NGK Spark Plugs (USA), Inc. • 46929 Magellan Drive • Wixom, MI 48393

Racing Spark Plugs For Performance Applications

NGK Spark Plugs technical support staff receives numerous technical calls concerning automotive racing applications. Many of these calls reveal racers have installed incorrect spark plugs and engines are inaccurately tuned.

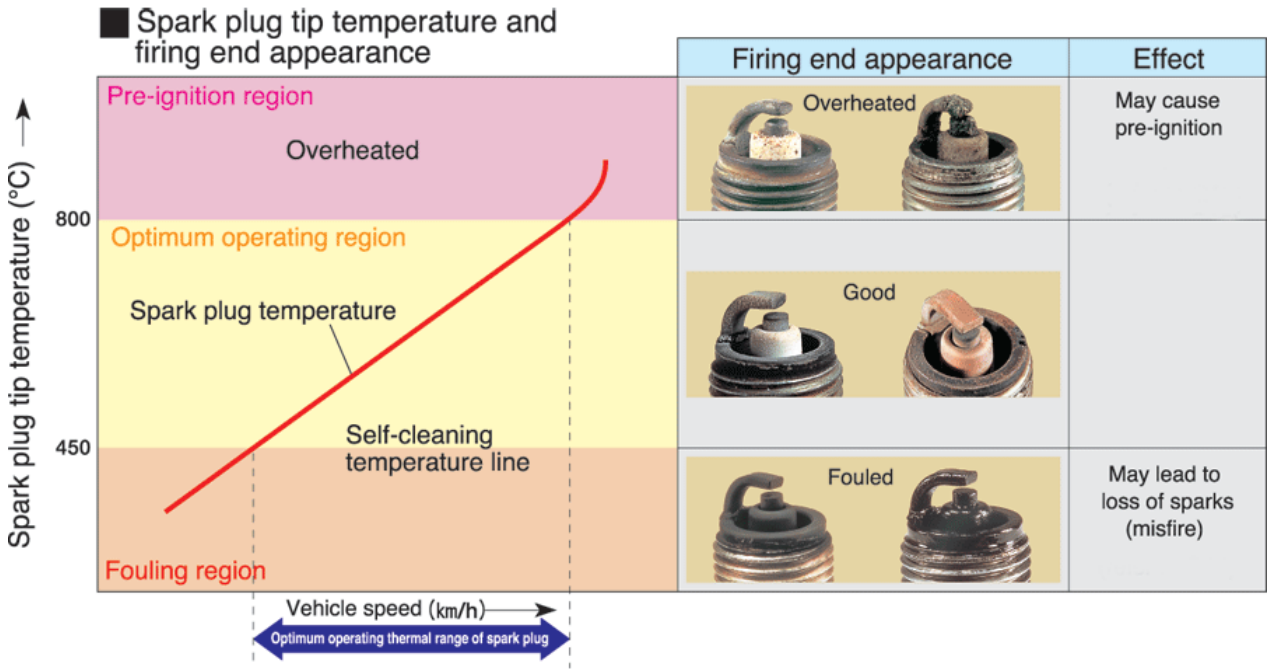
Planning Ahead:

Properly building and tuning your race engine for optimum performance is essential. Similar to a finely tuned instrument, engine components need to work simultaneously in order to build maximum horsepower. Racers often spend less time planning and more time installing various parts with expectations they will work. Taking your time to plan ahead will save time, money and hours of aggravation.

Contact reputable parts manufacturers, engine builders and tuners when building your race engine. Highly trained engine builders and tuners should be able to provide references.

Understanding Spark Plugs:

The spark plug has two functions; one is to ignite the air/fuel mixture and the other is to transfer heat from the combustion chamber. Spark Plug heat range is selected through a series of pre-ignition tests. Thermal couple spark plugs are used to record internal center electrode and ground electrode tip temperatures. Optimum firing end temperatures must fall between 500ºC to 800ºC. If the tip temperature falls below 450ºC the spark plug is considered to be in the fouling region. This means the tip temperature isn't hot enough to burn off carbon deposits. If the tip temperature rise's above 800ºC the spark plug tip temperature is too hot and the spark plug is considered to be in the pre-ignition region. Pre-ignition is detrimental to an engine and can ultimately lead to spark plug failure and extensive engine damage.

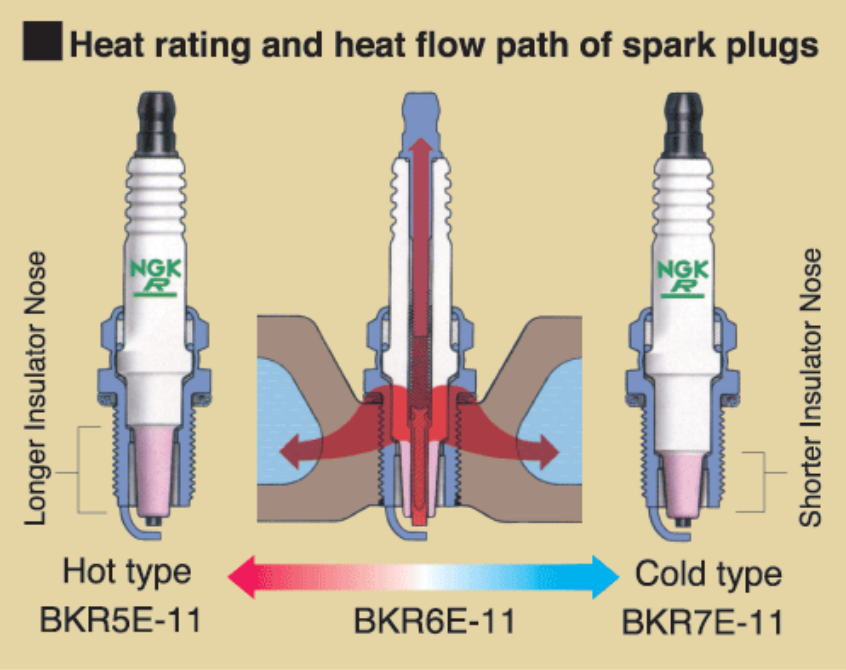


(Figure 1)

Hotter verses Colder Spark Plugs:

A spark plug must dissipate heat produced by compression and combustion gases. The heat rating is a measure of the amount of heat dissipation. Since race engines generally have higher compression ratios, the engine inherently generates more heat in the combustion chamber. This heat must be transferred out of the combustion chamber through the spark plug and into the cylinder head cooling passages.

It's commonly thought a hotter spark plug means hotter spark and cooler spark plug means cooler spark. The spark plug is dependent on the ignition system in order to fire. High energy ignition systems can increase firing end temperature however this has nothing to do with the spark plugs ability to transfer heat. While fine wire spark plugs ignite better than standard nickel alloy designs, the spark plugs heat rating remains the same based on the insulator design. Figure 2 shows the difference between cold and hot insulator designs.



(Figure 2)

Factors Affecting Spark Plug Design:

Engine Size & Cylinder Dimensions:

- Engine size affects the engine's temperature. (Knocking/Detonation is also a consideration)
- Affect on Spark Plug: Size, Heat Rating, Life, Gap Size, Gap Projection, Ground Electrode Type (avoid overheating and protect against severe vibration)

Piston Dimensions and Valve Configuration:

- Main considerations are the maximum clearance, and the combustibility of the mixture (its swirl characteristics and homogeny (i.e. how well it's mixed))
- Affect on Spark Plug: Size, Gap Projection, Ground Electrode Type, Indexed Plugs and other designs features affecting ignitability performance

Fuel Delivery System:

- Delivery (Carburetor, EFI etc.) affects fuel mixture's average ratio, density, homogeny (i.e. how easily, how fast and how complete the mixture will combust)

Affect on Spark Plug: Firing End Design:

Some Examples:

- Fine Centre Electrode, Projected or Larger Gap for improved ignitability performance
- Surface discharge for improved anti-fouling performance
- Extended Metal Shell type to protect insulator nose from Thermal Shock

Aspiration (Normal, Turbo, Supercharged):

- Pushing more air in the chamber, means more fuel can be injected, resulting in increased density
- Turbo and Supercharged engines generally run at higher pressures and temperatures

Affect on Spark Plugs:

- Required voltage to form a spark at the gap is directly proportional to pressure. A smaller gap may be required to avoid misfire or flashover
- Sufficient clearance required from insulator nose to metal shell to avoid side-sparking
- Plugs for Turbo & Supercharged engines are designed to survive High Speed/RPM as well as low speed conditions
- High Speed/RPM: Plugs require resistance to: overheating (heat rating), thermal shock (insulator exposure), pre-ignition, ground electrode overheating and /or breakage (electrode's shape, material, thickness, length)
- Low Speed or Traffic Jams: Good anti-fouling performance (two-stepped center electrode, hybrid plug)

Ignition System:

- Distributor (one coil), Direct Ignition (one coil per two plugs) or Coil on Plug (one coil per plug)
- At high rpm, less charge time is afforded to the coil, which results in reduced "available voltage"

Affect on Spark Plug Firing End Designs:

- Required Voltage: If the "required voltage" to form a spark is greater than the "available voltage" from the ignition system, misfire will occur. Better ignition systems ensure consistency in available voltage across wider rpm range
- Service Life: electrode wear is proportional to number of sparks and to coil energy.

Fuels:

- Unleaded, LPG, Methanol, Octane Rating etc

Affect on Spark Plugs:

- Spark Gap: Different fuels require different spark voltages
- Plating: Some fuels require special plating on the plugs
- Heat Rating: Some fuels burn hotter than others, raising average temperature in cylinder

Economy & Emissions:

- Vehicles are running leaner and more efficiently in order to reduce emissions and fuel consumption
- Lean mixtures (1) Are difficult to ignite and combust, and (2) Elevate cylinder temperature

Affect on Spark Plugs

- Plug must be designed with High Ignitability (fine center electrodes, projected, wide gap)
- Thermal Shock, Pre-ignition and overheating must be avoided

Spark Plugs Expectations:

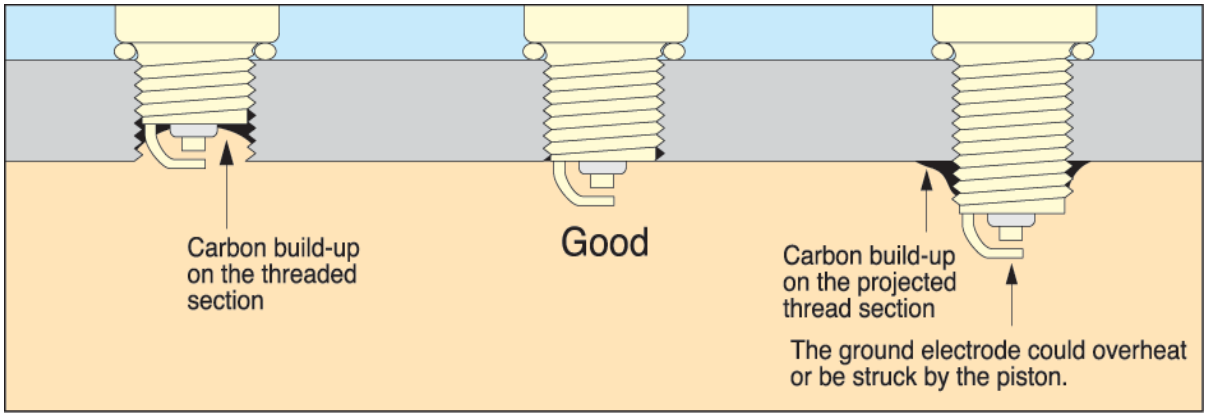
- Excellent Ignitability Performance
- Low Required Voltage & High Electrical Insulation
- Durability and Longevity
- **Low Temperature Performance**:
  - Self-Cleaning
  - Built-in Anti-Fouling Mechanisms
- **High Temperature Performance**:
  - Electrode Oxidization, Pre-Ignition
  - Thermal Shock
- Mechanical Strength and Vibration Resistance
- EMI Suppression

Spark Plugs Selection:

STEP #1:

Cylinder head design is essential when selecting spark plugs for racing applications. Our technical department first needs to know the engine make, model and year. It's pertinent we know if you're using the original equipment cylinder heads or aftermarket cylinder heads. This information helps determine the following.

- Seat Design Gasket/Tapered
- Thread Diameter
- Thread Reach
- Hex Size

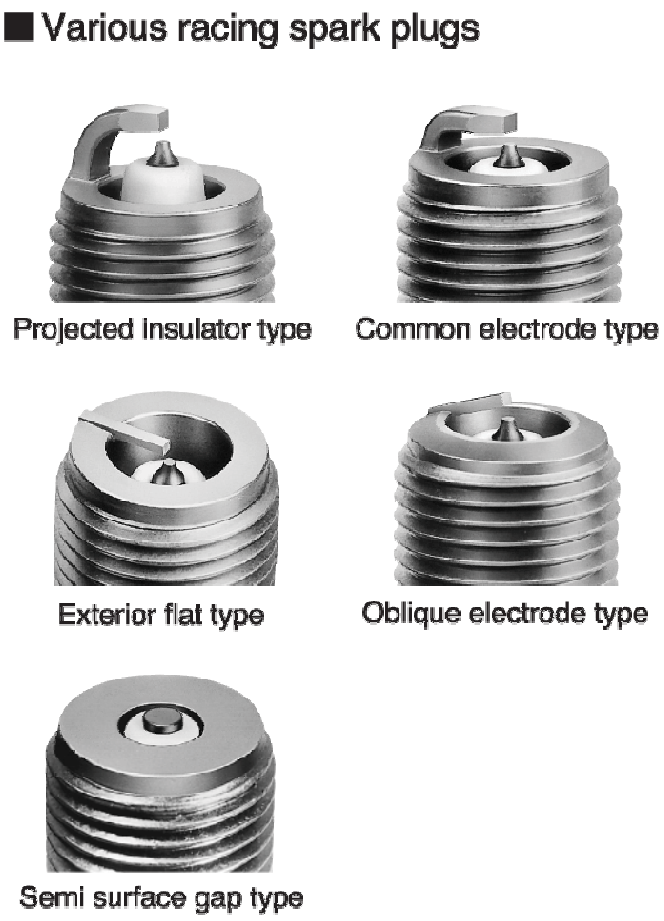


(Figure 3)

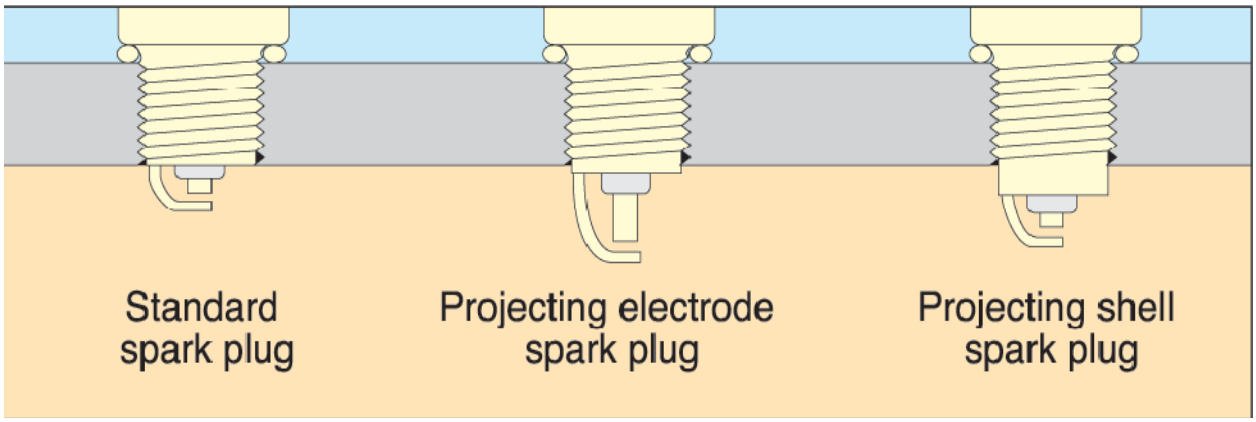
STEP #2:

Step two helps us determine center electrode - ground electrode configurations and whether a projected or non-projected insulator design should be utilized.

- Compression Ratio
- Piston design – flat top or domed
- Bore Size
- Cylinder Heads – shaved, ported, polished, valve size and cc's
- Cam Size – lift and duration
- Turbo, Super Charged, Blown – How much boost?
- Nitrous – How much? Dry or wet system?
- Street Driven – Track or both



(Figure 4)



(Figure 5)

STEP #3:

We've been able to determine thread diameter, thread reach, hex size, ground electrode / center electrode configurations and projected verses non-projected insulators. With this information we can now assist in heat range selection. The factors affecting heat range are as follows.

- Engine Size, Cylinder Dimensions, Compression
- Piston Dimensions and Valve Configurations
- Fuel Delivery
- Aspiration
- Ignition System
- Fuel Type – Race Fuel, Methanol, Ethanol

Tuning:

Now that we've selected a spark plug design for your application it's important to remember this is only a recommendation. It's now up to you the tuner to adjust the air/fuel ratio and timing to the spark plug. We highly recommend purchasing a Powerdex AFX Air/Fuel monitoring system to help assist you in the tuning process. Correct air/fuel means optimum performance, reliability and less chance of spark plug fouling.

Technical Assistants:

We've discovered a large number of consumers rely on information provided by way of tech forums. While tech forums can be useful tools, a lot of erroneous information is written in these forums. Who knows their product better than the manufacturer? Many manufacturers including NGK Spark Plugs have technical hot lines available and they should be utilized.

We can't emphasize enough the importance of planning and selecting the correct parts. Whether you're building an engine, transmission, differential or chassis making sure everything works together is essential.

Understanding the fundamentals of tuning requires an understanding of how each component works and how they concurrently work together. Knowing the function of each part and how they work together will help in the tuning process.

Racing engines are available in many designs and configurations. When contacting our technical department, ensure you have all pertinent information with you. Provide as much information so we can find the best suited part for your application. Our technical department can only provide a starting point based on information you've provided.

For more information regarding spark plugs for your race vehicle contact our technical department at (877) 473-6767 option #2 or visit us at www.ngksparkplugs.com.