1. Introduction

Older cars and motorcycles must be in a good state of repair and properly tuned to get best performance.

The following sections outline reasons why operators may not be getting the best performance when their vehicle is using a petrol grade and gives some guidance on what action can be taken to improve performance in conjunction with vehicle manufacturers’ recommendations as outlined in vehicle handbooks.

2. Drivability and Performance

For the majority of cars and motorcycles, drivability and performance on petrol grades of similar octane will be the same. There are minor variations in density, composition and volatility to meet the new regulations but if the car or bike is tuned for the petrol then these variations will not affect performance. Setting the correct air-fuel ratio is critical when running on any petrol. This is because without lead, the spark plugs can suffer fouling more quickly, especially if the engine is running rich.

Engines can run rich for many reasons, among them are:

- automatic and manual chokes are open too long or incorrectly adjusted
- driving cycles are short so engines do not reach operating temperature
- engines have been incorrectly tuned i.e. Air fuel mixture too rich
- pollution control systems contain worn parts
- vacuum control systems are leaking
- ignition system components are worn such as spark plugs, points on older vehicles

Running rich fuel mixtures can lead to excessive deposits on spark plugs, difficult starting, rough running, surging and hesitation due to misfire. This will also result in poor fuel economy, excessive exhaust emissions and wasted money.

If problems are encountered when running on petrol then some simple checks and resulting adjustments to the engine are listed below. It is recommended, where appropriate, that such checks are made against manufacturers’ settings or other relevant performance standards, and that the correct diagnostic equipment be used to make these checks. In cases where key settings and checks are available only to OEM workshops, we recommend the vehicle be referred directly to such workshops. The following checks can be carried out:
2.1 Spark plugs
Inspect for fouling. Spark plugs can misfire after they become coated with carbon deposits. This can occur for four main reasons:

- **a weak spark**
- **a rich mixture** (coating of the plugs with too much unburnt fuel),
- **Incorrect heat range of spark plug** (insufficient heat to burn carbon deposits off)
- **Deposits** from another source, e.g. engine oil.

*Note spark plugs from a correctly tuned engine using unleaded fuel are often coated with a thin black deposit. Fouled plugs have thicker black deposits which also cover the insulator, and often have a wet appearance.*

The lead in leaded fuel helped to catalyse carbon burnoff during engine warm-up. Now that lead has been removed from the fuel, carbon burnoff (self cleaning) requires a higher temperature. It is therefore more important than before to minimise the amount of carbon forming on the plugs when the engine is cold. This is achieved by use of the correct air-fuel ratio and will often require leaning the mixture slightly. It is also more important than before that spark plugs get up to temperature as quickly as possible.

2.2 Weak Spark

**Ignition system** - Check spark plug leads, distributor high-tension lead, distributor Points, coil and condenser. Check for physical defects to distributor - spring clips, mounting bolts, cracked cap etc.

**Spark Plugs** - Check condition of electrodes and ceramic insulator. Check electrode gap.
Plugs with carbon coating their insulators can sometimes be cleaned. If the carbon has penetrated the pores of the insulator, grit blasting may not be effective and the plugs will need to be replaced.

Check that plugs are of the recommended type and heat range.
If vehicle is used mainly for short trips and is not also used for long distance, high speed running, consult the spark plug agency about fitting hotter plugs.

*Note that for Bosch and Champion plugs, hotter plugs have higher heat range numbers whereas for NGK plugs, hotter plugs have lower numbers. Take care to use the type and make of plug recommended for the vehicle. Use of equivalents from other suppliers can cause problems.*

**Battery** - Check battery for age, charge and good clean connections.

2.3 Rich Mixture
Check the air-fuel mixture using a properly calibrated exhaust gas analyser and adjust if engine is burning too rich. Don’t rely on spark plug appearance as plugs are often black on unleaded fuels whether the mixture is rich or lean.

**Carburettor settings** - Check air-fuel mixture control settings and idle settings.

**Carburettor condition** - Check for causes of flooding or other defects - jammed Float, air leaks (both carburettor and manifold), linkages and bushings. Take care to check older needle-and-jet type carburettors for excessive wear and incorrect calibration.

**Automatic choke** - Check whether corroded or jammed in the on position and correctly adjusted.

**Air cleaner** - Check air intake and air filter housing for debris causing restricted airflow, this will cause a rich Air/fuel mixture, and air filters should be cleaned/checked regularly.
Fuel Pump - Check delivery pressure. If too low or high, renew diaphragm spring or replace Pump, consult your manufacture for correct flow rates.

Excessive idling - To minimise plug fouling when starting the engine, minimise engine idling time when the engine is cold. Excessive idling often results in rich running. Starting and stopping or idling a cold engine will leave carbon deposits on plugs. Motorcycles are very prone to this cause of fouling, as generally they only have 1 or 2 cylinders. Running a cold engine on idle, e.g. coasting downhill can also cause plug fouling.

Fuel Injected engines
These are designed for unleaded as well as leaded fuels and are able to cope much better with changes in fuel properties than carburetted engines because air-fuel ratios are more precisely controlled.
Single point injection systems can still suffer from minor mixture control problems on startup. If air-fuel ratios are set too rich, the engine will display the same rich running symptoms as carburetted cars, however, factory settings are usually reliable

Mixture settings - Adjust air-fuel ratio using exhaust gas analyser.
We have found that use of a properly calibrated exhaust gas analyser (tunescope) is the best way to ensure correct setting of the air-fuel mixture.

2.4 Fuel Quality
If vehicle is a motorcycle or small motor with starting problems, check that fuel is fresh and free of water. If the fuel has been left to vent or stored in an unsealed container, top up with fresh fuel, generally after 3 – 4 weeks fresh fuel will be required in small engines such as lawn mowers, motorcycles.

2.5 Additive
If additives such as upper cylinder lubricants or octane enhancers are being used, ensure that these are yielding a measurable benefit. Some octane boosters contain Ferocene which improves the octane and are not suited to Platinum spark plugs, they cause the plug to turn red and shorten the life of the plug from 100,000km to around 10,000km always seek advice from your manufacture.

2.6 Air intake
Ensure air intake is on winter setting during winter and other cold weather spells. Check that the original inlet temperature regulating system is in place and working properly, especially that the intake ducting leading from the vicinity of the exhaust manifold to air intake is intact.
Operation of the winter setting depends on this ducting being in place. Check that any other forms of warm air or hot water ducting to the fuelling system that were provided for when the engine was new are still in place and in operational order.

2.7 Thermostat
Check that thermostat is in working order. Thermostat valve should remain closed until engine comes up to normal operating temperature. This speeds engine warm up. A quick way to check if it’s working is to touch the top radiator hose with your hand it should be hot then do the same to the bottom hose it should be hot also this is a indication that the system is working once at operating temperature, if one is cold then seek advice from a mechanic.
3. Lubricant and Additive Deposits
Crankcase oil deposits on the spark plugs are a cause of misfire in engines with worn piston rings or valve guides. This can be checked by looking for signs of excessive oil burning. Over use of some aftermarket additives containing heavy residues can also cause plugs to foul. Upper cylinder lubricants and octane boosters are possible examples.

4. Detonation (Pinking)
High compression engines generally require high octane fuel. Pinking usually occurs when ignition timing is over advanced or when the octane number of the fuel is inadequate for the engine. The octane requirement of the engine will increase over time due to carbon and deposit buildup in the combustion chamber. The octane requirement normally varies cyclically as the combustion chamber deposits build up and then flake off. This is why many cars stop pinking after a high speed/high load run. Cars driven by sedate drivers are particularly sensitive to deposit build up and generally respond well to a bit of hard work in the country.

High engine temperatures can also cause pinking or possibly pre-ignition which is much more damaging than pinking. If pinking occurs mainly on long distance journeys or under hot running conditions, check the coolant temperature immediately after a long run. If this is close to boiling point check the temperature at which the thermostat opens. To do this, remove from car and immerse in a container of hot water. Bring to the boil, measuring the temperature with a thermometer. Then check this against the prescribed operating temperature for the thermostat. If the difference is more than a few degrees, fit a new thermostat, perhaps with a lower cut in temperature if available.

Also check the radiator for blockages and operation of the cooling fan. If the head has been removed, check water galleries for blockages and ensure that the replacement head gasket doesn’t restrict coolant flow.

The air/fuel ratio also has an influence on octane requirement; the highest occurring just rich of stoichiometric (chemically correct). Both lean and rich mixtures reduce the peak temperatures in the combustion chamber and so reduce the octane requirement of the engine.

Octane Rating
For various reasons the octane rating of leaded petrol in Australia has been reduced during the last quarter of the 20th century as follows:

- Up to 1979 octane 98 min
- Up to 1994 octane 97 min
- 1994-2004 octane 96 min

Many cars built before 1985 were designed for a 98 or 97 octane fuel and require careful tuning to run on a 96 octane fuel without pinging.

5. Ignition Timing
5.1 Centrifugal and Vacuum Advance
Check elements of these systems such as springs (tensions), vacuum hose (absence of leaks) and diaphragm, and correct operation under part throttle.

Vacuum systems advance the engine under part throttle (partial vacuum) conditions to compensate for slower burning of fuel drawn into the engine under reduced pressure. Over-compensation can result in pinking at low to medium engine speeds before the onset of more damaging high speed knock which might otherwise remain undetected.
5.2 Static Timing
First check distributor points and spark plug electrode gaps as these can affect spark timing. Then check the static ignition timing setting against that recommended by the manufacturer and reset if the engine is currently over advanced. If pinking is still occurring, retard the ignition timing by a further 2° to 6° in accordance with the engine manufacturer’s guidelines. If this does not fix the problem do not retard further.

Over retarding can cause engine overheating and valve burnout. If you use ignition timing markings to set the timing, ensure these are reliable indicators. The workshop manuals for some newer (Japanese) marques discourage the changing of factory timing settings. This advice should not inhibit the use of timing adjustments to fix cars with running problems. If in doubt, check with service department of the manufacturer or importer.

5.3 Electronic Ignition
Cars with electronic ignition can present special problems. Some earlier types allow for manual adjustment of distributor, but those with the timing sensor on the flywheel have no adjustment. Other types allow adjustments to be made through switching devices. If engine timing is in correct than inspect the electronic Ignition system for worn parts such as bushes / shafts on the distributor.

<table>
<thead>
<tr>
<th>RETARDED 5 DEGREES</th>
<th>STANDARD</th>
<th>ADVANCED 5 DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>96</td>
<td>99</td>
</tr>
<tr>
<td>89</td>
<td>95</td>
<td>98</td>
</tr>
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<td>96</td>
</tr>
<tr>
<td>86</td>
<td>92</td>
<td>94</td>
</tr>
<tr>
<td>85.5</td>
<td>91</td>
<td>93</td>
</tr>
</tbody>
</table>

6. Compression Ratio - Modified Cars
Cars whose compression ratio has been increased e.g. reconditioned or “hotted up” cars will have higher octane requirements than their equivalents in original condition. In more extreme cases, machining the combustion chambers, fitment of a replacement head or fitment of a spacer plate (possibly two head gaskets) may be the best solution. For some models, there are low compression pistons available that will either give standard compression in a reconditioned engine or a lower compression to allow the use of regular unleaded.

Aftermarket octane boosters are available but some of these have side effects such as plug fouling or accelerated engine wear. Regard these with caution. Recommended doses should not be exceeded.

Older engines, especially those with cast iron heads, may benefit from a decarb and valve grind after 100 000 to 150 000 km. Before reassembly, inspect the head and new gasket for rough spots and protrusions. These can act as hot spots and promote pre-ignition. Head removal also provides the opportunity for valve grinding or fitting hardened valve seat inserts.

Annex 1 Fuel Specifications
The quality of Western Australian petrol is governed by the West Australian Environment Protection (Diesel & Petrol) regulation of 2001 and by the Australian Fuel Quality Standard ; Petrol (gasoline) for Motor Vehicles. These specifications are made up of 15 to 20 compositional and performance properties and limits that must be met for all petrol retailed in Western Australia.
Australia. Maximum compositional limits apply to benzene (1% mass), aromatics (20 - 48% vol), lead (0.005g/L) and sulphur (0.05% mass).

**Storage stability** is governed by an oxidation stability test that gives the fuel at least three months shelf life after purchase provided the fuel is stored in dry well sealed containers. If necessary, antioxidant additives are added to batches of fuel at the time of manufacture to ensure an adequate shelf life.

Driveability and performance are controlled by **octane** and **volatility** properties. Two octane measurements are made - research octane number (RON) and motor octane number (MON). Both these properties are measured using a laboratory CFR engine against blended standards. RON measures resistance of a fuel to knock at lower engine speeds and under acceleration and MON its resistance to knock at high speeds and high engine temperatures.

The following are typical octane data for BP Petrol fuels quoted to the nearest 0.5 octane unit. The following table summarises some important fuel properties:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>RON typical</th>
<th>MON typical</th>
<th>Air/fuel ratio by mass stoichiometric</th>
<th>Air/fuel ratio by mass maximum power</th>
<th>Highest useful compression ratio *</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP Premium Unleaded</td>
<td>95</td>
<td>85</td>
<td>14.4</td>
<td>12.0</td>
<td>9 - 9.5</td>
</tr>
<tr>
<td>BP Regular Unleaded</td>
<td>91</td>
<td>82</td>
<td>14.7</td>
<td>12.5</td>
<td>8.5 - 9</td>
</tr>
<tr>
<td>BP Ultimate</td>
<td>98</td>
<td>88</td>
<td>14.4</td>
<td>12.0</td>
<td>9.5-10</td>
</tr>
<tr>
<td>BP Regular Unleaded with 10% ethanol (e10)</td>
<td>93</td>
<td>82</td>
<td>14.7</td>
<td>12.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Opal</td>
<td>93</td>
<td>88</td>
<td>14.4</td>
<td>12.0</td>
<td>9.5</td>
</tr>
<tr>
<td>BP 100 Racing Fuel</td>
<td>110</td>
<td>100</td>
<td>15.0</td>
<td>12.9</td>
<td>11.5 - 13</td>
</tr>
</tbody>
</table>

# Approximate compression ratios only - depends on engine design and application.
# Air/fuel ratios will vary slightly with fuel composition.

For further information, please call the BP Lubricants and Fuel Technical Helpline 1300 139 700 local call