SPARK PLUGS

Part 2 – Heat Range

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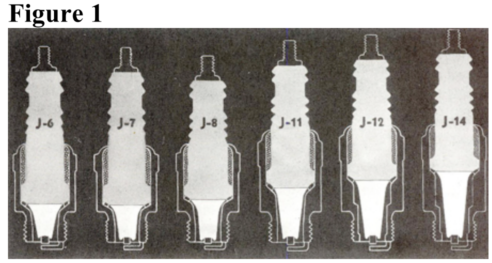
In Part 1 I discussed the basic features and design of spark plugs. In this part I focus on plug operating characteristics and selecting the right heat range of the spark plug for your car. The manufacturer's recommended plug is a good place to begin. Their recommendation is based on typical use of automobiles, that is a mix of stop and go use and some long distance driving. However, the use of many collector cars usually does not match that driving pattern and engines used for racing surely doesn't. I will not discuss selecting plugs for race purposes.

Heat Range Basics

The terms "hot" and "cold" when used in reference to spark plugs are often a source of confusion. The terms actually refer to the heat rating or thermal characteristics of the plug and more specifically to its ability to transfer heat from the firing end to the engine's combustion chamber.

The length of the core nose and electrode alloy material are the primary determinants of a plug's heat range. Refer to Figure 1. Cold plugs (those on the left in Figure 1) have shorter nose lengths and thus transfer heat more rapidly to the shell and the engine head. Conversely, hot plugs have long insulator noses (those on the right in Figure 1) which retain heat longer.

Figure 1



To perform efficiently, spark plugs need to operate within a range from about 700 degrees F to about 1600 degrees F. If the tip of the spark plug exceeds 1600 degrees F, preignition is likely to occur. On the other hand, if the temperature dips below 700 degrees, than the plug tip will not be hot enough to burn off carbon and any oil residue. That is why owner's manuals used to suggest an occasional highway drive if normal use did not include it to bring the plug temperature high enough to burn off these residues.

Combustion chamber temperatures are affected by many factors. Compression ratio and operating speed are primary factors. An engine with a compression ratio in the 7 to 8:1 range might have combustion chamber temperatures as follows: at idle – 550 to 1050 degrees f, at cruising speed 750 to 1450 degrees F, and at full load and speed 1050 to 1600 degrees F.

If the plugs operate mostly in the lower temperature range through limited use at highway speeds, they will foul. As the deposits accumulate on the plugs, these deposits will heat up rapidly during acceleration, increasing conductivity, and thereby, shorting out the plug which causes misfiring. Obviously, the ideal spark plug will be hot enough to prevent fouling at low speeds, yet cold enough to be free of preignition at full speed and load. No such plug exists. Therefore, engine manufacturers select the best possible compromise for a given engine and a set of assumptions about the "typical" owner's use.

Changes in System Designs

Over the years, spark plug manufacturers have made several changes in plug design to assist in combating normal plug problems. The use of a tapered seat instead of a gasket was one of these modifications. This helps heat transfer from the plug to the head. Another design change was to lengthen the plug nose and electrodes deeper into the combustion chamber. This change was intended for overhead valve engine designs. It takes advantage of the cooling effect of the incoming fuel/air charge at high speed to lower the plug's tip and electrodes. These changes enabled use of a slightly hotter plug to combat low temperature fouling and yet not overheat at full load, high speed operation. Another design modification was a booster gap in the center electrode (note: this gap is concealed by the insulator) which isolates the ignition coil from the short-circuiting effects of carbon and oil deposits.

With the increase in compression ratios, it was necessary to increase the voltage to obtain efficient ignition. This requirement was one of the many factors leading to the industry switching from 6 volts to 12 volts. The need for more firing power was provided by high energy ignition systems that came into use in the 1970s. With extra voltage, plugs were widened leading to better combustion. And, use of better metals and metal alloys, like platinum, enhanced electrode durability.

Getting the Right Plug

The best place to begin is with the manufacturer's recommended spark plug. Lots of engineering time was spent determining this best compromise. After a new set of the recommended plugs have been used for a period of time, they need to be removed and examined. This examination is best conducted using a bright light and a magnifying glass.

Figure 2 shows the plug tip of a plug of the correct heat range used in mixed periods of high speed and low speed operating conditions. There are slight powdery deposits ranging from brown to grayish tan on the plug nose. The electrodes may have rounded edges from the erosion caused by plug sparking. If the deposits are white to yellow, that indicates prolonged usage at high speeds.

Figure 2

Figure 2 - Normal Spark Plug

Figure 3 shows a plug with dry, black fluffy deposits resulting from incomplete combustion. Too rich an air-fuel mixture, excessive use of the hand choke or sticking automatic choke can create this result as can a defective coil, breaker points, or poor spark plug wires. Also, excessive idling, slow speed use, or stop-and-go driving can keep the plug temperatures so low that the normal combustion products are not burned off.

Figure 3

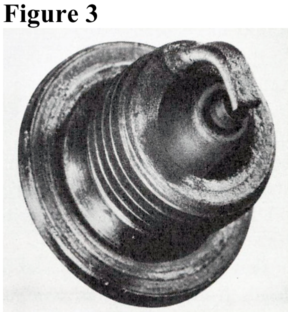


Figure 3 - Fuel-Fouled Spark Plug

Figure 4 shows a plug with wet, sludgy deposits indicating oil fouling. This condition is the result of excessive oil entering the combustion chamber through worn piston rings or loose valve guides.

Figure 4

Figure 4 - Oil-Fouled Spark Plug

Figure 5 is the result from a plug that is too hot — it has a white, burned off, and blistered nose and badly eroded electrodes. Insufficient engine cooling and improper ignition timing are typically causes.

Figure 5

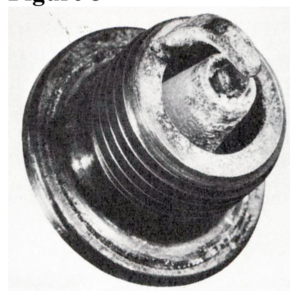


Figure 5 - Overheated Spark Plug

Examine all plugs. Differences between them can be revealing. If only one or a few plugs are oil fouled, it is indicative of excessive oil in only those cylinders. Similarly, if some are normal and others are fuel fouled (Figure 5), sticking valves may be the problem with those that are fouled.

Obviously, all improper conditions, other than the plug, should be fixed before focusing on the spark plugs. A condition I often encounter with collector cars is fuel-fouled plugs, the result of limited driving. This condition can be corrected by a hotter plug. A hotter plug can also be temporary fix for oil-fouled plugs. Spark plug manufacturers provide heat range charts that indicate the heat range of the plugs it supplies.

When changing to a hotter plug, it is best to increase the heat range in steps so that overheating the plug does not result. Also, if hotter plugs are installed and a long trip at highway speeds is contemplated, the original heat range plugs should be reinstalled before the trip.

Continuation

In the final segment in this series on spark plugs I will address the recommended steps involved in spark plug maintenance.