Info Sheet

Spark Plugs

The spark plug is the final component in the ignition system and has two primary functions:

- To ignite the air/fuel mixture
- To remove heat from the combustion chamber

It achieves the first of its objectives when the electrical energy from the high-tension side of the coil 'jumps' from the centre electrode to the ground electrode, igniting the fuel/air mixture in the cylinders. This is called the plugs "Electrical Performance".

The plugs "Thermal Performance" is defined by the design of the plug (see Heat Range below) and the efficiency with which it can dissipate combustion heat away from the cylinder head. The plugs do not create heat and their heat range has no relationship to the voltage transferred though the spark plug.

Spark plugs are very reliable in operation and very rarely suffer anything other than normal wear and tear in operation. The nature of the spark plug does mean that its operation is dependant on other systems on the vehicle (ignition) and its performance is susceptible to compromise by general engine condition. A description of these other areas is given on separate information sheets should you wish to study them.

Normal wear and tear is caused by the erosion of the gap between the centre and ground electrodes of the plug. The sparking process removes a tiny bit of material each time and eventually the plug would reach the stage where the electrical energy supplied by the coil was not enough to make the plug spark. The design of the A Series engine means that the plug is fired twice per cycle (as opposed to the more normal once) and this means that our cars are hard on plugs. This process happens very slowly and if everything else is OK with the ignition system and combustion then a set of plugs should easily last until the 3,000-mile service interval.

Problems occur when the plug gap (0.7mm when new) increases to the point where the ignition system can no longer provide enough power to make the plug spark. The gap will be very wide when this occurs (probably well over 1mm) and the problem is more likely to be caused by a weak coil or faulty leads. Other problems are usually the fault of a badly adjusted carburettor or damaged/worn engine components causing the plug to become fouled or damaged and reducing its efficiency.

These problems often manifest themselves as poor starting or running and changing the plugs might mask these problems. If you have to change the plugs before the 3,000 mile service there is something wrong or out of adjustment somewhere else – fix it.

Plug Heat Range

The heat range of the plugs is very important to ensure reliable and smooth engine operation. The heat range is a measure of the plugs ability to transfer heat away from the combustion chamber and this is determined by:

- The insulator nose length
- Gas volume around the insulator nose
- The materials/construction of the center electrode and porcelain insulator

Heat rating and heat flow path of NGK Spark Plugs

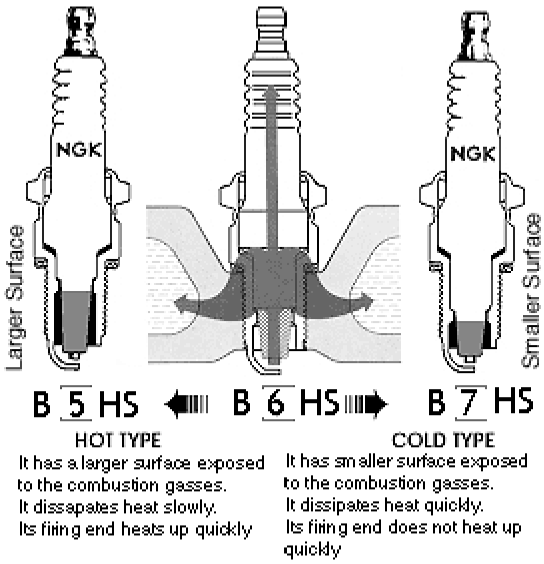


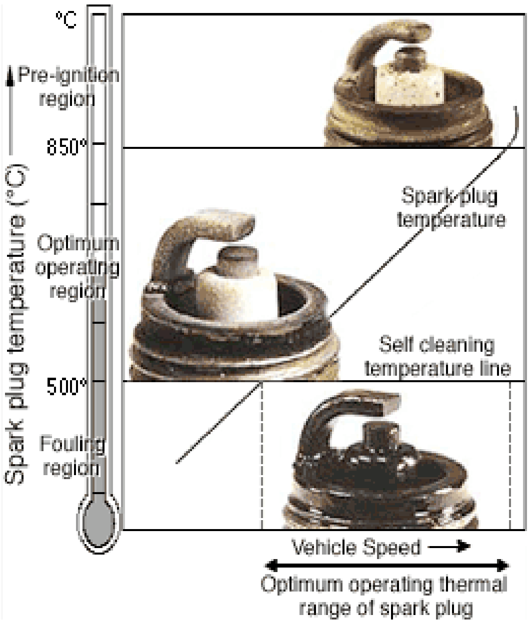
Figure 1

The spark plug tip temperature must remain between 500C-850°C, regardless of the type of engine the plug is fitted in. If the tip temperature is lower than 500°C, the insulator area surrounding the centre electrode will not be hot enough to burn off carbon and combustion chamber deposits. These accumulated deposits can result in spark plug fouling leading to misfire. If the tip temperature is higher than 850°C the spark plug will overheat which may cause the ceramic around the centre electrode to blister and the electrodes to melt. This may lead to pre-ignition/detonation and expensive engine damage. In identical spark plug types, the difference from one heat range to the next is the ability to remove approximately 70°C to 100°C from the combustion chamber. A projected style spark plug firing tip temperature is increased by 10°C to 20°C.

If you refer to figure 1 above you will see a comparison between one plug hotter (B5HS) and one plug colder (B7HS) from the recommended plug for A Series 602cc engines.

Tip Temperature and Firing End Appearance

Spark plugs are the "window" into your engine (your only eyewitness to the combustion chamber), and can be used as a valuable diagnostic tool. Like a patient's thermometer, the spark plug displays symptoms and conditions of the engine's performance. The experienced user can analyse these symptoms to track down the root cause of many problems, or to check air/fuel ratios.



The firing end appearance also depends on the spark plug tip temperature. There are three basic diagnostic criteria for spark plugs: good, fouled and overheated. The borderline between the fouling and optimum operating regions (500°C) is called the spark plug self-cleaning temperature. The temperature at this point is where the accumulated carbon and combustion deposits are burned off.

Below is a list of some of the possible external influences on a spark plug's operating temperatures. The following symptoms or conditions may have an effect on the actual temperature of the spark plug. The spark plug cannot create these conditions, but it must be able to cope with the levels of heat...if not, the performance will suffer and engine damage can occur.

Air/Fuel Mixtures seriously affect engine performance and spark plug operating temperatures.

- Rich air/fuel mixtures cause tip temperature to drop, causing fouling and poor drivability
- Lean air/fuel mixtures cause plug tip and cylinder temperature to increase, resulting in pre-ignition, detonation, and possibly serious spark plug and engine damage

Higher Compression Ratios/Camshaft Changes will elevate spark plug tip and in-cylinder temperatures

- As compression increases, a colder heat range plug, higher fuel octane, and careful attention to ignition timing and air/fuel ratios are necessary. Failure to select a colder spark plug can lead to spark plug/engine damage

Advancing Ignition Timing

- Advancing ignition timing by 10° causes tip temperature to increase by approx. 70°-100° C

Engine Speed and Load

- Increases in firing-end temperature are proportional to engine speed and load. When traveling at a consistent high rate of speed, or carrying/pushing very heavy loads, a colder heat range spark plug should be installed

Ambient Air Temperature

- As air temperature falls, air density/air volume becomes greater, resulting in leaner air/fuel mixtures. This creates higher cylinder pressures/temperatures and causes an increase in the spark plug's tip temperature. So, fuel delivery should be increased.
- As temperature increases, air density decreases, as does intake volume, and fuel delivery should be decreased

Humidity

- As humidity increases, air intake volume decreases
- Result is lower combustion pressures and temperatures, causing a decrease in the spark plug's temperature and a reduction in available power.
- Air/fuel mixture should be leaner, depending upon ambient temperature.

Barometric Pressure/Altitude

- Also affects the spark plug's tip temperature
- The higher the altitude, the lower cylinder pressure becomes. As the cylinder pressure decreases, so does the plug tip temperature
- Many mechanics attempt to "chase" tuning by changing spark plug heat ranges
- The real answer is to adjust jetting or air/fuel mixtures in an effort to put more air back into the engine

Types of Abnormal Combustion

Pre-ignition

- Defined as: ignition of the air/fuel mixture before the pre-set ignition timing mark
- Caused by hot spots in the combustion chamber...can be caused (or amplified) by over advanced timing, too hot a spark plug, low octane fuel, lean air/fuel mixture, too high compression, or insufficient engine cooling
- A change to a higher octane fuel, a colder plug, richer fuel mixture, or lower compression may be in order
- You may also need to retard ignition timing, and check vehicle's cooling system
- Pre-ignition usually leads to detonation; pre-ignition an detonation are two separate events

Detonation

- The spark plug's worst enemy! (Besides fouling)
- Can break insulators or break off ground electrodes
- Pre-ignition most often leads to detonation
- Plug tip temperatures can spike to over 3000°F during the combustion process (in a racing engine)
- Most frequently caused by hot spots in the combustion chamber. Hot spots will allow the air/fuel mixture to pre-ignite. As the piston is being forced upward by mechanical action of the connecting rod, the pre-ignited explosion will try to force the piston downward. If the piston can't go up (because of the force of the premature explosion) and it can't go down (because of the upward motion of the connecting rod), the piston will rattle from side to side. The resulting shock wave causes an audible pinging sound. This is detonation.
- Most of the damage than an engine sustains when "detonating" is from excessive heat
- The spark plug is damaged by both the elevated temperatures and the accompanying shock wave, or concussion

Misfires

- A spark plug is said to have misfired when enough voltage has not been delivered to light off all fuel present in the combustion chamber at the proper moment of the power stroke (a few degrees before top dead center)
- A spark plug can deliver a weak spark (or no spark at all) for a variety of reasons...defective coil, too much compression with incorrect plug gap, dry fouled or wet fouled spark plugs, insufficient ignition timing, etc.
- Slight misfires can cause a loss of performance for obvious reasons (if fuel is not lit, no energy is being created)
- Severe misfires will cause poor fuel economy, poor drivability, and can lead to engine damage

Fouling

- Will occur when spark plug tip temperature is insufficient to burn off carbon, fuel, oil or other deposits
- Will cause spark to leach to metal shell...no spark across plug gap will cause a misfire
- Wet-fouled spark plugs must be changed...spark plugs will not fire
- Dry-fouled spark plugs can sometimes be cleaned by bringing engine up to operating temperature
- Before changing fouled spark plugs, be sure to eliminate root cause of fouling

'Reading' Spark Plugs

Normal Condition
An engine's condition can be judged by the appearance of the spark plugs firing end. If the firing end of a spark plug is brown or light gray, the condition can be judged to be good and the spark plug is functioning optimally.

Dry and Wet Fouling
Although there are many different causes, a dry black deposit as in the top picture usually indicates a rich mixture and/or a failure to get up to self-cleaning temperature. A wet black plug tip usually indicates engine problems such as worn rings or a very badly adjusted carburetor.

Overheating
When a spark plug overheats, deposits that have Accumulated on the insulator tip melt and give the insulator tip a glazed or glossy appearance. Overheating could be the result of too low octane fuel, low oil level, wrong heat range of plugs or very arduous running conditions.

Deposits
The accumulation of deposits on the firing end is influenced by oil leakage, fuel quality and the engine's operating duration.

Lead Fouling
Lead fouling usually appears as yellowish brown deposits on the insulator nose. This can not be detected by a resistance tester at room temperature. Lead compounds combine at different temperatures. Those formed at 370-470°C (700-790°F) having the greatest influence on lead resistance.

Breakage
Breakage is usually caused by thermal expansion and thermal shock due to detonation or sudden heating/cooling

Normal Life
A worn spark plug not only wastes fuel but also strains the whole ignition system because the expanded gap (due to erosion) requires higher voltages. Normal rates of gap growth are as follows:
0.01~0.02 mm/1,000 km

Abnormal Erosion
Abnormal electrode erosion is caused by the effects of corrosion, oxidation and reaction with lead - all resulting in abnormal gap growth.

Melting
Melting is caused by overheating. Mostly, the electrode surface is rather lustrous and uneven. The melting point of nickel alloy is 1,200~1,300°C (2,200~2,400°F).

Erosion, Corrosion and Oxidation
The material of the electrodes has oxidized, and when oxidation is heavy it will be green on the surface.
The surfaces of the electrodes are also fretted and rough.

Lead Erosion
Lead erosion is caused by lead compounds in the fuel which react chemically with the material of the electrodes (nickel alloy) as high temperatures; crystals of nickel alloy fall off because of the lead compounds permeating and separating the grain boundary of the nickel alloy. Typical lead erosion causes the surface of the ground electrode to become thinner, and the tip of the electrode looks as if it has been chipped.