Spark plug gap

Always check that the spark plug gap is compatible with the engine manufacturer’s specification. A gap that is too small means that the spark duration will be very quick and the spark will be thin and weak. The consequences of this may be bad starting and high exhaust emission levels. This will result in an increase in fuel consumption. If the gap is set too large, the ignition system will not be able to cope with the demands and a misfire situation will occur. Some wide gap spark plugs have a longer ground electrode to accommodate a wide gap setting. These must be used where specified, as opening up a standard plug to a wider gap setting may result in the electrodes not running parallel to each other. This could result in abnormal and premature electrode wear.

The re-gapping of fine wire spark plugs that have very small diameter platinum or iridium alloy electrodes is not recommended due to the risk of damaging the electrodes. Virtually all NGK spark plugs are set to the correct gap for the catalogue applications at the point of manufacture.

Firing end appearances:

The appearance of the firing-end of a used spark plug graphically reflects the condition of an engine, the suitability of the spark plug heat range, and whether or not the fuelling and ignition systems are correctly set.

Normal condition: An engine’s condition can be judged by the spark plugs firing end appearance. If the firing end of a spark plug is brown or light grey, the condition can be judged to be good and the spark plug is functioning correctly.

Deposits: The accumulation of deposits on the firing end is influenced by oil leakage, fuel quality and the engines operating period. Deposits come from:

- Fuel: C (carbon), Pb (lead), Br (bromine)
- Lubricating oil: C, CA (calcium), S (sulphur), Ba (barium), Zn (zinc)
- Others: Fe (iron), Si (silicon), Al (aluminium), etc.
- Resistor plugs

Dry and wet fouling: Although there are many different causes, if the insulation resistance between the center electrode and the shell is over 10M ohms, the engine can be started normally. If the insulation resistance drops to 0, the firing end is fouled by either wet or dry carbon.
**Lead fouling:** Lead fouling usually appears as yellowish brown deposits on the insulator nose and this cannot be detected by a resistance tester at room temperature. Lead compounds combine at different temperatures; those formed at 370-420 degrees Celsius having the greatest influence on the resistance.

**Overheating:** After having overheated, the insulator tip is glazed or glossy, and deposits which have accumulated on the insulator tip have melted. Sometimes these deposits have blistered on the insulators tip.

**Breakage:** Breakage is usually caused by thermal shock due to sudden heating or cooling.

**Normal life:** A worn spark plug not only wastes fuel but also strains the whole ignition system because the expanded gap requires higher voltages. Worn spark plugs also reduce the engines efficiency, resulting in reduced fuel economy and increased exhaust emissions. The normal rate of gap growth is about 0.01-0.02mm/1,000 Km for four stroke engines and about 0.02-0.04mm/1,000 Km for two stroke engines.

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

**Abnormal erosion:** Abnormal electrode erosion is caused by the effects of corrosion, oxidation, reaction with lead, all resulting in abnormal gap growth.
**Lead erosion:** Lead erosion is caused by lead compounds in the gasoline which react chemically with the material of the electrodes (nickel alloy) at 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.

**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 degrees Celsius.

**Resistor plugs**

As well as reducing electrical noise for radio, television and mobile telephones etc., many modern ignition systems require resistor plugs to stop electrical noise from interfering with the vehicle’s on-board electronic control units (ECUs). Resistor spark plugs should always be fitted where specified.

NGK automotive resistor spark plugs contain a ceramic monolithic resistor. The resistor filters out excessive electrical noise generated by the ignition system. The most effective place to situate a resistor in the high tension circuit is as close to the spark plug as possible making the spark plug an ideal place to house the resistor.

In nearly all cases — apart from some very old low output ignition systems — resistor spark plugs can be used in place of the non-resistor versions with no detrimental effect on engine performance, power output or vehicle emissions.

**Tightening torque**

Check condition and cleanliness of threads in cylinder head, ensure plug is gapped according to vehicle manufacturer’s specification. Multi ground electrode and precious metal plugs should not be re-gapped (visual inspection only). Install new spark plug by hand until it seats (a length of rubber tubing pushed over the insulator can be a useful aid for plug installation where access is difficult). Tighten to specified torque setting as shown in the chart below.

If a torque wrench is unavailable then refer to vehicle/engine manufacturer’s installation instructions or the tightening angle advice which is displayed on current NGK packaging (excluding specialist race plugs). Note that this angle advice can differ between part numbers due to individual
spark plug design (e.g. seating type, thread diameter and gasket material).

It is important not to over or under tighten spark plugs during installation. Over tightening can lead to distortion of the spark plug. Under-tightening can cause overheating due to poor heat dissipation. In extreme cases incorrect tightening can cause spark plug breakage and/or engine damage.

NGK does not recommend the application of lubricant to spark plug threads as the resultant reduction of frictional forces at the thread faces will render the torque charts inaccurate and over tightening could occur.

If a gasket type spark plug is re-installed, it should only require a further 1/12 of a turn after it has been seated. Always carefully use the correct tools for removal/installation to prevent damage to the spark plug or engine. Inspect spark plug cover and renew if necessary.

### Corona Stain

A brown stain – often mistaken for gas leakage – is sometimes observed in a ring around where the insulator joins the metal shell of the spark plug. This discolouration is generally called Corona Stain and is the result of oil particles present in the air around the engine adhering to the insulator surface.

The Corona Stain is often seen on spark plugs that are installed deep into the engine such as on many four valves per cylinder engine applications. This is because oil particles are not blown away by air circulating around the engine compartment and thus adhere to the insulator surface. It is important to understand that Corona Stain causes no deterioration to the function of the spark plug.

### Fouling range

As a by-product of combustion, carbon will become deposited on components within the combustion chamber including the spark plug. Excessive carbon deposits on the plug can cause a misfire due to deterioration of spark quality. When the spark plug reaches a certain temperature it will start to burn off the carbon and enter a self-cleaning region.
Fouling will occur if plugs are operating at lower than the self-cleaning temperature of 400 degrees Celsius – 450 degrees Celsius (750 degrees Fahrenheit – 850 degrees Fahrenheit) or Air-fuel mixture richer than 8:1 to 10:1.

This can be seen as: Wet Fuel Fouled – Wet Black Deposit, The firing-end of the spark plug becomes saturated with fuel and its insulation ability deteriorates and misfiring occurs.

Recommendaion:
Check for rich air/fuel mixture. Check the entire ignition system. If condition recurs, engine overhaul may be necessary.

**Carbon Fouled**

**Black Carbon Fouling:** Carbon accumulates in large quantity and, while the firing-end of the plug is dry, its insulation is abnormally decreased. This, too, is regarded as a prime cause of misfiring.

Recommendaion:
Check for rich air/fuel mixture. Check the entire ignition system and cooling system (excessive cooling).

**Causes of carbon fouling:**
- Fuel mixture too rich
- Excessive use of choke
- Blocked air filter
- Incorrect spark plug gap setting
- Over-retarded ignition timing
- Compression loss due to imperfect cylinder-piston seal or valve seating
- Prolonged low speed driving or idling
- Too cold a spark plug fitted

Oil Fouled: When the firing end of a spark plug is fouled by oil, an electrical leakage path is formed and the insulation deteriorates, consequently the available voltage from the ignition system is lowered and a spark cannot jump at the spark gap.

Causes of oil fouling:
- Lubricating oil entering into combustion chamber

**Spark plug tip temperature**

![Spark plug tip temperature diagram]
Pre-ignition range

Pre-ignition is a condition whereby combustion is initiated within the combustion chamber before the spark occurs at the plug. This results in uncontrolled ignition and combustion conditions.

If a spark plug operates at a temperature in excess of 1000 degrees Celsius for a prolonged period the electrodes can start to overheat. When excessively overheated, pre-ignition can occur, the electrodes and insulator tip may melt and piston damage may result.

Pre-ignition is usually caused by a temperature exceeding 850 degrees Celsius – 1000 degrees Celsius (1600 degrees Fahrenheit – 1800 degrees Fahrenheit)

Causes of overheating:

- Over-advanced ignition timing
- Too lean fuel mixture
- Excessive deposits accumulated in combustion chamber
- Insufficient cooling
- Insufficient spark plug tightening or failure to fit gasket
- Too low octane gasoline
- Too hot a spark plug fitted

Overheated: The plug has been subjected to a relatively heavy load and evidence of overheating can be seen in the oxidized electrodes and melted deposits which have formed on the insulator surface.

Recommendation: Check for over-advanced ignition timing and too lean fuel mixture. Check spark plug tightening and gasket. If conditions recur, use plug one step colder in heat range.

Melted: Overheated plug with melted electrodes and blistered ceramic insulator surface.

Recommendation: Check for over-advanced ignition timing and too lean fuel mixture. Check spark plug tightening and gasket. If conditions recur, use plug one step colder in heat range.

Worn Spark Plug: A worn spark plug not only wastes fuel but also loads the whole ignition system because the expanded gap requires higher voltage. As a result, a worn spark plug may also cause engine damage and increased exhaust emissions.

Recommendation: Spark plugs should be replaced.

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

Recommendation: Check for excessive amounts of lubricating oil entering into the combustion chamber. High quality oil should be used.
Alternative Electrode Designs

Why have spark plugs with multiple ground electrodes?

Every time the plug sparks, minute particles of material are worn away from the electrodes. This phenomenon is called spark erosion. This continuous process over time increases the spark plug gap between the centre and the ground electrode. If the gap becomes too large, misfiring will occur.

In order to extend the service interval of vehicles, the service life of the spark plug must be increased. Some manufacturers are fitting multi electrode spark plugs as original equipment to achieve this. Multi electrode spark plugs can have two, three or four ground electrodes depending on the service life requirement of the manufacturer.

Do multi ground electrode spark plugs provide simultaneous sparks to each ground electrode every time the plug sparks?

No. No matter how many ground electrodes the plug has, every time the spark plug fires, only one spark occurs between the centre electrode and the ground electrode which has the lowest required voltage or the least distance to travel between the centre and the ground electrode.

What are fine wire plugs?

The spark plug plays a vital role in the quest to improve ignition quality, engine performance, reduce emissions and reduce fuel consumption. Spark plugs that employ small diameter centre and sometimes ground electrodes can offer benefits in several areas. These fine wire plugs require less voltage to create the spark, have a more consistent spark position, better gas flow around the firing position and experience less quench effect than other designs. As the electrodes erode during use we need to compensate for the use of smaller electrodes by some means otherwise the plugs would have an unacceptable service life.

Increasing the service life

By using small chips of special precious metals such as platinum or even iridium which are welded to the tips of the electrodes we can increase the service life significantly whilst maintaining the highest ignition performance. These metals are extremely hard and have very high melting points thus making them ideal for use in this hostile environment.
What is an NGK Hybrid plug?

Some modern vehicles use a direct fuel injection system and these vehicles demand high ignition quality and extreme anti-fouling performance. NGK has developed a plug that has several special features designed to offer the required performance. Essentially a very projected fine wire spark plug with platinum electrodes is combined with a semi-surface discharge design. The resulting plug has three ground electrodes, two of which are mostly redundant unless in extreme circumstances the plug becomes very carbon fouled. At this point the spark will discharge across the insulator nose to one of the side electrodes preventing a misfire and unburned fuel reaching the catalyst. This type of plug must only be used in the specific applications as listed in the NGK catalogues.