ETHANOL IN PETROL

A few years ago, I contributed the article below to the Bayside Vehicle Restorers Club club magazine. Now with fuel companies withdrawing “standard unleaded petrol” and replacing it with only E10 fuel. The petrol companies claim the government mandate of 5% E10 is forcing them to change. The Government claim the petrol companies are not forced to remove all standard unleaded. Despite the finger pointing “standard unleaded petrol” is becoming less and less available and you will have a choice of E10 or having to pay more to get a premium petrol at a price that has a premium of up to 15cents per litre more that standard.

When I contributed the article, I decided not to use E10 in any of my classic cars because of the potential damage E10 could cause. Members whose vehicles would happily run on standard unleaded now have to make the decision on what fuel to purchase. It is therefore worth re-printing the article.

The section in italics and in the extract of the report are my comments or conclusions and do not form part of the edited government report

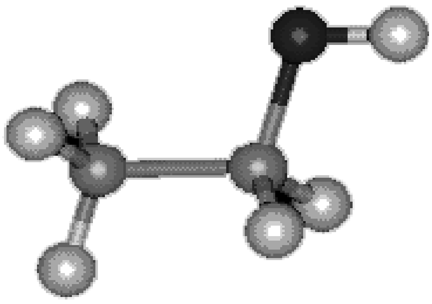
Should you worry about Ethanol?

Recently all of my local garages have ceased stocking normal “standard” unleaded fuel and have been stocking E10 fuel instead. It has a RON octane rating of 95 and dollar wise costs the same per litre as standard fuel or in some case a few cents less.

Now my Lancia engines have had the odd bouts of indigestion on standard unleaded and I usually run premium unleaded with a dose of *Valve Master.*

The prospects of higher-octane cheaper fuel led me to investigate ethanol petrol. An initial investigation indicated potentially good results especially if one reads the publicity from the fuel companies, but reading the Environment Australia report on ethanol in petrol has left me at best confused about the benefits even for modern vehicles. I am now firmly convinced that E10 is not good for our older vehicles. Below is an edited extract from an Environment Australia Report, *"Setting the Limit of Ethanol in Petrol. Published in 2002"*. The full Environment Australia Report is available from the web address of *http://www.environment.gov.au/atmosphere/fuelquality/publications/ethanol-limit/index.html*

What is ethanol and why is it used as an automotive fuel?



A molecular view of ethanol

Ethanol (ethyl alcohol) is a clear, colourless liquid with a faint odour. It has a high latent heat of vaporisation and contains oxygen, characteristics that are relevant to its environmental performance in combustion as a motor fuel, and in its storage and distribution.

Ethanol can be produced in two forms: hydrated and anhydrous. Hydrated ethanol, usually produced by distillation from biomass fermentation, contains 95% ethanol with the balance being water. It is suitable for use as a straight spark ignition fuel in warm climates or for blending as a 15% emulsion in diesel. A further process of dehydration is required to produce anhydrous ethanol (100% ethanol) for blending with petrol. The most common uses are:

- 10% ethanol (E10); this is the blend available in Australia.
- 85% ethanol (E85); this blend is used in some states of the US and requires particular vehicle technology known as ‘Flexible Fuel Technology' (FFT).
  V8 super cars now use E85
- 20-24% ethanol (E22); this blend, used in Brazil, requires specific vehicle optimisation.
- 100% ethanol (E100); this is also used in Brazil and requires vehicle technology dedicated to the fuel.

Ethanol is a known ‘octane enhancer’ and ‘oxygenate’. An octane enhancer increases the research octane number (RON) and reduces engine knock. An oxygenate is a fuel octane component containing hydrogen, carbon and oxygen in its molecular structure.

Oxygenates are often added to petrol to increase octane, extend petrol supplies and induce a lean-shift ('enleanment') in the engine's operation. Oxygenates 'enlean' the fuel by providing it with additional oxygen, effectively altering the air/ fuel ratio.

Ethanol blends tend to result in reduced emissions of carbon monoxide (CO), hydrocarbons (HCs), particulate matter, and certain known carcinogens. However, ethanol blends are likely to increase emissions of aldehydes, particularly acetaldehyde.

Several US studies conclude that the overall ozone forming potential of ethanol blends is the same or lower than that of petrol.

Ethanol can be considered as a renewable fuel when produced sustainably from agricultural sources and has potential for greenhouse gas emissions abatement.

How does ethanol affect engine operation?
Octane.

The octane number is a measure of the resistance 'knock'. As previously stated, ethanol in petrol is known to enhance the octane number of fuel.

The octane performance of a fuel is measured under two different operating conditions that provide the 'research' and 'motor' octane numbers (RON and MON) of the fuel.

RON relates to low speed operation, and MON relates to high engine speed operation.

The octane requirement of a particular engine results from a number of design factors such as compression ratio and combustion chamber design. Engines are designed to operate effectively on commercial fuel of specified octane numbers and fuel suppliers must ensure petrol octane meets these market needs.

The difference between the RON and MON is called the 'sensitivity'. Petrol manufacturers try to maintain this at about 8 to 10 units to prevent high speed knock and possible engine damage. The sensitivity of E10 is about 14 units, although this may vary depending on the composition of the base petrol.

This change in sensitivity is unlikely to effect our older vehicles as we tend not to use them at continued high RPM. & generally the compression tends to be low.

Oxygen content.

The oxygen for fuel combustion in an engine running on non-oxygenated fuel is sourced from the air. The oxygen content of a fuel has an effect on the Air-to-Fuel (A/F) ratio. The A/F ratio required for complete combustion (the stoichiometric balance) is 14.6:1, that is 14.6 kilograms of air to one kilogram of non-oxygenated fuel.

Ethanol blended fuels have an increased oxygen content (ethanol at 10% equates to an oxygen content of 3.5%), which will alter the A/F ratio at which the engine is operating.

The A/F ratio of the Brazilian-made Volkswagen, which is optimised to run on 22% ethanol, is set at 12.7:1. Changes in the oxygen content will have different impacts on various vehicle technologies. The Australian car fleet has a mix of vehicle technologies, including:

- pre-1986 vehicles designed to run on leaded petrol and not fitted with catalysts;
- open-loop carburetted vehicles - with oxidation only catalyst;
- open-loop fuel injected vehicles - with oxidation only catalyst;
- closed loop (computer controlled) carburetted vehicles with three-way catalysts for HC, CO and NO^x control, (this technology is also referred to as Electronic Control Module (ECM);
- closed-loop fuel-injected vehicles - either central point injection, banked port injection or sequential port injection with three-way catalyst; and
- (Recently) direct injection engines.

The electronic management system in a modern car has the ability to change the air/fuel ratio to maintain stoichiometric balance in order to minimise exhaust emissions.

Carburetted vehicles with open loop systems are unable to make adjustments to changes in the oxygen content of the fuel.

This means that you are effectively running your carburetted vehicle on an up to a 3% leaner mixture which may cause overheating and reduce power and if you do run at high RPM it compounds the sensitivity issue and will result in engine damage sooner.

Volatility.

Volatility refers to a fuel's ability to change from liquid to vapour and is characterised by three measurements - vapour pressure, flexible volatility index and distillation curve.

Volatility is commonly measured by RVP (Reid Vapour Pressure), which is the fuel's vapour pressure at 37.8 degrees Celsius. This is a measure of the fuel's more volatile components, which vaporise first. RVP is largely governed by the fuel's butane content.

Flexible Volatility Index (FVI) is a parameter used to ensure good hot weather operability of the fuel by limiting the fuel volatility so that vapour lock will not occur. It is the sum of the RVP and the percentage of fuel evaporated in a simple distillation test at 70^C. The distillation test is used to determine the fuel's volatility across the entire boiling range of petrol and the plot of the evaporation temperature versus volume distilled is referred to as the distillation curve.

Petrol that is too volatile may vaporise easily and boil in fuel pump lines or in carburettors at high operating temperatures. If too much vapour is formed, this could cause a decrease in fuel flow to the engine, resulting in symptoms of vapour lock, including loss of power, rough engine operation, or complete stoppage. Fuel economy could also deteriorate and evaporative emissions could increase.

Volatility is directly affected by regional temperatures. The states RVP and ethanol blends are required to meet the RVP limits set by the relevant states.

Although ethanol itself has a RVP less than that of petrol, its addition to petrol markedly increases the RVP of the blend, which can lead to increased evaporative emissions. It is generally accepted that the peak RVP of ethanol blends occurs at around 5-10% ethanol concentration, and is about 6.5% above the RVP of neat petrol. The increase in RVP can be overcome if ethanol is blended with a blendstock that has reduced RVP (usually lower butane). Mixing an ethanol blend with a half tank of normal petrol will result in a higher RVP.

To reduce RVP the fuel companies add more of the “Tar end” of the petrol spectrum to the mixture. I like to see the tar on the road and not in my petrol. You also need to be aware that if you mix ULP and E10 your are more likely to suffer vapour lock

Driveability Index.

The Drivability Index (DI) of petrol is a specification used to manage engine performance during cold weather and whilst the engine is warming up. Drivability problems usually show as hesitation and stumbling when accelerating, uneven idling and surging when cruising. The problems usually disappear as the car warms up. Petrol is a mixture of many hydrocarbons with differing boiling points. If petrol does not have sufficient front-end or lighter components and in particular, sufficient mid-range components, then a vehicle will not drive or run smoothly, particularly when the engine is cold.

DI is a mathematical expression of distillation properties that have been developed by the European automotive industry to describe the influence of fuel volatility on drivability. Ethanol has a higher heat of vaporization than other octane enhancers (such as ethers) resulting in poorer cold start performance for ethanol blends compared to petrol.

Luckily, it is warm in Queensland so in most case we do not have to put up with many cold starts. However because it is warmer up here do we get more tar in the E10?

General operability and materials compatibility.

Ethanol blends have varying effects on different technologies within the existing and future Australian car fleet. Numerous modifications are made to automobiles manufactured and sold in Brazil. Changes to the cylinder walls, cylinder heads, valve, valve seats, pistons, piston rings, intake manifolds, carburettors and electrical systems are among the modifications.

Nickel plating of steel fuel lines and fuel tanks is common in Brazil to provide corrosion protection against E20-type fuel. Most metal components in automobile fuel systems will corrode or rust in the presence of water, air or acidic compounds. The addition of ethanol increases petrol's ability to hold water. Several studies which have examined the effect of E10 on vehicle tanks and fuel system components have concluded that ethanol up to 10% does not increase corrosion in normal, everyday operation. Elastomer (rubber-like compounds used in fuel lines, etc) compatibility with ethanol blends is more difficult to generalise. A number of petrol constituents can have an effect on elastomer swelling and deterioration. For instance, aromatics, such as benzene have been shown to have detrimental effects on some fuel system elastomers. Some studies have shown that E10 blends contribute less elastomer swelling than would the amount of additional aromatics needed to obtain the same increase in octane number. However, the combination of ethanol with higher aromatic levels may cause greater swelling than either product by itself. Pre-1986 vehicles may have fuel components that are sensitive to ethanol blends, but specific documentation on the effect of fuel components on older fuel systems is often lacking. In response to this, auto technicians in the US are advised to replace parts on pre-1980 vehicles with components which are resistant to 10% ethanol blends such as EGR valves, fuel inlet needle tips and fluoro elastomers (for fuel lines, etc.). Occasionally, in older model vehicles, deposits in fuel tanks and fuel lines are loosened by E10. When this occurs, the vehicle's fuel filter may become blocked. Concerns have been raised that fuel containing blends of ethanol higher than 10% may cause paint damage to a vehicle during refuelling. Holden laboratory tests have shown that blends of 20% ethanol in petrol can damage some conventional paint systems.

E10 it would seem has no benefits for the fuel tanks, carburettor and lines and potentially has adverse effects. Maurice Grenfell reports he was up for a $1000 to replace the fuel lines and rubbers in his Mercedes Benz after just one tank of E10. It seems E10 can even rot you car's paint (see Phase separation below, it means that you could well get more than 10% ethanol).

Fuel consumption

Ethanol, like other alternative/renewable fuels, has a lower calorific value than petrol. Fuel consumption is influenced by a range of factors including, energy content of the fuel. Australian field trials have observed a fuel consumption increase of up to 2.8% with E10. This finding is consistent with theoretical energy losses of approximately 2-3%.

So unless you are paying at lest 3% less than standard unleaded costs you, you will get less Kms/dollar for E10 fuel.

Storage and handling

In the US, there is specific storage and handling procedures for ethanol blends at distribution and service stations, these include requirements for tanks and tank linings, piping and fittings, and pumps and dispensers. The Australian Institute of Petroleum is currently developing a code of practice for the storage of ethanol blends. Although some materials used to fabricate storage systems may have evolved over time to accommodate the storage of ethanol and ethanol blends, a recent US study has revealed that some single-walled fibreglass reinforced plastic tanks as well as some gaskets, sealants, adhesives and other component materials may not be compatible with ethanol.

This means that it is now possible to get even more rubbish in your fuel unless the service station has storage tanks that meet the E10 storage requirements. (I did not see the service stations change the underground tanks when they changed to E10.)

Phase separation in storage tanks

Ethanol blends are particularly sensitive to poor handling and storage practices because of the possibility of phase separation. Phase separation can occur when too much water is introduced into a storage tank. As ethanol has an affinity for water, ethanol blends are more likely to suspend moisture and carry it into the fuel system than non-oxygenated fuels. However, if too much water is introduced into an ethanol blend, the water and most of the ethanol (around 60% - 70%) will separate from the petrol and the remaining ethanol. The amount of water that can be absorbed by ethanol-blended petrol without phase separation varies from 0.3 to 0.5%, depending on temperature, aromatics and ethanol content.

Because ethanol is hygroscopic and absorbs water from the atmosphere (and any vessel containing water that it enters), it is prudent to ensure that water contamination does not occur in the distribution and storage of ethanol blends.

If phase separation occurs in the storage tank, you can end up getting a very high concentration of both ethanol and water in your next tank full of E10.

Phase separation in the vehicle's tank

Water in petrol can have dramatically different effects on an engine, depending on whether it is in solution or a separate phase. A small amount of water solution in a homogeneous ethanol/petrol blend has no adverse effect. Phase separation can occur in a vehicle's tank as a result of first fuelling with an ethanol blend then going out of the ethanol blend system. This situation arises if, for example, a quarter of a tank of ethanol blend is supplemented by three-quarters of a tank of petrol at refill, causing the concentration of ethanol in the blend to fall. It is therefore possible that in this situation, the presence of water normally contained within the ethanol blend will be sufficient to precipitate phase separation, giving you water in your fuel tank.

But look on the bright side, water will cause the tank to rust and the holes in the tank will let the water out. Now who would have thought that just refilling your tank with proper petrol after using E10 would cause problems?

Emissions outcomes for ethanol blends

The study indicates that, for the majority of the vehicles, total hydrocarbons and carbon monoxide emissions, as well as fuel economy, decreased, while NOx and acetaldehyde emissions increased as the ethanol content in the test fuel increased. Formaldehyde and vehicle exhaust CO^2 were largely unaffected

It seem using E10 will not do anything much to reduce our CO^2 (global warming) emissions. I seem to remember that Nitrous Oxide and acetaldehyde emissions are not a good thing. Remember all the environmental figures you hear about ethanol don't take into account the environmental impact or growing the crop used to make the ethanol.

After reading this report extract you may wish to drain your tank of ethanol "infected" petrol and tip it out however the full report warns that the BTEX plume is increased.

The full report states "spills of ethanol blends result in more persistent BTEX (benzene, toluene, ethylbenzene and xylene) and cause the toxic BTEX compounds of petrol to travel up to 2.5 times farther than in the absence of ethanol." So you can't even get rid of the stuff.

Richard Egglesfield

Additional info

Visit http://www.industry.qld.gov.au/dsdweb/v4/apps/web/content.cfm?id=6200 general Qld government site discussing Ethanol & http://www.industry.qld.gov.au/dsdweb/v4/apps/web/content.cfm?id=14777 5% Ethanol mandate consultation paper

Which vehicles can use E10 (they still get poorer economy and have less power)

The following table lists vehicle models suitability to run on E10 ethanol blended petrol. Do NOT use or E10 in motor vehicles not shown as suitably in the list below.

In general terms if your vehicle has a carburettor it is **unsuitable** for E10

If your vehicle is not listed with a tick in the yes box do not use E10

MOTOR VEHICLES

		E10 Suitable	
BRAND	**MODEL**	**Yes**	**No**
Alfa Romeo	All models post 1998		**x**
Alfa Romeo	All models pre 1998		**x**
Audi	Audi A3 1.8L (Engine Code 'APG' 2000 onwards) and A4 2.0L (Engine Code 'ALT' 2001 onwards)		**x**
Audi	All models post 1986 except above	√	
Bentley	All models post 1990	√	
BMC	All models		**x**
BMW	All models post 1986	√	
Citroen	All models post 1998	√	
Chrysler	All models post 1986	√	
Daihatsu	Charade (September 2004 onwards); Terios (September 2004 onwards); Copen (October 2004 onwards); Sirion (November 2004 onwards)	√	
Dodge	All models post 1986	√	
Fiat	All models pre 2006		**x**
Ford	Focus (2002 - 2004), F-series (1986-1992), Ka (All), Maverick (All), Transit (1996 - 2004)		**x**
Ford	Mondeo (prior to 2007)		**x**
Ford	Capri (All), Courier 2.0L & 2.6L (All), Econovan (pre-2002), Festiva (All), Laser 1.3L, 1.5L & 1.6L (All), Raider (All), Telstar (All)		**x**

Ford	All models post 1986 except above	√	
GMDaewoo	All models		**x**
Holden	Apollo (1/87-7/89), Nova (2/89-7/94), Barina (1985-1994), Drover (1985-1987), Scurry (1985-1986), Astra (1984-1989)		**x**
Holden	Astra SRi 2.2L (11/2006 onwards); Astra 2.2L Twin Top Convertible (11/2006 onwards)		**x**
Holden	All models post 1986 except above	√	
Honda	Insight - 2004 onwards; Civic range (including Civic Hybrid) - 2004 onwards; S2000 - 2004 onwards; CRV - 2003 onwards; MD-X - 2003 onwards; Accord & Accord Euro - 2003 onwards; Integra – 2002 onwards; Odyssey – 2004 onwards; Jazz – 2004 onwards; Legend – 2006 onwards	√	
Hyundai	All models post October 2003	√	
Jaguar	All models post 1986	√	
Jeep	All models post 1986	√	
Kia	All models post 1996	√	
Land Rover	All models post 1986	√	
Lexus	IS200 pre May 2002		**x**
Lexus	All models post 1986 except above	√	
Lotus	Elan (1989-1991); Esprit (4 cyl – 1987-1999); Elise (Rover engine – 1996-2004); 340R; Exige (Rover engine – 2001, 2002 & 2004); Europa (2006 onwards)		**x**
Lotus	Esprit (V8 – 1998-2004); Exige (Toyota engine – 2004 onwards); Elise (Toyota engine – 2004 onwards)	√	
Mazda	Mazda2 - May 2005 build onwards, Mazda3, Mazda6, RX-8, MX-5 – July 2005 build onwards, Tribute - April 2006 onwards, CX-7, CX-9	√	
Mazda	All models except above		**x**
Mercedes-Benz	All models post 1986	√	

MG	All models		x
BMC Mini			x
MINI	All models	√	
Mitsubishi	All **fuel injected** models post 1986	√	
Nissan	All models post 2004	√	
Peugeot	306 (XU engine only)		x
Peugeot	All models post July 1997 except above	√	
Porsche	All models pre MY2007		x
Porsche	All models from MY2007	√	
Proton	All models	√	
Rover	All models		x
Renault	All models post 2001		x
Rolls Royce	All models between 1990 and 2002	√	
Saab	All models post 1986	√	
Ssangyong	Rexton, Stavic & Chairman models with 3.2 litre petrol engine	√	
Subaru	All Subaru (before 1990),Subaru Liberty B4 (2002 to 2003), Subaru Liberty GT (2004 - 2006), Impreza WRX STI (1999 to 2005)		x
Subaru	All models post MY1990 except above provided the model-specific minimum octane rating is maintained	√	
Suzuki	Alto, Mighty Boy, Wagon R+, Swift/Cino, Sierra, Stockman, Vitara, X-90, Jimny (SOHC), Super Carry, Suzuki Baleno and Baleno GTX		x
Suzuki	All models except above (providing RON requirements are met)	√	
Triumph	All models		x
Toyota	Camry with carburettor engines pre July 1989 and Corolla pre July 1994; Supra - pre May 1993, Cressida - pre Feb 1993, Paseo - pre Aug 1995, Starlet - pre July 1999, Land Cruiser - pre Aug 1992, Coaster - pre Jan 1993, Dyna - pre May 1995, Tarago - pre Oct 1996, Hilux , Hiace, & 4 Runner - pre		x

	Aug 1997, Townace - pre Dec 1998	
Toyota	All models except above	√
Volkswagen	All **fuel injected** models post 1986	√
Volvo	All models post 1986	√

MOTORCYCLES

BRAND	MODEL	E10 Suitable Yes	No
BMW	All motorcycles post 1986	√	
Buell	All motorcycles	√	
Harley Davidson	All motorcycles post 1986	√	
Honda	All motorcycles and All Terrain Vehicles		x
Kawasaki	All motorcycles and All Terrain Vehicles		x
Piaggio	All motorcycles		x
Polaris	All motorcycles	√	
Suzuki	All motorcycles and All Terrain Vehicles		x
Victory	All motorcycles	√	
Yamaha	All motorcycle and All Terrain Vehicles		x

REASONS WHY ETHANOL BLENDED PETROL IS NOT RECOMMENDED FOR USE OLDER VEHICLES

Introduction

The following information outlines the key reasons why vehicle manufacturers do not recommend the use of any ethanol/petrol blended fuels in vehicles made before 1986. This information is also applicable to post-1986 vehicles listed as unsuitable to use ethanol blended petrol.

Ethanol has a number of important chemical and physical properties that need to be considered in a vehicle's design.

Carburettor Equipped Engines

Vehicles made before 1986 vehicles were predominantly equipped with carburettors and steel fuel tanks.

The use of ethanol blended petrol in engines impacts the air/fuel ratio because of the additional oxygen molecules within the ethanol's chemical structure.

Vehicles with carburettor fuel systems may experience hot fuel handling concerns. This is because the vapour pressure of fuel with ethanol will be greater (if the base fuel is not chemically adjusted) and probability of vapour lock or hot restartability problems will be increased.

As a solvent, ethanol attacks both the metallic and rubber based fuels lines, and other fuel system components.

Ethanol also has an affinity to water that can result in corrosion of fuel tanks and fuel lines. Rust resulting from this corrosion can ultimately block the fuel supply rendering the engine inoperable. Water in the fuel system can also result in the engine hesitating and running roughly.

Fuel Injected Engines

In addition to the issues mentioned above for carburettor equipped engines, the use of ethanol blended petrol in fuel injection systems will result in early deterioration of components such as injector seals, delivery pipes, and fuel pump and regulator.

Mechanical fuel injection systems and earlier electronic systems may not be able to fully compensate for the lean-out effect of ethanol blended petrol, resulting in hesitation or flat-spots during acceleration.

Difficulty in starting and engine hesitation after cold start can also result.

Exhaust And Evaporative Emission Levels

Lean-out resulting from the oxygenating effect of ethanol in the fuel may affect exhaust emissions.

Of more concern is that fuel containing ethanol can increase permeation emissions from fuel system components, particularly those that have aged for nearly 20 years. Therefore the increased vapour pressure of fuel with ethanol (if the base fuel is not chemically adjusted at the refining stage) will lead to increased evaporative emissions.