Policy Planning Development and Evaluation Division
The Research Unit
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General Effects of Some Fuel Additives

Suitability of Local Fuel Octane Levels and Ethanol for Four Luxury Vehicles

Purpose

The purpose of this document is to:

1. Examine the fuel additives Methylcyclopentadienyl manganese tricarbonyl (MMT) and Methyl tertiary-butyl ether (MTBE);
2. Highlight their effects on vehicles, the environment, and humans;
3. Determine the suitability of local fuel octane levels for luxury vehicles;
4. Determine if Ethanol as a fuel additive is suitable for luxury vehicles; and
5. Make a recommendation for a higher octane fuel.

Summary

Both MMT and MTBE are effective as additives which raise the octane levels of gasoline fuels, reduce tailpipe emissions, and increase the efficiency of the burning of fuel. However, they both pose risks to the environment and human health in their pure forms, and even after combustion. MMT differs from MTBE in that, MMT affects vehicles negatively over time, while MTBE does not. The International position on MMT is that it should be banned, and similarly there is a trend towards phasing out MTBE in favour of Ethanol in advanced countries.

Four luxury vehicles were researched for this document – Mercedes, Porsche, Audi and BMW; of these four, only Mercedes requires fuel with octane rating exceeding what is provided locally in Jamaica (91 anti-knock index (AKI)). Porsche, Audi and BMW all can operate on 90 unleaded with no damage to the engine based on the manufacturers' specifications. Mercedes, Porsche and BMW would benefit from the introduction of higher octane fuels (93 AKI), but only based on marginal performance. All luxury models researched are designed to operate optimally using the blend of 10 % ethanol present in Jamaica.

Looking at the data, a 93 octane (AKI) level fuel would be recommended if a new grade of fuel was to be considered. The main reasons for this are that:

1. The most advanced countries are phasing out 87 octane and moving to 93 octane; and
2. All luxury vehicles perform optimally using 93 octane fuel and gain no advantage by using 95 octane fuel.

Raising the octane level with the use of MTBE would be the most likely option, since the Manganese in MMT damages the catalytic converter in many vehicles, and 10 % -15 % ethanol is the maximum at which most luxury vehicles can safely operate.

1.0 Determining whether MMT and MTBE additives are harmful to vehicles and the environment.

1.1 MMT - Methylcyclopentadienyl manganese tricarbonyl

- is an additive which was originally used in leaded gasoline. It was later used in unleaded gasoline to increase the octane rating and to help prevent engine "knocking". The use of MMT was disallowed in 1977 by the US Congress via the Environmental Protection Agency (EPA), because of stated concerns that MMT might damage catalytic converters, increase hydrocarbon emissions, and health concerns regarding manganese emissions[i]. After years of appeals and legal action by MMT manufacturers, a ruling was handed down that allowed its use in 1994 at a level equivalent to 1/32 grams per gallon manganese (gpg Mn)[ii].

In its pure form, MMT is toxic to humans and extremely toxic to aquatic animals. Inhalation causes abdominal pain, dizziness, headache, laboured breathing, nausea, cough and sore throat. Short term exposure may cause effects on the central nervous system, kidneys, liver and lungs, resulting in tissue lesions. Exposure at high levels may result in death[iii]. However, MMT rapidly breaks down under the influence of light, and is therefore not likely to represent a significant risk to human health or the environment in general.

Nevertheless, independent studies and studies by car manufacturers have shown that "extended use of MMT will lead to build-up of Manganese-containing deposits on engine and emissions system components, thereby adversely affecting vehicle emissions performance and durability;" [iv] and most studies conducted by the Ethyl (the manufacturer of MMT) have concluded that the use MMT causes no harm. Health studies have also shown greater exposure to MMT for gas station attendants[v], and significant reduction in atmospheric manganese in Montreal following a ban of MMT[vi].

The use of MMT has been banned in California, Canada, Iran, Brazil, Czech Republic, Germany, New Zealand; places in the European Union and India; while there are strict regulations (very low levels) in the United States and Beijing, among other jurisdictions. Based on the precautionary principle, the International Council on Clean Transportation (ICCT) "recommends that the use of MMT be banned unless and until the unlikely event that further health studies indicate it is safe for the most vulnerable members of the population and vehicle studies demonstrate that vehicle emission controls are not harmed over their full useful life." [vii]

We urge policy makers at all levels of government to consider carefully this recommendation and to adopt a position that is in the interest of public health and welfare.

1.2 MTBE - Methyl tertiary-butyl ether

- is a gasoline additive, used as an oxygenate to raise the octane number. It has been in use since 1979 to help prevent engine "knocking" and reduce tailpipe emissions by causing gasoline to burn more completely. Despite its potential to contaminate groundwater, MTBE is widely used worldwide.

In its pure form, MTBE is classified as hazardous. Inhalation and ingestion may cause irritation, nausea, vomiting, diarrhoea, pneumonitis, harmful central nervous system effects, excitation, euphoria, headache, dizziness, drowsiness, blurred vision, fatigue, tremors, and convulsions, loss of consciousness, coma, respiratory arrest and death. It is also suspected of being carcinogenic, and has produced maternal and/or foetal toxicity and malformations in laboratory animals; however, the main health authorities have not classified it as being carcinogenic[viii]. Acute low toxicity to fish, aquatic invertebrates, algae, and microorganisms in the environment is also an effect[ix] [x].

Not much information can be found regarding effects of MTBE on vehicles. It seems there is a general belief that there is no significant effect on vehicle performance[xi].

Despite the positive attributes of MTBE as a fuel additive (reduced tailpipe emissions, anti-knock properties, more complete burning of fuel), and the widespread use worldwide; MTBE is banned in several jurisdictions worldwide, including several states in the US. This is primarily due to the groundwater contamination events in the early 1990's, and the hundreds of lawsuits resulting from those environmental events[xii]. Many petroleum companies favour the use of ethanol over MTBE, because of the fear of environmental hazards associated with MTBE, as well as legal action by citizens and governments[xiii].

serious problems in groundwater. MTBE is seen as a potentially serious long-term threat to drinking-water supplies if it comes to be widely used at high concentrations in petrol, particularly where there is inadequate control on leakage from underground storage tanks.

2.0 Suitability of fuel octane levels for luxury vehicles and the use of Ethanol as an additive

Gasoline fuels are given an octane rating based on what is known as the Anti-Knock Index (AKI). The AKI is the ability of the fuel to resist "knocking" in the engine at a given compression. Knocking occurs when the fuel explodes spontaneously under compression, without being ignited by the spark plug. This secondary explosion throws the engine timing out of sync, causes rattling, and may result in engine damage if left unchecked. The higher the octane rating of the fuel, is the greater the ability to resist spontaneous explosion at a given compression. This is especially important in "high-end" luxury vehicles, which generally have high compression ratio engines. Although modern vehicles have automatic compensations to reduce knocking by reducing the compression, the trade-off is less engine power (although not discernable in most cases). Adding ethanol to fuel raises the octane level of gasoline, similar to MMT or MTBE.

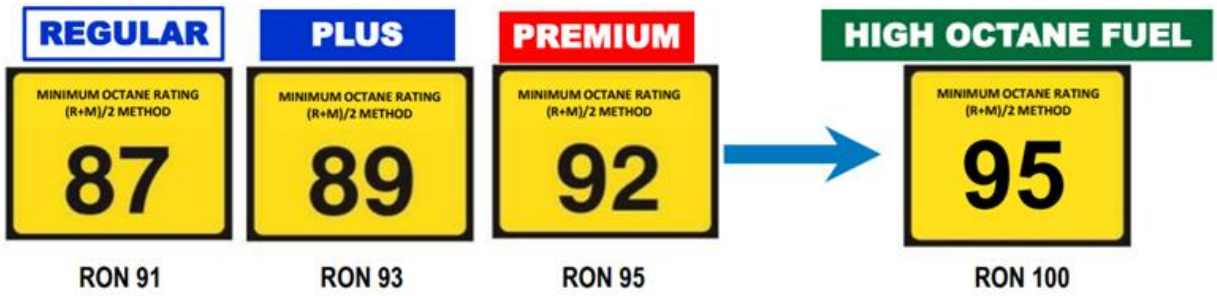
The two most popular luxury models of four 'high-end' make vehicles were researched (Mercedes, Porsche, Audi and BMW), to find the required octane levels of the fuel based on the manufacturers' specifications. It must be noted that octane level does not equate to fuel quality, but rather the ability of the fuel to be burnt efficiently; fuel quality is based on a number of factors, such as grade, components, and additives.

2.1 Difference between RON, MON, and AKI

Octane rating is based on three different indices, which are specific to different regions:

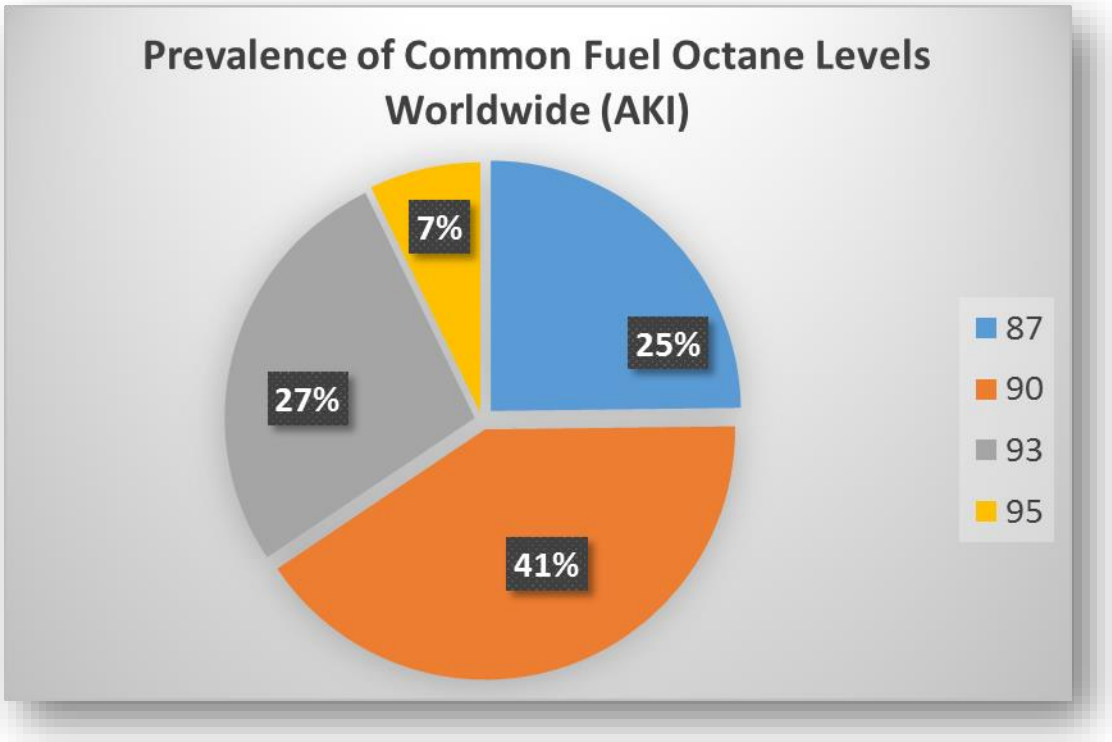
- Research Octane Number (RON) is the most widely used rating for fuel worldwide. It is often seen at the gas pumps and is mostly used in Europe and ranges from 95 to 100.
- Motor Octane Number (MON) is used at higher temperatures and speeds of about 900 rpm, and is usually lower than the RON.
- The Anti-Knock Index (AKI) is an average of the Research Octane Number and Motor Octane Number divided by two, and is used in the US, Americas, and Caribbean region in general.

In light of the above, this document uses the AKI as the index for octane level. The Research Octane Number of 98 would correspond to an AKI of 93 and the minimum required fuel would be 95 RON or 90 AKI for luxury vehicles.



2.2 Fuel Octane Levels in use Worldwide

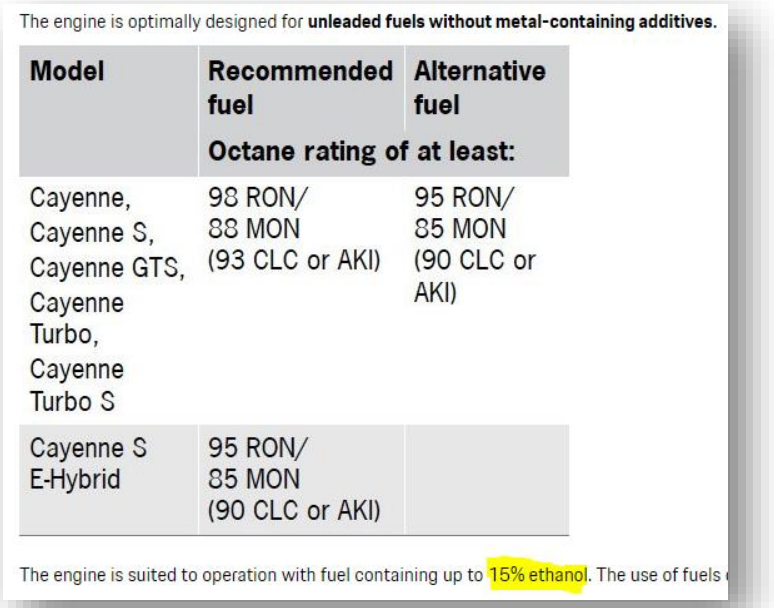
Fifty-five countries were examined worldwide and the research found that thirty-one dispense 87 octane, fifty-one dispense 90 octane, thirty-four dispense 93 octane and only nine dispensed 95 octane [AKI]. This means that majority of the jurisdictions had 90 premium as standard. The general trend showed that 87 octane was being phased out my most advanced economies, while 93 octane was being phased in as the new premium standard. However only a few service stations had 93 octane available comparatively overall. 95 octane was rare in most jurisdictions, and mostly used as racing fuel, or only available as special fuel or close to racing circuits.



3.0 Suitable Octane for Specific Vehicles

3.1 Porsche Cayenne & Porsche Carrera

Both Porsche Cayenne and Carrera models require at least 90 unleaded and will therefore operate without damage at this octane level; however, 93 unleaded is recommended for optimum performance. They can also operate on a blend of up to 15 % ethanol, and should not use fuels that contain metal additives (i.e. MMT).



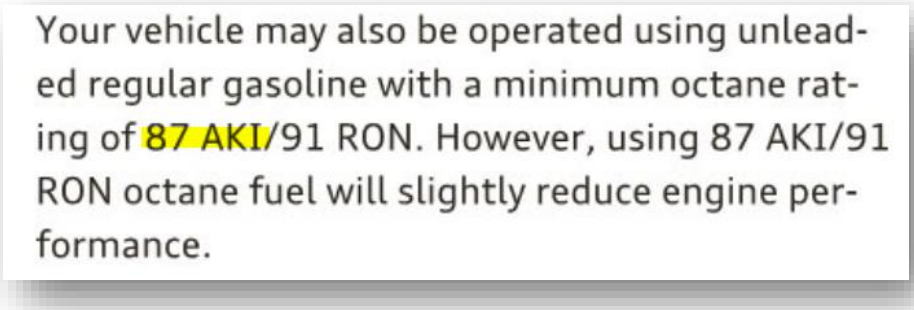
The engine is optimally designed for **unleaded fuels without metal-containing additives.**

Model	Recommended fuel	Alternative fuel
	Octane rating of at least:	
Cayenne, Cayenne S, Cayenne GTS, Cayenne Turbo, Cayenne Turbo S	98 RON/ 88 MON (93 CLC or AKI)	95 RON/ 85 MON (90 CLC or AKI)
Cayenne S E-Hybrid	95 RON/ 85 MON (90 CLC or AKI)	

The engine is suited to operation with fuel containing up to 15% ethanol. The use of fuels

3.2 Audi A4 & Audi Q5

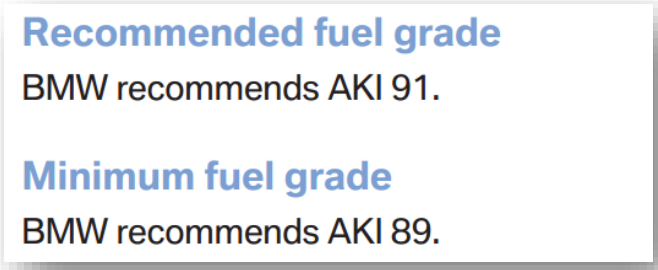
Both models require at least 87 unleaded and will therefore operate without damage at this octane level; however, 91 unleaded is recommended for optimum performance. They can also operate on a blend of up to 15 % ethanol and 15 % MTBE.



Your vehicle may also be operated using unleaded regular gasoline with a minimum octane rating of 87 AKI/91 RON. However, using 87 AKI/91 RON octane fuel will slightly reduce engine performance.

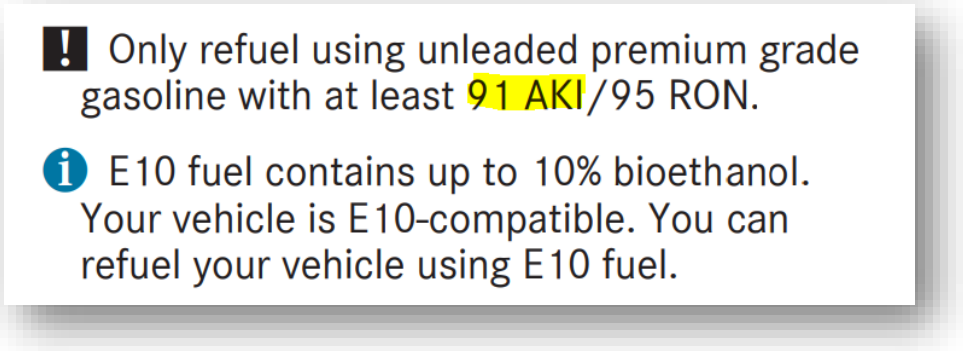
3.3 BMW 5 Series & BMW X6

Both models require at least 89 unleaded and will therefore operate without damage at this octane level, however 91 unleaded is recommended for optimum performance. They can also operate on a blend of up to 10 % ethanol, and should not use fuels that contain metal additives (i.e. MMT).



3.4 Mercedes AMG-GT & Mercedes GLE SUV

Both models require at least 91 unleaded and will therefore operate without damage at this octane level. In emergency circumstances, 87 unleaded can be used as a temporary measure, but will reduce engine performance and increase fuel consumption. They can also operate on a blend of up to 10 % ethanol, and should not use fuels that contain metal additives (i.e. MMT).



Endnotes

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[ii] EPA Comments on the Gasoline Additive MMT.
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[iv] MMT Effects on Gasoline Vehicles: A Literature Review.
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[v] Exposure of Gas Station Attendants to Methylcyclopentadienyl Manganese Tricarbonyl (MMT) Used in Gasoline.
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[vi] Reduced Atmospheric Manganese in Montreal Following Removal of Methylcyclopentadienyl Manganese Tricarbonyl (MMT).
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[ix] Material Safety Data Sheet Methyl tert-butyl ether MSDS.
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[xi] SETTING NATIONAL FUEL QUALITY STANDARDS - Paper 2A - Proposed Management of Petrol Octane Enhancing Additives/Products.
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[xii] Methyl Tertiary Butyl Ether (MTBE)
https://archive.epa.gov/mtbe/web/html/faq.html

[xiii] Methyl tertiary-Butyl Ether (MTBE) in Drinking-water - Background document for development of WHO Guidelines for Drinking-water Quality.
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