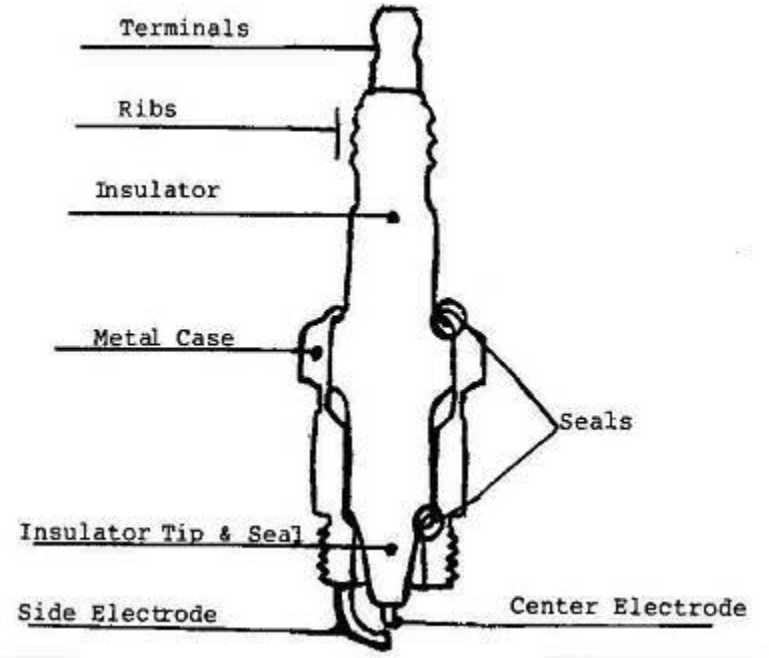
SPARK PLUG CONSTRUCTION



A spark plug is composed of a shell, insulator and the conductor. It pierces the wall of the combustion chamber and therefore must also seal the combustion chamber against high pressures and temperatures, without deteriorating over long periods of time and extended use.

Parts of the plug

Terminal

The top of the spark plug contains a terminal to connect to the ignition system. The exact terminal construction varies depending on the use of the spark plug. Most passenger car spark plug wires snap onto the terminal of the plug, but some wires have spade connectors which are fastened onto the plug under a nut. Plugs which are used for these applications often have the end of the terminal serve a double purpose as the nut on a thin threaded shaft so that they can be used for either type of connection.

Ribs

The physical shape of the ribs function to improve the insulator and prevent electrical energy from leaking from the terminal to the metal case along the side of the insulator. The disrupted and longer path makes the electricity encounter more resistance along the surface of the spark plug.

Insulator

The insulator is typically made from an aluminium oxide[[10]] ceramic[[11]] as is designed to withstand 550° C and 60,000 V. It extends from the metal case into the combustion chamber. The exact composition and length of the insulator partly determines the heat range of the plug.

Seals

As the spark plug also seals the combustion chamber of the engine when installed, the seals ensure there is no leakage from the combustion chamber. The seals are generally made of copper in the form of washer so that it can get compressed to give a good seal.

Metal case

The metal case of the spark plug bears the torque of tightening the plug, serves to remove heat from the insulator and pass it on to the cylinder head. It also acts as the ground for the sparks passing through the center electrode to the side electrode to body.

Insulator tip

The tip of the insulator surrounding the center electrode is within the combustion chamber and directly affects the spark plug performance, particularly the heat range.

Side electrode, or ground electrode

The side electrode is made from high nickel steel and is welded to the side of the metal case. The side electrode also runs very hot, especially on projected nose plugs. Some spark plug designs use multiple side electrodes that do not overlap the center electrode.

Center electrode

The center electrode is connected to the terminal through an internal wire and commonly a ceramic series resistance to reduce emission of radio noise from the sparking. The tip can be made of a combination of copper[[12]], nickel[[13]]-iron[[14]], chromium[[15]], or precious metals[[16]]. The center electrode is usually the one designed to eject the electrons (the cathode) because it is the hottest (normally) part of the plug; it is easier to emit electrons from a hot surface, because of the same physical laws that increase emissions of vapor from hot surfaces. In addition, electrons are emitted where the electrical field strength is greatest; this is from wherever the radius of curvature of the surface is smallest, i.e. from a sharp point or edge rather than a flat surface. It would be easiest to pull electrons from a pointed electrode but a pointed electrode would erode after only a few seconds. Instead, the electrons emit from the sharp edges of the end of the electrode; as these edges erode, the spark becomes weaker and less reliable. At one time it was common to remove the spark plugs, clean deposits off the ends either manually or with specialized sandblasting equipment, and file the end of the electrode to restore the sharp edges, but this practice has become less frequent as spark plugs are now merely replaced, at much longer intervals. The development of precious metal high temperature electrodes (using metals such as yttrium[[17]], iridium[[18]], platinum[[19]], tungsten[[20]], or palladium[[21]], as well as the relatively prosaic silver[[22]] or gold][23]]) allows the use of a smaller center wire, which has sharper edges but will not melt or corrode away. The smaller electrode also absorbs less heat from the spark and initial flame energy. At one point, Firestone marketed plugs with polonium[[24]] in the tip, under the questionable theory that the radioactivity would ionize the air in the gap, easing spark formation. (See external link below)

Spark plug gap

Spark plugs are typically designed to have a spark gap which can be adjusted by the technician installing the spark plug, by the simple mechanism of bending the ground electrode slightly to bring it closer to or further from the center electrode. The somewhat common belief that plugs are properly gapped as delivered in their box from the factory is incorrect, as proved by the fact that the same plug may be specified for several different engines, requiring a different gap for each. A spark plug gap gauge with round wires of precise diameters is used to measure the gap; use of a feeler gauge with flat blades instead of round wires, as is used on distributor points or valve lash, will give erroneous results, due to the shape of spark plug electrodes. The simplest gauges are a collection of keys of various thicknesses which match the desired gaps and the gap is adjusted until the key fits snugly. With current engine technology, universally incorporating solid state ignitions and computerized fuel injection, the gaps used are much larger than in the era of carburetors and breaker point distributors, to the extent that spark plug gauges from that era are much too small for measuring the gaps of current cars.

This adjustment can be fairly critical, and if it is maladjusted the engine may run badly, or not at all. A narrow gap may give too small and weak a spark to effectively ignite the fuel-air mixture, while a gap which is too wide may be too wide for a spark to fire at all. Either way, a spark which only intermittently fails to ignite the fuel-air mixture may not be noticeable directly, but will show up as a reduction in the engine's power and fuel efficiency. As the plug ages and the metal of the tip erodes, the gap will tend to widen; therefore experienced mechanics often set the gap on a set of new plugs at the engine manufacturer's minimum recommended gap rather than in the center of the specified acceptable range, to ensure longer life between plug changes. On the other hand, since a larger gap gives a "hotter" or "fatter" spark and more reliable ignition of the fuel-air mixture, and since a new plug with sharp edges on the center electrode will spark more reliably than an older, eroded plug, experienced mechanics also realize that the maximum gap specified by the engine manufacturer is the largest which will spark reliably even with old plugs, and will in fact be a bit narrower than necessary to ensure sparking with new plugs; therefore, it is possible to set the plugs to an extremely wide gap for more reliable ignition in high performance applications, at the cost of having to replace and/or regap the plugs much more frequently, as soon as the tip begins to erode.

Variations on the basic design

Over the years variations on the basic spark plug design have attempted to provide either better ignition, longer life, or both. Such variations include the use of two, three, or four equally spaced ground electrodes surrounding the center electrode. Other variations include using a recessed center electrode surrounded by the sparkplug thread, which effectively becomes the ground electrode. Also there is the use of a V-shaped notch in the tip of the ground electrode.

Sealing to the cylinder head

Most spark plugs seal to the cylinder head with a hollow metal washer which is crushed slightly between the flat surface of the head and that of the plug, just above the threads. If the torque used to install the plugs is not excessive, the washer can be reused when the plug is removed and reinserted, although this practice is, strictly speaking, not recommended and replacement washers are available.

Ford engines, however, were once distinct in using a tapered hole and a matching taper on the bottom of the plug above the threads, in order to seal the plug. The torque for installing and removing these plugs was higher, and it was easier to break them if the wrench were applied partially off axis.

More recently, some types of Ford Fiesta, and Ka also had a similar sealing system. The torque required to install these plugs is less than with the above type, and it is extremely critical that they not be over tightened, since over tightening can result in it being difficult or impossible to remove them. In addition, they have been known to corrode into the cylinder head, particularly if left in too long between removals. In such a situation, it is not unknown for a plug to snap below the hexagonal nut, leaving just the threaded portion (and the outer electrode) in the cylinder head. Ford has on occasion issued Technical Service Bulletin reminding technicians to use the correct methods of installation.

Tip protrusion

Three different sizes of spark plug

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The leftmost plug and center plug are identical in threading and electrodes and may be used interchangeably; the center plug is, however, a compact variant, with smaller hex and porcelain portions outside the head, to be used where space is limited. The rightmost plug has a longer threaded portion, to be used in a thicker head]] The length of the threaded portion of the plug should be closely matched to the thickness of the head. If a plug extends too far into the combustion chamber, it may be struck by the piston, damaging the engine internally. Less dramatically, if the threads of the plug extend into the combustion chamber, the sharp edges of the threads act as point sources of heat which may cause preignition; in addition, deposits which form between the exposed threads may make it difficult to remove the plugs, even damaging the threads on aluminium heads in the process of removal. The protrusion of the tip into the chamber also affects plug performance, however; the more centrally located the spark gap is, generally the better the ignition of the air-fuel mixture will be, although experts believe the process is actually much more complex and dependent on combustion chamber shape. On the other hand, if an engine is "burning oil", the excess oil leaking into the combustion chamber tends to foul the plug tip and inhibit the spark; in such cases, a plug with less protrusion than the engine would normally call for often collects less fouling and performs better, for a longer period. In fact, special "antifouling" adapters are sold which fit between the plug and the head to reduce the protrusion of the plug for just this reason, on older engines with severe oil burning problems; this will cause the ignition of the fuel-air mixture to be less effective, but in such cases, this is of lesser significance.

Source : http://engineering.wikia.com/wiki/Spark_plug