

## Section 6D1-2 Starting System – V6

### ATTENTION

Before performing any service operation or other procedure described in this Section, refer to Section 00 Warnings, Cautions and Notes for correct workshop practices with regard to safety and/or property damage.

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# 1 General Information

All V6 engines are fitted with a Mitsubishi starter motor. This consists of a solenoid switch on a DC motor. The motor has permanent magnet excitation, which has the advantage of low weight with high output torque and is visually identifiable by the absence of pole-shoe retaining screws.

The starter motor does not have field coil windings or pole shoes. These parts have been replaced by six permanent magnets that are held in the pole housing by clips. The positive brushes are now part of the brush plate assembly.

If the engine does not start during initial cranking, the starter motor will continue to crank for a maximum of 4 seconds with the ignition switch returned to the ON position. This is a normal function of the starting system on the V6 engine.

The solenoid switch is the only component of the starter motor assembly that is serviced separately. If any other parts require replacement, the starter motor must be replaced.

## 1.1 Components

### Starting System Components

The main components of the starting system are:

- battery,
- wiring,
- ignition switch,
- remote coded key,
- theft deterrent engine crank inhibitor (a function of the theft deterrent system),
- park / neutral and back-up switch (on vehicles with 4 speed automatic transmission),
- transmission manual shift shaft switch assembly (on vehicles with 5 speed automatic transmission),
- clutch pedal position switch (on vehicles fitted with manual transmission),
- engine control module (ECM),
- start relay,
- solenoid switch, and
- starter motor.

### Starter Motor and Solenoid Switch Components

#### Solenoid Switch

The solenoid switch is used to activate the DC motor and has two windings; the pull-in winding and the hold-in winding. The pull-in winding has heavier wire and is grounded through the DC motor winding and brushes. The hold-in winding is grounded through the solenoid casing.

#### Planetary Drive Train

The planetary drive train consists of an internally toothed ring gear and three planetary gear wheels, which rotate on sleeve bearings on the planetary drive shaft. The ring gear is keyed into the drive-end housing and is made from high-grade polyamide with mineral additives.

When the starter motor operates, the armature turns the planetary gears inside the fixed planetary ring gear. This drives the planetary shaft at a reduced speed ratio which turns the drive assembly. A fork lever in the drive-end housing forces the drive assembly forward to engage with the flexplate / flywheel ring gear on the engine and transmit cranking torque.

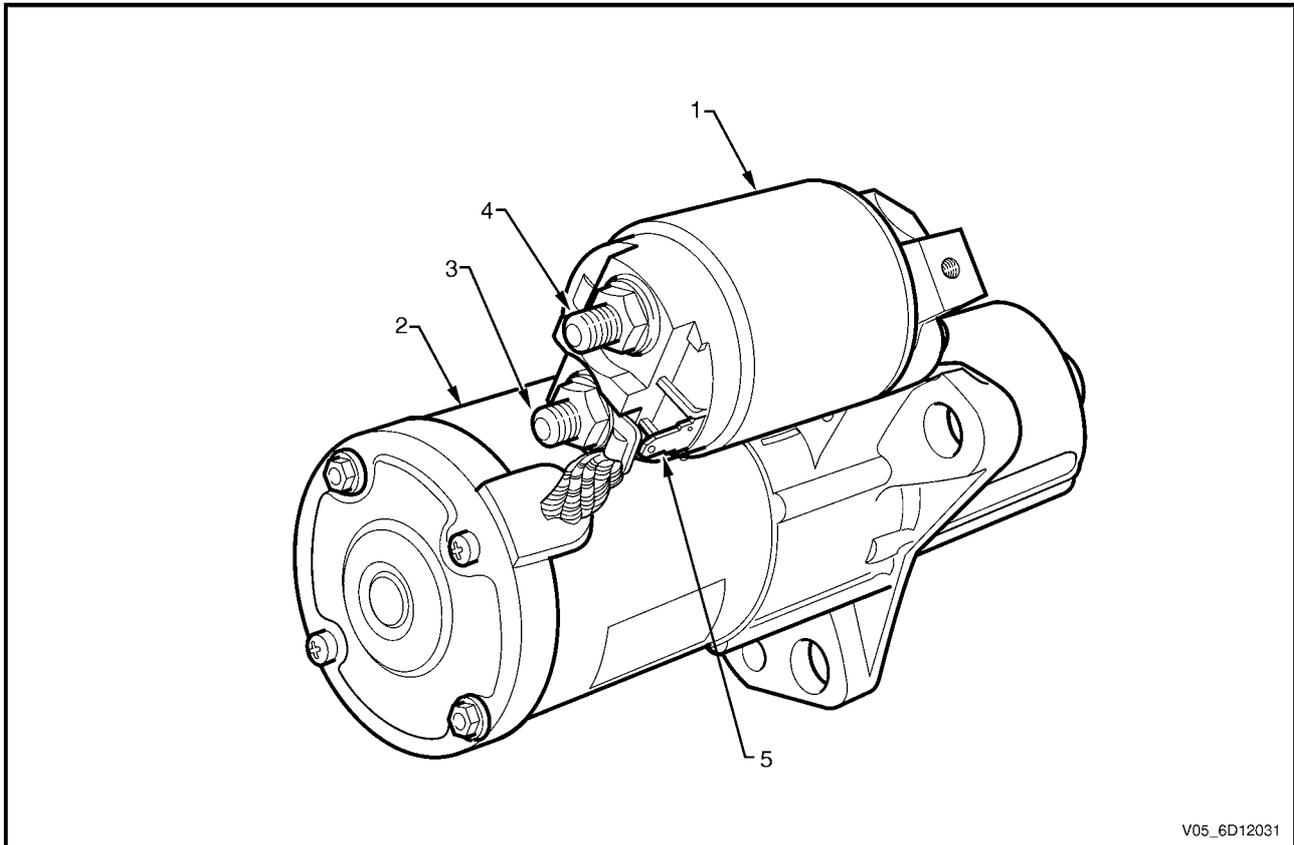
An internal clutch allows the drive assembly pinion gear to rotate freely when the engine starts. This prevents the armature from being driven at excessive speed by the engine.

## Armature

The armature shaft is supported at each end by oil absorbent, sintered metal bushes; one in the commutator end shield and one in the planetary drive shaft. The front end of the armature has a gear profile. This meshes with the three planetary gear wheels. These in turn, mesh with the internal teeth of the ring gear.

## Brushes

A brush plate supports four commutator brushes. This plate is fixed to the commutator end shield with two retaining screws. Two negative brushes are grounded to the pole housing. The two positive brushes are insulated from the pole housing and connected to the solenoid switch M terminal, refer to Figure 6D1-2 – 1



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Figure 6D1-2 – 1

### Legend

1	Solenoid Switch	4	Connector M15 – X2 pin A
1	Starter Motor	5	Connector M15 – X1 pin A
3	Starter Motor terminal M		

## 1.2 System Operation

### Operation

The ECM controls the activation of the start relay in response to inputs from:

- ignition switch,
- battery,
- theft deterrent engine crank inhibitor (a function of the theft deterrent system),
- park / neutral and back-up switch (on vehicles with 4 speed automatic transmission),
- transmission manual shift shaft switch assembly (on vehicles with 5 speed automatic transmission), and
- clutch pedal position switch (on vehicles with manual transmission).

The start relay controls the operation of the start solenoid.

The start solenoid controls operation of the starter motor and the drive assembly.

### Auto Start Feature

Vehicles fitted with the V6 engine have a new feature; Auto Start. Once the ignition switch has been turned to the START position, the starter motor will crank the engine.

If the ignition switch is returned to the ON position before the engine has started, the starter motor will continue to operate until the engine starts. If the engine fails to start, cranking will continue for approximately 4 seconds from when the ignition switch was returned to the ON position.

Turning the ignition switch to the OFF position will cancel the Auto Start and the starter motor will stop cranking.

### Clutch Pedal Switch (Manual Only)

The clutch pedal position switch provides an input to the ECU to ensure the clutch pedal is depressed while the vehicle is being started. This switch is normally open when the clutch pedal is at rest, closing when the pedal is pressed. Activation of this switch sends a signal to the ECM which will then allow operation of the starter motor.

### Sequence of Operation

- 1 When the ignition switch is turned to the START position, a signal is sent to the ECM to request engine cranking.
  - a For automatic vehicles the transmission must be in either park (P) or neutral (N) for the ECM to allow cranking to commence.
  - b For manual vehicles the clutch pedal must be depressed.
  - c The ECM will only allow cranking if the battery voltage is above the minimum battery voltage threshold value, refer to [Section 6C1-1 Engine Management – V6 – General Information](#) for further information.
- 2 The ECM operates the start relay which provides power to the pull-in winding of the start solenoid.
- 3 Current flow to the pull-in winding develops powerful magnetism which pulls in the solenoid switch plunger.
- 4 The plunger closes the switch contacts connecting battery voltage to the DC motor and pivots the fork lever to engage the drive assembly to the flexplate / flywheel ring gear. Closing the solenoid switch contacts deactivates the pull-in winding, the hold-in winding remains active.
- 5 With the solenoid switch contacts closed, current flows from the battery through the DC motor, which rotates the armature at high speed and provides cranking torque.
- 6 The ECM will initially allow cranking for up to 1 second to allow time for the validation of the security code data output from the remote coded key to be completed.
- 7 Once the security code serial data output from the remote coded key is validated by the ECM, the theft deterrent system is disarmed and cranking will continue. For further information on the theft deterrent system refer to [Section 12J Body Control Module](#).

## 2 Diagnostics

### 2.1 Diagnostic General Information

#### NOTE

There is a minimum battery voltage threshold value. If the battery voltage is below the set value, the ECU will inhibit cranking. Refer to [Section 6C1-1 Engine Management – V6 – General Information](#) for further information.

#### Basic Diagnostic Tools Required

#### CAUTION

Use of incorrect electrical circuit diagnostic tools when performing the cruise control diagnostic procedures could result in incorrect diagnostic results or damage to components.

The following electrical circuit testing tools are required to perform the diagnostic procedures detailed in this Section:

- digital multimeter with 10 mega ohms impedance, and
- connector test adapter kit Tool No. KM609.

For further information on the use of these tools, refer to [Section 12P Wiring Diagrams](#).

## 2.2 Tech 2 Data List

The Tech 2 displays the status of certain starting system parameters.

To view the data list:

- 1 Connect Tech 2 to the DLC.
- 2 On Tech 2 select:  
**Engine / V6 Engine / Data Display / Data List / Electrical/Theft Data.**

Tech 2 Parameter	Units Displayed	Typical Display Values
Crank Request	Inactive / Active	Inactive
Starter Relay	Off / On	Off

- 3 (For manual vehicles only) On Tech 2 select:  
**Engine / V6 Engine / Data Display / Data List / Engine Data 1.**

Tech 2 Parameter	Units Displayed	Typical Display Values
Clutch Pedal Switch	Inactive / Active	Inactive

### 2.3 Diagnostic Systems Check

Step	Action	Yes	No
1	Is the fault specifically isolated to this system / module?	Go to Step 2	Go to 0D Vehicle Diagnostics
2	1 Connect Tech 2 to the DLC. 2 Ignition ON, engine OFF. 3 On Tech 2 select: <b>Engine / V6 Engine / Diagnostic Trouble codes / Read            DTC's.</b> Are there any set DTC's?	Go to the appropriate DTC table in 6C1-2 Engine Management – V6 – Diagnostics.	Refer to 2.5 Starting System Inoperative / Malfunctioning

### 2.4 Wiring Diagram

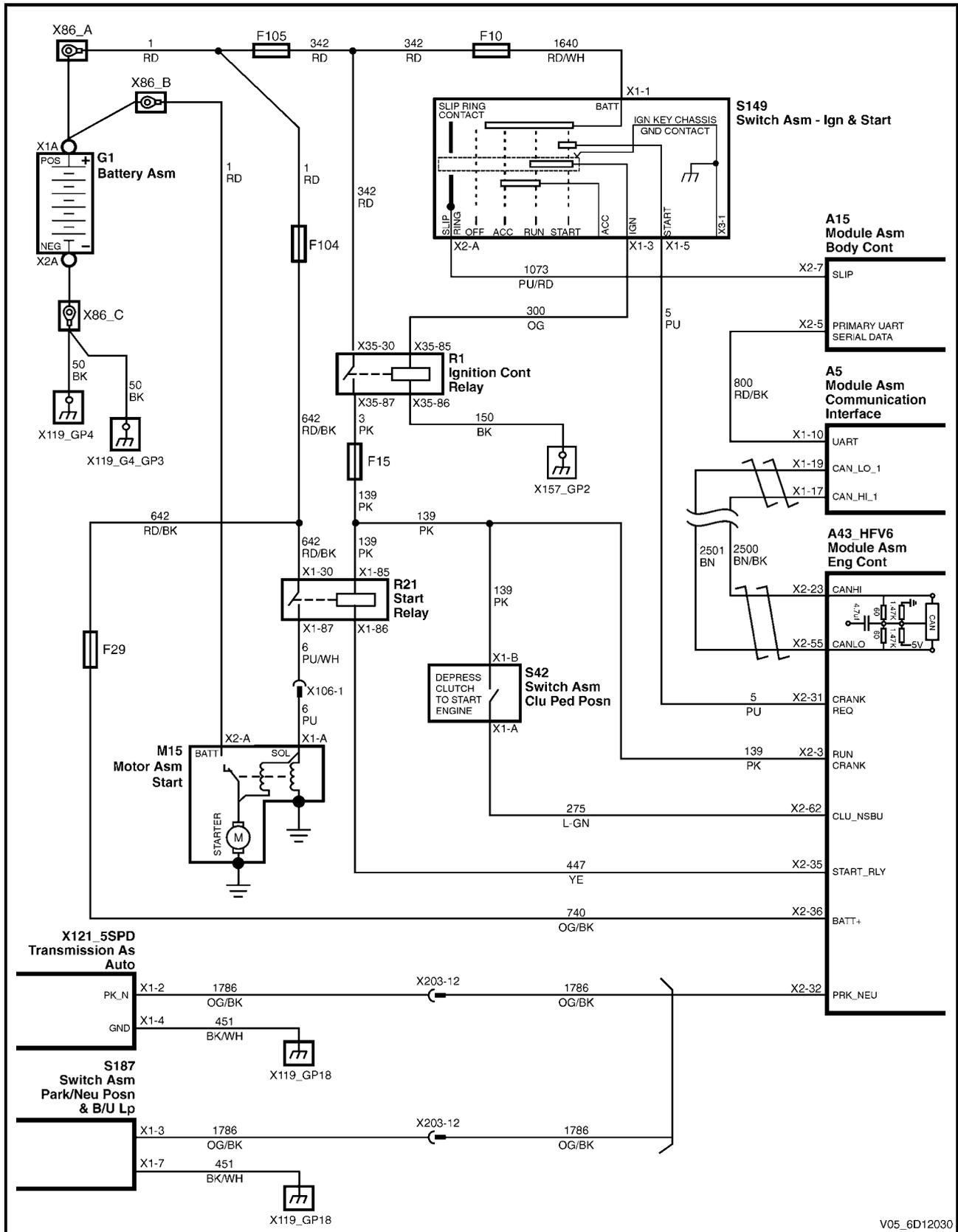


Figure 6D1-2 – 2

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## 2.5 Starting System Inoperative / Malfunctioning

### Circuit Description

The battery cable supplies a constant connection from the battery to starter solenoid connector M15 – X2 pin A (circuit 1).

When the ignition switch is turned to the START position, 12 V is applied to the ECM connector A43 – X1 pin 32 (circuit 5).

For vehicles with 4 speed automatic transmission, when the transmission is in park (P) or neutral (N), the park / neutral and back-up switch grounds ECM connector A43 – X2 pin 32 (circuit 1786).

For vehicles with 5 speed automatic transmission, when the transmission is in park (P) or neutral (N), the transmission manual shift shaft switch assembly grounds ECM connector A43 – X2 pin 32 (circuit 1786).

For manual vehicles the clutch pedal position switch applies 12 V to ECM connector A43 – X2 pin 62 (circuit 275) when the clutch pedal is depressed.

The ECM provides a ground for the start relay, ECM connector A43 – X2 pin 35 to start relay connector X100 – X1 pin 86 (circuit 447).

When activated the start relay provides 12 V to starter solenoid connector M15 – X1 pin A (circuit 6).

The solenoid closes its switch contacts to connect the battery voltage at the solenoid switch terminal M15 – X2 to the DC motor. The pull-in winding of the solenoid switch is grounded through the DC motor winding and brushes. The hold-in winding is grounded through the solenoid casing. The DC motor is grounded through the starter motor casing.

Security code data is exchanged between the remote key and the ECM via the ignition switch slip ring, ignition switch connector A149 – X2 pin A and BCM connector A15 – X2 pin 7 (circuit 1073). The data is sent via the tertiary UART serial data circuit from the BCM to PIM (circuit 800) and then to the ECM using the GM LAN serial data circuits, (circuits 2500 and 2501).

Refer to [2.4 Wiring Diagram](#) to aid in diagnosis.

### Diagnostic Table Notes

Reference to following information will assist when diagnosing starting circuit faults:

- 1 If the battery, starter motor and fuel system are deemed as serviceable and a 'no crank' and / or 'no start' condition exists, refer to the following Sections as required:
  - a [Section 12J Body Control Module](#) for theft deterrent engine crank inhibitor related faults
  - b [Section 6C1-2 Engine Management – V6 – Diagnostics](#) for starter relay circuit faults
- 2 For all wiring harness fault diagnoses, refer to [Section 12P Wiring Diagrams](#).
- 3 For wiring harness repairs, refer to [Section 12P Wiring Diagrams](#).
- 4 Refer to [Section 12O Fuses, Relays and Wiring Harnesses](#) for harness routing.
- 5 Ensure the battery, cables and connections are in good order. Refer to [Section 12A Battery](#).

### Diagnostic Table

Step	Action	Yes	No
1	Did you review 1.2 System Operation?	Go to Step 2	Go to <a href="#">1.2 System Operation</a>
2	Did you read 2.3 Diagnostic Systems Check	Go to Step 3	Go to <a href="#">2.3 Diagnostic Systems Check</a>
3	Turn the ignition switch to the START position and then release it. Did the engine crank or were there any clicking or chattering sounds from the solenoid?	Go to Diagnostic Table – Slow Cranking, Solenoid Clicks or Chatters	Go to Step 4

Step	Action	Yes	No
4	Inspect fusible link F104, refer to 12O Fuses, Relays and Wiring Harnesses. Is fusible link F104 blown?	Replace the faulty fusible link (refer to Note 3).  If the fusible link blows again, repair or replace circuit 1 (refer to Note 2)	Go to Step 5
5	Inspect fusible link F105, refer to 12O Fuses, Relays and Wiring Harnesses. Is fusible link F105 blown?	Replace the faulty fusible link (refer to Note 3).  If the fusible link blows again, repair or replace circuit 342 (refer to Note 2)	Go to Step 6
6	Inspect fuse F10, refer to 12O Fuses, Relays and Wiring Harnesses. Is fuse F10 blown?	Replace the faulty fuse (refer to Note 3).  If the fuse blows again, repair or replace circuit 1640 (refer to Note 2)	Go to Step 7
7	Inspect fuse F15, refer to 12O Fuses, Relays and Wiring Harnesses. Is fuse F15 blown?	Replace the faulty fuse (refer to Note 3).  If the fuse blows again, repair or replace circuit 139 (refer to Note 2)	Go to Step 8
8	<p style="text-align: center;"><b>NOTE</b></p> <p>On manual vehicles ensure the clutch pedal is depressed during this step. On automatic vehicles ensure that park (P) or neutral (N) is selected.</p> <p>Turn the headlamps on.</p> <p>Turn the dome lamps on.</p> <p>Turn the ignition switch to the START position.</p> <p>Do the lamps dim?</p>	Go to Step 9	Go to Step 10
9	Perform the 3.3 On-Vehicle Testing. Did you correct the condition?	Go to Step 24	Go to Step 2
10	<p>1 Connect Tech 2 to the DLC.</p> <p>2 Ignition on, engine off.</p> <p>3 On Tech 2 select: <b>Engine / V6 Engine / Data Display / Data List / Electrical/Theft Data.</b></p> <p>4 On Tech 2 scroll to <b>Crank Request</b></p> <p>5 While monitoring Tech 2, turn the ignition switch to START.</p> <p>Does Tech 2 display the following: <b>Inactive</b> with the ignition switch in the ON position, <b>Active</b> with the ignition switch in the START position?</p>	Go to Step 15	Go to Step 11

Step	Action	Yes	No
11	<p>1 Disconnect the ECM connector A43 – X2.</p> <p>2 Using a multimeter set to measure voltage, back probe between the harness connector A43 – X2 pin 31 and ground.</p> <p>3 With the aid of an assistant, monitor the voltage on the multimeter and turn the ignition switch to START.</p> <ul style="list-style-type: none"> <li>• With the ignition switch in the START position, the multimeter should display battery voltage</li> <li>• With the ignition switch in the ON position, the multimeter should display 0 V</li> </ul> <p>Does the multimeter display as described?</p>	<p>Refer to 6C1 - 3 Engine Management – V6 – Service Operations for further diagnosis.</p> <p>Go to Step 24</p>	<p>Go to Step 12</p>
12	<p>Test the ignition switch, refer to 9 Steering.</p> <p>Is the ignition switch serviceable?</p>	<p>Go to Step 13</p>	<p>Replace the faulty ignition switch. Refer to 9 Steering</p> <p>Go to Step 24</p>
13	<p>Check for short to ground or open circuit in circuit 5.</p> <p>Was the circuit serviceable?</p>	<p>Go to Step 14</p>	<p>Repair as required (refer to Note 2).</p> <p>Go to Step 24</p>
14	<p>Check for short to ground or open circuit in circuit 1640.</p> <p>Was the circuit serviceable?</p>	<p>Go to Step 2</p>	<p>Repair as required (refer to Note 2).</p> <p>Go to Step 24</p>
15	<p style="text-align: center;"><b>NOTE</b></p> <p>This procedure is only required on vehicles fitted with manual transmissions. If the vehicle is fitted with an automatic transmission, go to Step 18</p> <p>1 Scroll to <b>Starter Relay</b></p> <p>2 Ensure the clutch pedal is fully depressed.</p> <p>3 While monitoring Tech 2, turn the ignition switch to START.</p> <p>Does Tech 2 display the following:</p> <p><b>Off</b> with the ignition switch in the ON position,</p> <p><b>On</b> with the ignition switch in the START position?</p>	<p>Go to Step 21</p>	<p>Go to Step 16</p>
16	<p>1 Disconnect the ECM connector A43 – X2.</p> <p>2 Using a multimeter set to measure voltage, back probe between the harness connector A43 – X2 pin 62 and ground.</p> <p>3 With the aid of an assistant, monitor the voltage on the multimeter fully depress the clutch pedal.</p> <ul style="list-style-type: none"> <li>• With the clutch pedal fully depressed, the multimeter should display battery voltage</li> <li>• With the clutch pedal released, the multimeter should display 0 V</li> </ul> <p>Does the multimeter display as described?</p>	<p>ECU problem.</p> <p>Refer to 6C1 - 3 Engine Management – V6 – Service Operations for further diagnosis.</p> <p>Go to Step 24</p>	<p>Go to Step 17</p>
17	<p>Remove and test the clutch pedal position switch, refer to Clutch Pedal Switch.</p> <p>Was the switch serviceable?</p>	<p>Go to Step 18</p>	<p>Replace as required.</p> <p>Go to Step 24</p>

Step	Action	Yes	No
18	Check for short to ground or open circuit in circuits 139 and 275. Was the circuit serviceable?	Go to Step 2	Repair as required (refer to Note 2). Go to Step 24
19	1 Scroll to <b>Starter Relay</b> 2 Ensure the transmission is in park (P) or neutral (N). 3 While monitoring Tech 2, turn the ignition switch to START. Does Tech 2 display the following: <b>Off</b> with the ignition switch in the ON position, <b>On</b> with the ignition switch in the START position?	Go to Step 21	Go to Step 20
20	1 Disconnect the ECM connector A43 – X2. 2 Using a multimeter set to measure voltage, back probe between the harness connector A43 – X2 pin 32 and ground. 3 With the aid of an assistant, monitor the voltage on the multimeter. <ul style="list-style-type: none"> <li>With the place the transmission in park (P), the multimeter should display 0 V</li> <li>With the place the transmission in neutral (N), the multimeter should display 0 V</li> </ul> Does the multimeter display as described?	Refer to 6C1 - 3 Engine Management – V6 – Service Operations for further diagnosis. Go to Step 24	For vehicles fitted with the 4 speed automatic transmission refer to 7C4 Automatic Transmission – 4L60E – On-vehicle Servicing for further diagnosis of the park / neutral and back-up switch. For vehicles fitted with the 5 speed automatic transmission refer to 7D4 Automatic Transmission – 5L40E – On-vehicle Servicing for further diagnosis of the transmission manual shift shaft switch assembly Go to Step 24
21	Test the starter relay. Refer to 6C1-2 Engine Management – V6 – Diagnostics. Is the starter relay serviceable?	Go to Step 22	Repair or replace as required Go to Step 24
22	1 Using a multimeter set to measure voltage, back probe between the harness connector M15 – X1 pin A and ground. 2 With the aid of an assistant, monitor the voltage on the multimeter. <ul style="list-style-type: none"> <li>Turn the ignition switch to START, the multimeter should display 7.0 V</li> </ul> Does the multimeter display as described?	Repair or replace the starter motor as required. Refer to 4 Major Service Operations. Go to Step 24	Go to Step 23
23	Check for short to ground or open circuit in circuits 6 and 275. Was the circuit serviceable?	Go to Step 2	Repair as required (refer to Note 2). Go to Step 24
24	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
<b>When all diagnosis and repairs are completed, check the system for correct operation.</b>			

**Diagnostic Table – Slow Cranking, Solenoid Clicks or Chatters**

<b>Step</b>	<b>Action</b>	<b>Yes</b>	<b>No</b>
<b>1</b>	Did you review 1.2 System Operation?	Go to Step 2	Go to <a href="#">1.2 System Operation.</a>
<b>2</b>	Did you read 2.3 Diagnostic Systems Check	Go to Step 3	Go to <a href="#">2.3 Diagnostic Systems Check.</a>
<b>3</b>	Perform the 3.3 On-Vehicle Testing. Did you correct the condition?	Go to Step 4	Repair or replace the starter motor. Refer to 4 Major Service Operations. Go to Step 4
<b>4</b>	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
<b>When all diagnosis and repairs are completed, check the system for correct operation.</b>			

## 3 Minor Service Operations

### 3.1 Safety Precautions

Observe the following precautions. Failure to observe these precautions can result in serious damage to components.

- Refer to [Section 00 Warnings, Cautions and Notes](#) in this Service Information before disconnecting the battery.
- Use the starter motor on a negative ground system only.
- When installing a battery, attach the positive (+) cable to the battery first. Then attach the negative cable.
- When using a slave battery for starting purposes, ensure that both batteries are connected in parallel, that is, positive to positive terminals and negative to negative terminals.
- Only use jumper leads that have surge protection.

## 3.2 Maintenance

### Regular Checks

Check the following at regular intervals:

- Starter motor terminals – for corrosion and loose connectors.
- Wiring – for damaged insulation
- Mounting bolts – for tightness
- Battery terminals – for clean and secure connections.

### 3.3 On-Vehicle Testing

#### NOTE

The battery must be fully charged and in serviceable condition before beginning these tests, refer to [Section 12A Battery](#).

#### Prerequisites

- 1 Remove fuses F34 and F35 from the engine compartment fuse box to disable the ignition and prevent the engine from starting, refer to [Section 12O Fuses, Relays and Wiring Harnesses](#).

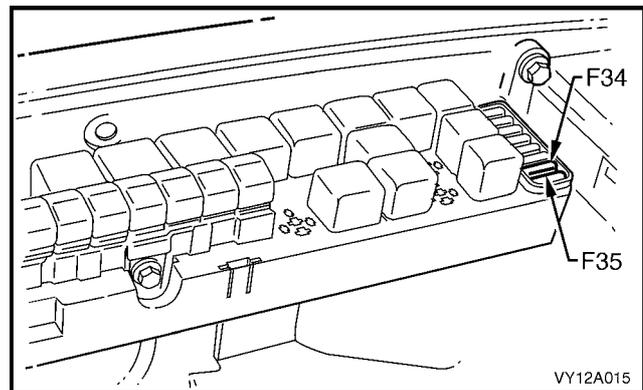


Figure 6D1-2 – 1

- 1 Chock the wheels.
- 2 For vehicles fitted with automatic transmission ensure the transmission is in P (park) or N (neutral) and the hand brake is applied.
- 3 For manual vehicles ensure the clutch is depressed when cranking the engine.
- 4 Ensure the engine is at room temperature or normal operating temperature and in good working order.

#### Bad Connection Test

A bad connection appears as a voltage reading when the multimeter leads are connected to two different positive (or negative) connections.

- 1 Using a multimeter set to measure voltage, connect the multimeter's positive lead to the positive battery post.
- 2 Connect the multimeter's negative lead to the starter motor M terminal.
- 3 Record the voltage that displayed during cranking.
- 4 Repeat this with the multimeter's negative lead connected to the solenoid switch connector M15 – X2 pin A (circuit 1).
- 5 Also repeat this connecting the multimeter's negative lead to the battery cable strands (circuit 1).
- 6 Restore all connections that show a significant resistance (voltage reading).

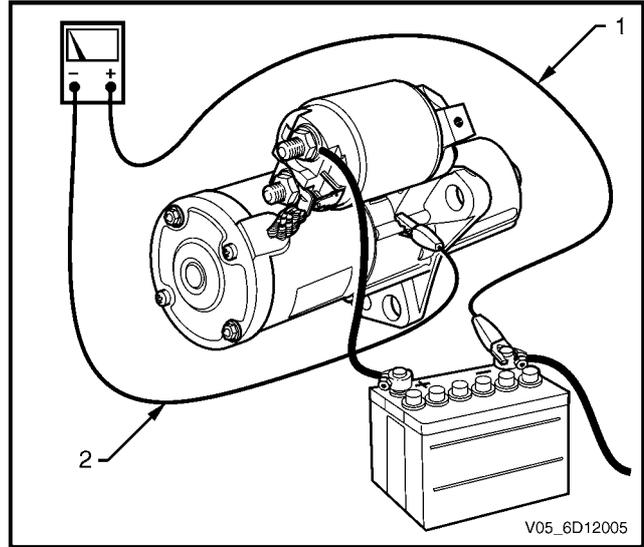
**Starter Motor Ground Test**

- 1 Using a multimeter set to measure voltage, connect the multimeter's positive lead (1) to the negative battery post.

**CAUTION**

**Connect the lead to the actual battery post and not to the cable or connector.**

- 2 Connect the multimeter's negative lead (2) to the starter motor housing.
- 3 Record the voltage that displayed during cranking.
- 4 Repeat this connecting the multimeter's negative lead to the battery cable strands (circuit 50).
- 5 Restore all ground connections that show a significant resistance.



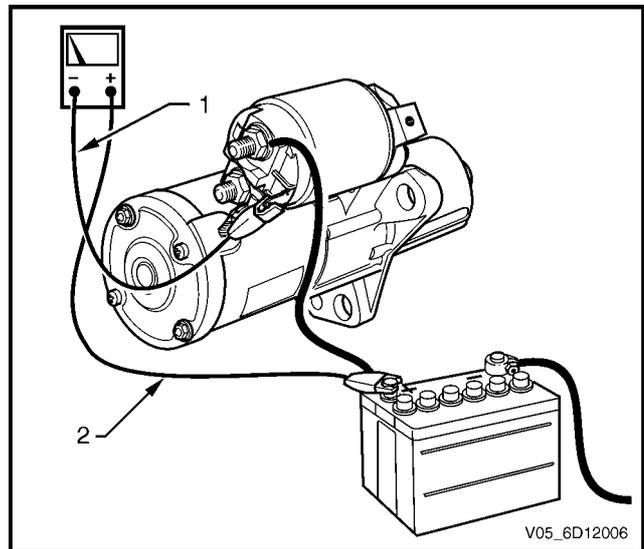
**Figure 6D1-2 – 2**

**Switching Circuit Test**

- 1 Using a multimeter set to measure voltage, connect the multimeter's negative lead (1) to the solenoid switch connector M15 – X1 pin A (circuit 6).
- 2 Connect the multimeter's positive lead (2) to the positive battery post.
- 3 Crank the engine.
- 4 Record the voltage that displayed during cranking.

Maximum switching circuit voltage difference .....2.5 V
---

- 5 If the voltage is above the specification, test the solenoid switching circuit to locate the cause of the high resistance and restore the connection.



**Figure 6D1-2 – 3**

### Cranking Voltage Test

- Using a multimeter set to measure voltage, attach the multimeter's negative lead to ground and the multimeter's positive lead to starter solenoid connector M15 – X1 pin A (3) of the solenoid switch.

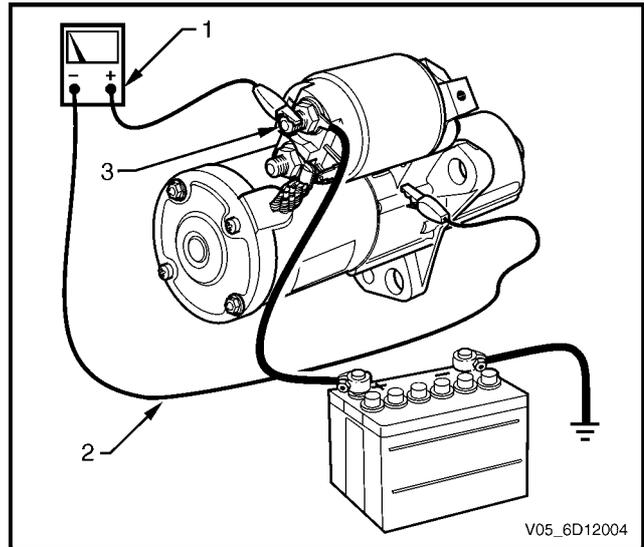
**CAUTION**

**Do not crank the engine for more than 30 seconds at a time. Allow 2 minutes for the starter motor to cool down between tests.**

- Crank the engine.
- Record the voltage that displayed during cranking.

Minimum cranking voltage .....	9.0 V
--------------------------------	-------

- Remove and repair or replace the starter motor and solenoid switch if the voltage is below the specifications and cranks poorly. Refer to [4 Major Service Operations](#).



**Figure 6D1-2 – 4**

### Current Draw Test

- Using a multimeter set to measure voltage, attach the multimeter's positive lead to the positive battery post.
- Attach the same multimeter's negative lead to the negative battery post.
- Using a multimeter set to measure current, attach the multimeter's positive lead to the battery post.
- Connect the negative lead of the multimeter set to measure current to a battery loading device, for example a carbon pile.
- Connect the free lead of the battery loading device to the negative battery terminal.
- Set the battery loading device to maximum resistance (open).
- Crank the engine.
- Record the voltage that displayed during cranking.
- With the ignition in the OFF position, adjust the battery loading device so the reading of the multimeter set to measure voltage matches the reading recorded in the last step.
- Record the current draw from the battery loading device.
- Set the battery loading device back to 'open'.
- Check the current draw is within specifications.

Cranking current range .....	100 – 140 A
------------------------------	-------------

- Remove and repair or replace the starter motor and solenoid switch if the current draw is outside the specification. Refer to [4 Major Service Operations](#).

## Clutch Pedal Switch

### Remove

#### NOTE

V6 Vehicles are fitted with two clutch pedal switch assemblies. The wiring diagrams treat both physical switches as one assembly designated as S42, Clutch Pedal Position Switch Assembly. However these are two physical switches with separate functions. One ensures the engine can only be cranked with the clutch pedal depressed. The switch mounted closest to the firewall is the switch which has input to the starting system.

- 1 Disconnect the wiring harness connectors from the switch.
- 2 Turn the switch 90°, then pull the switch assembly out from the support to remove.

### Test

- 1 Using a multimeter, probe the pins (1) of the switch assembly.
- 2 In the neutral position (plunger extended) there should be an open circuit across the switch.
- 3 In the active position (plunger depressed) there should be continuity across the switch.
- 4 Replace the switch as per the following reinstall procedure if the tests prove the switch to be faulty.
- 5 If the test proves the switch to be serviceable, reinstall it as per the following procedure.

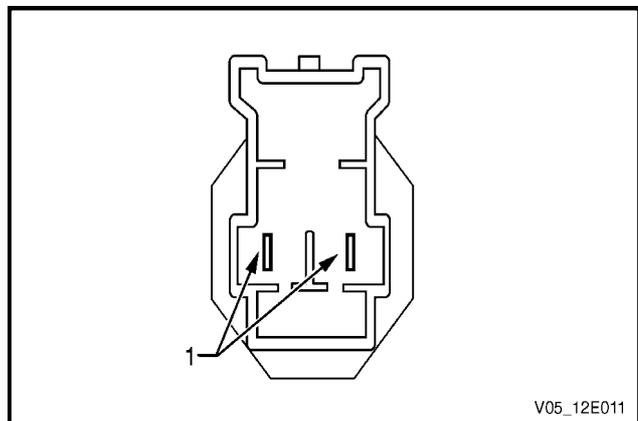


Figure 6D1-2 – 5

### Reinstall

- 1 Install the switch by pushing the switch assembly through the support and turning the switch 90°.
- 2 Connect the wiring harness connectors to the clutch switch.
- 3 Verify the operation of the clutch switch by operating the starting system and checking the clutch switch prevents operation of the starter motor when the clutch pedal is not pressed.

## 4 Major Service Operations

### CAUTION

Disconnection of the battery affects certain vehicle electronic systems. Refer to [Section 00 Warnings, Cautions and Notes](#) before disconnecting the battery.

### 4.1 Starter Motor – RWD

LT Section – 02-070

#### Remove

### WARNING

The starter motor is in close proximity to the left-hand side exhaust manifold and engine pipe. Allow the engine to cool before attempting to remove the starter motor.

- 1 Refer to [Section 00 Warnings, Cautions and Notes](#) in this Service Information before disconnecting the battery.
- 2 Disconnect the battery ground lead.
- 3 Raise the front of the vehicle. For jacking locations, refer to [Section 0A General Information](#).
- 4 Put safety stands in place.
- 5 Remove the starter motor mounting bolts (1).
- 6 Remove the starter motor from the engine block and lower the starter motor as far as possible to gain access to the wiring harness connections.

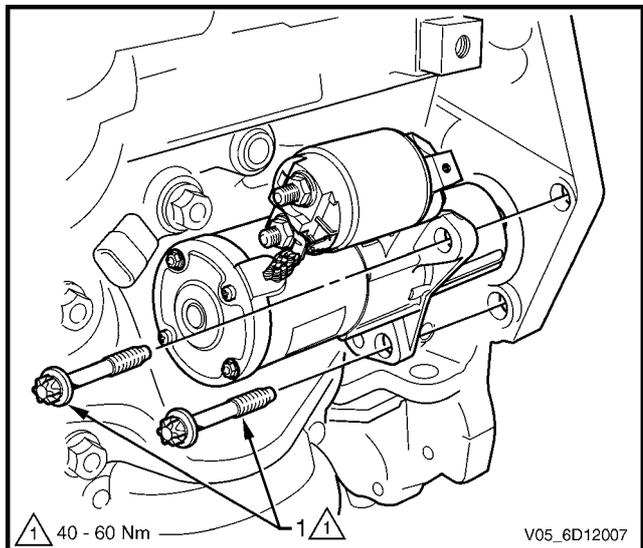


Figure 6D1-2 – 6

- 7 Remove the wiring harness connector M15 – X1 (1) from the solenoid switch (2).
- 8 Remove the nut (3) and battery lead connector M15 – X2 (4) from solenoid switch.
- 9 Remove the starter motor from below the vehicle between the catalytic converter and transmission bell housing.

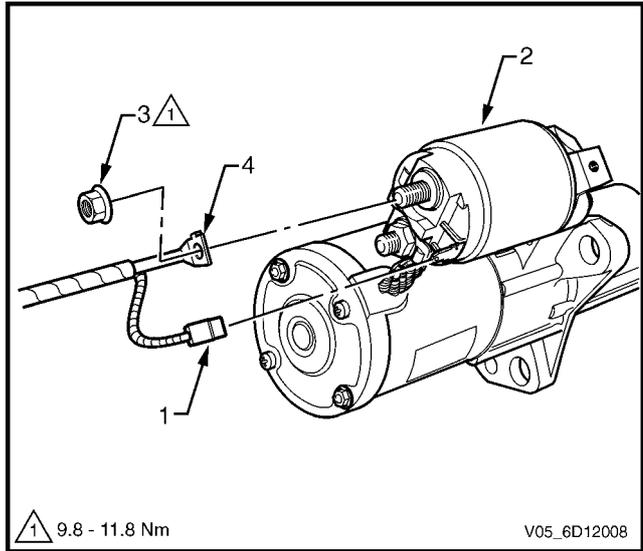


Figure 6D1-2 – 7

**Reinstall**

Reinstallation of the starter motor is the reverse of the removal procedure noting the following:

- 1 Tighten all fasteners to the correct torque specification.

Starter motor mounting bolt torque specification .....40.0 – 60.0 Nm  Solenoid switch connector M15 – X2 nut (B+) torque specification .....9.8 – 11.8 Nm
---

- 2 Check the starter motor operates correctly.

## 4.2 Starter Motor – AWD

### LT Section – 02-070

### Remove

#### WARNING

The starter motor is in close proximity to the left-hand side exhaust manifold and engine pipe. Allow the engine to cool before attempting to remove the starter motor.

- 1 Refer to [Section 00 Warnings, Cautions and Notes](#) in this Service Information before disconnecting the battery.
- 2 Disconnect the battery ground lead.
- 3 Raise the front of the vehicle. For jacking locations, refer to [Section 0A General Information](#).
- 4 Put safety stands in place.
- 5 Remove the front constant velocity joint from the front final drive pinion flange. Refer to [Section 4C2 Front Propeller Shaft and Universal Joints](#).
- 6 Remove the starter motor mounting bolts (1).
- 7 Remove the starter motor from the engine block and lower the starter motor as far as possible to gain access to the wiring harness connections.

#### NOTE

The starter motor is most easily removed from its installed position by tilting the front upwards and rotating the assembly so the solenoid switch moves toward the engine.

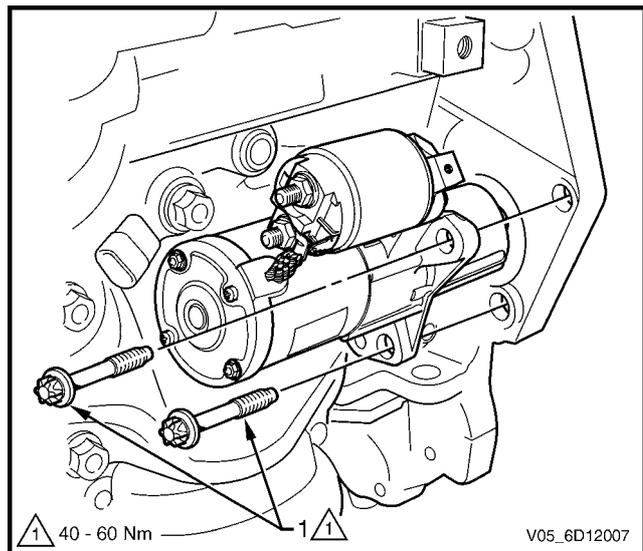


Figure 6D1-2 – 8

- 8 Remove the wiring harness connector M15 – X1 (1) from the solenoid switch (2).
- 9 Remove the nut (3) and battery lead connector M15 – X2 (4) from solenoid switch.
- 10 Remove the starter motor.

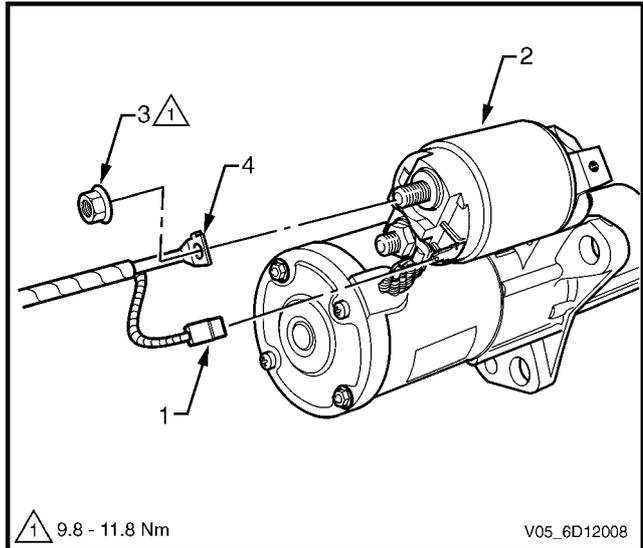


Figure 6D1-2 – 9

## Reinstall

Reinstallation of the starter motor is the reverse of the removal procedure noting the following:

- 1 Tighten all fasteners to the correct torque specification.

Starter motor mounting bolt torque specification .....	40.0 – 60.0 Nm
Solenoid switch connector M15 – X2 nut (B+) torque specification .....	9.8 – 11.8 Nm

- 2 Check the starter motor operates correctly.

## 4.3 Starter Motor Bench Tests

### LT Section – 02-070

#### Preliminary Checks

- 1 Check the drive assembly is fully retracted.
- 2 Check the drive assembly pinion turns freely on the planetary drive shaft.
- 3 Perform the No Load Test (as outlined in this Section) if the drive assembly is not fully retracted.
- 4 Disassemble and service the starter motor if it fails the No Load test, refer to [4.4 Starter Motor Disassemble and Reassemble](#) in this Section.

#### Pull-in Test

- 1 Clamp the starter motor, by the mounting lug in the drive-end housing, in a vice with soft jaws.
- 2 Remove the nut (1) and washer (2) from the solenoid switch M terminal (3).
- 3 Remove the braided cable (4) from the solenoid switch M terminal.

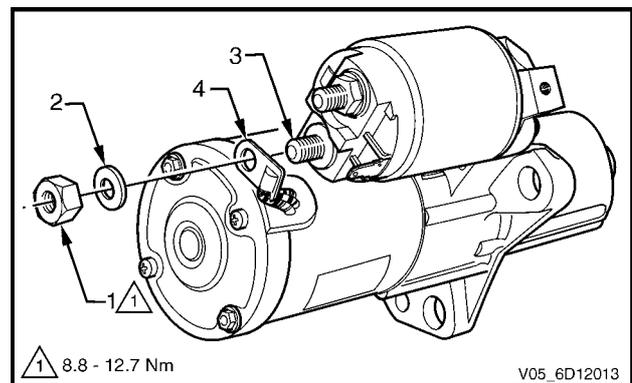


Figure 6D1-2 – 10

- 4 Connect the starter motor to an auxiliary battery, as follows:
  - a Connect the test lead (1) between the battery negative post to the solenoid switch M terminal (3).
  - b Connect the test lead (2) battery positive post.
- 5 Momentarily hold the free end of test lead (2) to solenoid switch terminal M15 – X1.
- 6 Check the solenoid switch activates and the drive assembly moves outward.
- 7 Disassemble and service the starter motor if the solenoid switch activates but the drive assembly does not move, refer to [4.4 Starter Motor Disassemble and Reassemble](#) in this Section.
- 8 Replace the solenoid switch if it does not activate (there is no sound or movement).

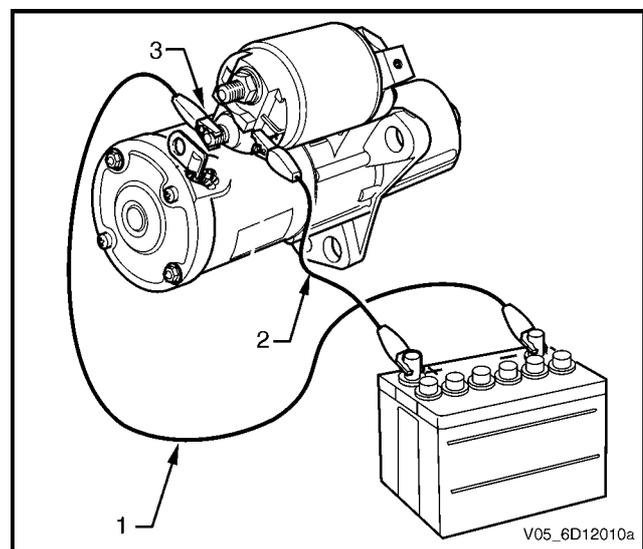


Figure 6D1-2 – 11

**Hold-in Test**

- 1 Connect the starter motor to an auxiliary battery, as follows:
  - a Connect the test lead (1) between the battery negative post to the solenoid switch M terminal.
  - b Connect the test lead (2) from the battery positive post to solenoid switch terminal M15 – X1.
  - c Connect the test lead (3) to the starter motor casing.
- 2 Disconnect the test lead (1) from the M terminal of the solenoid switch.
- 3 Check the drive assembly remains extended.
- 4 Replace the solenoid switch if the drive assembly returns back into the starter motor.

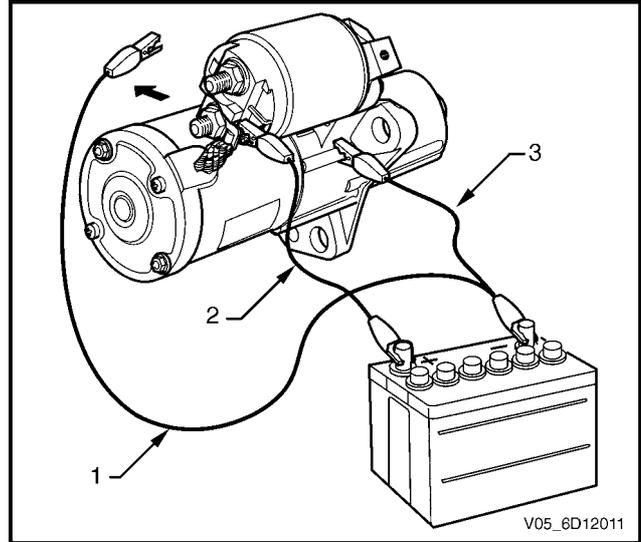


Figure 6D1-2 – 12

**Drive Assembly Return Test**

- 1 Connect the starter motor to an auxiliary battery, as follows:
  - a Connect the test lead (1) between the battery negative post to the solenoid switch M terminal.
  - b Connect the test lead (2) from the battery positive post to solenoid switch terminal M15 – X1.
  - c Connect the test lead (3) to the starter motor casing.
- 2 Disconnect the test lead (1) from the M terminal of the solenoid switch.
- 3 Disconnect the negative lead (2) from the starter motor casing.
- 4 Check the drive assembly returns back into the starter motor.
- 5 Replace the solenoid switch if the drive assembly does not retract.

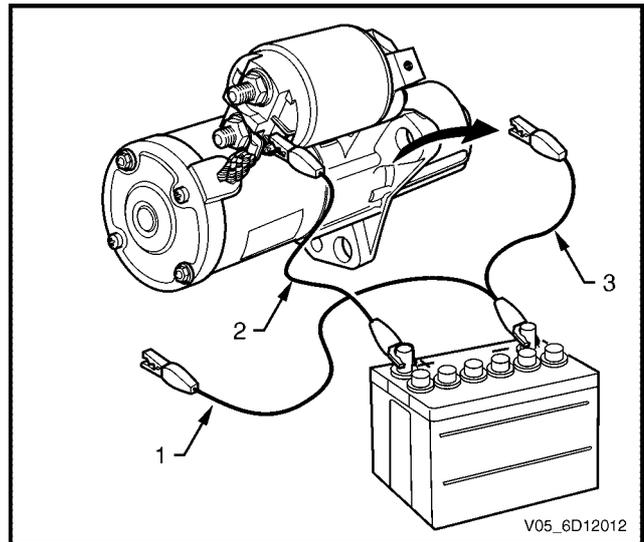


Figure 6D1-2 – 13

**No Load Test**

- 1 Clamp the starter motor securely to a test bench.
- 2 Connect the starter motor as shown in Figure 6D1-2 – 14.
- 3 Close the start switch to activate the starter motor.
- 4 Record the speed of the planetary drive shaft, current draw and the voltage.
- 5 Check the readings are within the specifications.

Minimum r.p.m. ....	2370
Maximum current draw .....	65 A
M Terminal voltage .....	12 ± 0.1 V

- 6 Disassemble and service the starter motor if the readings are not within the specifications, refer to [4.4 Starter Motor Disassemble and Reassemble](#).

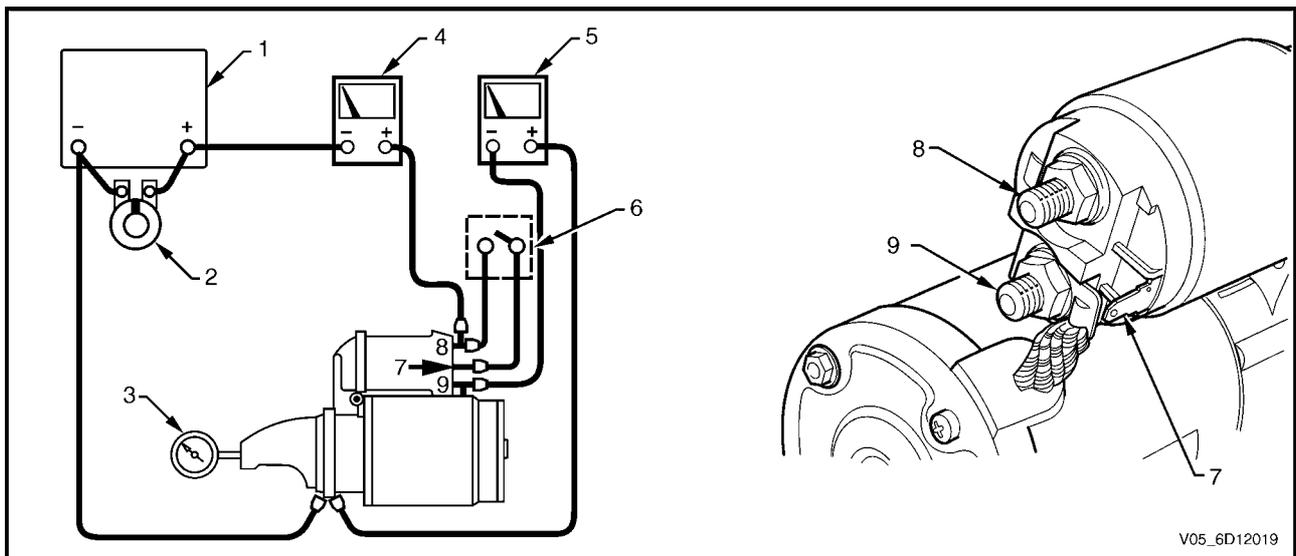


Figure 6D1-2 – 14

**Legend**

- |   |                                   |   |                                |
|---|-----------------------------------|---|--------------------------------|
| 1 | Battery                           | 6 | Start Switch                   |
| 2 | Carbon Pile                       | 7 | Solenoid Switch M15 – X1 pin A |
| 3 | Shaft Speed Indicator             | 8 | Solenoid Switch M15 – X2 pin A |
| 4 | Multimeter set to measure current | 9 | Solenoid Switch M terminal     |
| 5 | Multimeter set to measure voltage |   |                                |

## 4.4 Starter Motor Disassemble and Reassemble

### LT Section – 02-070

#### Disassemble

- 1 Clamp the starter motor, by the mounting lug in the drive-end housing, in a vice with soft jaws.
- 2 Remove the nut (1) and washer (2) from the solenoid switch M terminal (3).
- 3 Remove the braided cable (4) from the M terminal.

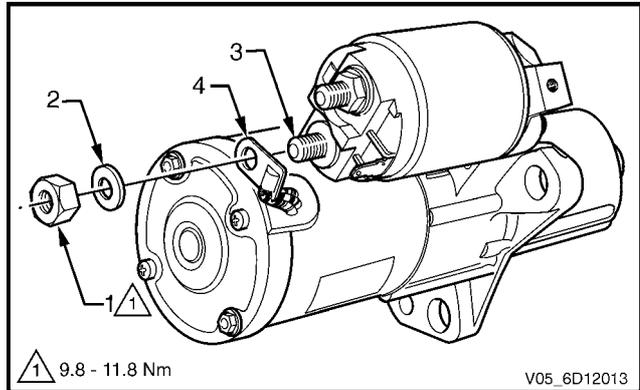


Figure 6D1-2 – 15

- 4 Scribe aligning marks (1) on the drive-end housing (2) and the solenoid switch housing (3) to aid reassembly.

#### CAUTION

When using an impact driver, avoid damaging the drive-end housing or rounding the screw slots of the solenoid switch mounting screws.

- 5 Remove the two solenoid switch mounting screws (4). It may be necessary to loosen the mounting screws using an impact driver.
- 6 Remove the solenoid switch from the drive-end housing.

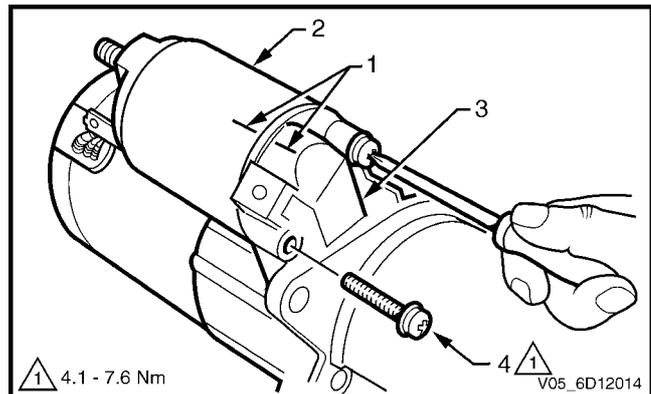


Figure 6D1-2 – 16

#### CAUTION

Do not lose the plunger return spring.

- 7 Unhook and remove the solenoid switch plunger (1) from the drive assembly fork lever (2).

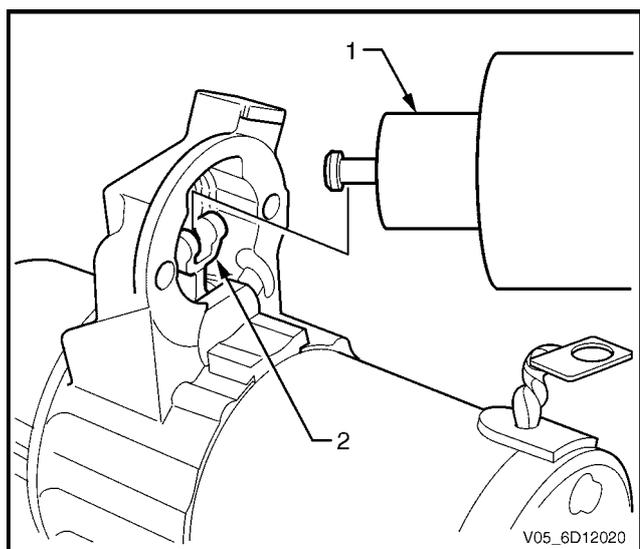


Figure 6D1-2 – 17

## Reassemble

- 1 Reassemble the solenoid in the reverse order of the disassembly procedure noting the following points.

### WARNING

**Dry all parts thoroughly before assembly, taking care not to breathe in any vapours.**

- 2 Lightly coat the solenoid switch plunger with 10% molybdenum disulphide grease.

### CAUTION

**Excess grease can enter the contact chamber of the solenoid switch and cause contact problems. Do not use too much grease.**

- 3 Hook the plunger over the fork lever.
- 4 Insert the return spring into the plunger.
- 5 Slide solenoid switch over the plunger.
- 6 Align the solenoid switch with drive-end housing ensuring the solenoid switch terminal M15 – X2 faces away from the pole housing.
- 7 Install and tighten the solenoid switch mounting screws.

Solenoid switch mounting screw torque specification .....4.1 – 7.6 Nm
---

- 8 With the starter motor reassembled, perform a No Load Test, refer to [4.3 Starter Motor Bench Tests](#).
- 9 If the starter motor fails the No Load Test specification, replace the starter motor.

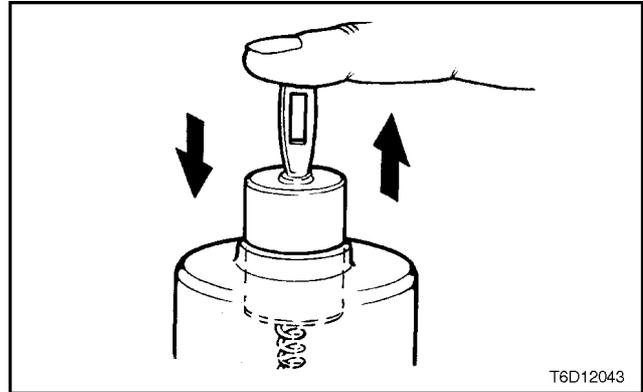
## 4.5 Solenoid Switch Tests

**LT Section – 02-070**

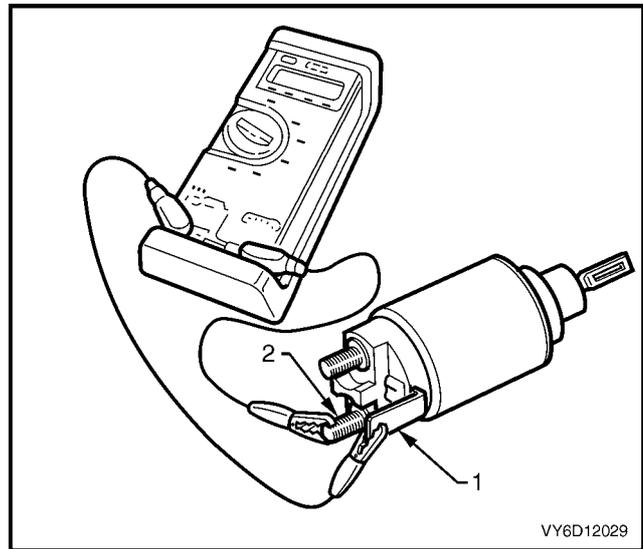
**Test the Solenoid Switch**

- 1 Inspect the solenoid switch for any external damage.
- 2 Replace the solenoid switch if it displays significant damage.
- 3 Install the return spring and plunger into the solenoid switch.
- 4 Check the movement of the plunger, as follows:
  - a Depress the plunger fully.
  - b Release the plunger.
  - c If the plunger sticks or binds in the switch bore, clean or replace the solenoid switch assembly as required.
- 5 Connect a multimeter set to measure resistance between the solenoid switch M terminal (1) and the solenoid switch terminal M15 – X1 (2).
- 6 Record the resistance reading.
- 7 Replace the solenoid switch if the resistance is outside the specification.

Pull-in winding resistance @ 20° C .....0.33 – 0.37 Ω
--



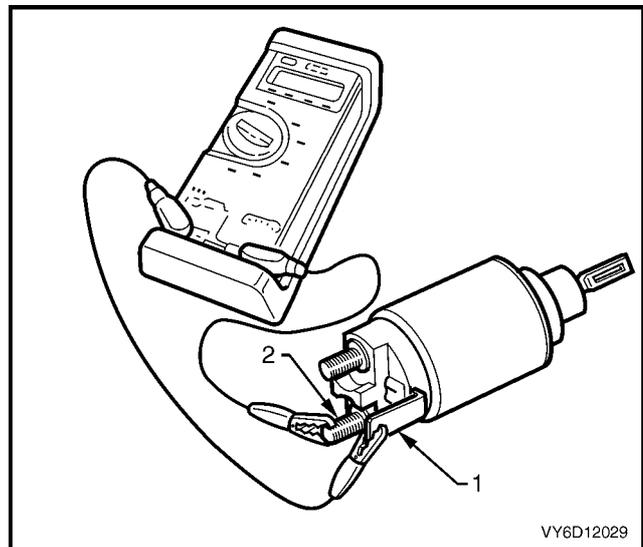
**Figure 6D1-2 – 18**



**Figure 6D1-2 – 19**

- 8 Connect a multimeter set to measure resistance between the solenoid switch housing (1) and the solenoid switch terminal M15 – X1 (2).
- 9 Replace the solenoid switch if the resistance is outside the specification.

Hold-in winding resistance @ 20° C .....0.75 – 0.87 Ω
--



**Figure 6D1-2 – 20**

- 10 Fit a rubber band (1) around the plunger and switch housing to avoid ejecting the plunger.
- 11 Hold the solenoid switch vertically with the plunger pointing upwards.
- 12 Use a power supply (2) capable of supplying 30 A or use a battery and a variable resistor.
- 13 Set the power supply to 3.0 V.
- 14 Connect the power supply negative lead to the solenoid switch body.
- 15 Connect the power supply positive lead to the solenoid switch terminal M15 – X1 (5).
- 16 Connect a test lamp (3) between the solenoid switch terminal M15 – X2 (7) and the battery.
- 17 Connect a multimeter set to measure voltage (4) between the solenoid switch terminal M15 – X1 (5) and the solenoid switch housing.
- 18 Press the solenoid plunger in until the test lamp illuminates.
- 19 Allow the plunger to move out by 8 – 10 mm.
- 20 Hold the plunger in this position.

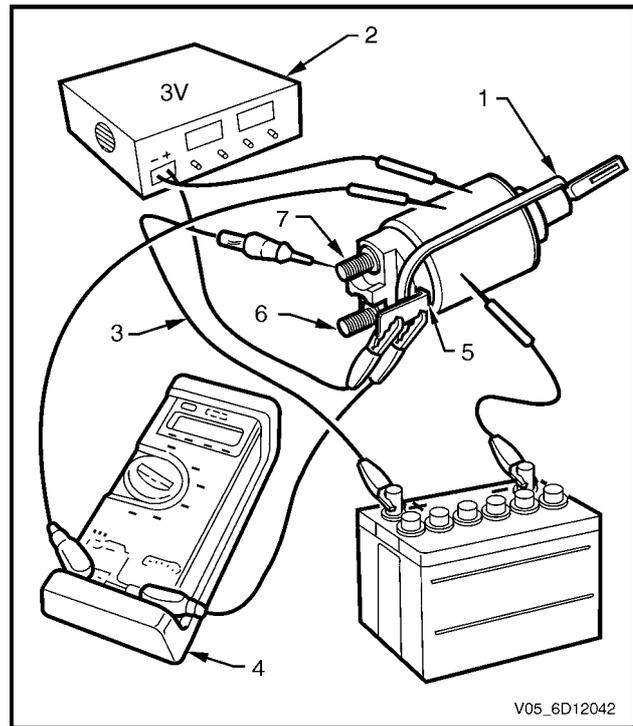


Figure 6D1-2 – 21

**CAUTION**

**The test duration for the following step should be no more than 2 seconds.**

- 21 Slowly increase the power supply voltage on the solenoid switch terminal M15 – X1 until the plunger pulls in.
- 22 Record the multimeter reading and reduce the voltage applied to the solenoid switch terminal M15 – X1.
- 23 Replace the solenoid switch if the voltage reading is significantly higher than the specification.

Pull-in voltage @ 20°C.....7.8 V
----------------------------------

- 24 Check the continuity across the main contacts in the switch.
- 25 Increase the voltage on the solenoid switch terminal M15 – X1 (5) until the plunger pulls in.
- 26 Ensure the test lamp illuminates fully.
- 27 Replace the solenoid switch if the test lamp illuminates poorly.

- 28 Set the power supply to 12 V (1).
- 29 Connect the power supply positive lead to the solenoid switch terminal M15 – X1 (2).
- 30 Connect the power supply negative lead to the solenoid switch housing (3).
- 31 Press the plunger in fully.
- 32 Release the plunger. The hold-in winding should hold the plunger in.
- 33 Replace the solenoid switch if the winding does not hold the plunger in.
- 34 Decrease the voltage until the plunger releases.
- 35 Record the multimeter reading.
- 36 Replace the solenoid switch if the voltage reading is significantly higher than the specification.

Hold-in voltage @ 20°C .....	0.2 – 2.0 V
------------------------------	-------------

- 37 Connect a test lamp between the solenoid switch terminal M15 – X2 and the 12 volt power supply.
- 38 Press the plunger in until the test lamp illuminates.
- 39 Attempt to press the plunger into the solenoid switch housing a further 1 mm.
- 40 Replace the solenoid switch if the plunger cannot move at least a further 1 mm.
- 41 Connect the positive lead of a 24 volt power supply (1) to the positive lead of a multimeter set to measure voltage.
- 42 Connect the negative lead of a 24 volt power supply to the solenoid switch housing (2).
- 43 Connect the multimeter negative lead to the solenoid switch terminal M15 – X2.(3)
- 44 Press the plunger (4) in fully.
- 45 Release the plunger. The plunger should return to its rest position.
- 46 Replace the solenoid switch if the plunger does not return.

**NOTE**

This indicates the windings have an internal winding short circuit. When the solenoid switch is connected in this way, the winding fields are in opposition to each other.

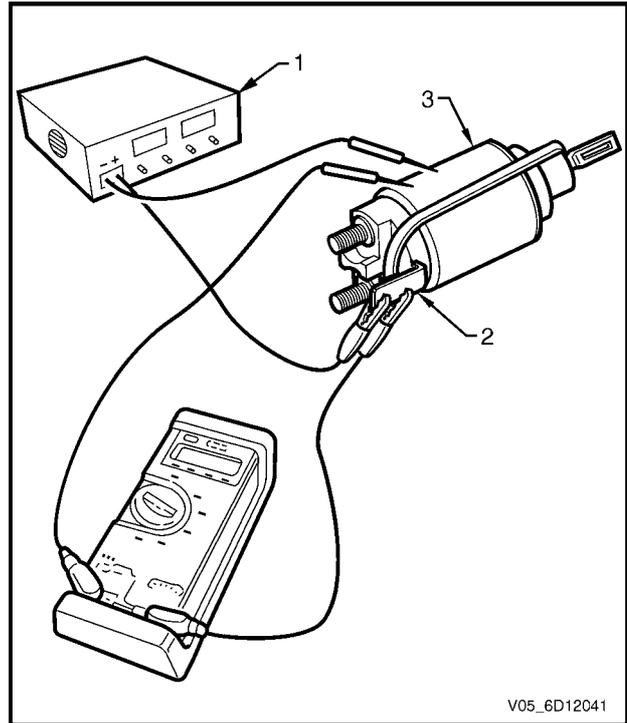


Figure 6D1-2 – 22

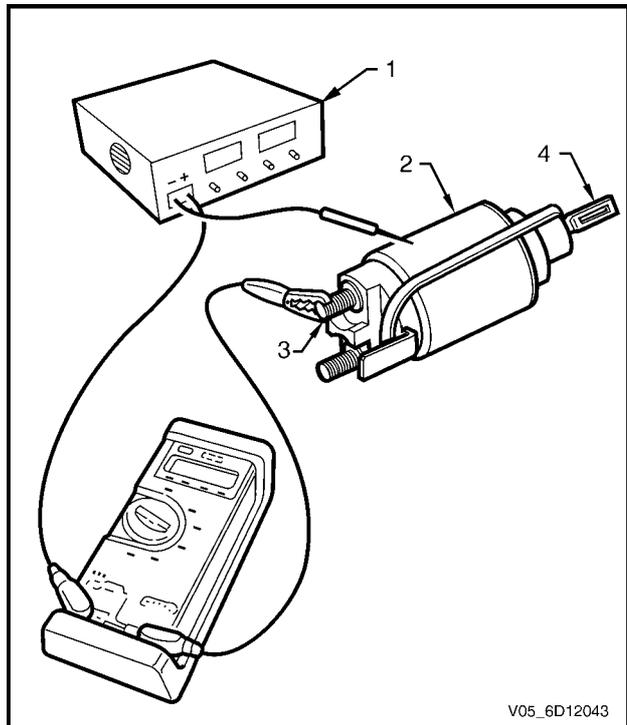


Figure 6D1-2 – 23

## 5 Specifications

Type..... Six Pole Permanent Magnet, Four Brush, Planetary Drive  
 Rotation (Drive-End View) ..... Clockwise  
 Number of Pinion Teeth..... 12

### No load:

Minimum RPM ..... 2370  
 Maximum Current Draw ..... 65 A at  $12.0 \pm 0.1$  V  
 M Terminal Voltage.....  $12 \pm 1$  V

### Locked:

Maximum Current (Including Solenoid Switch) ..... 780 A  
 M Terminal Voltage..... 4 V  
 Minimum Torque..... 20 Nm

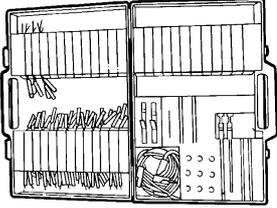
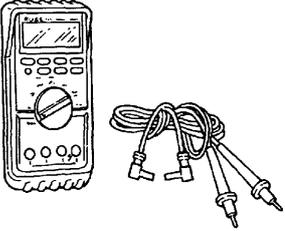
### Solenoid detached:

Pull-in Winding Resistance @ 20°C ..... 0.33 – 0.37  $\Omega$   
 Hold-in Winding Resistance @ 20°C ..... 0.75 – 0.87  $\Omega$   
 Pull-in Voltage @ 20°C ..... 8 V @ 20°C  
 Hold-in Voltage @ 20°C..... 1.7 – 3.0 V

## 6 Torque Wrench Specifications

	Nm
Solenoid Switch Mounting Screw .....	4.1 – 7.6
Solenoid Switch Terminal M Nut .....	8.8 – 12.7
Starter Motor Mounting Bolt.....	40.0 – 60.0
Solenoid Switch Terminal M15 – X1A Nut.....	9.8 – 11.8

## 7 Special Tools

Tool Number	Illustration	Description	Tool Classification
KM609		<p><b>Connector Test Adaptor Kit</b></p> <p>Used when carrying out electrical diagnostic circuit checks.</p> <p>Previously released</p>	Desirable
3588 (J39200)		<p><b>Digital Multimeter</b></p> <p>Must have at least 10 M<math>\Omega</math> input impedance and be capable of reading frequencies.</p> <p>Previously released.</p>	Available