Guide to reading a spark plug

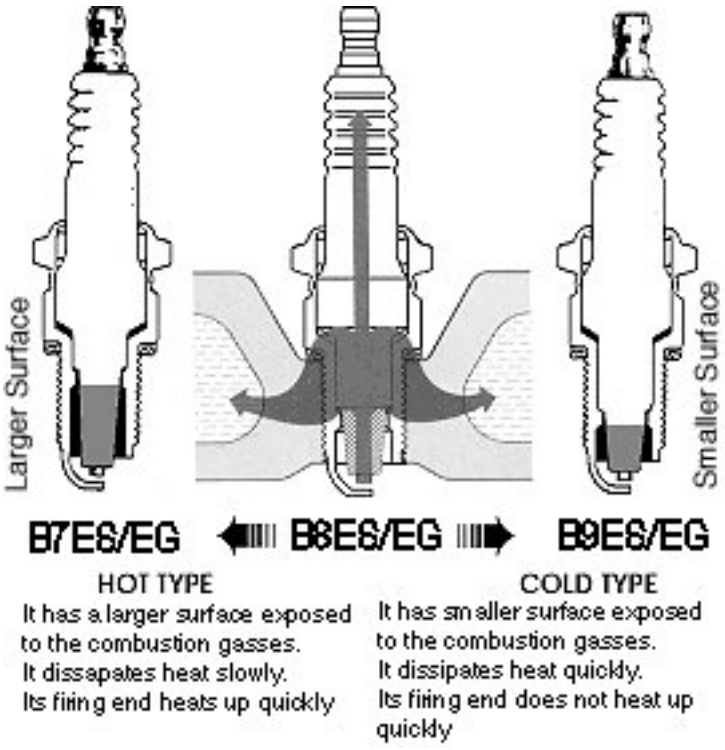
Lambretta Plugs	Std Machine - Town use	Std Machine - Motorway Tuned Machine - Town Use	Tuned Machine - Motorway
NGK	B7ES	B8ES / B8EG	B9EG
Champion	N4	N3	N2

Learning how to read a spark plugs is probably one of the most important factors in gaining an inside view as to how your engine is performing. Reading your plug can be used as a valuable diagnostic tool, as the spark plug displays symptoms and conditions of the engine's performance. With experience you can analyse these symptoms to track down the root cause of many problems, or to determine air/fuel ratios, I.E. correct jetting

Spark Plug Basics, How they Work:

The spark plug has two primary functions:

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



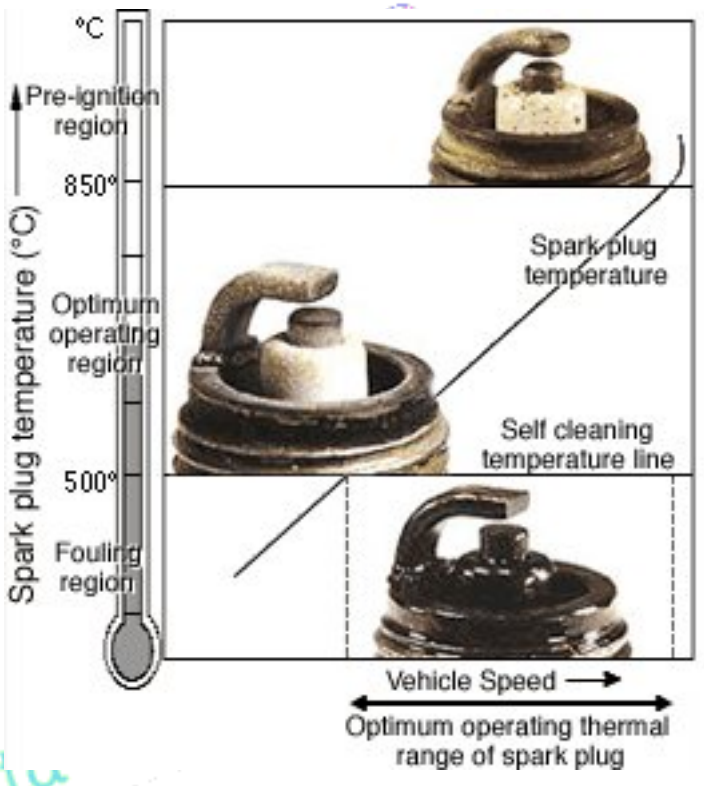
Spark plugs transmit electrical energy that turns fuel into working energy. A sufficient amount of voltage must be supplied by the ignition system to cause it to spark across the spark plug's gap. This is called "Electrical Performance."

The temperature of the spark plug's firing end must be kept low enough to prevent pre-ignition, but high enough to prevent fouling. This is called "Thermal Performance", and is determined by the heat range selected.
It is important to remember that spark plugs do not create heat, they can only remove heat. The spark plug works as a heat exchanger by pulling unwanted thermal energy away from the combustion chamber, and transferring the heat to the engine's cylinder head. The heat range is defined as a plug's ability to dissipate heat.

The rate of heat transfer is determined by; The insulator nose length, gas volume around the insulator nose, the materials/construction of the center electrode and porcelain insulator.

A spark plug's heat range has no relationship to the actual voltage transferred though the spark plug. Rather, the heat range is a measure of the spark plug's ability to remove heat from the combustion chamber. The heat range measurement is determined by several factors; the length of the ceramic center insulator nose and its' ability to absorb and transfer combustion heat, the material composition of the insulator and center electrode material.

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&def; 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.



Bearing in mind that the insulator nose length is a determining factor in the heat range of a spark plug, the longer the insulator nose, the less heat is absorbed, and the further the heat must travel into the cylinder head. This means the plug has a higher internal temperature, and is said to be a hot plug. A hot spark plug maintains a higher internal operating temperature to burn off oil and carbon deposits, and has no relationship to spark quality or intensity. A hot plug is normally used for shorter journeys on standard type machines

Conversely, a cold spark plug has a shorter insulator nose and absorbs more combustion chamber heat. This heat travels a shorter distance, and allows the plug to operate at a lower internal temperature. A colder heat range is necessary when the engine is modified for performance, subjected to heavy loads, or is run at high rpms for a significant period of time. The colder type removes heat more quickly, and will reduce the chance of pre-ignition/ detonation and melting or damage to the firing end. (Engine temperature can affect the spark plug's operating temperature, but not the spark plugs heat range). A colder plug needs to be used on longer journeys, and tuned machines.

Reading The Plug, Possible Causes

Fouled Plug

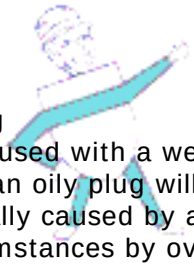
Wet fouled plugs are normally caused by rich air/fuel mixtures, these must be changed as the plug will not operate. The richness is more comonly caused by jetting, but can also be caused by an incorrect fuel to oil ratio. Fouled plugs can also be caused by selecting to colder grade in spark plug

which will not allow the plug to burn the mixture efficently. 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. Running rich can also be caused by a number of other factors, Change in Ambient air conditions, altitude, humidity

To Hot

If when reading your speak plug and it is shown to be running to hot, the reason behined it is probably a major cause of most holed pistons, seizeures and other general problems. Running to hot can be caused by quite a number of things, but the main problem is once your plug shows signs of this, it is normally to late and some damage has already occured. The reason for reading the plug is to stop it happening again! To hot of grade selected for type of journey / use, speed and or load. Lean air/fuel mixtures. Ignition timing to advanced. To high compression ratio. Change in Ambient air conditions, altitude, humidity.



Oily Plug

An oily plug can sometimes be confused with a wet plug, a wet plug will be smooth, where as an oily plug will have small deposits on it. Oily plugs are normally caused by a leaking drive side oil seal, or in some circumstances by over oiling on the fuel to oil ratio.

How it should be

This is how you want your spark plug to look like after a plug chop, or journey. It shows a nice chocolate brown colour indicating your Lambretta is operating as it should be.

The biggest problem with reading a plug is although you may well determine that your scooter is running rich, or to hot etc, but the real trick is why. Take the example of running to high a compression. This may not always be the simple compression ration of the combustion chamber in the cylinder head. As compression is raised, more performance is gained, but you then need to be more critical on ignition timing, type of fuel used, heat rating of spark plug etc. So although the compression maybe high, if you compensate with some or all of the methods just mentioned then there will be less chance of problems.

Another major factor of adjusting fuel / oil ratios that many people forget, or over look is oil ratio pre mixed with the fuel. By adding more oil, you in fact not running safer and gaining more lubrication, but in fact you are running leaner and run a much greater risk of problems.

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 driveability
- 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
- It is important to read spark plugs many times during the tuning process to achieve the optimum air/ fuel mixture, this is where there term plug chops comes from.

Higher Compression Ratios, Differing Air Induction will elevate spark plug tip and in-cylinder temperatures

- Compression can be increased by performing any one of the following modifications:
- reducing combustion chamber volume (i.e.: domed pistons, smaller chamber heads, mill ing heads, etc.)
- Vaslty improving air intake, ie remote filter, no filter, air box modifications.
- 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

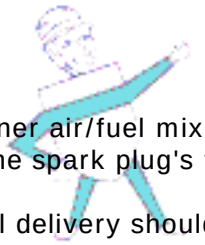
Advancing Ignition Timing

- Advancing ignition timing although gives more performance, dramatically increase working temprature.

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 tem-perature 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 temperature de-creases, 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 en-gine

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
- 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 2000°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 mo-tion 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 be-ing created)
- Severe misfires will cause poor fuel economy, poor driveability, 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