

FBHVC ESSENTIAL GUIDE TO...



Fuels

The myths & facts about Super E5 & E10

Ethanol in petrol

As a result of the introduction of the EU Renewable Energy Directive and revision of the EU Fuels Directive, the UK Government introduced the Renewable Transport Fuels Obligation (RTFO) in April 2008. These renewable fuel targets resulted in the widespread introduction of E5 petrol into the UK and Europe. Despite initial concerns about ethanol containing petrol it has been the main petrol grade in the market for over 10 years with no substantial technical issues with classic and historic vehicles.

The incidents that have been reported have been generally due to poor vehicle fuel-system condition, either allowing water ingress resulting in corrosion or the use of aftermarket tank sealant materials being removed and causing filter blocking etc. Provided fuel systems are in good condition and are well maintained there should be no problems operating on E5. Aftermarket additives are available that provide additional corrosion protection if required. During this time, both Unleaded 95 and Super Unleaded 97 petrol grades have contained up to 5% ethanol.

Multi-product pipelines carry petrol, diesel, dyed gasoil, kerosene and jet fuel with no physical separation between the fuels. The order of the products in the pipeline and operation is carefully controlled to ensure the various products remain on grade and limit the amount of mixed interface volume that has to be managed at the terminal.

In general ethanol is added at the tanker loading rack to a specially prepared petrol blend-stock in oil distribution terminals across the UK as it cannot be transported in multi-product pipelines due to concerns about the hygroscopic nature of ethanol trailing back into jet fuel and potentially affecting the quality by the deactivation of water coalescers in the jet fuel distribution system. Obviously it is important to ensure jet fuel remains free from water due to the low temperatures experienced at high altitudes in aviation.

Ethanol has good octane characteristics with a blending Research Octane Number (RON) of 121 and a blending Motor Octane Number (MON) of 97 and it can be economically attractive to use it in the Super grade to boost octane. A number of fuel suppliers have confirmed that they cannot guarantee ethanol free petrol at any of their service stations. The FBHVC is not aware of any UK retail service station suppliers offering ethanol free petrol on a reliable basis.

With the proposed introduction of E10 petrol, the FBHVC successfully lobbied the DfT to keep the low ethanol E5 grade to protect classic and historic vehicles initially for 5 years and this may be extended further in the future.

Corrosion and elastomer (flexible pipes, diaphragms and gaskets) compatibility is more of an issue with E10 petrol and many vehicle pre-2000 are not compatible without fuel system modifications. There are also a number of direct petrol injection vehicles manufactured up to 2011 that also have fuel system components that are not compatible with E10. These are mainly VW, Audi and Ford models that share the same injection system design. All these vehicles however are compatible with E5 petrol.

E10 petrol has been the main grade of petrol available in the USA for many years and has also been the main grade of petrol in many European countries since the end of 2010 with E5 offered as a protection grade for non-compatible vehicles. This appears to have been generally successful, demonstrating that the issues with ethanol containing petrol can be successfully managed by historic and classic vehicle owners. Burlen Fuel Systems who now manufacture SU, Zenith and Amal carburettors have confirmed that they have moved where possible to ethanol compatible materials for new carburettors and spare parts. New lawn mowers, chainsaws, strimmers etc. are all compatible with E10 petrol, older equipment should use the Super E5 protection grade.

Historic and classic vehicles will continue to be on the UK roads for many years to come but it is important that we move with the times and adapt our vehicles where necessary to run on liquid fuels with more renewable content. High mileage historic and classic vehicle owners may therefore decide to modify their vehicles to make them E10 compatible as a lower cost option.



Launch of E10 Petrol in the UK

After an extensive consultation process, the Department for Transport has announced that they will legislate to introduce E10 petrol as the standard 95-octane petrol grade by 1 September 2021. They will also require the higher-octane 97+ 'Super' grades to remain E5 to provide protection for owners of older vehicles. This product will be designated as the 'Protection' grade.

The introduction of the 95-octane E10 grade and the maintenance of the Super E5 protection grade will be reviewed by the Government after 5 years to ensure they remain appropriate to the needs of the market:

- In relation to the E5 protection grade, such a review will examine market developments over the period.
- HM Government have sought to reassure FBHVC members and historic vehicle owners that, without a suitable alternative becoming available, it is highly likely the Super E5 protection grade would continue to be available.
- Filling stations that stock 2 grades of petrol and supply at least one million litres of fuel in total each year will need to ensure one product is the Super E5 protection grade. While not all filling stations meet these criteria, almost all towns across the UK will have a filling station that supplies the 'Super' grade and currently one major retailer, a national supermarket group, has committed to offer the product. The main exception to this is in certain parts of the Highlands, north and west coast of Scotland, which will be covered by an exemption process and allowed to continue to market the 95-octane E5 grade.









The main reason for the withdrawal of a low ethanol grade would be commercial, if sales are not maintained at a reasonable level that makes it cost effective for the fuel suppliers. This is what happened to Lead Replacement Petrol (LRP). However the Super grade is in demand by many high performance car owners and for motor racing as well as classic and historic vehicles, so hopefully sales volumes will be maintained. It is also not possible to keep the fuel on-grade in service station tanks if sales volumes are too low. So the best way to keep the Super E5 protection grade for the long term is to encourage everyone that needs it, to purchase it on a regular basis throughout the year and it should be available for many years to come.

The Federation recommends that all vehicles produced before 2000 and some vehicles from the early 2000s that are considered non-compatible with E10 - should use the Super E5 Protection grade where the Ethanol content is limited to a maximum of 5%. To check compatibility of vehicles produced since 2000, we recommend using the new online E10 compatibility checker: <https://www.gov.uk/check-vehicle-e10-petrol>

E10 petrol can contain between 5.5% and 10% ethanol by volume. Product availability varies by manufacturer and geographical location and enthusiasts should check the situation in their location.

Super E5 protection grade suppliers & availability



Fuel Supplier	E5 Protection grade	Further information
	bp Ultimate Unleaded 97 with ACTIVE technology	https://www.bp.com/en_gb/united-kingdom/home/products-and-services/bp-ultimate-fuels/bp-ultimate-unleaded-with-active-technology.html
	Essar Super Unleaded	http://www.essaroil.co.uk/our-forecourts/
	Esso Synergy Supreme+ 99	https://www.esso.co.uk/en-gb/fuels/petrol
	JET ULTRA Premium Unleaded 97	https://www.jetlocal.co.uk/drivers/fuels
	Shell V-Power Unleaded	https://www.shell.co.uk/motorist/v-power-fuels/v-power-unleaded.html
Sainsbury's	Sainsbury Super Unleaded	https://stores.sainsburys.co.uk/
	Tesco Momentum 99 Unleaded	https://www.tesco.com/help/petrol-stations/
	Texaco Supreme Unleaded 97	https://texaco.co.uk/motorists/our-motor-fuels
	Total Excellium E5 97	https://services.totalenergies.uk/ (use the customer support web chat option)

What should I do if I have to fill the tank with E10?

The effects of ethanol are cumulative, apart from an immediate effect on air/fuel ratio. Some hesitation, stumbling and stalling may be experienced due to enleanment of the fuel mixture. At the earliest opportunity, refill with E5 petrol to dilute the ethanol content and there should be no lasting harm to your classic or historic vehicle.

Ethanol and aftermarket fuel additives

There are three key areas of concern with Ethanol compatibility with historic and classic vehicle fuel systems:

1. Corrosion of metal components
2. Elastomer compatibility - swelling, shrinking and cracking of elastomers (seals and flexible pipes) and other unsuitable gasket materials
3. Air/fuel ratio enleanment

Corrosion of metal components

Ethanol has increased acidity, conductivity and inorganic chloride content when compared to conventional petrol which is essentially neutral and can cause corrosion and tarnishing of metal components under certain conditions. These characteristics are controlled in the ethanol used to blend E5 and E10 European and UK petrol by the ethanol fuel specification EN15376 in order to help limit corrosion.

Conductivity of fuel is important in the case of ethanol blends because much of the corrosion experienced is galvanic due to dissimilar metals such as zinc, brass and steel in the fuel systems of vehicles. Petrol typically has a conductivity of around 25 pS/m (pico Siemens/meter) and this is due to trace polar materials and metals carried over from crude oil, refinery process additives and treatments such as alkylation. Modern petrol is hydrotreated to reduce the sulphur content and this also reduces the trace polar species and other ionic contaminants that contribute to conductivity. Petrol also contains detergent additives that also increase the conductivity. Petrol can also contain dissolved water and remain bright and clear up to around 60ppm dependent on the ambient temperature. Beyond 60ppm the water tends to drop out and phase separate. The addition of ethers and alcohols can significantly increase the dissolved water content of petrol. With ethers it is not unusual to find water contents of 400ppm and much greater levels with ethanol. A 5% ethanol blend will phase separate around 2500ppm (0.25%) water content dependent on the ambient temperature. The increased water content will also increase conductivity due to the ionic species present from impurities in the water. Evaporation of the petrol and ethanol in vehicle fuel systems can leave behind a corrosive ethanol water mixture that can damage metal components.

Corrosion inhibitor additives can be very effective in controlling ethanol derived corrosion and are recommended to be added to ethanol in the BS EN15376 standard. It is not clear if corrosion inhibitors are universally added to ethanol for E5 and E10 blending so as an additional precaution it is recommended that aftermarket corrosion inhibitor additives are added to E5 and E10 petrol.

These aftermarket ethanol corrosion inhibitor additives often called ethanol compatibility additives are usually combined with a metallic valve recession additive (VSR) and sometimes an octane booster and have been found to provide good protection against metal corrosion in historic and classic vehicle fuel systems.

Elastomer compatibility

As the ethanol molecule is smaller and more polar than conventional petrol components, there is a lower energy barrier for ethanol to diffuse into elastomer materials. When exposed to petrol/ethanol blends these materials will swell and soften, resulting in a weakening of the elastomer structure. On drying out they can shrink and crack resulting in fuel leaks.

Some aftermarket ethanol compatibility additives claim complete protection for operating historic and classic vehicles on E10 petrol. The FBHVC is not aware of, or has tested any additives that claim complete fuel system protection with respect to elastomer and gasket materials for use with E10 petrol. The FBHVC therefore recommends that elastomer and gasket materials are replaced with ethanol compatible materials before operation on E10 petrol.

Air/fuel ratio enleanment

Ethanol contains approximately 35% oxygen by weight and will therefore result in fuel mixture enleanment when blended into petrol. Petrol containing 10% ethanol for example, would result in a mixture-leaning effect equivalent to approximately 2.6%, which may be felt as a power loss, driveability issues (hesitations, flat spots, stalling), but also could contribute to slightly hotter running. Adjusting mixture strength (enrichment) to counter this problem is advised to maintain performance, driveability and protect the engine from overheating and knock at high loads.

Modern 3-way catalyst equipped vehicles do not require mixture adjustment to operate on E10 petrol because they are equipped with oxygen (lambda) sensors that detect lean operation and the engine management system automatically corrects the fuel mixture for optimum catalyst and vehicle operation.

Other ethanol specification issues

The European ethanol standard EN15376 sets out the following requirements for ethanol that can be blended with EN228 petrol. EN228 is the European petrol standard and in the UK it is referred to as BS EN228. As you can see the ethanol is not 100% pure due to the production process but critical aspects are controlled to protect the finished fuel quality.

EN15376 – Generally applicable requirements and test methods for un-denatured ethanol

Property	Unit	Limits		Test method
		minimum	maximum	
Ethanol + higher saturated alcohols	%(m/m)	98.7		EN15721
Higher saturated (C3 – C5) mono-alcohols content	%(m/m)		2.0	EN15721
Methanol content	%(m/m)		1.0	EN15721
Water content	%(m/m)		0.3	EN15489
				EN15692
Total acidity (expressed as acetic acid)	%(m/m)		0.007	EN15491
Electrical conductivity	$\mu\text{S/cm}$		2.5	EN15938
Appearance		Clear and colourless		EN15769
Inorganic chloride content	mg/kg		1.5	EN15492
Sulfate content	mg/kg		3.0	EN15492
Copper content	mg/kg		0.100	EN15488
				EN15837
Phosphorus content	mg/l		0.15	EN15487
				EN15837
Involatile material content	mg/100ml		10	EN15691
Sulfur content	mg/kg		10.0	EN15485
				EN15486
				EN15837

From this it can be seen that ethanol can have a maximum conductivity of $2.5\mu\text{S/cm}$ which is many times that of conventional petrol. The bioethanol used for petrol blending has a similar conductivity to deionised water. Whilst these conductivity levels are low they are sufficient to promote significant galvanic corrosion in the presence of dissimilar metals. The generation of electrode potentials between metals can set off the corrosion process. Metals that show good resistance to alcohol blends when exposed individually may be rendered susceptible to attack when coupled electrically to another electrically dissimilar metal.

With respect to acidity of petrol in its pure form it is indeed close to pH neutral. Production processes however, such as alkylation (reaction with sulphuric or hydrofluoric acid to enhance the octane) and caustic washing can mean that it is acidic or alkaline in the presence of water. As mentioned earlier, petrol can contain up to around 60ppm of dissolved water depending on the ambient temperature. The pH of petrol can be checked by water washing and measuring the pH of the water. Refiners strive to keep the petrol close to neutral as possible and there is a copper corrosion test in the EN228 petrol standard although many fuel refiners run the more sensitive silver corrosion test after incidents of modern fuel tank fuel gauge sender silver alloy corrosion after the introduction of 10mg/kg sulphur petrol due to the carry-over of elemental sulphur from the hydrotreatment process.

Ethanol for petrol blending is acidic in nature, due to the production process and you can see from the ethanol specification above that it can contain up to 0.3% m/m water. Despite passing through several purification steps following fermentation, bulk bioethanol may contain the dissolved salts chloride and sulfate which can be harmful to engines. See the specification for the maximum levels allowed. The vehicle manufacturers would like to see these levels reduced further particularly for higher levels of ethanol blending above E10 due to concerns about fuel injector deposits and exhaust after-treatment operation.

Operating classic and historic vehicles on E10 petrol

If you should decide to make the necessary vehicle fuel system modifications together with the addition of an aftermarket additive to operate your classic or historic vehicle on E10 petrol. The FBHVC strongly recommends that you regularly check the condition of the vehicle fuel system for elastomer and gasket material deterioration and metallic components such as fuel tanks, fuel lines and carburettors for corrosion. Some plastic components such as carburettor floats and fuel filter housings may become discoloured over time. Plastic carburettor float buoyancy can also be affected by ethanol and carburettors should be checked to ensure that float levels are not adversely affected causing flooding and fuel leaks.

There are quite a number of fuel hose standards. The Society of Automotive Engineers (SAE) J30 fuel hose standards are the most used by the automotive industry.

SAE J30R14T1 is the standard for ultra-low permeation properties. This type of hose is typically approved for use with leaded and unleaded gasoline, diesel, biodiesel, E85, methanol, ethanol and gasohol fuels. This hose is widely available in Europe. The fuel hose standard should be printed on the hose. Other SAE J30 fuel hose standards are also compatible with petrol/ethanol blends, always check with the supplier before purchasing.

Ethanol is a good solvent and can remove historic fuel system deposits from fuel tanks and lines and it is advisable to check fuel filters regularly after the switch to E10 petrol as they may become blocked or restricted. If your vehicle is to be laid up for an extended period of time, it is recommended that the E10 petrol be replaced with ethanol free petrol which is available from some fuel suppliers. Do not leave fuel systems dry, as this can result in the shrinking and cracking of elastomers and gaskets as they dry out. Carburettor float bowls should be drained however, if ethanol free petrol is not available. The reason for this is that the petrol will evaporate over time and can leave a corrosive water/ethanol residue in the float bowl.

What about 2-strokes?

1. The main issues with 2-stroke engines running on ethanol blends are:
 - a. Mixture enleanment leading to higher piston and cylinder temperatures and potentially scuffing and seizing. This can be corrected with mixture adjustments to lower combustion and hence piston temperatures. High octane fuel is best for 2-strokes to help prevent knock and pre-ignition leading to piston failure. There is no such thing as too high octane for an engine it is a minimum requirement to stop knock and overheating.
 - b. Materials compatibility – pipes, seals, gaskets and diaphragms which can often be replaced with modern ethanol compatible materials.
 - c. Corrosion of metal components which can be prevented by ensuring the petrol/ethanol mixture is not contaminated with water and an aftermarket corrosion inhibitor additive is added. Avoid aftermarket corrosion inhibitor additives that contain ash forming metallic valve recession additives and octane boosters as they can contribute to spark plug whiskering and fouling.
2. Modern lubricants have very low friction properties that can lead to cylinder bore glazing and are particularly sensitive during the initial break in process with new components where light load operation for extended periods should be avoided. Historic mineral based oils where recommended should not be affected by ethanol/petrol blends. Ethanol is fairly low boiling and will evaporate and burn quickly after a cold start and not contribute to cylinder lube oil dilution. It is however important that the engine is thoroughly warmed up before stopping to prevent any residual fuel remaining in the combustion chamber.

Synthetic fuels

There have been a number of announcements in 2020 with respect to E-Fuels that are hydrocarbon fuels produced from non-fossil sources. Renewable electricity is used to produce hydrogen from water by electrolysis and carbon is captured from the atmosphere (CO_2) and combined to produce a liquid fuel. Synthetic fuels have an advantage over conventional biofuels in that they do not compete with food supply or for land use. Whilst synthetic fuels have been produced from fossil hydrocarbon sources over many years and the processes are well understood, these fuels are unlikely to be available in volume for many years to come due to the high levels of renewable electricity required and the difficulty and cost of filtering CO_2 from the atmosphere, but do offer the hope that liquid fuels with their high energy density will continue to be available in the future.

Nigel Elliott - Automotive Fuels Specialist

Nigel lives with his wife Rachel in West Oxfordshire. He is a keen hillclimber and supporter of Shelsley Walsh Hillclimb and a member of the MAC, HDLCC, Bugatti Owners Club, HSA and BARC. He competes in a 1979 Triumph TR7-V8 4.6 litre twin Turbo modified production car. Nigel has owned a number of classic Range Rover's over the years and currently runs a future classic 2004 XKR Jaguar convertible.

Following a long and successful career working in engine and vehicle testing, fuels product development and quality for a multi-national oil company he retired in 2012 and set up a fuels quality consultancy. He is an active member of the British Standards Institute PTI/2 Liquid Fuels Committee as a co-opted expert, responsible for petrol, diesel and non-road fuel standards. Nigel was the Convenor of the European Fuel Standards (CEN) Diesel committee and a long term UK expert member of the Petrol Committee and has been heavily involved in the development of the Biodiesel and Ethanol standards and their implementation in road fuels.





The FBHVC is a voluntary organisation which exists to uphold the freedom to use historic vehicles on the road. It does this by representing the interests of owners of such vehicles to government, their agencies and organisations who focus on the preservation of our transport heritage. We have over 500 subscribing organisations representing a total membership of around 250,000 historic vehicle enthusiasts in addition to individual and trade supporters.

The Federation regularly provide information and clarification to their members and supporters on a range of topics including fuels. Have you visited our website recently? <https://www.fbhvc.co.uk> It has all the up to date material to assist with all aspects of historic vehicle ownership.

To find out how you can support the work we do please visit <https://www.fbhvc.co.uk/how-to-join>

Help us to help you, join today!