Aquasolve™ was created to control water in fuel.

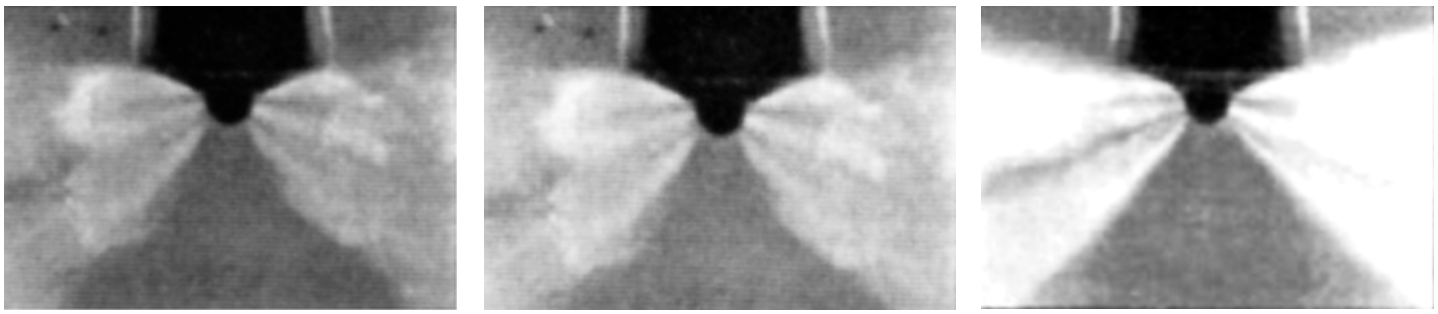
The ability of Aquasolve™ to create a permanent bond of oil and water enables it to benefit the whole combustion system.

The initial invention of Aquasolve™ followed by many years of research at City University London and other institutions primarily sought to provide a technology that would not compromise engine or fuel performance.

Areas of particular interest included spray pattern testing, diesel bug, freeze curve and pour point, emissions and fuel consumption together with the longevity plus stability of the resultant oil/water relationship.

A large element of early work also consisted of exploring potential bio fuels including ethanol.

Illustrated below is part of a sequence of spray pattern photographs of a modified diesel fuel in a specially adapted engine to enable "high speed" photography to capture the combustion process.



Spray pattern testing for Tallow as a bio fuel

What is Aquasolve™

Aquasolve™ is a family of compounds which are ash less, non-metallic and totally organic, and were developed for use as fuel components for all liquid combustible fuels. The use of the unique formula of Aquasolve™ will reduce toxic emissions, while increasing drive ability and improving overall efficiency of your vehicle. Aquasolve™ does this by delivering the fuel to your vehicles engine in a state which allows for better and more complete combustion. Engine testing at major laboratories has shown that the use of Aquasolve™ causes substantial reduction in total unburned hydrocarbons (HC), carbon monoxide (CO), nitrous oxide compounds (NO_X) and carbon dioxide (CO_2), as well as smoke and particulates in diesel.

In addition, the unique molecular binding properties of Aquasolve ™ prevent phase separation between fuel mixtures that are contaminated by water. Depending on the weather conditions, 3 – 6% of water is present as condensation in all fuel systems. The use of Aquasolve™ can provide a solution to the water contamination problems inherent in all fuel systems, while simultaneously improving the combustion characteristics of the fuel, and therefore increasing the effective power delivered from the engine.

How Aquasolve Works

Introduction of the fuel components of Aquasolve to fuels allows molecules to flow more freely, thereby resulting in more efficient combustion. For example, in building a campfire, one is more successful in using kindling to start the fire than using larger dense logs. Why? Because the smaller kindling has increased surface area and increased exposure to the air, resulting in more efficient combustion.

Aquasolve™ works similarly. By decreasing what is known as "inter-facial surface tension" between the fuel molecules, Aquasolve™ causes the fuel droplets to become smaller and more uniform in size and thus much easier to burn.

Additionally, independent researchers have reported that the efficiency of fuel combustion is improved by the direct injection of water or water vapours into the combustion chamber, close to the point of combustion. If we bind the water contaminants in the fuel as an integral component of the fuel, this produces the same results. The unique water binding capability of Aquasolve™ uses the small amounts of water present in all fuel systems to incorporate the water directly into the fuel. Incorporation of these small amounts of water leads to even greater reduction in the surface tension between fuel molecules, thus leading to even smaller fuel droplets, which allows for more efficient combustion.

Another unique feature is that Aquasolve™ creates smoother surfaces for fuel to be delivered to the engine. As Aquasolve™ passes through the fuel line and pump, Aquasolve™ creates a mono layer or a thin film of molecules over the surface in the fuel system. This thin film of molecules results in a smoother surface with less friction within the fuel system, thus acting as a natural lubricant and allowing for more efficient flow of fuel, and this natural lubricating effect also provides less wear and tear on your engine system components.

As the additized fuel is released by the fuel injector, Aquasolve™ causes the molecules to be atomized into smaller droplets. Like the campfire example, these smaller droplets burn more efficiently. The more efficient fuel flow and smaller droplet formation lead to more efficient fuel combustion, which translates directly into lower emissions and better fuel efficiency, which can provide direct cost savings per gallon of fuel consumed; i.e., more miles per gallon (up to 10% more mpg has been experienced).

Benefits

Added to gasoline, diesel or reformulated fuels, Aquasolve™ fuel components provide a number of significant benefits:

- Totally eliminates water contamination (and its effects) from your fuel system
- Acts as rust and corrosion inhibitor in your engine and fuel system
- Prevents bacterial and fungal growth in your fuel system (diesel bug)
- Stabilizes all Hydrocarbon fuels
- Significantly reduces emissions (CO, HC's, NOx, CO2) by up to 70%
- Improves fuel quality
- Improves fuel consumption by up to 10%
- Cleans filters and injectors

Research History

After the discovery of a compound developed over a period and tested to the point of proven feasibility, the Department of Thermo Fluids at City University London, under the direction of Prof David Thorley, undertook a series of studies to establish the effects of Aquasolve™ with regard to its compatibility with the mechanical and combustion requirements of modern engine development.

The Properties of the aliphatic alcohols are strongly influenced by hydrogen bonding. As the chain length increases, the influence of the polar hydroxyl group on the properties of the molecule diminishes. The molecule becomes less like water and more like a hydrocarbon. As a consequence; low-molecular-weight alcohols tend to be water-soluble; high-molecular weight alcohols are not.

Prof Thorley recalls that, in the early days when, as an engineer, he was trying to introduce some logic into this particular black art of organic chemistry and realised that we had to construct a bridge between the water and hydrocarbons by using surfactants that had an affinity, one with either oil and one with water, then building out from those towards a 'keystone' surfactant that completed the arch joining the water on one side to oil on the other.

So we completed the bridge with Aquasolve™.

The first major area of specific testing would be compatibility tests, summary of which follows.

Stability Studies

Tests have been carried out using the additive combined with water and diesel type fuels with a view to establishing the risks, or otherwise, of corrosion problems developing, and of the fuel/water/additive mix breaking down.

Materials tested included steel, aluminium, copper, brass, bundy tubing, rubber and reinforced nylon tubing.

Introduction

Numerous past attempts to combine small amounts of water with diesel, either mechanically or chemically, have shown limited success. The emulsions created have been unstable, separating out within minutes. There have also been significant corrosion problems associated with the use of such emulsions in diesel systems, often leading to research programmes being abandoned.

The development of Aquasolve™ however, has overcome the major hurdle of stability. Its use has enabled over 10% of water to be completely absorbed in diesel. The additive, which is a combination of various organic compounds, has been successfully employed to create not only a diesel/water emulsion but also a clear stable solution.

A large amount of testing was required to support its performance and a comprehensive test program has been done at The City University, London.

Initial tests used:-

i) the additive
ii) a clear solution of diesel, water and additive in the ratio of 30:3:4 (Referenced as S1)
iii) an emulsion of diesel, water and additive in the ratio of 30:3:2 (Referenced as E2)

Bench Testing

Static Corrosion Test

The basic diesel fuel system was divided into its components:- Tank - Fuel Line - Filters - Pump - Injectors.
Component materials used were ascertained to be:-

Metallic	**Non-Metallic**
Structural Steel	Reinforced Nylon Tubing
Cold-drawn Steel Tube	Bundy Tube
Aluminium Alloy	Rubber
Brass	
Copper	

These materials were corrosion tested at room temperature (20°c). Two control tests were set up for each sample:-

i) Air - in order to compare test samples with an original sample
ii) Diesel - in order to recognise any 'normal' effects due to contact with untreated diesel

Later further corrosion tests were conducted using solution S1 mixed with various proprietary diesel fuel improvers.

Each material sample was carefully cleaned (using emery cloth on the metallic and tissue on the non- metallic samples) and then fully immersed in the test fluids.

Using tongs, each sample was then individually removed from its jar of fluid, dried using tissue and weighed on electronic scales (range 0 - 160mg, readability 0.1mg). The weight was recorded and the sample returned to its jar of fluid.

The samples were left undisturbed for two months during which time any visible changes in samples or fluids were recorded. After two months, the samples were re-weighed using the same technique as before to establish whether any weight gain/loss has occurred.

The only metallic elements to show significant visible reactions were copper and brass. This amounted to discolouration of samples which included the additive. Rubber increased in weight in both S1 and E2 but also in diesel only. This indicated that the rubber used would not be a reliable element in diesel systems (although it had been sourced from diesel plant manufacturers).

Tank Corrosion Test

Since tank corrosion is usually initiated at the interface between the liquid and the air above, a test was set up to simulate conditions in a fuel tank.

Narrow strips of mild steel were placed in bottles half filled with test fluids S1 and E2 and control fluids diesel and water. One set of these four bottles was left undisturbed, another was inverted once and then left undisturbed and a third set was inverted daily. The tops of the bottles were loosened to allow air into the bottles and the effects of corrosion were observed.

The only liquid sample to show any sign of corroding the steel in any of the sets of bottles was water. Both the emulsion and solution left the steel perfectly clean, as did the diesel. This illustrates that the use of the additive in the diesel/water mixtures enables the water to be completely absorbed as there is no visible reaction with the steel.

Emulsion Separation Test

In order to establish whether it would be feasible to use the additive with diesel and water in an emulsion form, a test was conducted to observe the stability of such an emulsion and the effects that certain materials had on it. It was decided that the emulsion would be too unstable in the majority of situations to be encountered within a diesel system.

Conclusions

The static corrosion tests produced encouraging results for the steels and aluminium alloy samples. Although some problems were encountered with the copper and brass samples, further tests with fresh samples have begun to examine whether the reactions experienced by these samples are progressive.

Aviation

Aviation is subject to the same environmental issues as other transport systems and will be the subject of further research via an industrial partnership, which is in the course of development to secure airframe certification.

A preliminary test (Defstan 91/91) has been carried out at an MOD approved laboratory which addressed our concerns regarding freeze curve and FAME. This was encouraging and is available to view on our website: www.covalaquasolve.co.uk.

Performance

Over the whole research and development programme for Aquasolve™ the effect observed on performance figures has been reflected consistently by various tests executed by all parties.

These have shown up to 10% improvement in fuel usage.

Most on road test conditions depend on multiple factors, driving conditions, technique and age of vehicle.

Emissions

THERMO - FLUIDS ENGINEERING RESEARCH CENTRE REPORT ON ENGINE TESTS WITH MODIFIED FUELS CONTAINING VARIOUS ADDITIVES

CO Emissions

Diesel fuel was seen to produce the highest Carbon Monoxide at all loads where emissions were significant. CO was lower for each modified fuel and seemingly inversely proportional to the water content. The 10% solution gave the greatest reduction, approximately 1% of TGV at rack position 80; or a decrease of 25% in relation to diesel emissions.

As the variable injection timing test was conducted at a constant low load part load condition, the CO emissions were negligible in all cases.

CO2 Emissions

Diesel fuel results stand apart from the test fuels by approximately one percent of the total gas volume at mid and high loads. CO2 emissions generally appear to reduce depending on the amount of water contained in the test fuel. Although results for the modified fuels are tightly banded, it is possible to detect consistently lower CO2 output for the higher percentage water fuels. This trend is prevalent at mid and high load. There Is little difference in performance between any of the sample at low load.

There was shown to be no influence of injection timing. The relationship between water/additive content, if any, is not clear from this data. A general description would suggest that the highest water content fuels tended to show the later start of rapid pressure rise i.e. nearer to top dead centre. The results for diesel fluctuate within the bandwidth of the modified fuels and therefore no firmer conclusions can be drawn at this stage. The
diesel figures were plotted from a single test rather than mean values from a large sample as before; so the data set may not be representative of typical diesel performance.

When compared to load, slightly clearer relationships emerge. The SRPR is retarded furthest with diesel fuel and increases in proportion to the water content. At low load, results for all of the fuels are closely grouped and the widest differentials occur at mid to high range load. The peak ignition advance also appears at these points.

Test on modified fuel

Four hydrated fuels were studied containing 1, 2, 3 and 5% of water.

Observations

Power Output

The 3 and 5% fuels gave the best overall performance with behaviour closely akin to that of diesel. Once again, at low load, the pure diesel fuel produced the least torque of the sample. The 1% solution performed poorly with the 2% not faring much better. There was a general tendency for higher power output with increased water/ additive content.

Fuel Consumption

The same general characteristic of linearity is evident with this sample as has been seen in previous trials. The scatter between the fuel with the lowest flow rate for a given rack position (diesel) and that with the highest (5% modified fuel) is slightly less than 0.1 I/hr. This value remains constant at all conditions.

Exhaust Temperature

Despite all of the fuels in this sample having similar water/additive contents compared to previous batches, the relationship between concentration and exhaust temperature is once again clear. Allowing for a pair of anomalous results from tests with the 3 and 5% fuels, the tendency is for these fuels to provide the lowest exhaust temperatures at all conditions. A mean scatter of 20 to 25 degrees C is noted.

CO

These results verify data recorded from previous tests. Emissions expressed as a percentage of total gas volume are reduced in the order of 0.8% maximum. CO reduces with increased water and additive concentration.

CO2

The distinctive grouping of the hydrated fuels at a level below that of emissions from diesel fuel is repeated here. There is a general reduction in CO2 of 8 to 9% at low and mid range loadings. The results for all fuels becomes progressively more tightly banded until at the low equivalence ratio point, the CO2 content of the 3 and 5% modified fuels surpasses that from diesel.

Start of Rapid Pressure Rise

The tendency of combustion to occur earlier with the modified fuels is clearly illustrated here. A general advance of the point of rapid pressure rise of 1.5 degrees of crank angle is common amongst all fuels compared to diesel. From this data it is unclear which fuels cause the greatest advancement to occur. Results for the higher percentage fuels are erratic, but they do include the maximum reading of SRPR, whereas those for the low concentration fuels gave the highest values of SRPR in the most cases. Indeed, data from the tests with the 1 and 2% modified fuels was very consistent and predictable.

The Variable injection timing test showed the modified fuels to be closely banded at all conditions, with the 3% fuel producing the earliest combustion point; an advance of around 1.5% compared with the diesel control. This figure is constant at all conditions of static injection advance. The 5% fuel performs closest to the diesel figures with a mean advance of approximately 0.5 degrees. No other consistent trends are evident.

Extensive tests were carried out using a variety of engines by third parties including this extract:

Diesel Smoke Measurements Using a Sun Opacity Meter

OBJECTIVE: To determine the effect of Aquasolve™ additive on exhaust emissions levels of black smoke and particulates in a diesel passenger vehicle.

TEST: The Black Smoke Emissions test was a performed in a Ministry of Transport (M.0.T.) Cd testing facility in London, England.

FUEL: standard EN 590 diesel fuel as available at all service stations in the UK Engine Type: Ford Escort with 1.9 Litre 4 cylinder diesel Engine Experimental Protocol.

1) The vehicle was run through a standard MOT Black Smoke emissions test prior to addition of Aquasolve™ to determine the baseline smoke emissions profile for the vehicle. The mileage and emissions testing results were recorded as Baseline Prior to Adding Aquasolve™.

2) Aquasolve™ was added at 1/1000 treatment ratio and the vehicle was driven 100 miles over the next 24 hours to condition the engine to Aquasolve™.

3) The MOT Black Smoke emissions test was repeated and the results recorded.

Emissions Testing Procedures

The Black Smoke Exhaust Emissions Measurements were taken at fast idle and then rpm were run up until governor cuts in.

Black Smoke Measurements were done using a SUN Model ASA 200 Opacity analyser used for determining emissions of Black Smoke and particulates (particulate by conversion in Smoke table).

RESULTS

The results show that Aquasolve™ was very effective in reducing emissions of Black Smoke and particulates in a Diesel engine passenger vehicle.

The percent reductions in emissions are summarized below.

	% Reduction in Emissions
Black Smoke	66 %
Particulates	71.7 %

This is just one example of the emission results outlined earlier.

Bio Fuels

We have, since developing Aquasolve™, studied the suitability of bio fuels as part of the agenda for the use of Aquasolve™.

It has included butter, tallow, rape seed oil, ethanol etc. However because ethanol has become a part of the fuel equation for environmental reasons it has been studied more extensively.

There follows some notes from our research bearing in mind that all bio fuels attract moisture.

The principle benefit of the use of Aquasolve™ is in stabilising ethanol within the fuel mix. This is because ethanol is moisture sensitive and will readily split phase with the fuel if free water is present, despite being miscible with the fuel in the first place. It was noticed that in open phase testing where phasing could occur, the Aquasolve™ treated fuel remained as a stable single phase even with the evaporation of volatile elements. Later tests showed similar benefits in gasoline and a reduction in evaporation pressure.

The ability of Aquasolve™ to dissolve any free water also prevented diesel bug forming in this stable fuel environment.

Some early notes from City University: STABILISING ETHANOL DIESEL MIXTURES - APRIL 1990

Introduction

The use of oxygenates, i.e. fuel additives containing oxygen have always been of interest. Compounds such as the ethers, and alcohols, particularly ethanol and methanol, fall within this classification.

Their use ability as readily combustible materials has always suggested use as a combustion aid. More recently legislation in the United States has meant that a minimum of 2.0% alcohol should be present in fuel to aid cold starts as a means of reducing carbon dioxide and hydrocarbon emissions during the period when the engine temperature is too low for efficient combustion.

With the realisation that the fossil fuel supply is limited, interest in alcohols as alternative fuels or as fuel extenders has reawakened. One common problem has been that mixtures of hydrocarbons and alcohol, although miscible, at ambient temperatures at and in wide range of proportions, suffer from sensitivity to water contamination. The water causes a separation into ethanol and hydrocarbon phases, which Is undesirable for engines designed to operate at one setting. Consequently to take into account of this condition, a homogeneous fuel is important.

Most work with alcohol and diesel mixtures has employed additives to stabilize the ethanol/diesel fuel. A high content of “oxygenates” (-20%) has been achieved, though no distinction was made between the additive and alcohol content In the fuel. Some of the problems of using alcohol as diesel extender have been examined in this report.

Miscibility studies

Ethanol can be obtained from renewable biological sources. It is combustible and being a liquid Is easy to handle. By comparison, diesel is primarily produced by extraction from fossil fuels and can be regarded as coming from an unrenewable source.

Mixtures of ethanol and diesel were explored as possible alternatives to pure diesel. The two areas to be examined were the ability to form a one-phase liquid and the stability of such mixtures.

Ethanol and diesel were mixed with a wide variety of surfactant agents. Included in this list was additive mk 11 and the components involved in its formulation. The long-term miscibility and stability of the resulting mixtures were studied.

Since ethanol has been introduced to both diesel and petroleum fuels as a standard component, there is already concern being expressed by the industry and users about the effect of its application as a bio fuel and the problems that can occur.

Winter Diesel

Aquasolve™

(providing Antifreeze protection to all Hydrocarbon fuels)and (Anti-Gel protection to all Diesel fuels)

Technical Information

Aquasolve™ is an ashless, non-metallic, combustion enhancing, fuel additive designed to “Solubilize” controlled amounts of water in diesel fuel or gasoline in order to eliminate water contamination and condensation in fuel tanks. This has the added benefit of preventing the water from freezing in the fuel lines and fuel filters - a major cause of cold-weather engine shut down. A treatment ratio of 1:250 to 1:500 is recommended for initial treatment, and after the initial treatment, prophylactic doses of 1:1000 are recommended to keep your fuel system completely free of water.

With moderate agitation (such as occurs in normal driving) this will solubilize approximately an equal amount of water into tiny droplets (too small for the eye to see!) which are actually incorporated into the fuel. The effect of this is to reduce the freezing point of the fuel to -5°F (- 20°C). Please note that diesel normally freezes at -14°C.

Greater concentrations of Aquasolve™ can be added to remove greater concentrations of water from the fuel. In addition, Aquasolve™ provides natural lubricants which will improve the lubricity of the treated fuel enough that it will provide lower friction and wear than untreated fuel alone. The natural lubricants in Aquasolve™ will reduce the friction sufficiently (even in dry fuels) to provide engine efficiency improvements of up to 10% based on bench engine and chassis dynamometer tests.

Benefit Summary

- Solubilizes water in diesel fuel and gasoline
- Prevents rust and corrosion
- Prevents Diesel Bug - by removing free water, a necessary ingredient for microbial growth which can cause diesel filter plugging
- Reduces the freezing point of water in fuel
- Acts as a natural lubricant to the fuel
- Improves fuel quality
- Stabilises all hydrocarbon fuels
- Cleans injectors and carburettors
- Improves engine efficiency up to 10%
- Removes water & reduces fuel line freeze

Aquasolve™ is designed to remove water from a diesel or gasoline fuel system by a process known as "SOLUBILIZATION". By doing so, it significantly reduces the freezing point of water in the fuel system. There are many products on the market which claim to remove water and prevent fuel line freeze up. Most can even demonstrate their effectiveness by adding equal amounts of water directly to the fuel additive which shows complete solubility of the water in the additive. However, these tests are completely misleading. The water/additive combination will behave differently when added at the recommended concentration in the fuel, and those materials which demonstrate an ability to dissolve the water will not dissolve water in the fuel at additive concentrations lower than about 5%. Almost all of these products are based on alcohols or glycol ethers. Alcohols like methanol and isopropyl alcohol will not dissolve water in the fuel and will instead phase separate, going partly go into the water phase and actually increasing the volume of the water phase and significantly making the water phase more corrosive. However, these alcohols will reduce the freezing point of the water in the fuel. Methanol and ethanol are more effective than isopropanol, but methanol, in particular is more damaging to the seals and fuel system components. For this reason, Isopropanol is now more popular, but it requires larger amounts to reduce the freezing point and it will actually increase the friction in the injectors and pumps. The glycol ethers are less damaging to the fuel system components, but they are also less effective at reducing the freezing point of water.

In fact, none of the products currently marketed as water removers for fuels literally removes water from the fuel. Aquasolve™ works in two stages; first, by solubilizing the free water in the fuel and then removing it from the fuel system in the most effective way, incorporated as an integral part of the fuel in normal operation of the engine.

Aquasolve™ does not attempt to disperse the water into a separate alcohol phase to remove it, but instead "Solubilizes" controlled amounts into microscopic droplets which are now an integral part of the fuel, and which will easily pass through the fuel filters into the engine where the water actually contributes to the combustion process. Agitation of the fuel tank through normal driving is all that is required to achieve the solubilization of free water. Once the water is solubilized, it will not cause fuel injector or pump damage, in fact, fuel lubricated with Aquasolve™ has much better friction and wear properties than fuel alone, and water bound by the solubilization process is no longer corrosive.

By incorporating the free water contamination in the solubilization process, Aquasolve™ acts as a very effective corrosion inhibitor to prevent rust and corrosion of the fuel system components. Aquasolve™ will solubilize approximately an equal amount of water into the diesel fuel. A typical treatment to remove the water of condensation is a 1 litre bottle to 1000 litres of fuel. This treatment will also reduce the freezing point of the water normally present in diesel fuel below -20°F. For larger amounts of water in the fuel it will reduce the freezing point to -5°F when an equal amount of Aquasolve™ is added.

As a reference, 250 litres of diesel fuel, which is clear and shows no signs of water can actually contain more than one ounce of water dissolved in the fuel. As the temperature is reduced, this water falls out of the fuel and if it is below freezing, ice crystals will form. Larger amounts of water can be present in a fuel tank if the truck was filled soon after the underground storage tank was filled, thereby mixing the bottoms water into the fuel. Even at this rate, one bottle per 1000 litres should take the fuel to 0°F, unless a large volume of water has been added into the fuel.

A unique feature of the chemistry utilized in Aquasolve™ is that the active ingredient is incorporated with the water throughout the fuel, thereby permanently reducing the freezing point of the water, even if untreated fuel is added to the tank. A competitive product which is based on isopropanol, will reduce the freezing point of this normal water in diesel to 0°F when used at 750ml per 68 litres, but since the water is not removed in the process, and if untreated fuel is then added to the tank, the freezing point for this water in the fuel is now 23°F. In other words, this alcohol chemistry requires large concentrations of very expensive chemicals to be used continuously in order to even be mildly effective.

Reduces Rust and Corrosion - Aquasolve™ acts as a potent corrosion inhibitor to help control fuel system corrosion even in the presence of water.

Anti-Rust Test

Aquasolve™ has been subjected to extensive testing of the anti-corrosion actions using both the ASTM test method, as well as the Colonial Pipeline Corrosion tests.

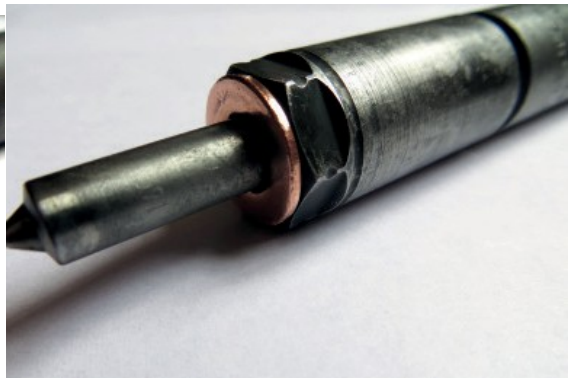
The results have shown that Aquasolve™ provides complete protection even for naked steel against the corrosive effects of boiling salt water on steel.

In the course of cold temperature tolerance it has been noted that one of the key ingredients of Aquasolve™ and its phthalate offers outstanding low temperature performance, which will serve to enhance its cold temperature capabilities.

The ability of Aquasolve™ to control the water in fuel even to the extent of suspending as a single phase solution 10% of water into diesel fuel, it was observed that when diesel itself froze there was no evidence of the water separating out of the mix.

When the temperature raised slightly (but still below freezing) the whole mix returned to a clear single phase solution.

Injector before use of Aquasolve



Injector after use of Aquasolve

We observed how ordinary diesel fuel behaves when frozen to -20°C, and then when returned to its usable state which is still below freezing; both agricultural and standard diesel was used.

We then observed how the same batch of diesel behaves when contaminated with 10% water by volume solubilized into a single phase solution with Aquasolve™, to see if the water would come out of solution when frozen and when the diesel returned to a usable state (still below freezing).

It shows that there was a consistent single phase condition when frozen and when returned to its operating temperature, the fuel remained as a permanent single phase clear solution.

A: Diesel fuel operating temperature (still below freezing).

B: Frozen diesel fuel -20°C

A **B** **A** **B**

Agricultural diesel untreated Agrcultural diesel plus 10% water treated with Aquasolve™

A **B** **A** **B**

Non agricultural diesel untreated Non agricultural diesel plus 10% water treated with Aquasolve™

Biostatic or Biocide

Why is Aquasolve™ a biostat? It is because Aquasolve™ dissolves water permanently into fuel, there is no water present to encourage the growth and survival of bacteria in the fuel system.

Biocides can effectively stop bacterial growth. The problem is that the bodies (black gel sludge) remain within the system, clogging filters and blocking fuel lines. It is still necessary to remove this debris, which has to be disposed of properly as it contains chemicals which may be regarded as hazardous for the environment.

Aquasolve™ when introduced destroys the environment in which bacteria can survive and also dissolves the bodies of the diesel bug completely as it bonds the water into the fuel leaving the fuel system free from damage. The continuous use of Aquasolve™ stops any further diesel bug contamination.

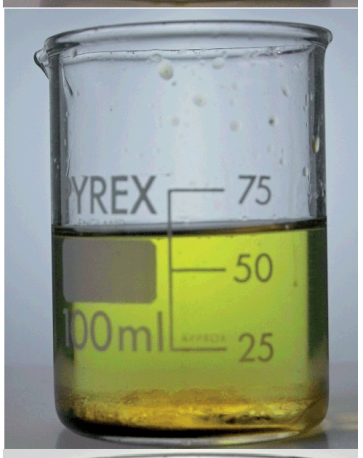
Why is AQUASOLVE™ biostatic?

The reason Aquasolve™ is biostatic is because any free water will be solubilized permanently into fuel oil by its regular use. In this permanent solute there is no water phase present to allow the bacteria to grow and develop i.e. 'Diesel Bug' as it is more commonly known. Consequently filters do not become blocked with largely dead bacteria and the detergent action of the product aides removal of deposits and assists lubricity.

Biocides and their history are well known, the controversy surrounding their use and the environmental consequences are a continual matter of debate.

NB
An example of a strong detergent's capacity to dissolve organic material is used in current stem cell research whereby the organic structure of an organ i.e. 'the heart' is stripped of all soft tissue by flowing special detergents through the structure, leaving behind a skeletal form on which stem cells can be grown into a new organ.

DIESEL BUG ADDED

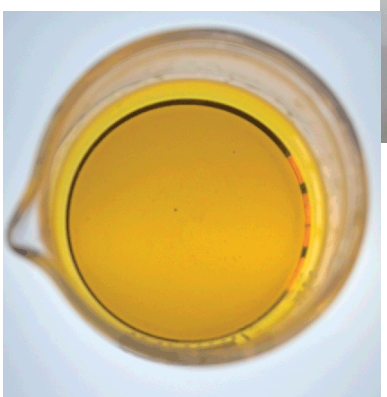


AQUASOLVE™ ADDED

DIESEL BUG SUSPENDED IN THE FUEL

DIESEL BUG SOLUBILIZED INTO THE FUEL

STANDARD DIESEL



DIESEL BUG COMPLETELY DISSOLVED INTO THE FUEL

Dealing with Water Contamination of Diesel Fuel and Gas Oils

Introduction

This briefing note provides guidance on how to deal with the contamination of diesel fuels and gas oils with water. Such fuels are used in stationary power plant for electricity generation and water supply using reciprocating engines, gas turbines and boiler plant and in the engines for various forms of transport. They include trucks, buses, railways and boats, agricultural machinery, plant hire equipment and military vehicles.

One important feature of the production process for these fuels is to reduce the water content to an extremely low value, i.e. a very small fraction of 1%. This is because the accepted view is that 'oil and water do not mix' and there is ample evidence that where such fuels are contaminated with water, bacteria can develop and cause a wide variety of problems.

However, downstream of the production process water can often, for a number of reasons, become present in these fuels and the fuel systems associated with the various applications. The reasons for this may be summarised as follows:

I. by accident through some unintentional event
II. natural ventilation and breathing of the fuel storage tanks that can lead to condensation forming on the tank walls and then accumulating at the bottom of the tank, and
III. the intentional addition of water to the fuel to influence the performance of the engine or power plant and/or to improve exhaust gas emissions – although this is outside the scope of this guidance note.

Recommended procedures (from laboratory studies and informed by practical experience in the field) for dealing with each of these scenarios are discussed below. The intention is to help ensure the new user of Aquasolve™ is able to deal successfully with any problems that may arise.

If a small quantity of water is added to a vessel containing a diesel fuel (e.g. 2% water in the resulting mix) the water will settle at the bottom of the vessel. Even if stirred vigorously, the water will again settle when the stirring stops. Add a small quantity Aquasolve™, agitate a little, and it will be observed that a rather cloudy emulsion is the result. If this emulsion is left for some time (perhaps a day or so, depending on the quantity of Aquasolve™ added) the mixture will tend, like similar emulsions, to settle into distinct layers.

However, by adding further small quantities of Aquasolve™ and gently agitating, it will be found that the mixture will become as clear again as the original fuel oil. During the research and development that produced Aquasolve™ samples of water-contaminated fuel were mixed up as long ago as 1986 and they remain as crystal clear now as the day they were created. In the discussion that follows it is always the aim that the fuel in the system that reaches the engine or power plant is in this clear, clean and stable condition.

Accidental Contamination of a Fuel System with Water

This is usually a one-off event involving, perhaps, the inadvertent admission of a relatively large quantity of water into a fuel tank. Typical causes are the:

- inspection cover or filler cap is left off the fuel tank whilst hosing down or during a storm
- fuel cap does not seal, permitting water to enter the system from storms or wave action on boats
- fuel tank is mistaken for a water tank when re-filling with water

Normally, the approach to dealing with this problem only requires that the water is drained off, followed by a thorough cleaning of the affected part of the system. The residence time of the water in the system will usually be very short and limited to the fuel tank alone and the pipes most closely connected to it. Flushing of the affected part of the system can be undertaken with a mixture of fuel and additive. Whilst re-commissioning the system it is recommended that the remaining fuel is treated with Aquasolve™ at the usual preventative dose rate to remove any small amounts of residual water that remain.

Case Study 1

The owner of a new yacht noticed that the water separator in his fuel system continually collected a significant quantity of water whenever he ran his main engine. His boat is fitted with three fuel tanks and the problem only occurred when fuel was drawn from one particular tank. The tanks and fuel system had been drained and cleaned professionally twice but the problem kept recurring. The possibility of being supplied with contaminated fuel was considered, but having refuelled from more than one source, and it being associated with just one tank, suggested that the underlying problem was associated with a specific system.

The first step was to search out the true cause of the contamination and rectify that. On close examination of all the fuel systems, it transpired that the filler cap fitted in the deck to the fuel tank concerned was not seating correctly. Consequently, whenever water washed over the deck from heavy seas or when hosing down the deck, it could easily enter the filling tube to the fuel tank. Step one, therefore, was to remedy this and ensure that the fuel filler cap sealed properly. The next stage was to drain and clean the affected tank and associated pipes yet again, change the fuel filter, and separate out the water from the mixture drained from the tank. The fuel could then be returned to the tank and treated with Aquasolve™, initially at twice the usual dose rate. Treatment for later refuelling was recommended at the standard dose rate and the condition of the fuel monitored.

In the more general case, if there is any doubt about the rate at which Aquasolve™ should be added a simple experiment can be conducted to determine the correct amount. Take a measured quantity, say 100-200 ml, of the contaminated fuel in a transparent container. Add a very small, but measured quantity of Aquasolve™. Initially, the fuel may turn slightly milky, or display a slight 'bloom'. The purpose of this experiment is to determine how much Aquasolve™ should be added so that the bloom disappears and the fuel becomes crystal clear. Knowing how much Aquasolve™ has been added to the initial sample, and multiplying this up for the amount of fuel in the tank determines how much Aquasolve™ should be added to the fuel tank.

Dealing with a Build-up of Contamination through Natural Ventilation and Condensation

Anticipating, and preventing the consequences of, contamination of a new and clean fuel system through condensation is quite straightforward. It can be achieved by dosing the system with the recommended dose of Aquasolve™ is normally 1:1000, every time the fuel tanks are refilled.

However, one may have discovered that the fuel system supplying an existing installation, i.e. it is of several months, if not years, old, is contaminated. The symptoms that can indicate this include:

- the water separator (if fitted!) contains water and/or a dark brown goo
- the boiler, or engine, fails to run correctly, or not at all, and inspection of the fuel filters, and possibly the fuel lines, indicates they contain a very viscous, possibly stringy, dark brown slime.

This is a consequence of the so-called 'diesel bug', anaerobic bacteria that can develop in fuel systems when water is present. Dealing with this problem in such systems is more involved, but not difficult. It only requires some patience and following a few simple procedures that are described below. It is a two-stage process, cleaning out the system and then setting up a regimen of regular dosage to prevent a recurrence. The following Case Study, also taken from a marine application, illustrates how one can approach this.

Case Study 2

This example involves a yacht that was five years old when purchased by a new owner. Some months later, after a trans-Atlantic crossing and cruising in the Caribbean it was observed that the water trap at the base of the fuel filter was accumulating a dark deposit and some water – a clear indication of gradual contamination by water, and almost certainly due to condensation in a humid environment.

The problem was resolved in two stages: seriously contaminated fuel, water and sludge were removed from the bottom of the tank and disposed of, and the remaining fuel was treated with Aquasolve™. Subsequent additions of fuel have been dosed with Aquasolve™ and the system is now completely free of contamination. A more detailed description of the procedure adopted follows.

The first step was to check the main fuel tank, access to which was gained via an inspection cover fitted into the top of the tank. Inserting a 4mm bore copper tube to the lowest point in the tank and siphoning out some liquid produced water, some very dark and viscous fluid and, finally, fuel that was also quite discoloured.

The fuel tank was approximately two thirds full, containing about 200 litres. With some installations it may be possible to remove all of the fuel, strain it and return it to the tank after mechanically cleaning the inside of the tank. This would have been extremely difficult in the present example due to internal baffle plates rendering full access impossible. It was therefore decided to clean the tank as best as possible and deal with the remaining fuel in situ. This involved stirring it vigorously, to try to remove any brown sludge that might be clinging to the side of the tank, and then leaving it for about an hour to settle. More sludge and dirty fuel was then siphoned from the tank. After stirring again another sample was removed. It was still slightly discoloured and contained some debris, but it indicated the condition of the remaining fuel that had to be treated.

200ml of this sample was put into a glass jar. About 1ml of Aquasolve™ was then added and it was noted that the fuel became hazy and less clear. Further small (and measured) quantities of Aquasolve™ were added until the discoloured fuel became completely transparent. In total, this required 2.5ml of Aquasolve™. Since the fuel tank contained about 200 litres of dirty diesel, 2.5 litres of Aquasolve™ was added and stirred in. In addition, the fuel filter was changed, the filter bowl cleaned out and the fuel system re-commissioned.

The next stage was to monitor the condition of the fuel over the next few days and months, during which that in the fuel tank was used up until it was quite low before refilling it from a trusted source. During this period the fuel in the transparent bowl of the water trap did become very slightly hazy, probably due to some residue of the dark sludge being cleaned from the surfaces of the tank and the fuel pipes. Another quarter litre of Aquasolve™ was added to the tank during a day-sail (the motion of the boat would aid mixing) and this cleared the fuel again. Since then, whenever the tank has been refilled, Aquasolve™ has been added at the normal recommended dosage and no further evidence of contamination has been observed.

The Addition of Water to a Fuel

As mentioned earlier, the Aquasolve™ technology can be used for this purpose but it is outside the scope of this briefing note. It should not be attempted with the formulation designed for dealing with the contamination issues discussed above. However, by way of a brief comment, situations in which water may be added to a hydrocarbon fuel usually fall into one of two general scenarios:

- The intentional addition of water to influence an existing fuel and
- The indirect addition of water in the development of new fuels

The Intentional Addition of Water to an Existing Fuel

There are circumstances where the incorporation of water into an existing fuel can be shown to have some beneficial effects when used in some engines and under certain operating conditions. These include improving the quality of the exhaust gas emissions and increasing the power output. The key benefit of the Aquasolve™ technology is its ability to create a strong and stable bond between the water and the fuel.

The Indirect Addition of Water in New Fuels

Water may be added indirectly to new fuel blends that make use of animal or vegetable oils. Such fuels sometimes incorporate alcohols to improve their combustion properties, but the presence of even minute quantities of water can inhibit the absorption of the alcohols. However, this can be overcome by using an appropriate blend of the Aquasolve™ technology due to the efficacy with which it bonds the water to the fuel.

Concluding Remarks

The powerful Aquasolve™ technology is capable of bonding water to a variety of hydrocarbon fuels. This ability enables it to be used both for dealing with contamination problems with existing fuels as well as in the development of new, environmentally friendly, fuels derived from animal and vegetable sources.