

## GROUP 16

# ENGINE ELECTRICAL

## CONTENTS

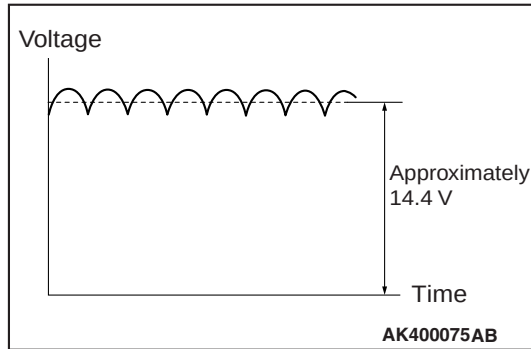
|                                                       |              |                                                                                 |                |
|-------------------------------------------------------|--------------|---------------------------------------------------------------------------------|----------------|
| <b>CHARGING SYSTEM . . . . .</b>                      | <b>16-2</b>  | <b>IGNITION SYSTEM . . . . .</b>                                                | <b>16-26</b>   |
| GENERAL INFORMATION . . . . .                         | 16-2         | GENERAL INFORMATION . . . . .                                                   | 16-26          |
| SERVICE SPECIFICATIONS . . . . .                      | 16-3         | SERVICE SPECIFICATIONS . . . . .                                                | 16-27          |
| SPECIAL TOOL . . . . .                                | 16-4         | SPECIAL TOOL . . . . .                                                          | 16-28          |
| ON-VEHICLE SERVICE . . . . .                          | 16-5         | ON-VEHICLE SERVICE . . . . .                                                    | 16-28          |
| ALTERNATOR OUTPUT LINE VOLTAGE<br>DROP TEST . . . . . | 16-5         | IGNITION COIL (WITH BUILT-IN POWER<br>TRANSISTOR) CHECK . . . . .               | 16-28          |
| OUTPUT CURRENT TEST . . . . .                         | 16-6         | IGNITION COIL RELAY CHECK<br><RH DRIVE VEHICLES> . . . . .                      | 16-28          |
| REGULATED VOLTAGE TEST . . . . .                      | 16-8         | SPARK PLUG CABLE CHECK . . . . .                                                | 16-29          |
| WAVEFORM CHECK USING<br>AN OSCILLOSCOPE . . . . .     | 16-9         | SPARK PLUG CHECK AND CLEANING<br>CAMSHAFT POSITION SENSOR CHECK                 | 16-29<br>16-30 |
| ALTERNATOR ASSEMBLY . . . . .                         | 16-12        | CRANK ANGLE SENSOR CHECK . . . . .                                              | 16-30          |
| REMOVAL AND INSTALLATION . . . . .                    | 16-12        | DETONATION SENSOR CHECK . . . . .                                               | 16-30          |
| DISASSEMBLY AND REASSEMBLY . . . . .                  | 16-15        | IGNITION SECONDARY VOLTAGE<br>WAVEFORM CHECK USING<br>AN OSCILLOSCOPE . . . . . | 16-30<br>16-30 |
| INSPECTION . . . . .                                  | 16-17        |                                                                                 |                |
| <b>STARTING SYSTEM . . . . .</b>                      | <b>16-18</b> | <b>IGNITION COIL . . . . .</b>                                                  | <b>16-34</b>   |
| GENERAL INFORMATION . . . . .                         | 16-18        | REMOVAL AND INSTALLATION . . . . .                                              | 16-34          |
| SERVICE SPECIFICATIONS . . . . .                      | 16-19        | <b>CAMSHAFT POSITION SENSOR . . . . .</b>                                       | <b>16-35</b>   |
| STARTER MOTOR ASSEMBLY . . . . .                      | 16-20        | REMOVAL AND INSTALLATION . . . . .                                              | 16-35          |
| REMOVAL AND INSTALLATION . . . . .                    | 16-20        | <b>CRANK ANGLE SENSOR . . . . .</b>                                             | <b>16-36</b>   |
| STARTER MOTOR ASSEMBLY<br>INSPECTION . . . . .        | 16-20        | REMOVAL AND INSTALLATION . . . . .                                              | 16-36          |
| DISASSEMBLY AND REASSEMBLY . . . . .                  | 16-22        | <b>DETONATION SENSOR . . . . .</b>                                              | <b>16-37</b>   |
| INSPECTION . . . . .                                  | 16-24        | REMOVAL AND INSTALLATION . . . . .                                              | 16-37          |

# CHARGING SYSTEM

## GENERAL INFORMATION

The charging system uses the alternator output to keep the battery charged at a constant level under various electrical loads.

## OPERATION



Rotation of the excited field coil generates AC voltage in the stator.

This alternating current is rectified through diodes to DC voltage having a waveform shown in the illustration.

The average output voltage fluctuates slightly with the alternator load condition.

When the ignition switch is turned on, current flows in the field coil and initial excitation of the field coil occurs.

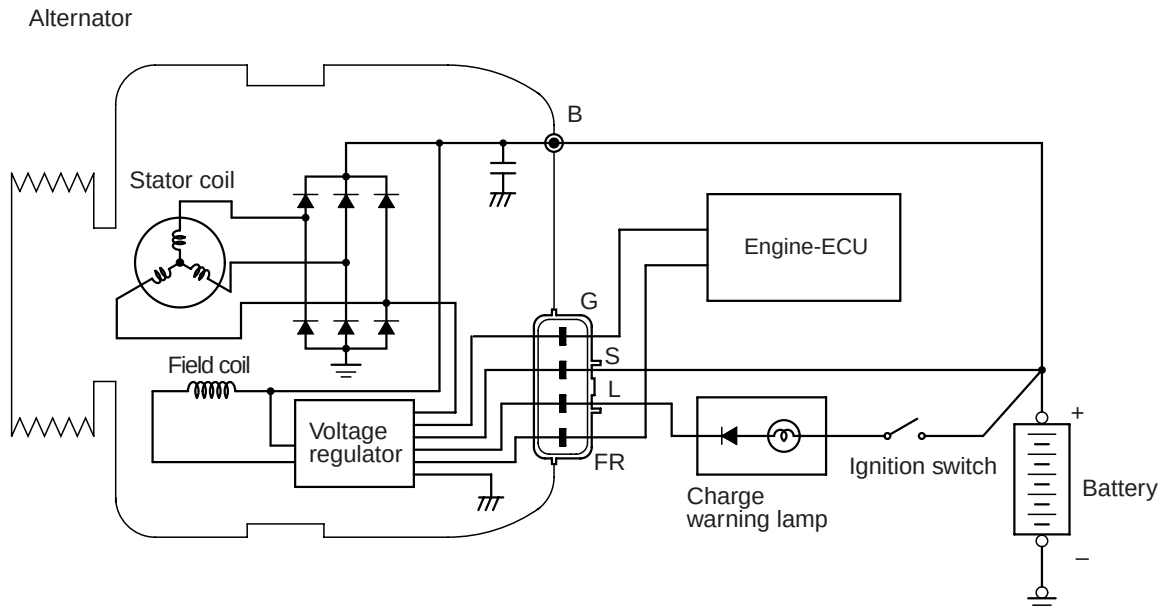
When the stator coil begins to generate power after the engine is started, the field coil is excited by the output current of the stator coil.

The alternator output voltage rises as the field current increases and it falls as the field current decreases. When the battery voltage (alternator "S" terminal voltage) reaches a regulated voltage of approximately 14.4 V, the field current is cut off.

When the battery voltage drops below the regulated voltage, the voltage regulator regulates the output voltage to a constant level by controlling the field current.

In addition, when the field current is constant, the alternator output voltage rises as the engine speed increases.

## SYSTEM DIAGRAM



AK304222 AB

**ALTERNATOR SPECIFICATIONS**

| Item              | Specifications           |
|-------------------|--------------------------|
| Type              | Battery voltage sensing  |
| Rated output V/A  | 12/90                    |
| Voltage regulator | Electronic built-in type |

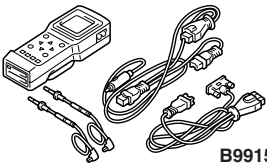
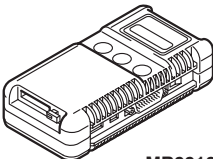
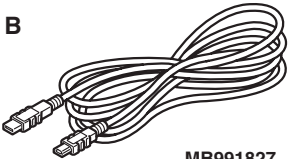
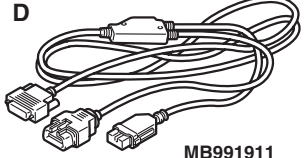
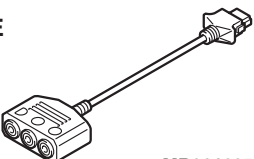
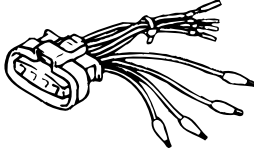
**SERVICE SPECIFICATIONS**

M1161000300407

| Item                                                         |       | Standard value | Limit                         |
|--------------------------------------------------------------|-------|----------------|-------------------------------|
| Alternator output line voltage drop (at 30 A) V              |       | –              | maximum 0.3                   |
| Regulated voltage ambient temperature at voltage regulator V | –20°C | 14.2 – 15.4    | –                             |
|                                                              | 20°C  | 13.9 – 14.9    | –                             |
|                                                              | 60°C  | 13.4 – 14.6    | –                             |
|                                                              | 80°C  | 13.1 – 14.5    | –                             |
| Output current                                               |       | –              | 70 % of normal output current |

## SPECIAL TOOL

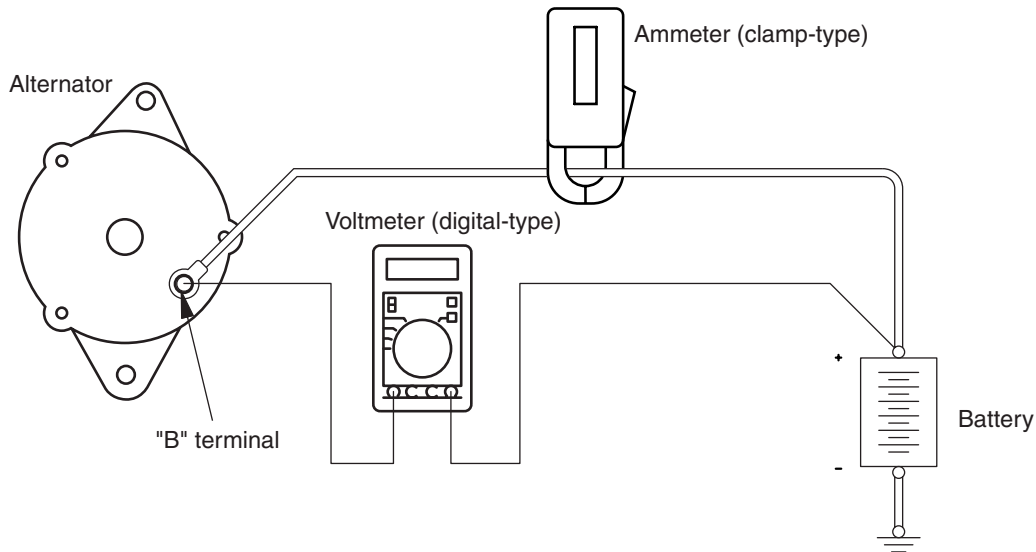
M1161000600356

| Tool                                                                                                                        | Number                                                                                                               | Name                                                                                                                                                                                                                                                                                                                                                                                                      | Use                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>B991502                                | MB991502                                                                                                             | M.U.T.-II sub assembly                                                                                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Checking the idle speed</li> </ul>                                                                                                                                                                                                                                |
| <p><b>A</b></p> <br>MB991824               | MB991955<br>A:<br>MB991824<br>B:<br>MB991827<br>C:<br>MB991910<br>D:<br>MB991911<br>E:<br>MB991825<br>F:<br>MB991826 | M.U.T.-III sub assembly <ul style="list-style-type: none"> <li>A: Vehicle communication interface (V.C.I.)</li> <li>B: M.U.T.-III USB cable</li> <li>C: M.U.T.-III main harness A (Vehicles with CAN communication system)</li> <li>D: M.U.T.-III main harness B (Vehicles without CAN communication system)</li> <li>E: M.U.T.-III measurement adapter</li> <li>F: M.U.T.-III trigger harness</li> </ul> | <ul style="list-style-type: none"> <li>Checking the idle speed</li> </ul> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <b>⚠ CAUTION</b><br/> <b>M.U.T.-III main harness B (MB991911) should be used. M.U.T.-III main harness A should not be used for this vehicle.</b> </div> |
| <p><b>B</b></p> <br>MB991827               |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                          |
| <p><b>C</b></p> <br>MB991910              |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                          |
| <p><b>D</b></p> <br>MB991911             |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                          |
| <p><b>E</b></p> <br>MB991825             |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                          |
| <p><b>F</b></p> <br>MB991826<br>MB991955 |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                          |
|                                          | MB991519                                                                                                             | Alternator test harness                                                                                                                                                                                                                                                                                                                                                                                   | Checking the alternator ("S" terminal voltage)                                                                                                                                                                                                                                                           |

## ON-VEHICLE SERVICE

## ALTERNATOR OUTPUT LINE VOLTAGE DROP TEST

M1161000900681



AK203361AE

This test determines whether the wiring from the alternator "B" terminal to the battery (+) terminal (including the fusible link) is in a good condition or not.

1. Always be sure to check the following before the test.

- Alternator installation
- Drive belt tension

(Refer to GROUP 11A – On-vehicle Service

[P.11A-7.](#))

- Fusible link
- Abnormal noise from the alternator while the engine is running.

2. Turn the ignition switch to the "LOCK" (OFF) position.
3. Disconnect the negative battery cable.
4. Connect a clamp-type DC test ammeter with a range of 0 – 100 A to the alternator "B" terminal output wire.

**NOTE:** The way of disconnecting the alternator output wire and of connecting the ammeter is possibly not found the problem that the output current is dropping due to the insufficient connection between terminal "B" and the output wire.

5. Connect a digital-type voltmeter between the alternator "B" terminal and the battery (+) terminal. [Connect the (+) lead of the voltmeter to the "B" terminal, and then connect the (-) lead of the voltmeter to the battery (+) cable].

6. Reconnect the negative battery cable.
7. Connect the M.U.T.-II/III.
8. Leave the hood open.
9. Start the engine.
10. With the engine running at 2,500 r/min, turn the headlamps and other lamps on and off to adjust the alternator load so that the value displayed on the ammeter is slightly above 30 A.

Adjust the engine speed by gradually decreasing it until the value displayed on the ammeter is 30 A. Take a reading of the value displayed on the voltmeter at this time.

**Limit: maximum 0.3 V**

**NOTE:** When the alternator output is high and the value displayed on the ammeter does not decrease until 30 A, set the value to 40 A. Read the value displayed on the voltmeter at this time. When the value range is 40 A, the limit is maximum 0.4 V.

11. If the value displayed on the voltmeter is above the limit value, there is probably a malfunction in the alternator output wire, so check the wiring between the alternator "B" terminal and the battery (+) terminal (including fusible link).

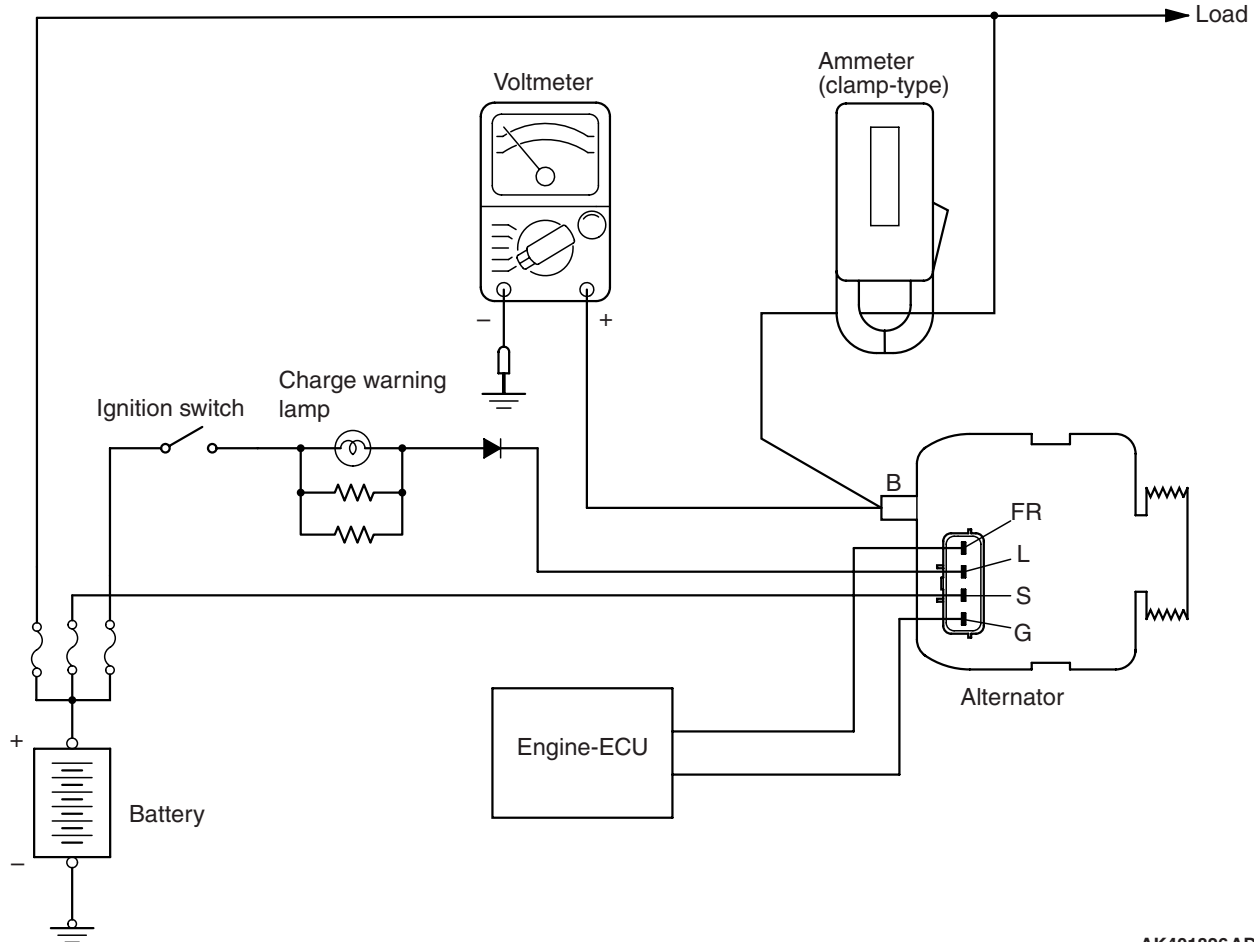
If a terminal is not sufficiently tight or if the harness has become discoloured due to overheating, repair and then test again.

12. After the test, run the engine at idle.
13. Turn off all lamps and the ignition switch.
14. Remove the M.U.T.-II/III.

15. Disconnect the negative battery cable.
16. Disconnect the ammeter and voltmeter.
17. Connect the negative battery cable.

## OUTPUT CURRENT TEST

M1161001000692



AK401826 AD

This test determines whether the alternator output current is normal.

1. Before the test, always be sure to check the following.

- Alternator installation
- Battery (Refer to GROUP 54A – Battery – On-vehicle Service [P.54A-5](#)).

**NOTE:** The battery should be slightly discharged. The load needed by a fully-charged battery is insufficient for an accurate test.

- Drive belt tension
- (Refer to GROUP 11A – On-vehicle Service [P.11A-7](#).)

- Fusible link
- Abnormal noise from the alternator while the engine is running.

2. Turn the ignition switch to the "LOCK" (OFF) position.
3. Disconnect the negative battery cable.

### **CAUTION**

**Never use clips but tighten bolts and nuts to connect the line. Otherwise loose connections (e.g. using clips) will lead to a serious accident because of high current.**

4. Connect a clamp-type DC test ammeter with a range of 0 – 100 A to the alternator "B" terminal output wire.

**NOTE:** The way of disconnecting the alternator output wire and of connecting the ammeter is possibly not found the problem that the output current is dropping due to the insufficient connection between terminal "B" and the output wire.

5. Connect a voltmeter with a range of 0 – 20 V between the alternator "B" terminal and the earth [Connect the (+) lead of the voltmeter to the "B" terminal, and then connect the (-) lead of the voltmeter to the earth].
6. Connect the negative battery cable.
7. Connect the M.U.T.-II/III.
8. Leave the hood open.
9. Check that the reading on the voltmeter is equal to the battery voltage.

*NOTE: If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator "B" terminal and the battery (+) terminal.*

10. Turn the lamp switch on to turn on headlamps and then start the engine.
11. Immediately after setting the headlamps to high beam and turning the heater blower switch to the high revolution position, increase the engine speed to 2,500 r/min and read the maximum current output value displayed on the ammeter.

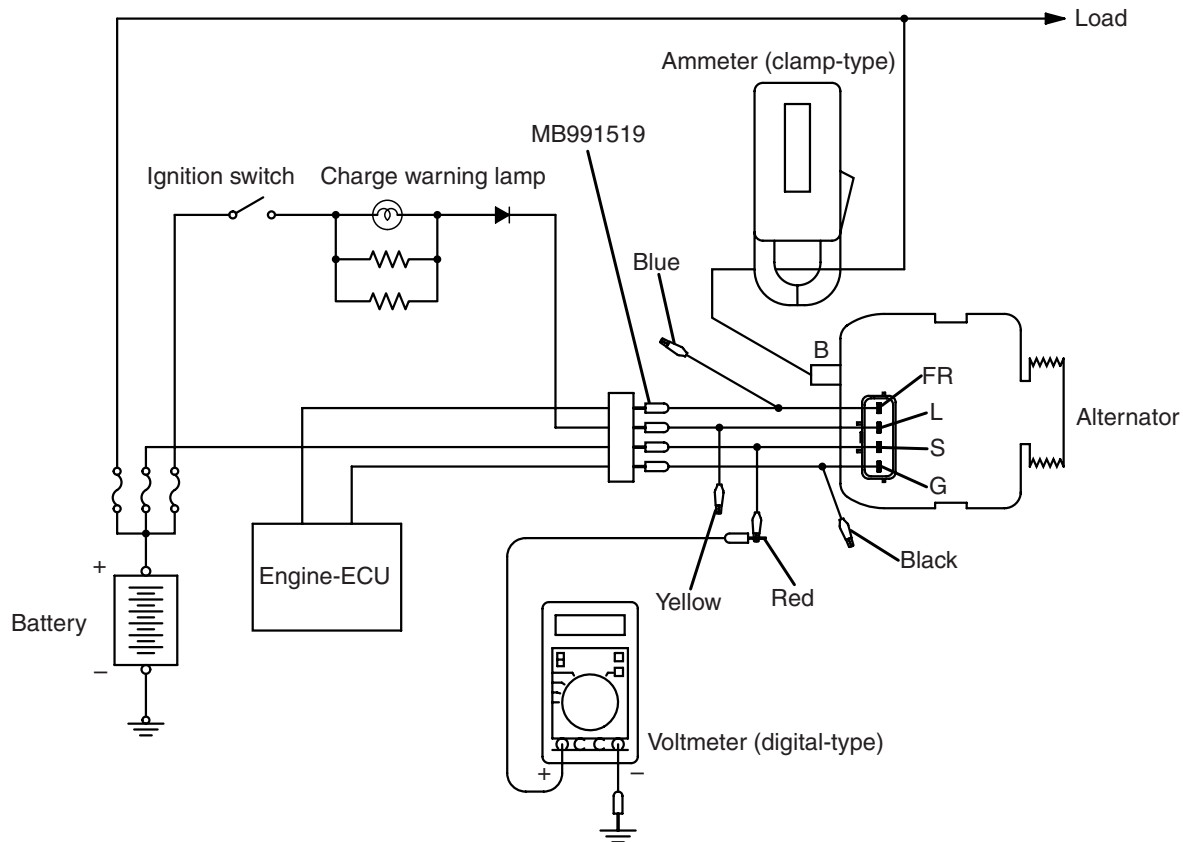
**Limit: 70% of normal current output**

**NOTE:**

- *For the nominal current output, refer to the Alternator Specifications.*
  - *Because the current from the battery will soon drop after the engine is started, the above step should be carried out as quickly as possible in order to obtain the maximum current output value.*
  - *The current output value will depend on the electrical load and the temperature of the alternator body.*
  - *If the electrical load is small while testing, the specified level of current may not be output even though the alternator is normal. In such cases, increase the electrical load by leaving the headlamps turned on for some time to discharge the battery or by using the lighting system in another vehicle, and then test again.*
  - *The specified level of current also may not be output if the temperature of the alternator body or the ambient temperature is too high. In such cases, cool the alternator and then test again.*
12. The reading on the ammeter should be above the limit value. If the reading is below the limit value and the alternator output wire is normal, remove the alternator from the engine and check the alternator.
  13. Run the engine at idle after the test.
  14. Turn the ignition switch to the "LOCK" (OFF) position.
  15. Remove the M.U.T.-II/III.
  16. Disconnect the negative battery cable.
  17. Disconnect the ammeter and voltmeter.
  18. Connect the negative battery cable.

## REGULATED VOLTAGE TEST

M1161001100871



AK401827 AC

This test determines whether the voltage regulator is correctly controlling the alternator output voltage.

1. Always be sure to check the following before the test.

- Alternator installation
- Check that the battery installed in the vehicle is fully charged.

(Refer to GROUP 54A – Battery – On-vehicle Service – Charging [P.54A-4](#)).

- Drive belt tension

(Refer to GROUP 11A – On-vehicle Service [P.11A-7](#).)

- Fusible link
- Abnormal noise from the alternator while the engine is running

2. Turn the ignition switch to the "LOCK" (OFF) position.

3. Disconnect the negative battery cable.

4. Use the special tool Alternator test harness (MB991519) to connect a digital voltmeter between the alternator "S" terminal and earth [Connect the (+) lead of the voltmeter to the "S" terminal, and then connect the (-) lead of the voltmeter to a secure earth or to the battery (-) terminal].

5. Connect a clamp-type DC test ammeter with a range of 0 – 100 A to the alternator "B" terminal output wire.

*NOTE: The way of disconnecting the alternator output wire and of connecting the ammeter is possibly not found the problem that the output current is dropping due to the insufficient connection between terminal "B" and the output wire.*

6. Reconnect the negative battery cable.

7. Connect the M.U.T.-II/III.

8. Turn the ignition switch to the "ON" position and check that the reading on the voltmeter is equal to the battery voltage.

*NOTE: If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator "S" terminal and the battery (+) terminal.*

9. Turn all lamps and accessories off.

10. Start the engine.

11. Increase the engine speed to 2,500 r/min.

12. Read the value displayed on the voltmeter when the alternator output current alternator becomes 10 A or less.

13.If the voltage reading conforms to the value in the voltage regulation, then the voltage regulator is operating normally.

If the voltage is not within the standard value, there is a malfunction of the voltage regulator or of the alternator.

14.After the test, lower the engine speed to the idle speed.

15.Turn the ignition switch to the "LOCK" (OFF) position.

16.Remove the M.U.T.-II/III.

17.Disconnect the negative battery cable.

18.Disconnect the ammeter and voltmeter.

19.Connect the alternator output wire to the alternator "B" terminal.

20.Remove the special tool, and return the connector to the original condition.

21.Connect the negative battery cable.

## Voltage Regulation Table

**Standard value:**

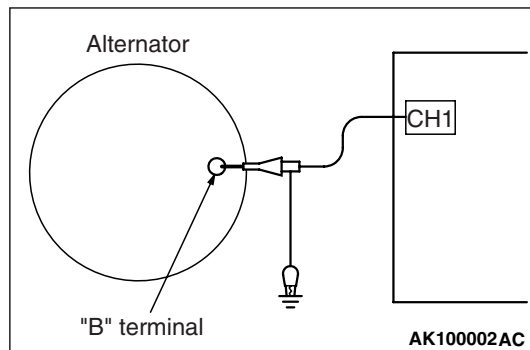
| Inspection terminal | Voltage regulator ambient temperature °C | Voltage V   |
|---------------------|------------------------------------------|-------------|
| Terminal "S"        | -20                                      | 14.2 – 15.4 |
|                     | 20                                       | 13.9 – 14.9 |
|                     | 60                                       | 13.4 – 14.6 |
|                     | 80                                       | 13.1 – 14.5 |

## WAVEFORM CHECK USING AN OSCILLOSCOPE

M1161001200209

### MEASUREMENT METHOD

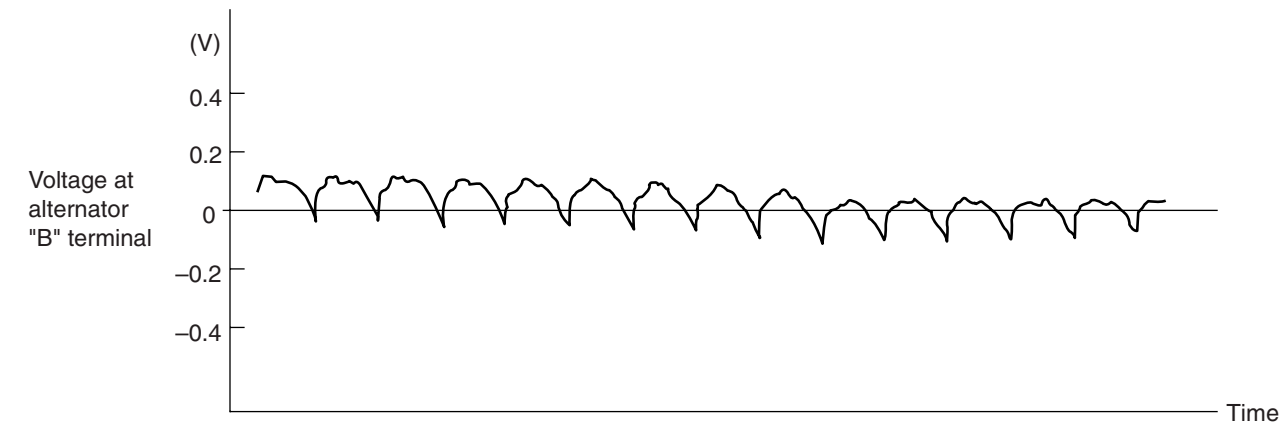
Connect the oscilloscope special patterns pick-up to the alternator "B" terminal.



STANDARD WAVEFORM

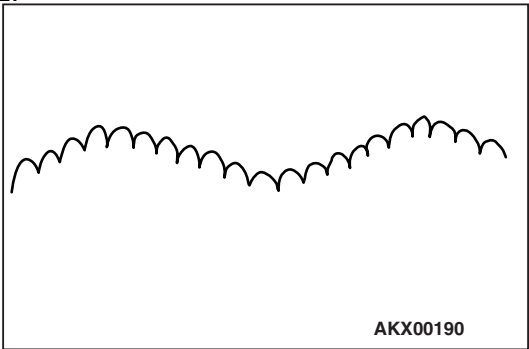
Observation Conditions

| Function         | Special pattern                    |
|------------------|------------------------------------|
| Pattern height   | Variable                           |
| Variable knob    | Adjust while viewing the waveform. |
| Pattern selector | Raster                             |
| Engine speed     | Curb idle speed                    |



AKX00189AG

NOTE:



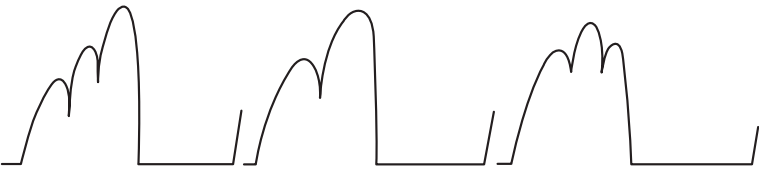
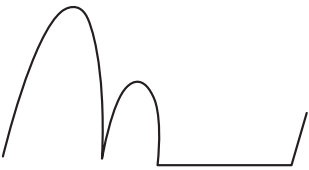
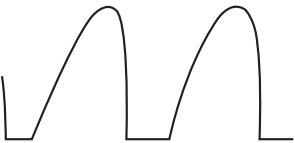
*when the voltage waveform reaches an excessively high value (approximately 2 V or higher at idle), it often indicates an open circuit due to a blown fuse between alternator "B" terminal and battery, but not a defective alternator.*

*The voltage waveform of the alternator "B" terminal can undulate as shown in the illustration. This waveform is produced when the regulator operates according to fluctuations in the alternator load (current), and is normal for the alternator. In addition,*

## EXAMPLE OF ABNORMAL WAVEFORMS

### NOTE:

1. The size of the waveform patterns differs largely, depending on the adjustment of the variable knob on the oscilloscope.
2. Identification of abnormal waveforms is easier when there is a large output current (regulator is not operating). (Waveforms can be observed when the headlamps are illuminated.)
3. Check the conditions of the charging warning lamp (illuminated/not illuminated). Also, check the charging system totally.

| Abnormal waveform                                                                                                    | Problem cause              |
|----------------------------------------------------------------------------------------------------------------------|----------------------------|
| <p>Example 1</p>  <p>AKX00191</p>  | Open diode                 |
| <p>Example 2</p>  <p>AKX00192</p>  | Short in diode             |
| <p>Example 3</p>  <p>AKX00193</p> | Broken wire in stator coil |
| <p>Example 4</p>  <p>AKX00194</p> | Short in stator coil       |

ALTERNATOR ASSEMBLY

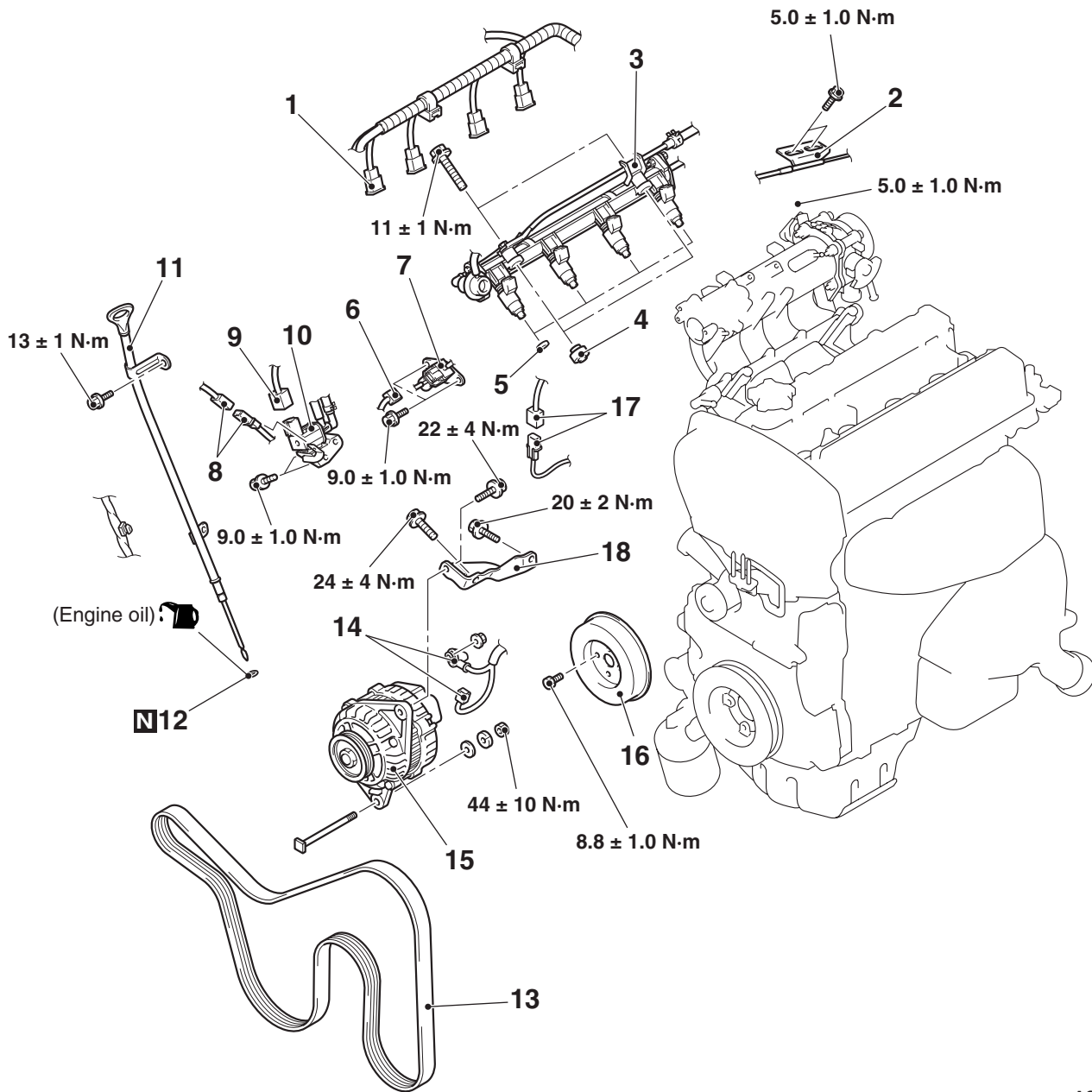
REMOVAL AND INSTALLATION

M1161001401358

 CAUTION

If the vehicle is equipped with the Brembo™ disc brake, during maintenance, take care not to contact the caliper with tool or parts, because the caliper paint will be scratched.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Pre-removal Operation</b></p> <ul style="list-style-type: none"><li>• Under Cover Removal (Refer to GROUP 51, Front Bumper <a href="#">P.51-2</a>).</li><li>• Strut Tower Bar Removal (Refer to GROUP 42, Strut Tower Bar <a href="#">P.42-9</a>).</li><li>• Crossmember Bar Removal (Refer to GROUP 32, Engine Roll Stopper and Centremember <a href="#">P.32-7</a>).</li><li>• Front Exhaust Pipe Assembly Removal (Refer to GROUP 15, Exhaust Pipe and Main Muffler <a href="#">P.15-13</a>).</li></ul> | <p><b>Post-installation Operation</b></p> <ul style="list-style-type: none"><li>• Front Exhaust Pipe Assembly Installation (Refer to GROUP 15, Exhaust Pipe and Main Muffler <a href="#">P.15-13</a>).</li><li>• Crossmember Bar Installation (Refer to GROUP 32, Engine Roll Stopper and Centremember <a href="#">P.32-7</a>).</li><li>• Strut Tower Bar Installation (Refer to GROUP 42, Strut Tower Bar <a href="#">P.42-9</a>).</li><li>• Drive Belt Tension Check (Refer to GROUP 11A, On-vehicle Service – Drive Belt Tension Check <a href="#">P.11A-7</a>).</li><li>• Under Cover Installation (Refer to GROUP 51, Front Bumper <a href="#">P.51-2</a>).</li></ul> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



AC406359AB

### Removal steps

1. Fuel injector connectors
2. Accelerator cable connection
3. Fuel injector, delivery pipe, fuel return pipe and fuel pressure regulator assembly
4. Insulators
5. Insulators
6. Fuel pressure solenoid valve connector
7. Fuel pressure solenoid valve
8. Detonation sensor connector
9. Purge control solenoid valve connector

### Removal steps (Continued)

10. Purge control solenoid valve
11. Oil level gauge and guide assembly
12. O-ring
13. Drive belt
14. Alternator connector and terminal
  - Engine front mounting bracket (Refer to GROUP 32, Engine Mounting P.32-4).
15. Alternator
16. Water pump pulley
17. Crank angle sensor connector
18. Alternator bracket

<<A>>

<<B>>

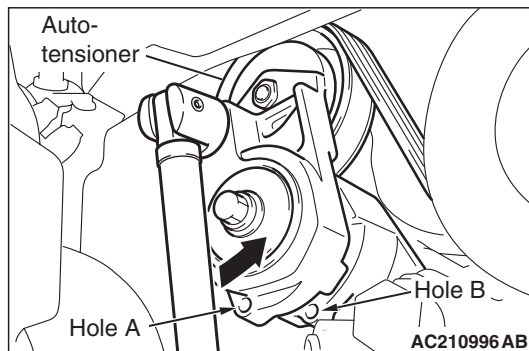
<<C>>

**REMOVAL SERVICE POINTS****<<A>> FUEL INJECTOR, DELIVERY PIPE,  
FUEL RETURN PIPE AND FUEL PRES-  
SURE REGULATOR ASSEMBLY  
REMOVAL**

After loosening the delivery pipe mounting bolts, move the fuel injector, delivery pipe, fuel return pipe and the fuel pressure regulator as an assembly aside in order to make room for the alternator removal.

**<<B>> DRIVE BELT REMOVAL**

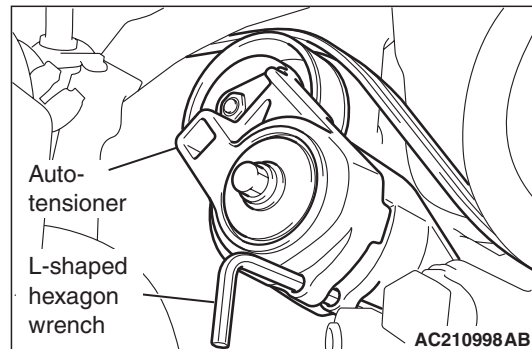
The following operations will be needed due to the introduction of the serpentine drive system with the drive belt auto-tensioner.



1. Securely insert the spindle handle or ratchet handle with a 12.7 mm insertion angle into the jig hole of the auto-tensioner.
2. Rotate the auto-tensioner anti-clockwise and align hole A with hole B.

**⚠ CAUTION**

**To reuse the drive belt, draw an arrow indicating the rotating direction (clockwise) on the back of the belt using chalk, etc.**



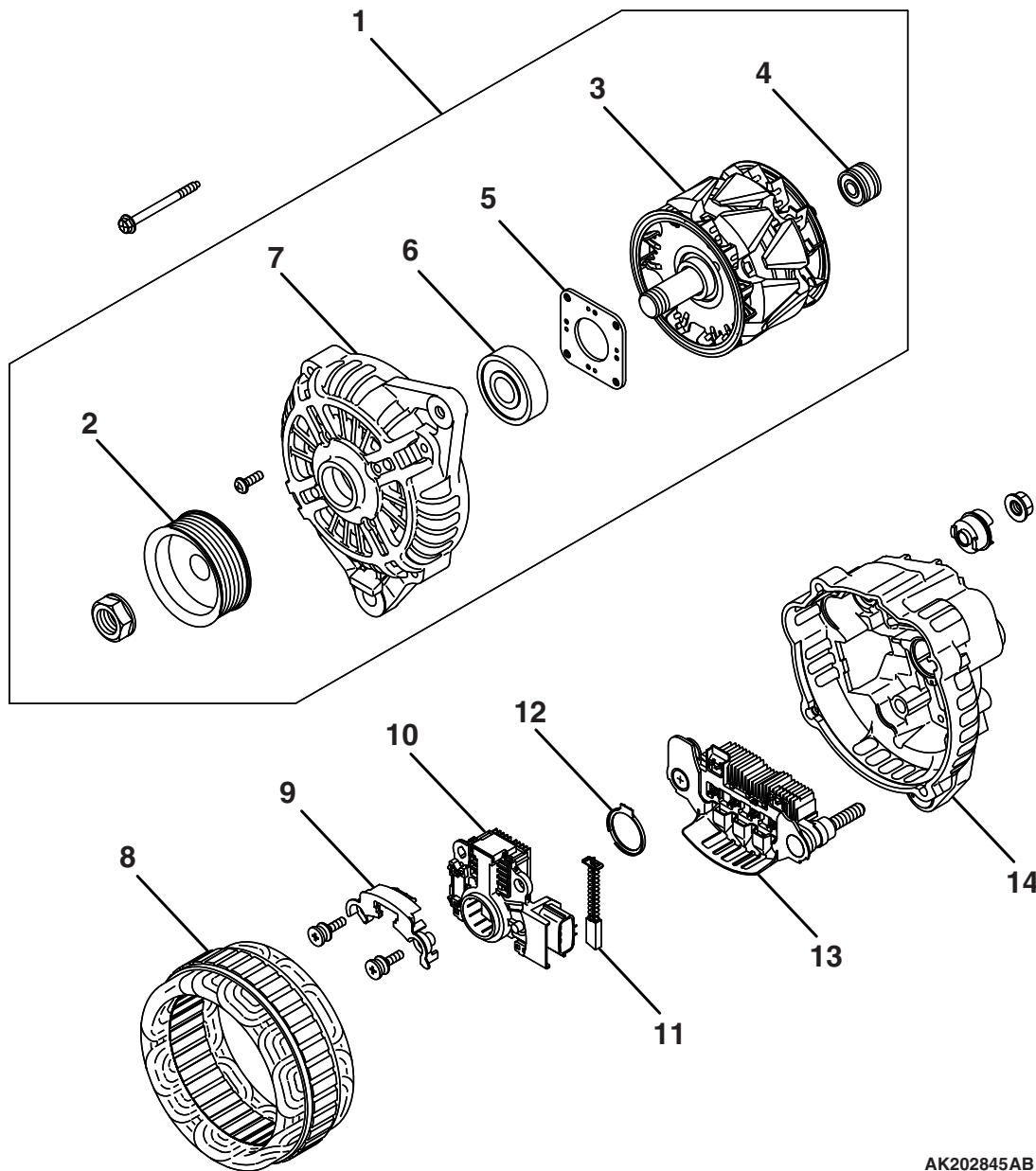
3. Insert an L-shaped hexagon wrench, etc. into the hole to fix and then remove the drive belt.

**<<C>> ALTERNATOR REMOVAL**

Raise the engine with a floor jack and remove the alternator upward from the engine room.

# DISASSEMBLY AND REASSEMBLY

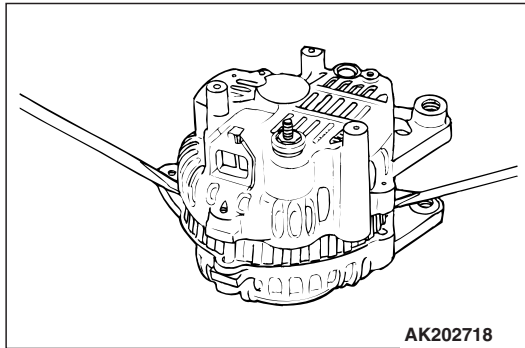
M1161001600199



AK202845AB

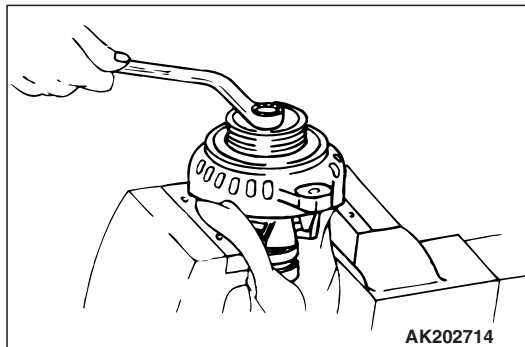
- Disassembly steps**
- <<A>> 1. Front bracket assembly  
<<B>> 2. Alternator pulley  
>>B<< 3. Rotor  
4. Rear bearing  
5. Bearing retainer  
6. Front bearing  
7. Front bracket

- Disassembly steps (Continued)**
- <<C>> 8. Stator  
9. Plate  
<<C>> >>A<< 10. Regulator assembly  
11. Brush  
12. Rubber packing  
13. Rectifier  
14. Rear bracket

**DISASSEMBLY SERVICE POINTS****<<A>> FRONT BRACKET ASSEMBLY  
REMOVAL****⚠ CAUTION**

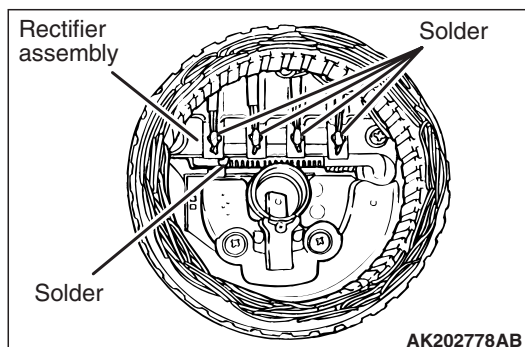
Do not insert the screwdriver blades too deep. Doing so could damage the stator coil.

Insert the blades of screwdrivers between the front bracket assembly and stator core, and pry and separate them with the screwdrivers.

**<<B>> ALTERNATOR PULLEY REMOVAL****⚠ CAUTION**

Perform operation carefully not to damage the rotor.

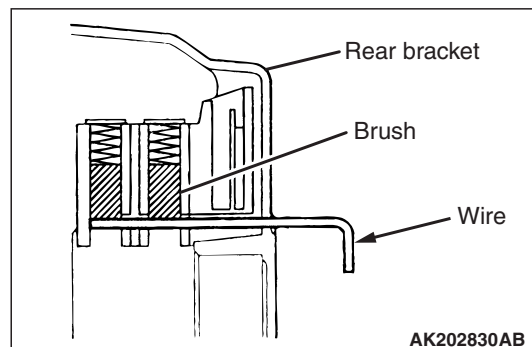
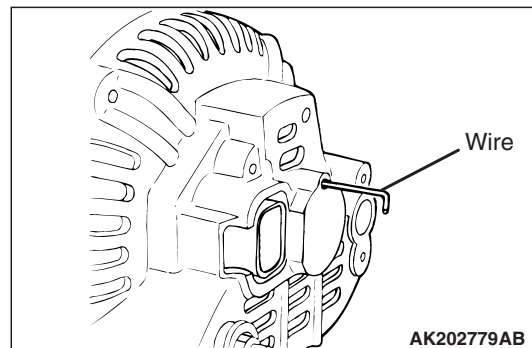
Clamp the rotor in a vise with the pulley facing up to remove the pulley.

**<<C>> STATOR / REGULATOR  
ASSEMBLY REMOVAL****⚠ CAUTION**

- Use a 180 – 250 W soldering iron, and finish unsoldering within four seconds. Diodes will be damaged by heat if unsoldering time is too long.

- Avoid applying undue force to the diode leads.

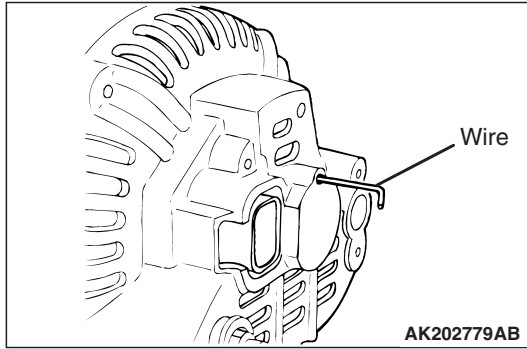
1. Unsolder the stator leads from the main diode of the rectifier assembly when the stator is removed.
2. When removing the rectifier assembly from the regulator assembly, undo the soldered points on the rectifier assembly.

**REASSEMBLY SERVICE POINTS****>>A<< REGULATOR ASSEMBLY  
INSTALLATION**

After installing the regulator assembly, insert a piece of wire through the hole in the rear bracket while pressing the brush to keep the brush against movement.

**NOTE:** Holding the brush with the wire facilitates installation of the rotor.

## >>B<< ROTOR INSTALLATION

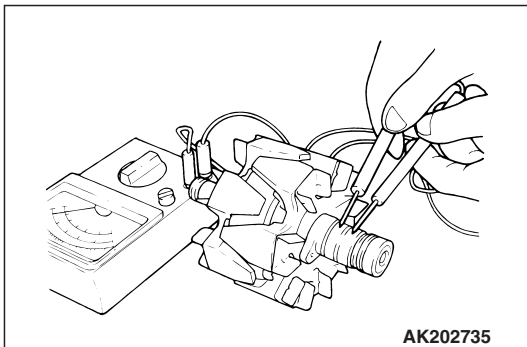


Remove the brush holding wire after the rotor has been installed.

## INSPECTION

M1161001700129

### ROTOR

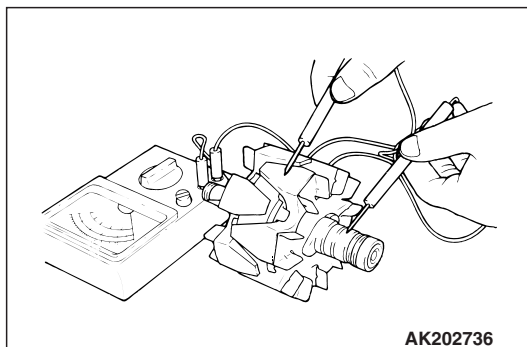


1. Measure the resistance between the two slip rings of the rotor coil to check the continuity between them.

Replace the rotor if the resistance is not within the standard value range.

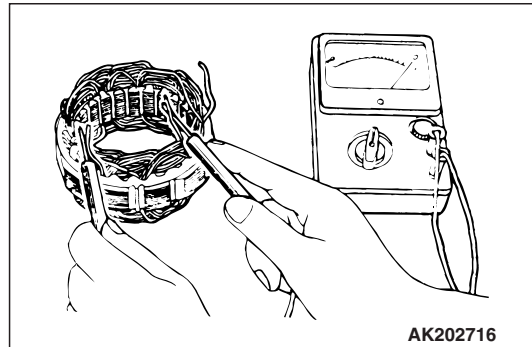
**Standard value: 3 – 5  $\Omega$**

2. Check the continuity between the slip rings and core.

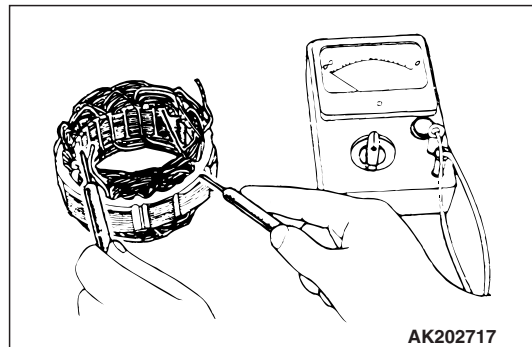


3. If continuity is present, replace the rotor.

### STATOR

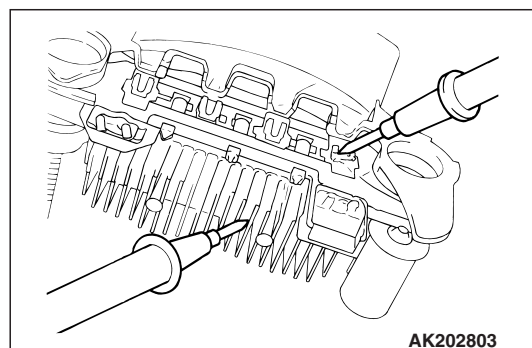


1. Check the continuity between coil leads.  
If there is no continuity, replace the stator.

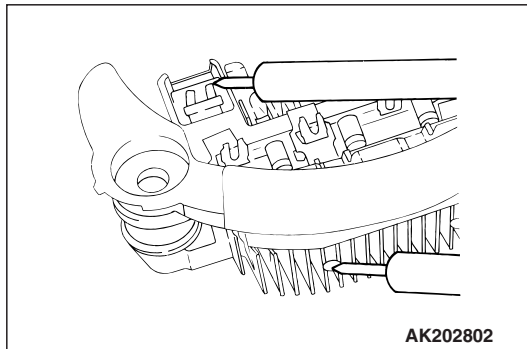


2. Check the continuity between coil and core.  
If there is no continuity, replace the stator.

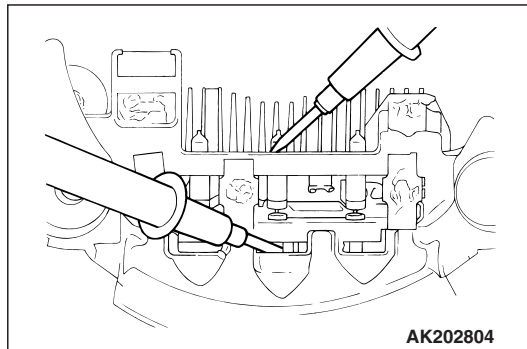
### RECTIFIER ASSEMBLY



1. Check the condition of the (+) heat sink by checking continuity between the (+) heat sink and each of the stator coil lead connecting terminals.  
If continuity is present for both terminals, the diode is shorted. Replace the rectifier assembly.



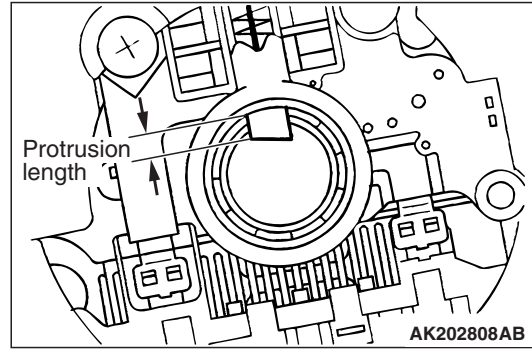
2. Check the condition of the (–) heat sink by checking continuity between the (–) heat sink and each of the stator coil lead connecting terminals. If continuity is present in both directions, the diode is shorted. Replace the rectifier assembly.



3. Check the condition of the diode trio by testing continuity of each of the three diodes using a circuit tester connected to both sides of the diode. Connect in a polarity and then reverse the polarity for each test.

If continuity exists or no continuity exists for both polarities, the diode is defective. Replace the rectifier assembly if any of the diodes is defective.

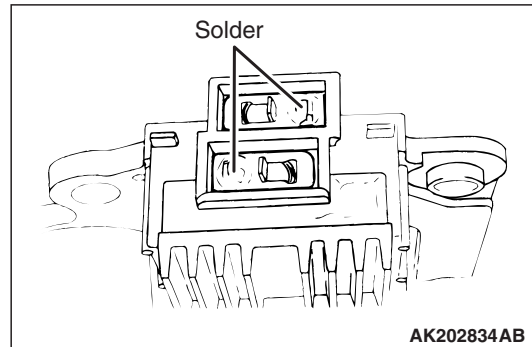
## BRUSH



1. Measure the length of the protrusion of the brush. Replace the brush if the protrusion length is shorter than the limit.

**Limit: 2 mm minimum**

2. Unsolder the lead of the brush. The brush will come out, becoming ready for removal.



3. Install a new brush by pushing it into the holder as shown in the drawing and soldering the lead.

# STARTING SYSTEM

## GENERAL INFORMATION

If the ignition switch is turned to the "START" position, current flows in the pull-in and holding coils provided inside magnetic switch, attracting the plunger. When the plunger is attracted, the lever connected to the plunger is actuated to engage the starter clutch. On the other hand, attracting the plunger will turn on the magnetic switch, allowing the "B" terminal and "M" terminal to conduct. Thus, current flows to engage the starter motor.

When the ignition switch is returned to the "ON" position after starting the engine, the starter clutch is disengaged from the ring gear.

An overrunning clutch is provided between the pinion and the armature shaft, to prevent damage to the starter.

M1162000100309

| Item                   | Standard value | Limit |
|------------------------|----------------|-------|
| Pinion gap mm          | 0.5 – 2.0      | –     |
| Commutator run-out mm  | 0.05           | 0.1   |
| Commutator diameter mm | 29.4           | 28.8  |
| Undercut depth mm      | 0.5            | 0.2   |

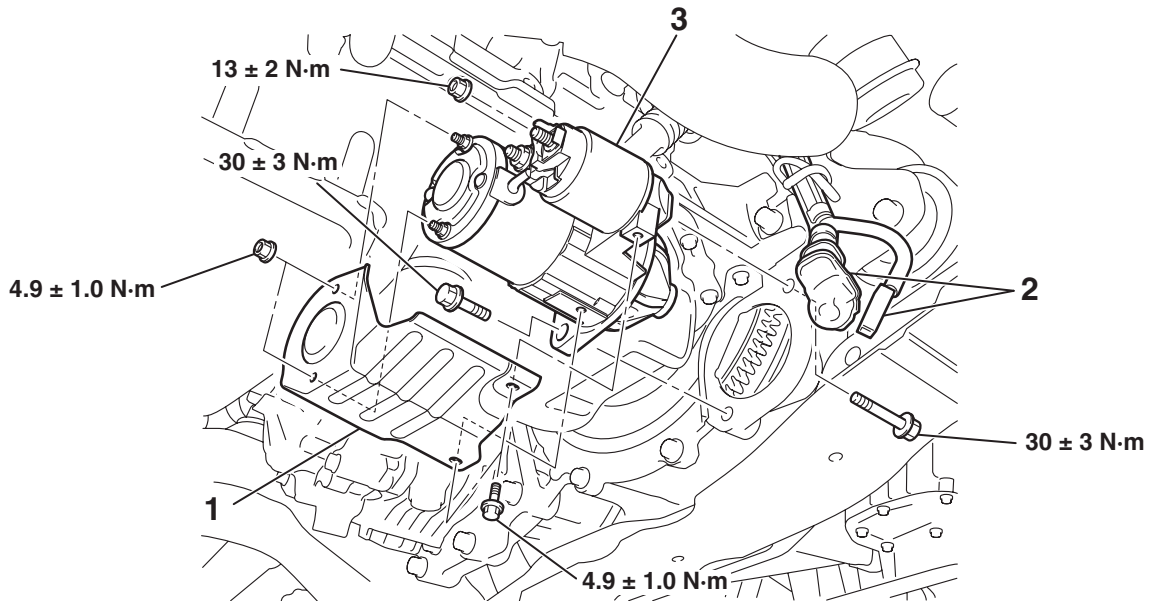
## STARTER MOTOR ASSEMBLY

## REMOVAL AND INSTALLATION

M1162001000781

**Pre-removal and Post-installation Operation**

- Under Cover Removal and Installation (Refer to GROUP 51, Front Bumper P.51-2).
- Crossmember Bar Removal and Installation (Refer to GROUP 32, Engine Roll Stopper and Centremember P.32-7).
- Front Exhaust Pipe Assembly Removal and Installation (Refer to GROUP 15, Exhaust Pipe and Main Muffler P.15-13).



AC210296AB

**Removal steps**

1. Starter cover

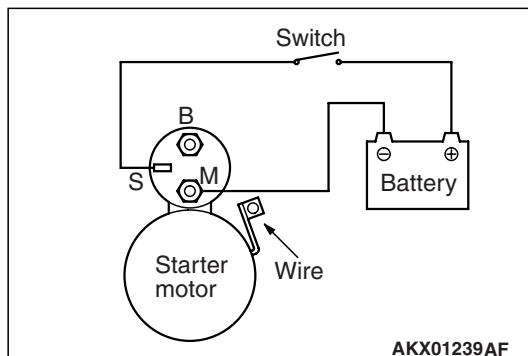
**Removal steps (Continued)**

2. Starter connector and terminal
3. Starter assembly

## STARTER MOTOR ASSEMBLY INSPECTION

M1162001100249

## PINION GAP ADJUSTMENT

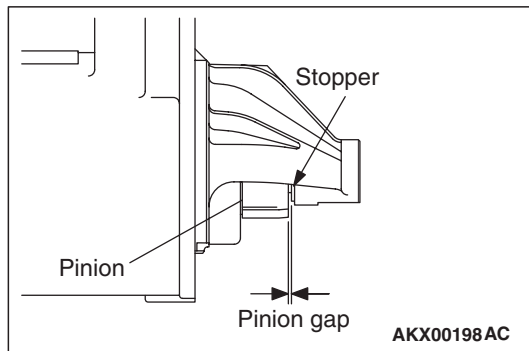


1. Disconnect the field coil wire from the M-terminal of the magnetic switch.
2. Connect a 12-volt battery between the S-terminal and M-terminal.

**CAUTION**

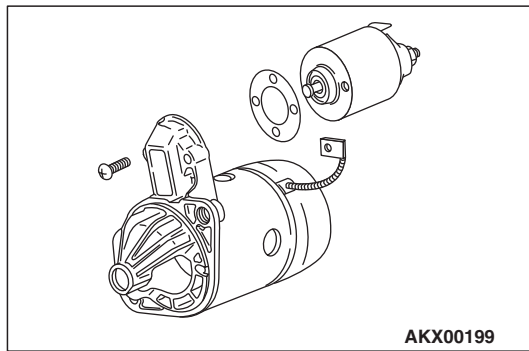
**This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.**

3. Set the switch to "ON", and the pinion will move out.



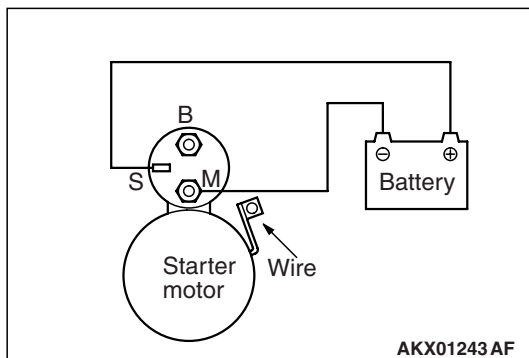
4. Check the pinion-to-stopper clearance (pinion gap) with a feeler gauge.

**Standard value: 0.5 – 2.0 mm**



5. If the pinion gap is out of specification, adjust by adding or removing gasket(s) between the magnetic switch and front bracket.

## MAGNETIC SWITCH PULL-IN TEST



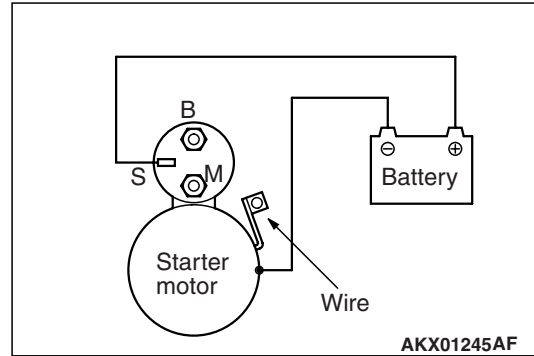
1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

### ⚠ CAUTION

**This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.**

2. Connect a 12-volt battery between the S-terminal and M-terminal.
3. If the pinion moves out, the pull-in coil is good. If it doesn't, replace the magnetic switch.

## MAGNETIC SWITCH HOLD-IN TEST



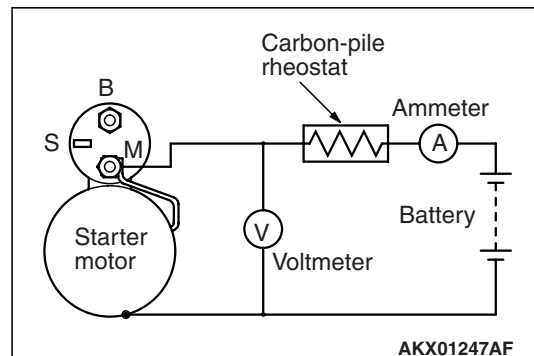
1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

### ⚠ CAUTION

**This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.**

2. Connect a 12-volt battery between the S-terminal and body.
3. Manually pull out the pinion as far as the pinion stopper position.
4. If the pinion remains out, everything is in order. If the pinion moves in, the hold-in circuit is open. Replace the magnetic switch.

## FREE RUNNING TEST

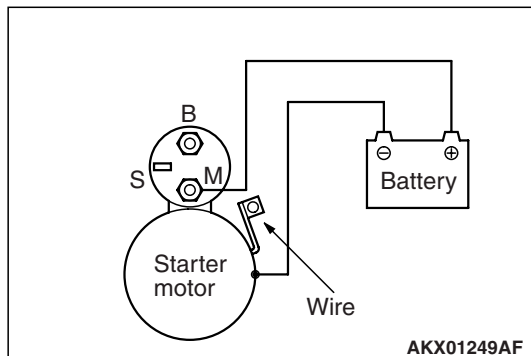


1. Place the starter motor in a vise equipped with soft jaws and connect a fully-charged 12-volt battery to the starter motor as follows:
2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat in series between the positive battery terminal and starter motor terminal.
3. Connect a voltmeter (15-volt scale) across the starter motor.
4. Rotate the rheostat to full-resistance position.
5. Connect the battery cable from the negative battery terminal to the starter motor body.
6. Adjust the rheostat until the battery positive voltage shown on the voltmeter is 11 V.

7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

**Current: maximum 95 Amps**

## MAGNETIC SWITCH RETURN TEST



1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

### ⚠ CAUTION

**This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.**

2. Connect a 12-volt battery between the M-terminal and body.

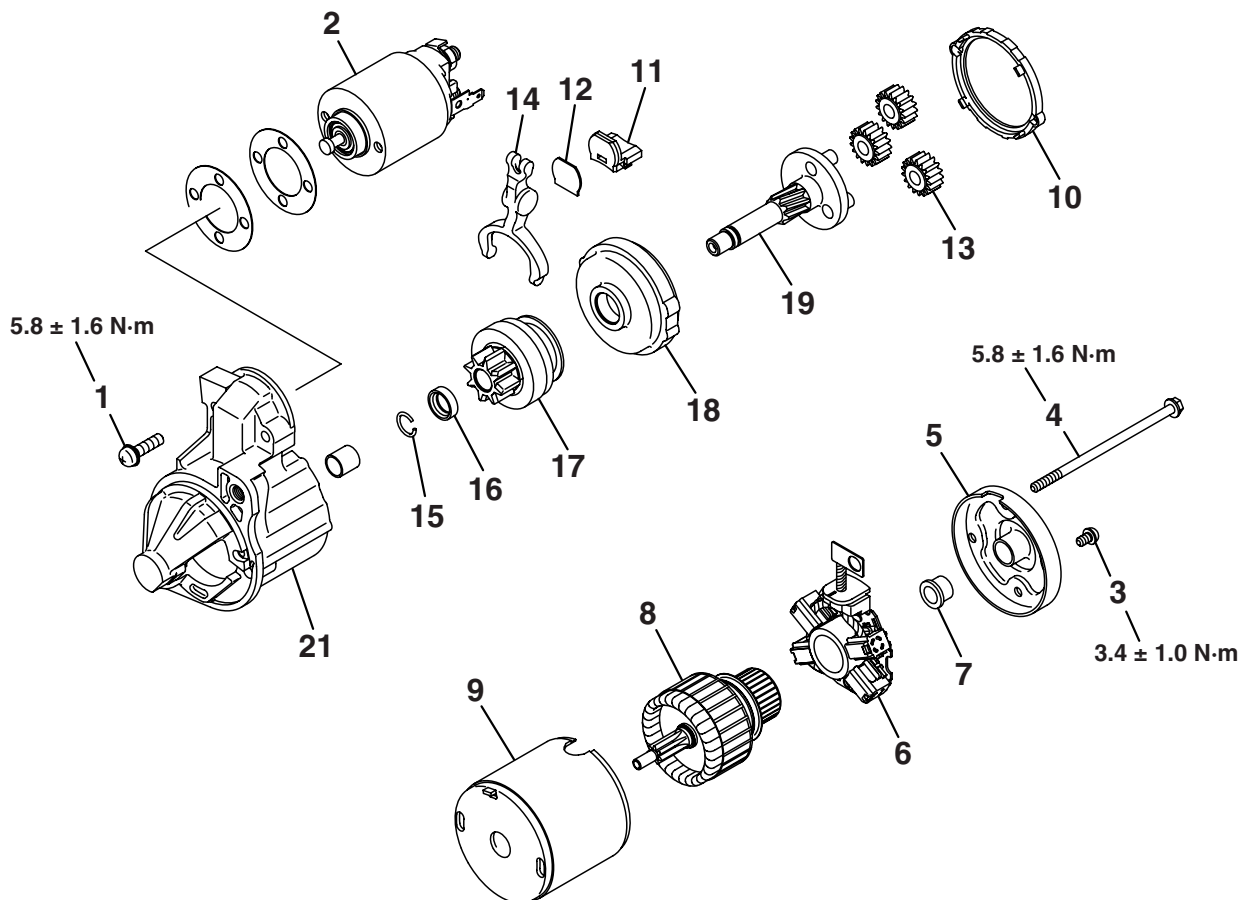
### ⚠ WARNING

**Be careful not to get your fingers caught when pulling out the pinion.**

3. Pull the pinion out and release. If the pinion quickly returns to its original position, everything is operating properly. If it doesn't, replace the magnetic switch.

## DISASSEMBLY AND REASSEMBLY

M1162001200246



AK304626AB

**Disassembly steps**

<<A>>

1. Screw
2. Magnetic switch
3. Screw
4. Bolt
5. Rear bracket
6. Brush holder
7. Rear bearing
8. Armature
9. Yoke assembly

**Disassembly steps (Continued)**

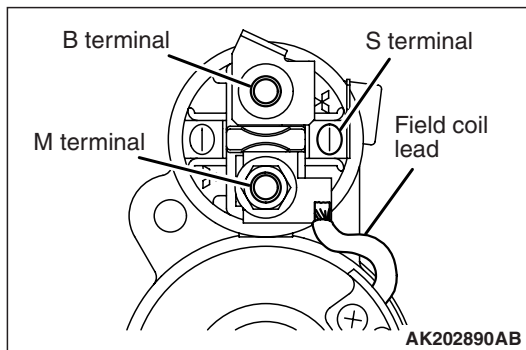
<<B>> >>A<<

<<B>> >>A<<

10. Packing A
11. Packing B
12. Plate
13. Planetary gear
14. Lever
15. Snap ring
16. Stop ring
17. Overrunning clutch
18. Internal gear
19. Planetary gear shaft
20. Front bracket

**DISASSEMBLY SERVICE POINTS**

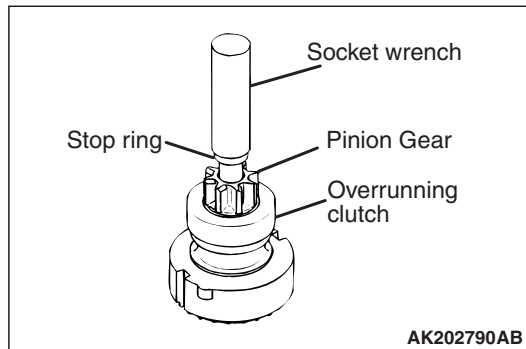
**<<A>> MAGNETIC SWITCH REMOVAL**



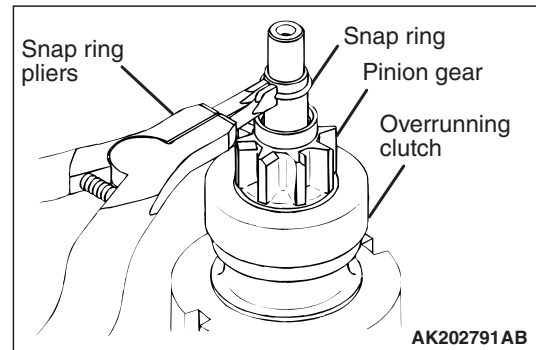
**⚠ CAUTION**

**Do not clamp the yoke assembly with a vise.**  
Disconnect the lead from the M terminal of the magnetic switch.

**<<B>> SNAP RING/STOP RING REMOVAL**



1. Apply a long socket wrench of an appropriate size to the stop ring and strike the wrench to drive out the stop ring toward the pinion gear side.



2. Remove the snap ring with snap ring pliers, then remove the stop ring and overrunning clutch.

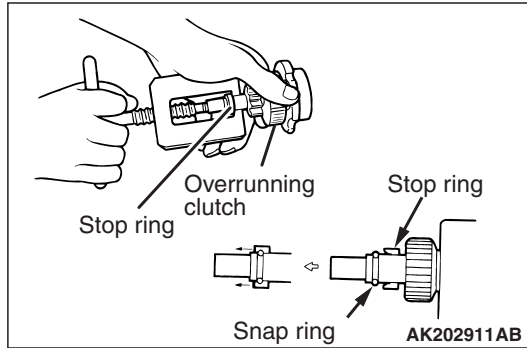
**STARTER MOTOR PARTS CLEANING**

Never clean in a solvent such starter motor parts as the magnetic switch, brush holder, and armature. If they are soaked in a solvent, their insulation could be impaired. When these parts require cleaning, wipe off contamination with cloth.

1. Never soak the drive unit in a solvent. If it is washed in a solvent, the grease having been packed in the overrunning clutch at the factory will be washed out. Wipe the drive unit with cloth if it requires cleaning.

## REASSEMBLY SERVICE POINTS

## &gt;&gt;A&lt;&lt; STOP RING/SNAP RING INSTALLATION

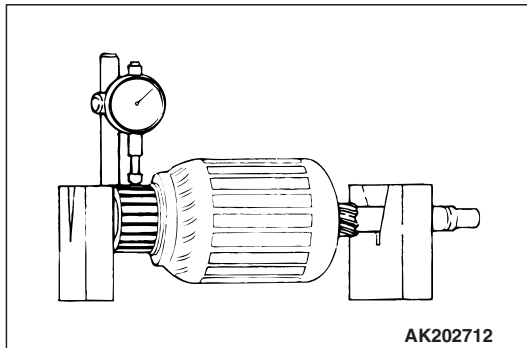


Use a suitable puller to pull the stop ring until it gets over the snap ring.

## INSPECTION

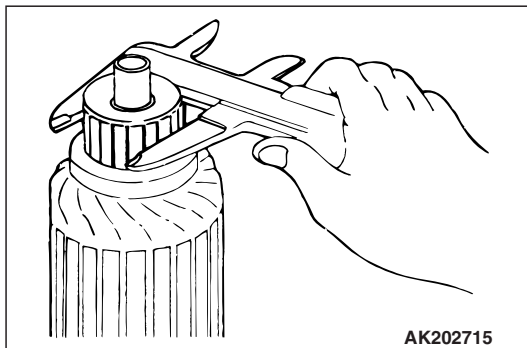
## COMMUTATOR

M1162001300180



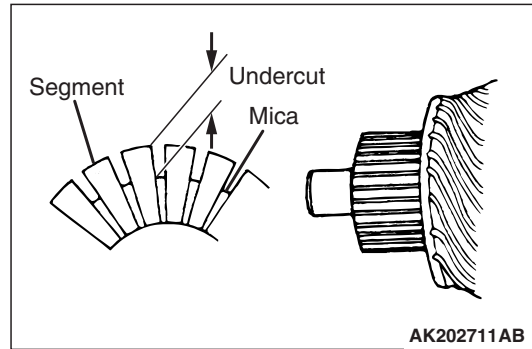
1. Support the armature with a pair of V block and turn it to measure the runout of the surface not rubbed by the brushes using a dial gauge.

**Standard value: 0.05 mm or less**  
**Limit: 0.1 mm**



2. Measure the diameter of the commutator.

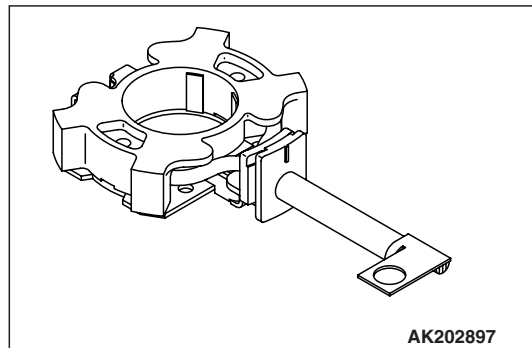
**Standard value: 29.4 mm**  
**Limit: 28.8 mm**



3. Measure the depth of the undercut between segments.

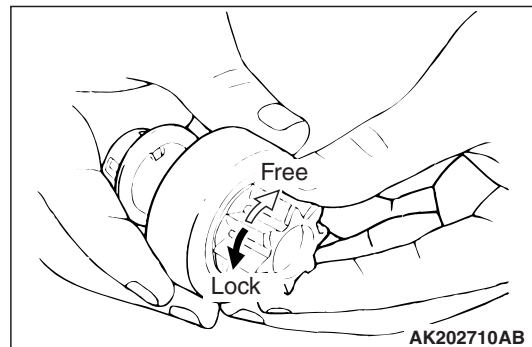
**Standard value: 0.5 mm**  
**Limit: 0.2 mm**

## BRUSH HOLDER



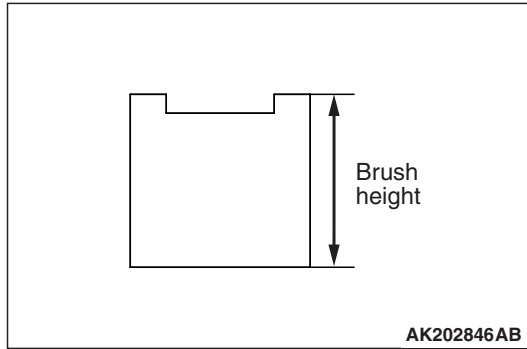
Push the brush into the brush holder to make sure that the spring is working on the brush.  
If the spring is not working, replace the brush holder.

## OVERRUNNING CLUTCH



1. Make sure that the pinion cannot be turned counterclockwise and can be turned clockwise freely.
2. Check the pinion for abnormal wear and damage.

## BRUSHES



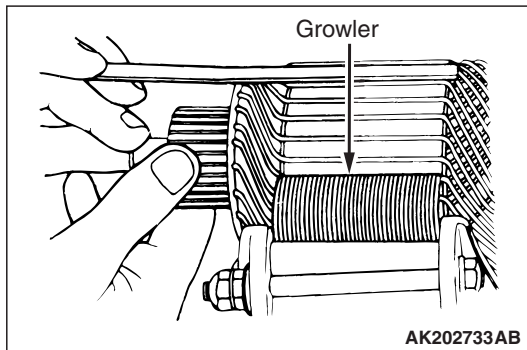
1. Check the commutator contacting surface of each brush for abnormal roughness. Also check the height of the brush. Replace the brush holder if the height is lower than the limit.

**Limit: 7.0 mm**

2. When the contact surface of the brush is rectified or the brush holder is replaced, recondition the contact surface with sandpaper wrapped around the commutator.

## ARMATURE COIL

1. Check the armature coil for short circuit as follows:

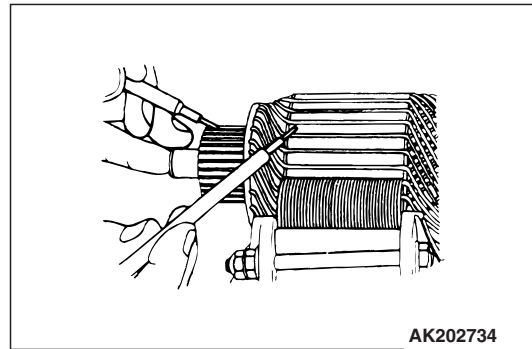


2. Set the armature in a growler.

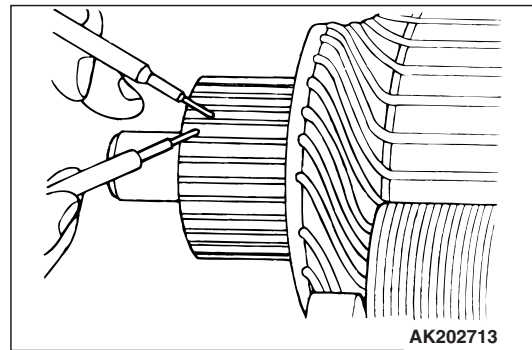
### **CAUTION**

**Clean the surface of the armature thoroughly before performing the test.**

3. While holding a thin strip of iron against the armature in parallel with its axis, turn the armature slowly. The armature is normal if the iron strip is not attracted to the armature or it does not vibrate.

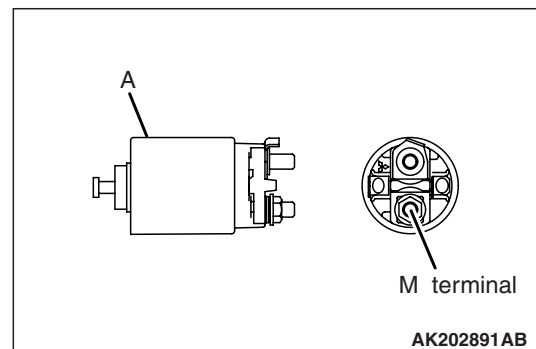


4. Check the insulation between commutator segments and armature coils. The armature coils are properly insulated if no continuity is present.

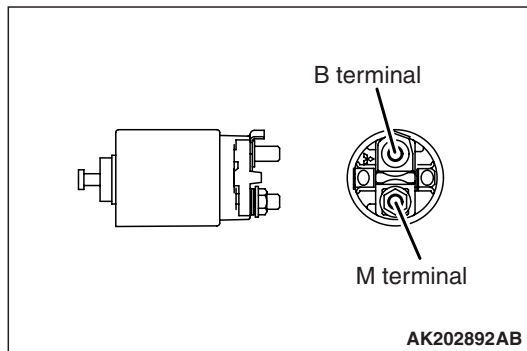


5. Check continuity between a segment and another. There is no open circuit in the tested coil if there is continuity.

## MAGNETIC SWITCH

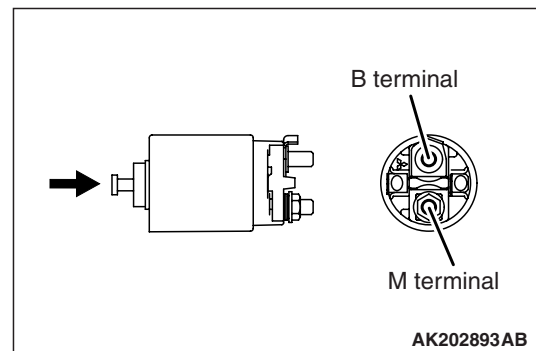


1. Coil open circuit test
  - Check that there is continuity between the M terminal and body A.
  - If there is no continuity, replace the magnetic switch.



## 2. Contact fusion check

- Check that there is no continuity between the B terminal and M terminal.
- If there is continuity, replace the magnetic switch.



## 3. Switch contact check

- Push the indicated end of the magnetic switch with a strong force to close the internal contacts. Without releasing the switch end, check that there is continuity between the B terminal and M terminal.
- If there is no continuity, replace the magnetic switch.

# IGNITION SYSTEM

## GENERAL INFORMATION

This system is equipped with two ignition coils (A and B) with built-in power transistors for the No. 1 and No. 4 cylinders and the No. 2 and No. 3 cylinders respectively.

Interruption of the primary current flowing in the primary side of ignition coil A generates a high voltage in the secondary side of ignition coil A. The high voltage thus generated is applied to the spark plugs of No. 1 and No. 4 cylinders to generate sparks. At the time that the sparks are generated at both spark plugs, if one cylinder is at the compression stroke, the other cylinder is at the exhaust stroke, so that ignition of the compressed air/fuel mixture occurs only for the cylinder which is at the compression stroke.

In the same way, when the primary current flowing in ignition coil B is interrupted, the high voltage thus generated is applied to the spark plugs of No. 2 and No. 3 cylinders.

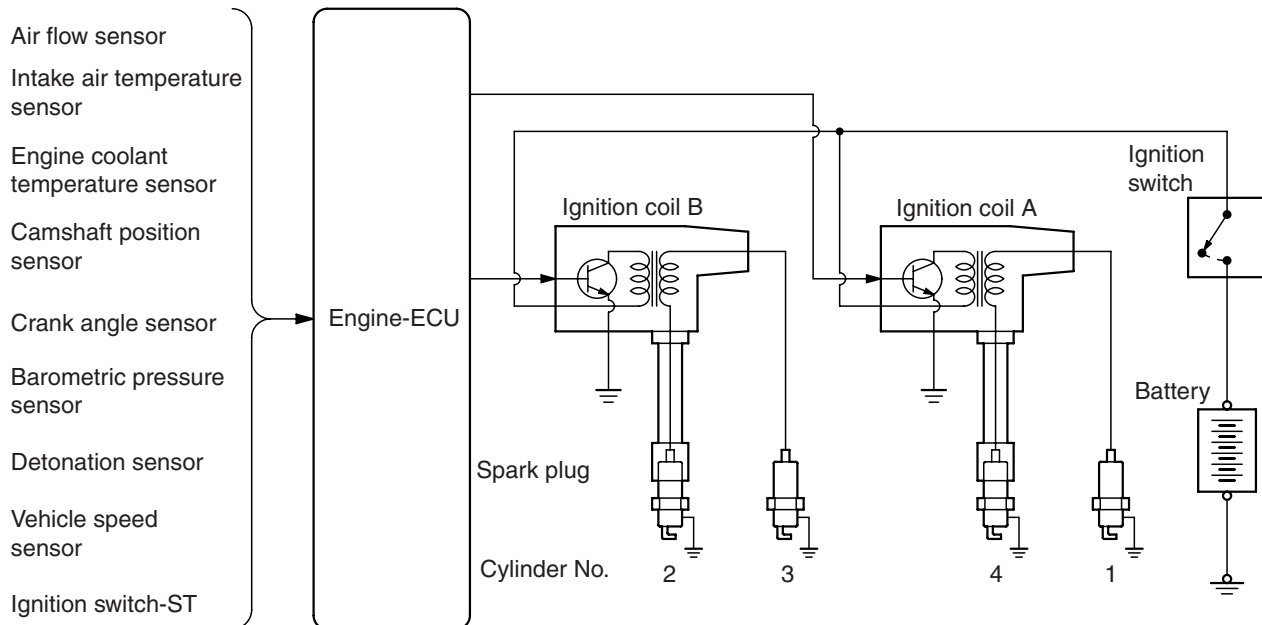
The engine-ECU turns the two power transistors inside the ignition coils alternately on and off. This causes the primary currents in the ignition coils to be alternately interrupted and allowed to flow to fire the cylinders in the order 1-3-4-2.

The engine-ECU determines which ignition coil should be controlled by means of the signals from the camshaft position sensor which is incorporated in the camshaft and from the crank angle sensor which is incorporated in the crankshaft. It also detects the crankshaft position in order to provide ignition at the most appropriate timing in response to the engine operation conditions. It also detects the crankshaft position in order to provide ignition at the most appropriate timing in response to the engine operation conditions.

When the engine is cold or operated at high altitudes, the ignition timing is slightly advanced to provide optimum performance.

M1163000100614

## SYSTEM DIAGRAM



AK101074 AH

## IGNITION COIL SPECIFICATION

| Item | Specification |
|------|---------------|
| Type | Molded 2-coil |

## SPARK PLUG SPECIFICATIONS

| Item | Specifications |
|------|----------------|
| NGK  | ILFR7H         |

## SERVICE SPECIFICATIONS

M1163000300403

## IGNITION COIL

| Item                                 | Standard value |
|--------------------------------------|----------------|
| Secondary coil resistance k $\Omega$ | 8.5 – 11.5     |

## SPARK PLUG

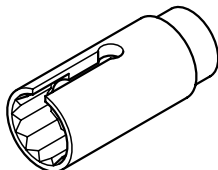
| Item              | Standard value | Limit |
|-------------------|----------------|-------|
| Spark plug gap mm | 0.5 – 0.6      | 0.75  |

## SPARK PLUG CABLE

| Item                  | Standard value | Limit      |
|-----------------------|----------------|------------|
| Resistance k $\Omega$ | –              | Maximum 19 |

## SPECIAL TOOL

M1163000600288

| Tool                                                                              | Number   | Name                     | Use                                        |
|-----------------------------------------------------------------------------------|----------|--------------------------|--------------------------------------------|
|  | MD998773 | Detonation sensor wrench | Detonation sensor removal and installation |

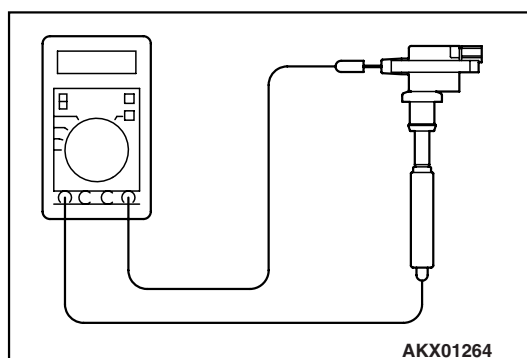
## ON-VEHICLE SERVICE

## IGNITION COIL (WITH BUILT-IN POWER TRANSISTOR) CHECK

M1163001200614

Check by the following procedure, and replace if there is a malfunction.

## SECONDARY COIL RESISTANCE CHECK

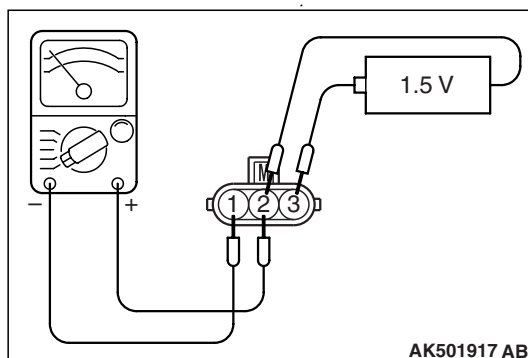


Measure the resistance between the high-voltage terminals of the ignition coil.

Standard value: 8.5 – 11.5 kΩ

## PRIMARY COIL AND POWER TRANSISTOR CONTINUITY CHECK

NOTE:



An analogue-type circuit tester should be used.

- Connect the negative (-) probe of the circuit tester to terminal No. 1.

**CAUTION**

This test must be performed quickly (in less than 10 seconds) to prevent coil from burning and power transistor from breakage.

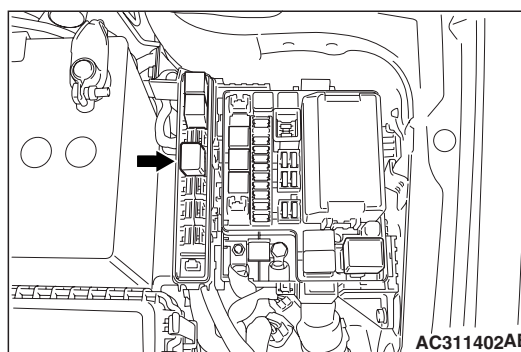
|                                  |                          |
|----------------------------------|--------------------------|
| 1.5 V power supply between 2 – 3 | Continuity between 1 – 2 |
| When current is flowing          | Continuity               |
| When current is not flowing      | No continuity            |

## IGNITION COIL RELAY CHECK &lt;RH DRIVE VEHICLES&gt;

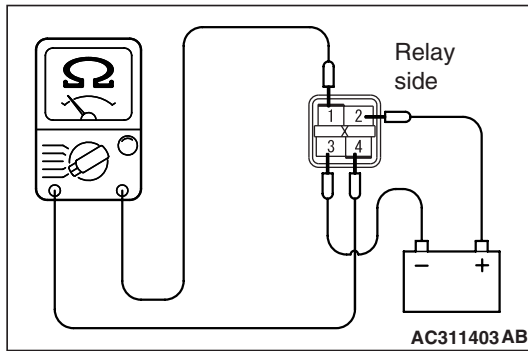
M1163006500029

**CAUTION**

The top and bottom of the ignition coil relay are difficult to identify. The triangle mark on the relay surface should be uppermost.



1. Removal the ignition coil relay.



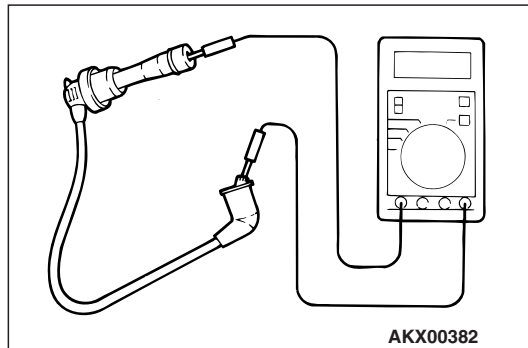
2. Use the jumper leads to connect ignition coil relay terminal 3 to the negative battery terminal and terminal 2 to the positive battery terminal.

3. Check the continuity between ignition coil relay connector terminals 1 and 4 while alternately connecting and disconnecting the jumper leads from the battery terminals.

| Jumper leads | Continuity between terminals 1 and 4 |
|--------------|--------------------------------------|
| Connected    | Less than 2 $\Omega$                 |
| Disconnected | Open circuit                         |

4. If there is a malfunction, replace the ignition coil relay.

## SPARK PLUG CABLE CHECK



Measure the resistance of the all spark plug cables. M1163001400157

1. Check cap and coating for cracks.
2. Measure resistance.

**Limit: Maximum 19 k $\Omega$**

## SPARK PLUG CHECK AND CLEANING

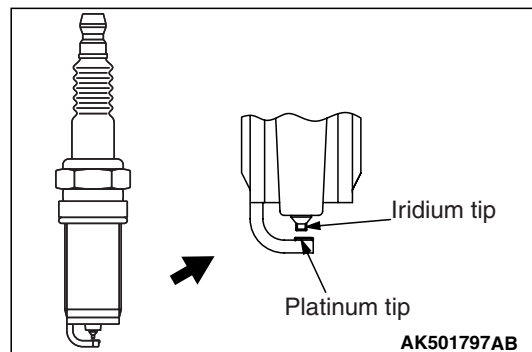
### **CAUTION**

When pulling off the spark plug cable from the plug always hold the cable cap, not the cable.

1. Remove the spark plug cables and ignition coils.
2. Remove the spark plugs.

### **CAUTION**

- Do not attempt to adjust the gap of the iridium plug.
- Always use a plug cleaner and finish cleaning within 20 seconds. Do not use wire brushes. Otherwise, the iridium and platinum tip may be damaged.



3. Check the plug gap and replace if the limit is exceeded.

**Standard value: 0.5 – 0.6mm**

**Limit: 0.75 mm**

**⚠ CAUTION**

Be careful not to allow foreign matter in cylinders.

4. Clean the engine plug holes.

5. Install the spark plugs.

6. Install the spark plug cables and ignition coils.

**CAMSHAFT POSITION SENSOR CHECK**

Check the camshaft position sensor system if self-diagnosis code, No. P0340 is shown.

(Refer to GROUP 13A – Troubleshooting – Inspection procedure for diagnosis code [P.13A-166.](#))

M1163004400305

**CRANK ANGLE SENSOR CHECK**

Check the crank angle sensor system if self-diagnosis code, No. P0335 is shown.

(Refer to GROUP 13A – Troubleshooting – Inspection procedure for diagnosis code [P.13A-155.](#))

M1163004500368

**DETONATION SENSOR CHECK**

Check the detonation sensor system if self-diagnosis code, No. P0325 is shown.

(Refer to GROUP 13A – Troubleshooting – Inspection procedure for diagnosis code [P.13A-151.](#))

M1163002900070

**IGNITION SECONDARY VOLTAGE WAVEFORM CHECK USING AN OSCILLOSCOPE**

M1163001700288

**MEASUREMENT METHOD**

1. Clamp the spark plug cable (No. 1 cylinder or No. 3 cylinder) with the secondary pickup.

**NOTE:**

- Because of the two-cylinder simultaneous ignition system, the waveforms for two cylinders in each group appear during waveform observation (No. 1 cylinder - No. 4 cylinder, No. 2 cylinder - No. 3 cylinder). However, waveform observation is only applicable for the cylinder with the spark plug cable clamped by the secondary pickup.
- Identifying which cylinder waveform is displayed can be difficult. For reference, remember that the waveform of the cylinder attached to the secondary pickup will be displayed as stable.

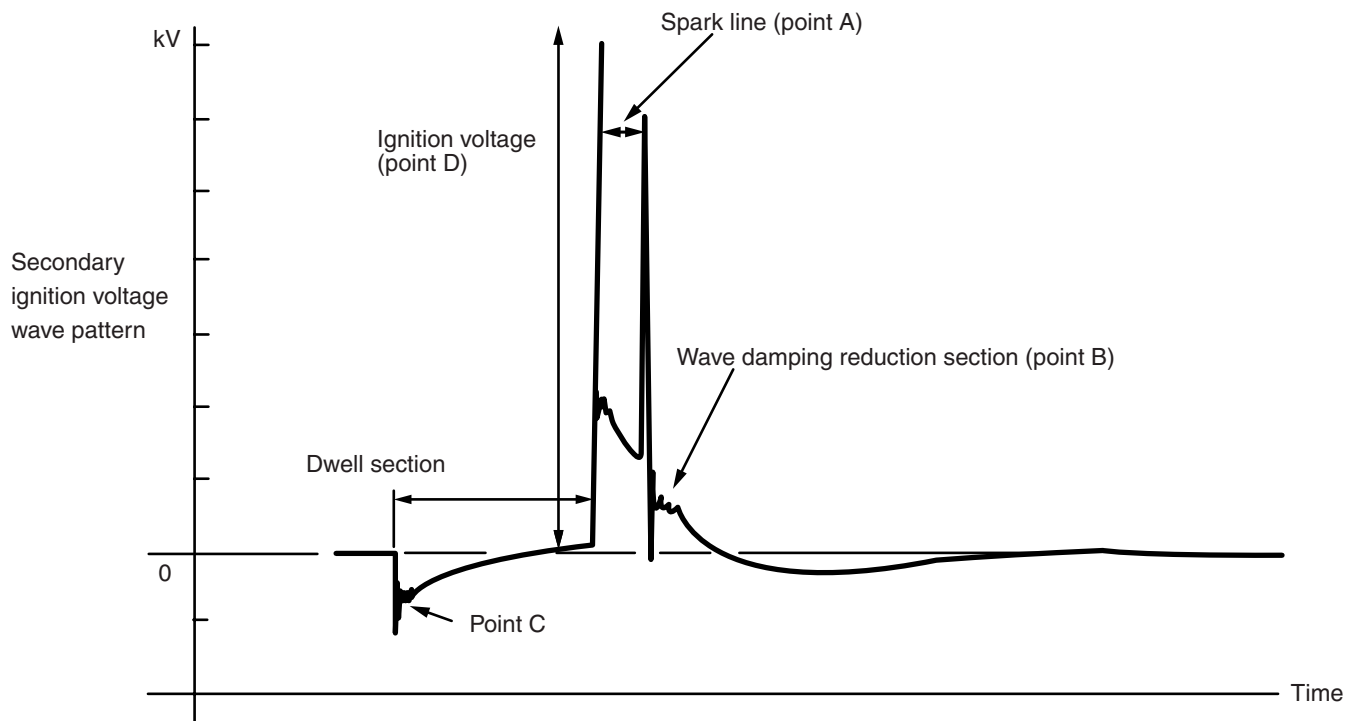
2. Clamp the spark plug cable with the trigger pickup.

*NOTE: Clamp the trigger pickup to the same spark plug cable clamped by the secondary pickup.*

## STANDARD WAVEFORM

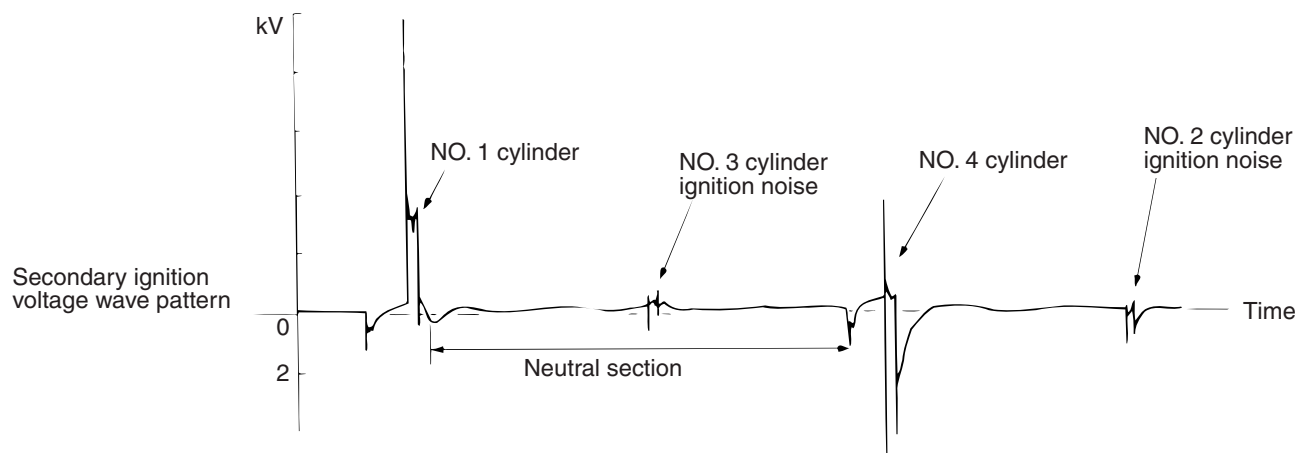
### Observation Conditions

| Function           | Secondary       |
|--------------------|-----------------|
| Pattern height     | High (or Low)   |
| Pattern selector   | Raster          |
| Engine revolutions | Curb idle speed |



**Observation Conditions (The only change from above condition is the pattern selector.)**

|                  |         |
|------------------|---------|
| Pattern selector | Display |
|------------------|---------|



AKX01275 AD

## WAVEFORM OBSERVATION POINTS

**Point A:** The height, length and slope of the spark line show the following trends (Refer to abnormal waveform examples, 1, 2, 3 and 4).

| Spark line |       | Plug gap | Condition of electrode | Compression force | Concentration of air mixture | Ignition timing | Spark plug cable |
|------------|-------|----------|------------------------|-------------------|------------------------------|-----------------|------------------|
| Length     | Long  | Small    | Normal                 | Low               | Rich                         | Advanced        | Leak             |
|            | Short | Large    | Large wear             | High              | Lean                         | Retarded        | High resistance  |
| Height     | High  | Large    | Large wear             | High              | Lean                         | Retarded        | High resistance  |
|            | Low   | Small    | Normal                 | Low               | Rich                         | Advanced        | Leak             |
| Slope      |       | Large    | Plug is fouled         | —                 | —                            | —               | —                |

**Point B:** Number of vibration in reduction vibration section (Refer to abnormal waveform example 5)

| Number of vibrations | Coil and condenser |
|----------------------|--------------------|
| 3 or more            | Normal             |
| Except above         | Abnormal           |

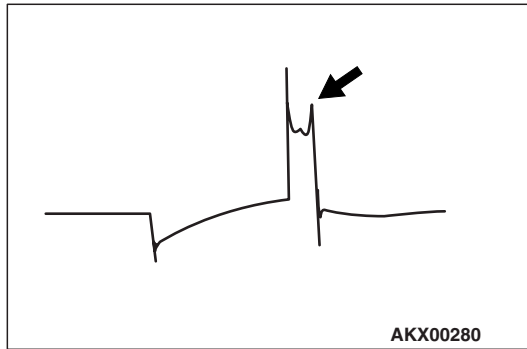
**Point C:** Number of vibrations at beginning of dwell section (Refer to abnormal waveform example 5)

| Number of vibrations | Coil     |
|----------------------|----------|
| 5 – 6 or higher      | Normal   |
| Except above         | Abnormal |

**Point D:** Ignition voltage height (distribution per each cylinder) shows the following trends.

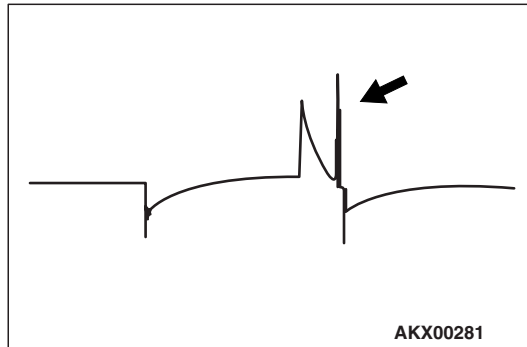
| Ignition voltage | Plug gap | Condition of electrode | Compression force | Concentration of air mixture | Ignition timing | Spark plug cable |
|------------------|----------|------------------------|-------------------|------------------------------|-----------------|------------------|
| High             | Large    | Large wear             | High              | Lean                         | Retarded        | High resistance  |
| Low              | Small    | Normal                 | Low               | Rich                         | Advanced        | Leak             |

## EXAMPLES OF ABNORMAL WAVEFORMS



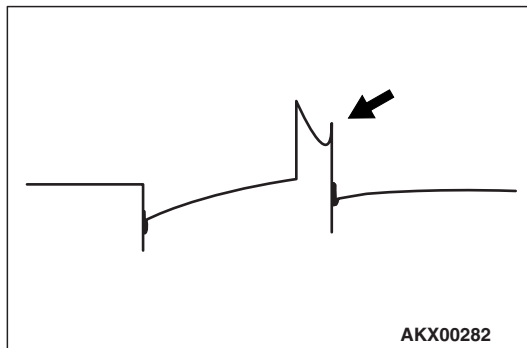
### Example 1

- Wave characteristics  
Spark line is high and short.
- Cause of problem  
Spark plug gap is too large.



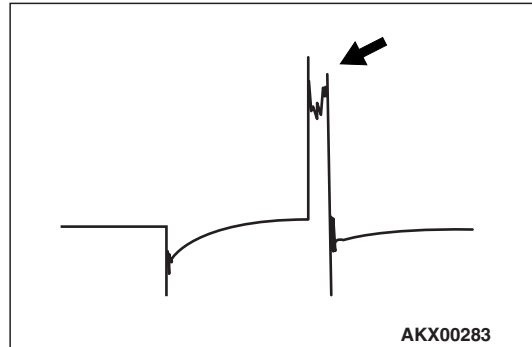
### Example 2

- Wave characteristics  
Spark line is low and long, and is sloping. Also, the second half of the spark line is distorted.
- Cause of problem  
Spark plug gap is too small.



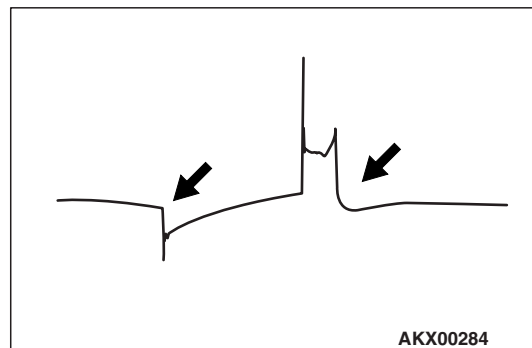
### Example 3

- Wave characteristics  
Spark line is low and long, and is sloping. However, there is almost no spark line distortion.
- Cause of problem  
Spark plug gap is fouled.



### Example 4

- Wave characteristics  
Spark line is high and short. Difficult to distinguish between this and abnormal waveform example 1.
- Cause of problem  
Spark plug cable is nearly falling off (Causing a dual ignition).



### Example 5

- Wave characteristics  
No waves in wave damping section.
- Cause of problem  
Layer short in ignition coil.

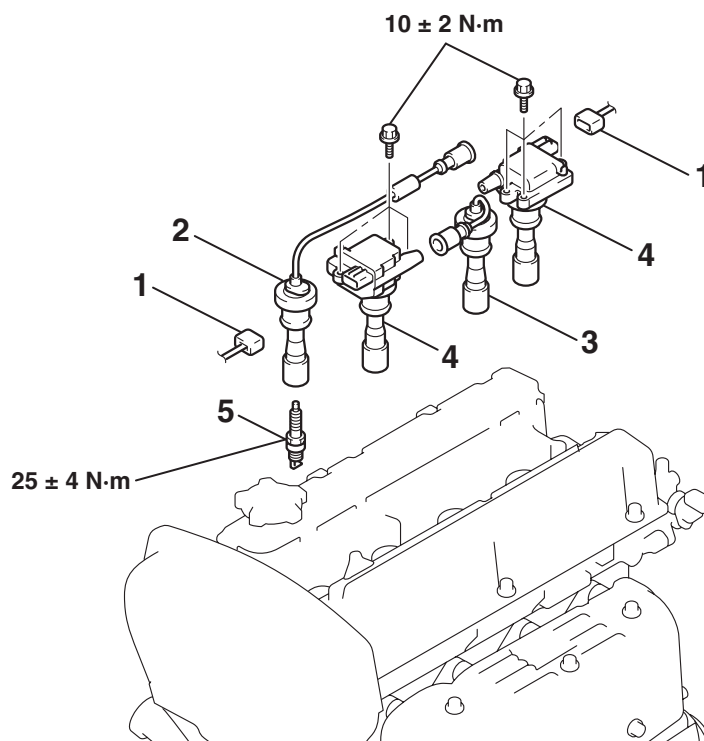
## IGNITION COIL

## REMOVAL AND INSTALLATION

M1163004000909

**Pre-removal and Post-installation Operation**

- Rocker Cover Centre Cover Removal and Installation (Refer to GROUP 11A, Camshaft and Valve Stem Seal [P.11A-17](#)).



AC210297AB

**Removal steps**

1. Ignition coil connectors
2. Spark plug cable No. 1
3. Spark plug cable No. 3

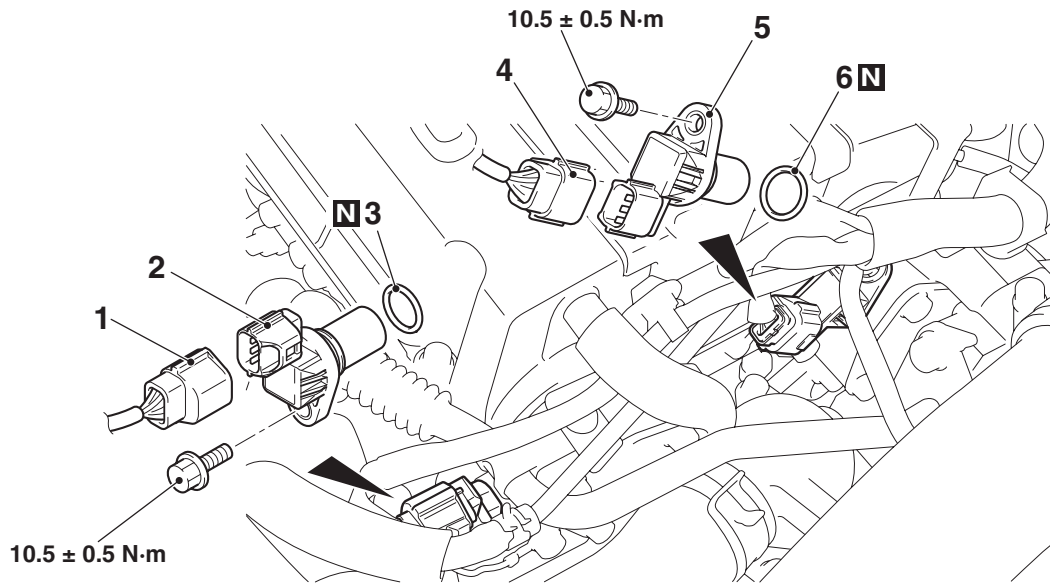
**Removal steps (Continued)**

4. Ignition coils
5. Spark plugs

## CAMSHAFT POSITION SENSOR

### REMOVAL AND INSTALLATION

M1163003400829



AC407255  
AC505000AB

#### Removal steps <exhaust side>

1. Camshaft position sensor connector
2. Camshaft position sensor
3. O-ring

#### Removal steps <inlet side>

4. Camshaft position sensor connector
5. Camshaft position sensor
6. O-ring

## CRANK ANGLE SENSOR

## REMOVAL AND INSTALLATION

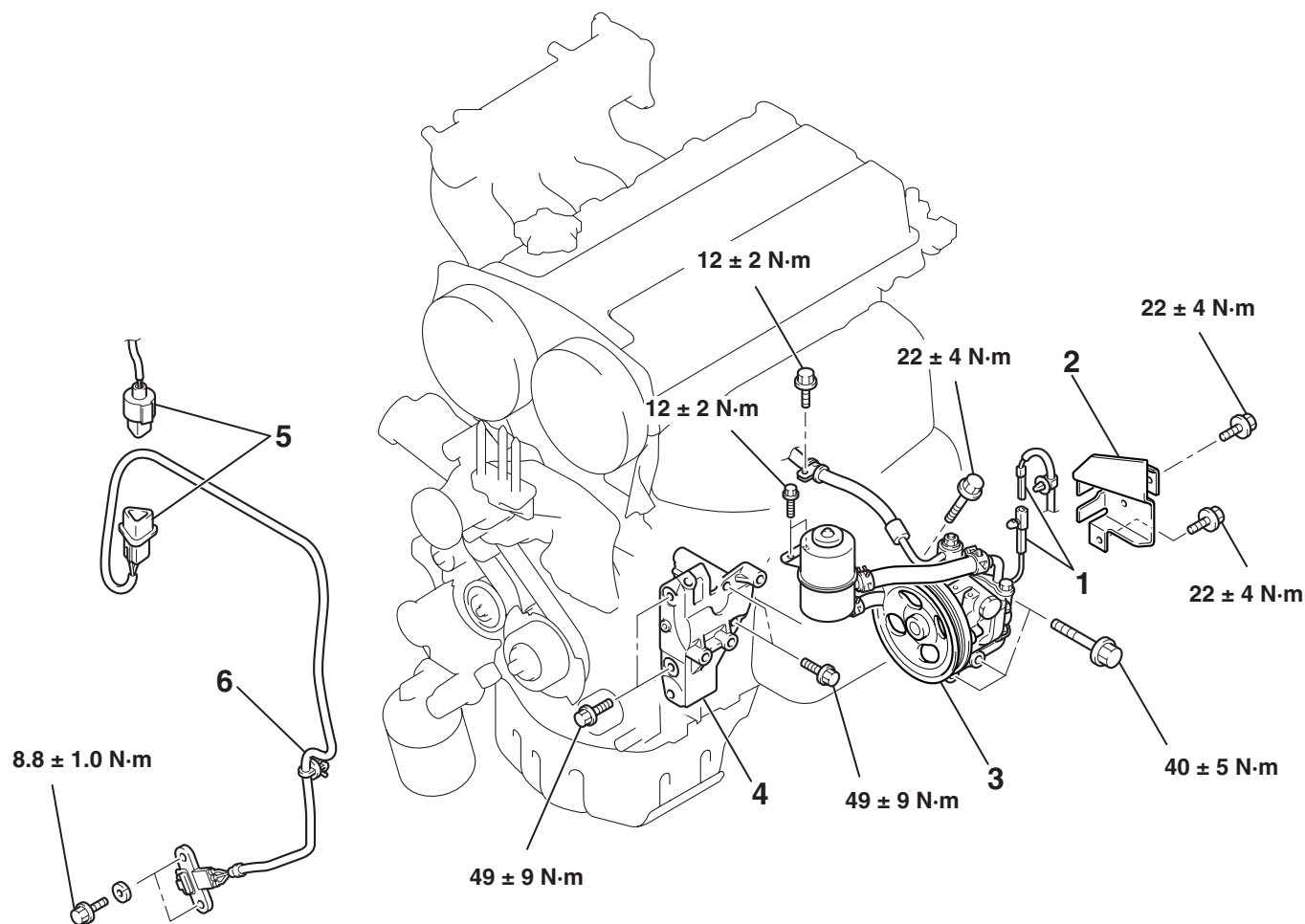
M1163004800143

**CAUTION**

If the vehicle is equipped with the Brembo™ disc brake, during maintenance, take care not to contact the caliper with tool or parts, because the caliper paint will be scratched.

**Pre-removal and Post-installation Operation**

- Timing Belt Removal and Installation (Refer to GROUP 11A, Timing Belt P.11A-36).
- Radiator Reserve Tank Assembly Removal and Installation (Refer to GROUP 14, Radiator P.14-24).



AC210409AB

**Removal steps**

1. Power steering pressure switch connector
2. Power steering oil pump heat protector

&lt;&lt;A&gt;&gt;

**Removal steps (Continued)**

3. Power steering oil pump, bracket and oil reservoir assembly
4. Power steering oil pump bracket
5. Crank angle sensor connector
6. Crank angle sensor

## REMOVAL SERVICE POINT

### <<A>> POWER STEERING OIL PUMP, BRACKET AND OIL RESERVOIR ASSEMBLY REMOVAL

*NOTE: Tie the removed power steering oil pump, bracket and oil reservoir assembly with a rope and set aside where they cannot hinder the removal of the power steering oil pump bracket.*

Remove the power steering oil pump, bracket and oil reservoir assembly with the hoses attached from the power steering oil pump bracket.

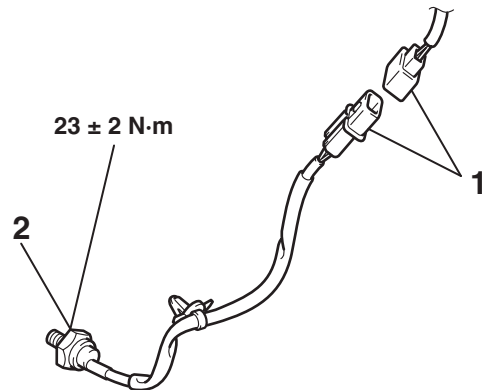
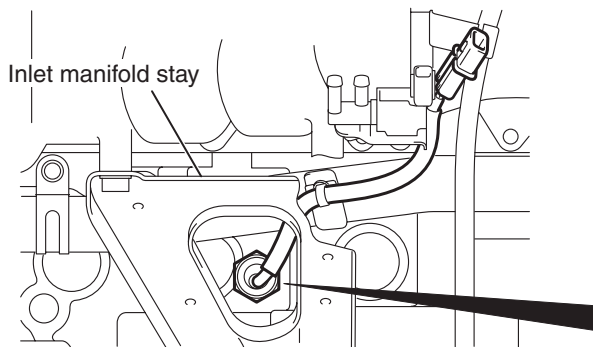
## DETONATION SENSOR

### REMOVAL AND INSTALLATION

M1163002800664

#### Pre-removal and Post-installation Operation

- Inlet Manifold Stay Removal and Installation (Refer to GROUP 15, Inlet Manifold [P.15-7](#)).



AC210411AB

#### Removal steps

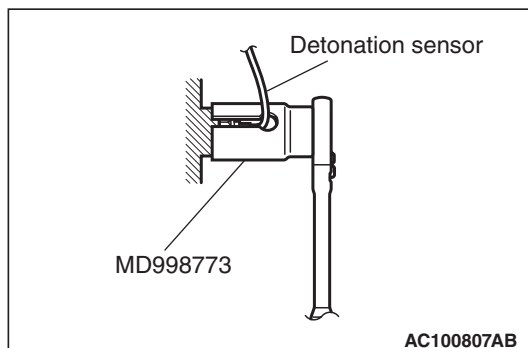
- <<A>> >>A<<
1. Detonation sensor connector
  2. Detonation sensor

## INSTALLATION SERVICE POINT

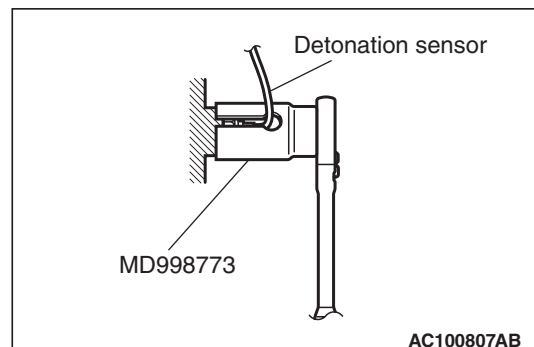
### >>A<< DETONATION SENSOR INSTALLATION

## REMOVAL SERVICE POINT

### <<A>> DETONATION SENSOR REMOVAL



Use special tool detonation sensor wrench (MD998773) to remove the detonation sensor.



Use special tool detonation sensor wrench (MD998773) to install the detonation sensor.

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## NOTES