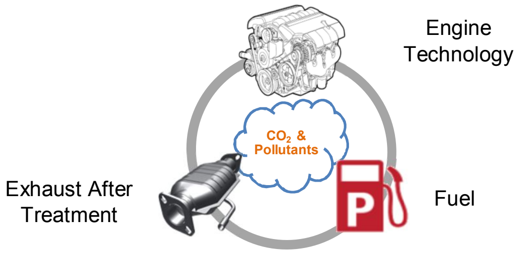
INTRODUCTION

Advanced engine technology, exhaust after treatment and high quality fuel are all required to deliver low CO_2 and pollutant emissions. Modern petrol engines are highly complex and provide a compact, economical power plant that is capable of meeting the customer requirements of light duty vehicles while satisfying stringent global standards which limit CO_2 and pollutant emissions.

In order to ensure performance and durability for the designed vehicle service life, careful consideration must be made to meet the needs and limitations of the engine and emission reduction technologies.

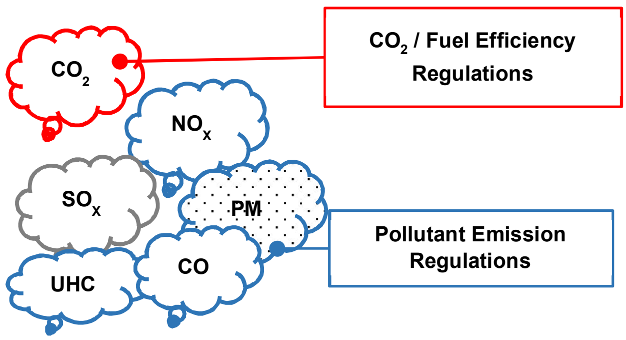
01 OVERVIEW



Low vehicle tailpipe emissions require advanced engine technology, exhaust after treatment and high quality fuel.

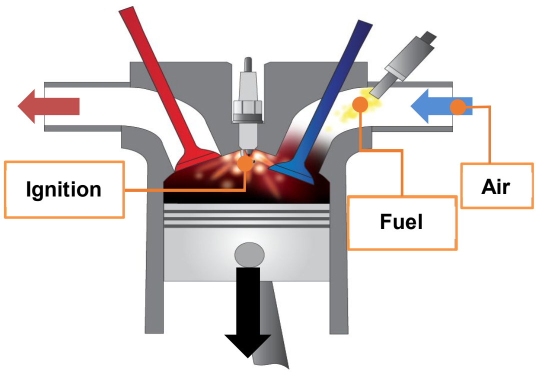
Pollutants from Combustion

Pollutants are produced during combustion due to the engine design and operation combined with impurities in the fuel



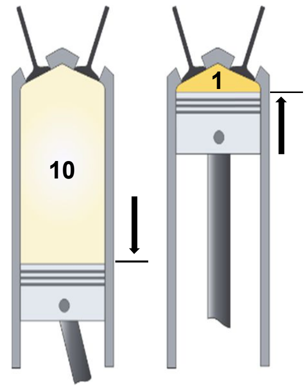
02 ENGINE

Petrol Combustion



Fuel, air, compression and a source of ignition are required for combustion within an engine.

Compression Ratio



10:1 Compression Ratio

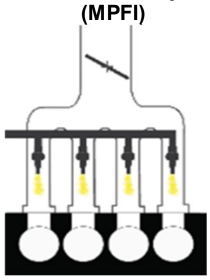
Compression ratio is the ratio of the volume of air and fuel that enters the engine divided by the final, compressed volume prior to combustion. This is presented as 10:1, for example.

Increasing compression ratio increases efficiency and reduces CO_2 emissions, but makes an engine more prone to knocking.

Fuel Injection Types

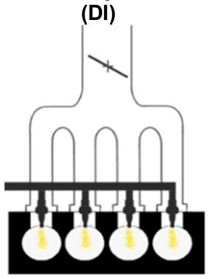
Current vehicles use either Multi Point Fuel Injection (MPFI) or Direct Injection (DI). The proportion of petrol engines using DI has increased over the last ten years due to the reduction in CO_2 emissions and increased power that is offered over MPFI. This helps vehicle manufacturers meet increasingly stringent global CO_2 and greenhouse gas standards.

Multi-Point Fuel Injection (MPFI)



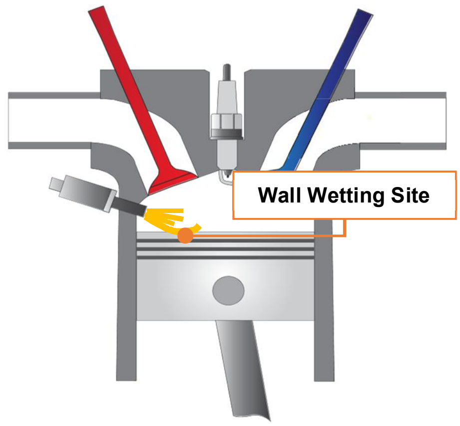
- One fuel injector per cylinder
- Fuel is injected into the air intake
- Good fuel mixing

Direct Injection (DI)



- One fuel injector per cylinder
- Fuel is injected directly into the cylinders
- Improved combustion

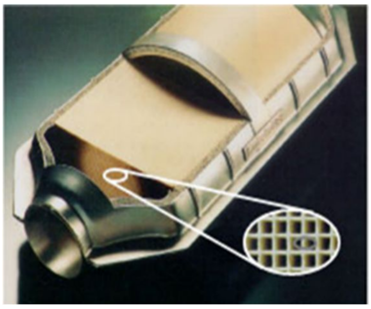
Particulate Formation



- DI engines are more prone to particulate production than MPFI as fuel is sprayed directly into the combustion chamber.
- Fuel that hits relatively cold surfaces like pistons, valves and cylinder walls leads to particulate formation, through a mechanism known as wall wetting.

03 EXHAUST EMISSIONS REDUCTION

Catalytic Converter



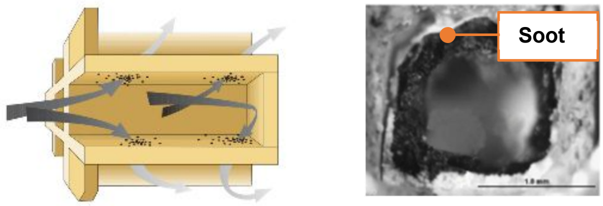
All petrol vehicles are fitted with a catalytic converter in order to meet stringent emission standards.

Source: AECC

- It encourages reactions between the pollutants and oxygen in the exhaust gas, forming CO_2 as a by-product.
- Pollutant conversion efficiency is sensitive to exhaust gas air: fuel ratio, temperature and deactivation (poisoning) from sulfur compounds.
- The efficiency of catalytic converters tends to reduce over time due to detrimental conditions, however, they are rarely replaced or renewed.

Particulate Filter

In order to meet European Euro 6 emission standards, all vehicles with direct injection engines require particulate filters.



Sources: Corning & Argonne National Laboratory

- A particulate filter is fitted in the exhaust system to trap soot particles in microscopic pores of a ceramic or metallic honeycomb.
- Pore size is around 11 times thinner than a human hair.
- Up to 90% of the mass of particles produced by the engine can be trapped, reducing tailpipe particulate emissions.

04 AUSTRALIAN FUEL

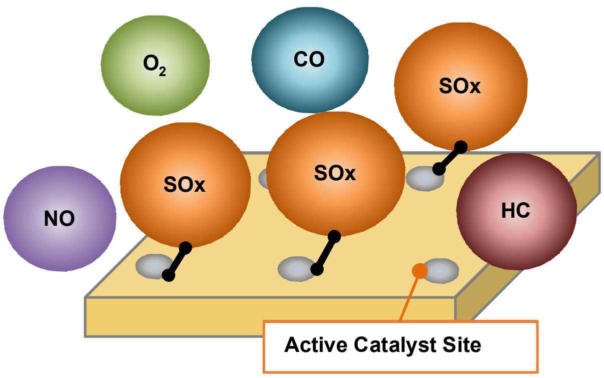
Fuel Sulfur Content

Sulfur in fuel forms compounds during combustion which inhibit the performance and durability of catalytic converters, increasing pollutant emissions. Other advanced markets have lower maximum sulfur content.

Petrol Type	Minimum Octane Rating	Maximum Sulfur Content
ULP	91 RON (Lower Octane)	150 ppm
PULP	95 RON (Higher Octane)	50 ppm
	(From 2017)	10 ppm

RON = Research Octane Number
ppm = parts per million

Impact on Pollutants

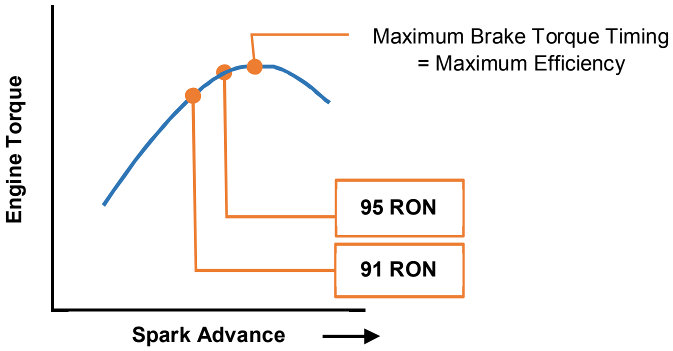


- The higher sulfur content of 91 RON ULP leads to higher levels of sulfur oxides (SO_x) in the exhaust gas.
- SO_x inhibits catalytic converter performance by bonding with the catalyst sites, reducing the reactions between other pollutants.
- 91 RON ULP leads to increased CO, UHC and NO_x emissions compared with 95 RON PULP due to its higher sulfur content.

Fuel Octane Rating

Higher octane fuel resists engine knock and enables high compression ratio engines to improve fuel efficiency and reduce CO_2 production. The European fuel standard requires a minimum octane rating of 95 RON.

Impact on Efficiency, Power and Torque



- For modern engines designed to use 95 RON fuel, using 91 RON will likely result in engine knock.
- To reduce engine knock, spark advance is retarded. This reduces the engine torque and decreases engine efficiency.
- Using 95 RON enables the engine spark timing to operate closer to the point of Maximum Brake Torque Timing (MBT)
- 95 RON enables higher engine efficiency, reducing CO_2

CONCLUSION

Achieving low vehicle emissions with spark ignition engines requires a compromise between pollutants and CO_2.

Low vehicle emissions can only be achieved by using engine and exhaust after treatment technology that is complemented by high quality fuel. 95 RON fuel offers a reduction in real world CO_2 and pollutant emissions over 91 RON.

From 2017, Europe, Japan and the USA will all have fuel standards with a maximum sulfur content of 10 ppm, enabling advanced engine and exhaust emission reduction technologies to meet stringent pollutant emission regulations in both the real world and in the laboratory.