WHEN AN ENGINE WON'T START

Every engine requires four basic ingredients to start: sufficient cranking speed, good compression, adequate ignition voltage (with correct timing) and fuel (a relatively rich air/fuel mixture initially). So any time an engine fails to start, you can assume it lacks one of these four essential ingredients.

But which one?

To find out which one, you need to analyze the patient and get some additional information. If the engine won't crank, you're probably dealing with a starter or battery problem. Has the starter been acting up (unusual noises, slow cranking, etc.). Is this the first time the engine has failed to crank or start, or has it happened before? Has the starter, battery or battery cables been replaced recently? If so, what exactly was done and why? Has the battery been run down recently? Have there been any other electrical problems? The answers to these questions should shed some light on what's wrong and help focus your diagnostic efforts in a specific direction.

If an engine cranks but refuses to start, it lacks ignition, fuel or compression. Again, more questions. Was it running fine but quit suddenly? The most likely causes here would be a failed fuel pump, ignition module or broken overhead cam timing belt. Has the engine been getting progressively harder to start? If you get a yes to this question, further questioning about the vehicle's maintenance and repair history would be in order. Recent repairs might indicate defective parts or improper installation.

CONDUCTING THE POST MORTEM

On to the patient. How you conduct your post mortem will depend on the symptoms. We've already said the patient was dead on arrival, but will the engine still crank? And if it cranks, does it crank normally?

The first step in most cases would be to attempt a start. If nothing happens when you turn the key, check the battery to determine its state of charge. Many starters won't do a thing unless there's at least 10 volts available from the battery.

A low battery doesn't necessarily mean the battery is the problem, though. The battery may have been run down in an attempt to start the engine. Or, the battery's low state of charge may be the result of a charging system problem. Either way, the battery needs to be recharged and tested.

If the battery is low, the next logical step might be to try starting the engine with another battery or a charger. If the engine cranks normally and roars to life, you can assume the no start was due to a dead battery or a charging problem that allowed the battery to run down. If the battery accepts a charge and tests okay, checking the output of the charging system should help you identify any problems there.

A charging system that is working properly should produce a charging voltage of somewhere around 14 volts at idle with the lights and accessories off. When the engine is first started, the charging voltage should rise quickly to about two volts above base battery voltage, then taper off, leveling out at the specified voltage. The exact charging voltage will vary according to the battery's state of charge, the load on the vehicle's electrical system, and temperature. The lower the temperature, the higher will be the charging voltage. The higher the temperature, the lower the charging voltage. The charging range for a typical alternator might be 13.9 to 14.4 volts at 80 degrees F, but increase to 14.9 to 15.8 volts at subzero temperatures.

If the charging system isn't putting out the required voltage, is it the alternator or the regulator? Full fielding the alternator to bypass the regulator should tell you. If the charging voltage goes up when the regulator is bypassed, the problem is the regulator (or the engine computer in the case of computer-regulated systems). If there's no change in output voltage, the alternator is the culprit.

Many times one or more diodes in the alternator's rectifier assembly will have failed, causing a drop in the unit's output. The alternator will still produce current, but not enough to keep the battery fully charged. This type of failure will show up on an oscilloscope as one or more missing humps in the alternator's waveform. Most charging system analyzers can detect this type of problem.

CRANKING PROBLEMS

Should you discover a cranking problem when you attempt to start the engine, you can focus your attention on the starter. A quick way to diagnose cranking problems is to switch on the headlights and watch what happens when you attempt to start the engine. If the headlights go out, a poor battery cable connection may be strangling the flow of amps. All battery cable connections should be checked along with the engine-to-chassis ground straps.

Measuring the "voltage drop" across connections is a good way to find excessive resistance. A voltmeter check of the cable connections should show no more than 0.1 volt drop at any point, and no more than 0.4 volts for the entire starter circuit. A higher voltage drop would indicate excessive resistance and a need for cleaning or tightening.

Slow cranking can also be caused by undersized battery cables. Some cheap replacement cables have small gauge wire encased in thick insulation. The cables look the same size as the originals on the outside, but inside there isn't enough wire to handle the amps.

If the headlights continue to shine brightly when you attempt to start the engine and nothing happens (no cranking), voltage isn't reaching the starter. The problem here is likely an open or misadjusted park/neutral safety switch, a bad ignition switch, or a faulty starter relay or solenoid. Fuses and fusible links should also be checked because overloads caused by continuous cranking or jump starting may have blown one of these protective devices.

If the starter or solenoid clicks but nothing else happens when you attempt to start the engine, there may not be enough amps to spin the starter. Or the starter may be bad. A poor battery cable, solenoid or ground connection, or high resistance in the solenoid itself may be the problem. A voltage check at the solenoid will reveal if battery voltage is passing through the ignition switch circuit. If the solenoid or relay is receiving battery voltage but is not closing or passing enough amps from the battery to spin the starter motor, the solenoid ground may be bad or the contacts in the solenoid may be worn, pitted or corroded. If the starter cranks when the solenoid is bypassed, your patient needs a new solenoid not a starter.

Most engines need a cranking speed of 100 to 200 rpm to start, so if the starter is weak and can't crank the engine fast enough to build compression the fire won't light. In some instances, a weak starter may crank the engine fast enough but prevent it from starting because it draws all the power from the battery and doesn't leave enough for the injectors or ignition system.

If the lights dim and there's little or no cranking when you attempt to start the engine, the starter may be locked up, dragging or suffering from high internal resistance, worn brushes, shorts or opens in the windings or armature. A starter current draw test will tell you if the starter is pulling too many amps.

A good starter will normally draw 60 to 150 amps with no load on it, and up to 200 amps or more while cranking the engine. The no load amp draw depends on the rating of the starter while the cranking amp draw depends on the displacement and compression of the engine. Always refer to the OEM specs for the exact amp values. Some "high torque" GM starters, for example, may have a no load draw of up to 250 amps.

An unusually high current draw and low free turning speed or cranking speed typically indicates a shorted armature, grounded armature or field coils, or excessive friction within the starter itself (dirty, worn or binding bearings or bushings, a bent armature shaft or contact between the armature and field coils). The magnets in permanent magnet starters can sometimes break or separate from the housing and drag against the armature.

A starter that does not turn at all and draws a high current may have a ground in the terminal or field coils, or a frozen armature. On the other hand, the start may be fine but can't crank the engine because the engine is seized or hydrolocked. So before you condemn the starter, try turning the engine over by hand. Won't budge? Then it's going to take a lot more than a starter to revive this patient.

A starter that won't spin at all and draws zero amps has an open field circuit, open armature coils, defective brushes or a defective solenoid. Low free turning speed combined with a low current draw indicates high internal resistance (bad connections, bad brushes, open field coils or armature windings).

If the starter motor spins but fails to engage the flywheel, the cause may be a weak solenoid, defective starter drive or broken teeth on the flywheel. A starter drive that is on the verge of failure may engage briefly but then slip. Pull the starter and inspect the drive. It should turn freely in one direction but not in the other. A bad drive will turn freely in both directions or not at all.

CRANKS BUT WON'T START

When you have an engine that cranks normally but won't start, you need to check for ignition, fuel and compression. Ignition is easy enough to check with a spark tester or by positioning a plug wire near a good ground. No spark? The most likely causes would be a failed ignition module, distributor pickup or Hall effect crankshaft position sensor.

A tool such as an Ignition System Simulator can speed the diagnosis by quickly telling you if the ignition module and coil are capable of producing a spark with a simulated timing input signal. If the simulated signal generates a spark, the problem is a bad distributor pickup or crankshaft position sensor. No spark would point to a bad module or coil. Measuring the coil's primary and secondary resistance can rule out that component as the culprit.

Module problems as well as pickup problems are often caused by loose, broken or corroded wiring terminals and connectors. Older GM HEI ignition modules are notorious for this. If you're working on a distributorless ignition system with a Hall effect crankshaft position sensor, check the sensor's reference voltage (VRef) and ground. The sensor must have 5 volts or it will remain permanently off and not generate a crank signal (which should set a fault code). Measure VRef between the sensor's power supply wire and ground (use the engine block for a ground, not the sensor's ground circuit wire). Don't see 5 volts? Then check the sensor's wiring harness for loose or corroded connectors. A poor ground connection will have the same effect on the sensor's operation as a bad VRef supply. Measure the voltage drop between the sensor's ground wire and the engine block. More than a 0.1 voltage drop indicates a bad ground connection. Check the sensor mounting and wiring harness.

If a Hall effect crank sensor has power and ground, the next thing to check would be its output. With nothing in the sensor window, the sensor should be "on" and read 5 volts (VRef). Measure the sensor's D.C. output voltage between the sensor's signal output wire and ground (use the engine block again, not the ground wire). When the engine is cranked, the sensor's output should drop to zero every time the shutter blade, notch, magnetic button or gear tooth passes through the sensor. No change in voltage would indicate a bad sensor that needs to be replaced.

If the primary side of the ignition system seems to be producing a trigger signal for the coil but the voltage isn't reaching the plugs, a visual inspection of the coil tower, distributor cap, rotor and plug wires should be made to identify any defects that might be preventing the spark from reaching its intended destination.

SPINS, SPARKS BUT WON'T START

If you see a good hot spark when you crank the engine, but it won't start, check for fuel. On older carbureted engines, pump the throttle linkage and look for fuel squirting into the carburetor throat. No fuel? Possible causes include a bad fuel pump, stuck needle valve in the carburetor, a plugged fuel line or fuel filter.

On newer vehicles with electronic fuel injection, connect a pressure gauge to the fuel rail to see if there's any pressure in the line. No pressure when the key is on? Check for a failed fuel pump, pump relay, fuse or wiring problem. On Fords, don't forget to check the inertia safety switch which is usually hidden in the trunk or under a rear kick panel. The switch shuts off the fuel pump in an accident. So if the switch has been tripped, resetting it should restore the flow of fuel to the engine. Lack of fuel can also be caused by obstructions in the fuel line or pickup sock inside the tank. And don't forget to check the fuel gauge. It's amazing how many no starts are caused by an empty fuel tank.

There's also the possibility that the fuel in the tank may be heavily contaminated with water or overloaded with alcohol. If the customer just filled up and his engine died, suspect bad gas.

On EFI-equipped engines, fuel pressure in the line doesn't necessarily mean the fuel is being injected into the engine. Listen for clicking or buzzing that would indicate the injectors are working. No noise? Check for voltage and ground at the injectors. A defective ECM may not be driving the injectors, or the EFI power supply relay may have called it quits. Some EFI-systems rely on input from the camshaft position sensor to generate the injector pulses. Loss of this signal could prevent the system from functioning.

Even if there's fuel and it is being delivered to the engine, a massive vacuum leak could be preventing the engine from starting. A large enough vacuum leak will lean out the air/fuel ratio to such an extent that the mixture won't ignite. An EGR valve that's stuck wide open, a disconnected PCV hose, loose vacuum hose for the power brake booster, or similar leak could be the culprit. Check all vacuum connections and listen for unusual sucking noises while cranking.

FUEL AND SPARK, BUT NO START

An engine that has fuel and spark, no serious vacuum leaks and cranks normally should start. So if it doesn't compression (or the lack thereof) must be the problem. If we're talking an overhead cam engine with a rubber timing belt, a broken belt would be the most likely cause especially if the engine has a lot of miles on it. Most OEMs recommend replacing the OHC timing belt every 60,000 miles for preventative maintenance, but many belts are never changed. Eventually they break, and when they do the engine stops dead in its tracks. And in engines that lack sufficient valve-to-piston clearance as many import engines and some domestic engines do, it also causes extensive damage (bent valves and valvetrain components & sometimes cracked pistons).

Overhead cams can also bind and break if the head warps due to severe overheating, or the cam bearings are starved for lubrication. A cam seizure may occur during a subzero cold start if the oil in the crankcase is too thick and is slow to reach the cam (a good reason for recommending 5W-20 or 5W-30 for winter driving). High rpm cam failure can occur if the oil level is low or the oil is long overdue for a change.

With high mileage pushrod engines, the timing chain may have broken or slipped. Either type of problem can be diagnosed by doing a compression check and/or removing a valve cover and watching for valve movement when the engine is cranked.

A blown head gasket may prevent an engine from starting if the engine is a four cylinder with two dead cylinders. But most six or eight cylinder engines will sputter to life and run roughly even with a blown gasket. The gasket can, however, allow coolant to leak into the cylinder and hydrolock the engine.