesel fuel additive chemistries can interact with the additives used in lubricant, a test has been devised to assess this aspect. The accepted test is often referred to as the Aral lubricant interaction test.

GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE was evaluated in a slight variation of this test. A summary of the actual test procedure is as follows: 10 grams of the additive are added to 10 grams of 11TBN fresh multi-grade lubricant in a 500 ml glass jar. Vigorous shaking for 1 minute agitates the contents of the jar. The jar and contents are then stored in an air-circulated oven at 90º for 72 hours. The contents of the jar are then inspected for any visual evidence of interaction. 500 ml of a diesel fuel are then added to the contents of the jar and mixed, by shaking, for 30 seconds. After standing for 5 minutes the fuel containing the additive mixture is filtered through a 0.8 micron cellulose filter paper using a 600 mbar vacuum. The filtration time for passing the entire volume through the filter paper is recorded.

A pass in this test is defined as being when 500 ml of fuel pass through the filter in less than 180 seconds.

The results obtained with GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE in the test fuel are shown below:

Additive	GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE
Treat-rate	1 litre to 500 litres
Filtration time (secs)	120

The results show that GB MULTIFUNCTIONAL DIESEL FUEL ADDITIVE meets the requirement of less than 180 seconds filtration time.