Alternator and starter diagnostics

There's always more to learn
Part I

Editor's note: The following is reprinted with permission from Westling Manufacturing's "Alternator and Starter Diagnostic Manual" which was published in 2003. Westling was an industry leader for three generations, and this valuable troubleshooting information deals with vehicles still on the road today.

Battery lead testing

The battery must be at three fourths charged before testing. Load the battery to half the CCA for 15 seconds.

Specific Gravity Chart	
1.265	100% charge
1.225	75% charge
1.190	50% charge
1.155	25% charge
1.120	discharged

Open Circuit Battery Voltage	
12.6 or higher	100% charge
12.4 or higher	75% charge
12.2 or higher	50% charge
12.0 or higher	25% charge
11.9 or lower	discharged

Maintain the specified load for 15 seconds. The voltage reading should be above 9.6 volts. The reading may be somewhat lower if the ambient temperature is less than 21 degrees C (70 degrees F). Thus, a battery with an adequate capacity to crank and start an engine may have voltage readings as listed.

Approximate Temperature	Minimum Voltage
21.0°C (70°F)	9.6
15.5°C (60°F)	9.5
10.0°C (50°F)	9.4
3.0°C (40°F)	9.3
-1.0°C (30°F)	9.1
-6.6°C (20°F)	8.9
-12.0°C (10°F)	8.7
-17.8°C (0°F)	8.5

If the battery does not reach the minimum prescribed voltage, charge it for 25 minutes at 35 amperes. Then repeat the test. If it still does not come up to minimum voltage specifications, replace the battery.

Starter cranking amps

How many amps to crank an engine?

How much power to crank an engine?

Depends on: engine size, engine temperature, oil viscosity, voltage to starter, cable size and condition.

Power is measured in watts. Volts times amps equals watts; 746 watts equals one HP.

Typical actual measurements are shown on right.

Engine	Starter Type	Temperature	Volts	Amps	Watts
3.0 Ford	PMGR 1.4 KW	30 degrees	10.5	150	1575
3.0 Ford	PMGR 1.4 KW	Operating temp.	10.5	85	892
4.9 Ford	Direct 4" mod	25 degrees	10.2	300	3060
4.9 Ford	Direct 4" mod	Operating temp.	11.0	200	2200
3.1 Chev	Direct 5 mt	30 degrees	10.0	165	1650
350 Chev	Direct 10 mt	30 degrees	10.5	250	2625
350 Chev	Direct 10 mt	Operating temp.	10.5	235	2468
350 Chev	PMGR	Operating temp.	11.0	170	1870
3.0 Chrys	PMGR	Operating temp.	10.8	160	1728
5.9 Chrys	PMGR	Operating temp.	11.0	175	1925

Diesel starting systems

Diesel cranking systems are alot more critical than gas engines because they must crank the engine at about 200 rpm to ensure enough heat is developed in the combustion chamber to ignite the fuel.

Also, it is imperative that the glow plug system and fuel injection system are working properly. The engine itself must be in good mechanical condition.

Voltage drop testing is very important to eliminate any marginal connections that will reduce cranking speed.

Voltage drop tests should be done in the same way as gasoline engines using the same specs, .1 volt per connection.

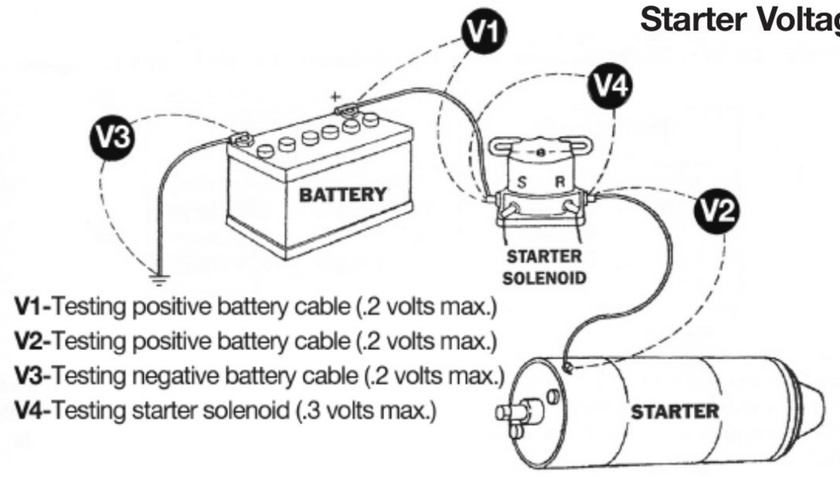
If one battery in a set is bad and needs to be replaced, then always replace batteries in sets or pairs, because one weaker battery in the system will react like a voltage drop, causing the amperage to increase, cranking speed to drop, and longer crank time. This is what often burns up cranking motors.

Some typical measurements for diesel systems are shown on page 22.

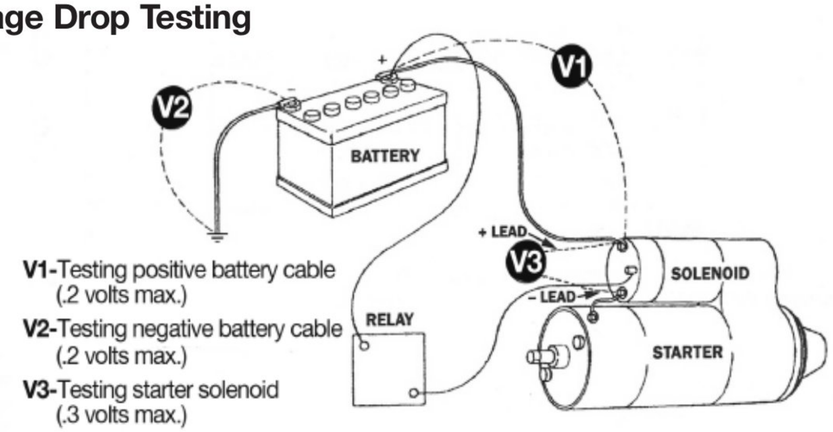
Electrical "problem identifier" list

The following is a "problem identifier"

Starter Voltage Drop Testing



Voltmeter hookups for voltage-drop testing a Ford-type cranking circuit.



Voltmeter hookups for voltage-drop testing a solenoid-type cranking circuit.

Diesel System Measurements

Engine	Starter Type	Temp	Volts	Watts
6.2 GM	Direct 27MT	60	10.5	500
6.5 GM	OSGR 28MT	60	10.8	370
7.3 Ford	OSGR MITS	60	10.5	380

list for failures and possible conditions or reasons.

Alternator failures/possible causes—

All alternator parts are subject to failure due to excessive heat. Underhood temperatures on late model vehicles are much higher due to tighter clearances and emission systems. Idling and stop and go city traffic will increase these temperatures and reduce the cooling air flow.

If high current draw accessories are added to a vehicle, or if a vehicle is converted to special use such as a police car, fire truck, tow truck, or snowplow, then a higher output alternator should be installed if possible.

Diodes: Overheating caused by high output for longer than normal periods of time.

Example 1: Starting a car with a totally dead battery and making the alternator recharge the battery. This condition is aggravated by using accessories at the same time, such as lights, a/c, or defroster.

Example 2: Adding accessories that draw high amperage, such as extra driving lights, high output stereo, snowplows, etc.

Example 3: Plugged cooling fins on heat sinks.

Stators: High temperatures burn the stator insulation causing them to short out. The same causes as diode failures.

Broken brushes: Usually caused by improper assembly. Often done in the field when an alternator is "reclocked."

Regulators: Voltage spikes are the number one killer. Caused by any kind of electrical arcing.

Example 1: Stator wires burned and touching one another.

Example 2: Removing a battery cable with the engine running causes extreme voltage buildup which stresses the regulator. Never do this for an alternator function test.

Example 3: Connecting battery cables backwards, including booster cables.

Example 4: Any failure of another electrical coil or component, such as an open suppression diode in an a/c cycling switch.

Starter failures and possible causes

Broken drive end housings: Usually caused by high torque loads.

Example 1: Engine "kick back" because of over advanced timing, or a wet or cracked distributor cap.

Example 2: Failure to reinstall the starter support strap on some models.

Example 3: Loose starter bolts.

Example 4: Worn, damaged, or missing teeth on ring gear.

Drive teeth milling: Milling wear on outside edge of teeth (or top edge) usually caused by improper shimming. The pinion teeth are too far away from the flywheel. This can also be caused by worn teeth on the flywheel.

Milling on the front edge of the teeth happens when the drive is not engaging the flywheel. This can be caused by improper shimming. Adding shims will correct this problem on Delco starters.

Solenoids: Solenoids generally fail due to excessive heat which shorts out the windings. This can be caused by failing to reinstall a starter heat shield.

Starter drive slipping: Sometimes caused by excessive pinion over-run.

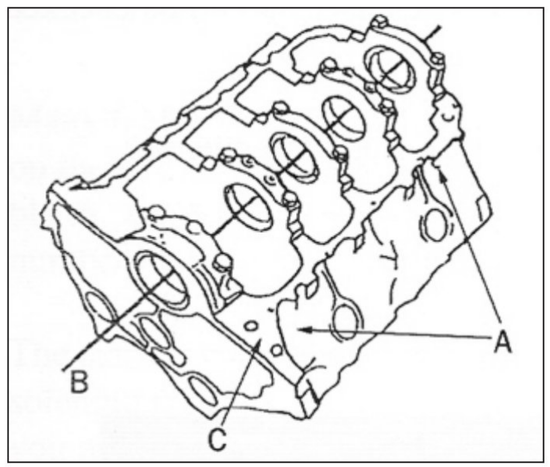
Example: Holding the ignition to start after the engine is running.

Starter drive with broken pinion teeth: Can be caused by excessive torque by engine kick back due to over advanced timing or wet or cracked distributor cap. Also caused by damaged or missing teeth on ring gear.

Delco starter pad mount

Memo from Gene Reierson, Westling quality control manager:

Previously I wrote a bulletin explaining a remedy for eliminating the "grinding" on some impossible-to-shim Delco starters. The remedy was to install a cast iron drive end starter (part no. 72 9105S). Since that time I have accumulated more information on why the problem exists.



After the ending block is cast, it must be machined for all parts attached. One of the first surfaces machined is the oil pan railing (letter A). This is also the same surface as letter C, which is the pad mount for the starter. The next machining is the crankshaft bearing surfaces. The main bearing caps are machined flat on the side that mates to the pan rail surface. Then the inside of the caps and block are machined for the bearing diameter, sometimes referred to as align boring, which is B in the illustration.

Since the blocks are not exactly the same after being cast, the dimensions between the pad mount (C) and crankshaft centerline (B) will vary. This changes the clearances between the drive pinion teeth and flywheel teeth. This difference may be adjusted by the use of shims. The other factor which may change the clearance is the height of the mounting surface of the starter drive end housing.

I have also learned that blocks and starter housings may have been cast in as many as three different foundries. With all of these variables, it is not uncommon for a Delco starter to need to be shimmed to attain proper drive pinion to flywheel clearance.

Most shims are .015 thick and when installed, will increase pinion clearance about .005. Remember that too little clearance will cause noise, drive engage-

ment problems, and premature bushing and drive failure. Too much clearance causes noise and will chip or wear out the pinion teeth and/or flywheel teeth. The proper clearance is .025 to .060.

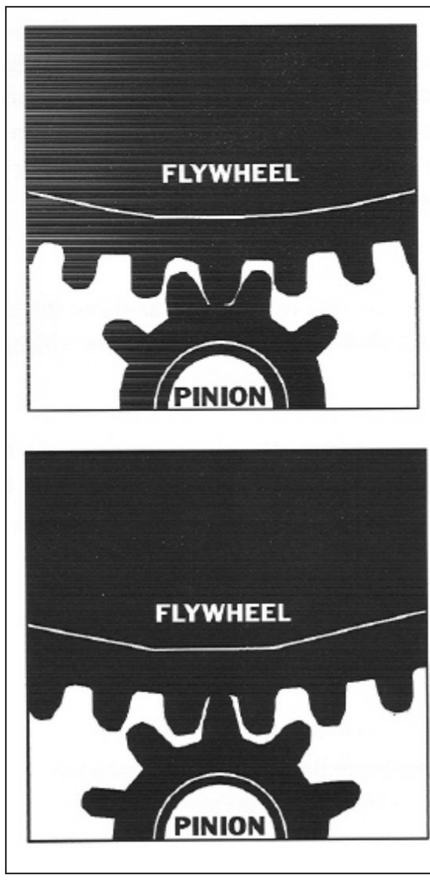
I hope this information explains and helps you to understand the Delco pad mount starter.

Starter shimming measurement

Delco-Remy (GM) pad-mount starters

The GM specification for pinion clearance is .020 to .060. Check the clearance between the bottom of the ring gear and top of pinion.

Why? Because some ring gear teeth may be longer than the pinion tooth. Clearance should be checked at three places around ring gear.



Why? The ring gear may be out of round. It could be within specs in one area and too much or too little on the opposite side.

A common paperclip is about .032 and will work as a gauge.

For starters that have too much pinion clearance, after all shims are removed, the drive end housing must be milled on the mounting pad.

Use Westling part no. 72 9106S 080 for three-eighth inch mounting bolts; part no. 72 9134S 080 for 10mm mounting bolts; 72 8153S 080 for 10mm mounting bolts (small case 5MT starter).

The .080 milled housing can now be shimmed to obtain the correct clearance.

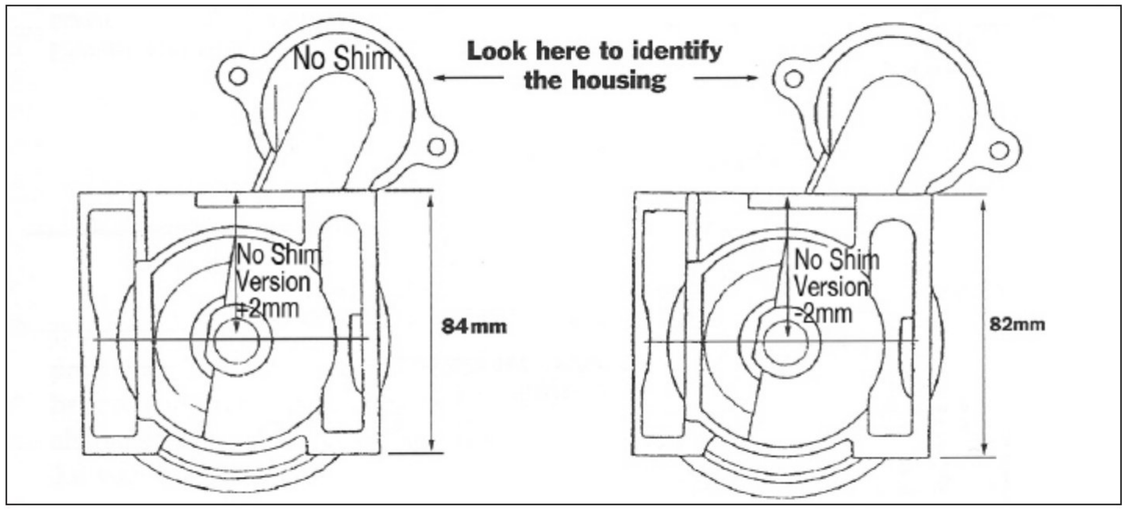
Shim versus no-shim housings

A special precaution: Shim/no-shim housings affecting these part numbers: 72 5010S, 72 5047S, 72 5054S, 72 8295S, 72 8296S and 72 9123S.

Many GM four and six cylinder engines have first and second production starters that have different dimensions on the pad mount. One design starter uses an .080 shim (2mm) and the other does not. It is not possible to "break out" these differences by production dates. Therefore, the starter shipped for this part number may be either style.

The starters can interchange with one another only if observing these rules. Look at the rear of the solenoid mounting casting. If the words "No Shim" in raised letters are cast into the housing, then you must not use an .080 shim.

If the casting does not have the words "no shim," then you must use a .080 shim.



Note: Either style starter may still require the additional use of standard .015 shims to fine tune the clearance.

These housings can be further identified by measuring the width of the mounting pad as shown above.

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See Part II in the February issue.

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