

SECTION : 1E

ENGINE ELECTRICAL

CAUTION : *Disconnect the negative battery cable before removing or installing any electrical unit or when a tool or equipment could easily come in contact with exposed electrical terminals. Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be in LOCK unless otherwise noted.*

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SPECIFICATIONS

STARTER SPECIFICATIONS

Application	Description
Starter (1.6L DOHC) No Load Test @ 12.0 volts Drive Pinion Speed at:	1.2 Kw 90 amps Max Min 2,600 rpm
Starter (1.8L DOHC) No Load Test @ 12.0 volts Drive Pinion Speed at:	1.4 Kw 85 amps Max Min 2,550 rpm
Solenoid Hold-in Windings @ 12.0 volts Pull-in Windings @ 12.0 volts	12–20 amps 60 – 90 amps

BATTERY SPECIFICATIONS

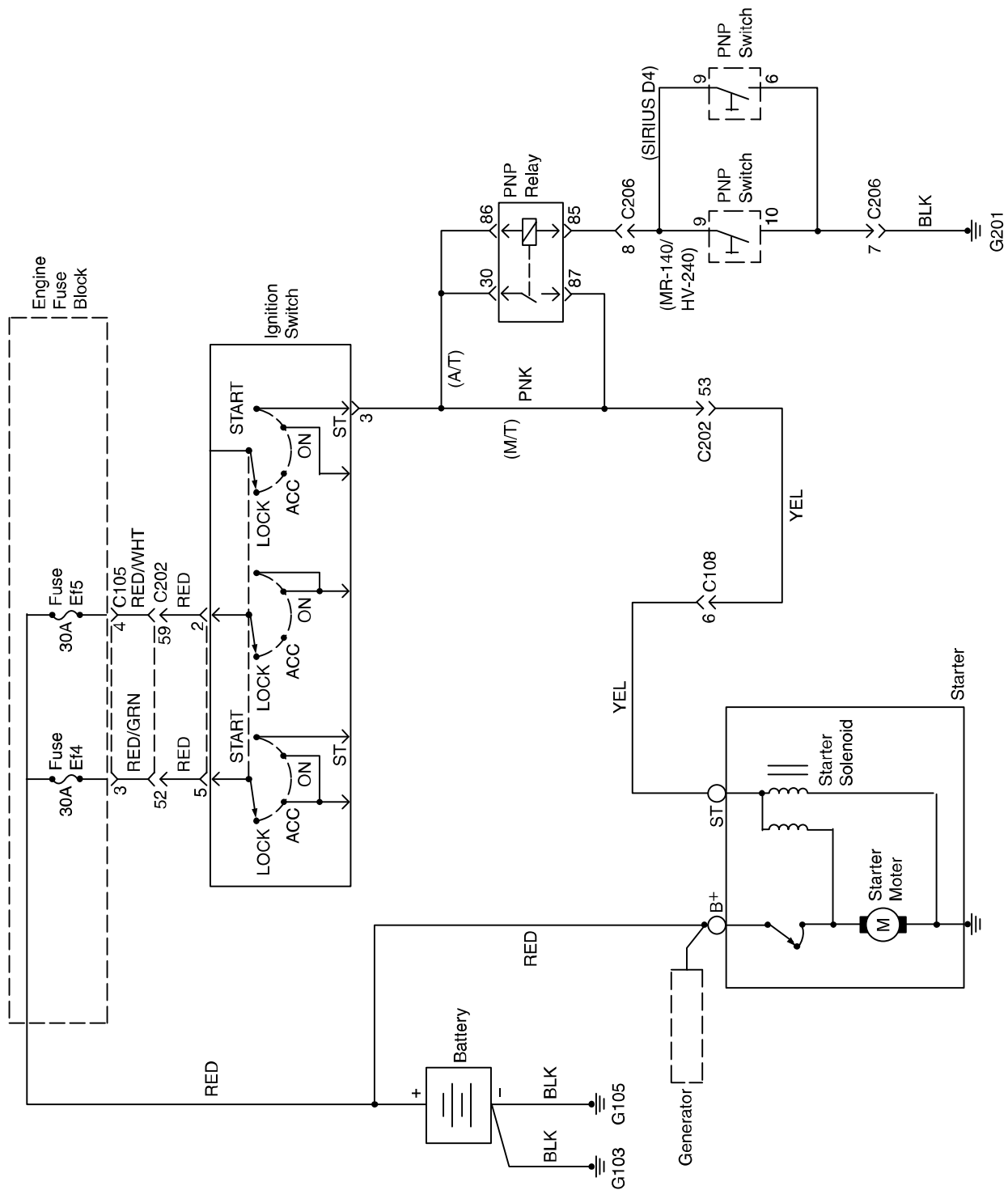
Application	Description
Cold Cranking Amps	610 amps
Cold Cranking Amps (Extremely Cold Area)	610 amps
Reserve Capacity Minimum	90 minutes
Load Test	270 amps
Minimum Voltage: 9.6 9.4 9.1 8.8 8.5 8.0	Estimated Temperature: 21° C (69.8° F) 20° C (68° F) 0° C (32° F) –10° C (14° F) –18° C (0° F) Below –18° C (Below 0° F)

FASTENER TIGHTENING SPECIFICATIONS

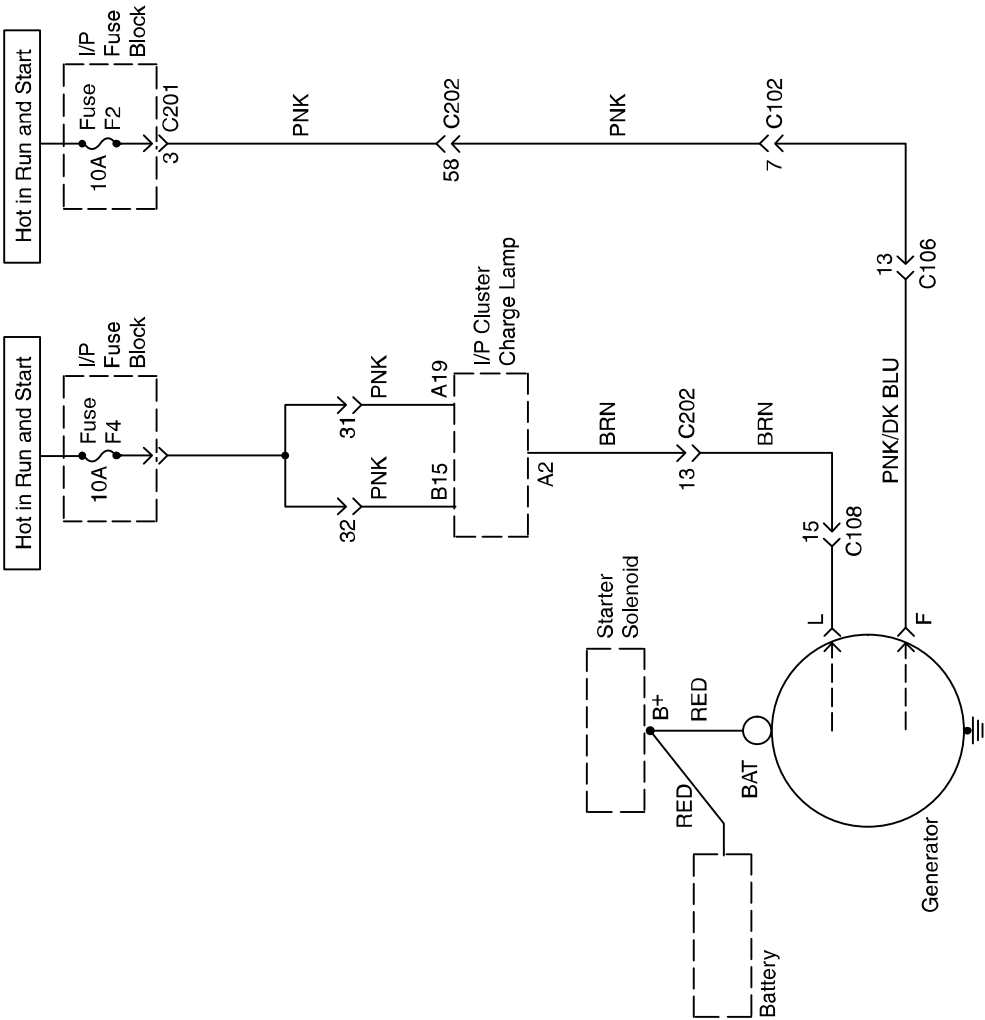
Application	N•m	Lb-Ft	Lb-In
Battery Cable Nuts	5	–	44
Battery Carrier Tray Lower, Side and Upper Bolts	20	15	–
Battery Retainer Clamp-to-Battery Rod Nuts	5	–	44
Generator Drive End Bearing Nut	81	60	–
Generator Lower Bracket-to-Engine Block Bolts (1.8L Engine)	37	27	–
Generator Lower Bracket-to-Generator Nut (1.4L/1.6L Engine)	25	18	–
Generator Through-Bolts	10	–	89
Generator-to-Intake Manifold and Cylinder Head Support Bracket Bolts (1.8L Engine)	37	27	–
Generator-to-Intake Manifold Strap Bracket Bolt (1.8L Engine)	22	16	–
Generator Upper Support Bracket Bolt (1.4L/1.6L Engine)	20	15	–
Intake Manifold-to-Cylinder Body Strap Bracket Bolts (Over Starter)	22	16	–
Starter Field Connector Nut	12	–	106
Starter Lower Mounting Stud Ground Wire Nut	12	–	106
Starter Mounting Studs/Nuts (1.4L/1.6L Engine)	25	18	–
Starter Solenoid Assembly Screws	8	–	71
Starter Solenoid Terminal-to-Battery Cable Terminal Nut	5.5	–	49
Starter Solenoid Terminal-to-Ignition Solenoid Terminal Nut	5.5	–	49
Starter Through-Bolts	6	–	53
Starter-to-Engine Block Mounting Bolt (1.8L Engine)	45	33	–
Starter-to-Engine Transaxle Mounting Bolt (1.8L Engine)	50	37	–

SCHEMATIC AND ROUTING DIAGRAMS

STARTING SYSTEM



CHARGING SYSTEM



DIAGNOSIS

NO CRANK

Step	Action	Value(s)	Yes	No
1	1. Turn the headlamps ON. 2. Turn the dome lamps ON. 3. Turn the ignition to START. Did the lights dim or go out?	–	Go to <i>Step 2</i>	Go to <i>Step 8</i>
2	Check the battery state of charge. Is the green eye showing from the built-in hydrometer?	–	Go to <i>Step 3</i>	Go to "Charging Procedure"
3	1. Connect the voltmeter positive lead to the positive battery terminal. 2. Connect the voltmeter negative lead to the negative battery terminal. 3. Turn the ignition to START. Does the voltmeter indicate the value specified?	< 9.6 v	Go to "Charging Procedure"	Go to <i>Step 4</i>
4	1. Connect the voltmeter negative lead to the negative battery terminal. 2. Connect the positive voltmeter lead to the engine block. Does the voltmeter indicate the value specified?	> 0.5 v	Go to <i>Step 5</i>	Go to <i>Step 6</i>
5	Clean, tighten, or replace the negative battery cable. Is the repair complete?	–	System OK	–
6	1. Connect the voltmeter positive lead to the starter "B+" terminal. 2. Connect the voltmeter negative lead to the negative battery terminal. Does the voltmeter indicate the value specified?	< 9 v	Go to <i>Step 7</i>	Go to <i>Step 13</i>
7	Clean, tighten, or replace the positive battery cable. Is the repair complete?	–	System OK	–
8	Inspect the engine fuse block fuse Ef5. Is the fuse OK?	–	Go to <i>Step 10</i>	Go to <i>Step 9</i>
9	Inspect the engine fuse block fuse Ef4. Is the fuse OK?	–	System OK	–
10	Check the connection at the starter "ST" terminal. Is the connection OK?	–	Go to <i>Step 12</i>	Go to <i>Step 11</i>
11	Clean or tighten the connection as needed. Is the repair complete?	–	System OK	–
12	1. Connect the voltmeter positive lead to the starter "ST" terminal. 2. Connect the voltmeter negative lead to the negative battery terminal. 3. Turn the ignition to START. Does the voltmeter indicate the value specified?	< 7 v	Go to <i>Step 13</i>	Go to <i>Step 14</i>
13	Repair or replace the starter as needed. Is the repair complete?	–	System OK	–
14	Determine the type of transaxle on the vehicle. Is the vehicle equipped with an automatic transaxle?	–	Go to <i>Step 15</i>	Go to <i>Step 32</i>

Step	Action	Value(s)	Yes	No
15	1. Disconnect the neutral safety back-up (PNP) switch. 2. Connect the negative voltmeter lead to the PNP switch connector terminal E. 3. Connect the positive voltmeter lead to battery positive. Does the voltmeter indicate the value specified?	11–14 v	Go to <i>Step 16</i>	Go to <i>Step 19</i>
16	1. Jumper the PNP switch connector terminals 9 and 10. 2. Connect the negative voltmeter lead to the ignition switch. 3. Connect the positive voltmeter lead to battery positive. Does the voltmeter indicate the value specified?	11–14 v	Go to <i>Step 17</i>	Go to <i>Step 18</i>
17	Replace the neutral safety backup switch. Is the repair complete?	–	System OK	–
18	Repair the wire as needed. Is the repair complete?	–	System OK	–
19	Repair the open wire between the PNP switch connector terminal E and ground. Is the repair complete?	–	System OK	–
20	1. Connect the voltmeter positive lead to the ignition switch connector terminal 3 by backprobing the connector. 2. Connect the voltmeter negative lead to ground. Does the voltmeter indicate the value specified?	11–14 v	Go to <i>Step 22</i>	Go to <i>Step 21</i>
21	Repair the open in the wiring between the engine block fuse Ef5 and the ignition switch connector terminal 2. Is the repair complete?	–	System OK	–
22	1. Connect the voltmeter positive lead to the ignition switch connector terminal 3 by backprobing the connector. 2. Connect the voltmeter negative lead to ground. 3. Turn the ignition to START. Does the voltmeter indicate the value specified?	11–14 v	Go to <i>Step 23</i>	Go to <i>Step 27</i>
23	1. Connect the voltmeter positive lead to the ignition switch connector terminal 3 by backprobing the connector. 2. Connect the voltmeter negative lead to ground. Does the voltmeter indicate the value specified?	11–14 v	Go to <i>Step 25</i>	Go to <i>Step 24</i>
24	Repair the open in the wiring between the engine block fuse Ef5 and the ignition switch connector terminal 3. Is the repair complete?	–	System OK	–
25	1. Connect the voltmeter positive lead to the ignition switch connector terminal 3 by backprobing the connector. 2. Connect the voltmeter negative lead to ground. 3. Turn the ignition to START. Does the voltmeter indicate the value specified?	11–14 v	Go to <i>Step 26</i>	Go to <i>Step 27</i>

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Step	Action	Value(s)	Yes	No
26	Repair the open in the wiring between the ignition switch connector terminal 3 and the starter "ST" terminal. Is the repair complete?	–	System OK	–
27	Replace the ignition switch. Is the repair complete?	–	System OK	–

STARTER MOTOR NOISE

To correct starter motor noise during starting, use the following procedure:

Checks	Action
Check for a high-pitched whine during cranking, before the engine fires. The engine cranks and fires properly.	The distance is too great between the starter pinion and the flywheel. Shimming the starter toward the flywheel is required.
Check for a high-pitched whine after the engine fires, as the key is being released. The engine cranks and fires properly. This intermittent complaint is often diagnosed as "starter hang-in" or "solenoid weak."	The distance is too small between the starter pinion and the flywheel. Shimming the starter away from the flywheel is required.
Check for a loud "whoop" after the engine fires but while the starter is still held engaged. The sound is like a siren if the engine is revved while the starter is engaged.	The most probable cause is a defective clutch. A new clutch will often correct this problem.
Check for a "rumble," a "growl," or, in severe cases, a "knock" as the starter is coasting down to a stop after starting the engine.	The most probable cause is a bent or unbalanced starter armature. A new armature will often correct this problem.

If the complaint is noise, correction can be achieved by proper shimming as follows:

1. Check for a bent or a worn flywheel.
2. Start the engine and carefully touch the outside diameter of the rotating flywheel ring gear with chalk or a crayon to show the high point of the tooth run-out. Turn the engine OFF and rotate the flywheel so that the marked teeth are in the area of the starter pinion gear.
3. Disconnect the negative battery cable to prevent cranking the engine.
4. Check the pinion-to-flywheel clearance by using a wire gauge of 0.5 mm (0.02 inch) minimum thickness (or diameter). Center a pinion tooth between two flywheel teeth and the gauge. Do not gauge in the corners, where a misleading larger dimension may be observed. If the clearance is under this minimum, shimming the starter away from the flywheel is required.
5. If the clearance approaches 1.5 mm (0.06 inch) or more, shimming the starter toward the flywheel is required. This condition is generally the cause of broken flywheel teeth or the starter housing. Shim the starter toward the flywheel by shimming only the outboard starter mounting pad. A shim of 0.40 mm (0.016 inch) thickness at this location will decrease the clearance by approximately 0.30 mm (0.012 inch). If normal starter shims are not available, plain washers or other suitable material may be used as shims.

BATTERY LOAD TEST

1. Check the battery for obvious damage, such as a cracked or broken case or cover, which could permit the loss of electrolyte. If obvious damage is noted, replace the battery.

CAUTION : *Do not charge the battery if the hydrometer is clear or light yellow. Instead, replace the battery. If the battery feels hot, or if violent gassing or spewing of electrolyte through the vent hole occurs, discontinue charging or reduce the charging rate to avoid personal injury.*

2. Check the hydrometer. If the green dot is visible, go to the load test procedure. If the indicator is dark but green is not visible, charge the battery. For charging a battery removed from the vehicle, refer to "Charging a Completely Discharged Battery" in this section.
3. Connect a voltmeter and a battery load tester across the battery terminals.
4. Apply a 300-ampere load for 15 seconds to remove any surface charge from the battery.
5. Remove the load.
6. Wait 15 seconds to let the battery recover, and apply a 270-ampere load.

Important : The battery temperature must be estimated by touch and by the temperature condition the battery has been exposed for the preceding few hours.

7. If the voltage does not drop below the minimum listed, the battery is good and should be reinstalled. If the voltage is less than the minimum listed, replace the battery. Refer to "Battery Specifications" in this section.

GENERATOR OUTPUT TEST

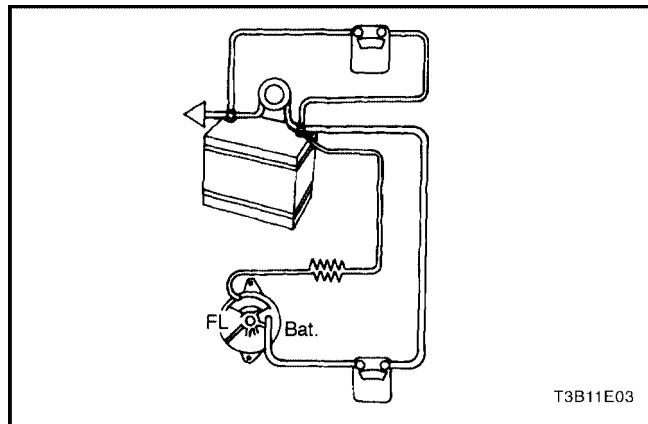
1. Perform the generator system test. Refer to "Generator System Check" in this section.
2. Replace the generator if it fails that test. Refer to "Generator" in the On-Vehicle Service portion of this section. If it passes the test, perform the on-vehicle output check which follows.

Important : Always check the generator for output before assuming that a grounded "L" terminal circuit has damaged the regulator.

3. Attach a digital multimeter, an ammeter, and a carbon pile load to the vehicle.

Important : Be sure the vehicle battery is fully charged, and the carbon pile load is turned off.

4. With the ignition switch in the OFF position, check and record the battery voltage.
5. Remove the harness connector from the generator.
6. Turn the ignition to RUN with the engine not running. Use a digital multimeter to check for voltage in the harness connector "L" terminal.
7. The reading should be near the specified battery voltage of 12 volts. If the voltage is too low, check the indicator "L" terminal circuits for open and grounded circuits causing voltage loss. Correct any open wires, terminal connections, etc., as necessary. Refer to "Charging System" in this section.
8. Attach the generator harness connector.
9. Run the engine at a moderate idle, and measure the voltage across the battery terminals. The reading should be above that recorded in step 14, but less than 16 volts. If the reading is over 16 volts or below the previous reading, replace the generator. Refer to "Generator" in the On-Vehicle Service section.
10. Run the engine at a moderate idle, and measure the generator amperage output.
11. Turn on the carbon pile, and adjust it to obtain the maximum amps while maintaining the battery voltage above 13 volts.
12. If the reading is within 15 amps of the generator's rating noted on the generator, the generator is good. If not, replace the generator. Refer to "Generator" in the On-Vehicle Service section.
13. With the generator operating at the maximum output, measure the voltage between the generator housing and the battery negative terminal. The voltage drop should be 0.5 volt or less. If the voltage drop is more than 0.5 volt, check the ground path from the generator housing to the negative battery cable.
14. Check, clean, tighten, and recheck all of the ground connections.



GENERATOR SYSTEM CHECK

When operating normally, the generator indicator lamp will come on when the ignition is in RUN position and go out when the engine starts. If the lamp operates abnormally or if an undercharged or overcharged battery condition occurs, the following procedure may be used to diagnose the charging system. Remember that an undercharged battery is often caused by accessories being left on overnight or by a defective switch that allows a lamp, such as a trunk or a glove box lamp, to stay on.

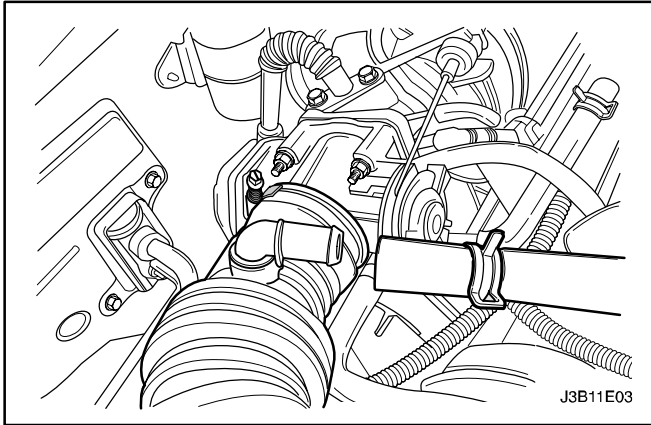
Diagnose the generator with the following procedure:

1. Visually check the belt and the wiring.
2. With the ignition in the ON position and the engine stopped, the charge indicator lamp should be on. If not, detach the harness at the generator and ground the "L" terminal in the harness with a 5-ampere jumper lead.
 - If the lamp lights, replace the generator. Refer to "Generator" in the On-Vehicle Service section.
 - If the lamp does not light, locate the open circuit between the ignition switch and the harness connector. The indicator lamp bulb may be burned out.
3. With the ignition switch in the ON position and the engine running at moderate speed, the charge indicator lamp should be off. If not, detach the wiring harness at the generator.
 - If the lamp goes off, replace the generator. Refer to "Generator" in the On-Vehicle Service section.
 - If the lamp stays on, check for a short to ground in the harness between the connector and the indicator lamp.

Important : Always check the generator for output before assuming that a grounded "L" terminal circuit has damaged the regulator. Refer to "Generator" in the Unit Repair section.

MAINTENANCE AND REPAIR

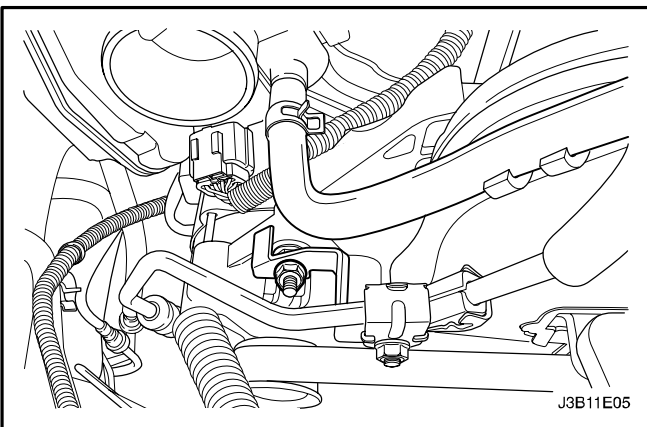
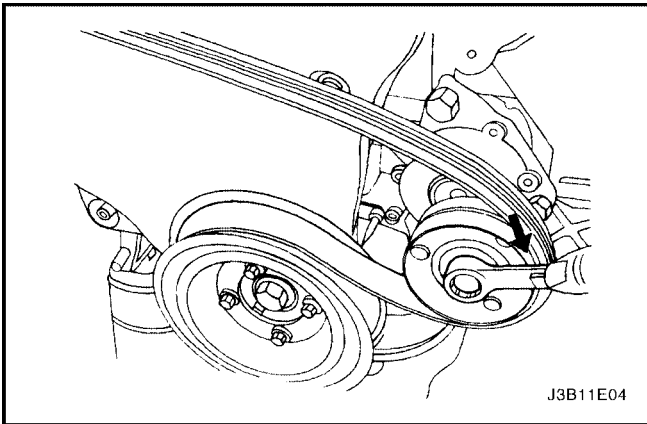
ON-VEHICLE SERVICE

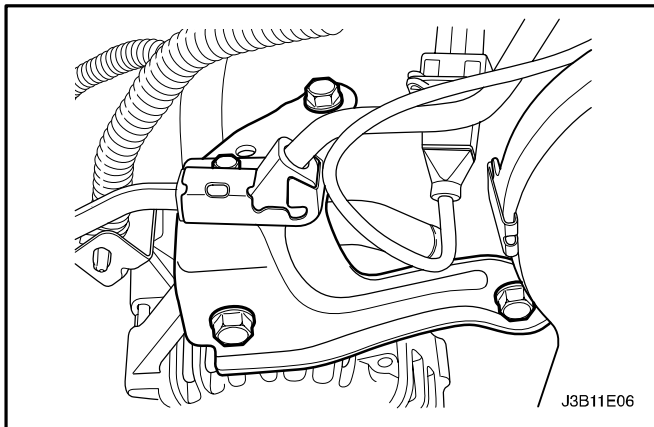


GENERATOR

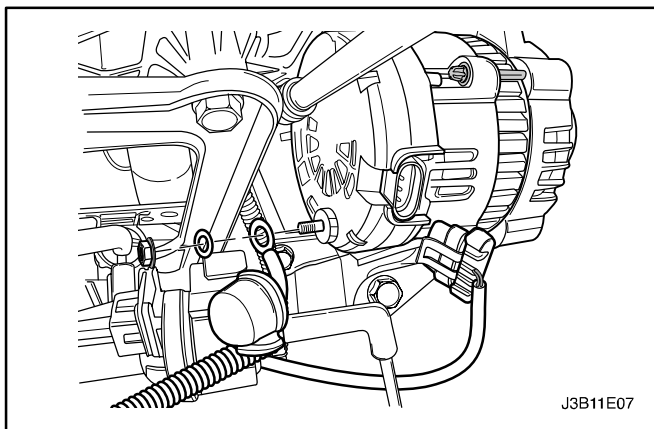
Removal Procedure

1. Disconnect the negative battery cable.
2. Disconnect the manifold air temperature (MAT) sensor electrical connector the air intake tube.
3. Remove all the clamps from the air cleaner outlet hose, and set aside the tube.
4. Raise and suitably support the vehicle.
5. Disconnect the harness connector from the back of the generator, and the generator lead to the battery.
6. Remove the serpentine accessory drive belt by lowering the vehicle and turning the automatic tensioner roller bolt clockwise to relieve tension on the belt. Refer to *Section 6B, Power Steering Pump*.
7. Push up the power steering reservoir and set it aside.
8. Remove the bolt of the generator upper engine connecting bracket to the 1.4L/1.6L engine.

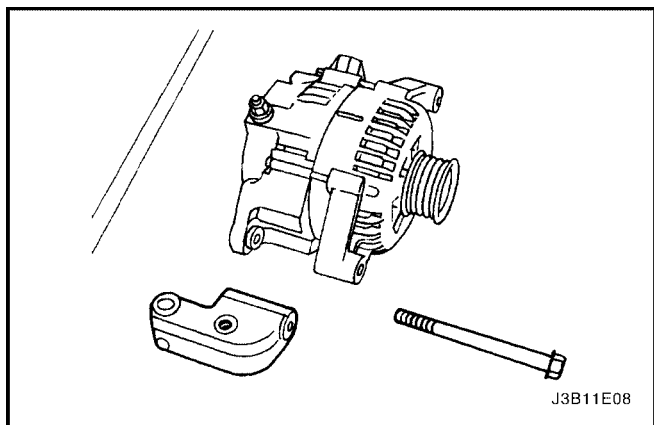




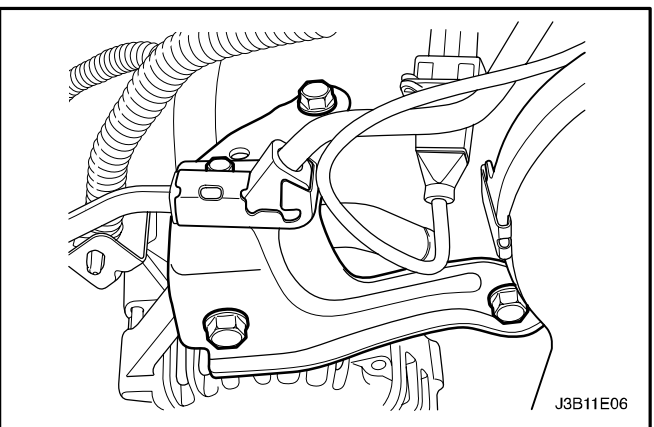
9. For vehicles equipped with the 1.8L engine, remove the generator upper mounting bolts to the intake manifold/cylinder head support bracket, the intake manifold strap bracket, and the intake manifold-to-cylinder body strap bracket.



10. Raise and suitably support the vehicle and remove the nut and washers which hold the generator lower bracket-to-generator bolt. Work the bolt loose and remove the generator.



11. For vehicles equipped with the 1.8L engine, remove the generator lower support bracket bolts.
12. Carefully remove the generator with the lower bracket attached for the 1.8L engine only.
13. Remove the generator lower support bracket nut, the bolt, and the washer.

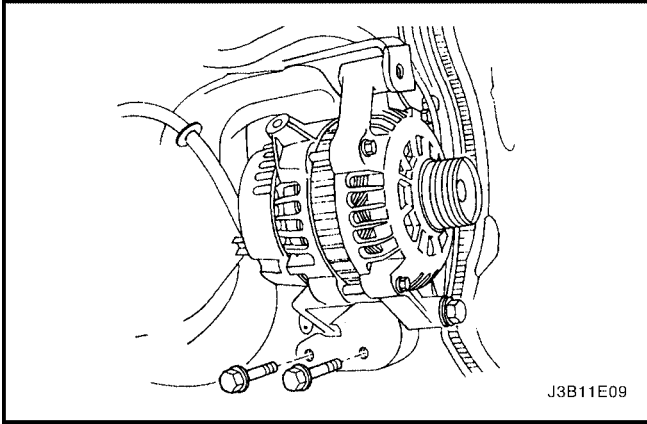


Installation Procedure

1. Install the generator to the generator lower bracket and insert the generator bolt.
2. Install the nut and washers on the generator lower bracket-to-generator bolt on the 1.4L/1.6L DOHC engines.

Tighten

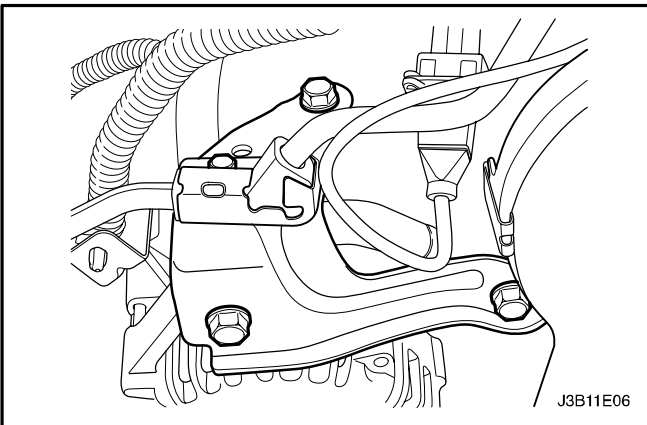
Tighten the generator lower bracket-to-generator nut to 25 N•m (18 lb–ft).



3. Install the generator and the lower support bracket assembly to the 1.8L engine block (as shown).

Tighten

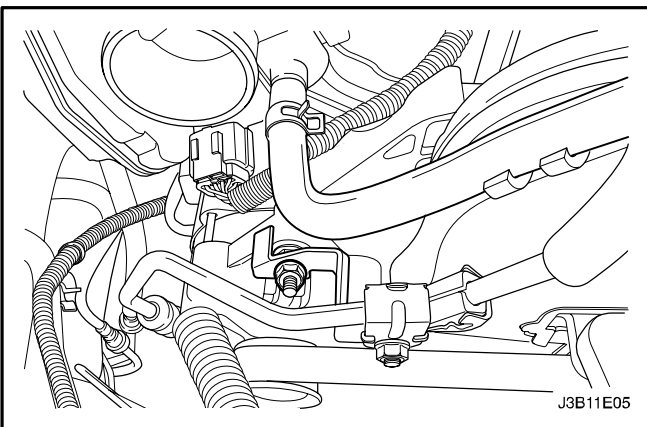
Tighten the generator and the lower bracket-to-engine block bolts to 37 N•m (27 lb–ft).



4. For vehicles equipped with the 1.8L engine (shown), install the generator-to-intake manifold and cylinder head support bracket bolts, the generator-to-intake manifold strap bracket bolt, and the intake manifold-to-cylinder body strap bracket bolts over the starter.

Tighten

Tighten the generator-to-intake manifold and cylinder head support bracket bolts to 37 N•m (27 lb–ft). Tighten the generator-to-intake manifold strap bracket bolt and the intake manifold-to-cylinder body strap bracket bolts to 22 N•m (16 lb–ft).

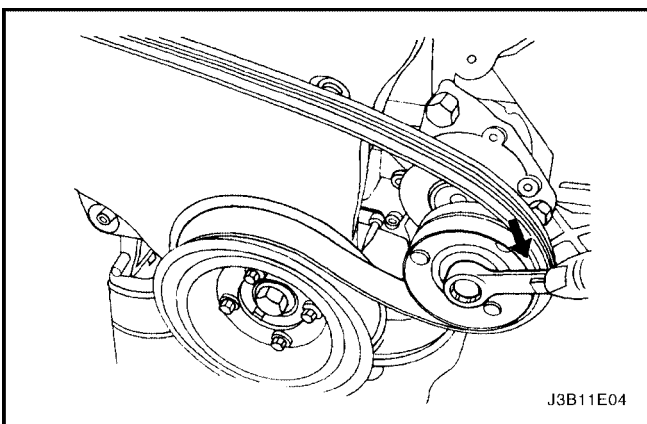


5. For vehicles with the 1.4L/1.6L engine, install the upper generator support bracket bolt and the washer.

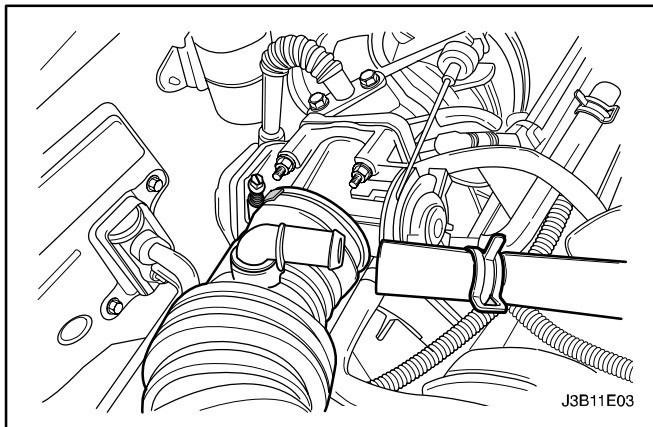
Tighten

Tighten the generator upper support bracket bolt to 20 N•m (15 lb–ft).

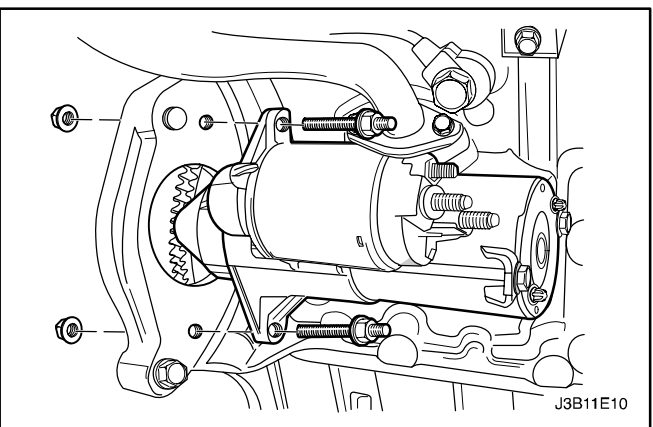
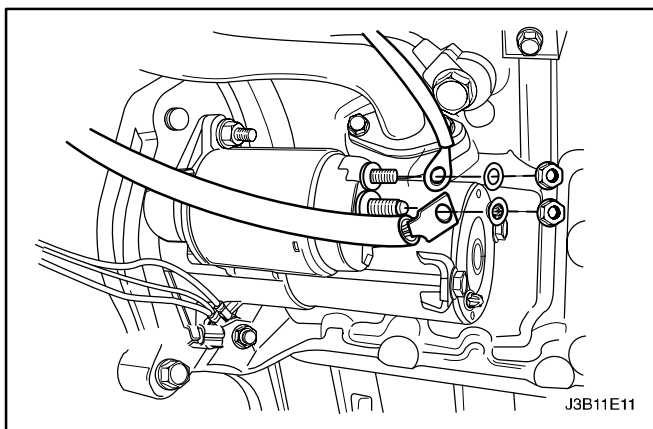
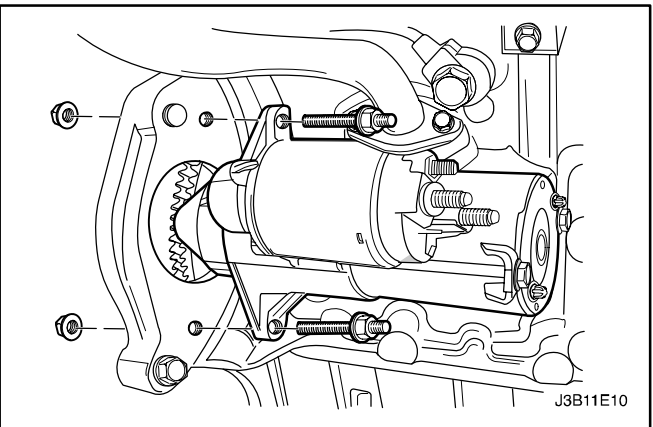
6. Connect the harness connector to the back of the generator, and the generator lead to the battery.



7. Route the serpentine accessory drive belt. Refer to *Section 6B, Power Steering Pump*.
8. Relieve tension on the belt by first applying downward pressure on the automatic tension roller bolt and releasing pressure once the belt is in place.
9. Install the power steering reservoir.



10. Install the air cleaner outlet hose and connect the MAT electrical connector.
11. Connect the negative battery cable.



STARTER

Removal Procedure

1. Remove the nut which secures the starter ground wire to the lower mounting stud and remove the ground wire.
2. Remove the lower starter stud/weld nut assembly (1.4L/1.6L engine).
3. For vehicles equipped with the 1.8L engine, remove the starter-to-engine block mounting bolt and the starter-to-transmission mounting bolt.
4. Remove the starter solenoid nuts to disconnect the electrical cable.
5. Remove the starter assembly.

Installation Procedure

1. Place the starter assembly in position using an assistant to prop up the starter to aid in screwing in the upper stud with the weld nut.
2. Install the upper and the lower starter mounting bolts.

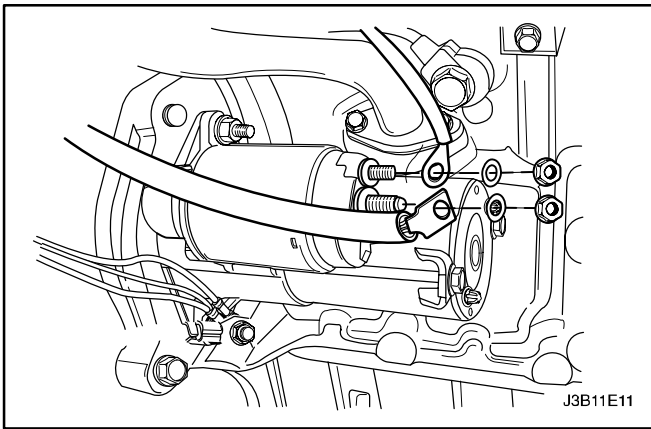
Tighten

Tighten the starter mounting studs to 23 N•m (16 lb ft).

3. Install the starter mounting bolts (1.8L engine).

Tighten

Tighten the starter-to-engine block mounting bolt to 45 N•m (33 lb-ft) and the starter-to-engine transaxle mounting bolt to 50 N•m (37 lb-ft).

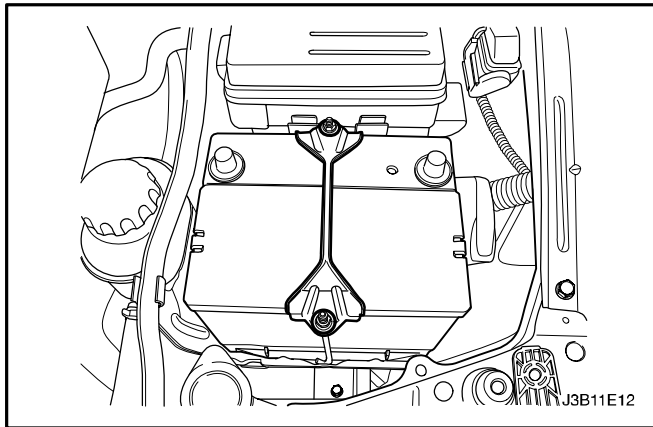


4. Position the starter electrical wire on the solenoid terminals and the ground wire on the lower stud.
5. Install the starter solenoid nuts and the ground wire nut.

Tighten

Tighten the starter solenoid terminal-to-battery cable terminal nut to 5.5 N•m (49 lb-in), and the starter solenoid terminal-to-ignition solenoid terminal nut to 5.5 N•m (49 lb-in).

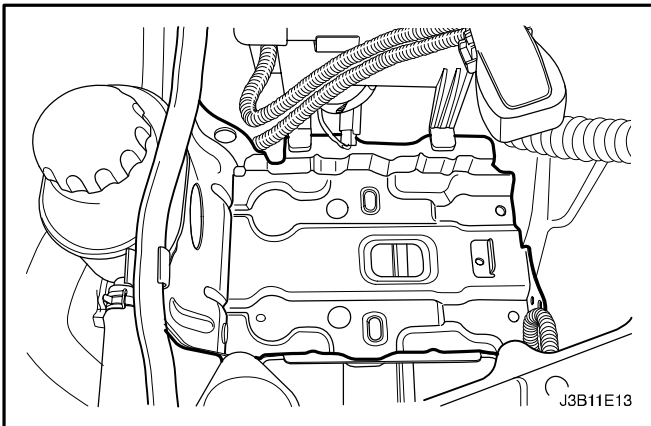
Tighten the starter lower mounting stud ground wire nut to 12 N•m (106 lb-in).



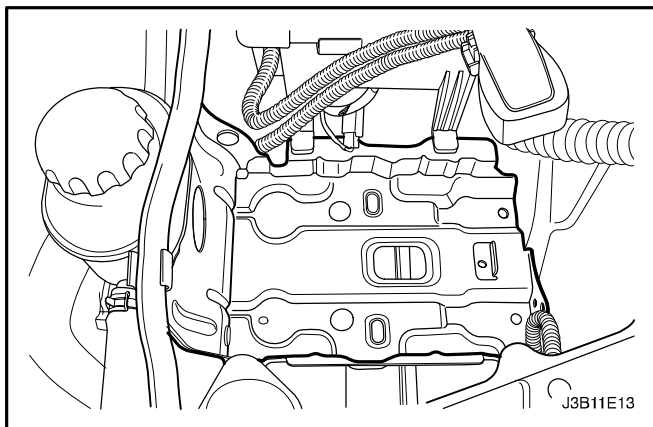
BATTERY AND BATTERY TRAY

Removal Procedure

1. Disconnect the negative battery cable and then disconnect the positive battery cable.
2. Remove the nuts from the battery rods that fasten the battery hold-down bar clamp.



3. Check the battery carrier tray for obvious cracks or damage. Unclip the lead to the negative battery cable from the side of the battery tray (if applicable). Detach the carrier tray if necessary by removing the upper battery carrier tray bolts, and the side bolt that connects the hydraulic clutch hose bracket to the battery carrier tray (if applicable).
4. Remove the lower battery tray bolts.



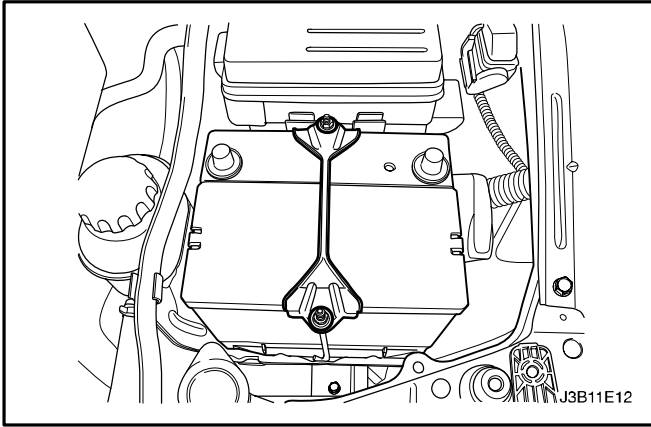
Installation Procedure

1. Install the battery carrier by fastening the carrier tray upper, lower, and side bolts.

Tighten

Tighten the battery carrier tray upper, lower and side bolts (if applicable) to 20 N•m (15 lb-ft).

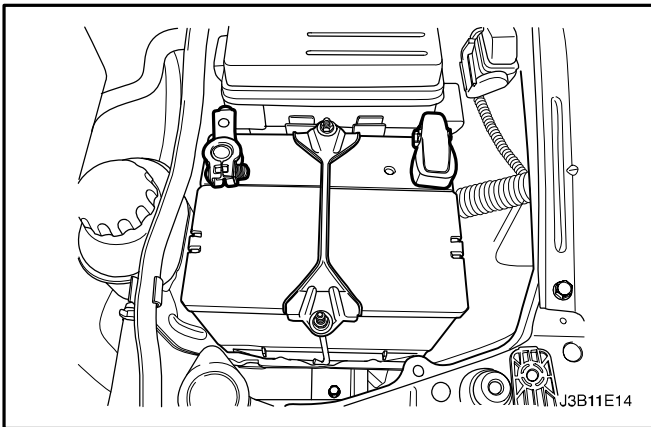
2. Push in the clip of the negative battery lead to the hole in the side of the battery tray (if applicable and as shown).



3. Install the battery into the tray.
4. Fasten the bar clamp to the battery by loosely attaching the battery rods from the battery tray cut-outs through the bar clamp holes, and loosely tightening the nuts.

Tighten

Tighten the battery retainer clamp-to-battery rod nuts to 5 N•m (44 lb-in).



5. Connect the negative and the positive battery cables.

Tighten

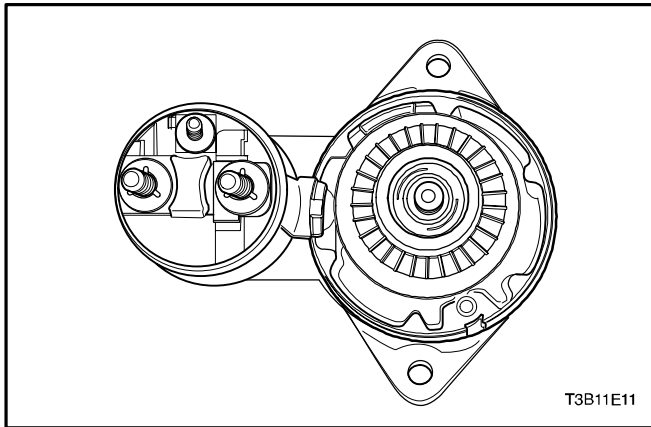
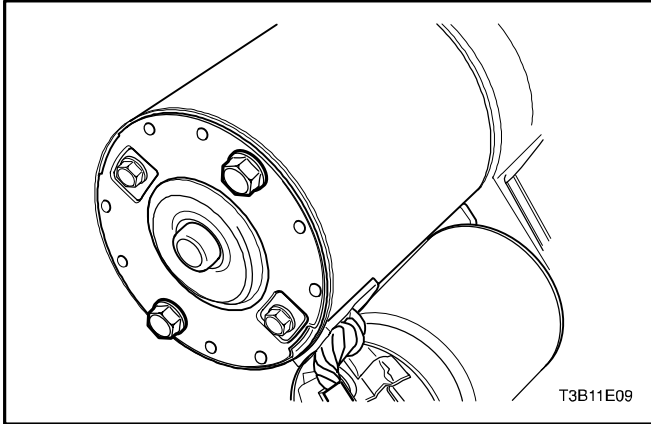
Tighten the battery cable nuts to 5 N•m (44 lb-in).

UNIT REPAIR

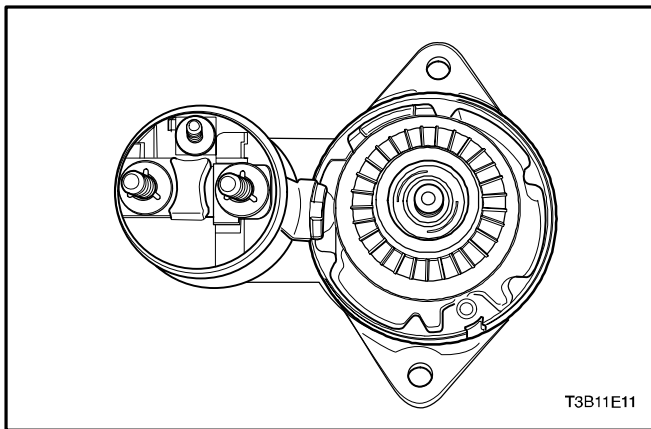
STARTER MOTOR

Disassembly Procedure

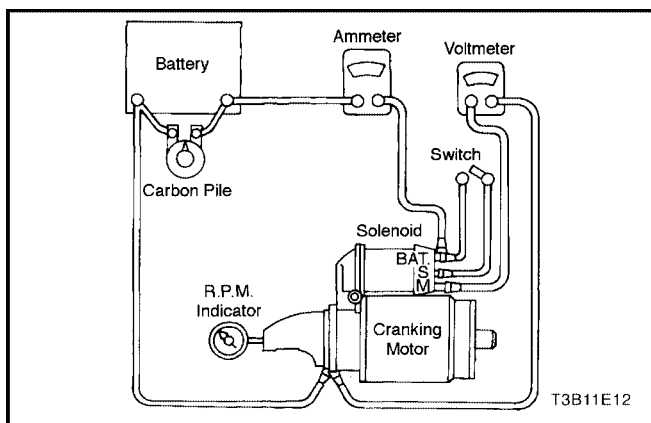
1. Remove the starter. Refer to "Starter" in this section.
2. Remove the starter through-bolts.



3. Remove the commutator end frame and brush holder assembly.
4. Inspect the brushes, the pop-out springs, and the brush holders for wear and damage. Replace the assembly, if needed.



5. Check the armature to see if it turns freely. If the armature does not turn freely, break down the assembly immediately, starting with Step 14. Otherwise, give the armature a no-load test.

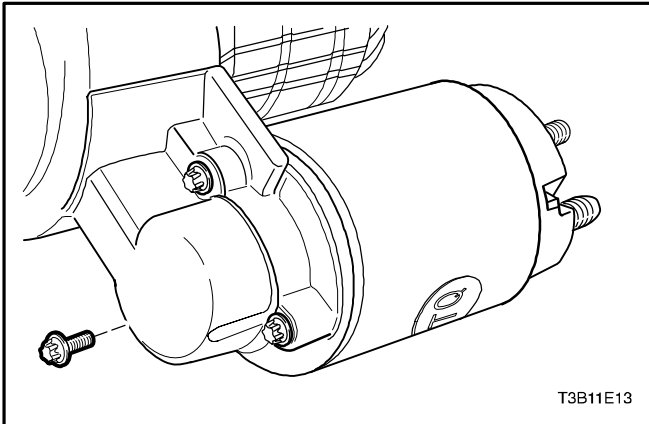


Notice : Complete the testing in a minimum amount of time to prevent overheating and damaging the solenoid.

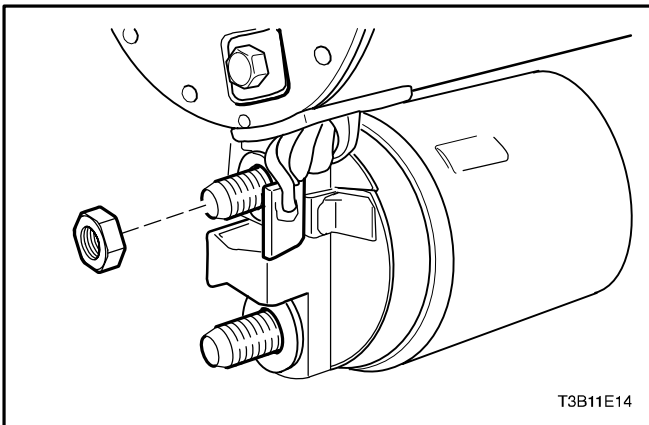
Important : If the specified current draw does not include the solenoid, deduct from the armature reading the specified current draw of the solenoid hold-in winding.

6. To begin the no-load test, close the switch and compare the rpm, the current, and the voltage readings with the specifications. Refer to "Starter Specifications" in this section. Make disconnections only with the switch open. Use the test results as follows:

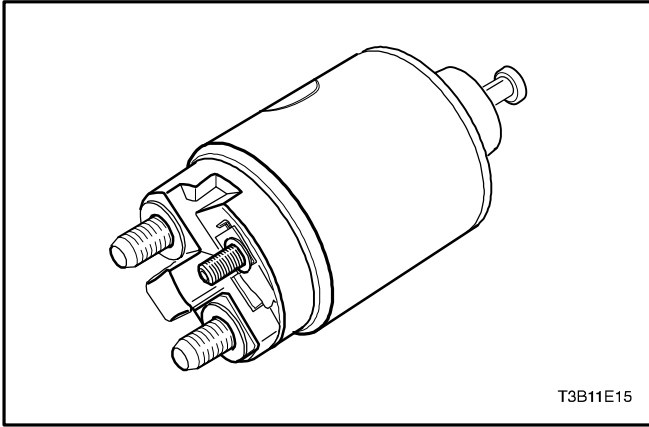
- 1) Rated current draw and no-load speed indicate a normal condition for the starter motor.
- 2) Low rpm combined with high current draw is an indication of excessive friction caused by tight, dirty, or worn bearings; a bent armature shaft; a shorted armature; or a shorted field coils.
- 3) Failure to operate with high current draw indicates a direct ground in the terminal or fields, or "frozen" bearings.
- 4) Failure to operate with no current draw indicates an open field circuit, open armature coils, broken brush springs, worn brushes, high insulation between the commutator bars, or other causes which would prevent good contact between the brushes and the commutator.
- 5) Low, no-load speed and low current indicate high internal resistance and high current draw, which usually mean shorted fields.



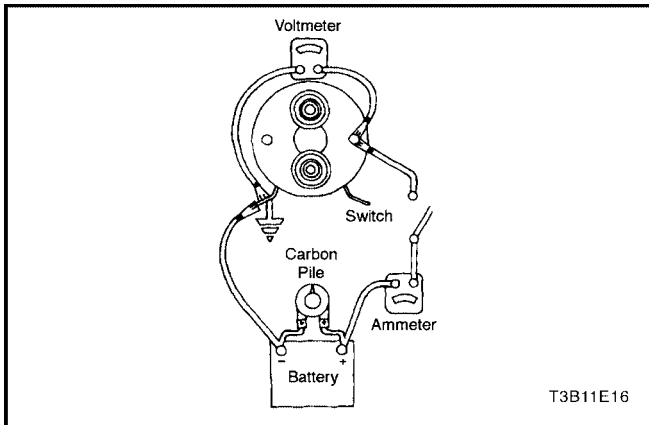
7. Remove the solenoid assembly screws.



8. Remove the field connector nut. Disconnect the field connector.



9. Remove the plunger return spring.



Important : If the solenoid is not removed from the starting motor, the connector strap terminals must be removed from the terminal on the solenoid before making these tests.

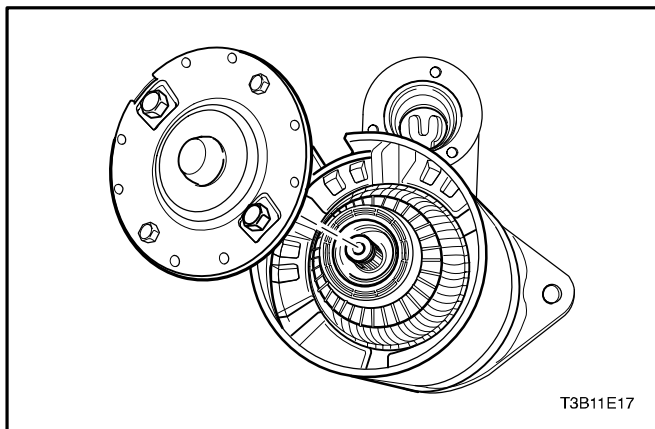
10. Test the solenoid windings by checking the current draw.

- 1) Check the hold-in windings by connecting an ammeter in series with a 12-volt battery, the switch terminal, and to ground.
- 2) Connect the carbon pile across the battery.
- 3) Adjust the voltage to 10 volts. The ammeter reading should be 13 to 19 amperes. Current will decrease as the windings heat up. Current draw readings that are over specifications indicate shorted turns or a ground in the windings of the solenoid. Both conditions require replacement of the solenoid. Current draw readings that are under specifications indicate excessive resistance. No reading indicates an open circuit.

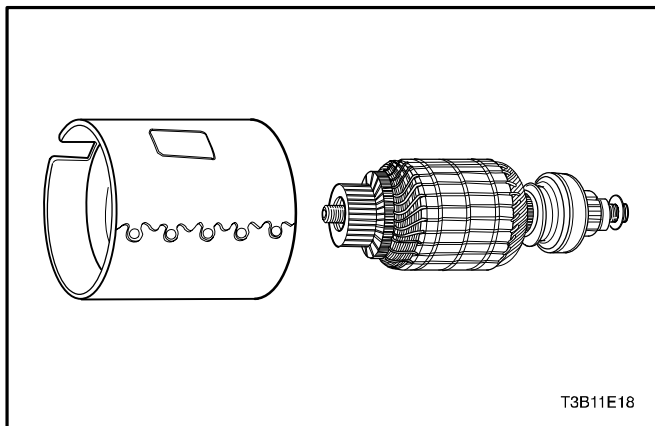
Important : Current will decrease as the windings heat up. Current draw readings that are over specifications indicate shorted turns or a ground in the windings of the solenoid. Both conditions require replacement of the solenoid. Current draw readings that are under specifications indicate excessive resistance. No reading indicates an open circuit.

11. Check both windings, connecting them according to the preceding test.

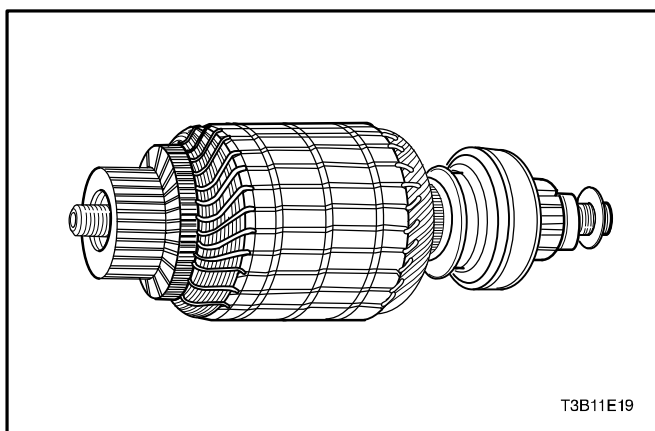
- 1) Ground the solenoid motor terminal.
- 2) Adjust the voltage to 10 volts. The ammeter reading should be 59 to 79 amperes.
- 3) Check the connections and replace the solenoid, if necessary.



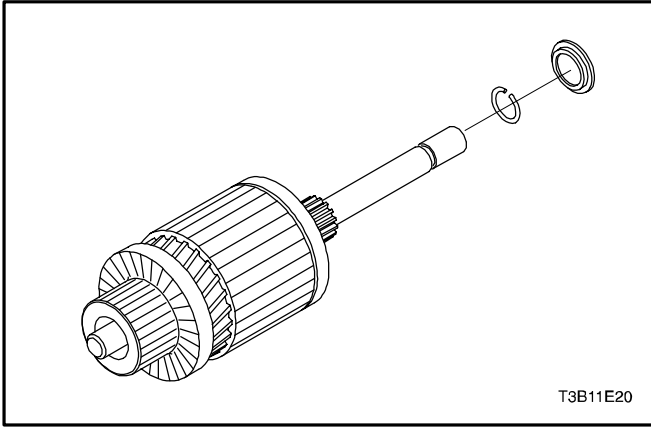
12. Slide the field frame with enclosed armature assembly away from the starter assembly.
13. Remove the shield.



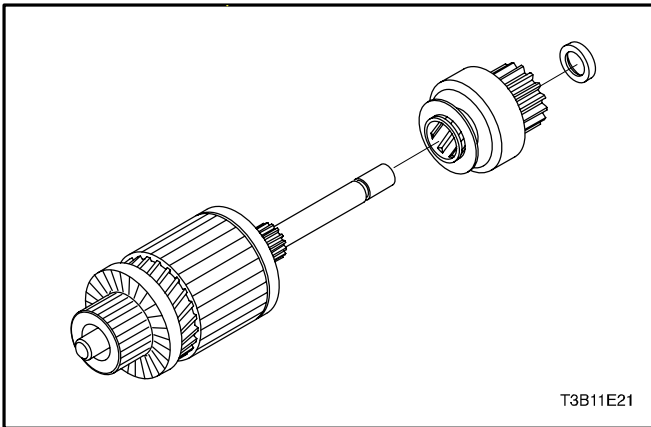
14. Separate the field frame from the armature.



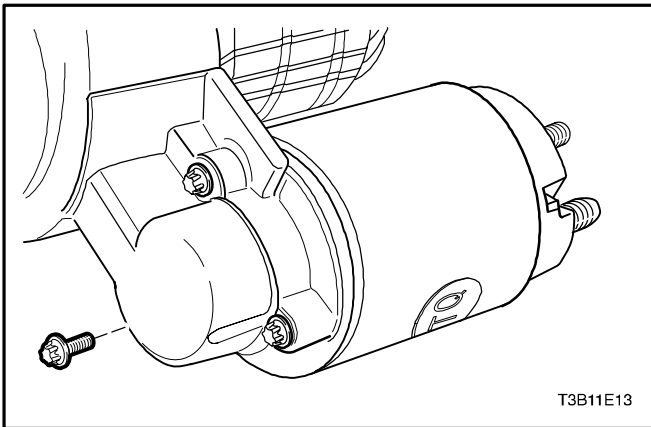
15. Inspect the shaft and the pinion for discoloration, damage, or wear. Replace, if necessary.
16. Inspect the armature commutator. If the commutator is rough, it should be turned down. The outside diameter of the commutator must measure at least 26.9 – 27.1mm (1.059 – 1.067 in.) after it is undercut or turned. Do not turn out-of-round commutators.
17. Inspect the points where the armature conductors join the commutator bars. Make sure they have a good connection. A burned commutator bar is usually evidence of a poor connection.
18. If test equipment is available, check the armature for short circuits by placing it on a growler, and holding back a saw blade over the armature core while the armature is rotated. If the saw blade vibrates, replace the armature.
19. Recheck the armature after cleaning between the commutator bars. If the saw blade vibrates, replace the armature.



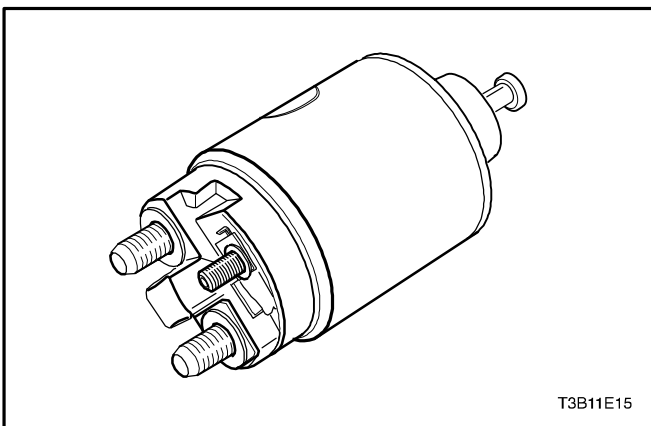
20. Remove the locking ring from the groove in the drive shaft.



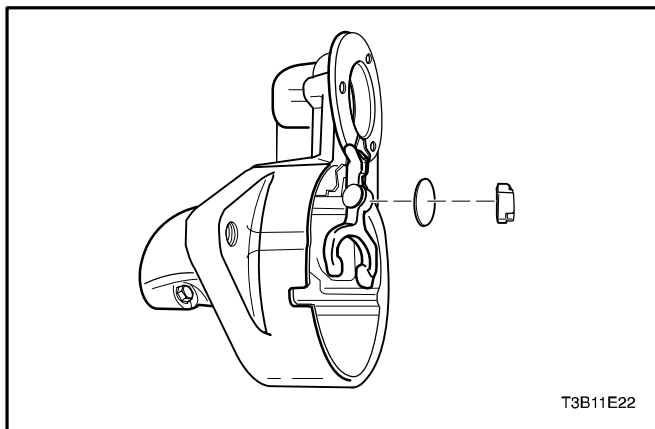
21. Remove the pinion stop and the drive from the drive shaft.



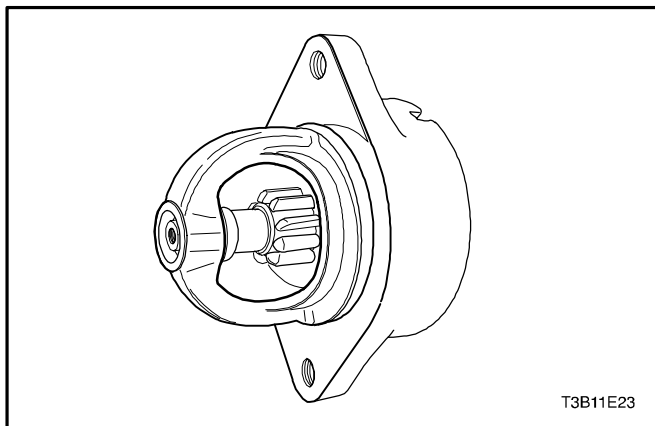
22. If not done in the previous steps, remove the screws that hold the solenoid assembly into the housing, and remove the nut from the field coil connector.



23. Rotate the solenoid 90 degrees and remove it along with the return spring.

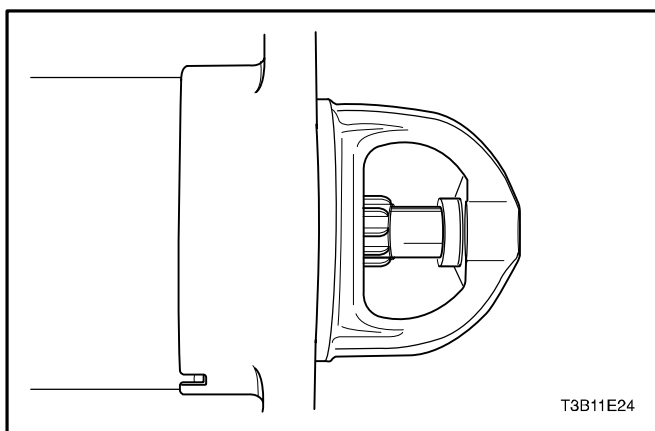


24. Remove the plunger with the boot and the shift lever assembly. Test the solenoid windings, if not done in Step 11.



Important : The pinion clearance must be correct to prevent the buttons on the shift lever yoke from rubbing on the clutch collar during the cranking.

25. When the starter motor is disassembled and the solenoid is replaced, it is necessary to check the pinion clearance.



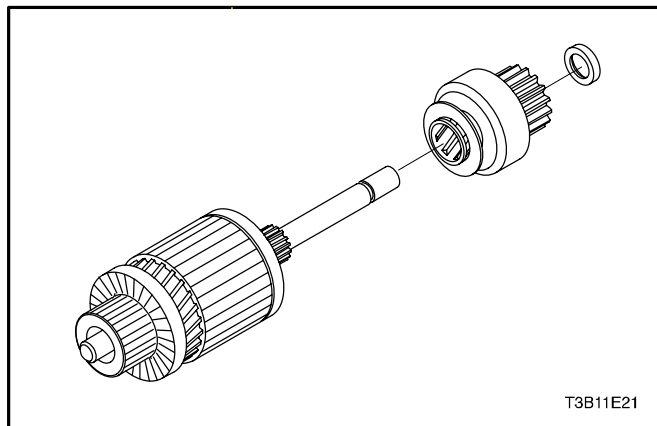
26. Disconnect the motor field coil connector from the solenoid motor terminal and carefully insulate the connector.
27. Connect one 12-volt battery lead to the solenoid switch terminal and the other to the starter frame.
28. Flash a jumper lead momentarily from the solenoid motor terminal to the starter frame, allowing shifting of the pinion in the cranking position, where it will remain until the battery is disconnected.

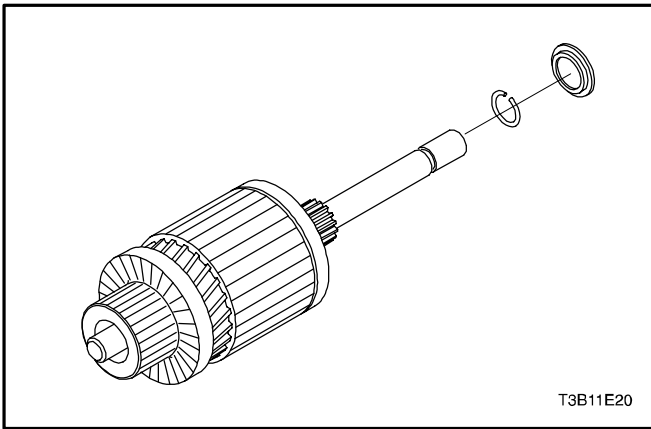
Important : A means for adjusting the pinion clearance is not provided on the starter motor. If the clearance does not fall within the limits, check for improper installation and replace all worn parts.

29. Push the pinion back as far as possible to take up any movement, and check the clearance with a feeler gauge. The clearance should be 0.25 to 3.56 mm (0.01 to 0.14 inch).

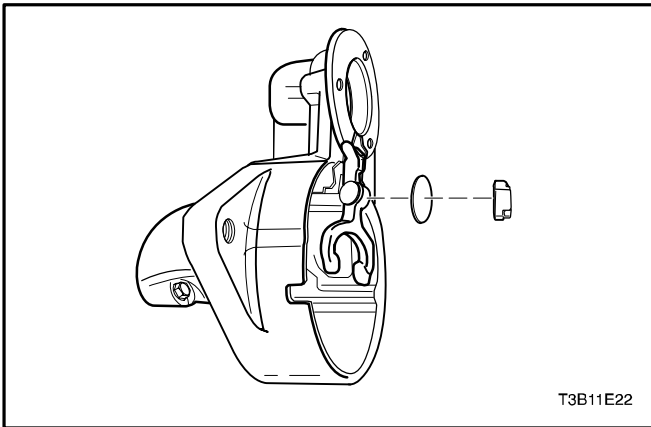
Assembly Procedure

1. Install the drive and the pinion stop on the drive-shaft.

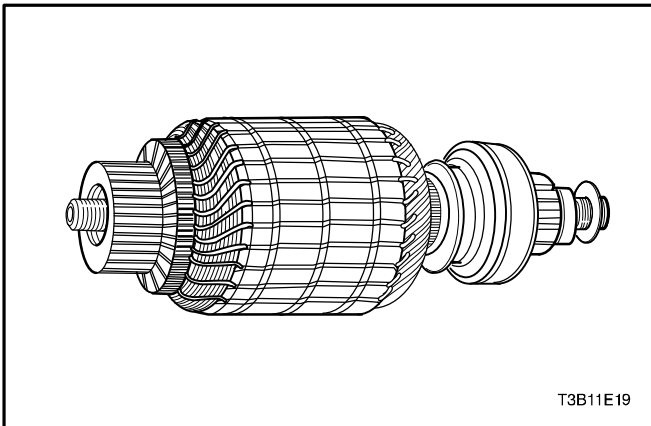




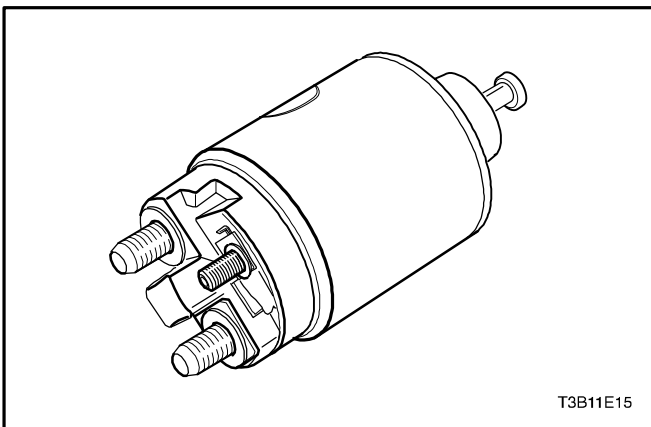
2. Install the lock ring into the groove on the driveshaft and insert the collar.



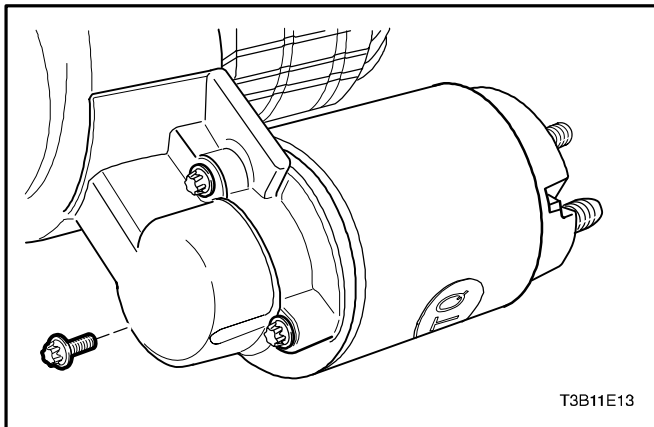
3. Install the shift lever, washer and the cushion.



4. Lubricate the drive end of the armature shaft with lubricant.



5. Position the solenoid assembly.



6. Fasten the solenoid assembly with the screws.

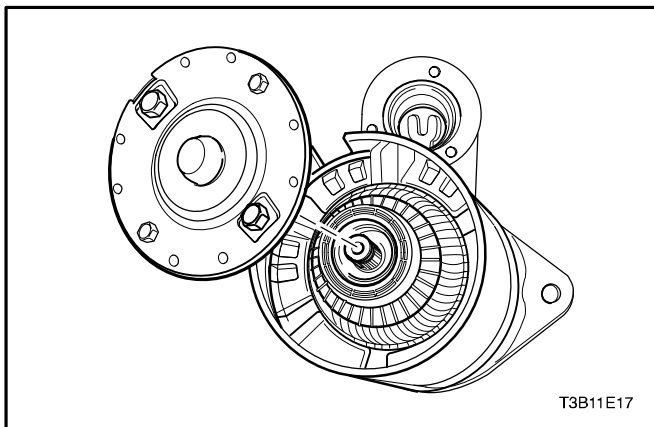
Tighten

Tighten the starter solenoid assembly screws to 8 N•m (71 lb-in).

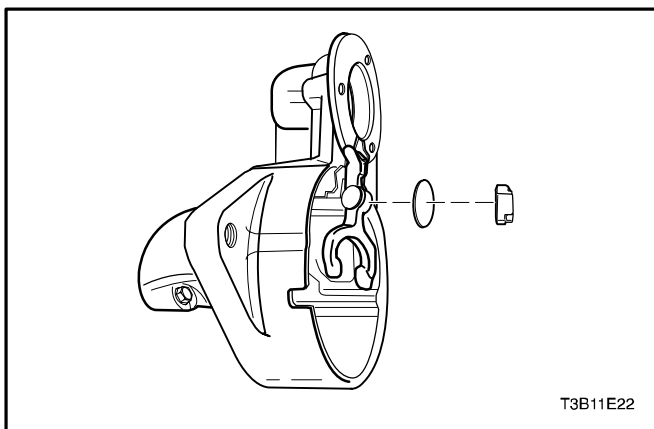
7. Install the field coil connection to the starter terminal. Install the nut.

Tighten

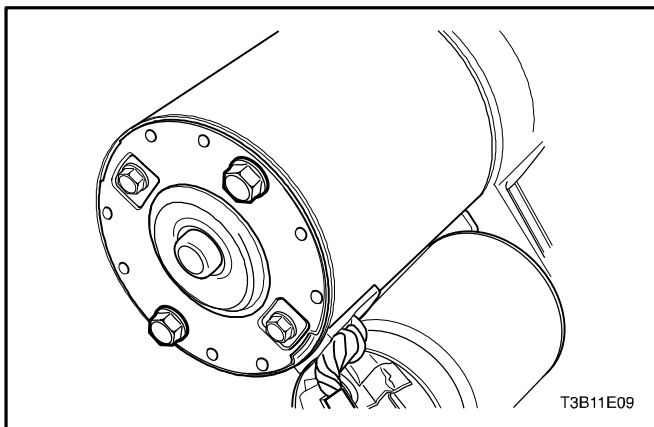
Tighten the starter field coil connector nut to 8 N•m (71 lb-in).



8. Position the armature assembly into the field frame.
9. Place the shield on the armature and field frame assembly.
10. Install the armature and field frame assembly with the shield into the starter housing.



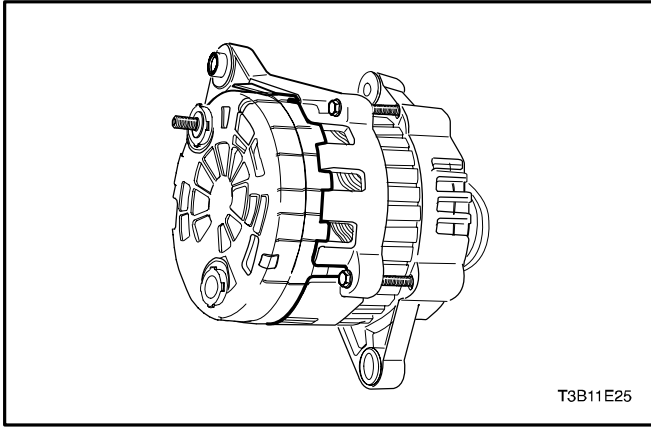
11. Position the commutator end frame/brush holder assembly, lining up the end frame holes with the through-bolt holes in the housing.



12. Install the starter through-bolts.
13. Install the starter. Refer to "Starter" in this section.

Tighten

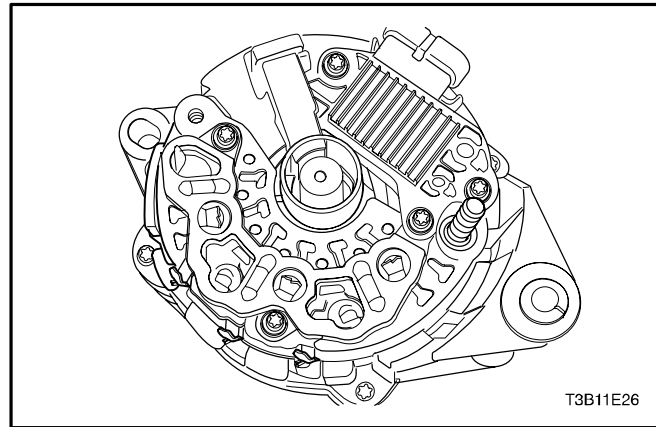
Tighten the starter through-bolts to 6 N•m (53 lb-in).



GENERATOR

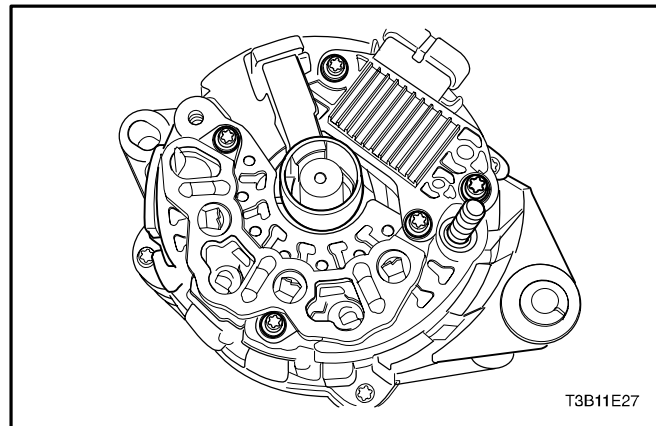
Disassembly Procedure

1. Remove the generator. Refer to "Generator" in the On-Vehicle Service section.
2. Mark a match line that cannot easily be removed on the end frame to make assembly easier.
3. Pry off the plastic cover to expose the stator connections.



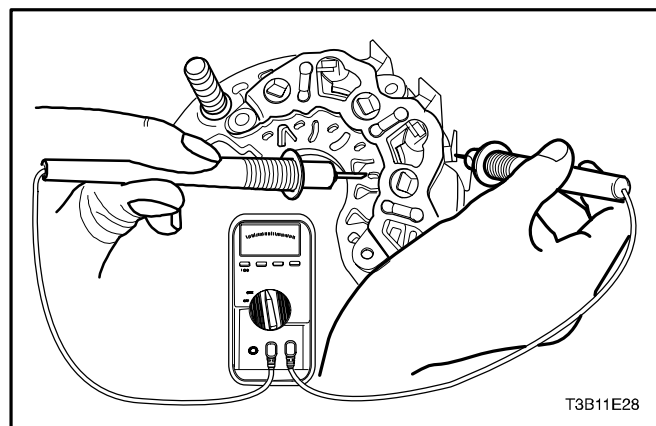
Notice : If the stator connections are not welded, melt the lead. Avoid excessive heating, as it can damage the diodes in the rectifier bridge.

4. Remove the stator connections from the rectifier bridge terminals by cutting the wires.

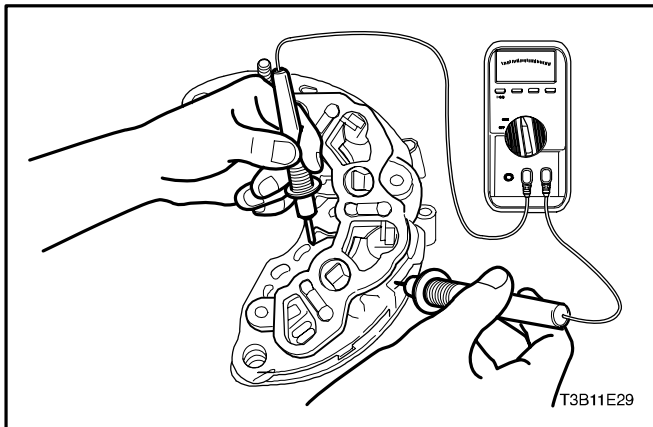


5. Pry off the baffle.
6. Remove the rectifier/regulator/brush holder assembly screws.
7. Remove the brush holder assembly and the regulator.

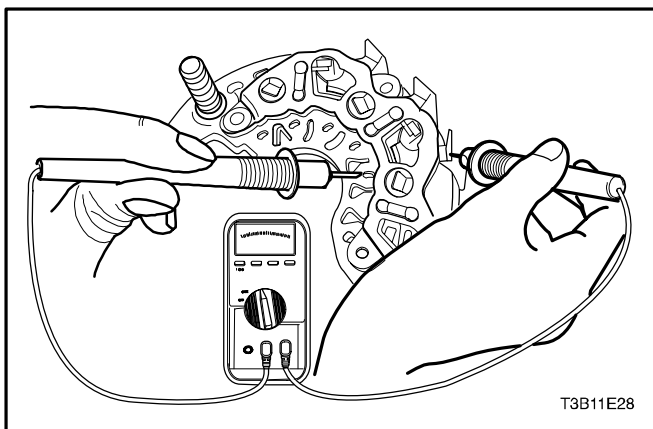
Important : If the brush can be reused, reassemble the brush to the holder with the retaining pin, after cleaning the brush with a soft, clean cloth.



8. Test the rectifier bridge by connecting the ohmmeter terminals to the bridge and the heat sink.



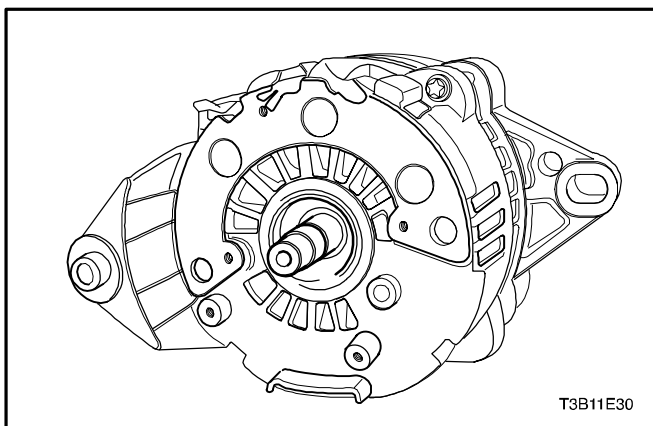
9. Retest by connecting the ohmmeter terminals in reverse.



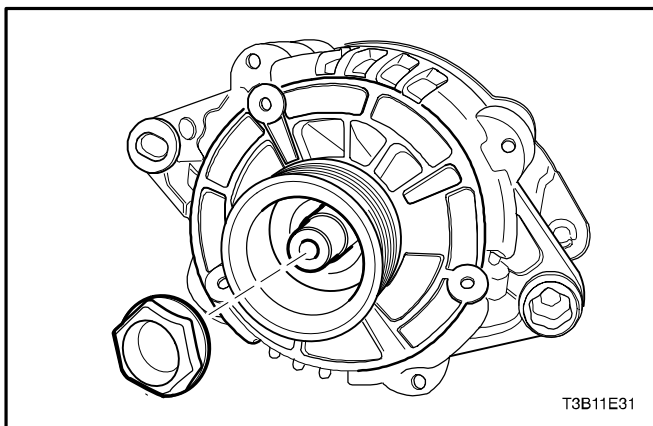
10. Replace the rectifier bridge, if each reading is the same.
11. Test the remaining two diodes after the above procedure.

Notice : Some kinds of digital ohmmeters are not suited for the test of the bridge diode. In this case, consult the manufacturer regarding the test capacity.

12. Test the diodes by connecting the ohmmeter terminals to the bridge terminal and the base plate. If the reading is the same, the rectifier bridge should be replaced.

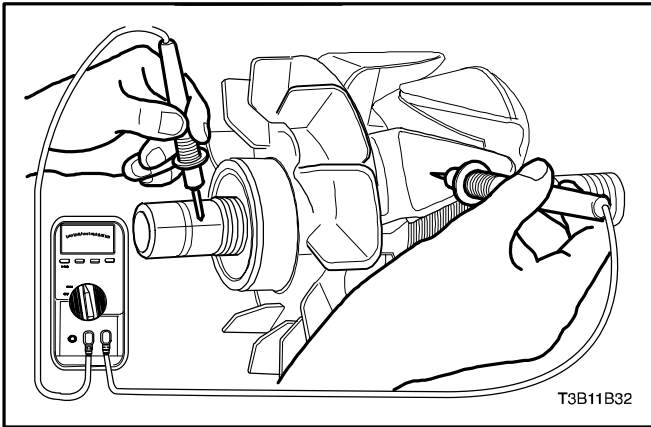


13. Remove the generator through – bolts.

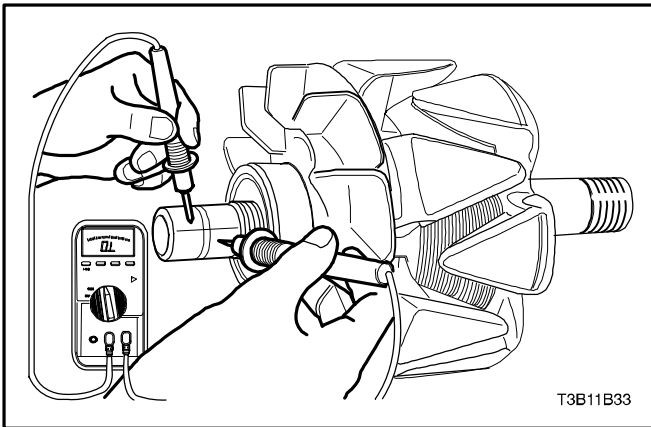


Important : The fastening torque of this nut is 81 N•m (60 lb–ft) and may not normally be unfastened using hand strength.

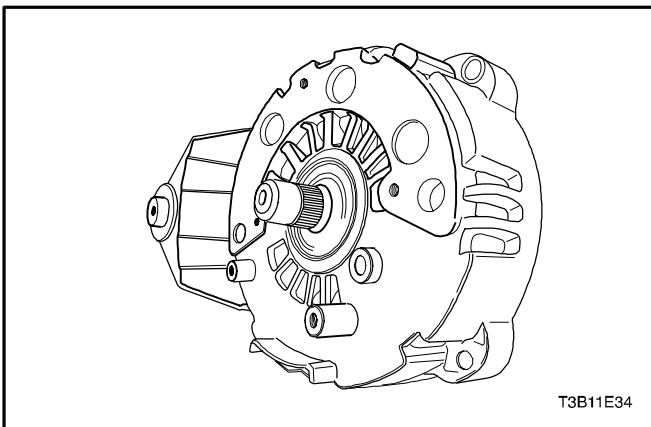
14. Move to the drive end of the generator and remove the drive end bearing nut.
15. Remove the pulley and the collars.



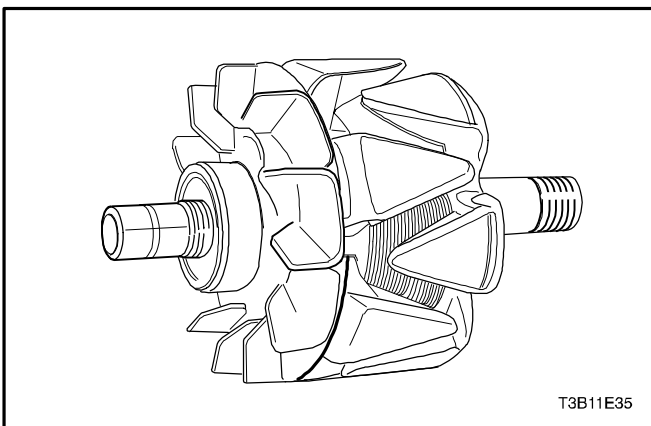
16. Test the rotor for an open circuit using the ohmmeter with the drive end frame assembled. The reading should be sufficiently high, or the rotor must be replaced.



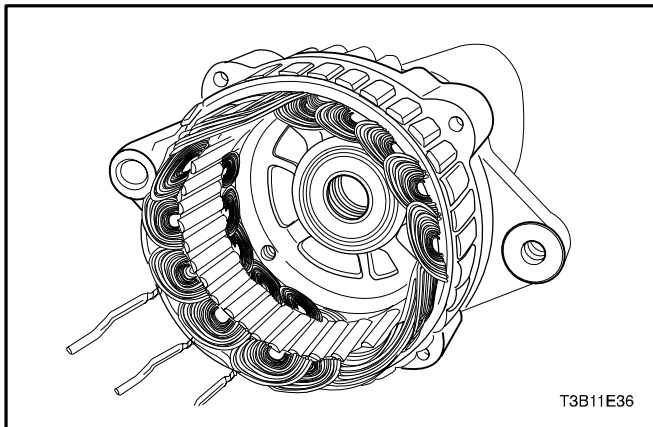
17. Test the rotor for open and short circuits. The reading should be 1.7 to 2.3 ohms, or the rotor should be replaced.



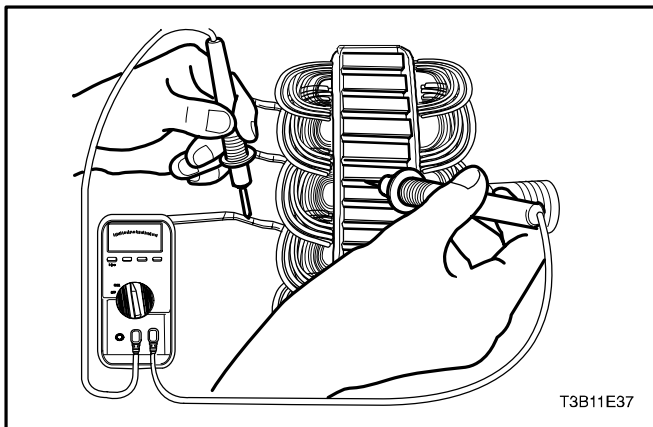
18. Remove the drive end frame from the shaft.
19. For vehicles with an internal generator fan, remove the drive end frame and the fan.



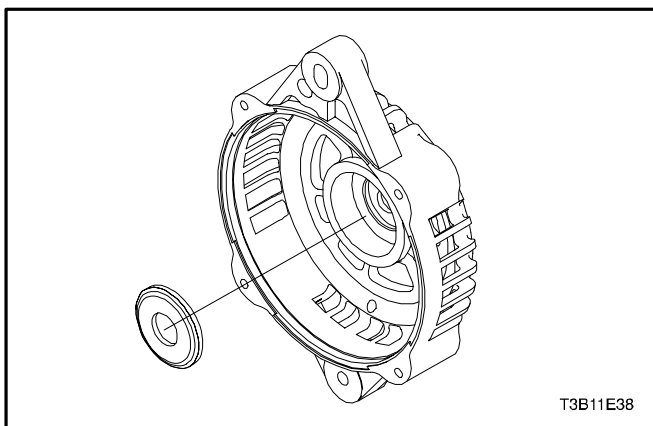
20. Remove the rotor assembly.



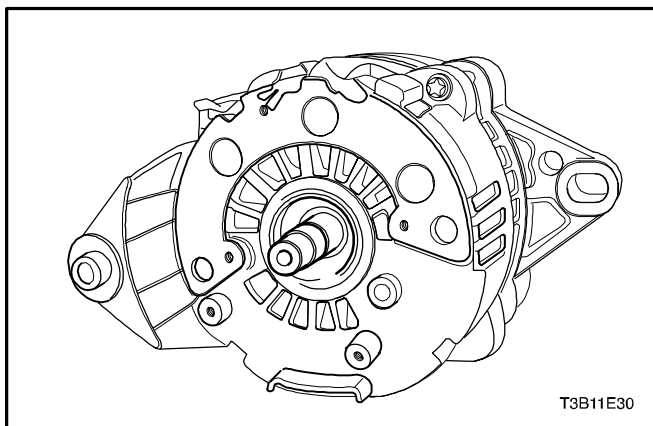
21. Remove the stator.



22. Test the stator for an open circuit using the ohmmeter.

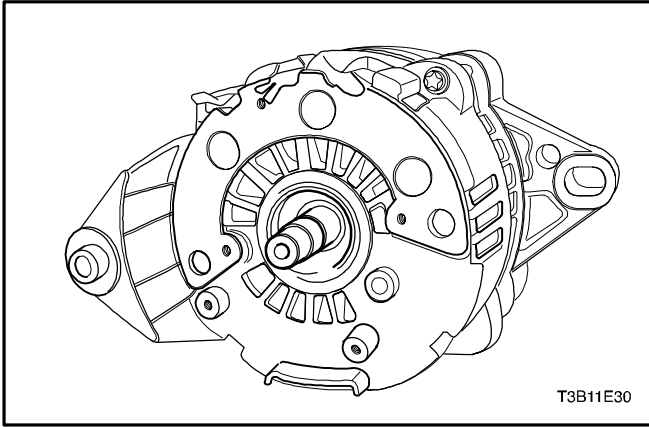


23. Remove the ring in the slip ring end frame.



Assembly Procedure

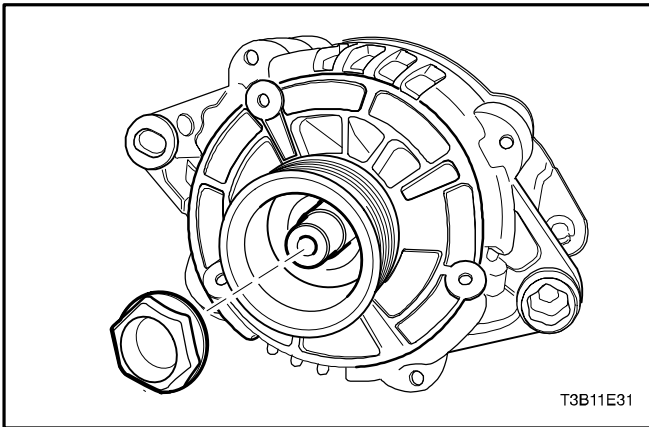
1. Install the new ring in the slip ring end frame.
2. Install the stator.



3. Position the rotor assembly shaft with the drive end frame in the slip ring end assembly until the gap between the outer lace and the end frame casting is 1.9 mm (0.075 inch).
4. Install the generator through-bolts.

Tighten

Tighten the generator through-bolts to 10 N•m (89 lb-in).

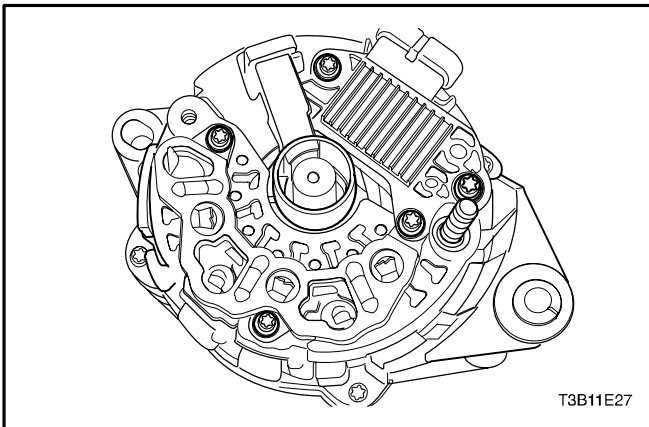


5. Position the fan, the collars, and the pulley on the rotor shaft and secure with the nut.

Tighten

Tighten the generator drive end bearing nut to 81 N•m (60 lb-ft).

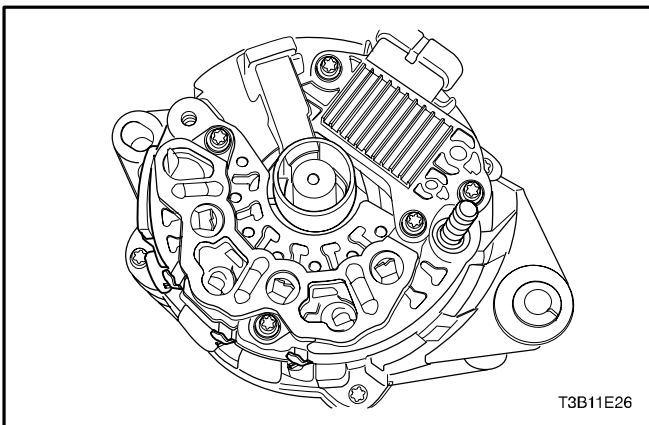
6. Install the generator. Refer to "Generator" in the On-Vehicle Service section.



7. Weld the brush holder terminal to the regulator terminal, if removed.
8. Fix the brush holder with the retainer pin, and weld the regulator/brush holder assembled terminal to the rectifier terminal.
9. Apply silicone grease between the bridge and the end frame for radiation purposes.
10. Fasten the screws holding the rectifier regulator/brush holder assembly to the end frame.
11. Punch the new baffle with the pin into the brush.

Notice : Take care to prevent damage to the vehicle by protecting the diode in the rectifier bridge from excessive heat while welding.

12. Weld the connectors of the rectifier bridge.



GENERAL DESCRIPTION AND SYSTEM OPERATION

BATTERY

The sealed battery is standard on all cars. There are no vent plugs in the cover. The battery is completely sealed, except for two small vent holes in the sides. These vent holes allow the small amount of gas produced in the battery to escape. The battery has the following advantages over conventional batteries:

- No water addition for the life of the battery.
- Overcharge protection. If too much voltage is applied to the battery, it will not accept as much current as a conventional battery. In a conventional battery, the excess voltage will still try to charge the battery, leading to gassing, which causes liquid loss.
- Not as liable to self-discharge as compared to a conventional battery. This is particularly important when a battery is left standing for long periods of time.
- More power available in a lighter and smaller case.

The battery has three major functions in the electrical system. First, the battery provides a source of energy for cranking the engine. Second, the battery acts as a voltage stabilizer for the electrical system. Finally, the battery can, for a limited time, provide energy when the electrical demand exceeds the output of the generator.

RATINGS

A battery has two ratings: (1) a reserve capacity rating designated at 27°C (80°F), which is the time a fully charged battery will provide 25 amperes current flow at or above 10.5 volts; (2) a cold cranking amp rating determined under testing at -18°C (0°F), which indicates the cranking load capacity.

RESERVE CAPACITY

The reserve capacity is the maximum length of time it is possible to travel at night with the minimum electrical load and no generator output. Expressed in minutes, Reserve Capacity (or RC rating) is the time required for a fully charged battery, at a temperature of 27°C (80°F) and being discharged at a current of 25 amperes, to reach a terminal voltage of 10.5 volts.

COLD CRANKING AMPERAGE

The cold cranking amperage test is expressed at a battery temperature of -18°C (0°F). The current rating is the minimum amperage, which must be maintained by the battery for 30 seconds at the specified temperature, while meeting a minimum voltage requirement of 7.2 volts. This rating is a measure of cold cranking capacity.

The battery is not designed to last indefinitely. However, with proper care, the battery will provide many years of service.

If the battery tests well, but fails to perform satisfactorily in service for no apparent reason, the following factors may point to the cause of the trouble:

- Vehicle accessories are left on overnight.
- Slow average driving speeds are used for short periods.
- The vehicle's electrical load is more than the generator output, particularly with the addition of after-market equipment.
- Defects in the charging system, such as electrical shorts, a slipping generator belt, a faulty generator, or a faulty voltage regulator.
- Battery abuse, including failure to keep the battery cable terminals clean and tight, or a loose battery hold-down clamp.
- Mechanical problems in the electrical system, such as shorted or pinched wires.

BUILT – IN HYDROMETER

The sealed battery has a built-in, temperature-compensated hydrometer in the top of the battery. This hydrometer is to be used with the following diagnostic procedure:

1. When observing the hydrometer, make sure that the battery has a clean top.
2. Under normal operation, two indications can be observed:
 - GREEN DOT VISIBLE – Any green appearance is interpreted as a "green dot," meaning the battery is ready for testing.
 - DARK GREEN DOT IS NOT VISIBLE – If there is a cranking complaint, the battery should be tested. The charging and electrical systems should also be checked at this time.
3. Occasionally, a third condition may appear:
 - CLEAR OR BRIGHT YELLOW – This means the fluid level is below the bottom of the hydrometer. This may have been caused by excessive or prolonged charging, a broken case, excessive tipping, or normal battery wear. Finding a battery in this condition may indicate high charging by a faulty charging system. Therefore, the charging and the electrical systems may need to be checked if a cranking complaint exists. If the cranking complaint is caused by the battery, replace the battery.

CHARGING PROCEDURE

1. Batteries with the green dot showing do not require charging unless they have just been discharged (such as in cranking a vehicle).
2. When charging sealed-terminal batteries out of the vehicle, install the adapter kit. Make sure all the charger connections are clean and tight. For best results, batteries should be charged while the elec-

trollyte and the plates are at room temperature. A battery that is extremely cold may not accept current for several hours after starting the charger.

3. Charge the battery until the green dot appears. The battery should be checked every half-hour while charging. Tipping or shaking the battery may be necessary to make the green dot appear.
4. After charging, the battery should be load tested. Refer to "Starter Motor" in this section.

CHARGING TIME REQUIRED

The time required to charge a battery will vary depending upon the following factors:

- **Size of Battery** – A completely discharged large heavy-duty battery requires more than twice the recharging time as a completely discharged small passenger car battery.
- **Temperature** – A longer time will be needed to charge any battery at -18°C (0°F) than at 27°C (80°F). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first. The battery will accept a higher current rate as the battery warms.
- **Charger Capacity** – A charger which can supply only 5 amperes will require a much longer charging period than a charger that can supply 30 amperes or more.
- **State-of-Charge** – A completely discharged battery requires more than twice as much charge as a one-half charged battery. Because the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted by the battery is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

CHARGING A COMPLETELY DISCHARGED BATTERY (OFF THE VEHICLE)

Unless this procedure is properly followed, a perfectly good battery may need to be replaced.

The following procedure should be used to recharge a completely discharged battery:

1. Measure the voltage at the battery terminals with an accurate voltmeter. If the reading is below 10 volts, the charge current will be very low, and it could take some time before the battery accepts the current in excess of a few milliamperes. Refer to "Charging Time Required" in this section, which focuses on the factors affecting both the charging time required and the rough estimates in the table below. Such low current may not be detectable on ammeters available in the field.
2. Set the battery charger on the high setting.

Important : Some chargers feature polarity protection circuitry, which prevents charging unless the charger leads are correctly connected to the battery terminals. A completely discharged battery may not have enough voltage to activate this circuitry, even though the leads are connected properly, making it appear that the battery will not accept charging current. Therefore, follow the specific charger manufacturer's instruction for bypassing or overriding the circuitry so that the charger will turn on and charge a low-voltage battery.

3. Continue to charge the battery until the charge current is measurable. Battery chargers vary in the amount of voltage and current provided. The time required for the battery to accept a measurable charge current at various voltages may be as follows:

Voltage	Hours
16.0 or more	Up to 4 hours
14.0–15.9	Up to 8 hours
13.9 or less	Up to 16 hours

- If the charge current is not measurable at the end of the above charging times, the battery should be replaced.
- If the charge current is measurable during the charging time, the battery is good, and charging should be completed in the normal manner.

Important : It is important to remember that a completely discharged battery must be recharged for a sufficient number of ampere hours (AH) to restore the battery to a usable state. As a general rule, using the reserve capacity rating (RC) as the number of ampere hours of charge usually brings the green dot into view.

- If the charge current is still not measurable after using the charging time calculated by the above method, the battery should be replaced.

JUMP STARTING PROCEDURE

1. Position the vehicle with the good (charged) battery so that the jumper cables will reach.
2. Turn off the ignition, all the lights, and all the electrical loads in both vehicles. Leave the hazard flasher on if jump starting where there may be other traffic and any other lights needed for the work area.
3. In both vehicles, apply the parking brake firmly.

Notice : To avoid vehicle damage, Make sure the cables are not on or near pulleys, fans, or other parts that will move when the engine starts.

4. Shift an automatic transaxle to PARK, or a manual transaxle to NEUTRAL.

CAUTION : In order to avoid injury, do not use cables that have loose or missing insulation.

5. Clamp one end of the first jumper cable to the positive terminal on the battery. Make sure it does not touch any other metal parts. Clamp the other end of

the same cable to the positive terminal on the other battery. Never connect the other end to the negative terminal of the discharged battery.

CAUTION : To avoid injury do not attach the cable directly to the negative terminal of the discharged battery. Doing so could cause sparks and a possible battery explosion.

6. Clamp one end of the second cable to the negative terminal of the booster battery. Make the final connection to a solid engine ground (such as the engine lift bracket) at least 450 millimeters (18 inches) from the discharged battery.
7. Start the engine of the vehicle with the good battery. Run the engine at a moderate speed for several minutes. Then start the engine of the vehicle which has the discharged battery.
8. Remove the jumper cables by reversing the above sequence exactly. Remove the negative cable from the vehicle with the discharged battery first. While removing each clamp, take care that it does not touch any other metal while the other end remains attached.

GENERATOR

The Delco–Remy CS charging system has several models available, including the CS. The number denotes the outer diameter in millimeters of the stator lamination.

CS generators are equipped with internal regulators. A Delta stator, a rectifier bridge, and a rotor with slip rings and brushes are electrically similar to earlier generators. A conventional pulley and fan are used. There is no test hole.

Unlike three–wire generators, the CS may be used with only two connections: battery positive and an “L” terminal to the charge indicator lamp.

As with other charging systems, the charge indicator lamp lights when the ignition switch is turned to RUN, and goes out when the engine is running. If the charge indicator is on with the engine running, a charging system defect is indicated. This indicator light will glow at full brilliance for several kinds of defects as well as when the system voltage is too high or too low.

The regulator voltage setting varies with temperature and limits the system voltage by controlling rotor field current. At high speeds, the on–time may be 10 percent and the off–time 90 percent. At low speeds, with high electrical loads, on–time may be 90 percent and the off–time 10 percent.

CHARGING SYSTEM

CS generators use a new type of regulator that incorporates a diode trio. A Delta stator, a rectifier bridge, and a rotor with slip rings and brushes are electrically similar to earlier generators. A conventional pulley and fan are used. There is no test hole.

STARTER

Wound field starter motors have pole pieces, arranged around the armature, which are energized by wound field coils.

Enclosed shift lever cranking motors have the shift lever mechanism and the solenoid plunger enclosed in the drive housing, protecting them from exposure to dirt, icy conditions, and splashes.

In the basic circuit, solenoid windings are energized when the switch is closed. The resulting plunger and shift lever movement causes the pinion to engage the engine fly–wheel ring gear. The solenoid main contacts close. Cranking then takes place.

When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. To prevent excessive overrun, the switch should be released immediately after the engine starts.

STARTING SYSTEM

The engine electrical system includes the battery, the ignition, the starter, the generator, and all the related wiring. Diagnostic tables will aid in troubleshooting system faults. When a fault is traced to a particular component, refer to that component section of the service manual.

The starting system circuit consists of the battery, the starter motor, the ignition switch, and all the related electrical wiring. All of these components are connected electrically.