Spark Plug Tutorial

This section of the Tech Zone will hopefully educate you in the how the Spark Plug works, and also introduce you to the technique of proper plug reading.

Thanks for making this article one of the most traveled and highest rated on the Internet!
We appreciate all of the links to this article from websites all over the Internet.

Introduction:

The spark plug's location exposes it to extreme temperature variations, chemicals, fuels and oils. It is also attacked by cylinder pressures produced by the piston and cam timing, then it is also assaulted by high-output ignition units. As a result of all of this, one can effectively learn what the engine is doing by reading the firing end of the spark plugs.

By careful examination of the plug's color, gap, and any deposits that reside on it, you will be shown the efficiencies as well as deficiencies of what is going on in the engine. Spark plugs should be checked at least yearly, and replaced as often as necessary. In most cases you can follow the manufacturers recommendations, but in a race car, our replacement intervals are quite frequent.

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How a Spark Plug Works:

The basics of a spark plug is that it must perform two primary functions.

1. To Ignite the Air/Fuel mixture
2. To ***REMOVE*** the heat out of 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 the spark to jump the across the spark plug gap, thus creating what is called ***Electrical Performance***.

Additionally, 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 of the spark plug.

It is important to understand that spark plugs CANNOT create heat, only remove it! The spark plug works as a heat exchanger, pulling unwanted thermal energy away from the combustion chamber and transferring the heat to the engine's cooling system. The heat range is defined as a plug's ability to dissipate heat. The rate of heat is determined by:

- The insulator nose length
- Gas volume around the insulator nose
- Materials and/or construction of the center electrode and porcelain insulator

Now to the actual function: As the Ignition is triggered it sends the spark through the rotor, to the cap, down the wire and then it jumps the gap of the spark plug, a spark kernel is created that ignites the air/fuel mixture in the combustion chamber. Proper timing of this spark is not the only concern as described above. You must have the proper heat range (described later) as well as the correct gap.

Opening The Plug Gap:

On weaker or stock ignitions, opening up the gap CAN increase the spark kernel size, thereby creating a more efficient burn. The problem lies in that any added gap creates more strain on the other ignition parts.

- Coils may not have enough stored energy to fire, or in the least case, not enough energy to cross the gap, creating a miss-fire.
- Plug wires will break down due to the added resistance as the spark tries to reach ground.
- Rotor and Cap, as well as points (if you still have an interest in prehistoric ignitions), and the carbon bushing in the center of the distributor cap will show early failures.

All of this is because the greater the gap and the higher the voltage requirement to jump the gap. Do not forget the gap between the rotor arm to the distributor cap too. A high performance rotor is a bit longer at the tip, allowing less spark loss or chance of spark scatter in the cap as the spark attempts to jump the plug gap.

As many of us know that race, it is also possible to slow down a car if the gap is too big. I will get into this later when I describe proper spark plug gaps.

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Spark Plug Heat Range:

A spark plug's heat range has no relationship on the actual voltage transferred through 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
- The insulator nose's ability to absorb and transfer combustion heat
- The material composition of the insulator
- The material composition of the center electrode

The longer the insulator nose gives you a larger surface area exposed to combustion gasses and heat is dissipated slowly. This also means the firing end heats up more quickly. We are talking about exposed ceramic length, not extended tip length.

The insulator nose length is the distance from the firing tip of the insulator to the point where the insulator meets the metal shell. Since the insulator tip is the hottest part of the spark plug, the tip temperature is a primary factor in pre-ignition and fouling. No matter what the plugs are installed in, be it a lawnmower, a boat, your daily driver or your race car, the spark plug tip temperature must remain between 450°C to 850°C. If the tip temperature is lower than 450°C, the insulator area surrounding the center electrode will not be hot enough to deter fouling and carbon deposit build-ups, thus causing misfires. If the tip temperature exceeds 850°C, the spark plug will overheat which can cause the ceramic around the the center electrode to blister as well as the electrodes will begin to melt. This may lead to pre-ignition/detonation and expensive engine damage. (see the plug pictures that are part of this article)

In identical spark plugs, the differences from one heat range to the next is the ability to remove approximately 70°C to 100°C from the combustion chamber. A projected style spark plug firing temperature is increased by 10°C to 20°C.

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 (450°C) is called the spark plug self-cleaning temperature. This is the temperature point where the accumulated carbon and combustion deposits are burned off automatically.

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 water journals. This means that 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.

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 can be necessary when an engine is modified for performance, subjected to heavy loads, or it is run at high RPMs for significant periods of time. The higher cylinder pressures developed by high compression, large camshafts, blowers and nitrous oxide, not to mention the RPM ranges we run our engines at while racing, make colder plugs mandatory to eliminate plug overheating and engine damage. The colder type plug removes heat more quickly, and will reduce the chance of pre-ignition/detonation and burn-out of the firing end. (Engine temperatures can affect the spark plug's operating temperature, but not the spark plug's heat range).

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Influences on Spark Plug Temp and Performance:

Below is a list of possible external influences on a spark plug's operating temperatures. The following symptoms or conditions may have an affect on the actual temperature of the spark plug. The spark plug cannot create these conditions, but it must be able to deal with all the levels of heat, otherwise performance will suffer and engine damage can occur:

Air/Fuel Mixtures seriously affect engine performance and spark plug temps.

- Rich air/fuel mixtures cause tip temperature to drop, causing fouling and poor drivability.
- Lean air/fuel mixtures cause plug tip and cylinder temperatures to increase resulting in pre-ignition, detonation, and possibly serious spark plug and internal engine damage.
- It is important to read spark plugs many times during the tuning process to achieve optimum air/fuel mixture. Computer-controlled engine applications do a pretty good job of this with the various sensors that report back to the ECM.

Higher Compression Ratios and Forced Induction will elevate spark plug tip and in-cylinder temperatures.

- Compression can be increased by performing any one of the following modifications:

    - a) reducing combustion chamber volume (i.e.: domed pistons, smaller chamber heads, milling heads, etc.)
    - b) adding forced induction (Nitrous, Turbocharging, Supercharging)
    - c) camshaft change
- As compression increases, a colder heat range plug is required, as well as higher octane fuel and paying careful attention to ignition timing and air/fuel ratios are also necessary.

Advanced Ignition Timing: Advancing timing by 10° causes plug temperature to increase by approximately 70°C to 100°C.

Engine Speed and Load: Increases in firing-end temperatures and are proportional to engine speed and load. When traveling at a constant high rate of speed, or carrying/pushing very heavy loads, a colder heat range spark plug should be installed.

The heavier your vehicle or greater the amount of work the engine sees (racing applications, construction trucks, vans, RVs & Motorhomes, etc.), the more critical this becomes.

Ambient Air Temperature:

- As air temperature falls, air density volume increases, resulting in leaner air/fuel mixtures. This creates higher cylinder pressures and temperatures that causes an an increase in the spark plug's tip temperature. 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 volume decreases. The result is lower combustion pressures and temperatures, causing a decrease in the spark plug's temperature and a reduction in available power. Air/Fuel mixture should be leaner, depending on ambient air temperature.

Barometric Pressure and Altitude:

- Affects the spark plug's temperature
- The higher the altitude, the lower the cylinder pressure becomes. As the cylinder temperature decreases, so does the tip temperature.
- Many tuners attempt to "chase" tuning by changing spark plug heat ranges.
- The real answer is to play with the jetting or air/fuel mixtures in an effort to put more air back in the engine.

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Spark Plug Types and Designs:

There are hundreds of different spark plug types designed for different engines as well as specific applications. The two main ones we use in racing are the standard tip and extended tip. It is my opinion that any time you can use the extended tip, do it! The longer tip gets the spark kernel started further into the center of the bore for a more complete combustion process. This is also achieved with the better aftermarket cylinder heads on many available engine applications. The newer heads position the spark plug location closer to a more optimum location.

But, there are also specially designed spark plugs that are supposed to increase the spark kernel size. You see, the larger the spark kernel that is generated by the spark jumping the electrode gap, the more complete burn, the better power and efficiency and the smoother the car will run for longer periods of time. These specially designed plugs will have multiple angles that allow the spark to find the easiest path as well as getting the spark kernel out from under the ground electrode which can quench the kernel size limiting it's size and expansive growth.

Of these plugs, there are those that work, those that are hype, and those that are a great idea but they are manufactured by companies whose only purpose is profit instead of quality. Use common sense and don't believe all the hype that a marketing company bombards you with.

One thing to be wary of is plug material. Of the plugs I've tested, the fine-wire gold plugs have made the best power, but at the price of a short life, which requires short replacement intervals. The Platinum plugs are only good for longevity, though most imports run better with a platinum plug. This has to do with the material of the cylinder head and engine block and the plugs ability to properly ground.

People always ask my plug recommendations. I must say that I like the NGK V-Power Plugs, the Champion Premium Fine-Wire Gold plugs, and the Nippondenso U-Groove plugs for domestics. In the Imports, the Bosch or NGK Platinum plugs usually work best. I have been testing the AC RapidFire plugs currently and I must say I am impressed by the results. Plugs that are useless to me are the Split-Fire plugs (poor materials -- actually an Autolite plug with the "V" tip), and of course the Autolite plug itself. I have seen the most failures and poor performance out of these plugs. This is not a bash session, so those of you that love your Split-Fires or Autolites, I'll wait for you at the finish line ... <G>

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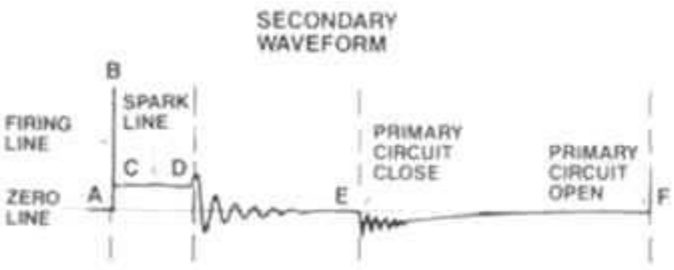
RFI or "Radio Frequency Interference":

Many people believe that spark plugs fire instantly. This is partly true because they fire in milliseconds, although if one looks at an oscilloscope pattern you will see much more than a single instantaneous firing event. Many things also occur that you cannot see even with the oscilloscope. Part of what you cannot see, but can in many cases hear, is the noise that is picked up in the speakers of your car stereo. This is called RFI, or Radio Frequency Interference.

Spark Plug Firing Voltages:



When the breaker points or solid state ignition unit (switching device) interrupts current flow in the primary ignition circuit and induces current flow into the secondary windings of the coil, there is an instantaneous voltage spike. (as seen in the illustration at right in position A to B). This represents the voltage required to overcome the spark plug and distributor rotor gaps. Once the spark gaps have been bridged, the secondary voltage required to sustain the spark across the gap is much less and drops (as seen in position B to

C above). The spark continues to arc across the gap at more or less constant voltage until the arc is extinguished (at position D above). This is due to coil energy drop in that it can not sustain the spark any longer. During this arc duration (Spark Duration), the plug actually fires several times. This is caused by high frequency oscillations in the primary and secondary windings of the coil, which continues to induce voltage spikes. They continue and slowly diminish (positions D to E above) even after they are no longer strong enough to sustain spark. All of this takes place in roughly one thousandth of a second.

With our race designed ignition units, they concentrate their efforts on sustaining spark duration as well as limiting the voltage drop after the gaps have been bridged. Most aftermarket ignitions concentrate on giving us 20° of spark duration (crank degrees) as well as much higher spark energy output. A high performance coil helps this out, but the Capacitive discharge and digital ignition units assist in storing and delivering this power through the coil more efficiently, faster and give the ability to achieve higher RPMs more safely and efficiently in fuel mixture burning. The coil is only the pawn of the ignition trigger or control unit. The coil is the real workhorse and takes most of the abuse ... make sure you use a good coil. (Read below about aftermarket ignition amplifiers and controls)

The Cause of RFI:

If we were to slow down the oscilloscope to perhaps 0.00000025 seconds and greatly expand the pattern (as pictured at right), we would see that what appears to be consistent from position C to D in the the first illustration above is actually a series of extremely high bursts of energy. These energy bursts are discharged at the same frequency band as radio and TV frequencies. It is these bursts that make your car radio snap - crackle - and pop ... as well as just about anything electronic including telephones, aircraft control towers and heart pace makers by causing static and interference.

Sources of RFI:

Automotive ignition systems are not the only things that spew RFI into the atmosphere. Lawn mowers, snowmobiles, ATV's, tractors, power lines, traffic control devices, etc. all do it. One publication refers it to "electronic air pollution". As many of us know, we live in a sea of constant electromagnetic waves.

Any time you have a flow of electric current you will have a magnetic field. Coils, relays, switches, solenoids, generators, servomotors all affect communication equipment, electronic circuits and computers. The higher the voltages, the more critical this becomes. Anytime you have the spark jump a gap or a contact, you have a miniature radio transmitter.

RFI Standards:

Back in the 1930's, engineers recognized that RFI could be a nuisance. As the years, testing and technology advancements went by, it turned into an even greater problem. Especially with the advent of high-tech communications systems, computers and electronic engine control devices. The Society of Automotive Engineers (SAE) decided to set up standards for measuring as well as the control of RFI. These are called "EMI Standards" or the more technical name for radio static of Electromagnetic Interference (EMI).

The current standard for EMI was adopted in 1961 and is known as J551. It limits RFI at frequencies between 20-1,000 MHz. All spark plug manufacturers must adhere to it. The most common method used to suppress RFI is to install a resistor in series with the spark plug's center electrode.

Other ways that control RFI include:

- The metal fenders, grille and hood of your car. These provide a shielding affect which absorbs much of the RFI emitted from your ignition components. Plastic and composite body panels are basically transparent to RFI and provide little to no shielding.
- The use of capacitors, silicone grease at connections, proper grounding of all circuits and routing wires to reduce electromagnetic interference are all helpful in reducing RFI.
- The use of carbon impregnated secondary wiring (plug wires) and resistor spark plugs have the most impact when reducing and controlling RFI. In our race cars with our high output ignitions, it is best to use a specifically designed plug wire for our applications. These are usually the what is called "Spiral Wound" style plug wires. The construction of these wires starts with a Ferro0-Magnetic impregnated inner core, helical wrapped copper alloy conductor, a high dielectric insulator then a heavy fiberglass braid. Wrapping this is a 8mm to 10mm silicone jacket. Also, secure connections of the plug wire's terminal ends are mandatory along with secure fitting boots.

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Adding an Aftermarket Ignition Unit (Amplifier):

OK, I felt I had better address this now. There are numerous ignition units available that say they give you "X" horsepower gain, or do this or that for your engine. In most cases the ignition unit will benefit your engine, but is it needed? To decide if adding an ignition unit to your vehicle is going to be worthwhile you need to ask yourself a few simple questions:

- Am I trying to get maximum spark energy, engine efficiency, lowered emissions, and power output from my engine?
- Am I modifying the engine (cams, head porting, exhaust system, larger carbs/injectors, compression, or any other assortment of aftermarket performance parts) so that cylinder pressures will be increased?
- Am I adding a serious power enhancer (Nitrous, Supercharger, Turbocharger, etc)?
- Am I planning on racing the vehicle?
- Am I increasing the RPM range of the engine?

If you answered YES to even one of the questions above you could consider the addition of one of the available ignition units. If you answered YES to 2 or more of the above questions, you'd better install a quality ignition amplifier (Mallory Hyfire, Holley Annihilator, Crane Hi-6, MSD, etc).

Of course there is going to be B.S, hype from many ignition manufacturers, and the facts surrounding what an ignition unit can really do.

Some Facts:

1. A small power increase and strides in efficiency will be seen in most cases. Note that if you are racing, not having a good ignition amplifier can cause serious power loss and engine damage if the air/fuel mixture is not ignited properly
2. Without the correct or adequate coil the ignition unit cannot do its job properly
3. Analog ignition units are slow and not as good as digital units
4. Opening up your plug gaps just because you have added an amplifier CAN SLOW YOU DOWN and cost your horsepower. *(read below)*

5. Not all ignition units are the same (Inductive amplifier and Capacitive Discharge amplifier, not to mention brands)
6. If it takes 10k volts to fire your spark plug, that is what you will get. Just because you have a bazillion volt system does not mean the box will give that to your plugs and combustion process. Don't believe that just because the ignition has the highest "millijoule" rating that it is the best.
7. Using the wrong coil can have serious implications (we have seen coils overheat, boil over, and catch the vehicle on fire because the coil could not handle what the box was telling it to do).
8. Not all ignition triggers are equal (breaker point, magnetic, magnetic breakerless, hall effect, photo optic, etc). Each can affect the efficiency of your ignition unit.
9. One of the main benefits of an ignition amplifier is the spark duration of 20° crank degrees per spark. *(this is the B to C distance on the chart above under **RFI**)*

Some Hype:

1. "Guaranteed horsepower claims"
2. "Our amplifiers will help ALL vehicles"
3. "It will work with any coil" (this usually means that their unit does "squat"). Remember, the coil is the workhorse and the box is managing the coil.
4. "You can now increase the spark gap for better performance". This usually means again that their box does "squat". If you "have to" open the gaps up to get spark energy, the box is not supplying what they claim. Increasing plug gaps should be decided on an individual engine basis, not by the box.
5. The lowest plug wire resistance is not always the best either. A coil has to build energy (resistance) and then release it. This resistance is a combined part of the coil, plug wires, plugs, etc. The more efficient units can operate with slightly higher plug wire resistances to eliminate outside interferences. Weaker units require extremely low resistance plug wires and ignition coils, virtually just blowing the spark through the coil and wires to get to the plugs.
6. "All these controls will help you achieve more performance". Many of the available "gadget boxes" are just that. If you have a real need for timing controls, high speed retards, etc, then get a box that uses these features. Just because the box has these controls does not mean you will get more performance. Computer programmable ignitions (where you hook your laptop or PC to the ignition) are for dyno rooms. Once you have a setting that works for your specific engine, it probably never needs to be tweaked again. You can play with those settings for months and never get a single HP gain from them. When I see these on street cars and/or many bracket cars I have to laugh.

Sure, we have our preference of what brand(s) of ignition units we like and those we don't. There are reasons for these decisions (reliability, factual claims, performance output, consistency). We have tested numerous ignition brands/styles and know what works for an individual's application. The term "Ignition System" fits. If you want your ignition to work correctly it needs to be a compatible system for your specific application. (example of an excellent ignition unit ... and one I have on my personal vehicle)

If you cannot decide how to choose your ignition system, use the Live Support link at the top of this page and a representative will assist you.

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Proper Plug Gapping:

- Proper gapping of the spark plug is necessary to get maximum spark energy, lowest RFI release as well as what is best for the longevity of the secondary ignition components (coil, cap, rotor, wires, plugs).
- When checking plug gaps, the correct way is to use ONLY wire gauges, though many of us are using the slider style gapping tools. These flat or feeler gauge style gauges do not accurately measure true width of spark plug gap.
- When increasing the gap size for our high performance applications utilizing advanced ignition systems such as Mallory, Accel, Jacobs, Crane and Holley ... it is important **never to go more than plus or minus .008"**. This is to maintain parallel surfaces between ground and the center electrodes.
- Something many do not know, is that with Higher Compression ratios and Superchargers as well as Nitrous, in many cases smaller spark plug gaps must be used as well as the use of a much hotter ignition system (see above). These higher cylinder pressures require more energy to jump the spark plug gap.
- The rule of thumb on plug gaps is to open them up in .002" increments at a time. When the car (race vehicle) begins to lose power or slow down then go back .001-.002" and this in most cases is the optimum gap.

Remembering that the Ignition Unit, plug brand as well as heat range, cap and/or rotor styles and in many cases fuel type or brand will change the optimum spark plug gap settings.

Lastly, NEVER use the porcelain insulator as a fulcrum point when setting these gaps, this can cause damage to the spark plug.

Reading Your Spark Plugs

As stated on the opening page, a lot can be learned about your engine condition and what it sees by properly reading and "understanding" your spark plugs. This page will show you pictures as well as explanations on cause and affect of what you see when viewing you spark plugs.

Each picture is a thumbnail, meaning you can click it for a Full-Size view.

Normal Condition:

click on image for full size view

The Spark plug to the left is what a normal plug should look like.

Grayish-tan to white in color indicates the plug is operating at the proper heat range as well as correct jetting and the cylinder is running healthy.

RACER TIP: That vertical color band on the ceramic shows you where the plug is indexed. Meaning that band is aimed slightly at the exhaust valve. Optimum location places the band **HERE**. If the band is anywhere but here, it means that when the plug is not at it's optimum location. There is still discussion as to whether indexing a plug is worthwhile, but on may applications looking for that last horsepower, it doesn't hurt.

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Worn Out Condition

click on image for full size view

Excessive electrode wear, misfire during acceleration and hard starting.

Simply put as in it's description, it's worn out ... it looks ok color wise, so replace it with same plug or at least compatible heat range. You've all heard the term " If it works, don't fix it". Don't look for flaws with this plug ... just blame yourself for not changing it sooner.

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Mechanical Damage

click on image for full size view

This is caused by foreign objects in the combustion chamber or an improper plug reach where it contacts the piston. Even a piece of carbon can do this.

To solve this, make sure you have the correct length tip spark plug as well as removing any foreign materials in the combustion chamber. In some cases you may have excessive carbon buildup on the backs of the intake valves that will have to be addressed.

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Detonation:

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In cases of severe detonation, insulators may become cracked or chipped. Improper spark plug gap settings will also cause the insulator tip to crack or chip.

Detonation is tricky ... make sure that you are using the correct octane fuel first and then verify correct ignition timing. Next check for an inoperative EGR system (if equipped) as well as proper function of the Knock Sensor (if equipped). Also, you will want to make sure you are using the correct heat range plug.

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Overheated:

click on image for full size view

On this symptom you will notice a chalky appearance, white insulator, rapid electrode wear as well as an absence of deposits. The actual shell may also be discolored.

To cure this you must first verify that the plug is the correct heat range, the ignition timing settings are correct, the air/fuel mixture is not too lean, there are no vacuum leaks and that the EGR valve (if equipped) is functioning properly.

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Ash Deposits

click on image for full size view

These are light-brownish deposits that are encrusted to the ground and/or center electrode(s). This situation is caused by oil and/or fuel additives. This condition can cause misfires.

The cure for this is to verify worn valve guides or valve seals, not using fuel additives, or you might even try changing fuel brands. By the way, a hotter plug is what most people try to fix this problem. You need to first understand that the plug is NOT typically the problem.

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Oil Fouled:

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Oily coating caused by poor oil control. Oil is leaking past worn valve guides, piston rings, or on some race engines a possible intake gasket leak and then entering the combustion chamber.

Check for worn valve guides (NEVER knurl valve guides), intake gasket sealing alignment, as well as worn cylinder walls and piston rings. A leak down test is a good place to start for what is causing this.

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Initial Pre-ignition

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This will usually look as a melted center electrode and/or ground electrode.

Check for incorrect heat range plug, over-advanced timing, lean fuel mixtures, inoperative EGR valve or Knock Sensor (if equipped) and also look for hot spots or deposit accumulation inside the combustion chamber.

If you or your engine builder took the time, all areas of combustion chamber should have been de-burred to eliminate this problem. This includes the sharp edges on the chamber, piston top, and cylinder wall valve reliefs (if applicable).

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Sustained Pre-ignition

click on image for full size view

This will be pretty obvious ... melted and/or missing center and/or ground electrodes as well as a destroyed insulator.

Check for incorrect heat range plug, over-advanced timing, lean fuel mixtures, inoperative EGR valve or Knock Sensor (if equipped) and also look for hot spots or deposit accumulation inside the combustion chamber.

If you or your engine builder took the time, all areas of combustion chamber should have been de-burred to eliminate this problem. This includes the sharp edges on the chamber, piston top, and cylinder wall valve reliefs (if applicable).

After you see this, you'd better look for possible internal engine damage as well. (pistons, cylinder walls, valves, rings, etc.)

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Splashed Deposits

click on image for full size view

These look as if they are small islands of contaminants on the insulator. This is usually a dirty carburetor bores or air intake as well as the possibility of a dirty or faulty injector.

You must use aggressive carb and choke cleaner or other solvent cleaner (a pressurized fuel injection service on fuel injected vehicles or injector removal and cleaning) before installing new spark plugs.

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Carbon Fouled:

click on image for full size view

This is very common visual condition on our race engines. Soft, black, sooty, dry-looking carbon. This indicates a rich mixture, weak ignition or wrong heat range plug (too cold).

You will first need to verify plug heat range. On carbureted engines, check choke as well as choke pull-off (if equipped) for proper function and adjustment. On fuel injected engines, check for clogged injectors and the cold-start valve and circuit. You also need to check for correct fuel pressure settings.

As a general rule on all computer-controlled engines, you need to also make sure that all input signals to the computer are working and accurate. This includes, but is not limited to, all temperature and pressure sensors as well as the EFI system components.

Lastly on all engines, check for vacuum leaks and weak spark or low voltage output. (Good reason for a better coil and aftermarket ignition unit "amplifier").