CULTIVATING A GREENER PATH AHEAD

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# SUREKLEEN

# FUEL KLEEN

(Former name: Fuel Set)

## FUEL SYSTEM CONDITIONER

## TECHNICAL INFORMATION

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## FUEL KLEEN

**Fuel Kleen** (former name is Fuel Set) is a blend of surfactants (detergents), oxygenates and corrosion inhibitors developed to meet the challenge of today's high-performance engines.

The primary benefits of **Fuel Kleen** are:

- Solubilises liquid water into the fuel.
- Reduces or eliminates the conditions favourable to the growth of microorganisms.
- Stabilises fuel by inhibiting the formation of gums and varnish.
- Inhibits corrosion of fuel system components.
- Promotes a uniform fuel spray pattern in combustion chambers, thus reducing carbonisation and improving combustion efficiency.
- Inhibits formation of corrosive acids in combustion chambers.

**Fuel Kleen** is added directly to fuel storage tanks to eliminate the problems associated with water contamination.

**Fuel Kleen** ensures that vehicle fuel systems remain clean and free from corrosion, gums and varnishes.

The main benefit of **Fuel Kleen** is derived from its regular use to maintain fuel systems free from liquid water. This prevents biological activity, reduces corrosion and inhibits reaction of the fuel with water.

Regular use of **Fuel Kleen** ensures that carburettors and fuel injectors work at peak performance eliminating poor running problems and expensive maintenance.

The benefits of **Fuel Kleen** extend throughout the fuel system.

## GASOLINE AND DIESEL FUEL PROBLEMS

Gasoline (petrol) and diesel are complex mixtures comprising hundreds of individual hydrocarbon compounds as well as a small proportion of nitrogen, sulphur- and oxygen-containing compounds (heteroatom compounds). The composition of fuels also varies with feedstock, from season to season and with refinery blending practice.

Of the many compounds making up hydrocarbon fuels, olefins, diolefins, high boiling components and heteroatom compounds (together with moisture and atmospheric oxygen) are responsible for most of the problems associated with fuel quality. The fluid catalytic cracking (FCC) unit of the refinery is a major source of these substances and if proper sweetening or after-treatment processes are inadequate, their presence can be particularly troublesome.

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Olefins and diolefins are susceptible to oxidation and polymerisation and are largely responsible for the formation of gums and varnishes in fuel systems and engines. Deposition of these materials in critical fuel metering components of engines (carburettors and fuel injectors) and in intake ports and valves is a principal cause of poor engine performance and driveability problems.

Water is also a major source of problems in fuel systems. No matter how well refined the original fuel, water finds its way into virtually all fuels. Water can enter the fuel during transport, during storage at the distribution point, during transfer from tank to tank or during storage in the vehicle tank itself. While poor practices in the fuel distribution system may contribute to water in fuel, the main culprit is condensation from the atmosphere in fuel storage tanks.

Left untreated, water in hydrocarbon fuels tends to separate and form liquid water at the bottom of tanks and on metal surfaces in storage tanks and in fuel lines, carburettors, fuel injectors, etc. This water promotes corrosion, catalyses decomposition of the fuel itself and allows microorganisms to thrive at the fuel/water interface. In extreme cases, particularly in diesel fuels, mats of microorganisms can form in fuel tanks causing severe engine problems because of pieces breaking off and blocking fuel lines and injectors.

Sulphur reducing bacteria thrive under these conditions and feed off the sulphur compounds in the fuel producing hydrogen sulphide that in turn reacts to form corrosive sulphur compounds.

## THE EFFECT OF FUEL SYSTEM DEPOSITS ON ENGINE PERFORMANCE AND DRIVEABILITY

The relatively simple and inefficient carburetted engines of the past could tolerate lower quality, variable fuel composition. By today's standards quite high levels of deposits could be tolerated in the fuel system without significantly affecting performance or driveability. Deposits in the carburettor body and air bleed area were the main cause of driving problems (hesitation, surge and stalls, for example), increased fuel consumption and increased exhaust emissions.

By contrast, today's advanced engine designs incorporating such features as port fuel injection, timed manifolds, high swirl/fast burn and multiple valves need to be kept almost deposit free to avoid problems and provide acceptable performance.

With the introduction of fuel injection, car manufacturers quickly discovered that even minute traces of deposits in the fuel metering system caused serious problems. These deposits adversely affected the fuel spray pattern and restricted fuel flow, seriously affecting driveability and performance. Fuel economy and exhaust emissions were also adversely affected but were less noticeable to the driver.

Deposits in other parts of the fuel system have also been found to cause performance and driveability problems with modern engines. Intake port and valve deposits cause loss of power by restricting airflow at full throttle and increased hydrocarbon and NOx

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emissions especially at low throttle speeds. Valve seat and valve face deposits cause poor seating resulting in rough idle and, in extreme cases, valve burning.

Deposits in the combustion chamber cause ORI (octane requirement increase), a significant restraint on engine performance.

## DETERGENT FUEL ADDITIVES AND DEPOSIT CONTROL

Many of the requirements of modern fuels cannot be met by refining alone, fuel additives are employed to enhance performance or correct fuel problems. Additives are not new; they have been used in gasoline since the introduction of tetraethyl lead in 1923. Since then, the range of additives has expanded to embrace antioxidants, metal deactivators, corrosion inhibitors, anti-icing agents, upper-cylinder-lubricating oils, deposit modifiers and cleanliness additives.

Cleanliness additives also described as detergents or deposit control additives were first introduced by Chevron in 1954 to keep engines and fuel systems clean. These compounds behave in a manner analogous to detergents in water. They function by competing with deposit pre-cursers (olefins, diolefins, etc.) for engine surfaces thus preventing build-up of gums and varnishes and help to disperse existing deposits.

The early detergents were adequate for cleaning carburettors and fuel injectors but had a negative effect on intake valve deposits. Improvements in cleanliness additive technology led to the development of products that not only removed carbon deposits from port fuel injectors and carburettors, but also controlled deposits on intake valves, manifolds and ports.

Low molecular weight amines, amine carboxylates and amine phosphates have all been used in the past to help clean and keep clean carburettors and fuel injectors. In some cases, unsuitable detergents exacerbated the problems by decomposing and forming carbon deposits on the hot intake valves.

More recently, driveability problems have re-surfaced with high-performance vehicles such as BMW and Mercedes. These problems have been identified as resulting from extremely small deposits on intake valves. To combat these problems, several car manufacturers have taken the initiative in insisting on the use of deposit control additives in the fuels used for their vehicles.

As a result of these problems and the initiatives taken by car manufacturers, North America and Europe have adopted deposit control additives in all grades of gasoline. Similar steps have occurred more recently in Japan and the trend is expected to continue as the demand for cleaner engines coupled with cleaner emissions and better performance continues to grow.

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## FUEL KLEEN AND DEPOSIT CONTROL

**Fuel Kleen** has been developed primarily as a modern high-performance additive to control the formation of undesirable compounds in fuel that contribute to the formation of engine deposits and to minimise the effect on fuel quality of the presence of liquid water in fuel systems.

The detergents in **Fuel Kleen** have been proven to assist in keeping intake valves clean thus promoting the correct spray pattern in the combustion chamber and promoting clean combustion of the fuel.

As the performance of engines becomes ever more demanding, the requirement for clean fuel to achieve maximum economy and performance will increase. **Fuel Kleen** represents a significant advance in achieving control over fuel quality at every stage of the fuel distribution system.

## COMPOSITION OF FUEL KLEEN

**Fuel Kleen** is a complex, proprietary blend developed over more than a decade of laboratory and field-testing.

The main ingredients of **Fuel Kleen** are surfactants (detergents), oxygenates and corrosion inhibitors.

Minor components include metal deactivators, deposit modifiers and non-active components including dyes for identification, safety and regulatory purposes.

## HOW DOES FUEL KLEEN WORK?

**Solubilisation of Water**

**Fuel Kleen** eliminates one of the prime causes of fuel problems – liquid water in the fuel.

The detergents in **Fuel Kleen** solubilise the free water and allow it to form a homogeneous mixture with the hydrocarbon fuel.

The oxygenates present in **Fuel Kleen** assist this process by acting as coupling agents to promote the dissolution of water into the fuel.

Water dispersed into the fuel in this way is vapourised during normal combustion of the fuel and passes harmlessly from the engine along with the other products of combustion.

In neglected fuel systems, particularly those in which biological contamination has been allowed to build up, an initial high dose of **Fuel Kleen** may be required to eliminate the

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accumulated water. The detergent properties of **Fuel Kleen** can also assist in the dispersion of biological contamination by breaking up the accumulated material.

**Deposit Control**

Detergents are the major active component of **Fuel Kleen**. They are essential for maintaining fuel systems free from liquid water as described above.

In addition, detergents inhibit the formation of deposits in the fuel system, reduce NOx emissions and play a part in the observed reduction of carbon emission with **Fuel Kleen**.

The mechanism for this latter effect is believed to be due to the ability of the detergents to function in both the liquid and the vapour phase to prevent deposit formation and remove existing carbon. This function may be enhanced by the catalytic effect of oxygenates present in **Fuel Kleen** (see below).

**Fuel Combustion Characteristics**

**Fuel Kleen** has been shown to promote cleaner burning of hydrocarbon fuels in field trials spanning more than a decade. It is thought to work in two ways. It maintains the correct fuel spray pattern in combustion chambers thus reducing carbonisation and improving combustion efficiency and improving fuel combustion.

Hydrocarbon fuels are complex mixtures of hundreds of different compounds and the reaction pathways during combustion are extremely complex and far from fully understood. Addition of significant levels of oxygenates (>0.1%) are known to alter pre-flame reaction pathways.

Oxygenates in **Fuel Kleen**, possibly in conjunction with the detergents, catalyse more efficient fuel combustion resulting in improved fuel economy and cleaner emissions. The mechanism of these catalytic functions has not been elaborated.

## CORROSION INHIBITION AND METAL DEACTIVATION

Removing liquid water from fuel systems is the first and most important step in reducing corrosion in fuel systems.

**Fuel Kleen** contains corrosion inhibitors that coat the metal surfaces of the fuel system and inhibit any residual corrosion due to water dispersed in the fuel.

**Fuel Kleen** inhibits the copper catalysed oxidation of unsaturated hydrocarbons that leads to the formation of gums and varnishes.

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## FUEL STABILITY

During storage, hydrocarbon fuels are subject to deterioration mainly because of oxidation and copper catalysed reactions of unsaturated hydrocarbons to form gums.

**Fuel Kleen** is not an antioxidant but inhibits the formation of gums as described above.

In addition, and most importantly, **Fuel Kleen** contributes to fuel stability by maintaining a fuel system free from liquid water considerably reducing the tendency of the fuel to become "sour".

## SULPHUR

Sulphur is present to some degree in all fuels, particularly diesel fuels. No additive can change the level of sulphur in a given fuel. However, by eliminating the presence of liquid water in the fuel system and by reducing corrosion in the fuel system, **Fuel Kleen** inhibits the premature formation of acidic sulphur compounds that can attack sensitive fuel system components that contact the fuel prior to combustion.

## INDEPENDENT EVALUATION OF FUEL KLEEN

### 1. Scientifics Ltd., Doncaster, England

*Scientifics Ltd, was commissioned to evaluate **Fuel Kleen** for any possible adverse effects on engines, fuel systems or fuel.*

The study concluded that **Fuel Kleen** is unlikely to have any detrimental effect on the engines or fuel systems of either petrol or diesel engine vehicles.

The study also confirmed the ability of **Fuel Kleen** to disperse water within the fuel and thus reduce the likelihood of fungal growths.

### 2. Ricardo Consulting Engineers Ltd., Sussex, England

*Ricardo Consulting Engineers were commissioned at the request of the Royal Navy to evaluate **Fuel Kleen** in preventing injector nozzle coking in an Indirect Injection diesel engine.*

The study compared the performance of **Fuel Kleen** treated diesel fuel and untreated fuel with a reference fuel. The results obtained clearly demonstrated the benefit of **Fuel Kleen** at reducing injector nozzle coking.