ENGINE ELECTRICAL

CONTENTS

CHARGING SYSTEM

GENERAL

OUTLINE OF CHANGE

The service procedure for the alternator has been added to correspond to the addition of the diesel-powered vehicle.

GENERAL INFORMATION

ALTERNATOR SPECIFICATIONS

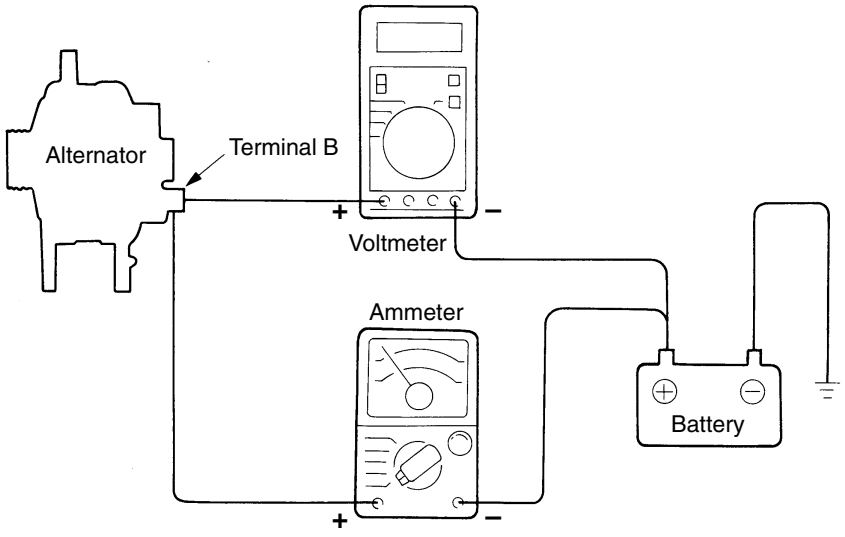
Items	Diesel engine without A/C	Diesel engine with A/C
Type	Battery voltage sensing	Battery voltage sensing
Rated output V/A	12/80	12/110
Voltage regulator	Electronic built-in type	Electronic built-in type

SERVICE SPECIFICATIONS

Items		Standard value	Limit
Alternator output line voltage drop (at 30A) V		–	Max. 0.3
Regulated voltage ambient temperature at voltage regulator V	–20°C	14.7 – 15.3	–
	20°C	14.4 – 14.7	–
	60°C	13.9 – 14.4	–
	80°C	13.7 – 14.2	–
Output current		–	70% of normal output current

ON-VEHICLE SERVICE <Diesel-powered vehicle>

ALTERNATOR OUTPUT LINE VOLTAGE DROP TEST



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

(1) Always be sure to check the following before the test.
- Alternator installation
- Alternator drive belt tension (Refer to GROUP 11C – On-vehicle Service.)
- Fusible link
- Abnormal noise from the alternator while the engine is running

(2) Turn the ignition switch off.

(3) Disconnect the negative battery cable.

(4) Disconnect the alternator output wire from the alternator "B" terminal and connect a DC test ammeter with a range of 0 – 100 A in series between the "B" terminal and the disconnected output wire. (Connect the (+) lead of the ammeter to the "B" terminal, and then connect the (–) lead of the ammeter to the disconnected output wire.)

NOTE
An inductive-type ammeter which enables measurements to be taken without disconnecting the alternator output wire should be recommended. Using this equipment will lessen the possibility of a voltage drop caused by a loose "B" terminal connection.

(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 the connect the (–) lead of the voltmeter to the battery (+) cable.)

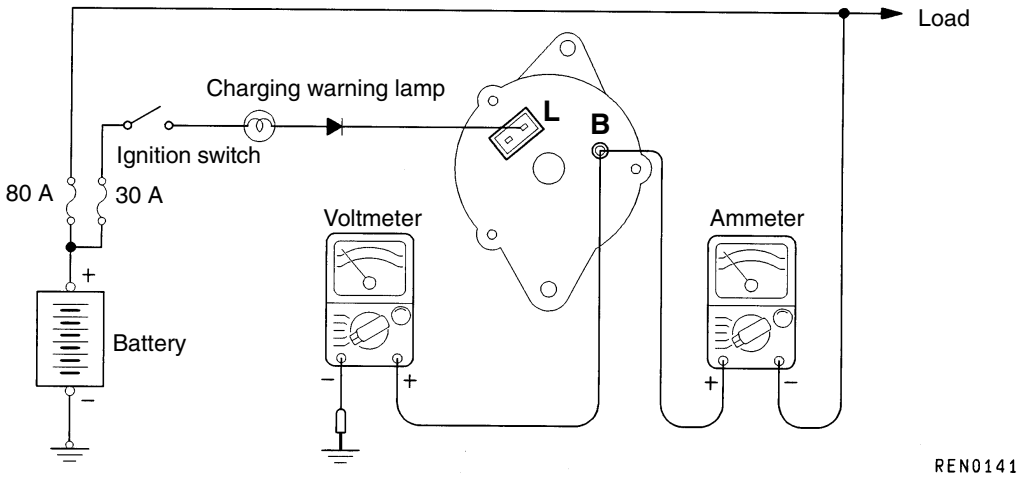
(6) Connect a tachometer.
(7) Reconnect the negative battery cable.
(8) Leave the hood open.
(9) Start the engine.
(10) With the engine running at 2,500 r/min, turn the headlamps and other lamps on and off to adjust the alternator load so that the value displayed on the ammeter is slightly above 30 A.
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: max. 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.

(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 discolored due to overheating, repair and then test again.
(12) After the test, run the engine at idle.
(13) Turn all lamps and the ignition at idle.
(14) Disconnect the negative batter cable.
(15) Disconnect the ammeter, voltmeter and tachometer.
(16) Connect the alternator output wire to the alternator "B" terminal.
(17) Connect the negative battery cable.

OUTPUT CURRENT TEST



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 54 – Battery.)

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

- Alternator drive belt tension (Refer to GROUP 11C – On-vehicle Service.)
- Fusible link
- Abnormal noise from the alternator while the engine is running.

(2) Turn the ignition switch off.
(3) Disconnect the negative battery cable.
(4) Disconnect the alternator output wire from the alternator "B" terminal. Connect a DC test ammeter with a range of 0 – 100 A in series between the "B" terminal and the disconnected output wire. (Connect the (+) lead of the ammeter to the "B" terminal. Connect the (–) lead of the ammeter to the disconnected output wire.)

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.

NOTE
An inductive-type ammeter which enables measurements to be taken without disconnecting the alternator output wire should be recommended.

(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 a tachometer.
(7) Connect the negative battery cable.
(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.

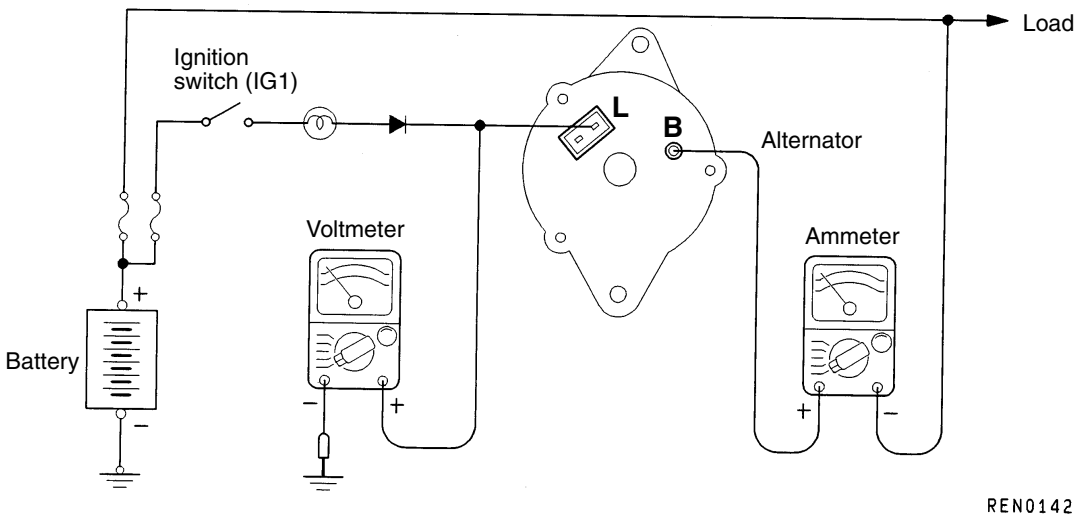
(10) Turn the light switch on to turn on headlamps and then start the engine.
(11) Immediately after setting the headlamps to high beam and turning the heater blower switch to the high revolution position, increase the engine speed to 2,500 r/min and read the maximum current output value displayed on 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 off.
(15) Disconnect the negative battery cable.
(16) Disconnect the ammeter, voltmeter and tachometer.
(17) Connect the alternator output wire to the alternator "B" terminal.
(18) Connect the negative battery cable.

REGULATED VOLTAGE TEST



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 54 – Battery.)
- Alternator drive belt tension (Refer to GROUP 11C – On-vehicle Service.)
- Fusible link
- Abnormal noise from the alternator while the engine is running

(2) Turn the ignition switch to the OFF position.
(3) Disconnect the negative battery cable.
(4) Connect a digital-type voltmeter between the alternator "L" terminal and the earth. (Connect the (+) lead of the voltmeter to the "L" terminal, and then connect the (–) lead of the voltmeter to a secure earth or to the battery (–) terminal.)
(5) Disconnect the alternator output wire from the alternator "B" terminal.
(6) Connect a DC test ammeter with a range of 0 – 100 A in series between the "B" terminal and the disconnected output wire. (Connect the (+) lead of the ammeter to the "B" terminal. Connect the (–) lead of the ammeter to the disconnected output wire.)
(7) Connect a tachometer.
(8) Reconnect the negative battery cable.
(9) Turn the ignition switch to the ON position and check that the reading on the voltmeter is 2 – 5 V.

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

(10) Turn all lamps and accessories off.
(11) Start the engine.
(12) Increase the engine speed to 2,500 r/min.
(13) Read the value displayed on the voltmeter when the alternator output current alternator becomes 10 A or less.

(14)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.
(15)After the test, lower the engine speed to the idle speed.
(16)Turn the ignition switch off.
(17)Disconnect the negative batter cable.
(18)Disconnect the ammeter, voltmeter and tachometer.
(19)Connect the alternator output wire to the alternator “B” terminal.
(20)Connect the negative battery cable.

Voltage Regulation Table

Standard value:

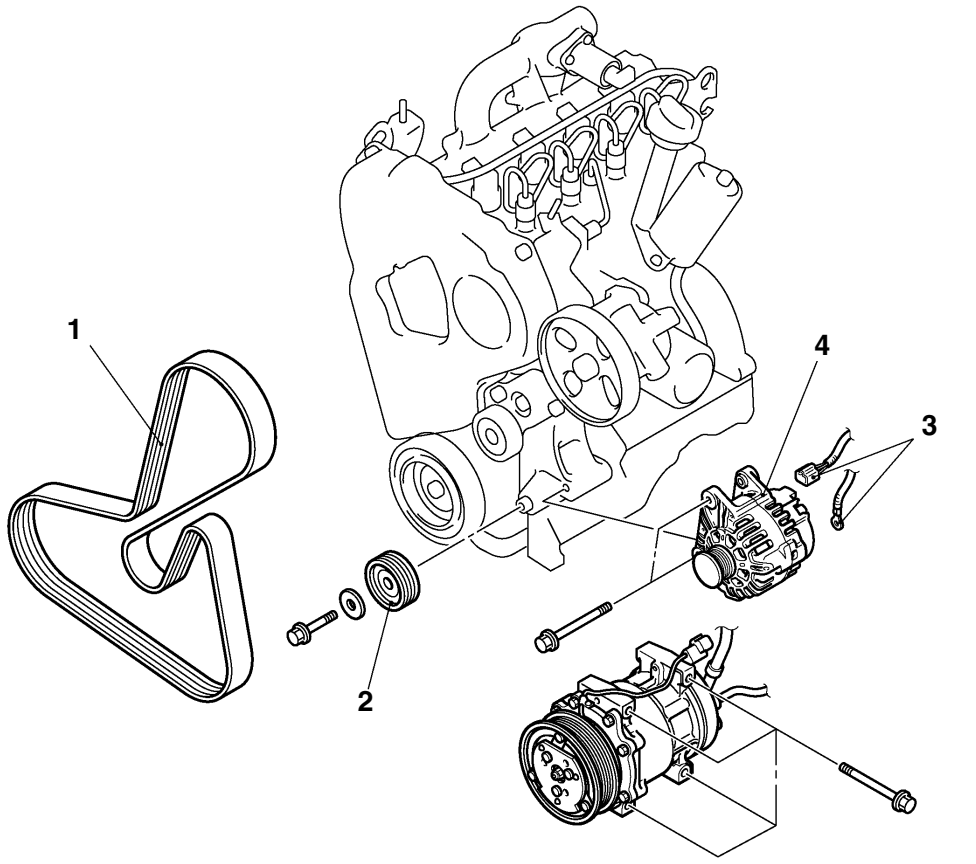
Inspection terminal	Voltage regulator ambient temperature °C	Voltage V
Terminal “L”	–20	14.7 – 15.3
	20	14.4 – 14.7
	60	13.9 – 14.4
	80	13.7 – 14.2

ALTERNATOR <F9Q1>

REMOVAL AND INSTALLATION

Pre-removal Operation
- Under Cover Removal
- Intercooler Air Hose Removal (Refer to GROUP 15 – Intercooler.)

Post-installation Operation
- Intercooler Air Hose Installation (Refer to GROUP 15 – Intercooler.)
- Under Cover Installation

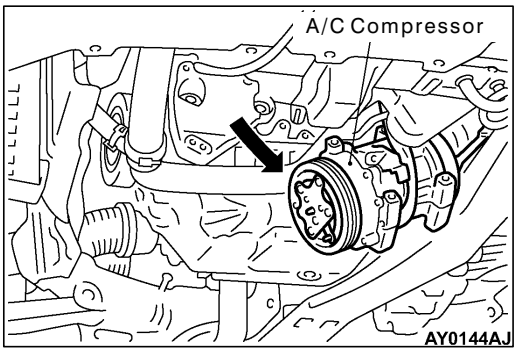


Removal steps

1. Drive belt
2. Idler pulley
- A/C Compressor mounting bolt

◀A▶

3. Alternator connector
4. Alternator



REMOVAL SERVICE POINT

◀A▶ ALTERNATOR REMOVAL

Put the A/C compressor aside so that enough space to remove the alternator can be secured.

IGNITION SYSTEM

GENERAL

OUTLINE OF CHANGES

<4G93-GDI>

An ignition failure sensor has been added. Other service specifications are the same as before.

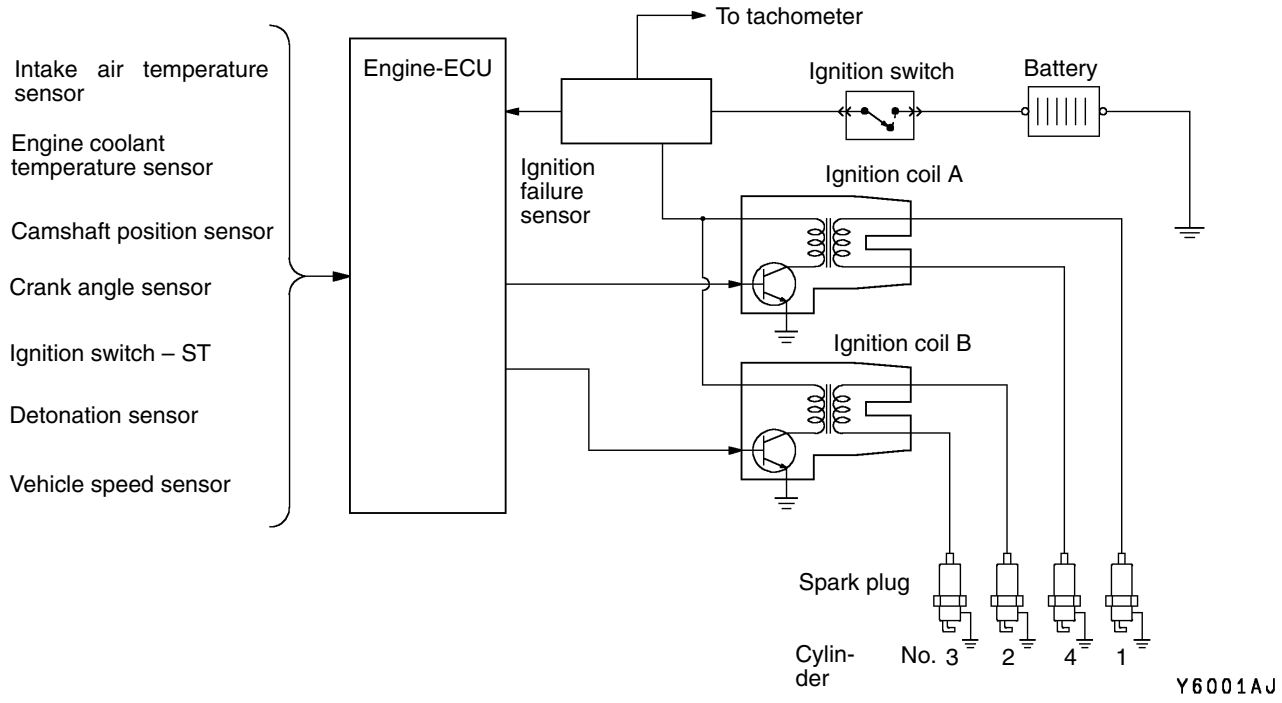
<4G13-MPI>

The following service specifications have been established. Other items are the same as before.

- A distributorless 2-coil ignition system has been adopted.
- The spark plugs have been changed.
- An ignition failure sensor has been added.

GENERAL INFORMATION

SYSTEM DIAGRAM <4G13-MPI>



IGNITION COIL SPECIFICATIONS

Items	4G13-MPI
Type	Molded 2-coil

SPARK PLUG SPECIFICATIONS

Items	4G13-MPI
NGK	BKR6E-11
DENSO	K20PR-U11

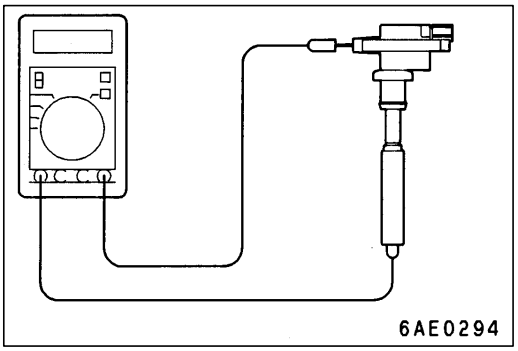
SERVICE SPECIFICATIONS

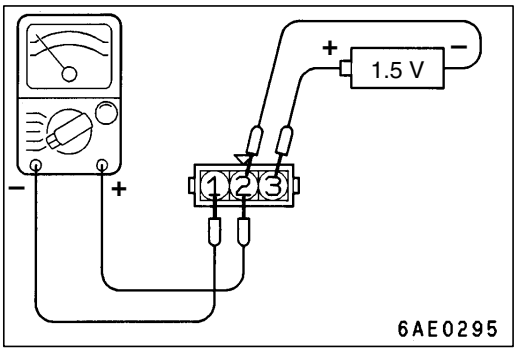
IGNITION COIL

Items	4G13-MPI
Secondary coil resistance kΩ	8.5 – 11.5

IGNITION FAILURE SENSOR

Items	4G93-GDI, 4G13-MPI
Resistance Ω	0.1 or less





ON-VEHICLE SERVICE

IGNITION COIL (WITH BUILT-IN POWER TRANSISTOR) CHECK

<4G13-MPI>

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

SECONDARY COIL RESISTANCE CHECK

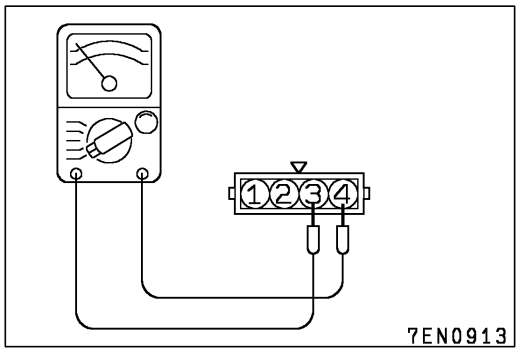
Measure the resistance between the high-voltage terminals of the ignition coil.

Standard value: 8.5 – 11.5 kΩ

PRIMARY COIL AND POWER TRANSISTOR CONTINUITY CHECK

NOTE
An analog-type circuit tester should be used.

Voltage: 1.5 V	Terminal No.		
	1	2	3
When current is flowing	○	⊖	⊕
When current is not flowing			



IGNITION FAILURE SENSOR CHECK

NOTE
An analog-type circuit tester should be used.

Check that the resistance between terminals 3 and 4 is at the standard value.

Standard value: 0.1 Ω or less

WAVEFORM CHECK USING AN ANALYZER <4G13-MPI>

Ignition Secondary Voltage Waveform Check

MEASUREMENT METHOD

1. Clamp the secondary pickup around the spark plug cable.

   NOTE
   (1) The peak ignition voltage will be reversed when the spark cables No. 2 and No. 4, or No. 1 and No. 3 cylinders are clamped.
   (2) 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.
   (3) 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.

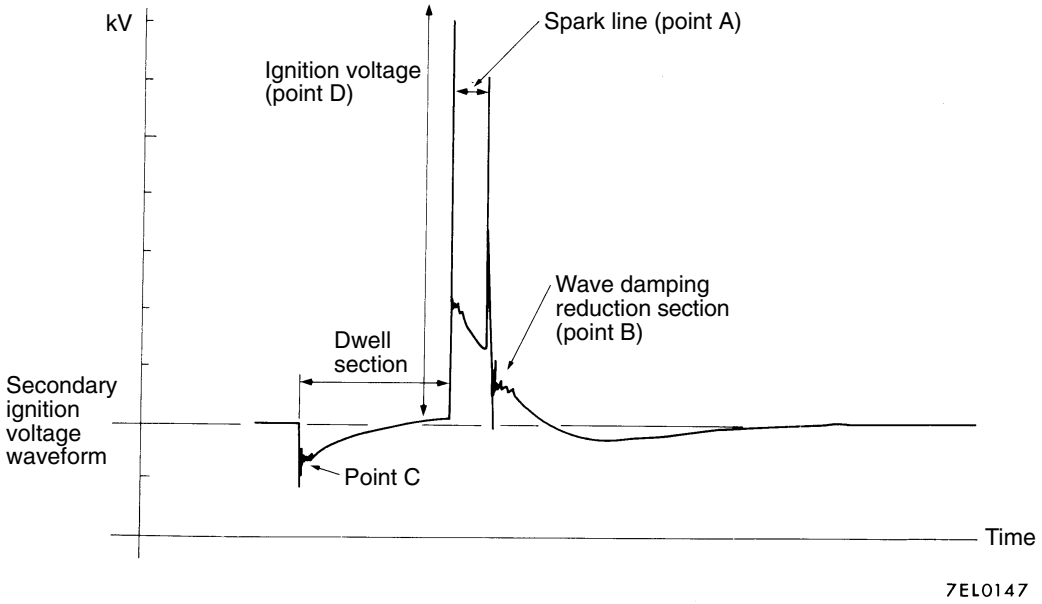
2. Clamp the spark plug cable with the trigger pickup.

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

STANDARD WAVEFORM

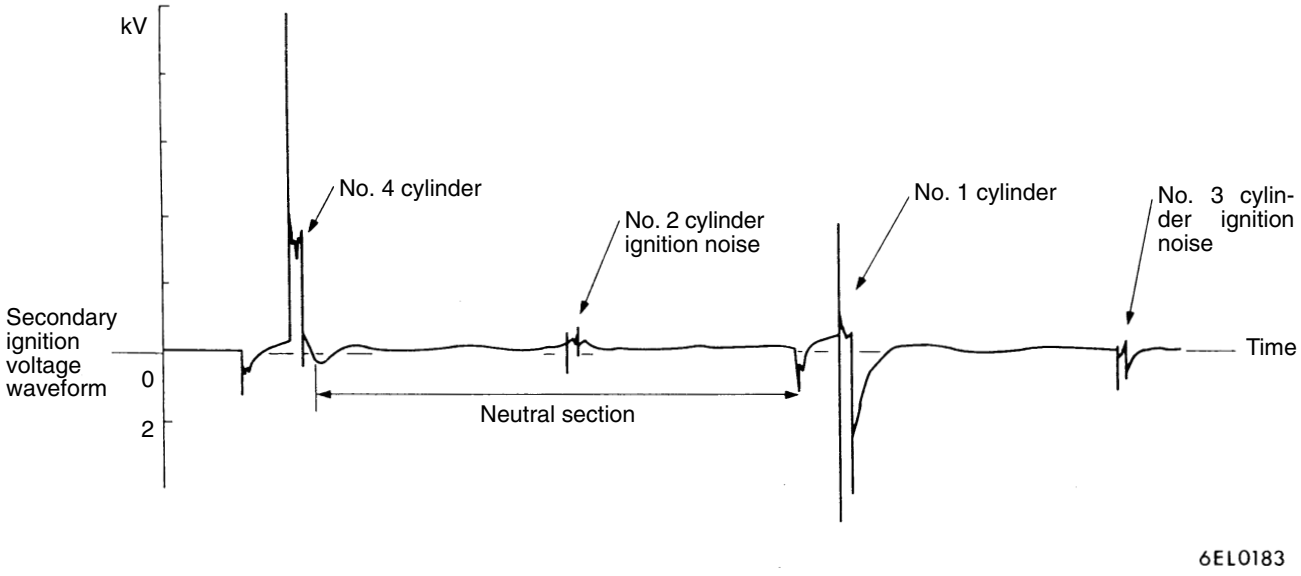
Observation Conditions

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



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

Pattern selector	Display



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
Three or more	Normal
Except above	Abnormal

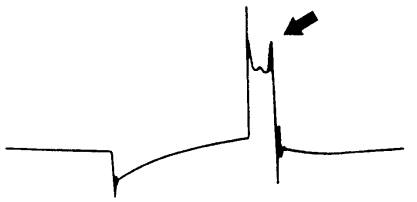
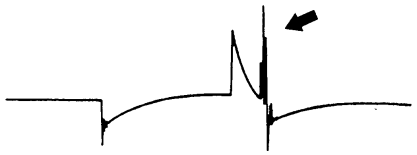
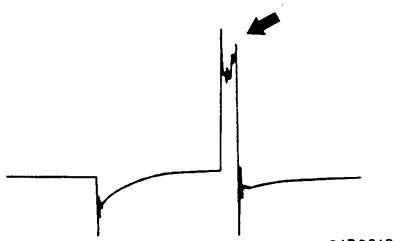
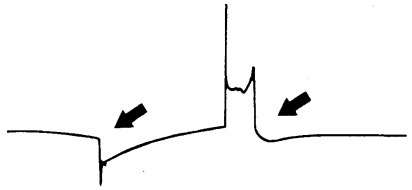
Point C: Number of vibrations at beginning of dwell section (Refer to abnormal waveform example 5).

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

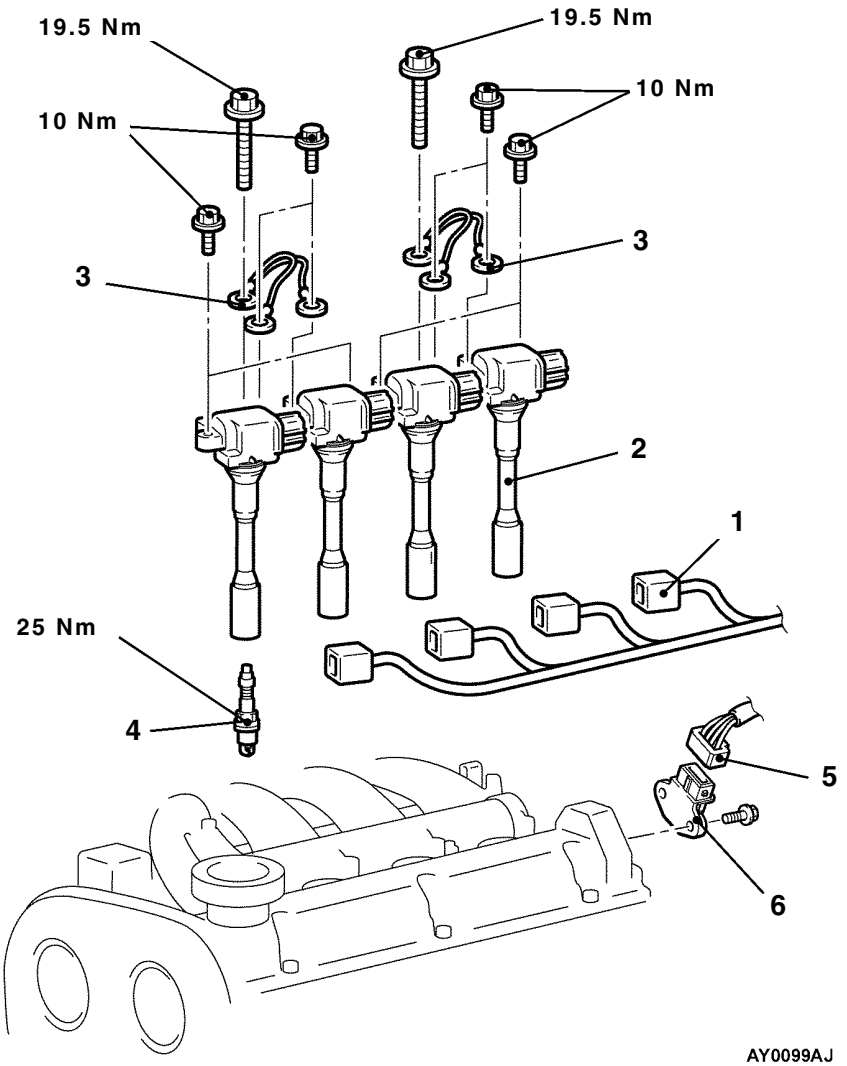
EXAMPLES OF ABNORMAL WAVEFORMS

Abnormal waveform	Wave characteristics	Cause of problem
Example 1  01P0215	Spark line is high and short.	Spark plug gap is too large.
Example 2  01P0216	Spark line is low and long, and is sloping. Also, the second half of the spark line is distorted. This could be a result of misfiring.	Spark plug gap is too small.
Example 3  01P0217	Spark line is low and long, and is sloping. However, there is almost no spark line distortion.	Spark plug gap is fouled.
Example 4  01P0218	Spark line is high and short. Difficult to distinguish between this and abnormal waveform example 1.	Spark plug cable is nearly falling off. (Causing a dual ignition)
Example 5  01P0219	No waves in wave damping section.	Rayer short in ignition coil.

IGNITION COIL <4G93-GDI>

REMOVAL AND INSTALLATION

Pre-removal and Post-installation Operation
Engine Cover Removal and Installation
(Refer to GROUP 11A – Camshaft, Camshaft Oil Seal.)



Ignition coil removal steps

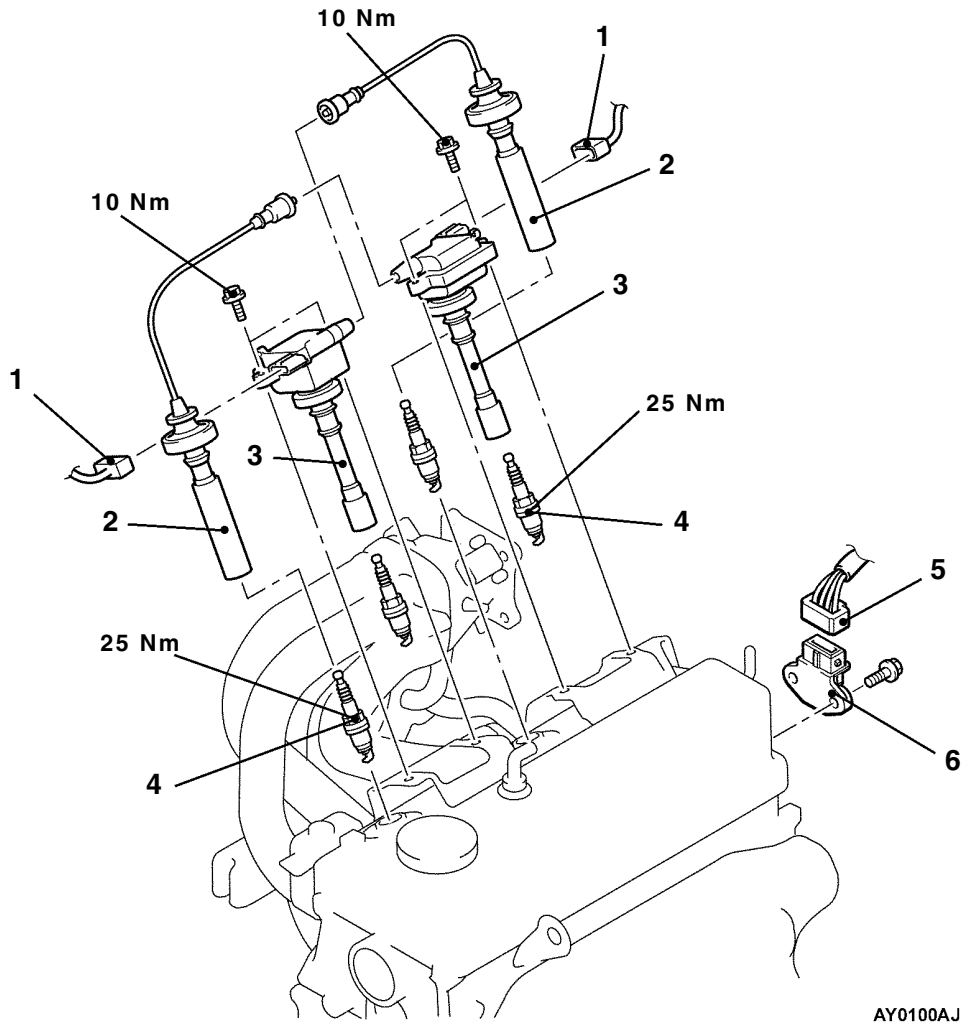
1. Ignition coil connector
2. Ignition coil
3. Earth strap
4. Spark plug

Ignition failure sensor removal steps

5. Ignition failure sensor connector
6. Ignition failure sensor

IGNITION COIL <4G13-MPI>

REMOVAL AND INSTALLATION



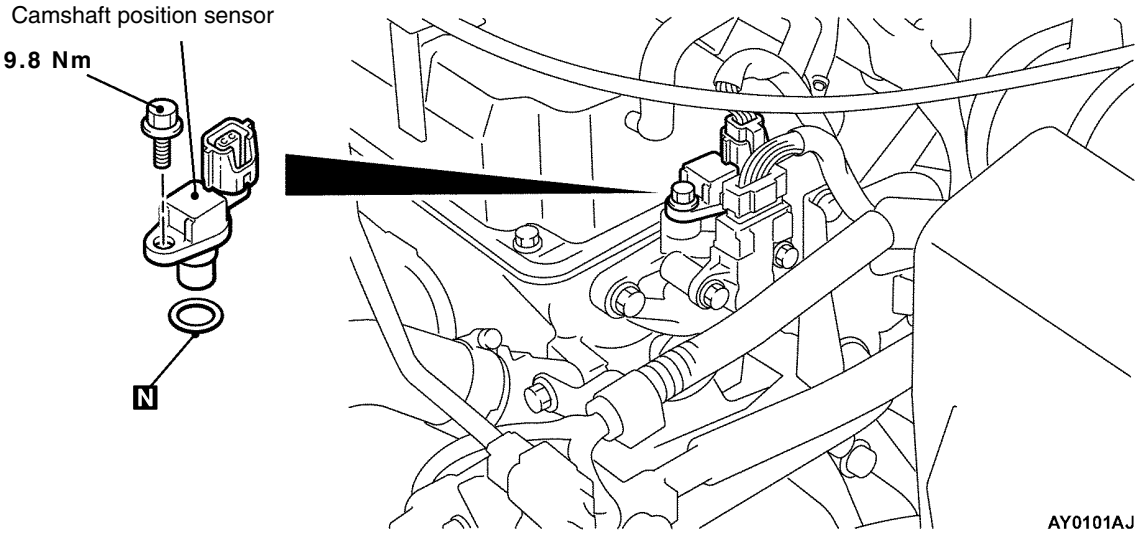
Ignition coil removal steps

1. Ignition coil connector
2. Spark plug cable assembly
3. Ignition coil
4. Spark plug

Ignition failure sensor removal steps

5. Ignition failure sensor connector
6. Ignition failure sensor

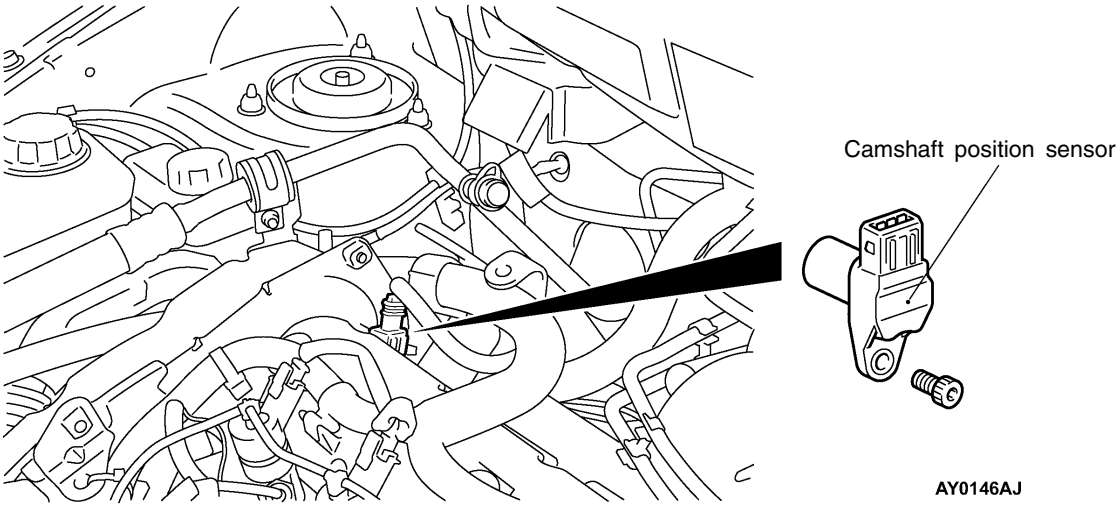
CAMSHAFT POSITION SENSOR <4G13-MPI>



CAMSHAFT POSITION SENSOR <F9Q1>

REMOVAL AND INSTALLATION

Pre-removal and Post-installation Operation
Engine hanger (Refer to GROUP 15 – Intake Manifold and Exhaust Manifold.)

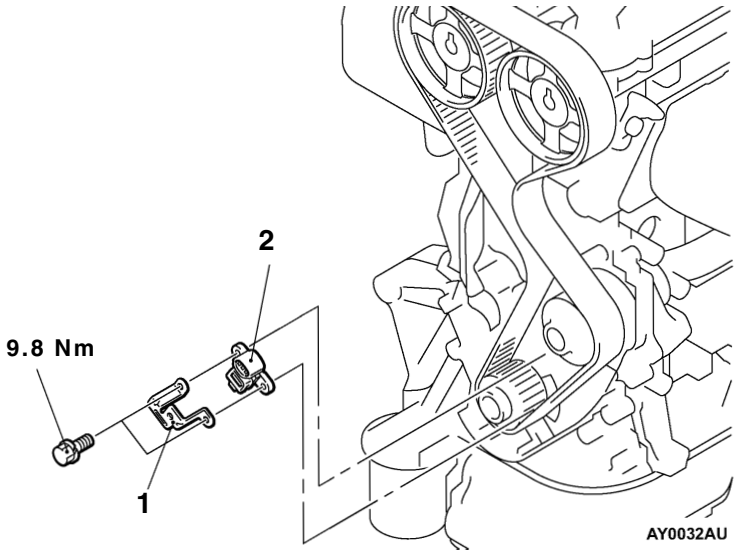


CRANK ANGLE SENSOR

REMOVAL AND INSTALLATION

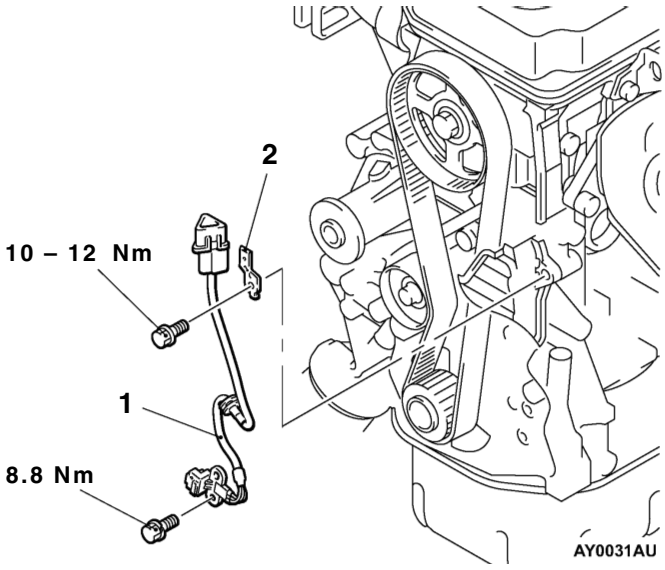
Pre-removal and Post-installation Operation
- Timing Belt Cover Removal and Installation

<4G93-GDI>



Removal steps
1. Bracket
2. Crank angle sensor

<4G13-MPI>



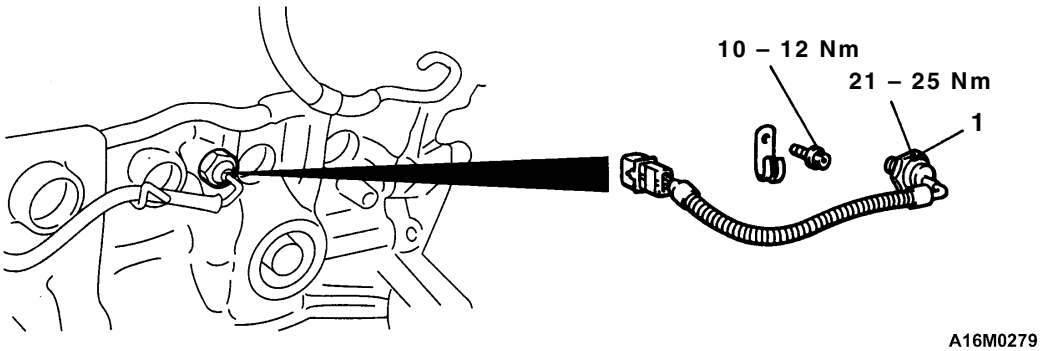
Removal steps
1. Crank angle sensor
2. Connector bracket

DETONATION SENSOR

REMOVAL AND INSTALLATION

Pre-removal and Post-installation Operation
- Engine Cover Removal and Installation <4G93-GDI> (Refer to GROUP 11A – Camshaft, Camshaft Oil Seal.)
- Intake Manifold Stay Removal and Installation (Refer to GROUP 15.)

<4G93-GDI>



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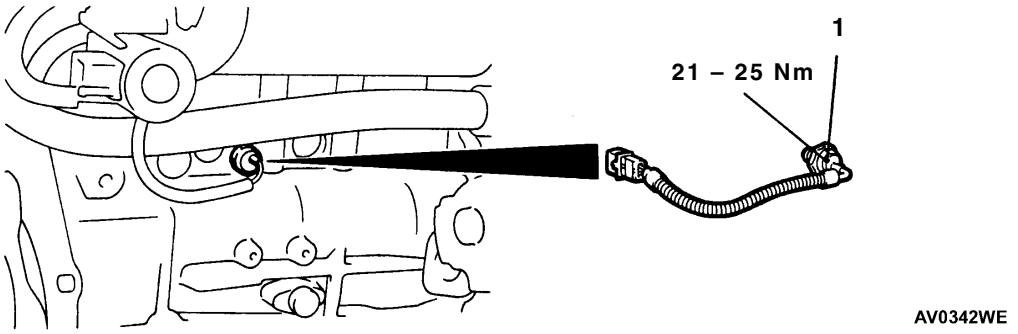
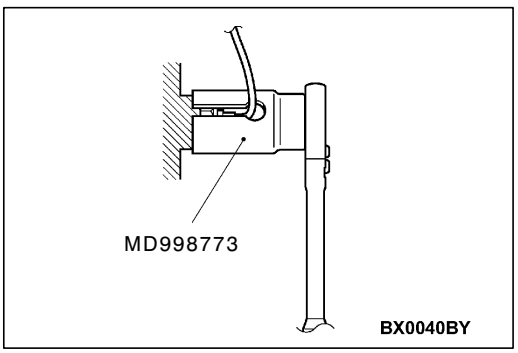


◀A▶ ▶A◀ 1. Detonation sensor

Caution
Do not subject the detonation sensor to any shocks.



REMOVAL SERVICE POINT

◀A▶ DETONATION SENSOR REMOVAL

INSTALLATION SERVICE POINT

▶A◀ DETONATION SENSOR INSTALLATION

GLOW SYSTEM

GENERAL

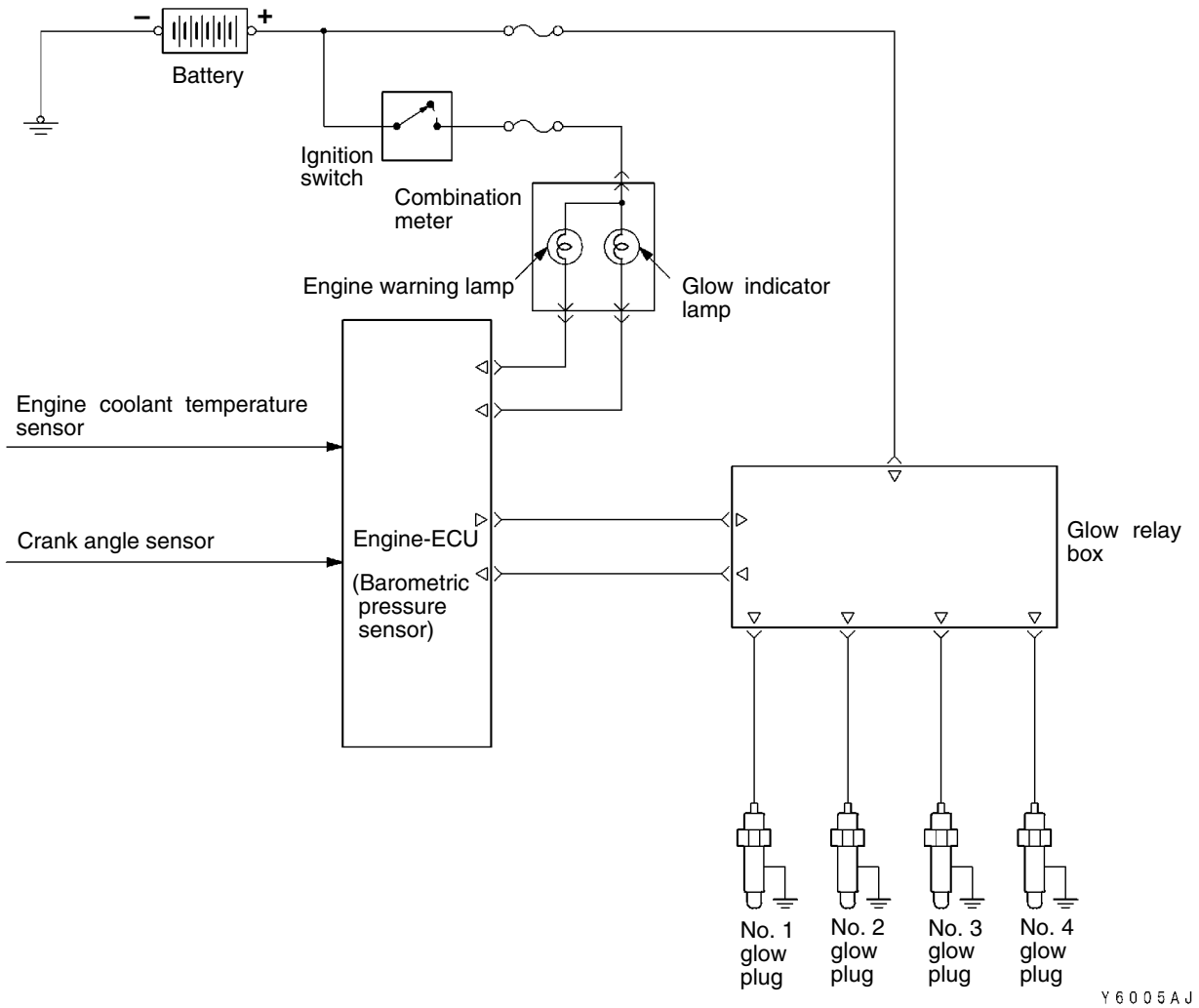
OUTLINE OF CHANGES

The following maintenance service points have been established to correspond to the adoption of the F9Q1 engine.

GENERAL INFORMATION

The glow system reduces the time required for starting at low temperatures to provide a degree of starting and operation that is identical to petrol-engine vehicles by pre-heating the glow plugs at super-quick speed. The engine-ECU controls both the time during which current is supplied to the glow plugs after the ignition switch is turned to the ON position and also the glow indicator lamp illumination time in accordance with the engine coolant temperature.
When the engine-ECU detects an abnormality in the glow system, it outputs diagnosis code (diesel fuel system) in response to the abnormal item.

SYSTEM DIAGRAM



SERVICE SPECIFICATIONS

Items		Standard value
Voltage between glow plug lead and glow body V	Immediately after ignition switch is turned to ON (without starting the engine)	9 – 11 (Drops to 0 V after 0.5 – 16 seconds have passed)
	While engine is cranking	6 or more
	While engine is warming up	12 – 15 (Drops to 0 V when if 10 – 60 seconds have passed since the engine was started)
Glow plug resistance Ω		0.6

ON-VEHICLE SERVICE

GLOW SYSTEM CHECK

1. Check that battery voltage is 11 – 13 V.
2. Check that the engine coolant temperature is 40°C or less.
3. Measure the voltages at the glow plug circuits of each cylinder.
   - For the No. 1 glow plug cylinder, measure between glow relay box connector terminal (5) and earth.
   - For the No. 2 glow plug cylinder, measure between glow relay box connector terminal (7) and earth.
   - For the No. 3 glow plug cylinder, measure between glow relay box connector terminal (3) and earth.
   - For the No. 4 glow plug cylinder, measure between glow relay box connector terminal (4) and earth.
4. Measure the voltage immediately after the ignition switch is turned to ON (without starting the engine).

   Standard value:
   9 – 11 V (Drops to 0 V after 0.5 – 16 seconds have passed)

   In addition, check to be sure that the glow indicator lamp illuminates immediately after the ignition switch is turned to ON.

   NOTE
   The voltage generated time (continuity time) varies depending on the engine coolant temperature when the ignition switch is ON.

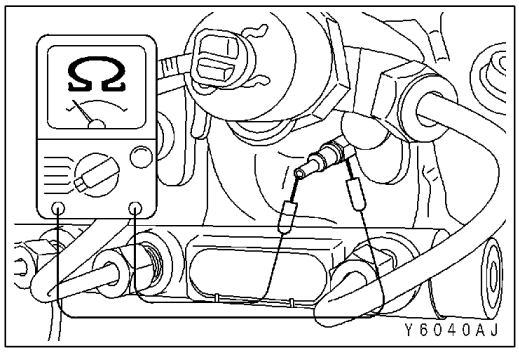
5. Measure the voltage while the engine is cranking.

   Standard value: 6 V or more

6. Start the engine and measure the voltage while the engine is warming up.
   The voltage always drops to 0 V when 10 – 60 seconds have passed after starting the engine.

   Standard value: 12 – 15 V

   NOTE
   The voltage generated time (continuity time) varies depending on the engine coolant temperature when the ignition switch is ON.



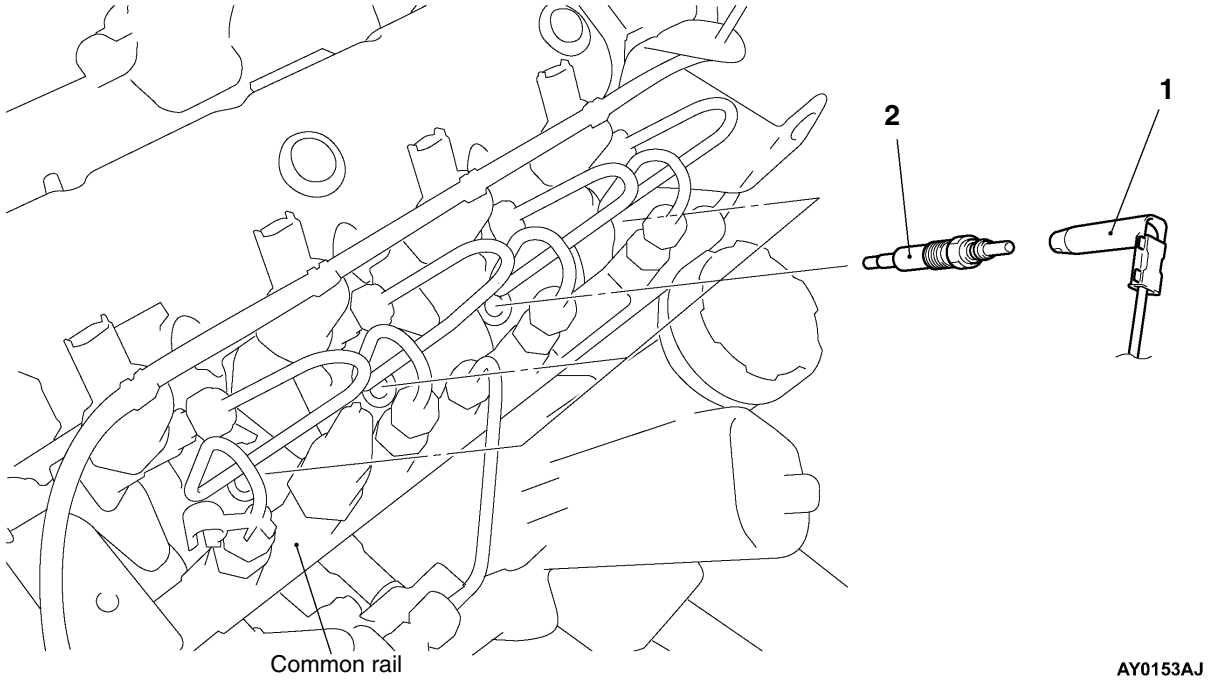
GLOW PLUG CHECK

1. Remove the glow plug leads.
2. Measure the resistance between the glow plug terminals and the body.

   Standard value: 0.6 Ω

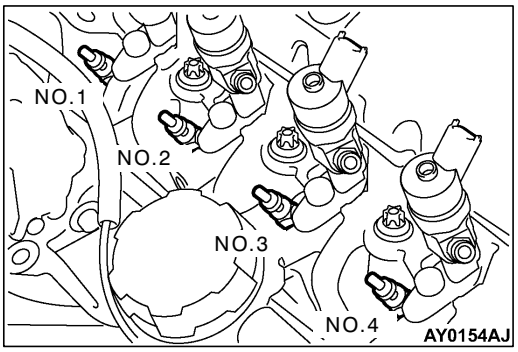
GLOW PLUG

REMOVAL AND INSTALLATION



Removal steps

1. Glow plug connector connection
◀A▶ 2. Glow plug



REMOVAL SERVICE POINT

◀A▶ GLOW PLUG (NO.1) REMOVAL

After removing the common rail, remove the Glow plug (NO.1). (Refer to GROUP 13D – Injection Pump and Nozzle)