SPARKPLUG WIRES

BACKGROUND

Contrary to what many people believe, ignition wires have a lot to do with how a car performs. Obviously, if the wires are removed, the car won't run. That's pretty basic. What's not so basic is that ignition wires are very much like nerves in the body, conducting energy from one central signal-maker to all the remote areas of the system. Both wires and nerves allow a small signal, spark or nerve impulse to release a tremendous blast of energy, combustion or muscular contraction, and both protect their valuable signals by insulating the relatively low-level internal electric energy from the much higher external energy noise levels. Both conductors are easily damaged by a variety of under-the-hood agents, and are extremely affected by their surrounding environment.

Perhaps the most important characteristic they share is the fact that when either malfunctions, the symptoms can appear to be many things not even related to the real problem, nervous disorders can resemble anything from heart problems to a skin rash. Bad ignition wires can appear as types of carburetion, injection or choke problems, bad valves and rings, even automatic transmission problems. In short, bad ignition wires, like bad nerves, really are the great pretenders.

The first high-tension leads were simple strips of copper running from the distributor to the spark plugs. They worked quite well for Henry Ford, as well as scores of other manufacturers. But a problem occurred when engines evolved into powerplants with more than four cylinders. No longer could the simple exposed pieces of copper do the job. The length of copper needed to connect a plug to the distributor, more than two feet in the case of a straight eight, became an electrical nightmare. The problem wasn't in the mechanics of routing the copper; rather the electrons simply would not reach the plug. They would just ground out on the block.

While designers were grappling with that problem, along came another. This time it wasn't the length of the wire but the shape of the engine: V-configuration, flat-opposed, long straight-8, those early years saw a virtual explosion of engine configurations. The flat copper lengths of metal clearly would not do, so the high-tension lead was born. It was merely a solid metal core wire wrapped in an insulator.

Since the days of solid rubber tires, hand-operated windshield wipers, and sliding mesh transmissions, electrical systems have steadily improved. Today's experimenter can choose from conventional point-type systems, capacitive discharge, fully electronic or even computer ignitions, which actually change the spark in response to the changing engine environment or running conditions. However, the basic problem faced by engine builders years ago still exists today, although it's been updated a bit. None of the high-tech ignition systems are worth their microprocessing circuitry unless the electrons reach the spark plugs. If you tried to use the ignition wires of yesterday on today's engines, most likely the engine wouldn't be able to do more than sputter, if it would run at all.

Thankfully, the burst of automotive technology that has given rise to modern ignition systems is also found in the high-tension department. You can now choose from any number of plug wires that are more than capable of allowing the electrons generated by the coil to reach the plugs. The problem is that while they appear identical on the outside, internally there's a vast difference in the wire's longevity, durability, and capability which ultimately leads to the wire's ability to fire the plug.

HOW TO CHECK FOR FAILING WIRES

Generally speaking, the time from when a street car's wires first start to cost power, performance and economy to when they give noticeable (hard starting, sputtering, popping in the exhaust) engine problems is 30,000 to 40,000 miles or about 2-3 years.

The rule for checking wires on a scope is simple: "If the wires check bad, they are bad. If the wires check good, they could still be bad."...but even new OEM wires can, depending on the type, cost up to 11% power and 15% fuel economy when running a modified engine..

It's like if a guy comes into the hospital, not moving) and you see a big bullet hole in his head (the scope says the wire is bad), you know he's dead. Even if you don't see a gunshot wound, if he isn't moving, he may still be dead (the scope says the wire is good; it still may be bad).

The reason for the uncertainty is that there are three common wire failure modes a scope cannot detect.

1. First, engine analysis scopes, particularly inductive pickup types, cannot pick up really high-speed phenomena, such as the dynamic increase in conductor resistance, or a dynamic loss in insulator resistance. These failures occur and then recover so fast, the scope trace doesn't even get a chance to react before the electrons are lost. Engine performance suffers, and the scope trace looks normal.

2. The second failure mode is a gradual increase in conductor resistance that absorbs spark energy by reducing spark current flow. Remember, the scope cannot detect spark current, only spark voltage, but it's current, not voltage that ignites fuel.

3. By far the greatest loss of fuel energy comes from weak, but not shorted, wire insulation. This condition also cannot be detected on a scope.

ONE FACT TO ALWAYS KEEP IN MIND WHEN DEALING WITH HIGH VOLTAGE IN GENERAL AND SPARKPLUG WIRES IN PARTICULAR: UNLIKE A HOUSEHOLD EXTENSION CORD WHICH EITHER MAKES CONTACT OR DOESN'T, SPARKPLUG WIRES CAN LOSE ONLY PART OF THE SPARK ENERGY. FROM 1 TO 80% LOSS IS NOT UNCOMMON. WITH A HIGHER PERCENTAGE LOSS (ABOVE 20%) THE ENGINE KIND OF RUNS OK AND YOU NEVER REALIZE HOW MUCH MILEAGE AND POWER YOU'RE LOSING UNTIL YOU CHANGE YOUR SPARKPLUG WIRES.

Three simple tests that can give you a true picture of what shape the wires are in:

1. The Midnight Test.
This is done in as dark an environment as possible. Bring the engine to about 1,000 rpm while you put the transmission in gear (if automatic). Have someone work the gas against the brake while you look at the engine. There are three criteria to took for where the wires could be bad:

If you actually see and hear sparks flying. This is the worst and means the wires have been bad for at least six months. If you don't see sparks but there's a blue corona glow around the wires, it means one of two things: either (a) the wires are operating within their normal range, but you can reduce corona significantly by replacing them with low corona, large diameter types, or (b) the wires are marginal and throwing away energy during all times of the driving cycle.
If the wires are dark you are safe to run your fingertips lightly along the wires. If they stay dark they may well be okay. If they make the tips of your fingers glow blue (you probably won't feel anything), they are losing energy during the parts of the driving cycle that require the largest voltage.

2. The Peel-Back Test.
Shut off the engine. Disconnect the wire from the sparkplug and bend back the sparkplug boot (on the wire side) to expose the wire insulation. If you see a clear line difference between the exposed and protected insulation, then the exposed insulation is probably porous at best and contaminated at worst. This type insulation becomes a natural sponge and highly leaky when faced with moisture and contaminants. (NOTE: You can only do this test on poorer quality wires because good quality wires have the sparkplug boots vulcanized to the wire insulation. If you have these top quality vulcanized wires, do the peel-back test on the distributor end.)

3. The Flex Test.
This should be done when the engine is cold. The colder the wire the better. Remove the wire that looks like it has been subjected to the highest heat, such as behind the air-conditioner compressor,

and so forth. Connect an ohmmeter between the sparkplug and distributor terminal. Flex each wire back and forth, pulling on it over its entire length. If you feel any brittleness, or if the ohmmeter moves as you flex the wire, it means the conductor is ready to open up. You might try this on two or three wires to be on the safe side.

CHOOSING THE CORRECT IGNITIONWIRE

Ignition-wire stress requirements on a modified vehicle are much more severe than they were on the stock engine, so you should change the ignition wires to the high-performance type when you first modify your engine. The basic rule is that high-performance type wires, due to their extra-composition insulation, are more than adequate with the stock engine, but even new OEM wires can, depending on the type, cost up to 11% power and 15% fuel economy when running a modified engine. If the wires are used and weak, the loss will be worse.

In theory, the perfect ignition wire would work equally well for stock or modified engines. The definition of a perfect ignition wire is simply that it delivers all the spark energy from the distributor to the sparkplug, regardless of engine environment or running conditions.

Sounds simple, especially when you consider that there are only two things that would prevent a wire from being perfect: (1) failure to fully conduct the voltage energy (conduction), and (2) failure to fully prevent the signal voltage from escaping (insulation).

WHAT TO LOOK FOR

You only have to evaluate a wire from three standpoints: Going from the easiest to judge to the hardest, they are:

1. Ease of installation, with the ability to keep the wires "out of trouble."

With custom-tailored sets, different wire manufacturers, like different clothing manufacturers, get in the habit of cutting for either a loose or tight fit. In many cases, it is impractical or even impossible, though desirable, to route ignition wires in the original location after doing engine modifications. The extra equipment we add may be in the way, making access to the original routing difficult. Therefore, select a manufacturer who goes for the loose fit so you can lay the wire in without putting it under tension. In a recent study on the ideal length for an ignition wire, it was found that even on stock engines, 56% of the wire kits are cut too short to give long wire life. The same study showed that if you put cosmetics aside, it is better to have a wire up to 14 inch too long than even I inch too short. Though extra length also reduces the maximum output voltage due to added capacitance loading, a few inches will have no appreciable effect, even though a few feet will. Fourteen inches too long means a 7-inch loop at the distributor (to go out and back). There are very few vehicles where a 7-inch loop would allow a wire to reach into trouble, i.e., throttle linkage, exhaust manifold, and so forth, or where this capacitance effect would be significant. (If you'd like to learn other facts we uncovered in the study, call and talk to our Technical Services Dept.)

Perhaps the most important consideration is the ability to either keep the sparkplug boot cool, or use a type of boot like ceramic, which can easily shrug off high temperature. Exhaust -manifold temperatures traditionally run hotter on heavily modified or souped-up vehicles. To complicate matters, the sparkplug terminals cannot always be brought out from the sparkplug at the optimal angle due to headers or other space-taking equipment. The sparkplug boot can actually be forced closer to a hotter-than-average header or manifold. When this extra heat is combined with the extra voltage stress common to high-powered engines, it can quickly lead to sparks climbing to ground outside the spark. plug porcelain; that is, no ignition in that cylinder. This condition is particularly difficult to diagnose because it is so unpredictable as to when it will happen.

The manufacturers of high-performance wires have different techniques for keeping their boots cool. Some use spacer shields, like the water jackets on a machine gun. These have the

disadvantage of being really big and can be difficult to install, especially on some Fords with the recessed spark plugs, or Chevys with headers.
Others use contourable sparkplug terminals where the installer hand-bends the sparkplug terminal to give maximum free air clearance between the boot and the manifold. Engine heat, during normal driving, then makes the terminal metal take set and the angle becomes fixed. The disadvantage is that it takes a little longer (about 5-8 minutes) to install because most mechanics like to really aim the terminal toward the maximum free air space.

2. The conductor. How well will it conduct new? How well will it stand up to time and the environment?

Even in the most radical of race applications, the best ignition wire is the type that has a fine wire spiral (looks like a Slinky spring) wound around a ferrite or impregnated core. Common trade names are Spiral Core, Energy Core, and Magnetic Core. (There maybe others I'm not aware of.) This type construction absorbs shock and never leads to harmonic vibration. It holds up better than the stranded solid metal core and is more durable than fiber core. As an added and unexpected bonus this type construction is radio suppression street legal. It isn't that often one type of anything works best in all applications; however, in ignition wires this type does. For capacitive discharge, you need one of the low resistance types, wire spiral wound, with resistance at less that 1,000 ohms/ft.

The problem with using stranded solid-metal core is that as the engine revs this dense metal core starts a harmonic vibration, like a piano string, which is virtually invisible to the eve, but in a short time fractures the conductor electronically, tearing up the insulation invisible from the inside out. The result of solid stranded metal is that when the engine is under load the wire breaks down, but a idle or static revving the wire is okay. I can be a real S.O.B. to diagnose because the breakdown never appears on a scope The only reason anyone would ever use fiber-core wires, which have no place in race applications, is to suppress radio static.

The problem with fiber-core wires is that they absorb too much valuable spark energy so power and mileage suffer. The absorbed spark energy, in a high-revving engine, also heats and tears up the fiber-core conductor. Some of the most serious disadvantages of fiber (rag) wires are (a) resistance goes up when it's cold, leading to harder starts; (b) extreme susceptibility to conductor runaway (that's where there's a break in the conductor leading to a micro-spark invisibly jumping inside the wire; (c) fiber is brittle when cold, which leads to the first break, followed by conductor runaway; (d) fiber is not physically strong, which can also lead to that first break; (e) every fiber composition we tested was subject to electrolysis (the condition where the passage of electricity through a material permanently changes its electrical properties); and (f) fiber develops dynamic or non-linear resistance, resistance which changes with the changing current. Just when the ignition system is trying to deliver the most energy, it is encountering the most resistance.
Why is fiber so popular if it has all these problems? Money, dinero, cost, bottom line. Fiber is easy to make and therefore low in cost. Also, fiber's specific problems have only recently been fully researched and understood. Ignition wires themselves have not been taken too seriously until about four years ago. (Note CDC, most OEM's still use fiber core wires!)

There are three ways to get around the flaws of fiber wire core and still get radio noise suppression:

A lumped resistance somewhere in the line. Since radio noise can escape from any part of the wire, a lumped resistor method will not suppress radio noise as well as continuous resistance down the entire wire length.

1. Monel-type metal resistance down the entire length of the wire.
Using a continuous metal-alloy resistance is the best of the resistance methods, but there is a problem getting enough resistance to give adequate suppression. To increase resistance, manufacturers tend to make the wire very thin, which can lead to some really fragile terminations. If radio interference or cross fire is not going to be a problem, you may want to use a solid metal core to get the best performance, but be careful. A cop may be tuned in to your increased radio noise and give you a ticket. If you can get the low resistance type and radio suppression, so much

the better because there is no real evidence that solid metal core performs any better than spiral core.

2. Tuned conductors make use of the fact that most useful spark energy is below 5,000 cycles per second; but radio transmission, for all practical purposes, is above 25,000 cycles per second. By proper construction, you can actually get the wire to pass only the lower spark frequency current filtering and suppressing the higher frequency broadcast current. This is called a 10,000 -cycles- per- second low-pass filter. When you combine the low-pass technique with a little Moneltype resistance as an added clean-up, you get excellent suppression and not too much loss in useful spark energy.

3. Insulation. How well will it hold in the signal when new? How well will it last with time? How well will it resist contaminants in the environment?
As a rule of thumb, it's safe to say that more spark energy is lost from bad sparkplug-wire insulation than from all other causes combined. A number of coatings are available:
Hypalon is mechanically the strongest of the insulators; its disadvantage, though, is its low heat tolerance. It's not good for more than 250 degrees F; however, it's inexpensive.

Moving up the ladder in cost is EPDM. It can withstand higher heat than Hypalon-325 degrees F-before breaking down, but it isn't mechanically rugged.

Blended rubber compounds are the next category of insulators, and the vast majority of them are good up to about 400 degrees E They're very strong-almost on par with Hypalon.

The next step up is silicone insulators, whose popularity can be accounted for on a number of fronts. First, they're able to tolerate heat and operate in environments as hot as 500 degrees F without breaking down. While not inexpensive, they're within the reach of the average backyard mechanic. A set of wires for a V8 costs between $80 and $ 100, but you can expect the set to last a long time. Silicone is incredibly resistant to gasoline, oil and other solvents and petroleum based products commonly used under the hood. If you spill oil while adding it to the crankcase, it may find its way onto silicone high-tension leads without being absorbed, as it would be on some other insulators. The silicone will shrug off the contaminants. it's a natural to be used with fiber-core suppression wires because it remains pliable in cold weather, eliminating brittleness. Finally, it's simply silicone's resistance to heat that has made it the most desirable wires to have under the hood. Although the lead itself won't be exposed to 500 degrees F-if that happens, the engine has probably caught fire and you're well on your way to a piece of molten metal for an engine-the sparkplug boot is sitting on top of a very hot piece of ceramic/metal. The presence of silicone in the boot helps to prevent the boot from cracking and drying from exposure to the heat.

The last insulator is Teflon-coated silicone wire. Although it's expensive stuff, it's also the best you can buy. It's the most heat- and corrosion -resistant material and is mechanically strong. Teflon impregnated sparkplug boots don't stick to the plug, which makes removing the boot easy when changing plugs. The combination of Teflon and slicone results in a wire that withstands temperatures of 700 to 750 degrees F, a wire that's natural for endurance racing or small engine compartments with poor ventilation. While the cost, as stated above, isn't exactly low, the price isn't exorbitant either: a set typically costs about $80 and should last for many years. Check around. For that price, any good wire set will be warranteed for the life of the vehicle.

Ultra-high engine temperatures are one of the biggest reasons that spark plug boots fail. In some extreme cases, not even pure silicone can stand up to the heat generated by something like a 454 in a 60 foot motor home, pulling a 15 degree grade with all the lights and a/c on, plus dragging a boat or worse, a car behind. Applications like these can incinerate normal plug wires. just about the only material strong enough to stand up to this type of space-shuttle re-entry grade heat is the same material the spark plug itself is made of - porcelain!

Ceramic is almost the perfect material for spark plug boots. It's virtually impervious to heat and it has a very high dielectric strength - over four times the voltage retention of silicone boots.
We have conducted tests on plug wires with ceramic boots to determine just how much heat they can stand up to. We installed a set on a modified big block Chevrolet, set up on an engine dyno. To

make sure we had enough heat, we turned off the cooling fans and used the OEM cast iron exhaust manifolds. The engine was started and ran at 3,500 for 30 minutes, recording air temperatures of over 2,000 degrees right around the exhaust manifold/spark plug areas, dropping quickly to 470 degrees at 2 inch(5 cm) from the spark plug. Even though the exhaust manifolds themselves glowed cherry-red, there was no significant breakdown of the spark plug wire at 380 degrees (F, is 193 degrees C), or the ceramic boots, at 1820 degrees (F, is 993 degrees C, actual recorded temperature). The only drawback to ceramic spark plug boots was, until recently, they were only available in a straight configuration, somewhat limiting their use on a great variety of vehicles. All that is now a thing of the past, because Jacobs Electronics has introduced a right-angle ceramic spark plug boot for tight clearance applications. If you have ever had to pull over to the side of the road or coast back into the pits because of a burned spark plug wire, you know how frustrating it can be when a high dollar machine, with high tech accessories and equipment is brought to a standstill by something as rudimentary as a simple spark plug wire. Those days are over, because the technology of spark plug wires now rivals the rest of the engine components.

One of the largest areas of spark-energy loss is in the junction between the sparkplug boot and the wire insulation. While the boots initially slip over the wire with a tight fit, time and heat loosen the boot's grip on the wire. Also, no matter how tight the fit, the boot breathes (air comes out between this boot-to-wire junction when the engine and sparkplug get hot, and air, moisture and contaminants are drawn back in through this same junction as the motor cools off). As a result of this breathing process, electrically conductive contaminants work their way between the boot and wire insulation. This conductive path wastes significant quantities of spark energy.

For this reason, all the top-quality ignition wires have the sparkplug boot vulcanized (bonded into one piece of rubber) onto the wire. Making one piece of rubber out of the boot and wire insulation prevents this significant loss of spark energy. The Japanese OEMs are starting to do this on their vehicles.

In racing applications, vulcanization has another important advantage in that it prevents the boot from becoming dislodged or moved from the multiple sparkplug removals and replacements so common to racing. Vulcanization of sparkplug boot to the wire is something every serious racer should look for in ignition wire. While there are some people who feel it may be a desirable but not necessary process, my experience has been that it makes a big, long-term performance improvement.

INSTALLING THE WIRES

Many of the problems people have with installing ignition wires have to do with routing. Car manufacturers spend a lot of time and money researching the best possible path for ignition wiring in terms of resistance to arcing, cross firing and stress, and it's advisable to use their routing paths when replacing your car's wires. A problem, however, arises on engines that have been modified from stock. It is crucial that ignition wires be routed away from exhaust manifolds, sharp metal protrusions and flat metal surfaces, but many of the aftermarket ignition wire sets don't allow enough extra wire for custom setups. Too short a wire (if the wire is under tension at all) will cause the conductor to eventually break down and separate due to the constant pulling stress of engine vibration. You are better off having a lead that is too long by quite a bit than one that is even I inch too short. Ignition wires can be purchased as either custom tailored (loose or ultra close fit); that is, manufacturer terminates both sparkplug and distributor end, or universal, that is, manufacturer terminates the sparkplug end and you terminate the distributor end to the exact required length.

INSTALLING CUSTOM TAILORED ENERGY CORE SETS

1. Before removing wires, note the routing of the old wires and replace each wire in the same location. OEMs planned this routing for maximum clearance from heat as well as arc-over protection. If you have modified the engine and cannot route the wires in the OEM paths, be extra careful to follow step 5 below.
2. Remove the wire set from the carton and lay out according to size. Remove one lead starting from the rear right, and compare the length to the ones just removed. Select the one closest in

size and replace it in the same location.
3. Once the cylinder number location has been determined, snap a wire marker, provided with some sets, around the appropriate lead as it is being installed.

4. If you've bought the contourable sparkplug terminal (commonly called "Vari-Angle") type wire, you will note that the terminals may be bent by hand up to a 90 degree angle. Bend the terminal for maximum exhaust clearance. Push the Snap-Loc grip in until you feel a click, making sure of a solid connection.
5. After installing each lead, check for the following:
Wires should never be near moving engine parts, such as throttle linkage, alternator, fan, and so forth, which could cut or abrade them.

The engine of the vehicle with the wires attached becomes a moving unit. Make sure the wires, which are now rocking back and forth with the engine, do not rub against stationary body parts; that is, fenders, firewall, and so forth. Road grit on stationary parts can act like sandpaper on the wire insulation within 5,000 miles.

Avoid resting wire on exhaust headers or manifold. These wires are specially treated to resist heat, but a minimum of 3/8 inch (10 mm) air circulation is required to avoid premature deterioration.

6. When installing wire separators, be sure not to force wire straight into the separator. You must roll the wire into the space. This avoids any ripping from excessive force. Any lubricant helps as long as it will not leave residue. Sweat, light soapy water and evaporating oil are good. Engine oil or axle grease are bad because they remain on the wire and in time penetrate its insulation. By utilizing these separators, you can keep leads neat and orderly while protecting them from hot areas, cross-fire, and moving parts.

For those who like to do the best job possible, wire manufacturers have devised a way for installers to custom-lay their wires to the exact lengths they desire. These are known as universal wire sets. They are shipped twice as long as required but are terminated at both ends with sparkplug terminals and boots. The installer connects the longest lead to the sparkplug furthest from the distributor cap, and lays it in along the route he desires. When he gets to the distributor, he cuts the wire and terminates the distributor end himself, continuing to do that for each individual lead. In this way, with the factory terminating the critical sparkplug end, the installer custom fits the wires to his engine. Replace the wires one at a time to avoid cross-wiring the ignition, and push the terminals on tightly, listening for a click from the sparkplug end to be certain of full engagement. Certain experts feel that due to a condition called crossfire, you don't want to run the wires in cylinders 5 and 7 in General Motors V8 engines next to each other, and this is particularly true with wires that have less radio suppression in them. Cross firing is a possible situation where voltage and current in one plug wire will radiate into an adjacent wire core and induce a premature spark in a cylinder. If that cylinder is next in line to fire, this premature spark could appear as significant timing advance in the induced firing cylinder.

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