HYUNDAI

DIESEL ENGINE
D4EA
(BOSCH COMMON RAIL)

Shop Manual

SUPPLEMENT

FOREWORD

This shop manual is intended for use by service technicians of authorized Hyundai dealers to help them provide efficient and correct service and maintenance on Hyundai vehicle.

To ensure customer satisfaction with Hyundai products, proper service and maintenance by Hyundai technicians is essential. Consequently, it is important that service personnel fully understand the contents of this manual, which should be kept in a handy place for quick and easy reference.

All the contents of this manual, including photographs, drawings, and specifications, are the latest available at the time of printing. As modifications affecting service occur, dealers will be provided technical service bulletins or supplementary volumes. This manual should be kept carefully up-to date upon receipt of the new information.

Hyundai Motor Company reserves the right to make changes in design or to make additions to or improvements in its products without imposing any obligations upon itself to install them on its products previously manufactured.

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If you don't use HYUNDAI Genuine Parts (Engine oil, Transaxle oil, etc.) or use bad fuel, it can cause damage to the vehicle.

CONTENTS

TITLE	GROUP
ENGINE MECHANICAL SYSTEM	EM
FUEL SYSTEM	FL
SCHEMATIC DIAGRAMS	SD

This is the supplement shop manual of the New Diesel Engine equipped with fuel injection system of BOSCH Common Rail.
This New Diesel Engine, named D4EA for 4 cylinders, is applied to the vehicle of SANTAFE, TRAJET and ELANTRA.
For any information not covered in this supplement, please refer to the related shop manual published earlier.

NOV. 2000,
Printed in Korea

ENGINE MECHANICAL SYSTEM

GENERAL ..... EM - 2

ENGINE BLOCK ..... EM -21

MAIN MOVING SYSTEM ..... EM -35

COOLING SYSTEM ..... EM -46

LUBRICATION SYSTEM ..... EM -58

INTAKE AND EXHAUST SYSTEM ..... EM -63

CYLINDER HEAD ASSEMBLY ..... EM -78

TIMING SYSTEM ..... EM -86

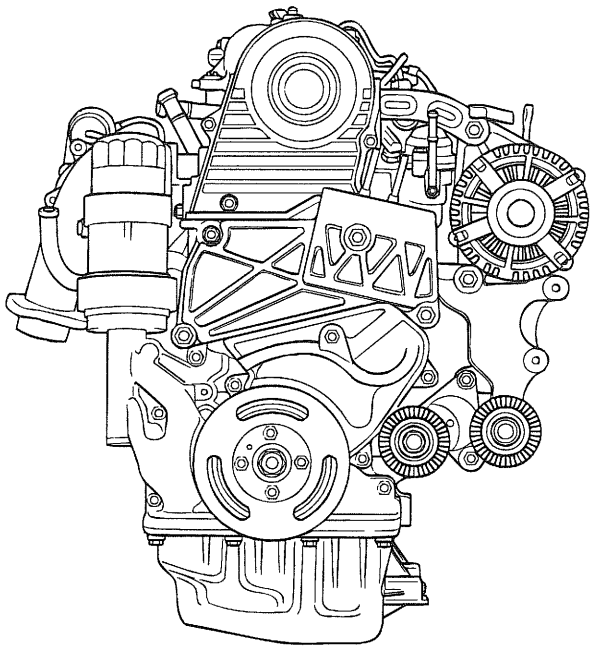
GENERAL

WARNING ECHB0100

REMOVAL AND INSTALLATION OF INJECTOR AND HIGH PRESSURE PUMP.

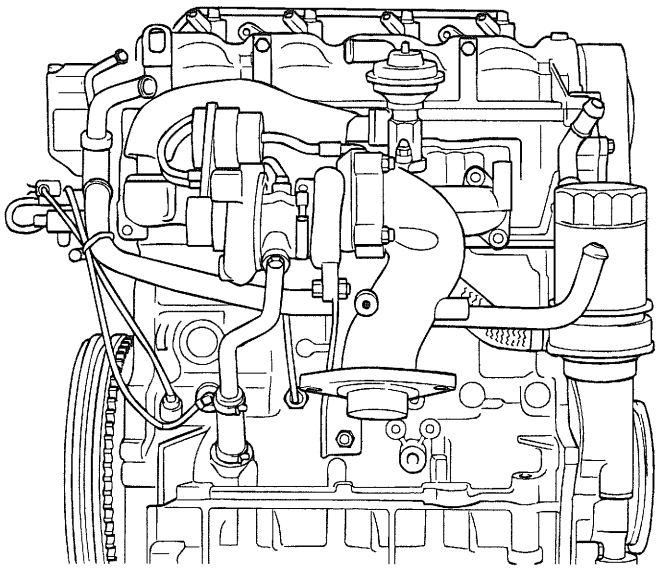
1. Fuel system is subject to extremely high pressure (1350 bar).
2. Never perform any work on injection system with engine running or within 30 seconds after stopping the engine.
3. Always pay attention to safety precautions.
4. Ensure the absolute cleanliness.
5. Never remove the injectors.

2.0TCI ENGINE



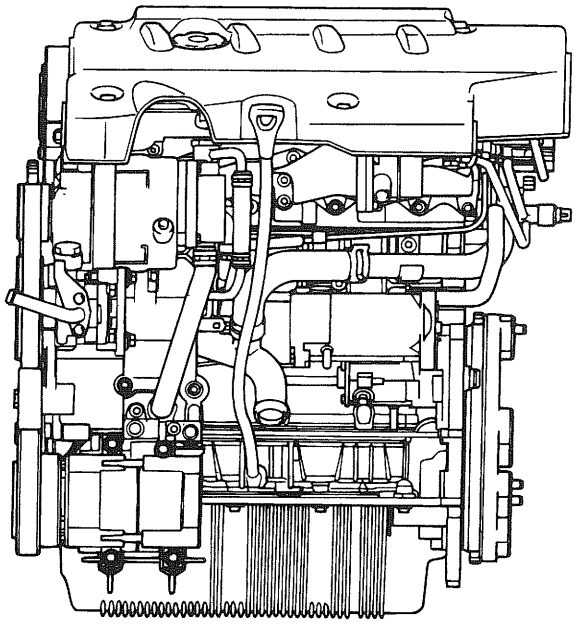
TORQUE : Nm (kg·cm, lb· ft)

KCHB001A



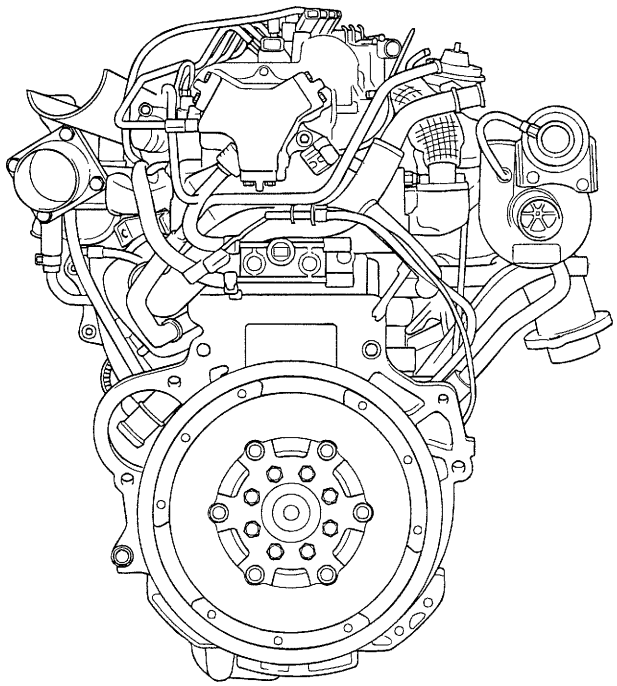
TORQUE : Nm (kg·cm, lb· ft)

KCHB001B



TORQUE : Nm (kg·cm, lb· ft)

KCHB001C



TORQUE : Nm (kg·cm, lb· ft)

KCHB001D

SPECIFICATIONS(D4EA) ECHB0200

Description	Specification 2.0(D4EA)	Limit
General		
Type	In-line, Single Overhead Camshaft	
Number of cylinders	4	
Bore	83 mm (3.27 in.)	
Stroke	92 mm (3.62 in.)	
Total displacement	1991 cc (121.5 cu.in.)	
Compression ratio	17.7:1	
Firing order	1-3-4-2	
Valve timing		
Intake valve		
Opens (BTDC)	7°	
Closes (ABDC)	43°	
Exhaust valve		
Opens (BBDC)	52°	
Closes (ATDC)	6°	
Cylinder head		
Flatness of gasket surface	Max. 0.03 mm (0.0012 in.)	0.2 mm (0.008 in.)
Dimensions for reworking oversize valve seat hole		
Intake		
0.3 mm (0.012 in.) O.S.	29.993-30.006 mm (1.18-1.1813 in.)	
0.6 mm (0.024 in.) O.S.	30.023-30.036 mm (1.182-1.1825 in.)	
Exhaust		
0.3mm (0.012 in.) O.S.	25.393-25.406 mm (0.9997-1.0002 in)	
0.6mm (0.024 in.) O.S.	25.423-25.436 mm (1.0009-1.0014 in.)	
Dimensions for reworking oversize valve guide hole (both intake and exhaust)		
0.05mm (0.002in.) O.S.	12.805-13.205 mm (0.504-0.519 in.)	
0.25mm (0.010in.) O.S.	12.825-13.225 mm (0.5049-0.5206 in.)	
0.50mm (0.020in.) O.S.	12.85-13.25 mm (0.5059-0.5216 in.)	
Camshaft		
Cam height		
Intake	34.697 mm (1.366 in.)	34.197 mm (1.346 in.)
Exhaust	34.570 mm (1.361 in.)	34.070 mm (1.341 in.)
Journal O.D.	28 mm (1.10 in.)	
Bearing oil clearance	0.040-0.074 mm (0.0020-0.0029 in.)	
End play	0.05-0.15 mm (0.002-0.006 in.)	

Description	Specification 2.0(D4EA)	Limit
Valve		
Valve length		
Intake	95.7 mm (3.77 in.)	
Exhaust	95.4 mm (3.76 in.)	
Stem O.D.		
Intake	5.953 mm (0.234 in.)	
Exhaust	5.925 mm (0.233 in.)	
Face angle	44.5°	
Thickness of valve head (margin)		
Intake	1.6 mm (0.063 in.)	
Exhaust	1.3 mm(0.0512 in.)	
Valve stem to valve guide clearance		
Intake	0.022-0.049 mm (0.00086-0.00193 in.)	0.1 mm (0.0039 in.)
Exhaust	0.050-0.077 mm (0.0020-0.0030 in.)	0.15 mm (0.0059 in.)
Valve guide		
Length		
Intake	36.5 mm (1.437 in.)	
Exhaust	36.5 mm (1.437 in.)	
Service over size	0.05, 0.25, 0.50 mm (0.002, 0.010, 0.020 in.)	
Valve seat		
Width of seat contact	1.21mm (0.0477 in.)/ 1.61mm(0.0634 in.) (IN/EX)	
Seat angle	44°~44°. 5'	
Service size	0.3 mm (0.012 in.), 0.6 mm (0.024 in.) oversize	
Valve spring		
Free length	39.14 mm (1.541 in.)	38.14 mm (1.502 in.)
Load	21.4 kg/32 mm (47.2 lb/1.26 in.) at installed height	
Cylinder block		
Cylinder bore	83 + 0.03 mm (3.27 + 0.0012 in.)	
Out-of-round and taper of cylinder bore	Less than 0.01 mm (0.0004 in.)	
Flatness of gasket surface	Less than 0.05 mm (0.0020 in.)	0.1 mm (0.0039 in.)

Description	Specification 2.0(D4EA)	Limit
Piston		
O.D.	82.919 - 82.951 mm (3.26 - 3.27 in.)	
Piston - to - cylinder clearance	0.069 - 0.091 mm (0.0027 - 0.0036 in.)	
Ring groove width		
No. 1	1.915 - 1.945 mm (0.075 - 0.076 in.)	
No. 2	2.06 - 2.08 mm (0.08 - 0.082 in.)	
Oil	3.02 - 3.04 mm (0.119 - 0.1196 in.)	
Service size	0.25 mm (0.010 in), 0.5 mm (0.020 in.) 0.75 mm (0.030 in.), 1.00 mm (0.039 in.) oversize	
Piston ring		
Side clearance		
No. 2	0.065 - 0.11 mm (0.00256 - 0.00433 in.)	
Oil ring	0.03 - 0.07 mm (0.00118 - 0.00275 in.)	
End gap		
No. 1	0.2 - 0.3 mm (0.0079 - 0.0118 in.)	
No. 2	0.3 - 0.45 mm (0.0118 - 0.0177 in.)	
Oil ring side rail	0.2 - 0.45 mm (0.0079-0.0177 in.)	
Connecting rod		
Connecting rod pin O.D	28.022 - 28.034 mm (1.103 - 1.104 in.)	
Connecting rod bearing oil clearance	0.024 - 0.042 mm (0.0009 - 0.0016 in.)	0.1 mm (0.0039 in.)
Crankshaft main bearing oil clearance	0.024-0.042 mm (0.0009-0.0016 in.)	0.1 mm (0.0039 in.)
Crankshaft		
Journal O.D.	60.002 - 60.020 mm (2.362 - 2.363 in.)	
Out-of-round of journal and pin	Less than 0.015 mm (0.0006 in.)	
Taper of journal and pin	Less than 0.005 (0.0002 in.)	
End play	0.09 - 0.32 mm (0.0035 - 0.0126 in.)	
Flywheel		
Runout		0.13 mm (0.0051in.)
Oil pressure (1500 rpm) **[Oil temperature is 95-105°C (203-221°F)]**	More than 392.3 kPa (56.88 psi)	

Description	Specification 2.0(D4EA)	Limit
Oil pump		
Tip clearance		
Drive gear	0.12 - 0.2 mm (0.00472-0.0078 in.)	
Driven gear	0.13 -0 .23 mm (0.0051-0.009 in.)	
Side clearance	0.02 - 0.07 mm (0.00078 - 0.0027 in.)	
Relief spring		
Free length	47.5 mm (1.835 in.)	
Opening pressure	686.5±49 kPa (99.54 ± 7.1 psi)	
Silent shaft		
Front journal diameter	27.99 - 28.01 mm (1.102 - 1.1027 in.)	
Rear journal diameter	41.99 - 42.01 mm (1.6531 - 1.6539 in.)	
Oil clearance		
Front	0.050 - 0.09 mm (0.0020 - 0.0036 in.)	
Rear	0.050-0.091 mm (0.0020-0.0036 in.)	
Cooling method	Forced circulation with electric fan	
Cooling system quantity (Radiator)	5 lit (5.3 U.S.qts., 4.4 Imp.qts.)	
Thermostat		
Type	Wax pellet type with jiggle valve	
Normal opening temperature	82°C(180°F)	
Opening temperature range	80°C-84°C (176°F-183°F)	
Wide open temperature	95°C (203°F)	
Radiator cap		
Main valve opening pressure	107.9±14.7 kPa (1.1±0.15 kg/cm², 15.64±2.13 psi)	
Main valve closing pressure	83.4 kPa (0.85 kg/ cm², 12.1 psi)	
Vacuum valve opening pressure	-6.86 kPa (-0.07 kg/ cm², -1.00 psi)	
Air cleaner		
Type	Dry type	
Element	Unwoven cloth type	
Exhaust pipe		
Muffler	Expansion resonance type	
Suspension system	Rubber hangers	
Coolant temperature sensor		
Type	Thermister type	
Resistance		
20°C (68°F)	2.45±0.14 kΩ	
80°C (176°F)	0.3222 kΩ	

SERVICE STANDARDS

Standard value	
Coolant concentration	
Tropical area	40%
Other area	50%

LUBRICANT

Engine coolant	Ethylene glycol base for aluminum radiator

SEALANT

Engine coolant temperature sensor	LOCTITE 262, three bond No. 1324 or equivalent
Oil pressure switch	3M ATD No. 8660 or Three bond No. 1141E

NOTE

O.D.= Outer Diameter

I.D.= Inner Diameter

O.S.= Oversize Diameter

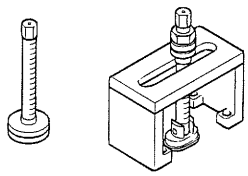
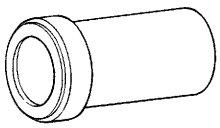
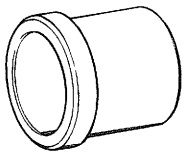
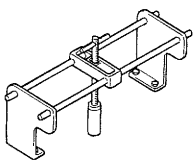
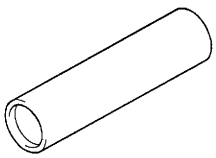
U.S. = Undersize Diameter

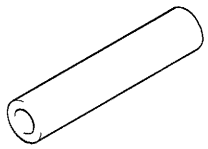
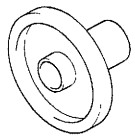
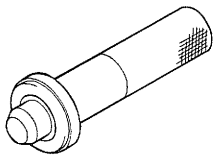
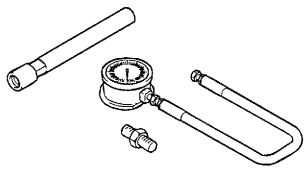
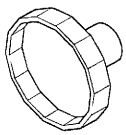
TIGHTENING TORQUE ECHB0300

Item	Nm	kg·cm	Lb·ft
Engine mount insulator bolt	90-110	900-1100	65-80
Engine mounting bracket nuts	60-80	600-800	43-58
Engine mounting bracket bolts	60-80	600-800	43-58
Engine Support bracket bolt and nut	43-55	430-550	32-40
Front roll stopper bracket to cross member bolts	40-55	400-550	29-40
Front roll stopper insulator bolt and nut	50-65	500-650	36-47
Rear roll stopper bracket to cross member bolts	50-65	500-650	36-47
Rear roll stopper insulator bolt and nut	50-65	500-650	36-47
Transaxle mounting bracket bolts	60-80	600-800	43-58
Transaxle mounting insulator bolt	90-110	900-1100	65-80
Front exhaust pipe to exhaust manifold	30-40	300-400	22-29
Rocker cover bolt	10-14	100-140	7-10
Camshaft sprocket bolt	120-150	1200-1500	88-110
Camshaft bearing cap bolt	27-30	270-300	20-22
Crankshaft position sensor	7-11	70-110	5-8
Air cleaner body installation bolt	8-10	80-100	6-7
Crankshaft sprocket bolt	185-195	1850-1950	136-144
Damper pulley to crankshaft sprocket	30-34	300-340	22-25
Cylinder head bolt (cold engine)	50+120°+90°	500+120°+90°	36+120°+90°
Timing belt auto tensioner bolt	50-55	500-550	36-40
Drive blet Auto tensioner bolt	26-31	260-310	19-23
Timing belt auto tensioner adjustable bolt	10-12	100-120	7-9
Drive belt idler bolt	46-51	460-510	34-38
Front exhaust pipe clamp bolt	20-30	200-300	14-22
Oil pan	10-12	100-120	7-9
Oil pan drain plug	35-45	350-450	25-33
Oil screen	10-12	100-120	7-9
Oil pressure switch	15-22	150-220	11-16
Oil screen bracket bolt	34-38	340-380	25-28
Oil pump cover bolt	20-27	200-270	15-20
Oil seal case bolt	10-12	100-120	7-9
Plug cap	20-27	200-270	14-20
Oil jet bolt	9-13	90-130	7-10
Oil pump rotor bolt	8-10	80-100	6-97
Timing belt upper cover	8-12	80-120	6-9
Timing belt lower cover	8-12	80-120	6-9
Relief plug	42-52	420-520	31-38

Item	Nm	kg·cm	Lb·ft
Flywheel	70-80	700-800	52-59
Drive plate	70-80	700-800	52-59
Connecting rod cap bolt	25+90°	250+90°	18+90°
Engine coolant pump to cylinder block bolt			
14 mm	48-52	480-520	35-38
10 mm	10-12	100-120	7-9
Engine coolant temperature sensor	40-55	400-550	30-41
Engine coolant inlet fiting attaching bolt	20-25	200-250	15-18
Air cleaner mounting bolts	8-10	80-100	6-7
Resonator mounting bolt (Nut)	8-10	80-100	6-7
Intake manifold mounting bolt (M8)	15-20	150-200	11-14
Front exhaust manifold bolt to cylinder block	25-38	250-380	18-28
Center exhaust pipe nuts to catalytic converter	30-40	300-400	22-29
Center exhaust pipe bolts to main muffler	30-40	300-400	22-29
Center exhaust pipe bolt to bracket	10-15	100-150	7-11
Hanger bolt to body	10-15	100-150	7-11
Hanger bolt to main muffler	10-15	100-150	7-11
Exhaust manifold nuts	25-38	250-380	18-28
Oxygen sensor	40-50	400-500	29-36
Heat protector bolt to exhaust manifold	12-15	120-150	9-11
Air cleaner bracket bolt	10-13	100-130	7-9
Exhaust manifold cover to exhaust manifold bolt	12-15	120-150	9-11
Oxygen sensor to exhaust manifold	40-50	400-500	29-36
Front exhaust pipe bracket bolt	20-30	200-300	14-22
Main muffler hanger support bracket bolt	10-20	100-200	7-14
Oil level gauge	10-12	100-120	7-9
Balance shaft bolt	53-57	530-570	39-42
Starter bolt to cylinder block	48-52	480-520	35-38
Turbocharger support bolt	35-45	350-450	26-33
Crankshaft bedplate bolt			
15 mm	25+45°+90°	250+45°+90°	18+45°+90°
12 mm	33-37	330-370	24-27

SPECIAL TOOLS ECHB0400

Tool (Number and name)	Illustration	Use
Balance shaft bearing remover&installer (09212-27000)	 KCHB600B	Removal and installation of balance shaft rear bearing (use with 09212-32300)
Ballanceshaft drive gear and comshaft oil seal installer (09214-32000)	 ECA9930A	Installation of the ballance shaft drive gear on crankshaft and camshaft oil seal
Front case oil seal installer (09231-27100)	 ECA9930C	Installation of the front case oil seal
Valve guide remover (09222-27100)	 ECHB600I	Removal of valve guides
Valve spring compressor (09222-27300)	 KCHB600C	Removal and installation of inlet and exhaust valves
Valve stem oil seal installer (09222-27200)	 KCHB600E	Installation of valve stem oil seals

Tool (Number and name)	Illustration	Use
Valve guide installer (09222-27000)	 KCHB600F	Installation of valve guides
Crankshaft rear oil seal installer (09231-27000)	 KCHB600G	Installation of the crankshaft real oil seal
Injector oil seal installer (09351-27400)	 KCHB600A	Installation of the injector oil seal
Compression gauge&adapter (09351-27000) (09351-27100)	 KCHB600D	Checking engine compression pressure
Oil filter wrentch (09263-27100)	 KCHB600H	Removal and installation of oil filter

TROUBLESHOOTING ECHA0400

Symptom	Probable cause	Remedy
Low compression	Damaged cylinder head gasket Worn or damaged piston rings Worn piston or cylinder Worn or damaged valve seat	Replace gasket Replace rings Repair or replace piston and/or cylinder block Repair or replace valve and/or seat ring
Oil pressure drop	Low engine oil level Faulty oil pressure switch Clogged oil filter Worn oil pump gears or cover Thin or diluted engine oil Oil relief valve stuck (open) Excessive bearing clearance	Check engine oil level Replace Replace Replace Change and find out cause Repair Replace
High oil pressure	Oil relief valve stuck (closed)	Repair
Excessive engine vibration	Loose engine roll stopper (front, rear) Loose transaxle mount bracket Loose engine mount bracket Loose center member Broken transaxle mount insulator Broken engine mount insulator Broken engine roll stopper insulator	Re-tighten Re-tighten Re-tighten Re-tighten Replace Replace Replace
Noisy valves	Thin or diluted engine oil (low oil pressure) Worn or damaged valve stem or valve guide	Change Replace
Connecting rod and/main beaing noise	Insufficient oil supply Thin or diluted engine oil Excessive bearing clearance	Check engine oil level Change and find out cause Replace
Timing belt noise	Incorrect belt tension (alternator tensioner, timing belt)	Adjust belt tension
Low coolant level	Leakage of coolant Damaged radiator core joint Corroded or cracked hoses (radiator hose, heater hose, etc) Faulty radiator cap valve or setting of spring Faulty thermostat Faulty engine coolant pump	 Replace Replace Replace Replace Replace
Clogged radiator	Foreign material in coolant	Replace
Abnormally high coolant temperature	Faulty thermostat Faulty radiator cap Restricted of flow in cooling system Loose or missing drive belt Faulty engine coolant pump Faulty temperature sensor wiring Faulty electric fan Faulty thermo-sensor on radiator Insufficient coolant	Replace Replace Replace Adjust or replace Replace Repair or replace Repair or replace Replace Refill coolant
Abnormally low coolant temperature	Faulty thermostat Faulty temperature sensor wiring	Replace Repair or replace

Symptom	Probable cause	Remedy
Leakage from oil cooling system	Loose hose and pipe connection Blocked or collapsed hose and pipe	Retighten Replace
Inoperative electrical cooling fan	Damaged, fuse	Replace or repair
Exhaust gas leakage	Loose connections Broken pipe or muffler	Retighten Repair or replace
Abnormal noise	Detached baffle plate in muffler Broken rubber hanger Pipe or muffler contacting vehicle body Broken pipe or muffler	Replace Replace Correct Repair or replace

CHECKING ENGINE OIL ECJA0500

1. Position a vehicle on a level surface.
2. Turn off the engine.

   NOTE

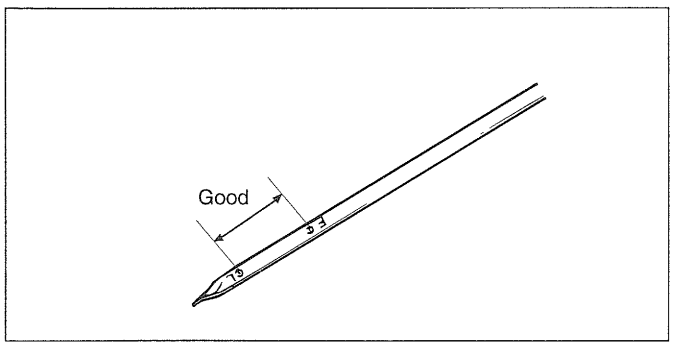
   If a vehicle that has not been used for a prolonged period, run the engine for several minutes.
   Turn off the engine and wait for 5 minutes at least, and then check the oil level.

3. Check that the engine oil level is within the level range indicated on the oil dipstick. If the oil level is found to have fallen to the lower limit (the "L" mark), refill to the "F" mark.

   NOTE

   When refilling, use the proper grade of engine oil.

4. Check that the oil is not dirty or mixed with coolant or gasoline and it has the proper viscosity.

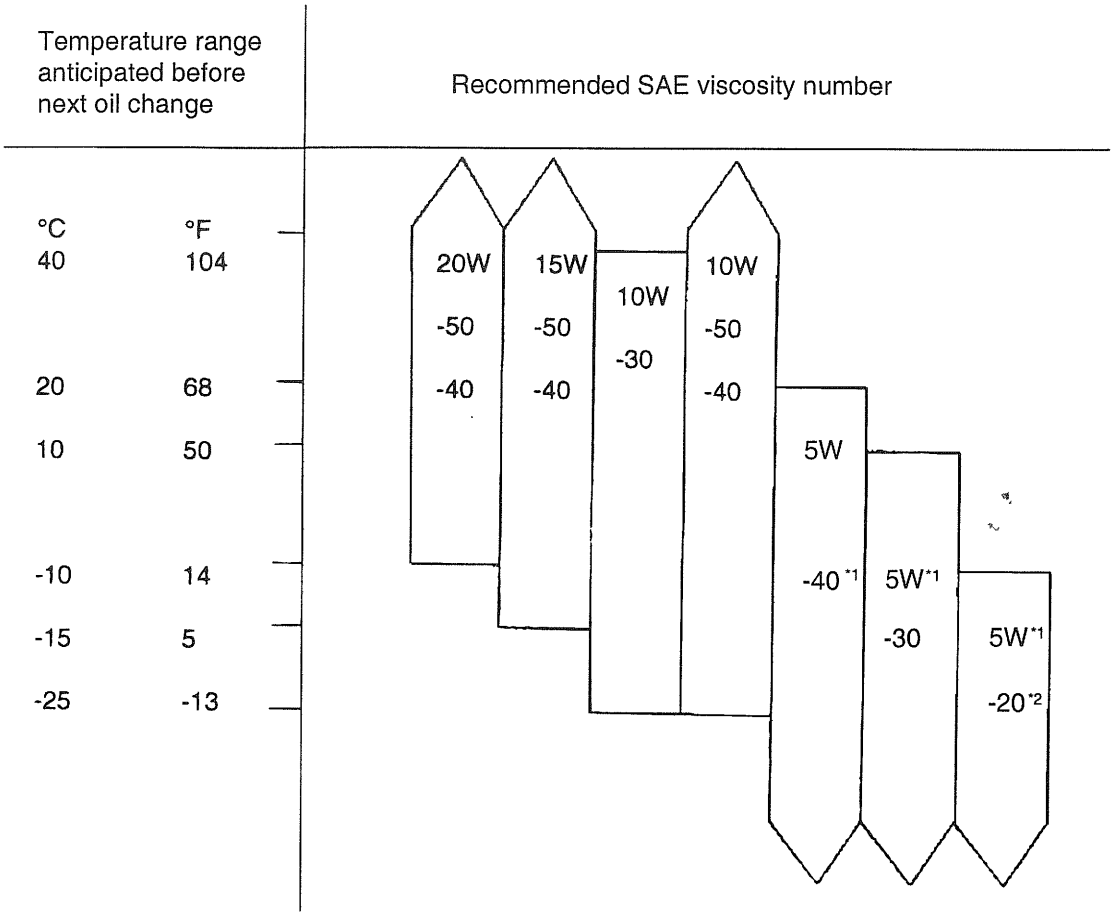


EDA9000A

SELECTION OF ENGINE OIL ECHB0700

Recommended API classification: CE OR ABOVE SE OR ABOVE [For EC.]

Recommended SAE viscosity grades:



***1 Restricted by driving condition and environment.**
***2 Not recommended for sustained high speed vehicle operation**

EDA9990B

NOTE

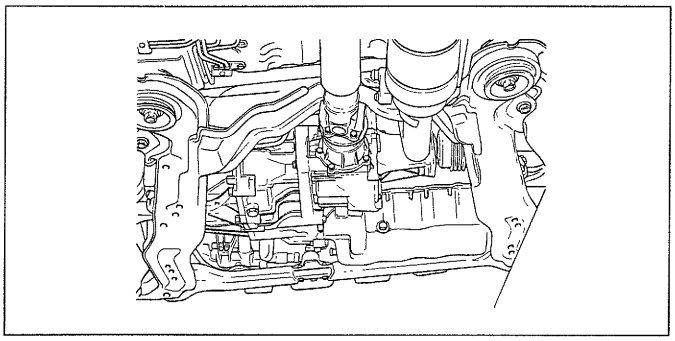
For best performance and maximum protection of all types of operation, select only those lubricants which:

1. *Satisfy the requirements of the API classification.*
2. *Have the proper SAE grade number for expected ambient temperature range.*

Lubricants which do not have both SAE grade number and an API service classification on the container should not be used.

CHANGING ENGINE OIL ECHB0800

1. Run the engine until it reaches normal operating temperature.
2. Turn off the engine.
3. Remove the oil filler cap and the drain plug. Drain the engine oil.



KCHB002D

4. Tighten the drain plug to the specified torque.

Tightening torque

Oil pan drain plug :

35-45 Nm (350-450 kg.cm, 25-33 lb.ft)

NOTE

Whenever tightening the oil drain plug, use a new drain plug gasket.

5. Fill new engine oil through the oil filler cap opening.

Capacity :

Drain and refill : 5.4 lit (5.7 U.S.qts., 4.75 Imp.qts.)

Oil filter : 0.5 lit (0.53 U.S.qts., 0.44 Imp.qus.)

Total : 5.9 lit (6.23 U.S.qts., 5.19 Imp.qts)

NOTE

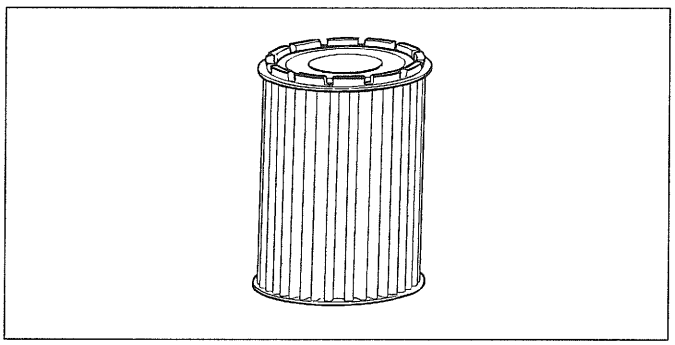
Do not overfill. This will cause oil aeration and loss of oil pressure.

6. Install the oil filler cap.
7. Start and run the engine.
8. Turn off the engine and then check the oil level. Add oil if necessary.

REPLACING THE OIL FILTER ECHB0900

All Hyundai Motor Company engines are equipped with a high quality, disposable oil filter. The quality of aftermarket replacement filters is considerably diverse.

High quality replacement filters should be used to assure the most efficient service.



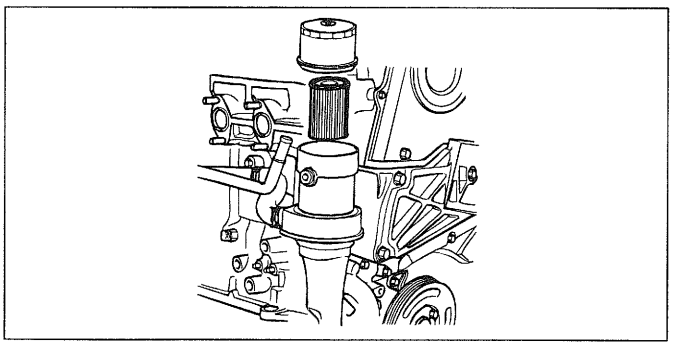
ECHB001A

PROCEDURE FOR REPLACING THE OIL FILTER

1. Use a filter wrench (09263 - 27100) to remove the oil filter upper cap.
2. Installing a new oil filter on the lower case.
3. Tighten the oil filter upper cap to the specified torque.

Oil filter : 22-25 Nm (220-250 kg.cm, 16-18 lb.ft)

4. Start and run the engine and check for engine oil leak.
5. After turning off the engine, check the oil level and add oil as necessary.



ECHB001B

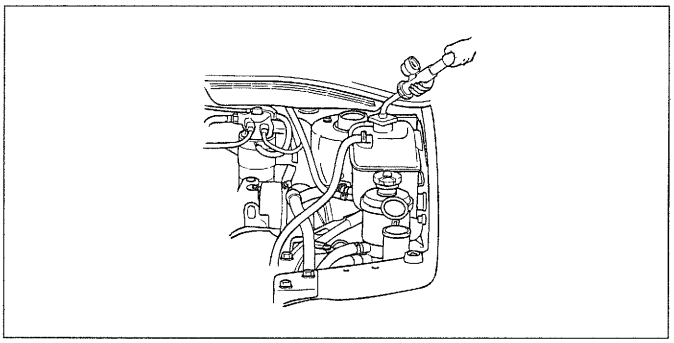
CHECKING COOLANT LEAK ECHB1000

1. Loosen the radiator cap.
2. Confirm that the coolant level is up to the filler neck.
3. Install a radiator cap tester to the radiator filler neck and apply 150 KPa (21psi, 1.53 kg/cm²) pressure. Hold it for two minutes in that condition while checking for leakage from the radiator, hoses or connections.

NOTE

1. *Radiator coolant may be extremely hot. Do not open the system because hot, or scalding water could gush out causing personal injury. Allow the vehicle to cool before servicing this system.*
2. *When the tester is removed, be careful not to spill any coolant from it.*
3. *Be sure to clean away completely any from the area.*
4. *Be careful when installing and removing the tester and when testing, not to deform the filler neck of the radiator.*

4. If there is leakage, repair or replace with the appropriate part.



KCHB002A

RADIATOR CAP PRESSURE TEST

1. Use an adapter to attach the cap to the tester.
2. Increase the pressure until the gauge stops moving.

Main valve opening pressure :

107.9kPa±14.7kPa (1.1±0.15 kg/cm², 15.64±2.13)

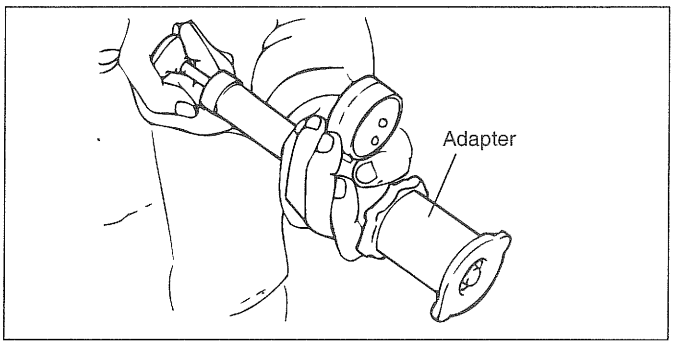
Main valve closing pressure :

83.4 kPa (0.85 kg/cm², 12.1 psi)

3. Check that the pressure level is maintained at or above the limit.
4. Replace the radiator cap if the reading does not remain at or above the limit.

NOTE

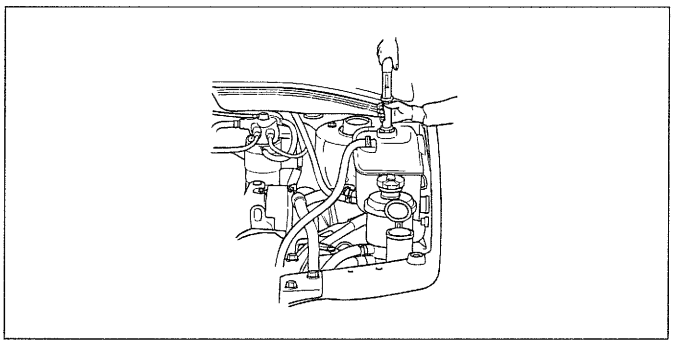
Be sure that the cap is clean before testing, since rust or other foreign material on the cap seal will cause an incorrect reading.



ECA9090A

SPECIFIC GRAVITY TEST ECHB1100

1. Measure the specific gravity of the coolant with a hydrometer.
2. Measure the coolant temperature and calculate the concentration from the relation between the specific gravity and temperature, using the following table for reference.



KCHB002B

RELATION BETWEEN COOLANT CONCENTRATION AND SPECIFIC GRAVITY

Coolant temperature °C (°F) and specific gravity					Freezing temperature °C (°F)	Safe operating temperature °C (°F)	Coolant concentration (Specific volume)
10 (50)	20 (68)	30 (86)	40 (104)	50 (122)			
1.054	1.050	1.046	1.042	1.036	-16 (3.2)	-11 (12.2)	30%
1.063	1.058	1.054	1.049	1.044	-20 (-4)	-15 (5)	35%
1.071	1.067	1.062	1.057	1.052	-25 (-13)	-20 (-4)	40%
1.079	1.074	1.069	1.064	1.058	-30 (-22)	-25 (-13)	45%
1.087	1.082	1.076	1.070	1.064	-36 (-32.8)	-31 (-23.8)	50%
1.095	1.090	1.084	1.077	1.070	-42 (-44)	-37 (-35)	55%
1.103	1.098	1.092	1.084	1.076	-50 (-58)	-45 (-49)	60%

Example

The safe operating temperature is -15°C (5°F) when the measured specific gravity is 1.058 at coolant temperature of 20°C (68°F)

⚠ *CAUTION*

- ***If the concentration of the coolant is below 30%, its anti-corrosion properties will be adversely affected.***
- ***if the concentration is above 60%, both the anti-freeze and engine cooling property will decrease, affecting the engine adversely. For these reasons, be sure to maintain the concentration level within the specified range.***
- ***Do not mix types of anti-freeze.***

RECOMMENDED COOLANT

Antifreeze	Mixture ratio of anti freeze in coolant
ETHYLENE GLYCOL BASE FOR ALUMINUM	50% [Except tropical areas] 40% [Tropical areas]

CHECKING COMPRESSION PRESSURE ECHB1200

1. Before checking engine compression, check the engine oil level. Also check that the starter motor and battery are all in normal operating condition.
2. Start the engine and wait until the engine coolant temperature reaches 80-95°C (176-205°F).
3. Turn off the engine and remove the aircleaner element.
4. Remove the injectors.
5. Crank the engine to remove any foreign material in the cylinders.
6. Insert the compression gauge (09351 - 27000) into the injector hole.
7. Crank the engine and read the gauge.

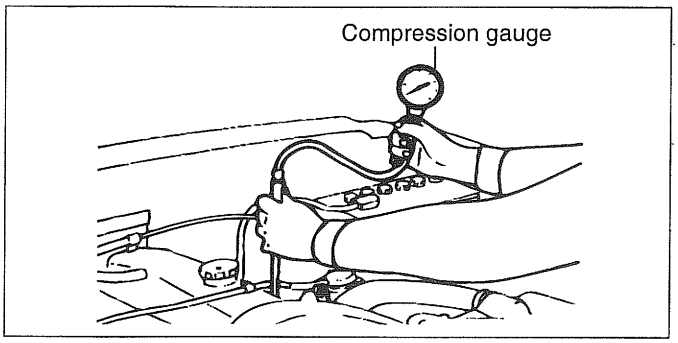
Standard value : 2942 kpa (30 Kg/cm², 426 psi)

8. Repeat steps 6 to 7 for all cylinders, ensuring that the pressure difference for each of the cylinders is within the specified limit.

Limit : Max. 100 kpa (1.0 kg/cm² ,14 psi) between cylinders

9. If a cylinder's compression or pressure differential is outside the specification, add a small amount of oil through the injector hole, and repeat steps 6 to 8.
   1) If the addition of oil causes the compression to rise, it is likely that there may be wear between the piston ring and cylinder wall.

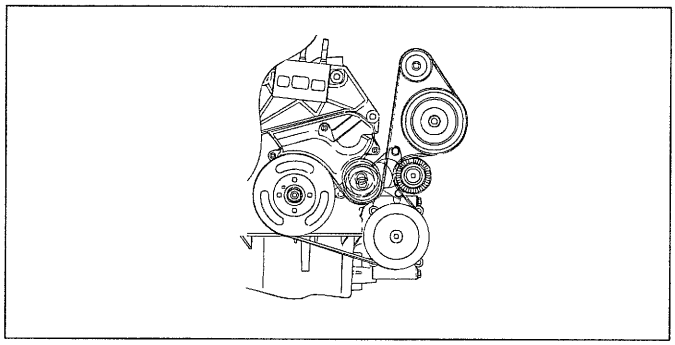
2) If compression remains the same, valve seizure, poor valve seating or a compression leak from the cylinder head gasket are all possible causes.



ECLA005A

ADJUSTING DRIVE BELT AND TENSIONER ECHB1300

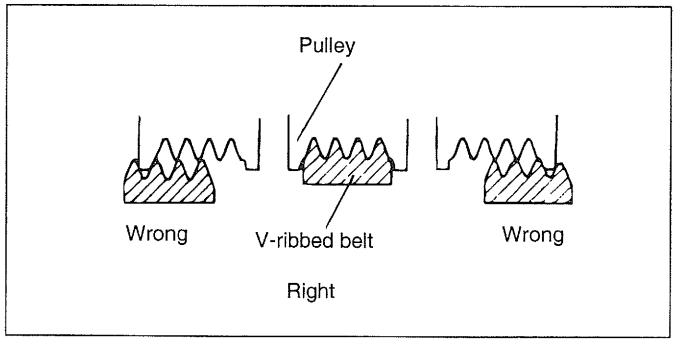
1. Check that the belts are not damaged and are properly placed for the pulley grooves.



KCHB002E

2. Install the belt in the following order.
[Alternator ⇒ Power steering ⇒ Idler ⇒ Air conditioner pulley ⇒ Crankshaft pully]

3. When installing the belt on the pulley, make sure it is centered on the pulley

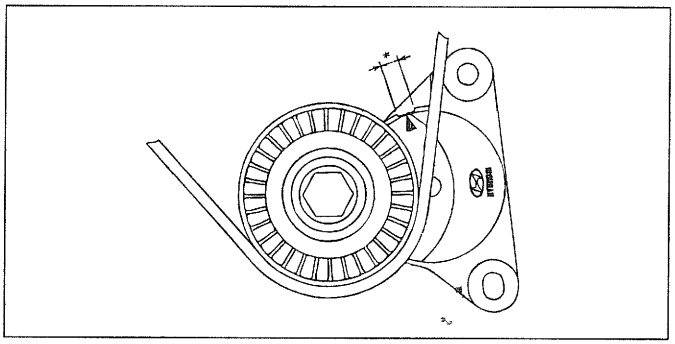


ECA9980A

⚠ *CAUTION*

1. ***When installing the V-ribbed belt, check that the V-ribs are properly aligned.***
2. ***If noise or slippage is detected, check the belt for wear, damage, or breakage on the pulley contact surface, and check the pulley for scoring. Also check the amount that the belt is deflected.***

4. The tensioner mark should be between the "*" position.
If not, replace the belt.

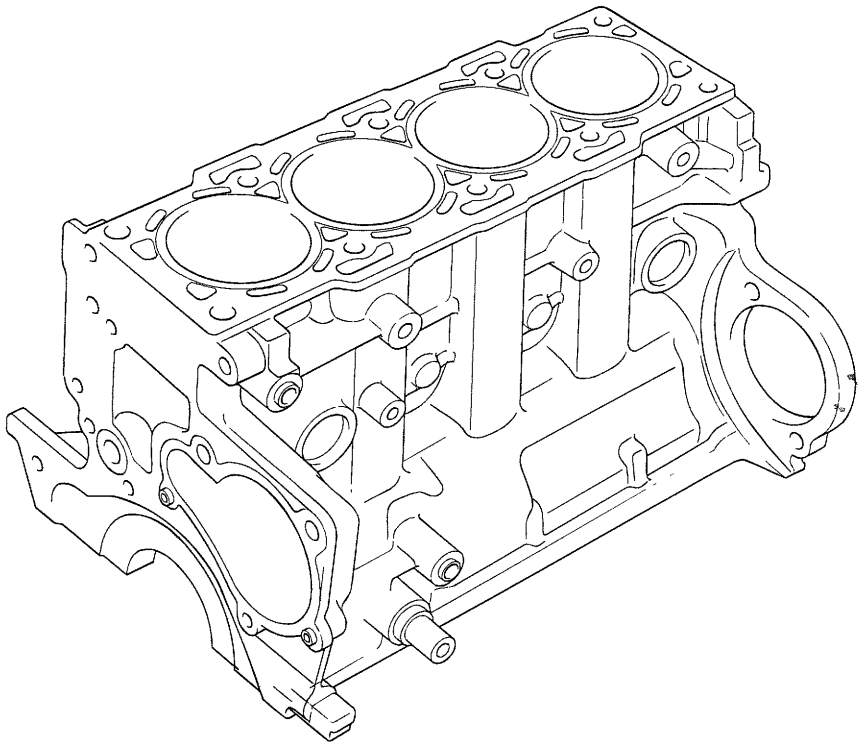


KCHB002F

ENGINE BLOCK

ENGINE BLOCK

COMPONENTS ECHB1500



TORQUE : Nm (kg·cm, lb· ft)

KCHB003A

DISASSEMBLY ECHA1600

Remove the cylinder head, timing belt, front case, flywheel, pistons and crankshaft.

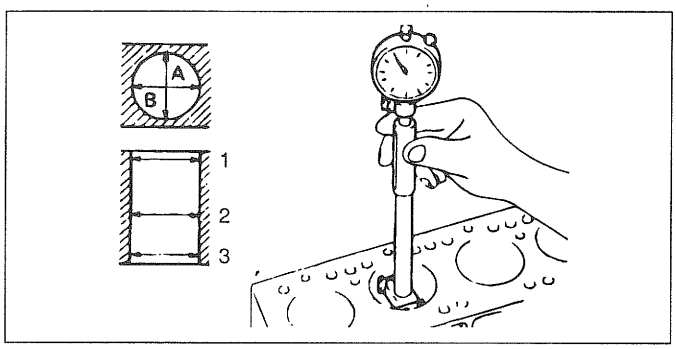
For further details, refer to the appropriate section.

INSPECTION ECHB1700

CYLINDER BLOCK

1. Check the cylinder block for scores, rust and corrosion. Also check for cracks or any other defects. Replace the block if defective.

2. Measure the cylinder bore with a cylinder gauge at the three levels indicated and in the directions of A and B.
   Level 1: No. 1 piston ring position at TDC
   Level 2 : Center of cylinder
   Level 3 : Bottom of cylinder



ECA9450A

3. If the cylinder bores show more than specified out-of-round or taper, or if the cylinder walls are badly scuffed or scored, the cylinder block should be rebored and honed. New oversize piston and rings should be installed.

Standard value

Cylinder bore : 83+0.03 mm (3.27+0.0012 in.)

Out-of -round and taper of cylinder bore :

Max. 0.01mm(0.0004 in.)

4. If a ridge exists at the top of the cylinder, cut it away with a ridge reamer.

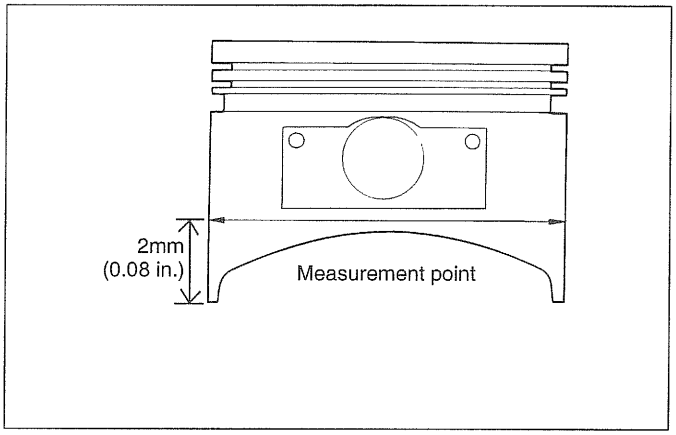
PISTON SERVICE SIZE AND MARK MM (IN.)

Identification Mark	Size
0.25	0.25 (0.010) O.S.
0.50	0.50 (0.020) O.S.
0.75	0.75 (0.030) O.S.
1.00	1.00 (0.039) O.S.

5. To rebore the cylinder bore to oversize, maintain the specified clearance between the oversize piston and the bore, and make sure that all pistons used are of the same oversize. The standard measurement of the piston outside diameter is taken at a level 2 mm (0.08 in.) above the bottom of the piston skirt and across the thrust faces.

Piston-to-cylinder clearance :

0.069 - 0.091 mm



ECA9451A

6. Check for damage and cracks.

7. Check the top surface of the cylinder block for flatness. If the top surface exceeds limits, surface to minimum limit or replace.

Standard value

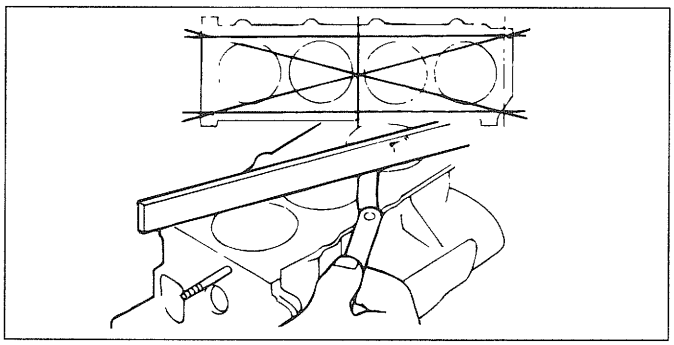
Flatness of cylinder block : Max. 0.05mm(0.0020 in.)

Service limit

Flatness of cylinder block : 0.1mm(0.0039 in.)

NOTE

When the cylinder head is assembled, grinding less than 0.2 mm (0.008 in.) is permissible.



ECA9450B

BORING CYLINDER

1. Oversize pistons should be selected on the basis of the largest cylinder bore.

Identification Mark	Size
0.25	0.25 mm (0.010 in.) O.S.
0.50	0.50 mm (0.020 in.) O.S.
0.75	0.75 mm (0.030 in.) O.S.
1.00	1.00 mm (0.039 in.) O.S.

NOTE

The size of a piston is stamped on top of the piston.

2. Measure the outside diameter of the piston to be used.
3. On the basis of the measured O.D., calculate the new bore size.
   New bore size = Piston O.D + clearance between piston and cylinder - 0.02 mm (0.0008 in.) (honing margin.)
4. Bore each of cylinders to the calculated size.

NOTE

To prevent distortion that may result from temperature rise during honing, bore the cylinders, holes in the firing order sequence.

5. Hone the cylinders, finishing them to the proper dimension (piston outside diameter + gap with cylinder).
6. Verify the clearance between the piston and cylinder.

NOTE

When boring cylinders, finish all four cylinders to the same oversize. Do not bore only one cylinder to the oversize.

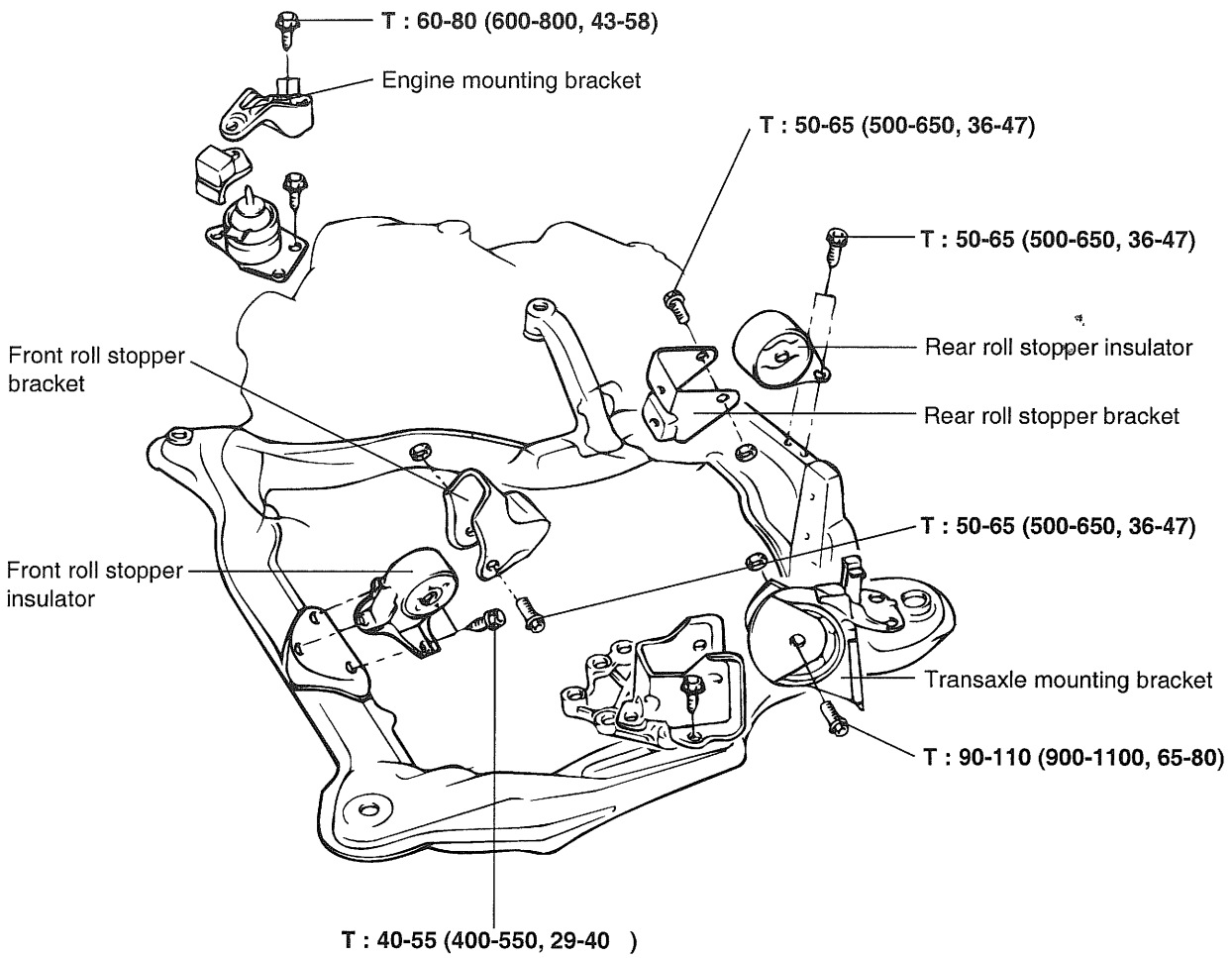
REASSEMBLY ECHA1800

Install the following parts by referring to their respective paragraphs.

1. Crankshaft
2. Flywheel
3. Piston
4. Cylinder head
5. Timing belt train
6. Front case

ENGINE MOUNTS

COMPONENTS ECHB2000

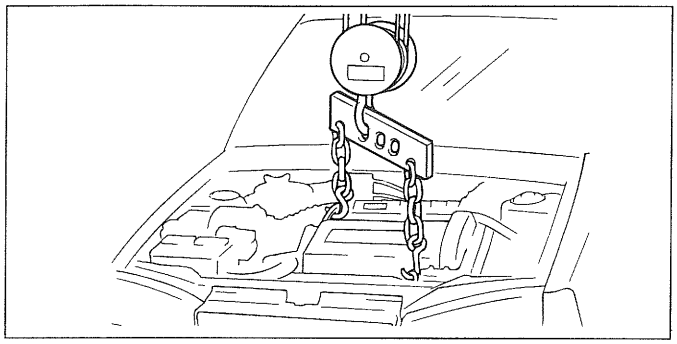


TORQUE : Nm (kg.cm, lb·ft)

EDJA300A

REMOVAL ECJA2100

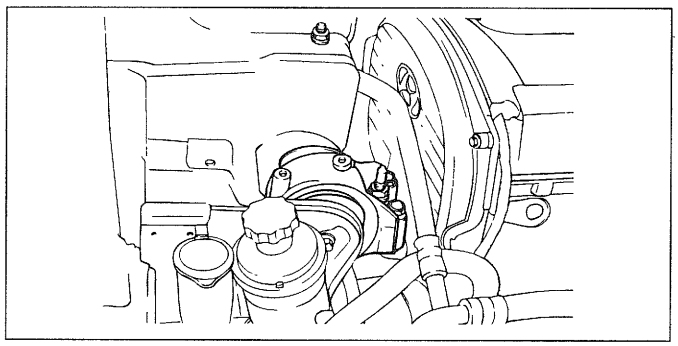
Attach a chain or cable to the engine hooks and lift enough so that there is no pressure on the motor mounts.



ECA9120A

ENGINE MOUNTING

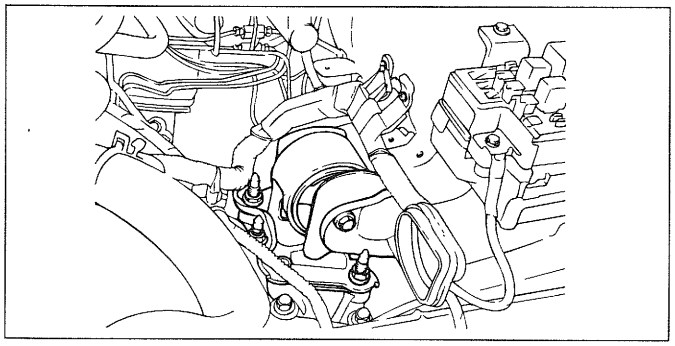
1. Remove the engine mounting insulator bolts.
2. Remove the engine mounting bracket from the engine.



ECA9006A

TRANSAXLE MOUNTING

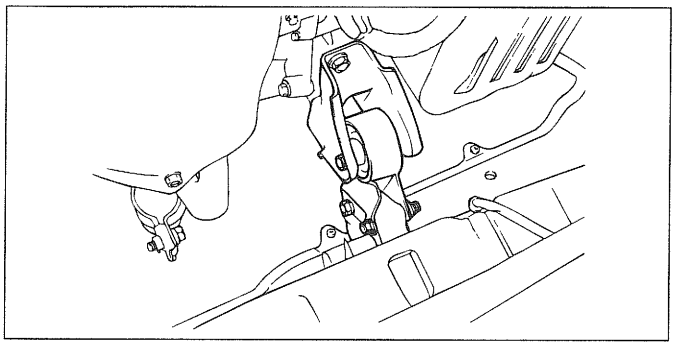
1. Remove the transaxle mounting insulator bolts.
2. Remove the tranaxle mounting bracket from the transaxle.



ECA9007A

FRONT ROLL STOPPER

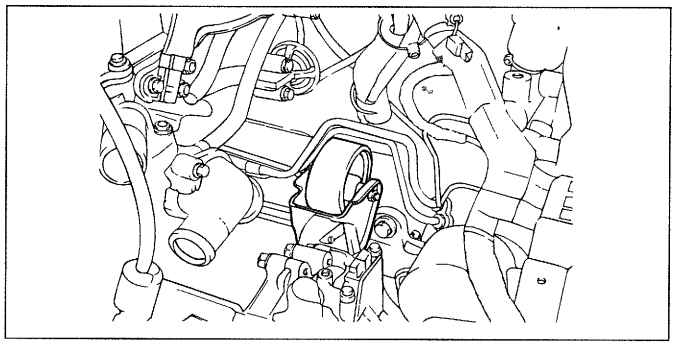
Remove the front roll stopper bracket from the sub-frame.



ECA9008A

REAR ROLL STOPPER

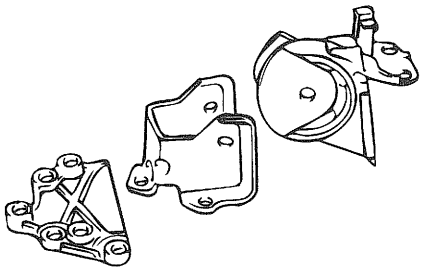
1. Remove the bolt from the rear roll stopper.
2. Remove the rear roll stopper from the subframe.



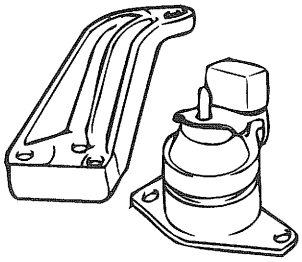
ECA9009A

INSPECTION ITEMS ECHB2200

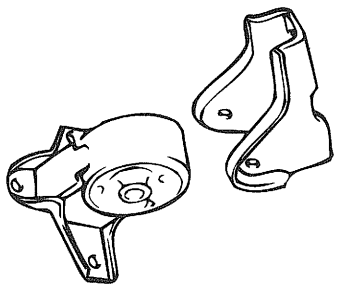
Transaxle mounting



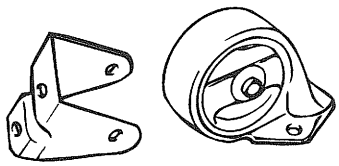
Engine mounting



Front roll stopper assembly



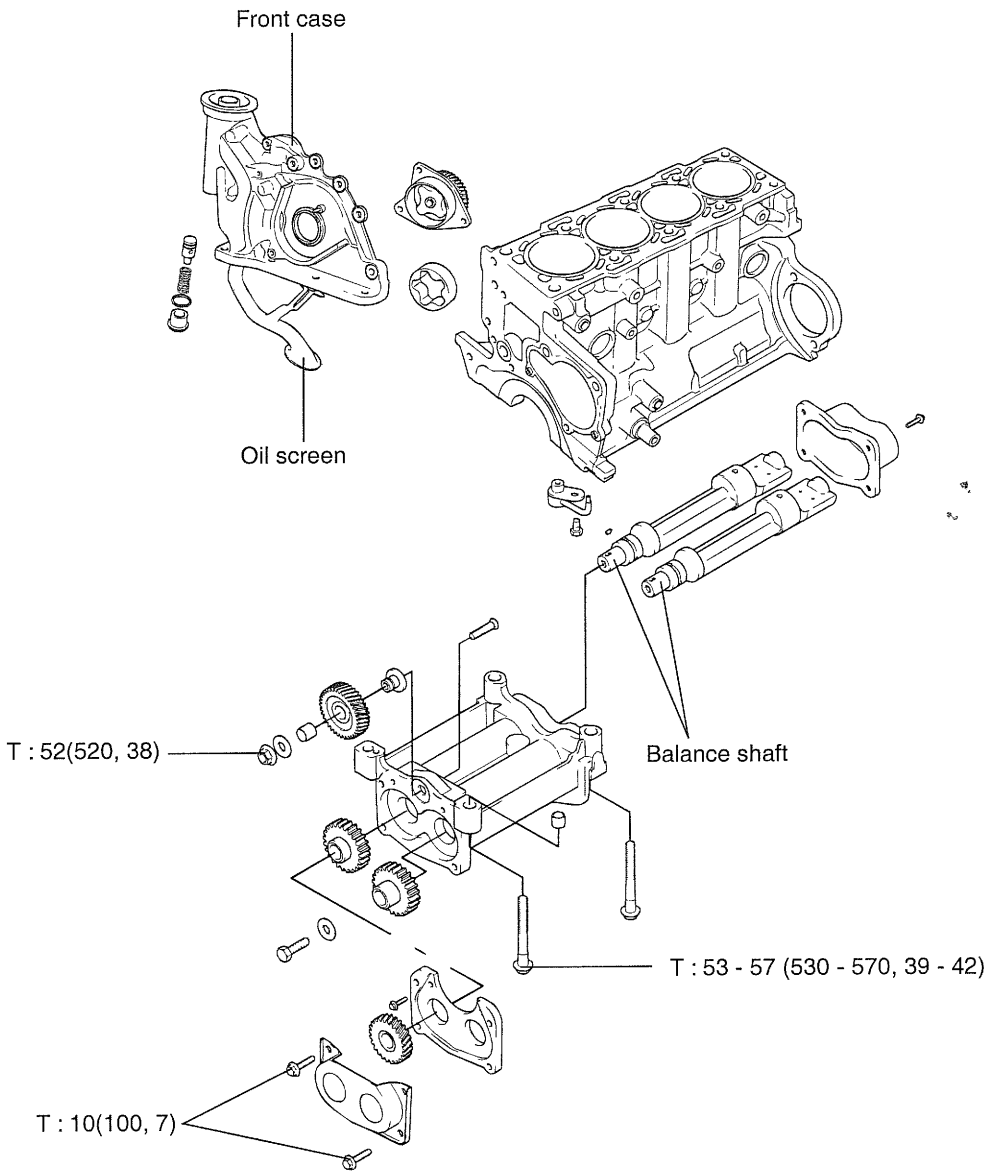
Rear roll stopper assembly



EDHA005Z

FRONT CASE

COMPONENTS ECHB2500

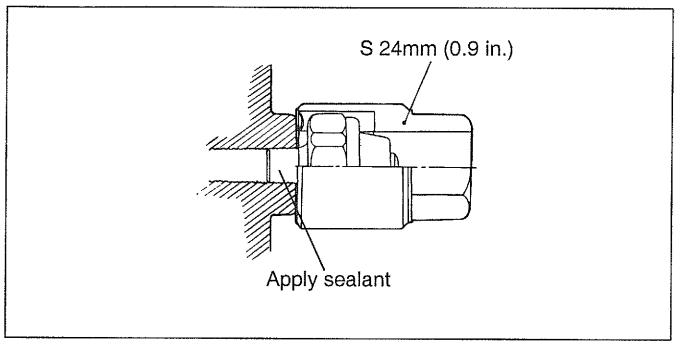


TORQUE : Nm (kg.cm, lb·ft)

KCHB004A

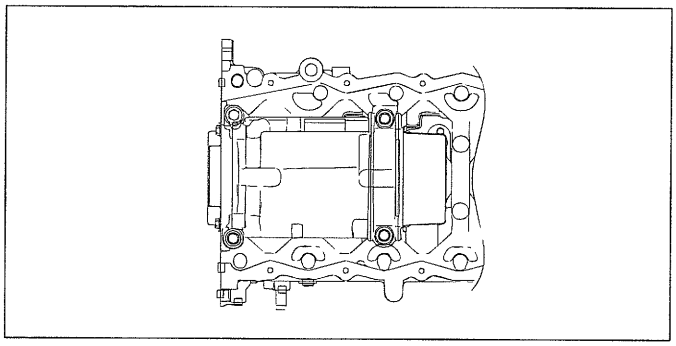
DISASSEMBLY ECHB2600

1. Remove the timing belt. Refer to "Timing Belt."
2. Remove all the oil pan bolts.
3. Tap the oil pan with a rubber hammer and remove the pan.
4. Remove the oil screen and gasket.
5. Remove the front case assembly.
6. Remove the oil pressure switch.



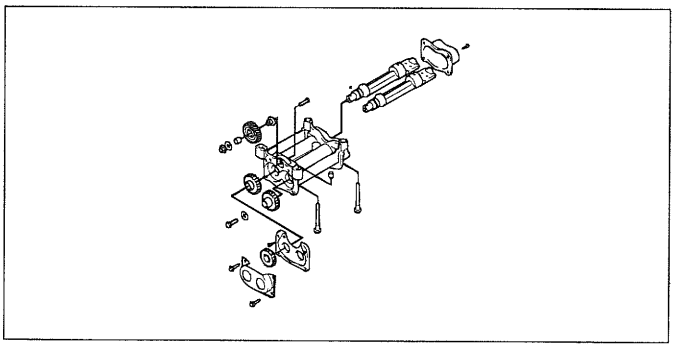
ECHA260A

7. Remove all the balance shaft bolt.



KCHB004C

8. Disassembly the balance shaft assembly.



KCHB004D

9. Remove the front case mounting bolts and remove the front case assembly and gasket from the cylinder block.
10. Remove the oil pump gears from the front case.

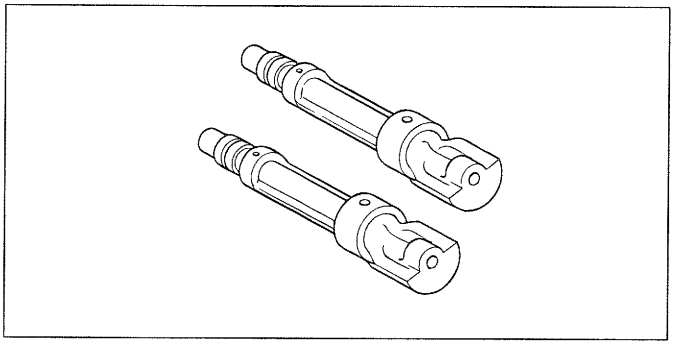
INSPECTION ECHB2700

FRONT CASE

1. Check all oil holes for clogging. Clean the holes if necessary.
2. Check the balance shaft bearing for wear, damage and seizure. If there is anything wrong with the bearing, replace the bearing.
3. Check the front case for cracks and other damage.
4. Replace a cracked or damaged front case.

BALANCE SHAFT

1. Check the journals for wear or seizure.
2. If excessive wear or seizure is evident, check the bearing carefully.
3. If necessary, replace the balance shaft bearing or the shaft itself.



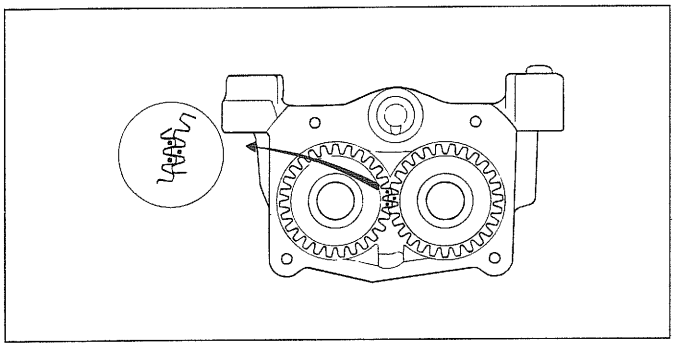
KCHB004E

OIL SEAL

1. Check the oil seal lip for wear and damage. Replace the oil seal if necessary.
2. Check the oil seal lip for deterioration. Replace the oil seal if necessary.

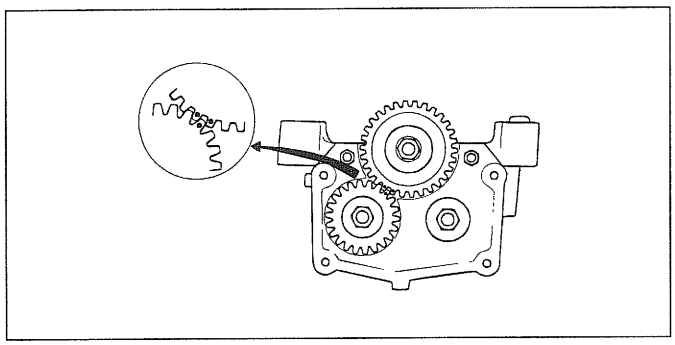
REASSEMBLY ECHB2800

1. Apply engine oil to the gear and align the two timing marks.



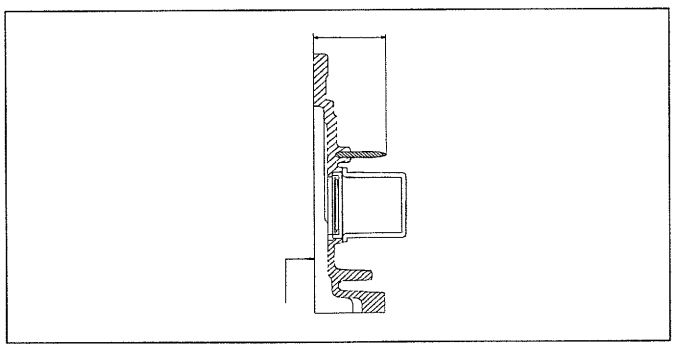
KCHB004F

2. Apply Locitite272 to the drive gear and intermediate gear bolt.



KCHB004G

3. Using the special tool, the crankshaft front oil seal installer (09231-27100), install the crankshaft front oil seal into the front case.



KCHB004I

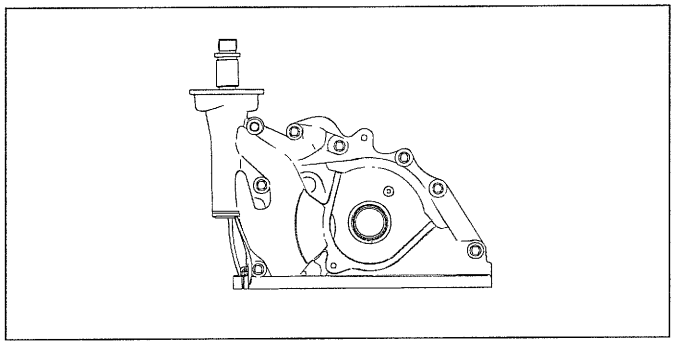
4. Install a new front case gasket to the front case assembly and tighten the flange bolts temporarily.

5. Install the front case assembly with a new gasket. Tighten bolts to the specified torque.

Tightening torque

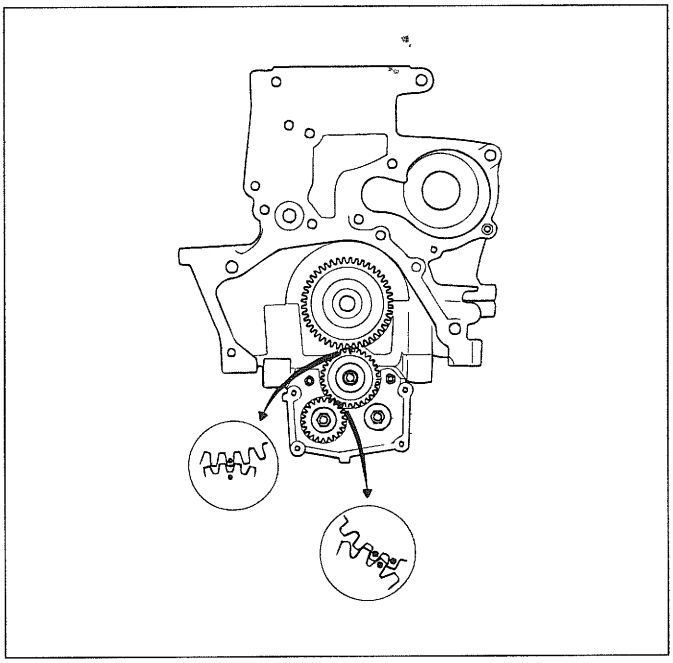
Front case assembly :

20-27Nm(200-270kg.cm, 14-20 lb.ft)



KCHB004H

6. Install a balance shaft assembly to the cylinder block.



KCHB004J

7. Apply sealant to the groove of the pan flange as shown.

NOTE

1. *Apply sealant approximately 4 mm (0.16 in.) in thickness.*
2. *After the application of the sealant, install the oil pan within 15 minutes.*

8. Install the oil pan and tighten the bolts to the specified torque.

Tightening torque

Oil pan bolt : 10-12Nm(100-120kg.cm, 7-9 lb.ft)

9. Using a 24 mm deep socket, install the oil pressure switch after applying sealant to the threaded area.

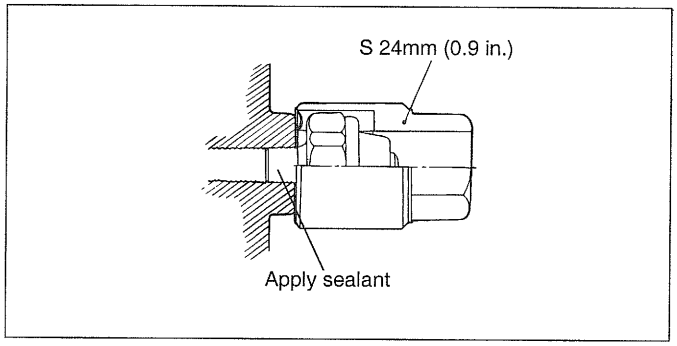
Sealant : Threebond 1104 or equivalent

NOTE

Do not torque the oil pressure switch excessively.

Tightening torque

Oil pressure switch : 15-22Nm(150-220kg.cm, 11-16 lb.ft)



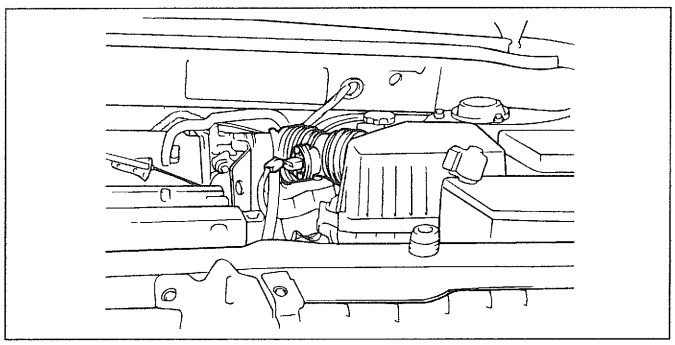
ECHA260A

ENGINE AND TRANSAXLE ASSEMBLY

ENGINE AND TRANSAXLE ASSEMBLY ECHB2300

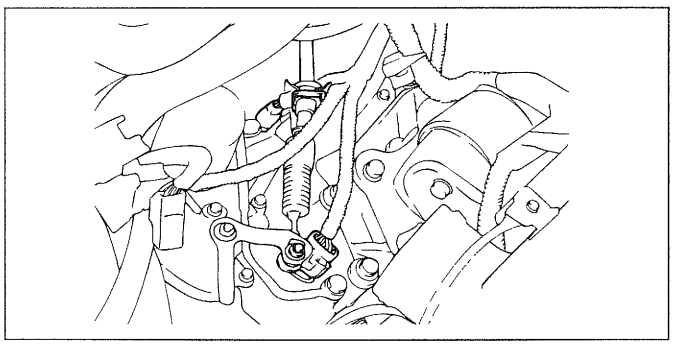
REMOVAL

1. Remove the battery.
2. Detach the air cleaner.



ECJA870B

3. Disconnect the engine harness connectors.
   1. Engine wiring connectors (alternator, starter, etc.)
   2. Power steering switch connector, oil pressure gauge connector.
   3. Back up lamp switch connector.
   4. A/T solenoid, inhibitor switch connector.
   5. Coolant temperature sensor.
   6. Oxygen sensor connector.



ECA9014A

4. Drain the engine coolant.
5. For a vehicle with automatic transaxles, disconnect the transaxle oil cooler hoses.

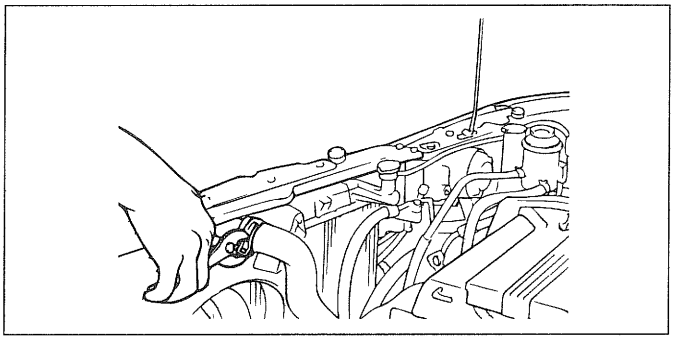
NOTE

- *When disconnecting hoses, make identification marks to avoid making any mistake when installing them again.*

CAUTION

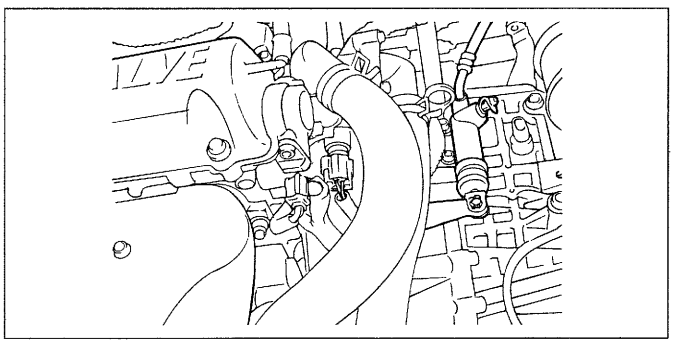
- ***Be careful not to spill any of oil or fluid out of the hoses. Plug the openings to prevent the entry of foreign material.***

6. Disconnect the radiator upper and lower hoses on the engine side then remove the radiator assembly.



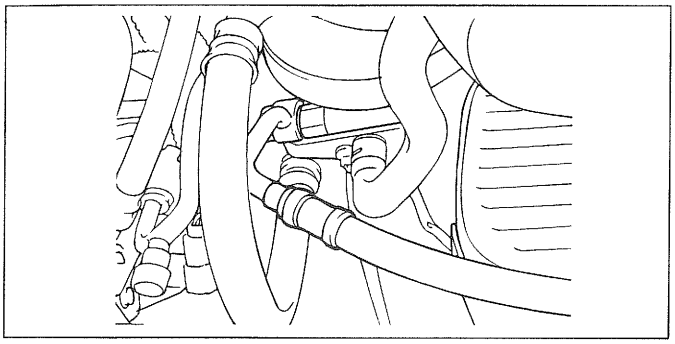
EDJA330A

7. Disconnect the engine ground.
8. Disconnect the brake booster vacuum hose.
9. Disconnect the heater hoses (inlet and outlet) on the engine side.
10. Using a special tool, remove the main fuel line at the common rail (supply/return).
11. Disconnect the speedometer cable from the transaxle.
12. Disconnect the clutch cable or control cable from the transaxle.



ECHA004N

13. Disconnect the power steering suction hose and return hose from the pump.

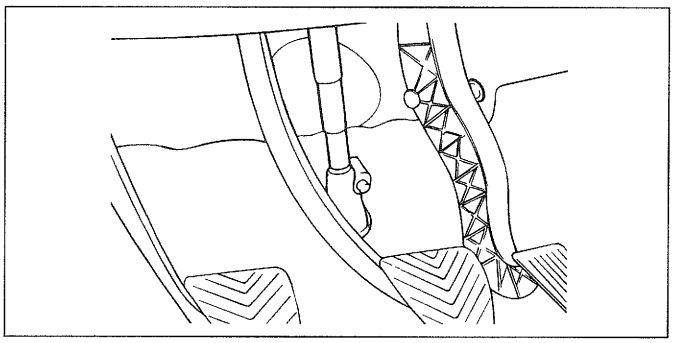


ECHA004H

14. Detach the steering dust cover in the engine compartment and then disconnect the gear box universal joint bolt.

NOTE

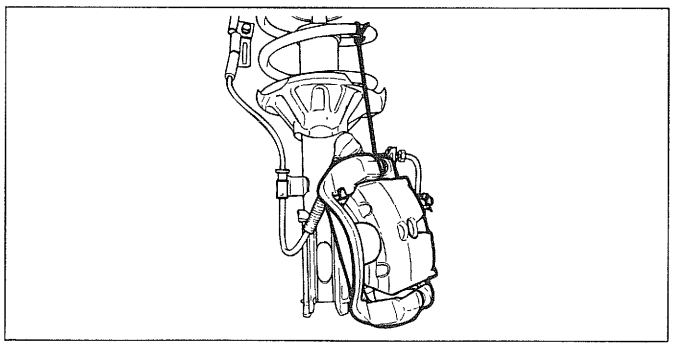
Make sure to make identification marks between the universal joint and the gear box for reassembly.



ECHA004I

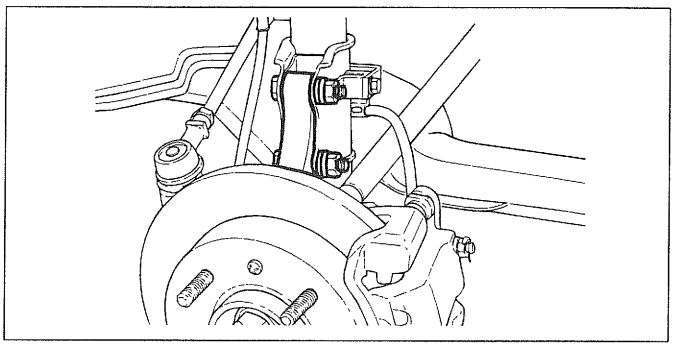
15. Raise the vehicle and then remove the front tire.

16. Remove the calliper assembly from the knuckle. Tie it using wire, hang it from the suspension.



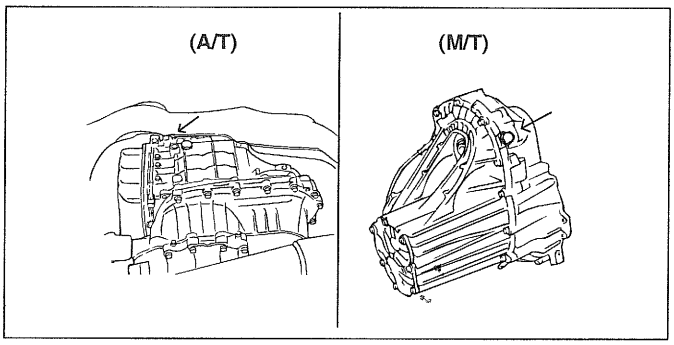
ECHA004J

17. Loosen the strut lower bolt and then remove it.



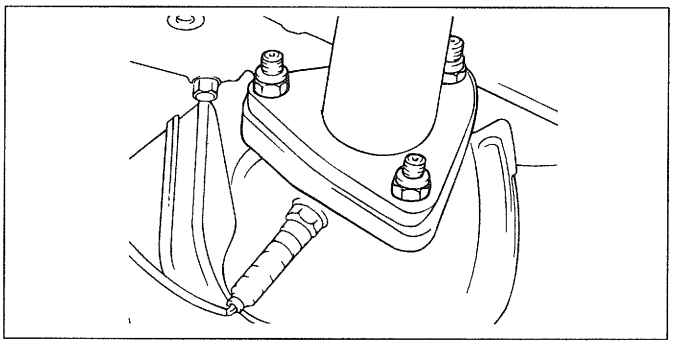
ECHA004K

18. Drain the transaxle oil.



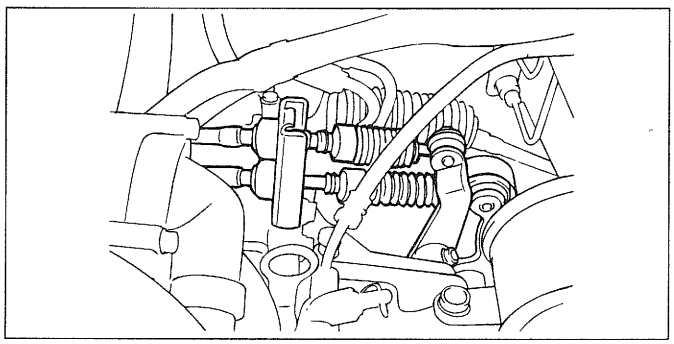
EDHA004Z

19. Remove the front muffler bolts.



ECJA230B

20. Remove the transaxle control rod and extension rod (M/T only).

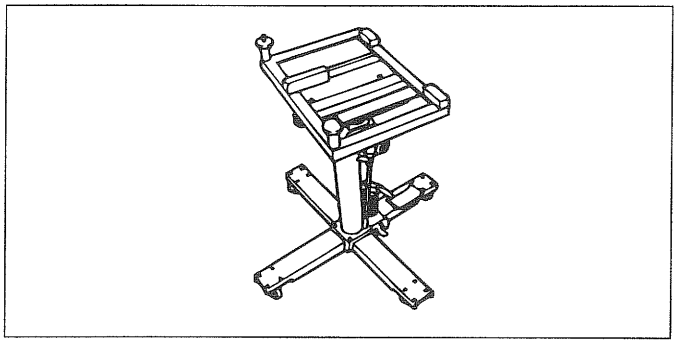


EDHA006F

21. Put the special fixture on the T/M jack and then adjust it to the sub-frame.

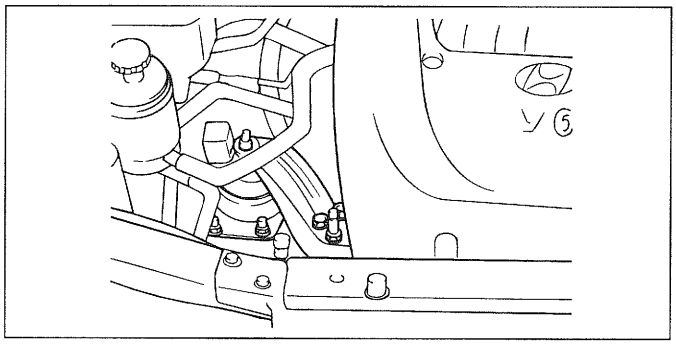
NOTE

Check that all the cables, harness connector and hose are disconnected from the engine and transaxle assembly.

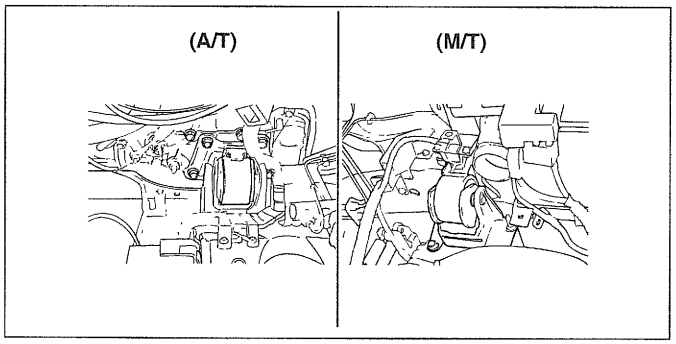


ECHA004O

22. Remove the engine mounting bracket and the transaxle mounting bracket.

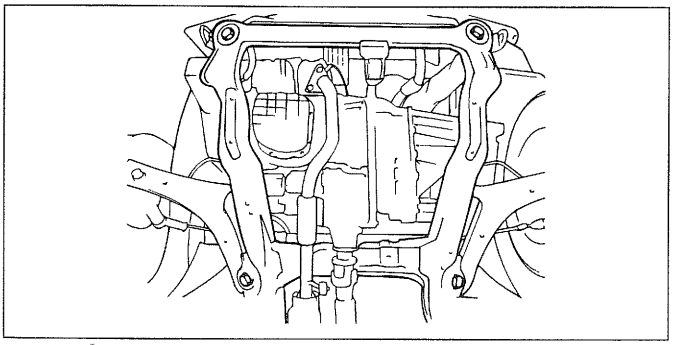


EDHA004A

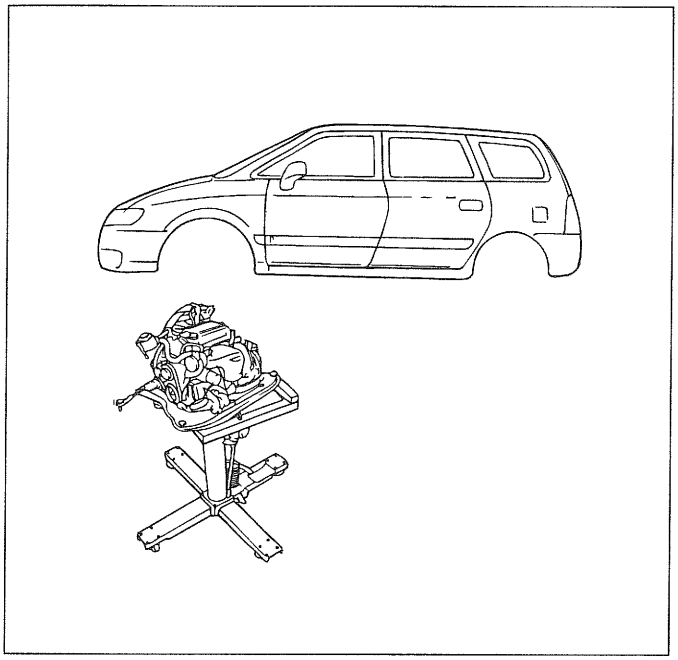


EDHA004C

23. Remove the sub-frame installation bolts.

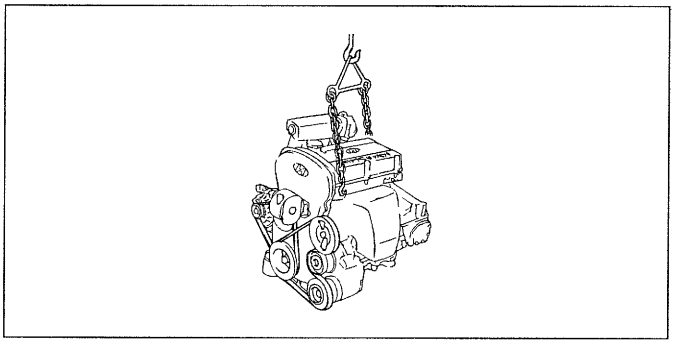


EDJA230C



EDHA006I

24. After removing the drive shaft, lower the engine and transaxle assembly on the jack then, remove the front roll stopper and the rear roll stopper.



ECA9021A

25. Remove the engine and transaxle assembly as a unit.

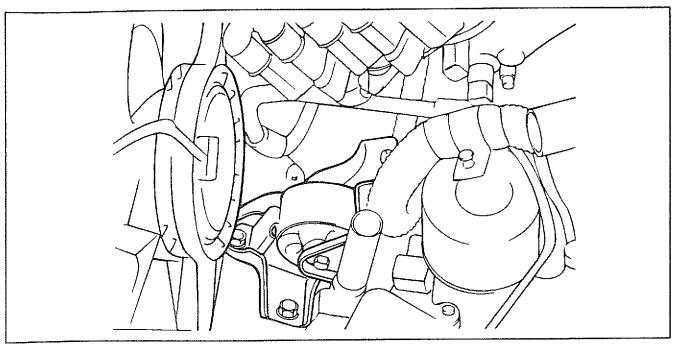
INSTALLATION ECJA2400

1. When installing the engine and transaxle, check the connections of harnesses, pipes, hoses, etc. make sure that none of them are caught, damaged, etc.

2. Install the front roll stopper to the bracket roughly.

Tightening torque

Service standard : 50-65 Nm (500-650kg.cm, 36-47 lb.ft)

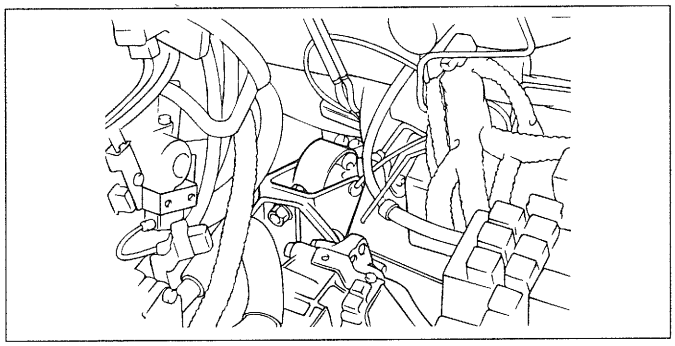


ECHA005A

3. Install the rear roll stopper to the bracket.

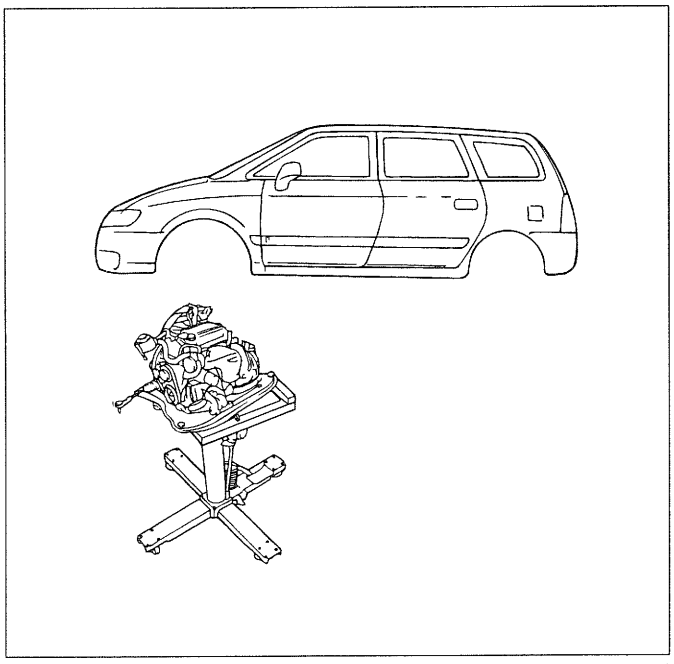
Tightening torque

Service standard : 50-65Nm(500-650kg.cm, 36-47 lb.ft)



ECHA005B

4. Install the engine/transaxle to the sub-frame assembly. Use the T/M jack to raise the assembly slowly adjust it to the vehicle body.

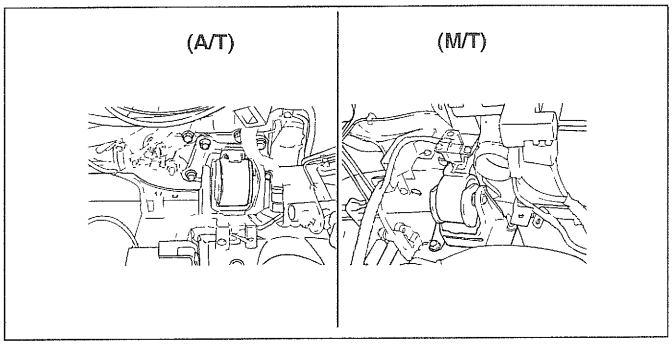


EDHA006I

5. Install the transaxle mounting bracket.

Tightening torque

Service standard : 90-110Nm(900-1100kg.cm, 65-80 lb.ft)

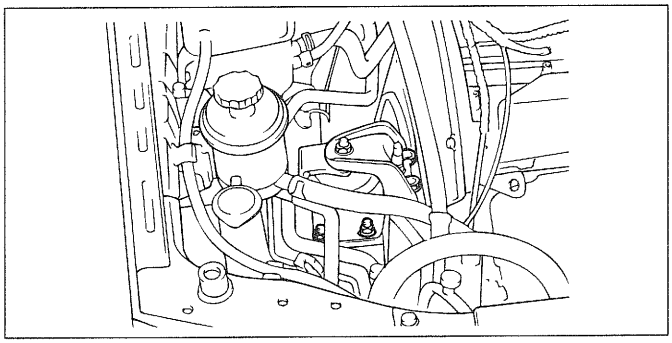


EDHA004C

6. Install the engine bracket (right side).

Tightening torque

Service standard : 60-80Nm(600-800kg.cm, 43-58 lb.ft)



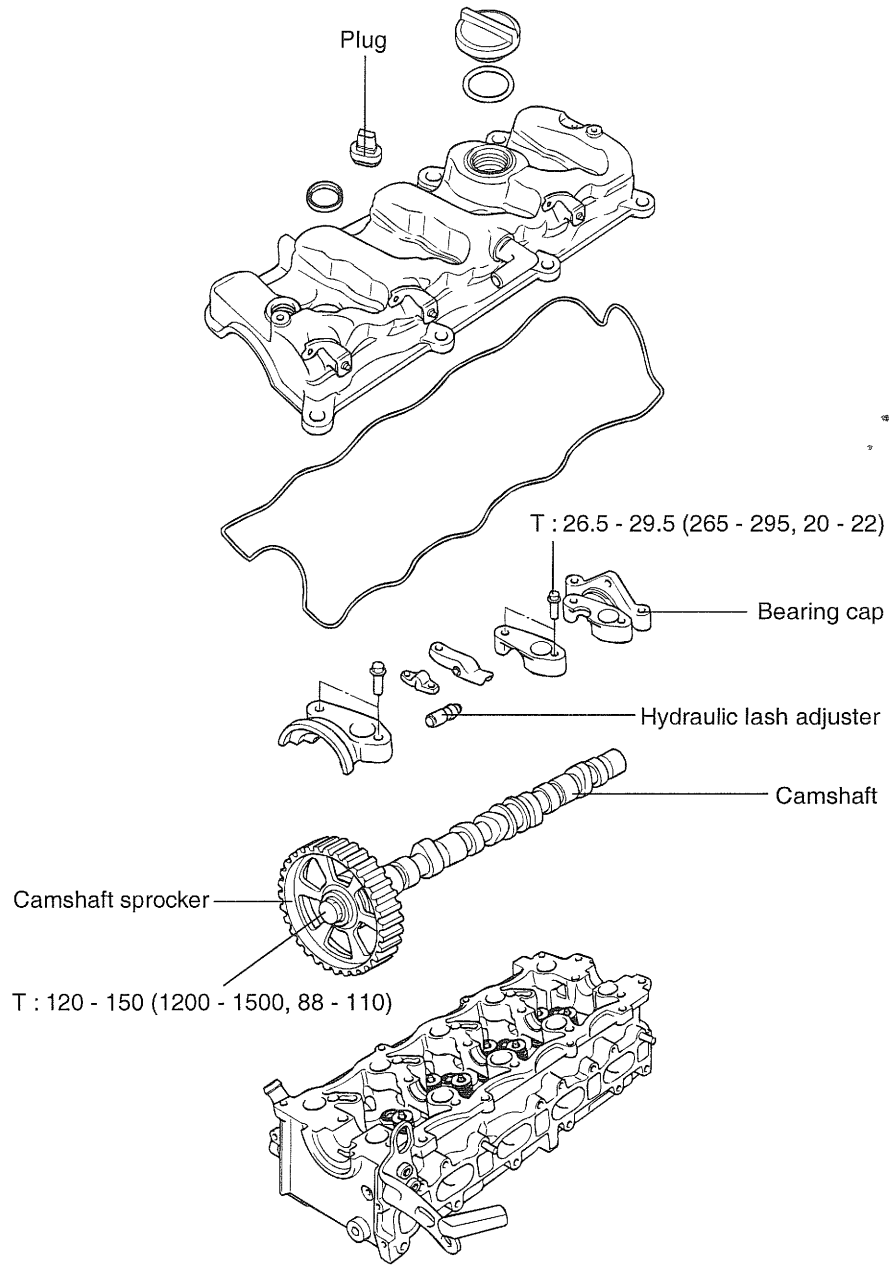
ECHA005E

7. To install all of parts, follow the removal procedures in the reverse order.
8. Refill the coolant and then check for leaks.
9. Refill the transaxle oil and check for leaks, then test its operation.
10. Check the operation of the transaxle control cable and accelerator cable.
11. Check the proper operation of each gauge.

MAIN MOVING SYSTEM

CAM SHAFT

COMPONENTS ECHB3000



TORQUE : Nm (kg.cm, lb·ft)

KCHB013A

DISASSEMBLY ECHB3100

1. Disconnect the negative terminal from the battery.
2. Drain the engine coolant.
3. Remove the breather hose between the air cleaner and the rocker cover.
4. Remove the air cleaner.
5. Remove the timing belt cover.
6. Remove the rocker cover and crank shaft position sensor.
7. Loosen the camshaft sprocket bolts then remove the camshaft sprockets.
8. Loosen the camshaft bearing cap bolts and remove the bearing caps, camshafts, rocker arms and lash adjusters.

WARNING

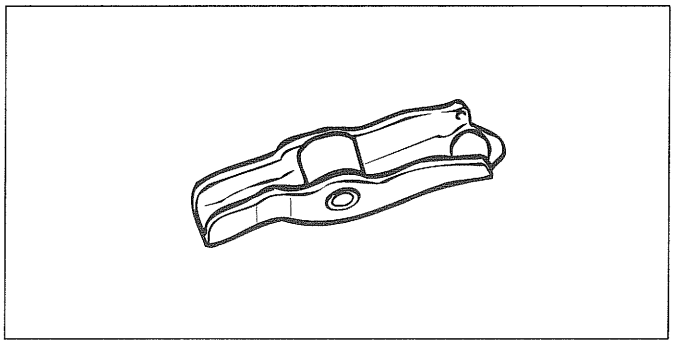
REMOVAL AND INSTALLATION OF INJECTOR AND HIGH PRESSURE PUMP.

1. Fuel system is subject to extremely high pressure (1350 bar).
2. Never perform any work on injection system with engine running or within 30 seconds after stopping the engine.
3. Always pay attention to safety precautions.
4. Ensure the absolute cleanliness.
5. Never remove the injectors.

INSPECTION ECHB3200

ROCKER ARMS

1. Check rotation of the roller. If they do not rotate smoothly or are loose, replace them.
2. Check the roller surface. Replace if there is any dent, damage or evidence of seizure.
3. Check the valve contact surface for possible damage or evidence of seizure. Replace if necessary.

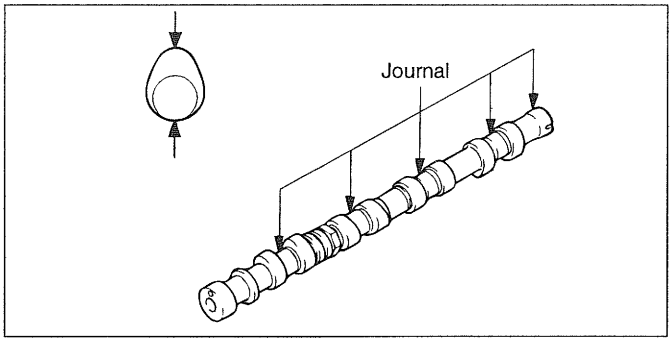


KCHB013B

CAMSHAFTS

1. Check the camshaft journals for wear. If the journals are badly worn, replace the camshaft.
2. Check the cam lobes for damage. If the lobe is damaged or worn excessively, replace the camshaft.

Cam height
[Standard]
Intake : 34.697 mm (1.366 in.)
Exhaust : 34.570 mm (1.361 in.)
[Limit]
Intake : 34.197 mm (1.346 in.)
Exhaust : 34.070 mm (1.341 in.)



ECA9240B

REASSEMBLY ECHB3300

1. Install the camshafts on the cylinder head.

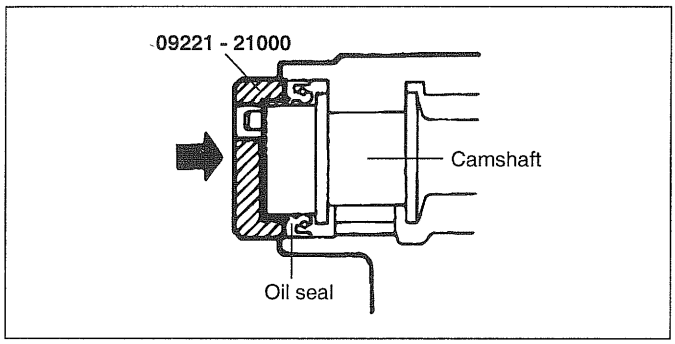
   NOTE

   Apply engine oil to journals and cams of the camshafts.

2. Install the bearing caps.

3. Check that the camshaft can be easily turned by hand. After checking, remove the bearing caps and the camshafts, and then install the rocker arms.

4. Make sure that the dowel pins on the camshaft sprocket ends are located on the top.



ECLA019E

5. Tighten the bearing caps to the specified torque in two or three increments as shown.

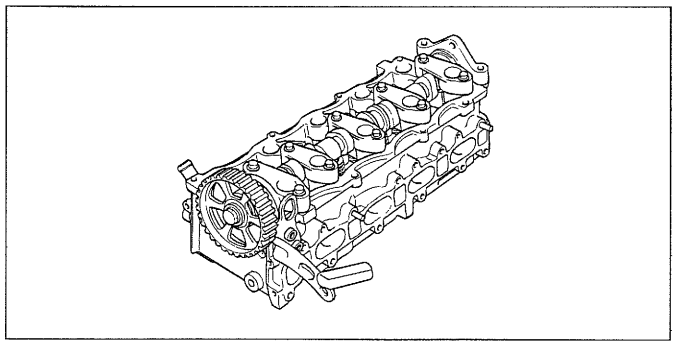
   NOTE

   Tighten the rocker arms uniformly.

Tightening torque

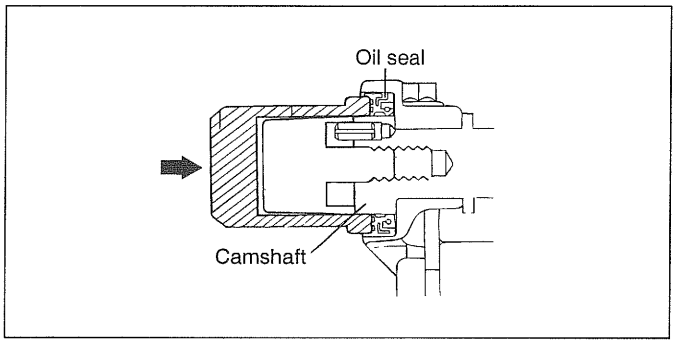
Bearing cap bolts:

27 - 30 Nm (270 - 300 kg.cm, 20 - 22 lb.ft)



KCHB013D

6. Using the special tools, camshaft oil seal Installer. Be sure to apply engine oil to the external surface of the oil seal.
   Insert the oil seal along the camshaft front end and install it by driving the installer with a hammer until the oil seal is fully seated.



KCHA330C

7. Install the camshaft sprocket bolts to the specified torque.

Tightening torque

Camshaft sprocket bolts :

120 - 150 Nm (1200 - 1500 kg.cm, 88 - 110 lb.ft)

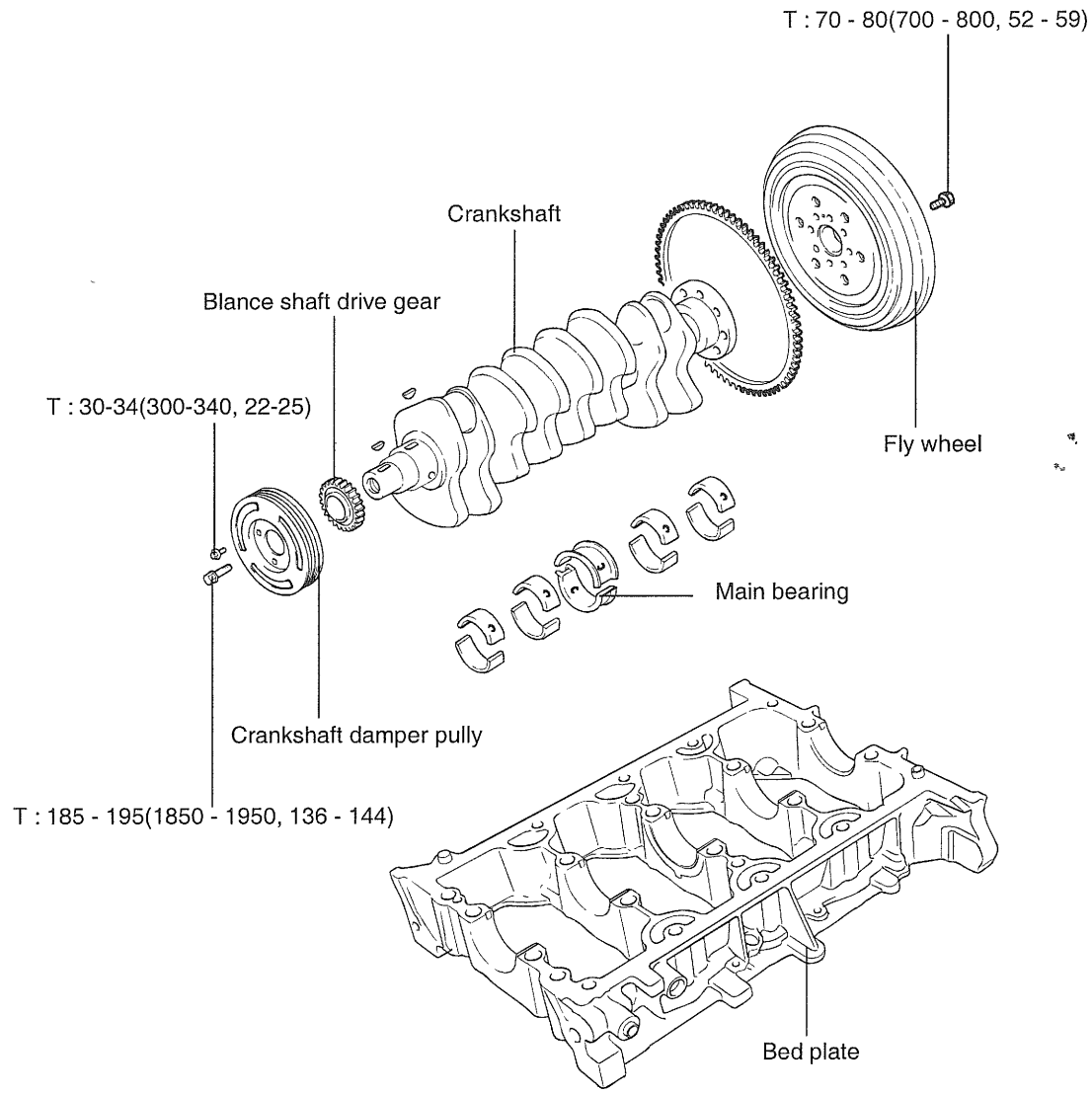
8. Install the rocker cover.

Tightening torque

Rocker cover bolts : 10-14 Nm (100-140 kg.cm, 7-10 lb.ft)

CRANK SHAFT

COMPONENTS ECHB4000



TORQUE : Nm (kg.cm, lb·ft)

KCHB005A

DISASSEMBLY ECHB4100

1. Remove the timing belt, front case, flywheel, cylinder head assembly and oil pan. For details, refer to the respective chapters.
2. Remove the rear plate and the rear oil seal.
3. Remove the connecting rod caps.

   NOTE

   Mark the main bearing caps to be able to reassembl in the original position and direction.

4. Remove the bedplate and the crankshaft. Keep the bearings in order according to the cap number.

INSPECTION ECHB4200

CRANKSHAFT

1. Check the crankshaft journals and pins for damage, uneven wear and cracks. Also check the oil holes for restrictions. Repair or replace any defective part.
2. Inspect the crankshaft journal for taper and out-of-round.

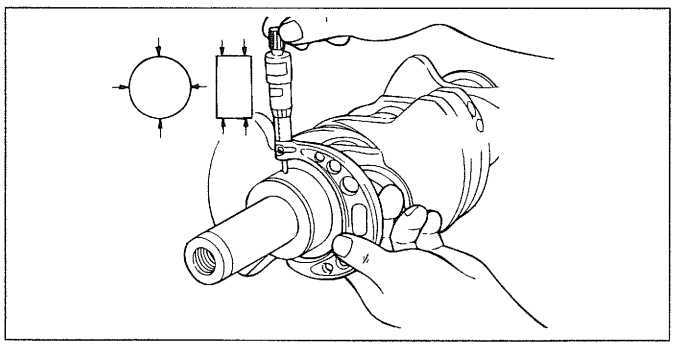
Standard value

Crankshaft journal O.D :

60.002 - 60.020 mm (2.362 - 2.363 in.)

Crankshaft pin O.D :

50.008 - 50.026 mm(1.969 - 1.9695 in.)



ECA9410A

MAIN BEARINGS AND CONNECTING ROD BEARINGS

Visually inspect each bearing for peeling, melting, seizure and improper contact. Replace any defective bearings.

MEASURING OIL CLEARANCE

Check the oil clearance by measuring the outside diameter of the crankshaft journal as well as the the inside diameter of the bearing. The clearance can be obtained by calculating the difference between the measured diameters.

Standard value

Oil clearance

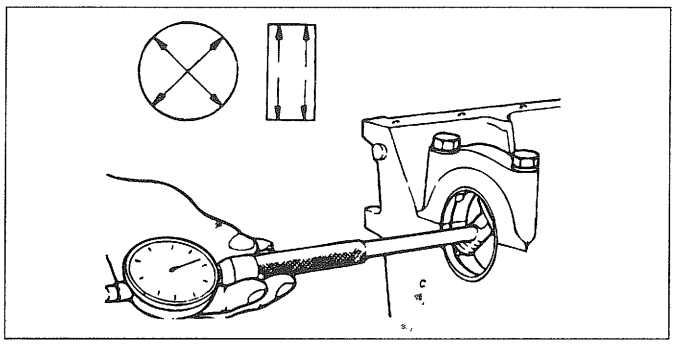
Crankshaft main bearing :

0.024 - 0.042 mm (0.0009 - 0.0017 in.)

Connecting rod bearing :

0.024 - 0.042 mm (0.0009 - 0.0017 in.)

Limit : 0.1 mm (0.0039 in.)

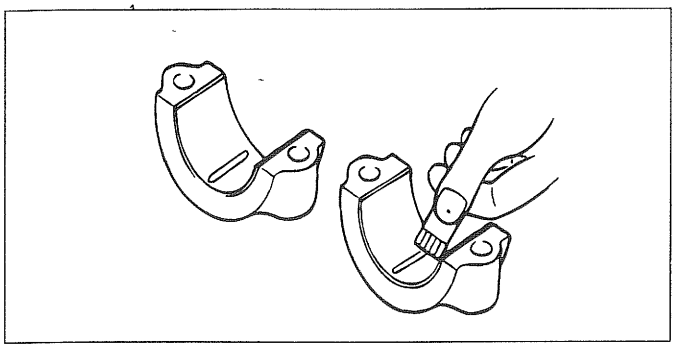


ECA9410B

HOW TO USE PLASTIGAUGE

Plastigauge may be used to measure the clearance.

1. Remove oil, grease and any other dirt from the bearings and journals.
2. Cut the plasticgauge to the same length as the width of the bearing and place it in parallel with the journal, avoiding the oil holes.
3. Install the crankshaft, bearings and caps and tighten them to the specified torques. During this operation, do not turn the crankshaft. Remove the caps. Measure the width of the plasticgauge at the widest part by using the scale printed on the gauge package. If the clearance exceeds the service limit, the bearing should be replaced or an undersize bearing should be used. When installing a new crankshaft, be sure to use standard size bearings. If the standard clearance can not be obtained even after replacing the bearing, the journal and pin should be ground to thr undersize and a bearing of the corresponding size should be installed.



ECA9410C

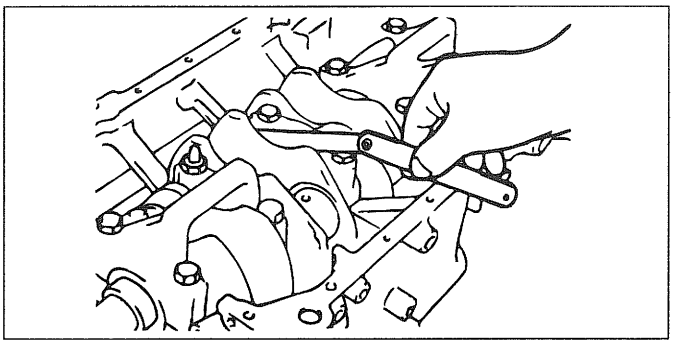
OIL SEAL

Check the front and rear oil seals for damage or worn surfaces. Replace any seat that is defective.

BEDPLATE

After installing the bedplate, make sure the crankshaft turns smoothly and the end play is correct. If the end play exceeds the limit, replace the crankshaft bearings.

Standard value: 0.09 - 0.32 mm (0.0035 - 0.026 in.)



ECA9410D

DRIVE PLATE (A/T)

Replace distorted, damaged, or cracked drive plates.

FLYWHEEL (M/T)

1. Check the clutch disc contacting surface of the flywheel for damage and wear. Replace the flywheel if excessively damaged or worn.
2. Check the clutch disc contacting surface of the flywheel for run-out.

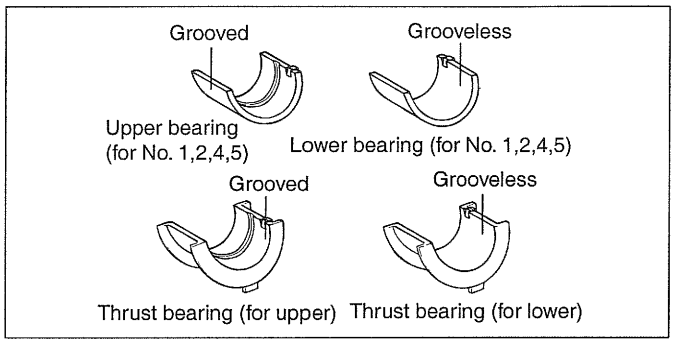
Limit

Flywheel run-out : 0.13mm(0.0051 in.)

3. Check the ring gear for damage, cracks and wear. Replace if necessary.

REASSEMBLY ECHB4300

1. Install a grooved main bearing (upper bearing) on the cylinder block side.
2. Install a grooveless main bearing (lower bearing) on the main bearing cap side.
3. Lower center thrust bearing is grooveless. Upper center thrust bearing is grooveed.



KCHB005C

4. Apply engine oil to journals and pins. Install the crankshaft.
5. Install the bedplate with the arrow mark directed toward the front of the engine.
6. Tighten the cap bolts to the specified torque.

Tightening torque

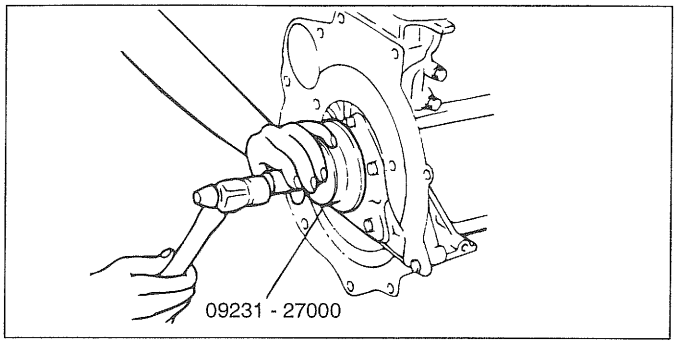
Main bearing cap bolts :

15 mm : 25 Nm (250 kg·cm, 18lb·ft) + (90°)

12 mm : 33 - 37 Nm (330 - 370 kg·cm,24 - 27 lb·ft)

7. Cap bolts should be tightened evenly in 4 to 5 increments before they are tightened to the specified torque.
8. Make sure that the crankshaft turns freely and check the end play of the crankshaft.

9. Using a special tool (09231 - 27000). Install the oil seal in the oil seal case. A new oil seal should be used.



ECHB014Z

<For M/T>

10. Install the rear plate to the cylinder block.

11. Install the flywheel assembly and tighten the bolts to the specified torque.

Tightening torque

Flywheel bolt :

70 - 80 Nm (700 - 800kg.cm, 52 - 59 lb.ft)

<For A/T>

12. Install the adapter plate to the cylinder block.

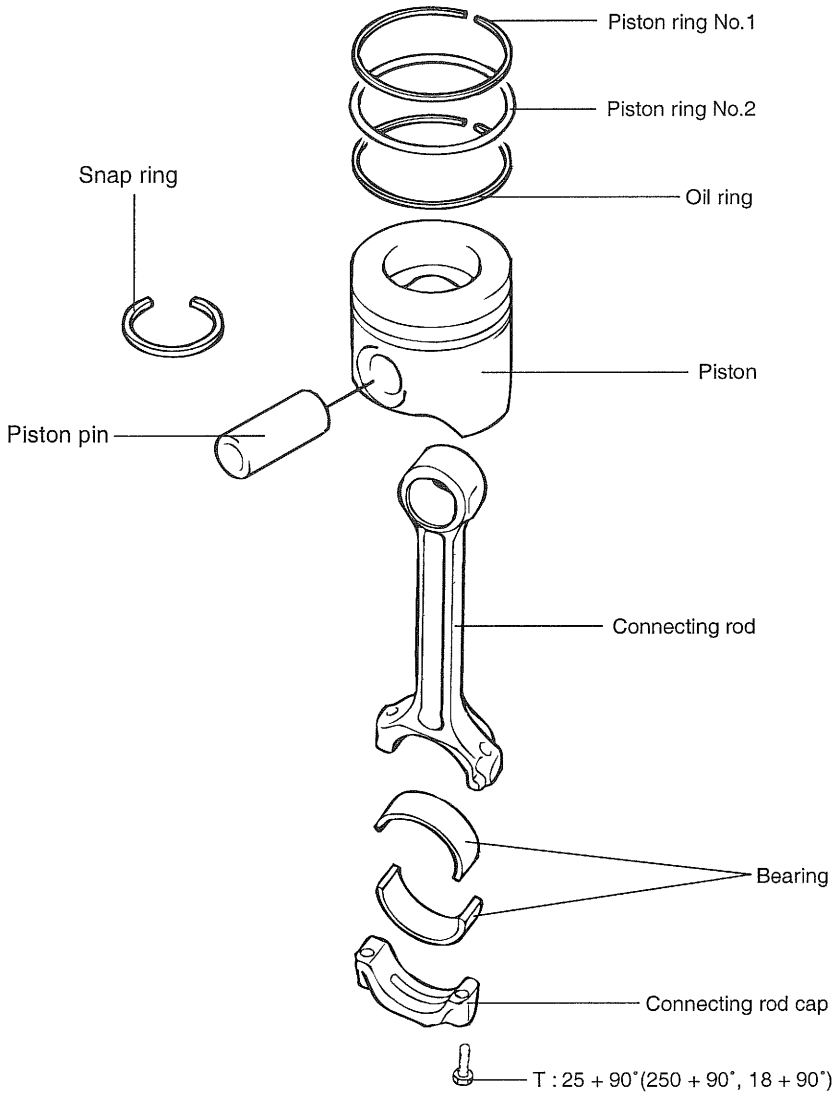
13. Install the drive plate and tighten the bolts to the specified torque.

Tightening torque

Drive plate : 70 - 80 Nm (700 - 800kg.cm, 52 - 59 lb.ft)

PISTON

COMPONENTS ECHB3500



TORQUE : Nm (kg.cm, lb·ft)

KCHB006A

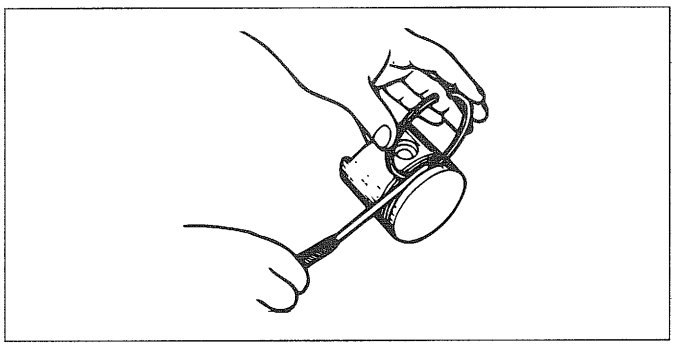
INSPECTION ECHB3600

PISTON

1. Check each piston for scuffing, scoring, wear and other defects. Replace any piston that is defective.
2. Check that the piston pin fits in the piston pin hole. Replace any piston and pin assembly that is defective. The piston pin must be smoothly pressed by hand into the pin hole (at room temperature)

PISTON RING

1. Check each piston ring for breakage, damage and abnormal wear.
   Replace the defective rings.
2. When the piston requires replacement, its ring should also be replaced.
3. Measure the clearance between piston ring and ring home.



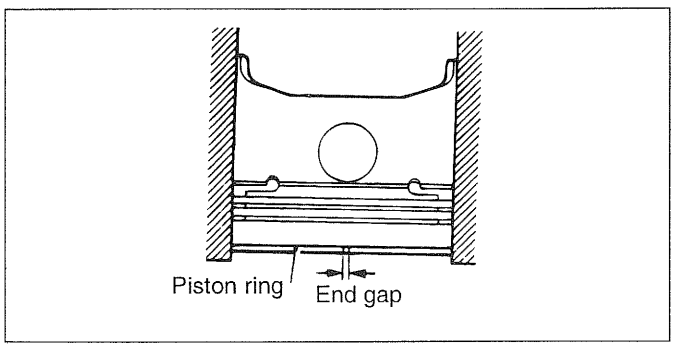
ECLA010B

Standard Value : Ring - to - ring groove clearance

No. 2 : 0.065 - 0.11 mm (0.00256 - 0.00433 in.)

Oil ring : 0.03 - 0.07 mm (0.00118 - 0.00275 in.)

4. Place a piston ring in the cylinder bore and set it square by pushing it down with piston.
5. Measure the end clearance using a thickness gauge.



ECLA010D

Standard Value : End gap

No. 1 : 0.2 - 0.3 mm (0.0079 - 0.0118 in.)

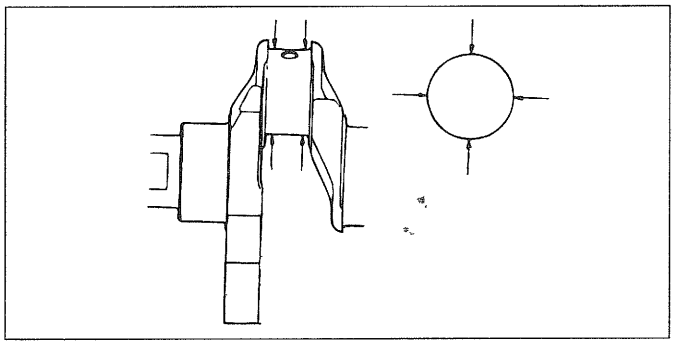
No. 2 : 0.30 - 0.45 mm (0.0118 - 0.0177 in.)

Oil ring : 0.2 - 0.45 mm (0.0079 - 0.0177 in.)

Limit : 0.8 mm (0.0315 in.)

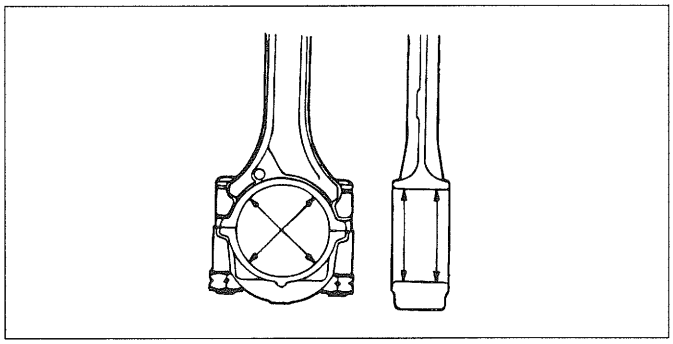
CONNECTING ROD BEARING

1. Check the bearing surfaces for uneven contact pattern, streaks, scratches, and seizure. If defects are evident, replace. If the surfaces are seriously nicked and seized, check also the crankshaft. If the crankshaft is also damaged, replace the crankshaft or grind to undersize for reuse.



ECLA010E

2. Measure the connecting rod bearing I.D. and crankshaft pin O.D. If the clearance (oil clearance) exceeds the limit, replace the bearing and, if necessary, the crankshaft. Or, grind the crankshaft to an undersize and, at the same time, replace the bearing with an undersize.



ECLA010F

Standard value :

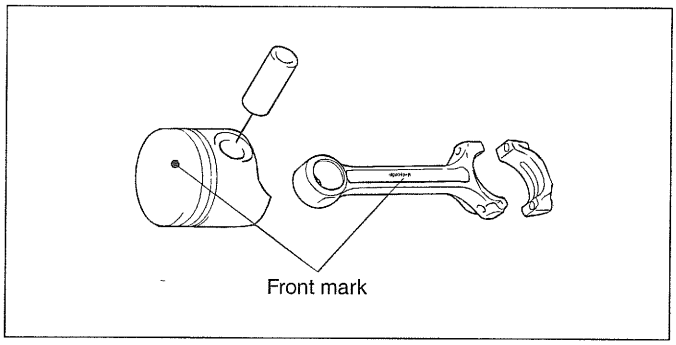
0.024 - 0.042 mm (0.0009 - 0.0016 in.)

Limit : 0.10 mm (0.0039 in.)

INSTALLATION ECHB3700

CONNECTING ROD, PISTION PIN AND PISTON

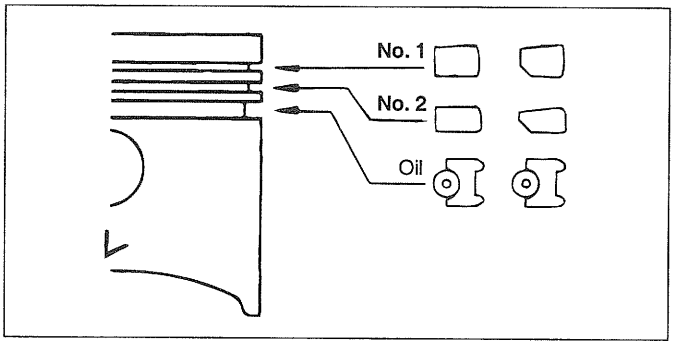
1. Match the piston with the connecting rod.
2. Line up the front marks and insert the piston pin. The piston pin must be smoothly pressed by hand into position. Replace the piston pin if there is excessive play.



KCHB006B

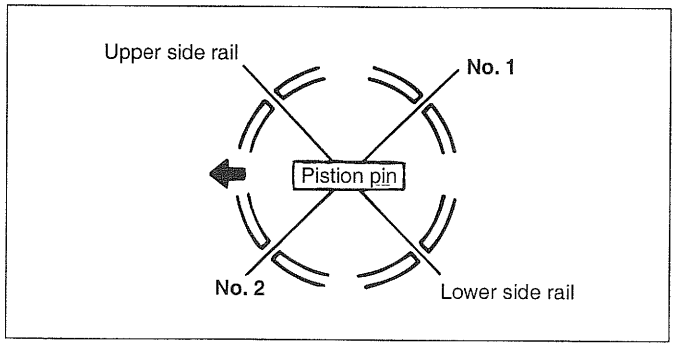
PISTON RING

1. Install the oil ring expander and oil ring to the piston. Then, install No.2 piston ring and No.1 piston ring, in that order. Make sure that the ring side, on which manufacturer and size marks are stamped, faces to the piston crown.



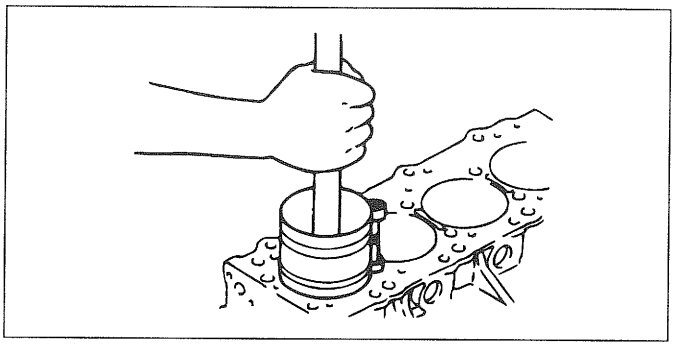
ECLA010L

2. Position ends of piston and oil (side rail, spacer) rings as illustrated.



ECLA010M

3. Insert the piston and connecting rod assembly from above the top of cylinder. Ensure that the front mark on piston crown and that (ID mark) on the connecting rod face toward the front of engine (to the crank pulley side).
4. Clamp firm the piston rings with the ring band and install the piston assembly into cylinder. Do not strike it hard into the piston, as broken piston ring or damaged crank pin could result.



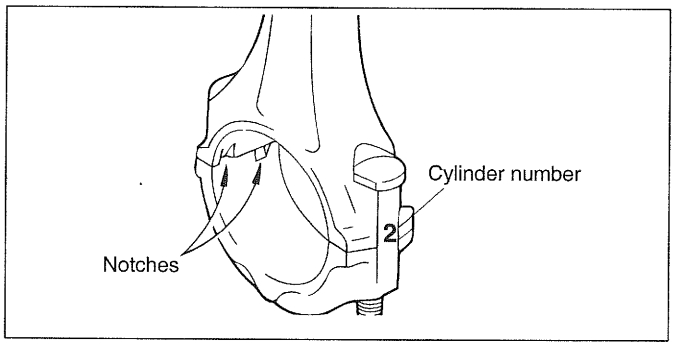
ECLA010N

5. Tighten the connecting red cap bolts.

Tightening torque

Connecting rod cap bolts :

25 Nm (250 kg·cm, 18·4 lb·ft) + 90°



ECA9360A

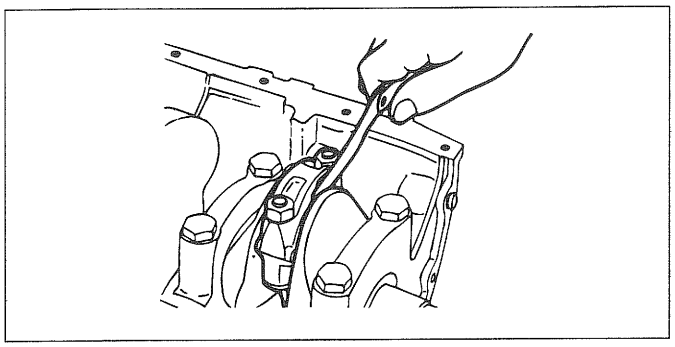
NOTE

Re-use of the bolt must be limited to 3 times.

6. Make sure the clearance of connecting rod big end side.

Standard Value : 0.10 - 0.35 mm (0.0039 - 0.0138 in.)

Limit : 0.4 mm (0.0157 in.)

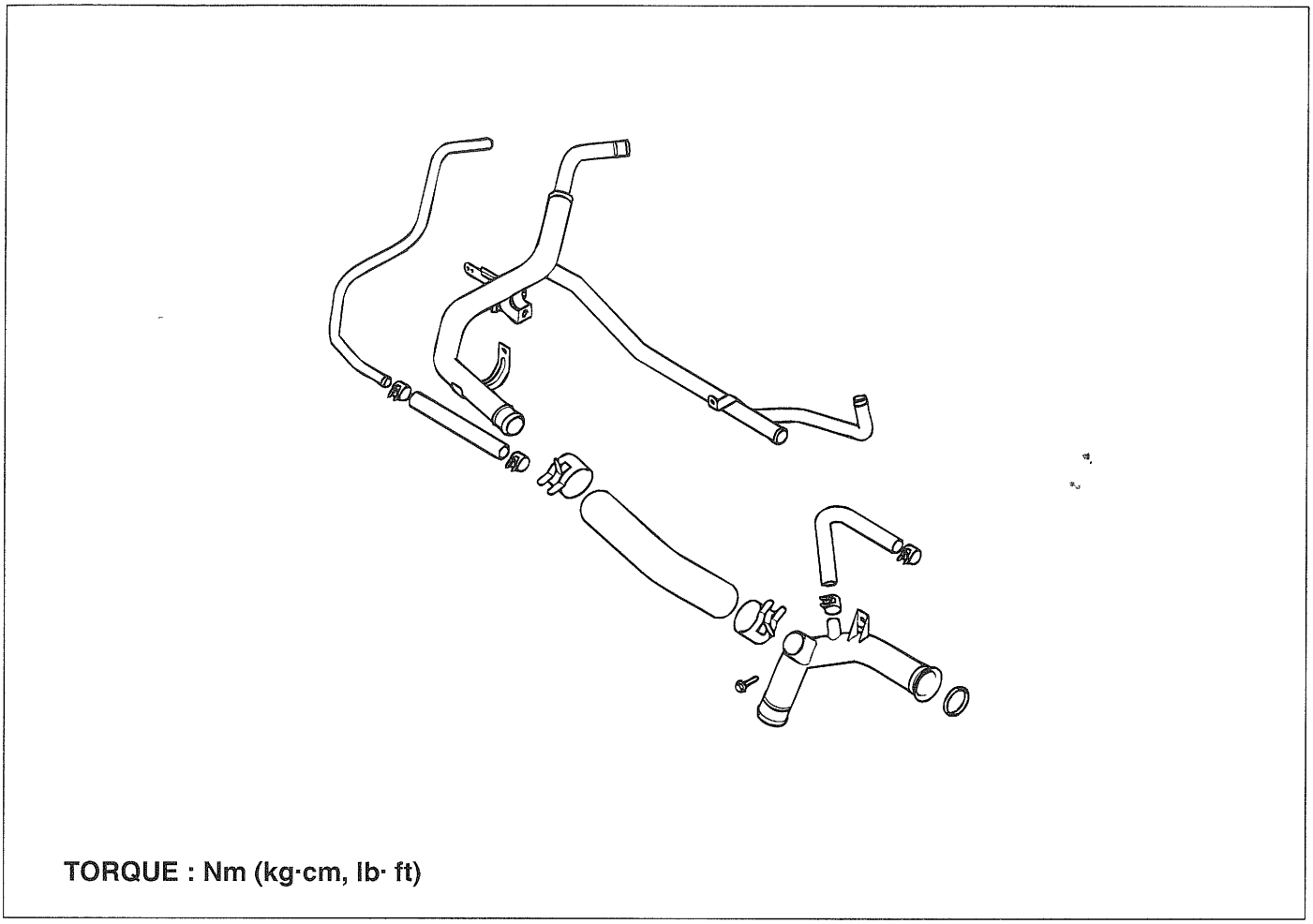


ECLA010O

COOLING SYSTEM

ENGINE COOLANT HOSE/PIPES

COMPONENTS ECHB4500



TORQUE : Nm (kg·cm, lb· ft)

KCHB007C

INSPECTION ECHA4600

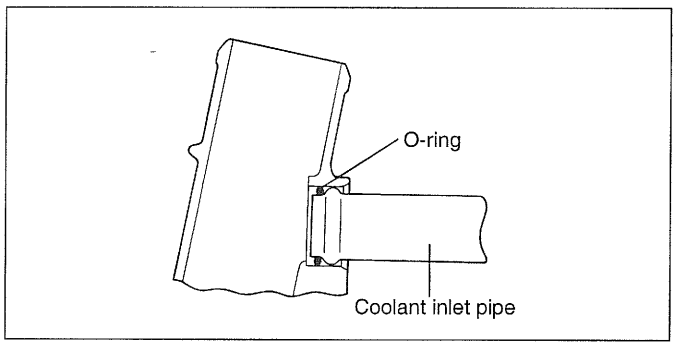
Check the engine coolant pipe and hose for cracks, damage and restrictions. Replace if necessary.

REASSEMBLY ECHA4700

Fit an O-ring in the groove provided at the engine coolant inlet pipe end. Wet the periphery of the O-ring with water and insert the engine coolant inlet pipe.

NOTE

1. *Do not apply oil or grease to engine coolant pipe O-ring.*
2. *Keep the engine coolant pipe connections free of sand, dust, etc.*
3. *Insert the engine coolant pipe into the end of the engine coolant pump inlet.*
4. *Whenever installing the engine coolant inlet pipe, always replace the O-ring with a new one.*



ECA9570A

COOLANT TEMPERATURE SENSOR ECHB5000

REMOVAL

1. Drain the coolant to a level below the bottom of the sensor.
2. Disconnect the ground cable from the battery and then remove the sensor connector.
3. Remove the coolant sensor.

INSTALLATION ECJA4900

1. Tighten the coolant temperature sensor to the specified torque after applying the sealant to the screw area.

Recommened sealant :

Threebond No. 1324N or LOCTITE 262

Tightening torque

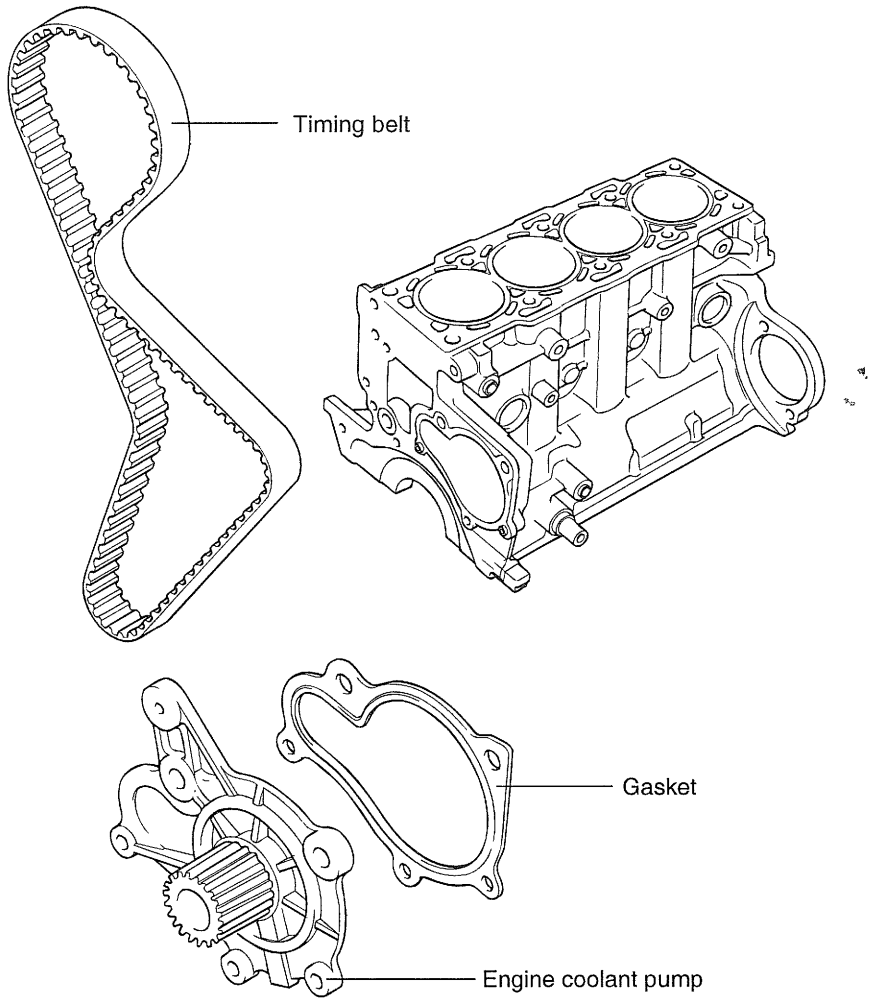
The coolant temperature sensor :

20-40Nm (200-400 kg.cm, 14-29 lb.ft)

2. Connect the sensor to the harness.
3. Connect the ground cable to the battery.
4. Refill the engine coolant.

ENGINE COOLANT PUMP

COMPONENTS ECHB5500



TORQUE : Nm (kg.cm, lb·ft)

KCHB007A

REMOVAL ECHB5600

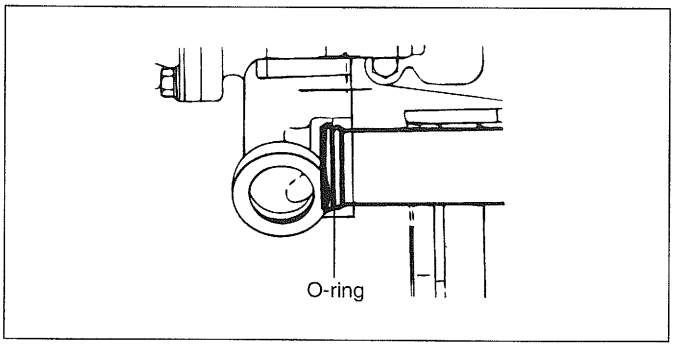
1. Drain the coolant and disconnect the coolant pump inlet pipe.
2. Remove the drive belt and engine support bracket.
3. Remove the timing belt covers and the timing belt tensioner.
4. Remove the engine coolant pump mounting bolts.
5. Remove the engine coolant pump assembly from the cylinder block.

INSPECTION ECHB5700

1. Check the pump for cracks, damage or wear. Replace the pump assembly if necessary.
2. Check the bearing for damage, abnormal noise, and sluggish rotation. Replace the pump assembly if necessary.
3. Check the seal for leaks. Replace the pump assembly if necessary.
4. Check for engine coolant leakage. If the engine coolant leaks, the seal is defective. Replace the engine coolant pump assembly.

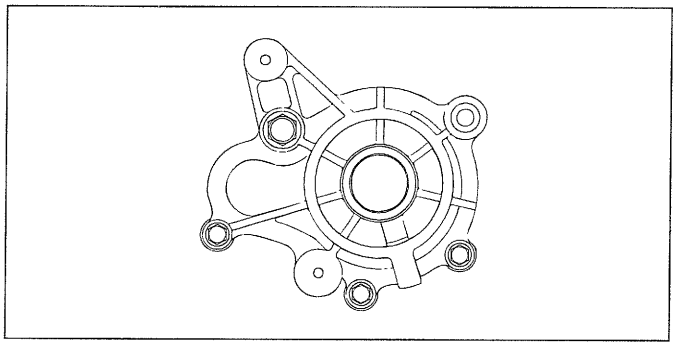
INSTALLATION ECHB5800

1. Clean the gasket surfaces of the engine coolant pump body and the cylinder block.
2. Install the new O-ring onto the groove on the front end of the engine coolant pipe, then wet the O-ring with water. Do not apply oil or grease.



ECHA013A

3. Install a new engine coolant pump gasket and engine coolant pump assembly. Tighten the bolts to the specified torque.



KCHB007B

Tightening torque

Engine coolant pump bolt :

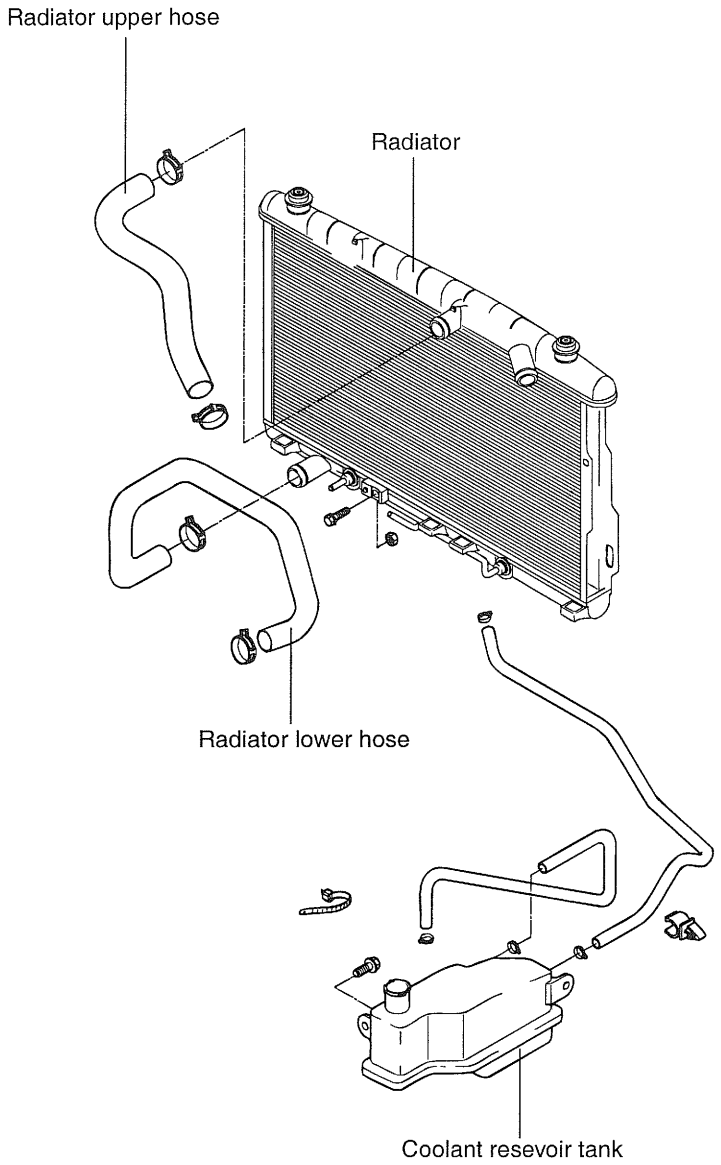
10 mm : 10 - 12 Nm (100 - 120kg·cm, 7 - 9 lb·ft)

14 mm : 48 - 52 Nm (480 - 520 kg·cm, 35 - 38lb·ft)

4. Install the timing belt tensioner and timing belt. Adjust the timing belt tension, then install the timing belt covers.
5. Refill the coolant.
6. Run the engine and check for leaks.

RADIATOR

COMPONENTS ECHB6000

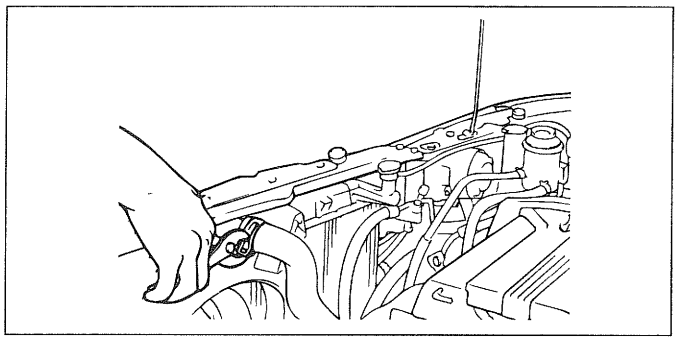


TORQUE : Nm (kg.cm, lb·ft)

KCHB020A

REMOVAL ECJA5600

1. Disconnect the ground cable from the battery terminal.
2. Disconnect the fan motor connector.
3. Loosen the radiator drain plug to drain the coolant.
4. Disconnect the upper and lower hoses and overflow tube after making marks on the radiator hose and the hose clamp. to ease. reassembly.



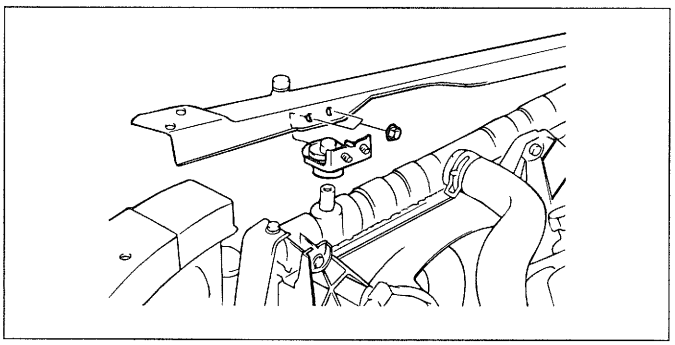
EDJA330A

5. For vehicles with automatic transaxles, disconnect the oil cooler hoses from the automatic transaxle.

⚠ ***CAUTION***

Cover or plug the hose and inlets of the radiator so that dust and other foreign materials can not enter after the hose is disconnected from the radiator.

6. Remove the radiator upper mounting bolt.



EDHA001C

7. Remove the radiator together with the fan motor.
8. Remove the radiator fan motor and condenser fan motor from the radiator.

INSPECTION ECHA5700

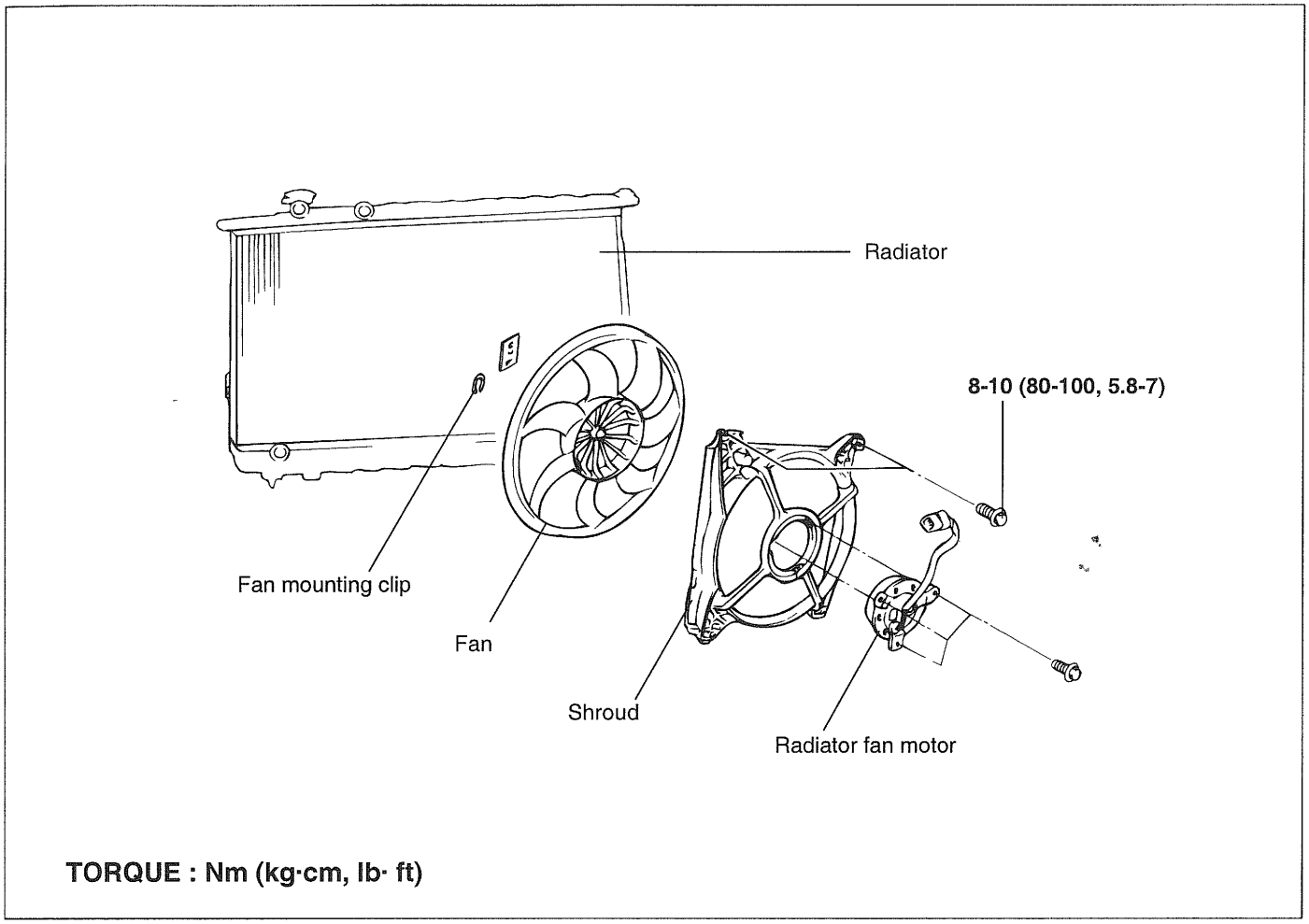
1. Check for foreign material between the radiator fins.
2. Check the radiator fins for damage and straighten if necessary.
3. Check the radiator for corrosion, damage, rust or scale.
4. Check the radiator hoses for cracks, damage or deterioration.
5. Check the reservoir tank for damage.
6. Check the automatic transaxle oil cooler hoses for cracking, damage or deterioration (only A/T).

INSTALLATION ECHA5800

1. Fill the radiator and reservoir tank with clean coolant mixture.
2. Run the engine until the coolant has warmed up enough so that the thermostat valve is open. Then, stop the engine.
3. Remove the radiator cap and pour the coolant into the filler neck of the radiator. Fill the reservoir tank with the coolant to the upper level. Replace the radiator cap.
4. Check that there are no leaks from the radiator, hoses or connections.

RADIATOR FAN MOTOR

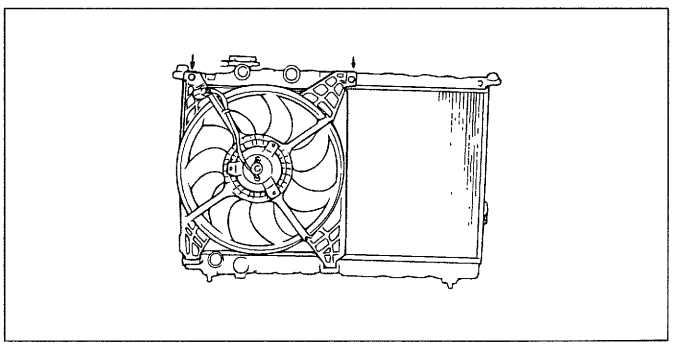
COMPONENTS ECHB6500



ECA9059A

REMOVAL ECJA6000

1. Disconnect the ground cable from the battery cable.
2. Disconnect the connectors from the fan motor and the harness from the shroud.
3. For vehicles with automatic transaxles, remove the oil cooler hose from the shroud.
4. Remove the four bolts holding the shroud.
5. Remove the shroud with the fan motor.
6. Remove the fan mounting clip and detach the fan from the fan motor.
7. Remove the three screws and detach the fan motor.



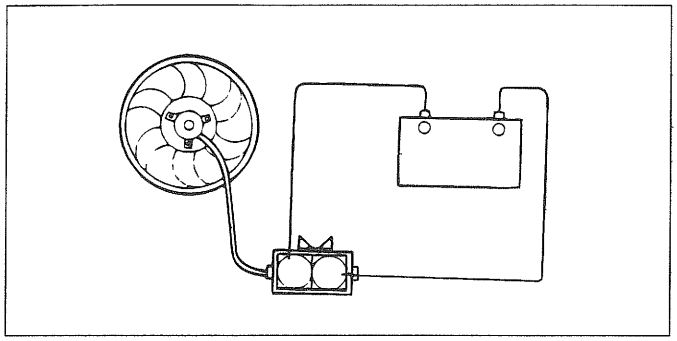
ECA9060A

INSPECTION

Radiator Fan Motor

1. Check that the radiator fan rotates when battery voltage is applied between the terminals (as shown in the table below).

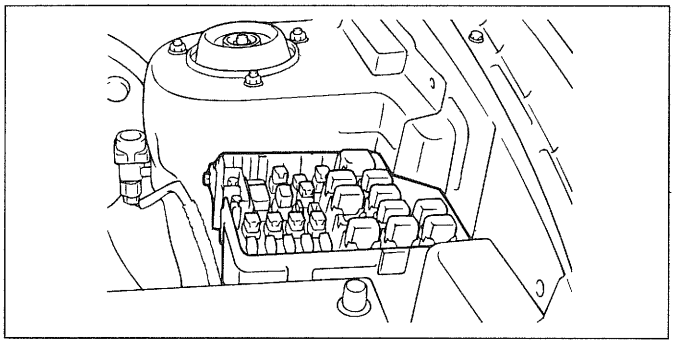
2. Check that abnormal noise is not produced while the motor is turning.



ECHA011C

RADIATOR FAN MOTOR RELAY

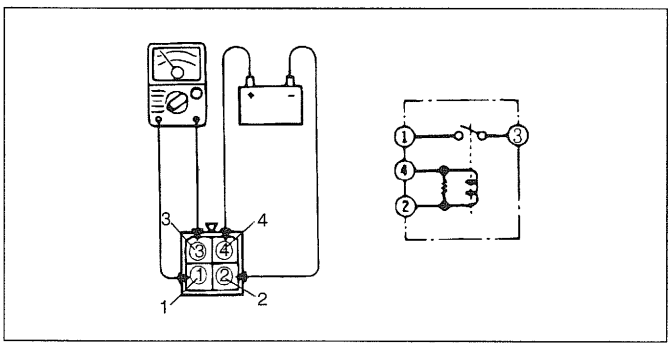
1. Remove the radiator fan motor relay (High and Low) from the relay box in the engine bay.



ECJA630A

2. Check the continuity of the terminals "2" and "4" with an ohmmeter.

Item	Terminal No.	Yes or No
ON	Terminal 1-3	Continuity
OFF	Terminal 1-3	Non continuity
	Terminal 2-4	Continuity



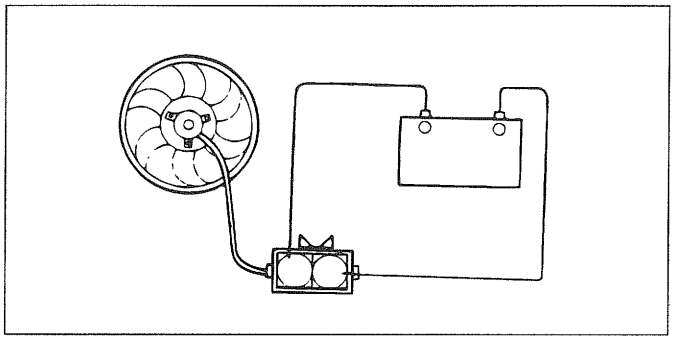
HFR25016

INSPECTION ECHB6700

RADIATOR FAN MOTOR

1. Check that the radiator fan rotates when battery voltage is applied between the terminals (as shown in the table below).

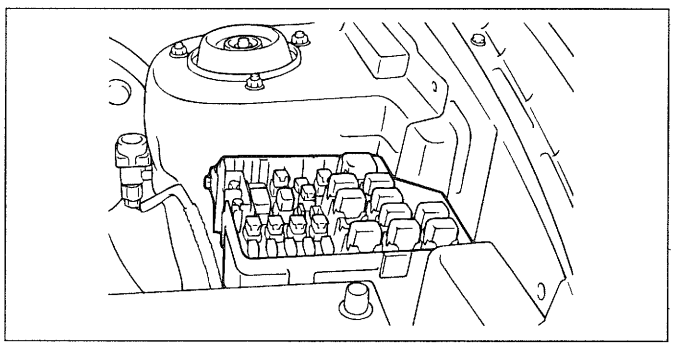
2. Check that abnormal noise is not produced while the motor is turning.



ECHA011C

RADIATOR FAN MOTOR RELAY

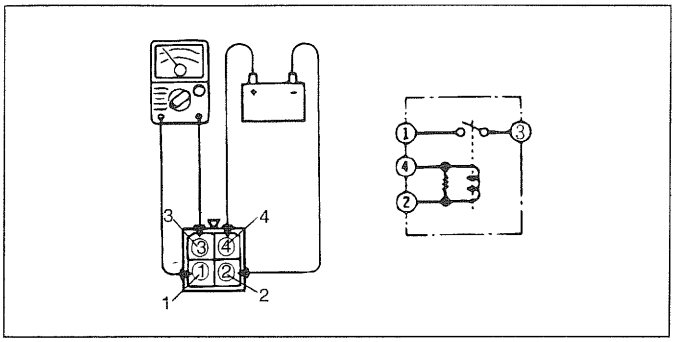
1. Remove the radiator fan motor relay (High and Low) from the relay box in the engine bay.



ECJA630A

2. Check the continuity of the terminals "2" and "4" with an ohmmeter.

Item	Terminal No.	Yes or No
ON	Terminal 1-3	Continuity
OFF	Terminal 1-3	Non continuity
	Terminal 2-4	Continuity



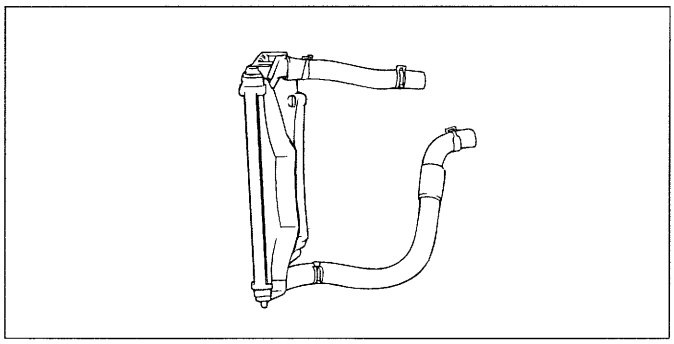
HFR25016

INSTALLATION ECJA6100

Installation is in the reverse order of removal procedures.

NOTE

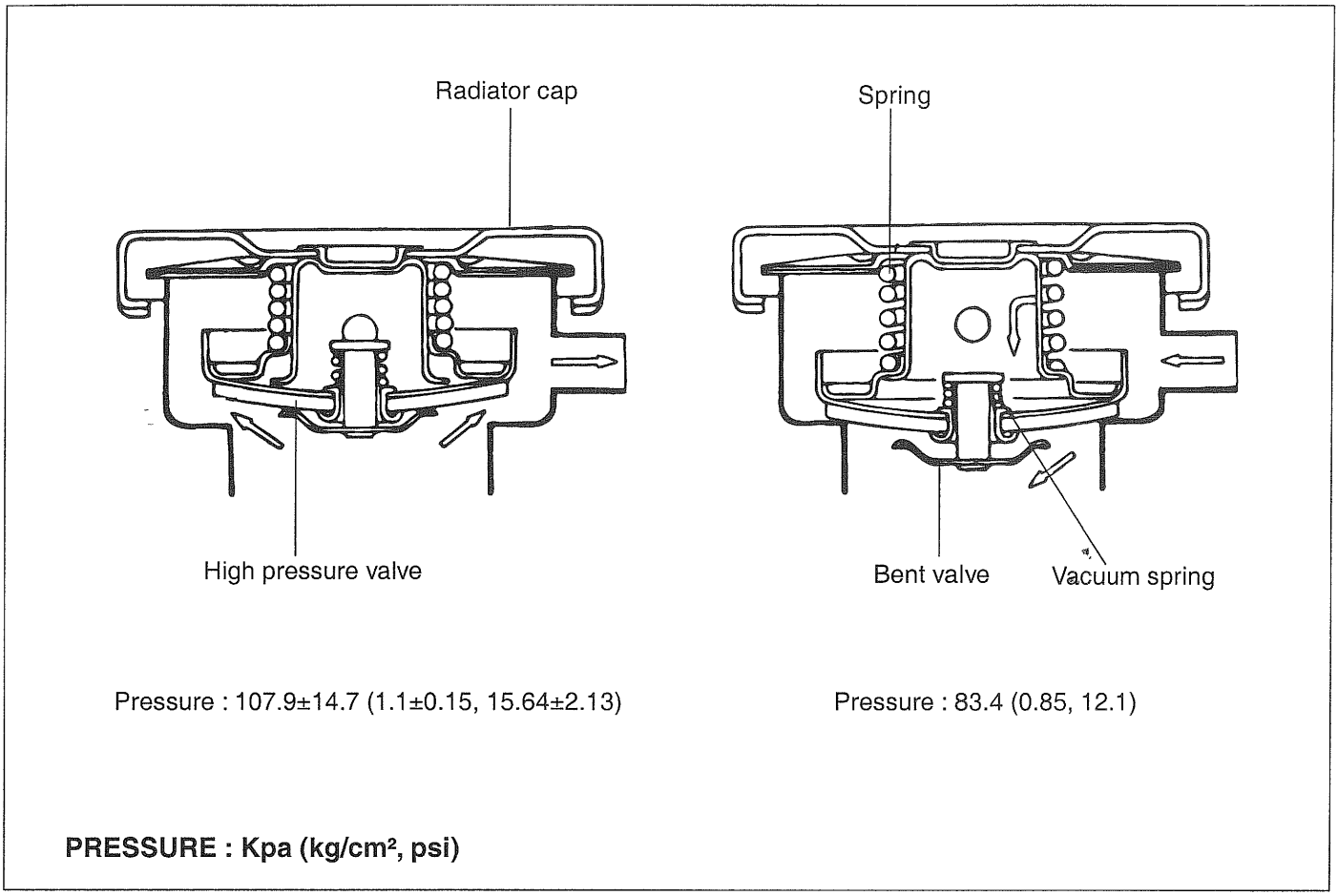
- *Make sure the cooling fan does not come into contact with the shroud when installed.*
- *After installation, make sure there is no unusual noise or vibration when the fan is rotating.*



ECA9061A

RADIATOR CAP

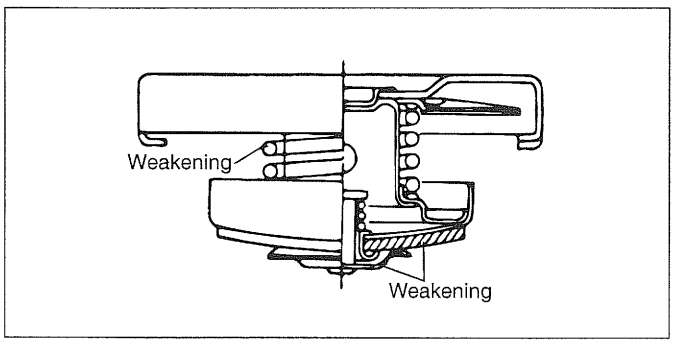
COMPONENTS ECHB7000



ECHA014A

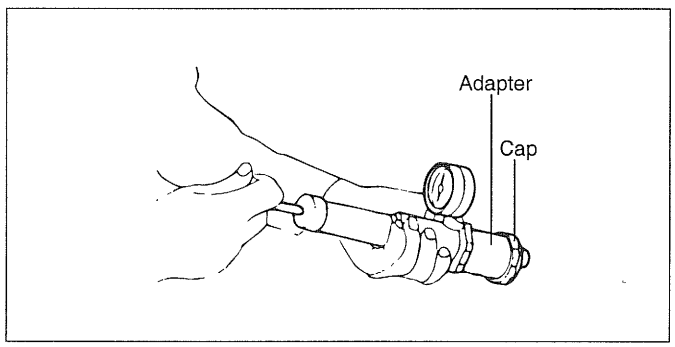
INSPECTION ECJA6300

1. Check the radiator cap for damage, cracks or weakening.



ECHA014B

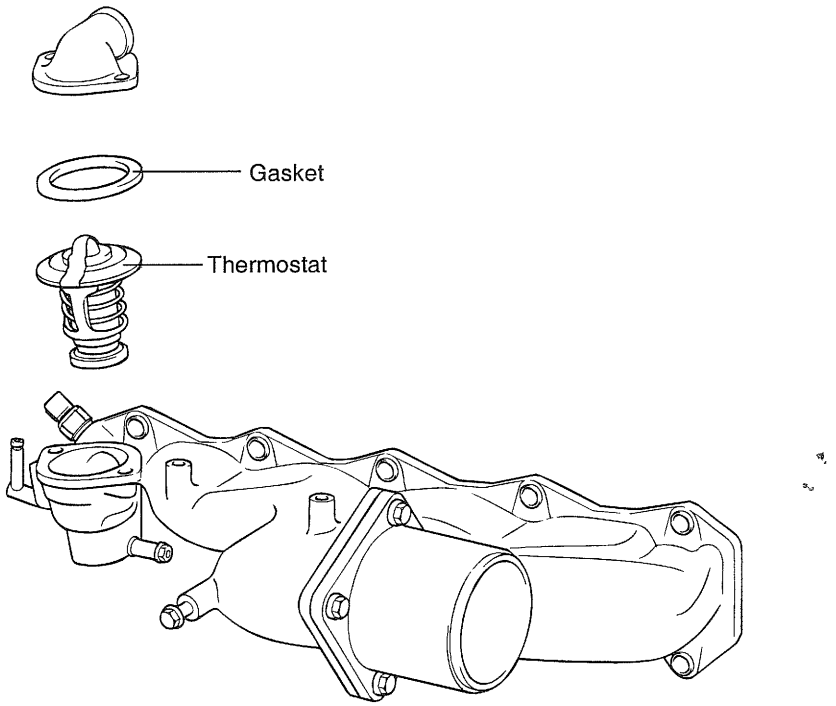
2. Connect the tester to the radiator cap.
3. Increase the pressure until the indicator stops moving.
4. Replace the radiator cap if the reading does not hold steady for about 10 seconds.



ECHA014C

THERMOSTAT

COMPONENTS ECHB7200



TORQUE : Nm (kg·cm, lb· ft)

KCHB015A

REMOVAL ECHA6700

1. Drain the coolant so its level is below the thermostat.
2. Remove the inlet fitting and gasket.
3. Remove the thermostat.

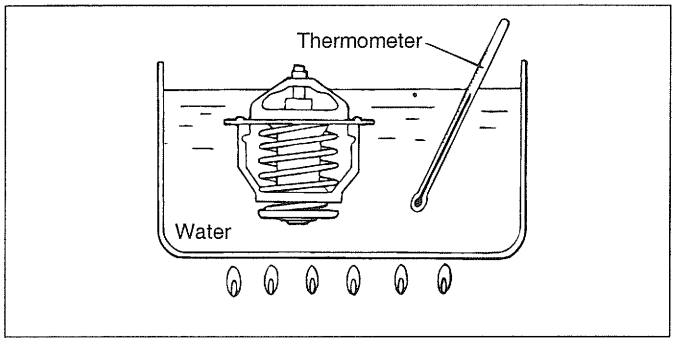
INSPECTION ECHA6800

1. Heat the thermostat as shown in the illustration.
2. Check that the valve operates properly.
3. Verify the temperature at which the valve begins to open.

Valve opening temperature :

80-84°C(176-183.2°F)

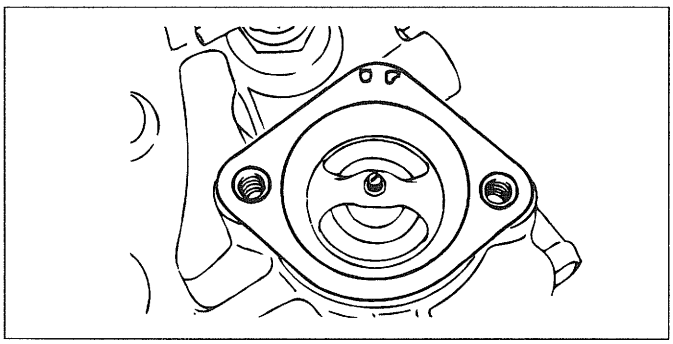
Full opening temperature : 95°C(203°F)



ECA9600A

INSTALLATION ECHA6900

1. Check that the flange of the thermostat is correctly seated in the socket of the thermostat housing.
2. Install the inlet fitting.



ECHA013B

Tightening torque

Engine coolant inlet fitting bolt :

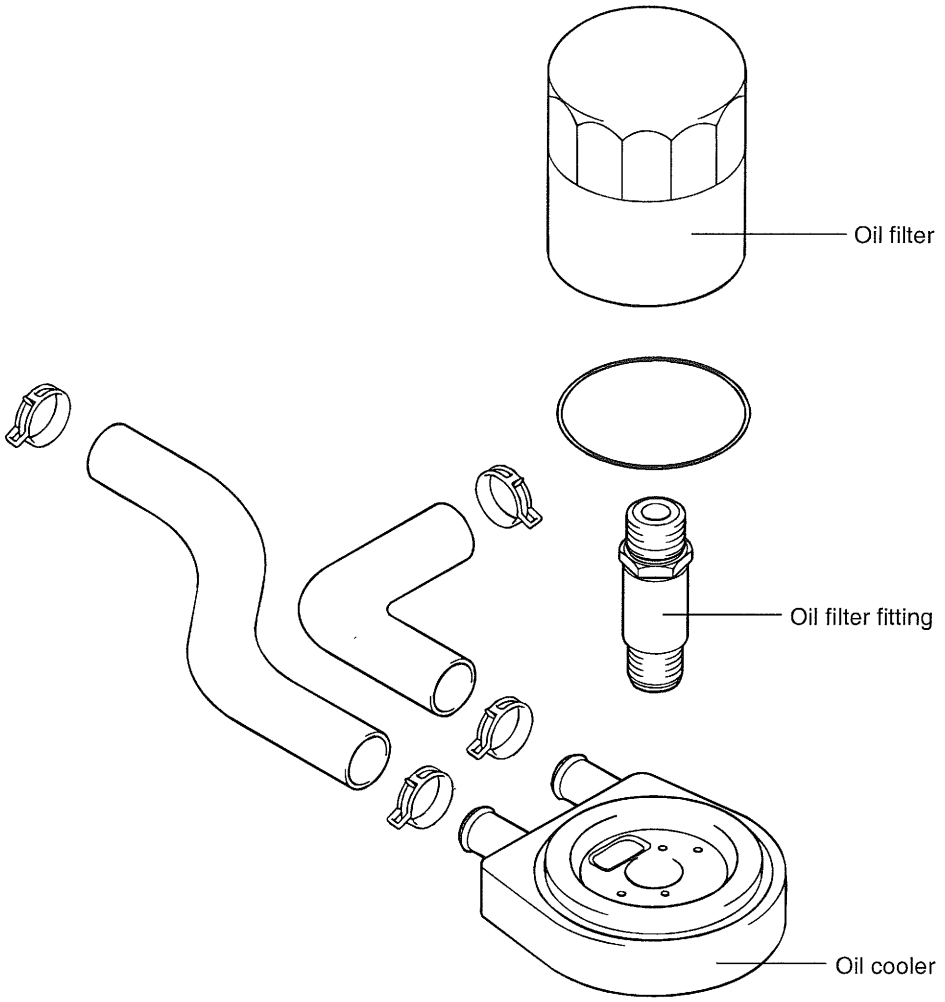
10-15Nm(100-150kg.cm, 7-11lb.ft)

3. Refill the coolant.

LUBRICATION SYSTEM

ENGINE OIL

COMPONENTS ECHB8500



TORQUE : Nm (kg.cm, lb·ft)

KCHB021A

REMOVAL ECHB8510

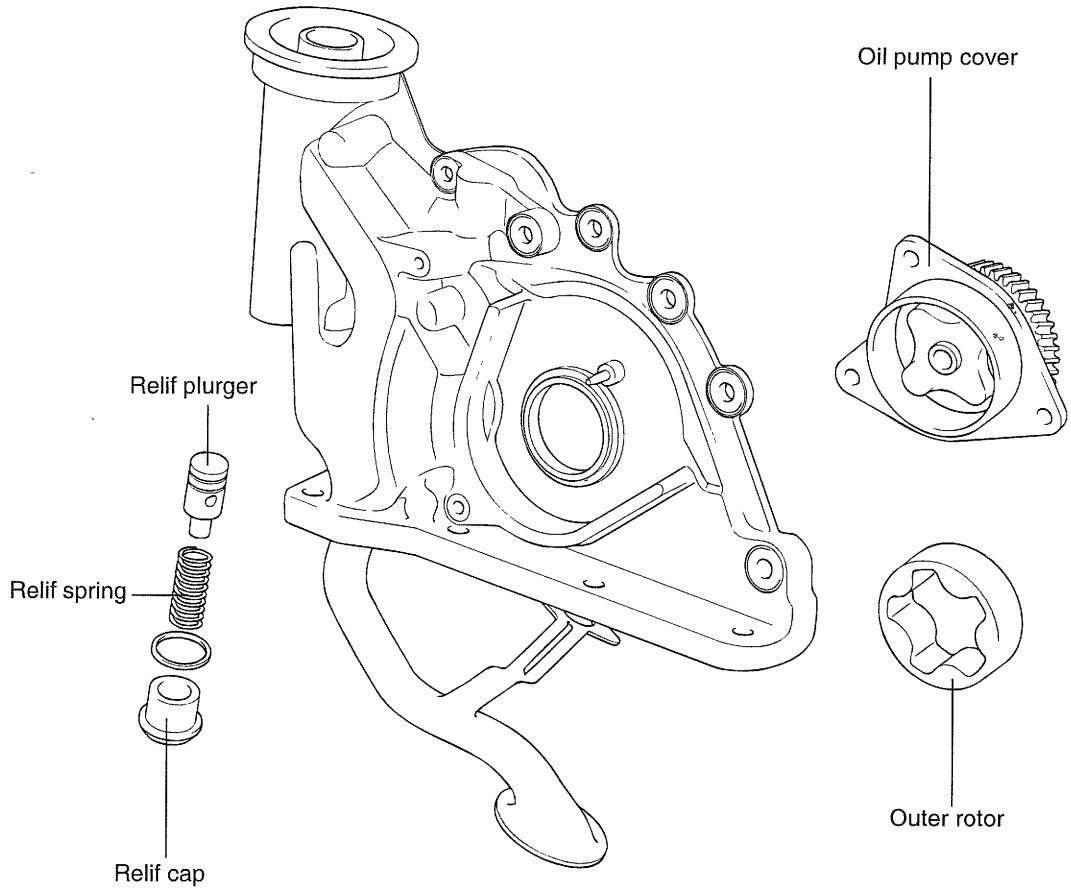
1. Remove the oil filter.
2. Remove the coolant hose from the oil cooler.
3. Remove the oil filter fitting.
4. Remove the oil cooler from the oil pump.

INSPECTION ECHB8520

1. Check for oil leaks.
2. Check the oil cooler for damage.

OIL PUMP

COMPONENTS ECHB8000



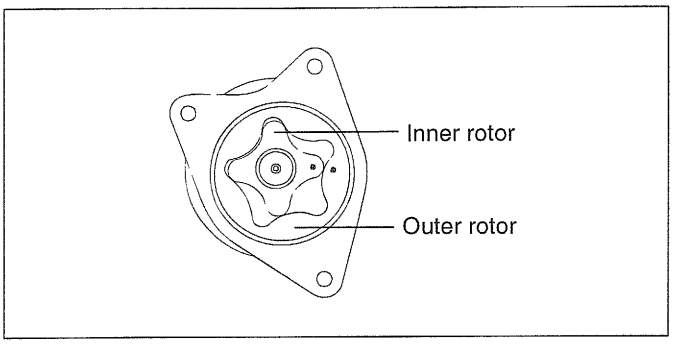
TORQUE : Nm (kg.cm, lb·ft)

KCHB009A

DISASSEMBLY ECHB8100

OIL PUMP

Before removing the oil pump outer and inner gears, mark the outer gear to make sure that it goes back to the position with correct direction.

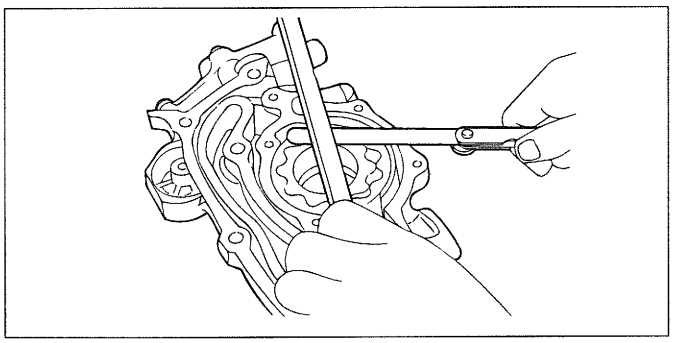


ECHB009B

INSPECTION ECHB8200

OIL PUMP

1. Install the outer and inner gear into the front case and make sure that they turn smoothly with no excessive play between them.
2. Check the side clearance (drive gear and drivengear))



EDA9340B

Standard : 0.02 - 0.07 mm (0.00078 - 0.0027 in.)

3. Check the tip clearance.

[Standard]

Drive gear : 0.12 - 0.2 mm (0.00472 - 0.0078 in.)

Driven gear : 0.13 - 0.23 mm (0.0051 - 0.009 in.)

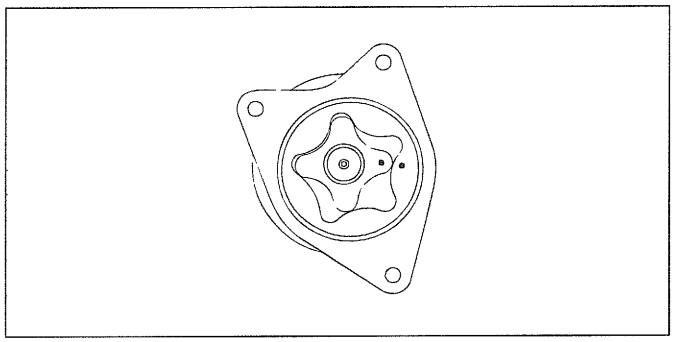
INSTALLATION ECHB8300

OIL PUMP

Install the outer gear, ensuring it is in position with correct direction according to the alignment mark made during disassembly.

NOTE

When installing the gears, be sure to apply engine oil to the entire surfaces of the gears.



KCHB009B

REMOVAL ECHB7700

OIL PRESSURE SWITCH

To remove the oil pressure switch, use Oil Pressure Switch Wrench.

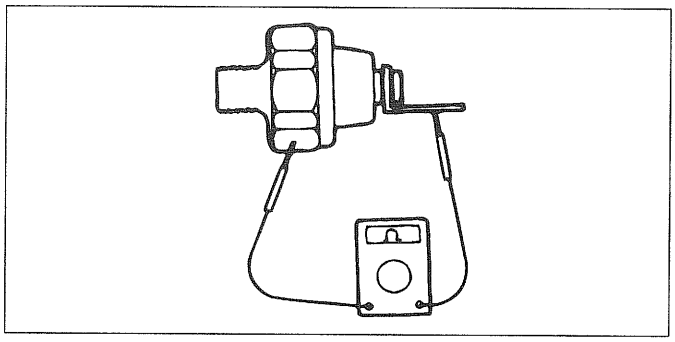
INSPECTION ECHB7800

OIL FILTER BRACKET

1. The oil filter mounting surface must be free from damage.
2. Check for cracks and oil leaks.
3. Make sure that the relief plunger slides smoothly and the relief spring is not damaged.

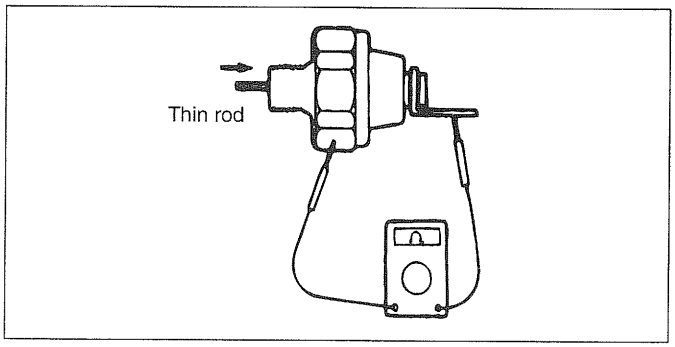
OIL PRESSURE SWITCH

1. Connect a tester (ohm range) between the terminal and the body of the switch to check for continuity. The switch is normal if there is continuity. If there is no continuity, replace the switch.



ECLA013C

2. Insert a thin rod in the oil hole of the switch and push it in lightly. The switch is normal if no continuity is detected (infinite resistance on the tester). If there is continuity, replace the switch.

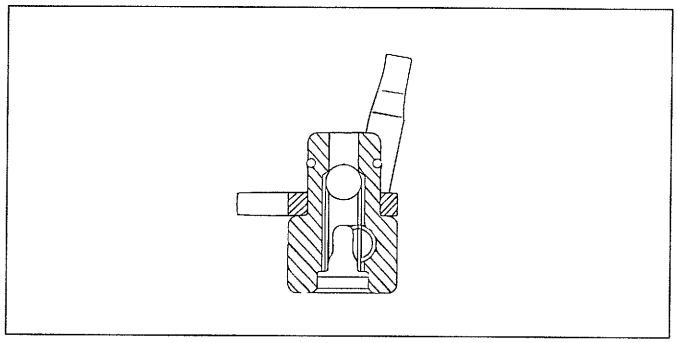


ECLA013D

3. Apply a 0.5 kg/cm² pressure to the oil hole. The switch is normal if there is no continuity. Also check for air leaks. If any air leaks are detected, the cause may be a broken diaphragm. Replace the switch if it leaks.

OIL JET, CHECK VALVE

1. Check the oil jet and check valve for clogging.
2. Check the oil jet for damage and deformation.



KCHB008D

INSTALLATION ECHB7900

OIL PRESSURE SWITCH

Before installation, apply sealant to the switch threads.

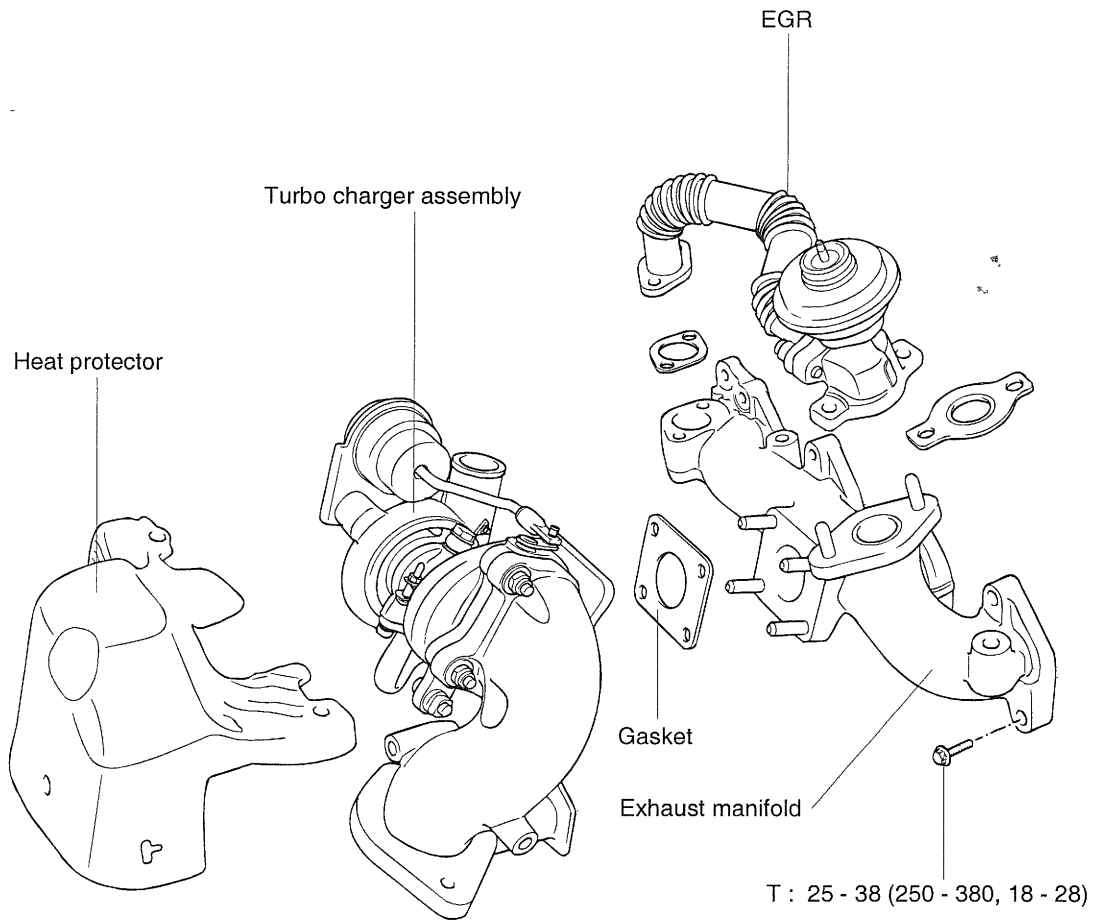
NOTE

The sealant must not get into the thread top surface. Use care not to torque excessively.

INTAKE AND EXHAUST SYSTEM

EXHAUST PIPE

COMPONENTS ECHB8600

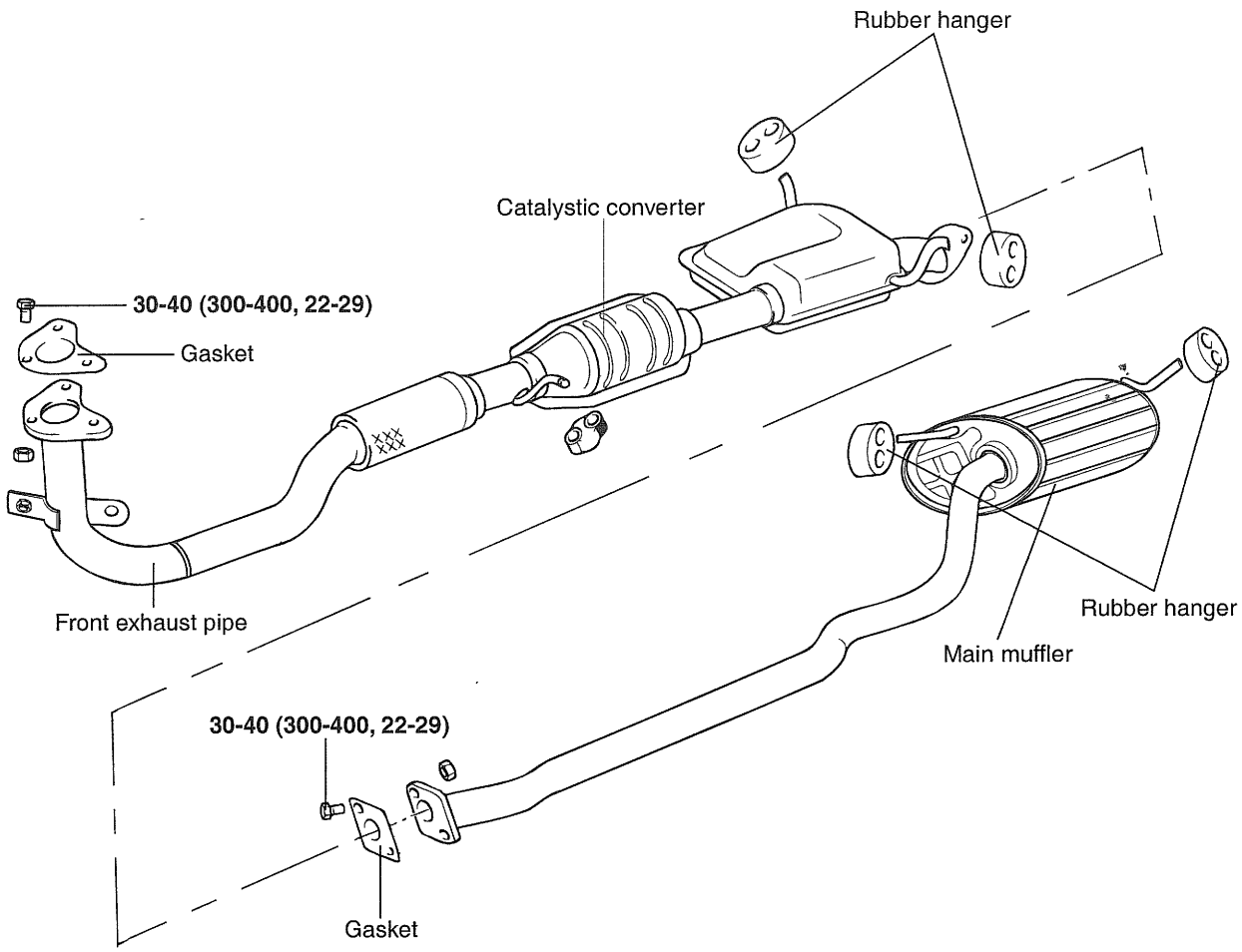


TORQUE : Nm (kg.cm, lb·ft)

KCHB010A

MUFFLER

COMPONENTS ECHB8700



TORQUE : N·m (kg·cm, lb·ft)

ECJA800A

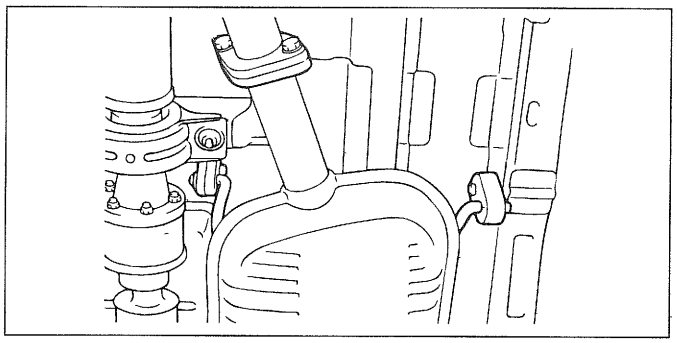
REMOVAL ECJA8100

MAIN MUFFLER

⚠ ***CAUTION***

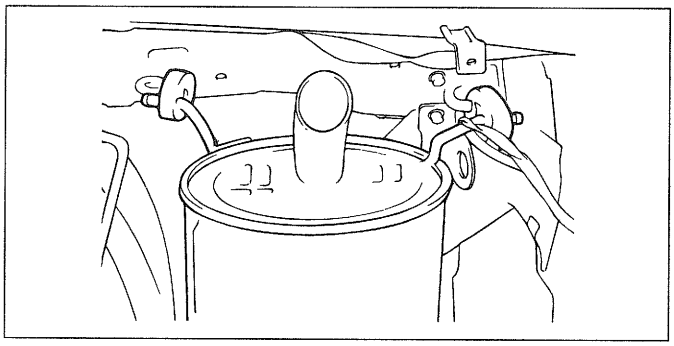
Before removing or inspecting the exhaust system, ensure that the exhaust system is cool.

1. Disconnect the main muffler from the center exhaust pipe.

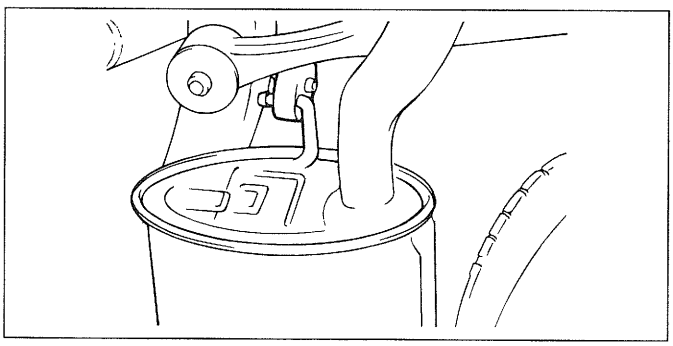


ECJA810A

2. Remove the rubber hangers and remove the main muffler.



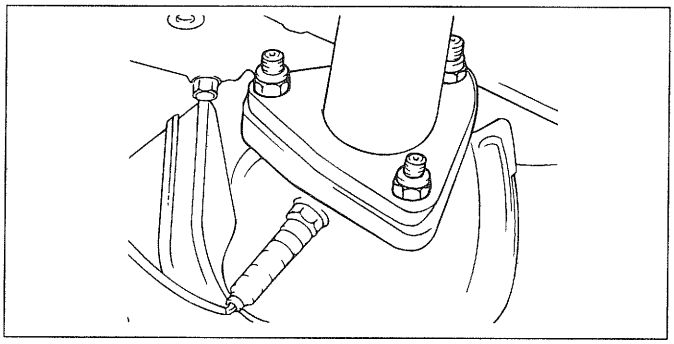
ECJA810B



ECJA810C

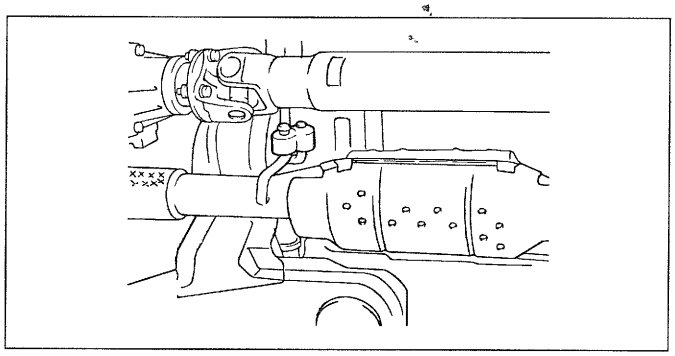
FRONT EXHAUST PIPE (INCLUDING CATALYTIC CONVERTER)

1. Remove the front exhaust pipe from the center exhaust pipe.
2. Remove the front exhaust pipe bolts and exhaust manifold pipe mounting nuts.

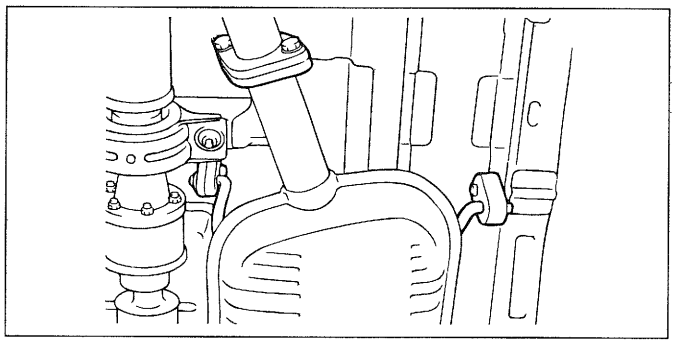


ECJA230B

3. Remove the front exhaust pipe from the rubber hanger.



EDJA810C



ECJA810A

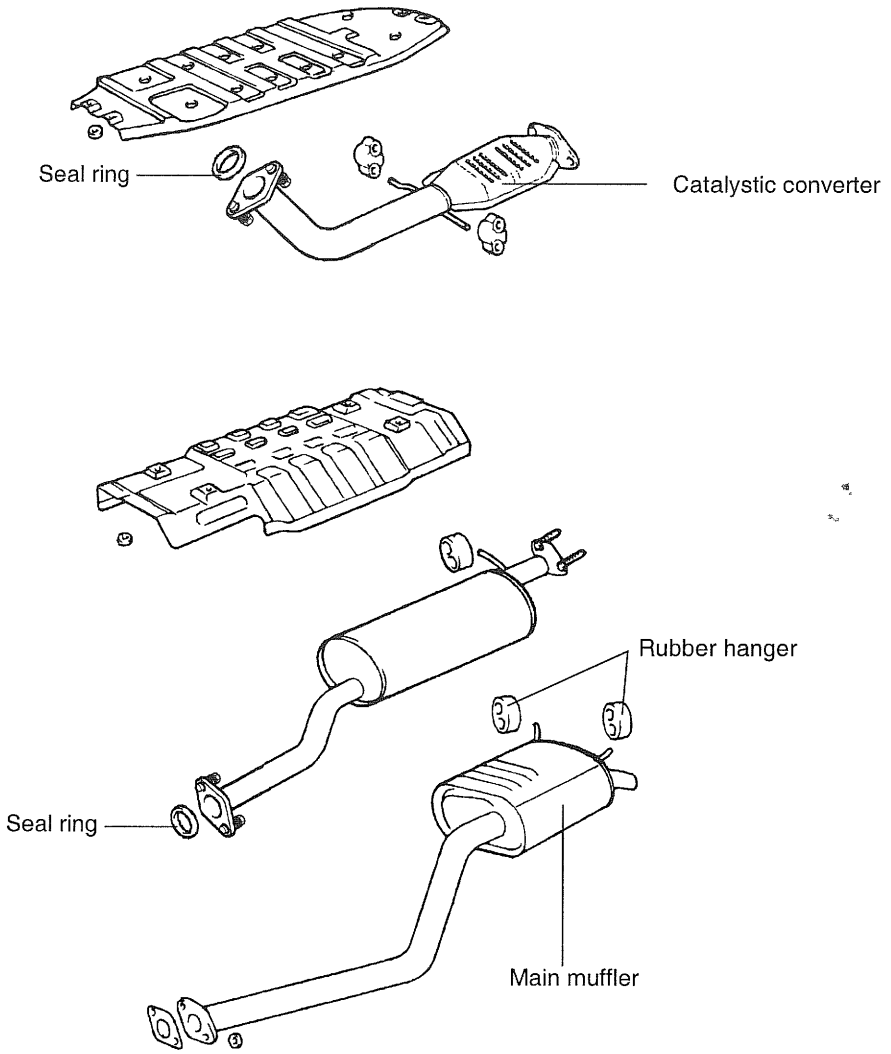
INSPECTION ECHA8200

1. Check the mufflers and pipes for leaks, corrosion and damage.
2. Check the rubber hangers for deterioration and cracks.

INSTALLATION ECJA8300

1. Temporarily install the front exhaust pipe (catalytic converter assembly), the center exhaust pipe and the main muffler in this order.
2. Install the rubber hangers so that they hang equally (left and right).
3. Tighten the parts securely and then confirm that there is no interference with any of components.

COMPONENTS ECHB8740



TORQUE : Nm (kg.cm, lb·ft)

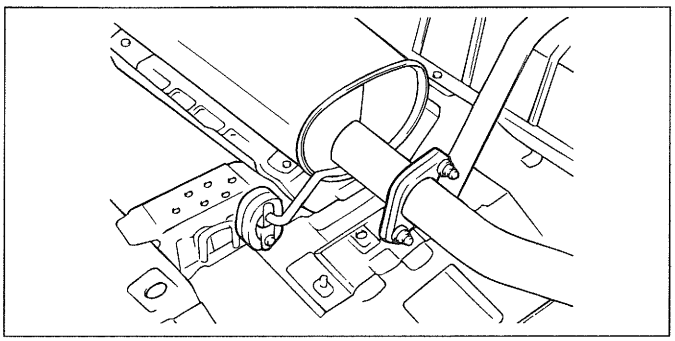
KCHB500A

REMOVAL ECHB8750

MAIN MUFFLER

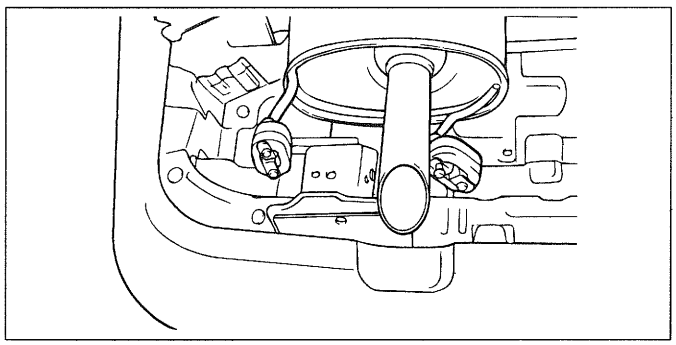
> ⚠ *CAUTION*
>
> ***Before removing or inspecting the exhaust system, ensure that the exhaust system is cool enough.***

1. Disconnect the main muffler from the center exhaust pipe.



ECHA019E

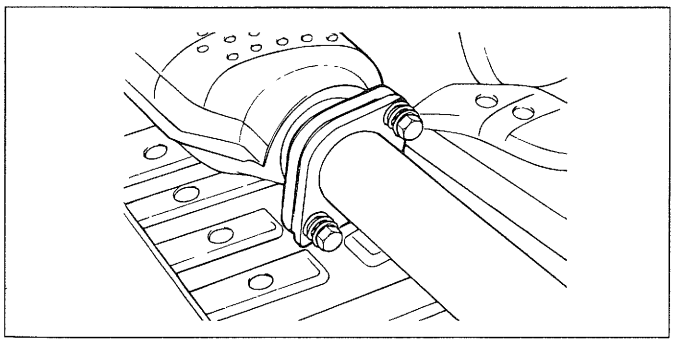
2. Remove the rubber hangers and take out the main muffler.



ECHA019B

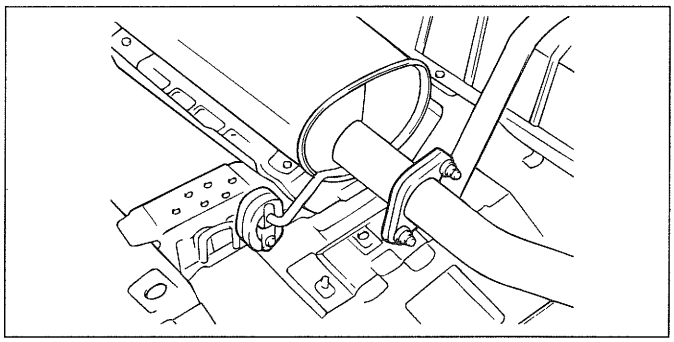
CENTER EXHAUST PIPE

1. Disconnect the center exhaust pipe from the main muffler.
2. Remove the center exhaust pipe from the front exhaust pipe.



KCHB500C

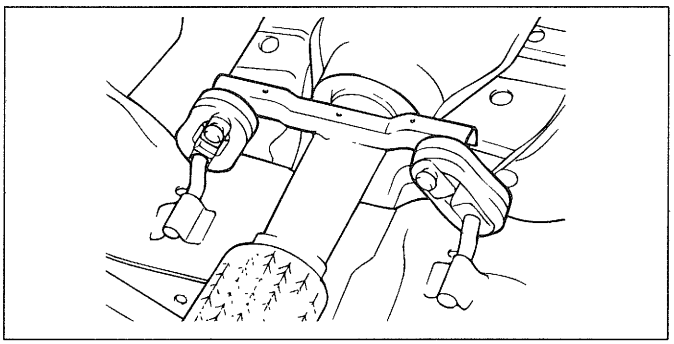
3. Remove the rubber hangers and take out the center exhaust pipe.



ECHA019E

FRONT EXHAUST PIPE (INCLUDING CATALYTIC CONVERTER)

1. Remove the front exhaust pipe from the center exhaust pipe.
2. Remove the front exhaust pipe bolts and exhaust manifold pipe mounting nuts.
3. Remove the front exhaust pipe from the rubber hanger.



ECHA019H

INSTALLATION ECHB8770

1. Temporarily, install the front exhaust pipe (catalytic converter assembly), the center exhaust pipe and the main muffler in this order.
   Assembly procedure

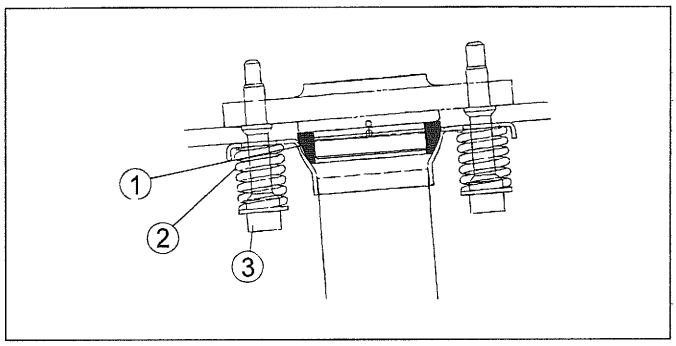
   1) Insert seal ring into exhaust manifold flange.

   2) Insert spring into bolt.

   3) Tighten left side lightly after tightening right side lightly.

   4) Tighten left side after tightening right side according to the torque indicated.

   5) The distance (8.5 mm : Between flanges) must be checked.



KCHB501B

NOTE

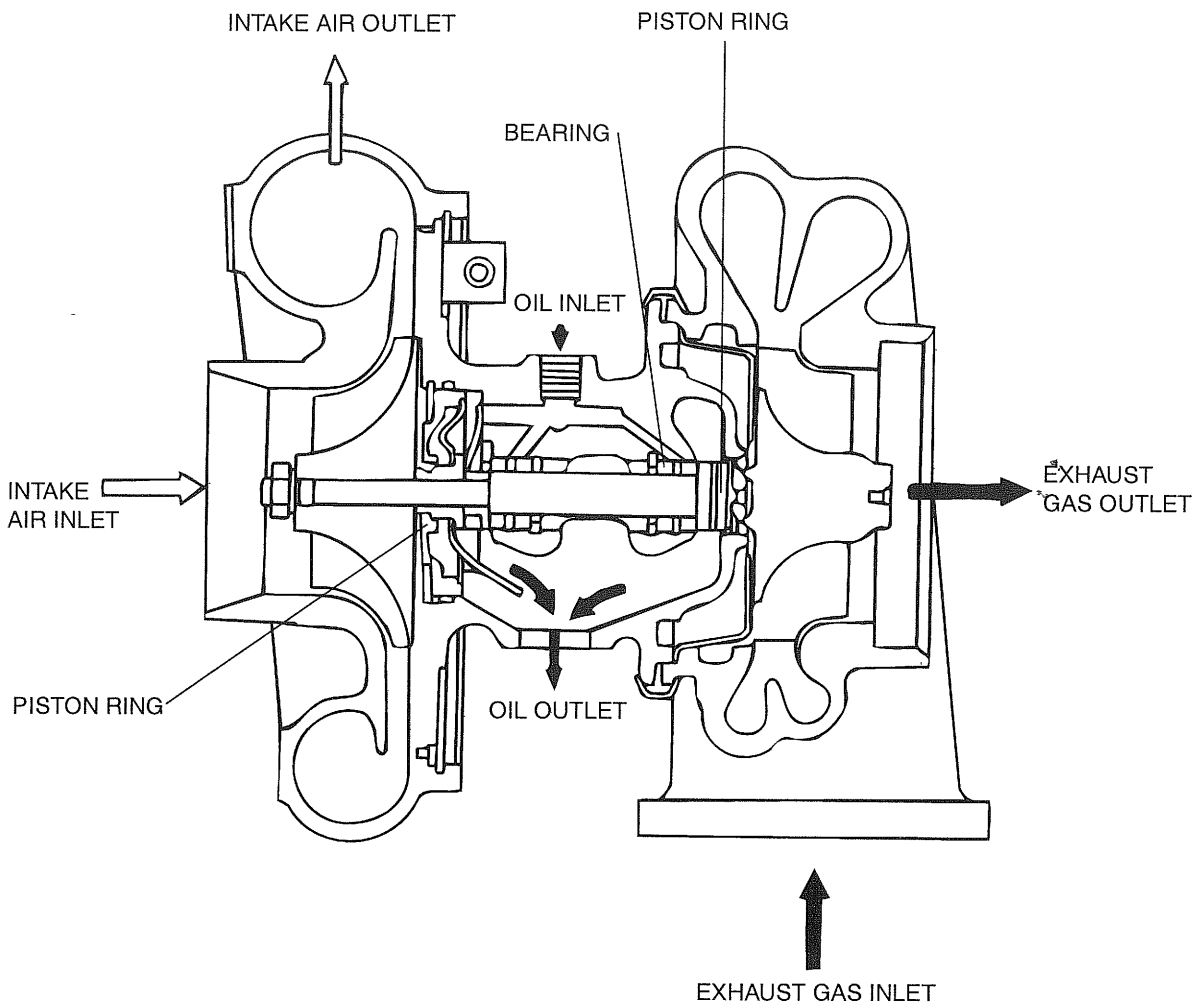
Whenever installing the seal ring, always replace a new one.

2. Install the rubber hangers so that they can be identical (left and right) in length.

3. Tighten the parts securely and then confirm that there is no interference with any of components.

TURBO CHARGER (TC)

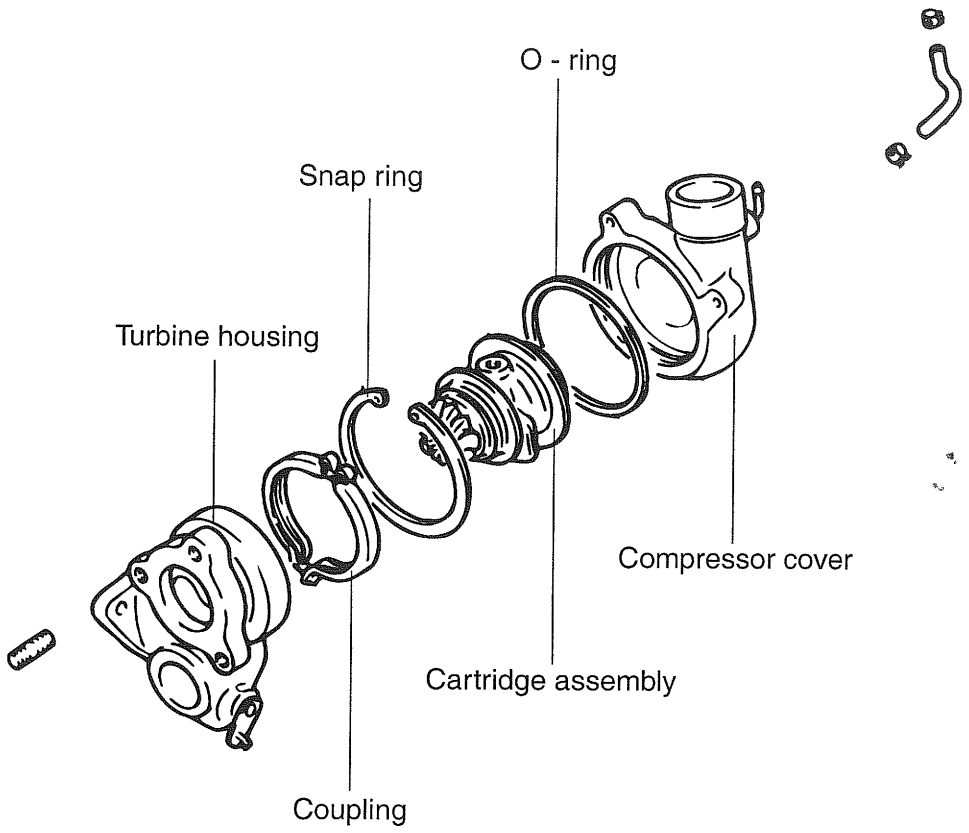
COMPONENTS ELCB0650



TORQUE : Nm (kg.cm,lb.ft)

ECLB002A

COMPONENTS ELCB0660



*** Replace the gasket with new ones after removal.**

TORQUE : Nm (kg.cm,lb.ft)

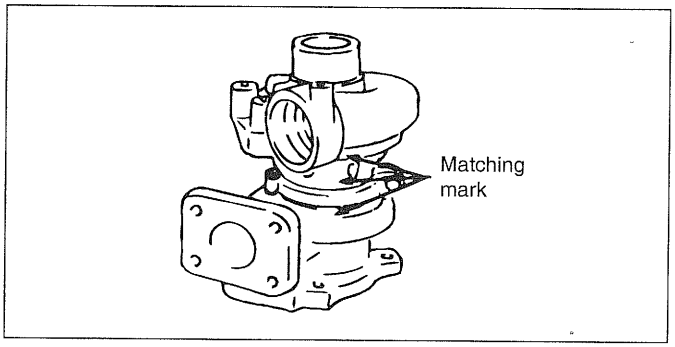
ECLA016A

DISASSEMBLY ECHB8820

1. Before removal, make the matching mark on compressor cover bearing housing and turbine housing.

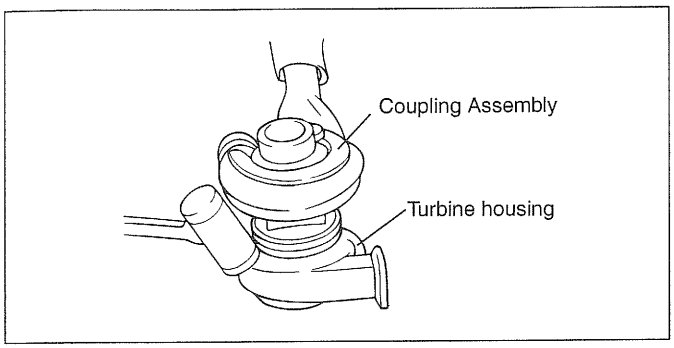
   ⚠ *CAUTION*

   Be sure not to damage the compressor and turbine wheel blade.



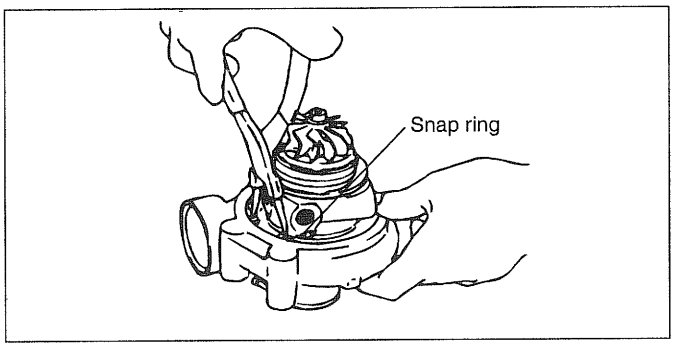
ECLA016B

2. Loosen the assembly and tap the housing by plastic hammer when removing the housing.



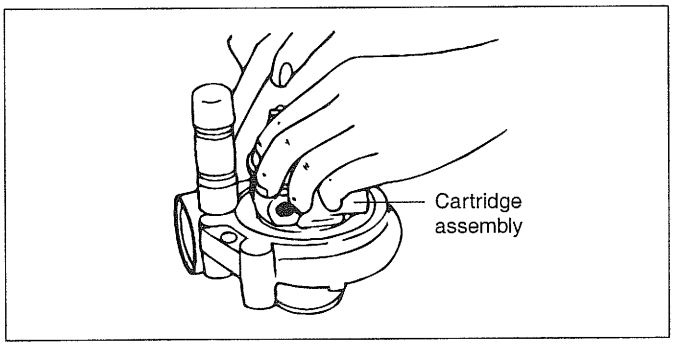
H7ET008B

3. Remove the snap ring using snap ring filler.



ECLA016C

4. Remove by tapping the compressor cover of cartridge assembly with plastic hammer.



ECLA016D

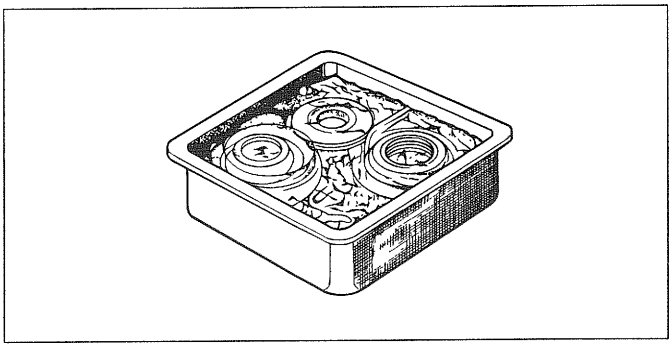
CLEANING

1. Use a heavy duty carbon solvent to loosen the carbon from the parts.

   ⚠ *CAUTION*

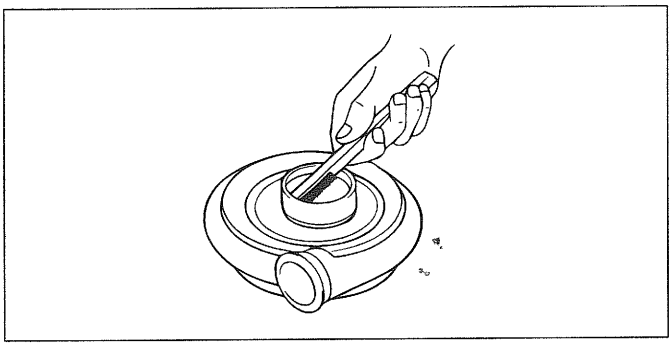
   Do not use caustic solutions, wire brushes, or wire wheels to remove carbon deposits from any turbo charger part.

2. A small, closed, agitated cleaning tank and solvent will give the best results.



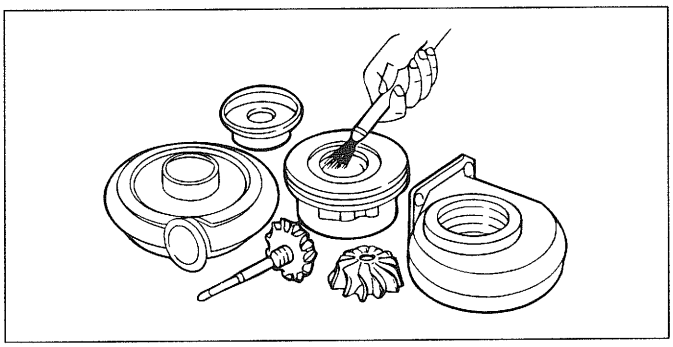
H7ET009A

3. After the carbon is loosened, use a hard, bristle type brush and remove all dirt particles.



H7ET009B

4. Clean all drilled passages with air under pressure and put oil on cleaned parts to prevent corrosion.



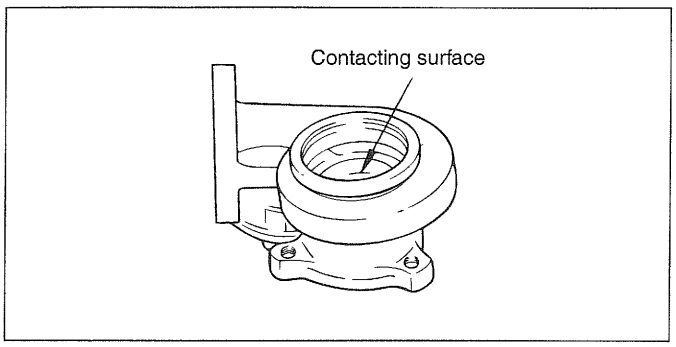
H7ET009C

INSPECTION

1. Check the inner housing contacting turbine wheel for crack, pitching and other damages caused by over-heat.

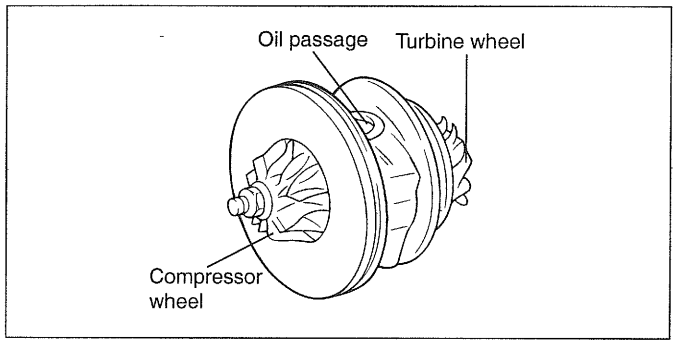
2. Make sure that the waste gate valve lever operates freely by hands.

3. Make sure there are no damages on the inner housing surface contacting compressor wheel.



ECLA016E

4. Turbine wheel and shaft assemblies with cracks in the blades or broken blades can not be used again. If the blades are slightly bent, it can be used again but severely bent blades can not be reused.



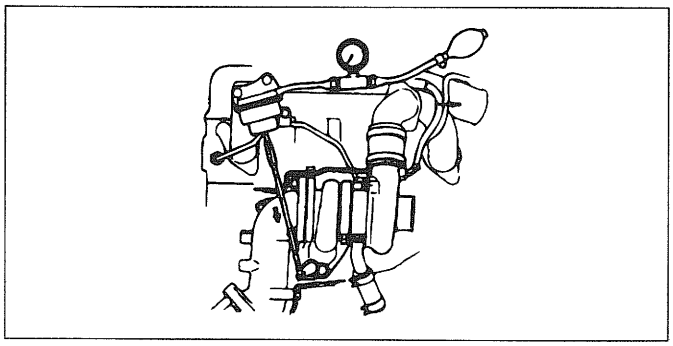
ECLA016F

5. Check if there are foreign materials disturbing the oil flow in the oil passage of cartridge assembly.

WASTE GATE INSPECTION

1. Check the waste gate rod operation under the pressure below.

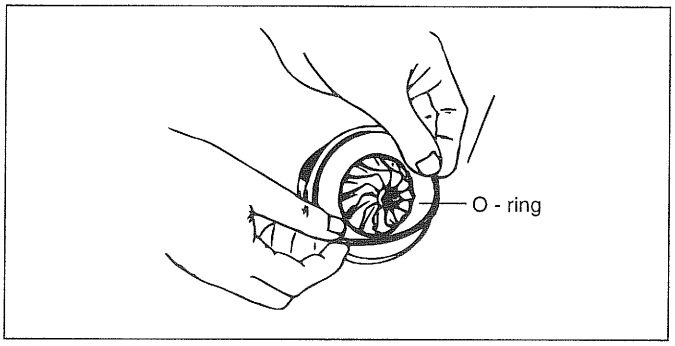
Nominal Value : 77.5 kPa (0.79 kgf / cm²)



ECLA016J

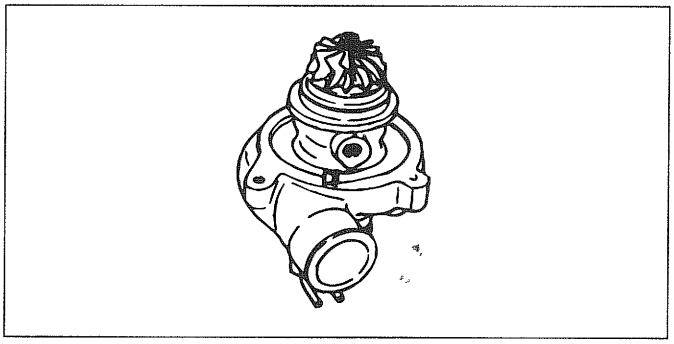
REASSEMBLY ELCB0690

1. Apply engine oil to new O-ring and insert the O-ring to the groove of cartridge assembly.



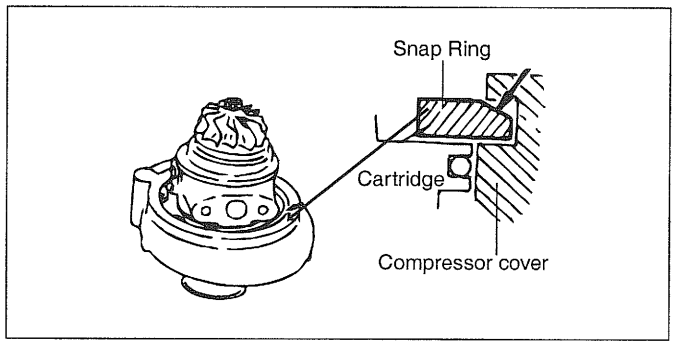
ECLA016G

2. Assemble cartridge assembly and compressor cover matching the mark.



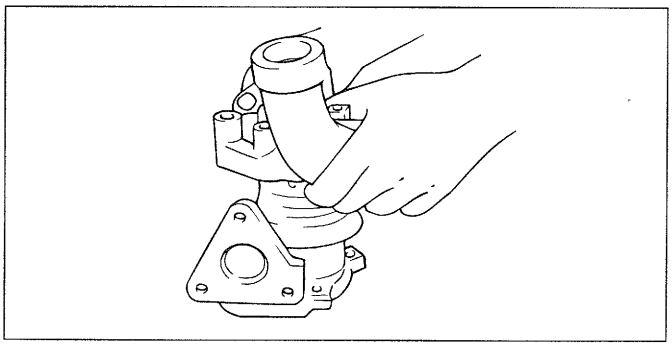
ECLA016H

3. Install the snap ring as shown in the figure.



ECLA016I

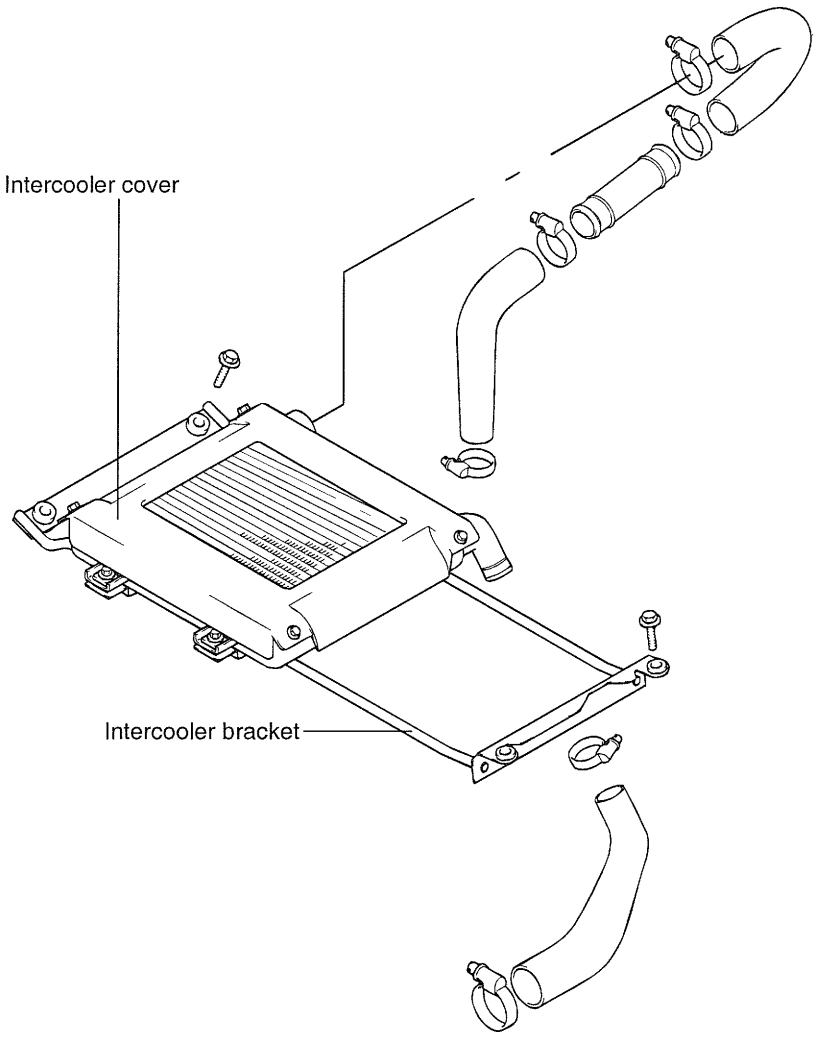
4. Before reassembly, make sure that the turbine housing matching mark is matched with compressor cover and cartridge assembly.



H7ET010D

INTERCOOLER

COMPONENTS ECHB8840



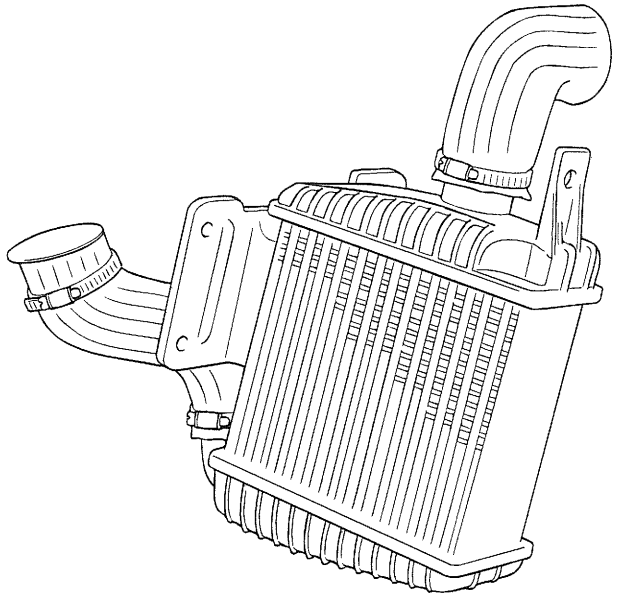
TORQUE : Nm (kg.cm, lb·ft)

KCHB011A

REMOVAL ECHB8850

1. Remove the intercooler cover.
2. Disconnect the fan motor and air temperature switch connector.
3. Remove the air hoses.
4. Remove the intercooler assembly.
5. Remove the fan motor assembly.
6. Remove the intercooler bracket.

COMPONENTS ECHB8860



TORQUE : Nm (kg·cm, lb· ft)

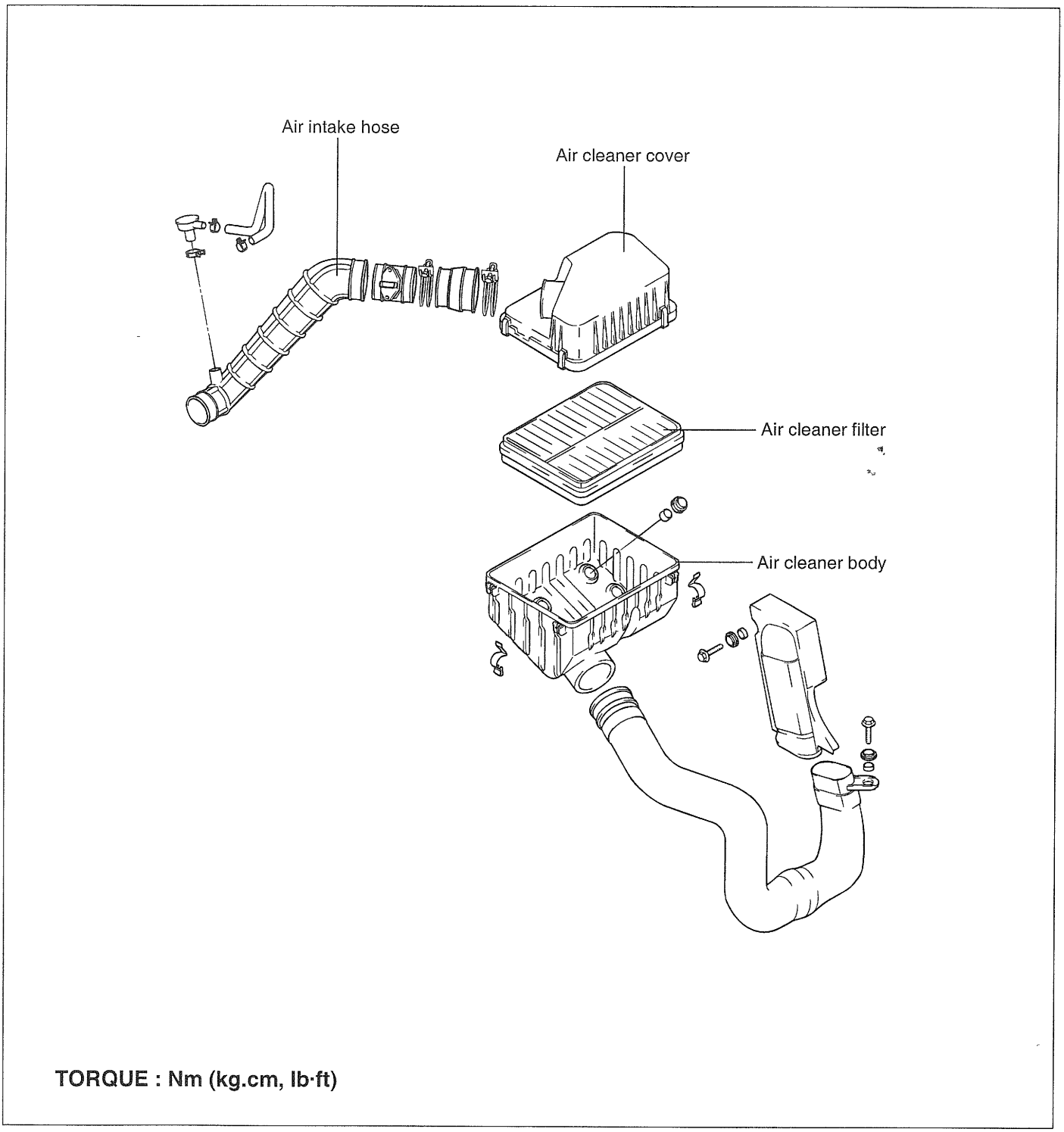
KCHB011B

REMOVAL ECHB8870

1. Remove the front tire (Driver side).
2. Remove the inner fender protector (Driver side).
3. Remove the battery.
4. Remove the air hoses.
5. Remove the intercooler assembly.

AIR CLEANER (ACL)

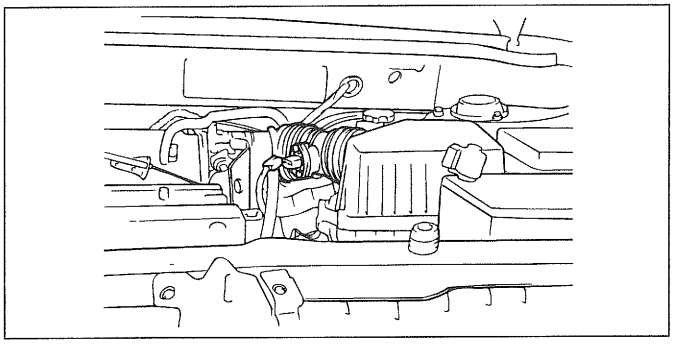
COMPONENTS ECHB8900



KCHB023A

REMOVAL ECHB8910

1. Disconnect the air flow sensor connector.
2. Remove the air intake hose at the air cleaner.
3. Remove the three bolts attaching the air cleaner mounting brackets.
4. Detach the air cleaner.



ECJA870B

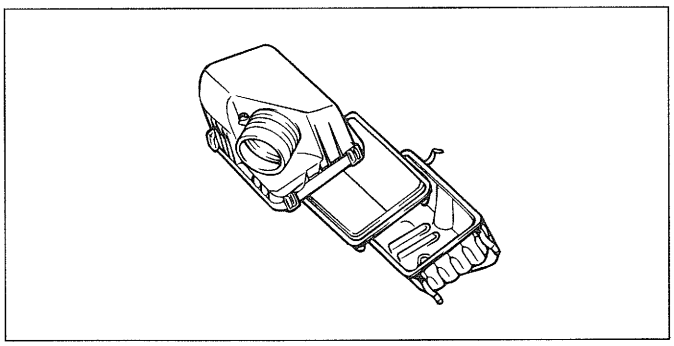
5. Remove the air flow sensor from the air intake hose.

⚠ ***CAUTION***

Do not pull on the air flow sensor wires.

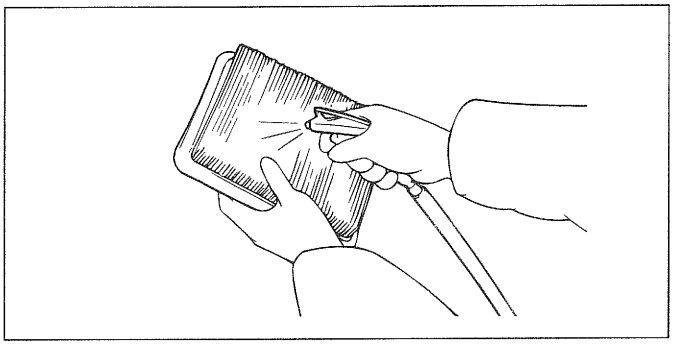
INSPECTION ECJA8700

1. Check the air cleaner body, cover, or filter for distortion, corrosion or damage.
2. Check the air duct for damage.



ECJA870A

3. Check the air cleaner element for restriction, contamination or damage. If the element is slightly restricted, remove the dust and debris by blowing compressed air from the inside of the element.



ECA9066A

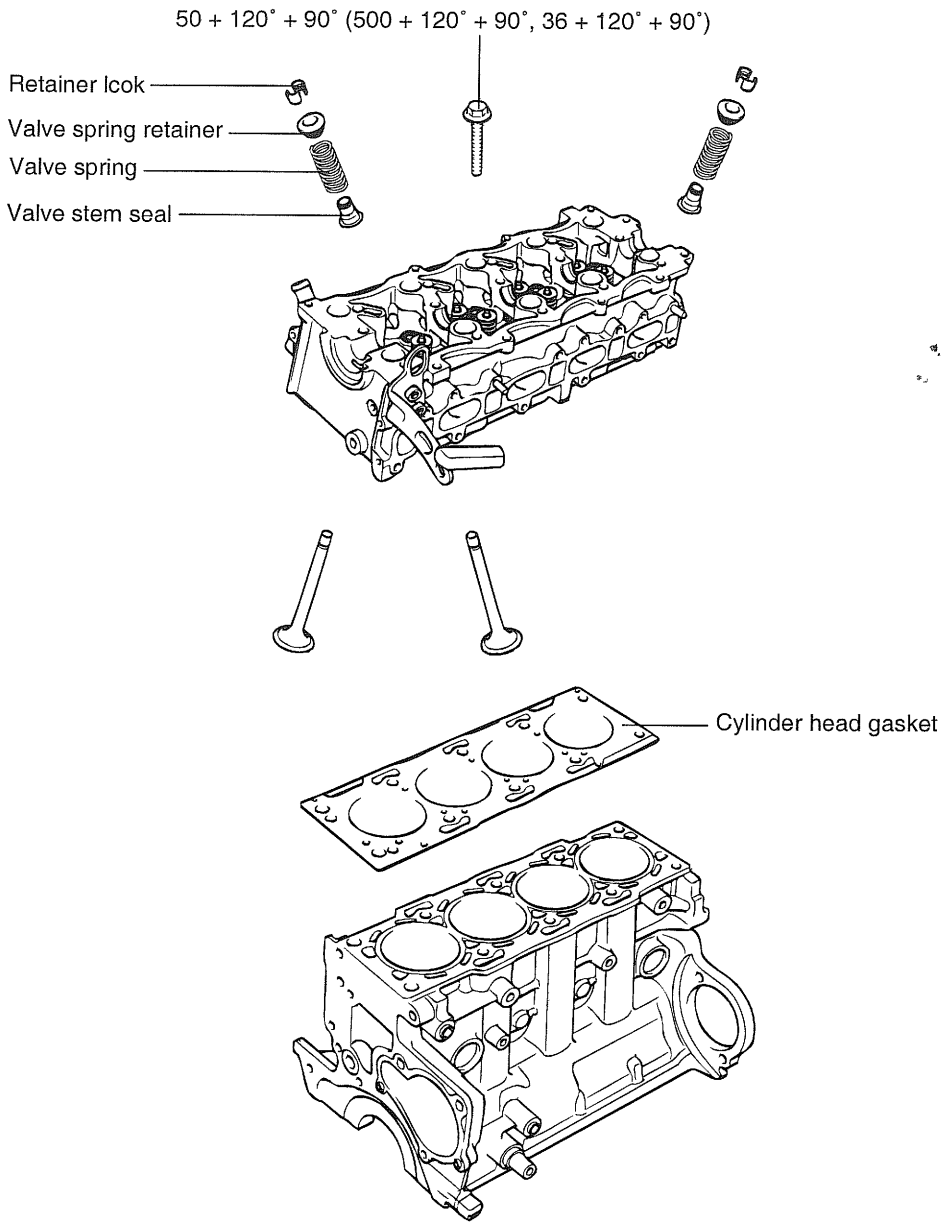
INSTALLATION ECHA8800

Install the air cleaner assembly following the reverse order of removal.

CYLINDER HEAD ASSEMBLY

CYLINDER HEAD

COMPONENTS ECHB8950

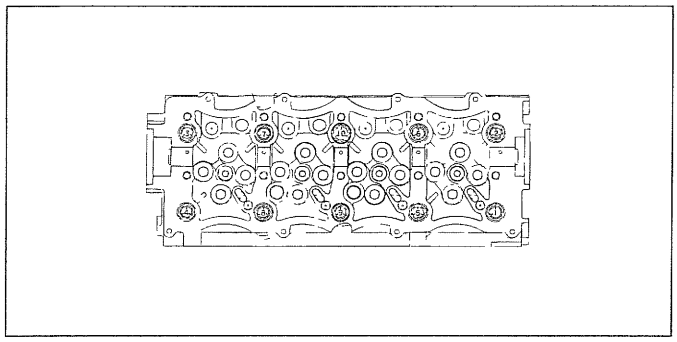


TORQUE : Nm (kg.cm, lb·ft)

KCHB012A

DISASSEMBLY ECHB8960

1. Rmove the cylinder head bolts in the order shown in the illustration.

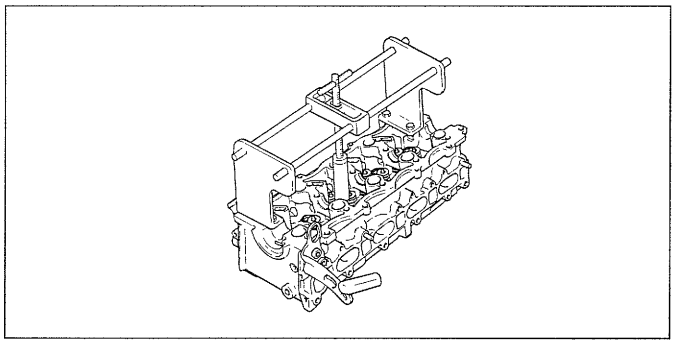


KCHB012B

2. Using the special tool (09222 - 27300) remove the valve spring retainer lock. Then remove the spring retainer, valve spring, spring seat and valve.

NOTE

Arrange these parts so that they can be reinstalled in their original positions.

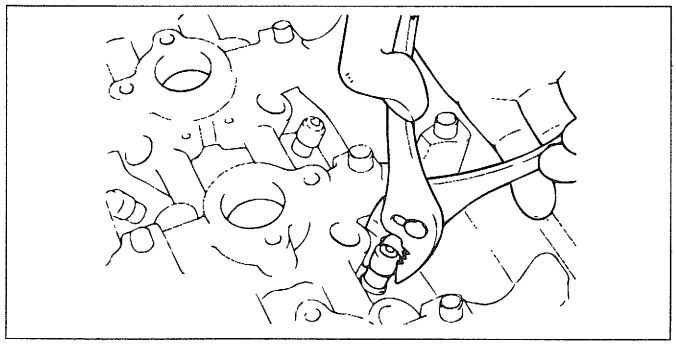


KCHB012F

3. Remove the valve stem seals with pliers.

NOTE

Do not reuse the valve stem seals.



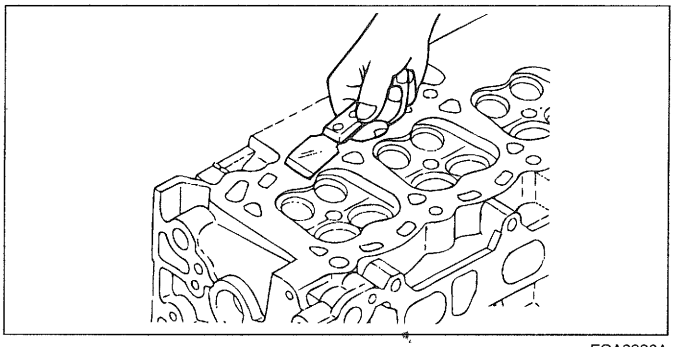
ECA9270C

INSPECTION ECHB8970

CYLINDER HEAD

1. Check the cylinder head for cracks, damage and coolant leakage. If cracked, replace the cylinder head.

2. Remove scale, sealing compound and carbon deposits completely. After cleaning the oil passages, apply compressed air to verify that the passages are not clogged.



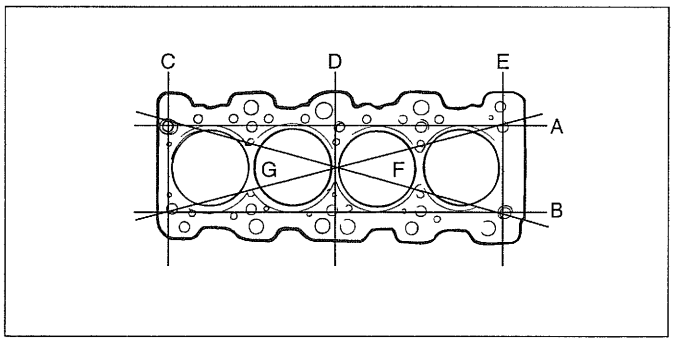
ECA9280A

3. Check the cylinder head surface for flatness in the direction as shown in the illustration. If flatness exceeds service limit in any direction, either replace the cylinder head or machine the cylinder head matching surface lightly.

Flatness of cylinder head gasket surface

Standard : Less than 0.03mm(0.0012 in.)

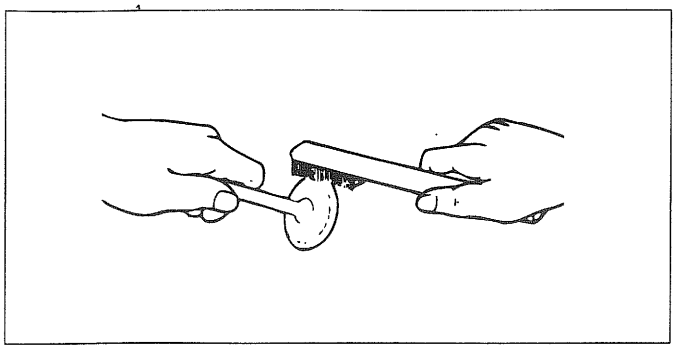
Limit : 0.2 mm (0.008 in.)



ECHA920A

VALVES

1. Using a wire brush, clean the valve thoroughly.



ECA9281A

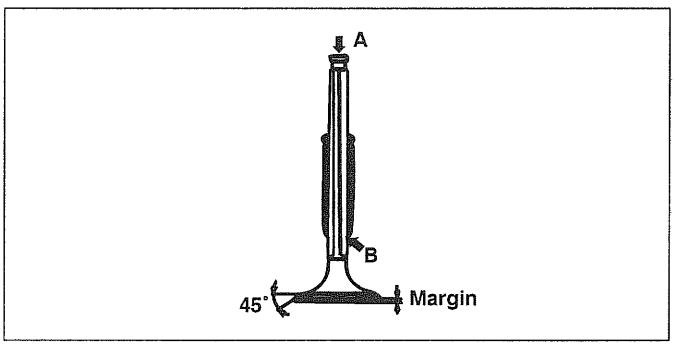
2. Check each valve for wear, damage and distortion of the head and the stem at B Position. Replace, if necessary. If stem end, A, is hollowed out or worn, resurface as necessary. This correction must be limited to a minimum. Also resurface the valve face.
Replace the valve if the margin has decreased to less than the service limit.

Margin

[Standard]

Intake : 1.6 mm (0.063 in.)

Exhaust : 1.3 mm (0.0512 in.)



ECA9281B

VALVE SPRINGS

1. Check the free height of each valve spring. If they exceed the service limit, replace the springs.

2. Using a square, test the squareness of each spring. If a spring is excessively out- of-square, replace it.

Valve spring

[Standard]

Free height : 38.7 mm(1.52 in.)

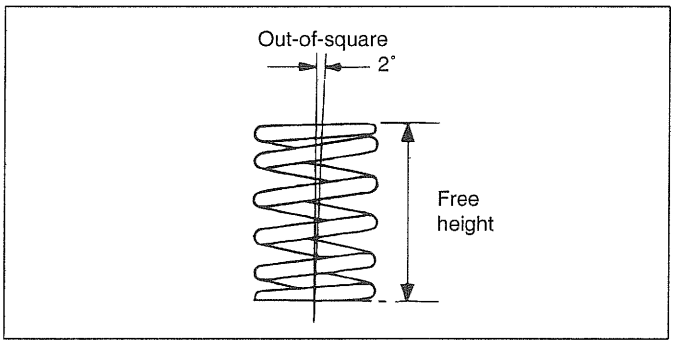
Load : 21.4 kg / 32 mm (47.2 lb / 1.26 in.)

Out of square : 1.5° or less

[Limit]

Free height : 37.7 mm (1.48 in.)

Out of square : 4°



ECA9281C

VALVE GUIDES

Check the valve stem-to-guide clearance. If the clearance exceeds the service limit, replace the valve guide with the next oversize part.

Valve stem-to-guide clearance

[Standard]

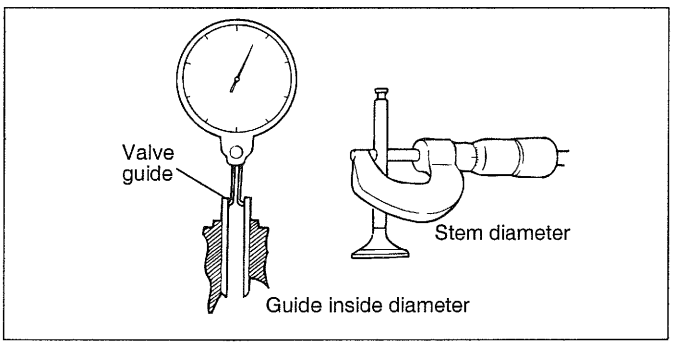
Intake : 0.020 - 0.049 mm (0.0008 - 0.0020 in.)

Exhaust : 0.050 - 0.077 mm (0.0020 - 0.0033 in.)

[Limit]

Intake : 0.1 mm (0.0040 in)

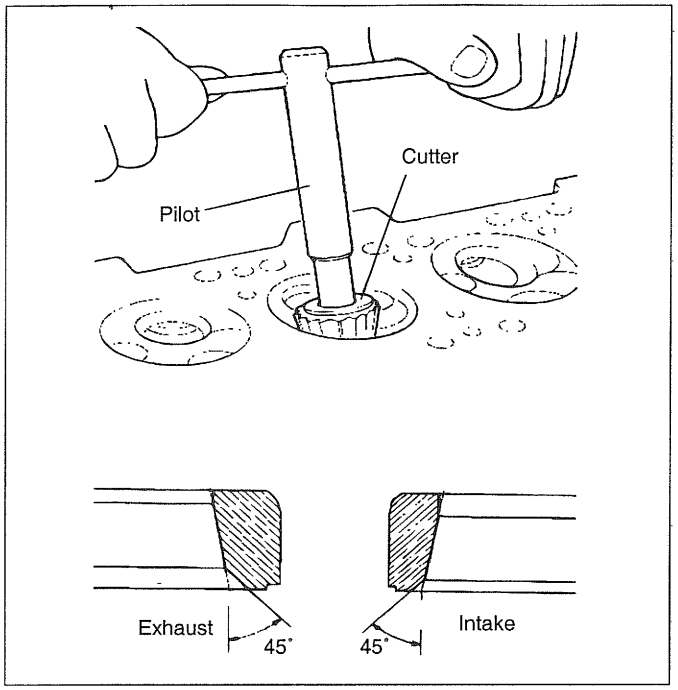
Exhaust : 0.15 mm (0.0059 in.)



ECA9281D

RECONDITIONING VALVE SEAT

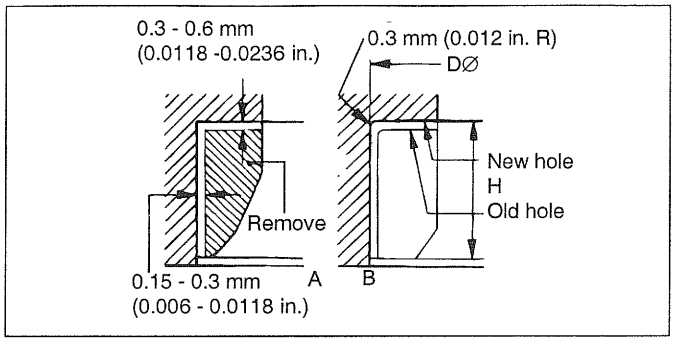
Check the valve seat for overheating and unequal contact with the valve face. Recondition or replace the seat if necessary. Before reconditioning the seat, check the valve guide for wear. If the valve guide is worn, replace it and then recondition the seat. Recondition the valve seat with a valve seat grinder or cutter. The valve seat contact width should be within specificatons and centered on the valve face. After reconditioning, the valve and valve seat should be lapped lightly with a lapping compound.



ECHA920B

REPLACING THE VALVE SEAT RING

1. Cut away the inner face of the valve seat to reduce the wall thickness.



ECA9281F

2. Enlarge the diameter of the valve seat so that it matches the specified oversize hole diameter of the new valve seat ring.
3. Heat the cylinder head to about 250°C (480°F) and press-fit an oversize seat ring for the bore in the cylinder head.
4. Using lapping compound, lap the valve to the new seat.

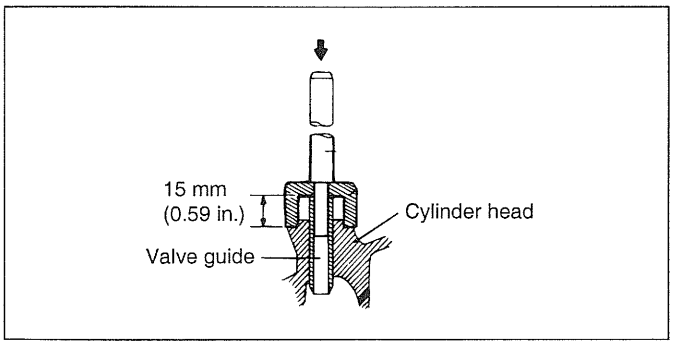
Valve seat contact width :
IN : 1.21 mm (0.0477 in.)
EX : 1.61 mm (0.0634 in.)

VALVE SEAT INSERT OVERSIZES

Description	Size mm (in.)	Size mark	Oversize hole diameter I.D. mm (in.)
Intake valve	0.3 (0.012) O.S.	30	29.993 - 30.006 (1.18 - 1.1813)
Seat ring	0.6 (0.024) O.S.	60	30.023 - 30.036 (1.182 - 1.1825)
Exhaust valve	0.3 (0.012) O.S.	30	25.393 - 25.406 (0.9997 - 1.0002)
Seat ring	0.6 (0.024) O.S	60	25.423 - 25.436 (1.0009 - 1.0014)

REPLACING VALVE GUIDE

1. Using the special tool (09222 - 27000), withdraw the old valve guide toward the bottom of cylinder head.
2. Recondition the valve guide hole so that it can match the newly press-fitted oversize valve guide.

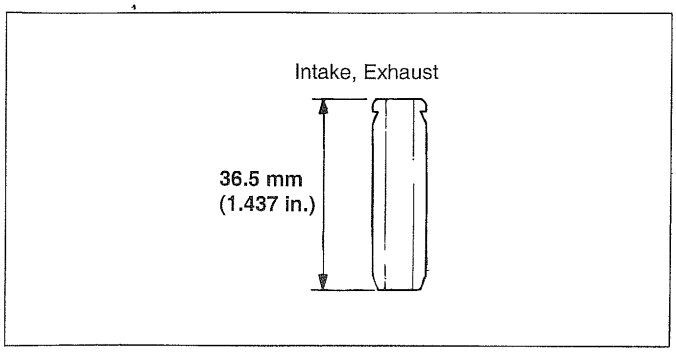


ECHB013Z

3. Using the special tool (09222-21200 A, B), press-fit the valve guide. The valve guide must be press-fitted from the upper side of the cylinder head. Keep in mind that the intake and exhaust valve guides are different in length.

NOTE

Do not install a valve guide unless it is oversize.



ECHB012E

4. After the valve guide is press-fitted, insert a new valve and check for proper stem-to-guide clearance.

5. After the valve guide is replaced, check that the valve is seated properly. Recondition the valve seats as necessary.

VALVE GUIDE OVERSIZES

Over size mm (in.)	Size mark	Oversize valve guide hole size mm (in.)
0.05(0.002)	5	12.805 - 13.205 (0.504 - 0.519)
0.25 (0.010)	25	12.825-13.225 (0.5049 - 0.5206)
0.50 (0.020)	50	12.85 - 13.25 (0.5059 - 0.5216)

REASSEMBLY ECHB8980

NOTE

1. *Clean each part before assembly.*
2. *Apply engine oil to the sliding and rotating parts.*

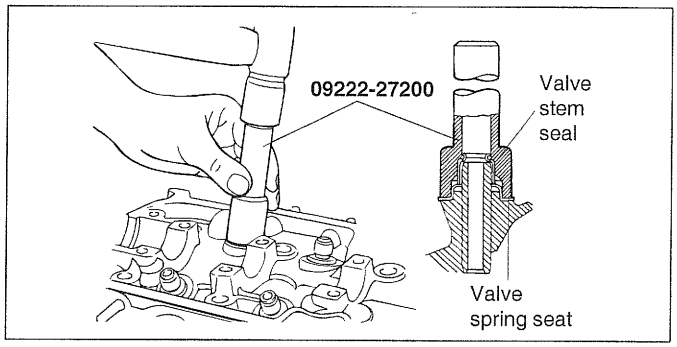
1. Install the spring seats.

2. Using a special tool (09222 - 27200), tap the seal in position lightly.

NOTE

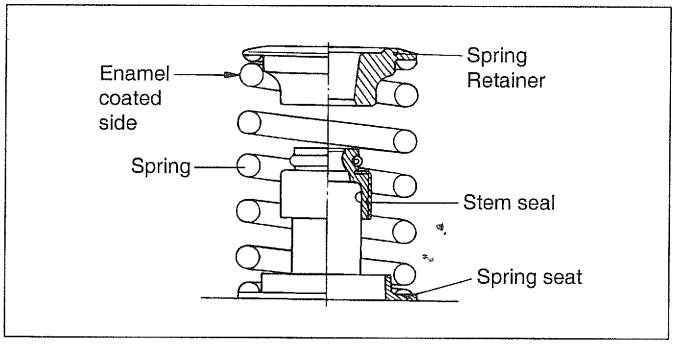
- *Do not reuse old valve stem seals.*
- *Incorrect installation of the seal could result in oil leakage past the valve guides.*

3. Apply engine oil to each valve. Insert the valve into the valve guide. Avoid pushing the valve into the seal by force. After inserting the valve, check that it moves smoothly.



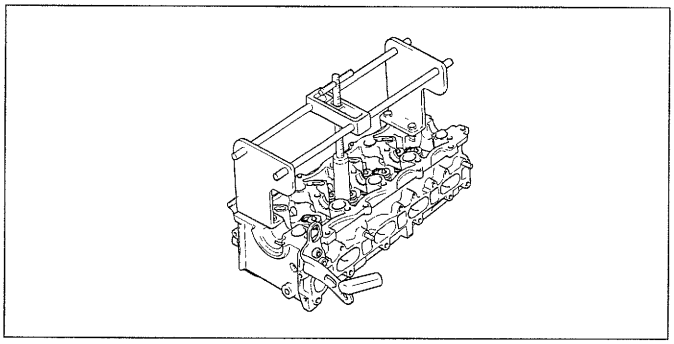
ECHB012Z

4. Place valve springs so that the side coated with enamel faces the valve spring retainer and then install the retainer.



ECA9290B

5. Using the special tool (09222 - 27300), compress the spring and install the retainer locks. After installing the valves, ensure that the retainer locks are correctly in place before releasing the valve spring compressor.



KCHB012F

NOTE

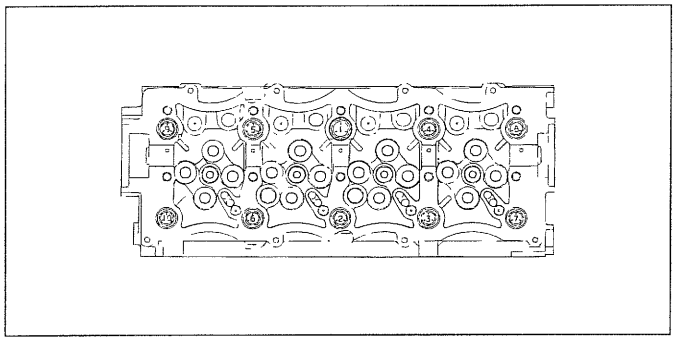
When the spring is compressed, Check that the valve stem seal is not pressed against the bottom of the retainer.

6. Clean both gasket surfaces of the cylinder block and cylinder head.

7. Verify the identification marks on the cylinder head gasket.

8. Install the gasket so that the surface with the identification mark faces toward the cylinder head.

9. Tighten the bolts to the specified torque.



KCHB012C

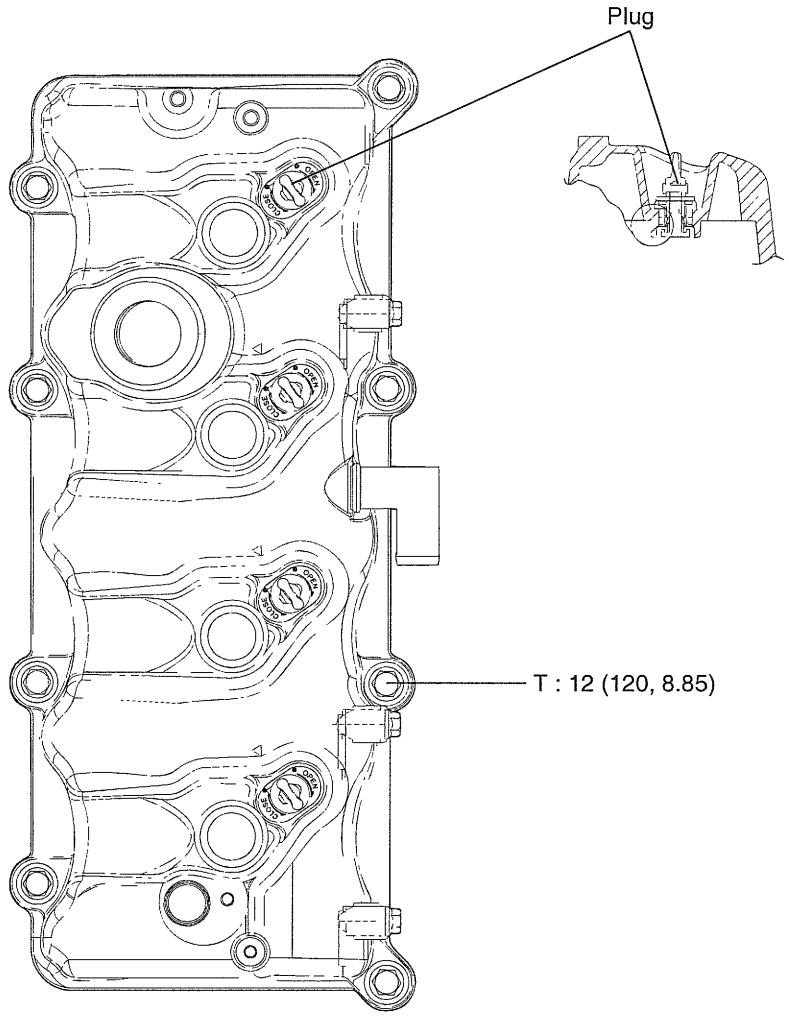
Tightening torque

15 mm : 5 Nm (250 kg.cm, 18 lb.ft)+120°+ 90°

12 mm : 33 - 37 Nm (330 - 370 kg.cm, 24 - 27 lb.ft) + 120°+ 90°

ROCKER COVER & PLUG

COMPONENTS ECHB9500

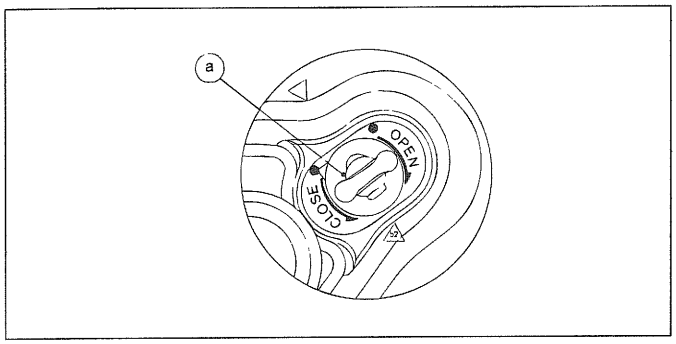


TORQUE : Nm (kg.cm, lb·ft)

KCHB022A

REMOVAL ECHB9600

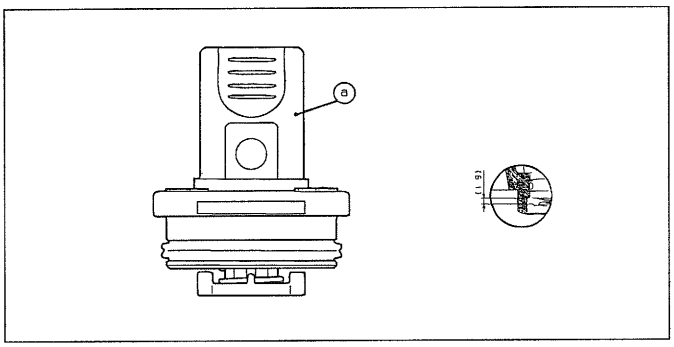
1. Remove the intercooler cover.



KCHB022B

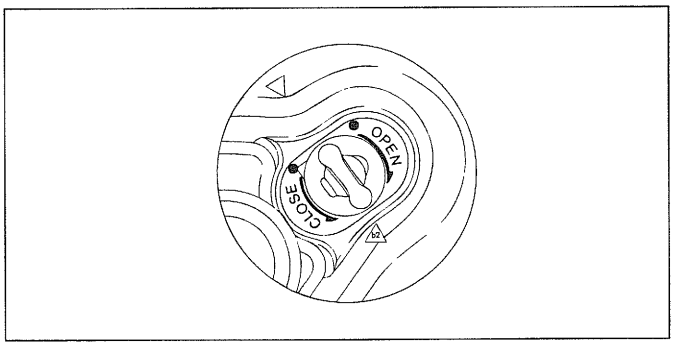
INSTALLATION ECHB9700

1. Apply the oil to the plug.



KCHB022C

2. Push the plug assembly and then turn the left.

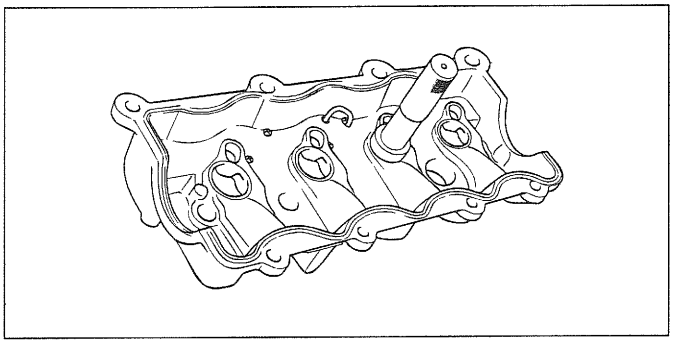


KCHB022D

NOTE

Whenever installing the plug, always replace a new one.

3. Using a special tool (09351 - 27400), install the injector oil seal.



KCHB022E

4. Tighten the rocker cover bolts to the specified torque.

Tightening torque

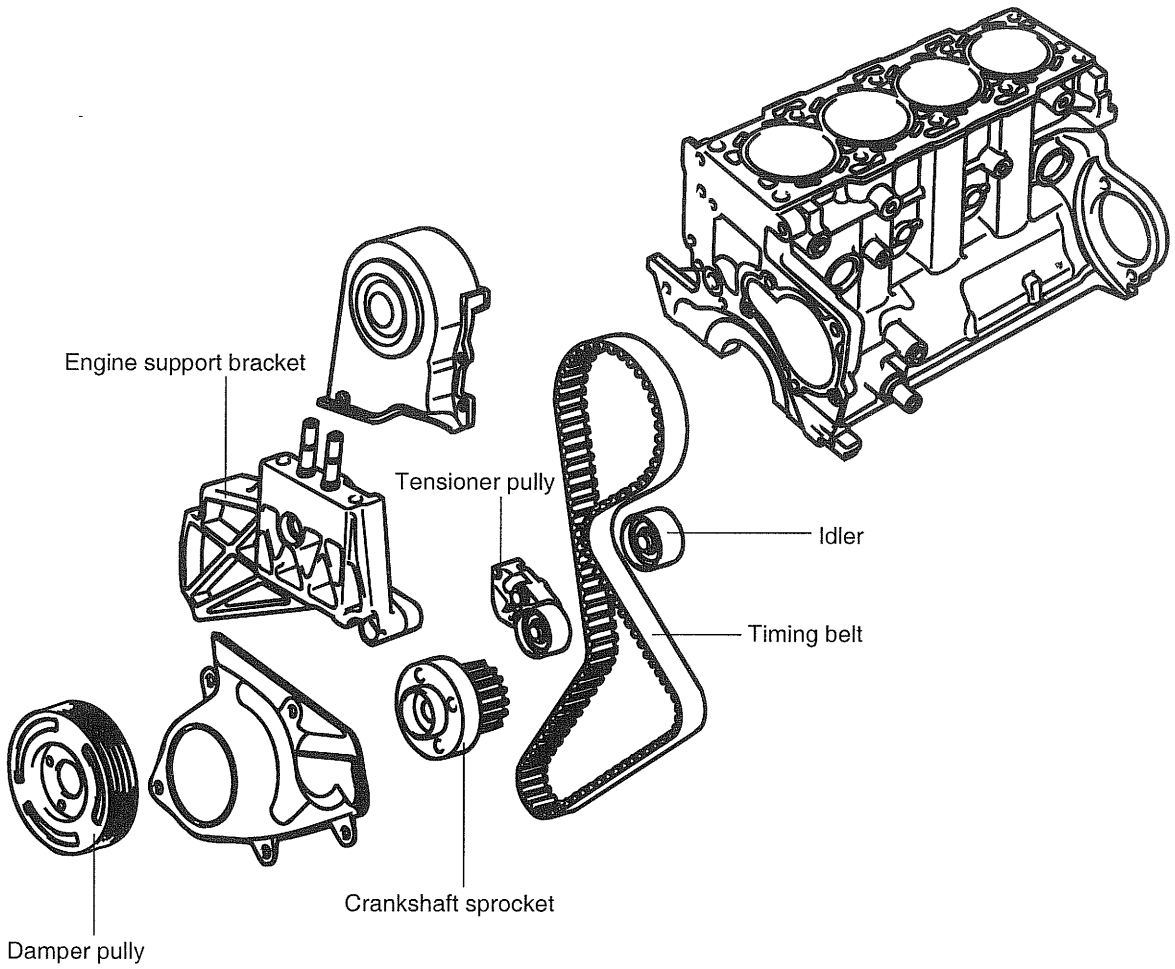
1st step : 4Nm (40kg·cm, 2.95 lb.ft)

2nd step : 12Nm (120 kg·cm, 8.85 lb.ft)

TIMING SYSTEM

TIMING BELT

COMPONENTS ECHB9000



TORQUE : Nm (kg.cm, lb·ft)

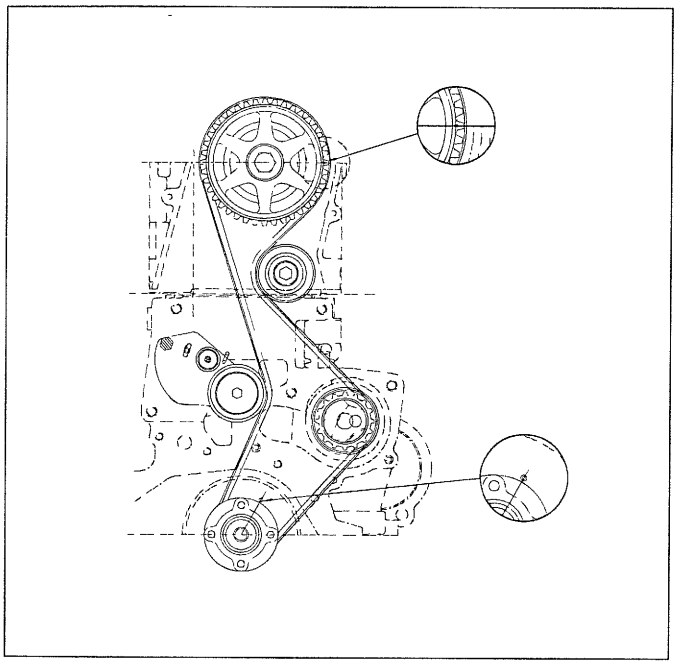
KCHB014A

REMOVAL ECHB9100

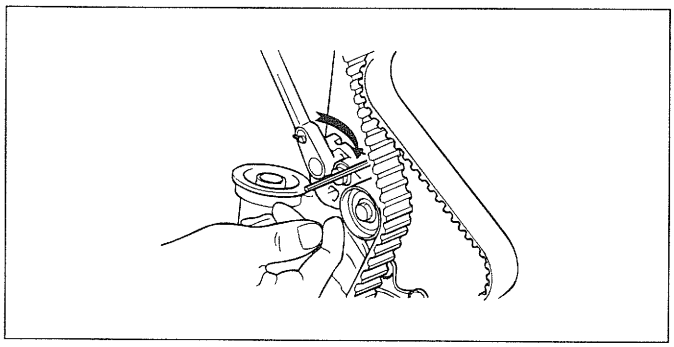
CAUTION

Rotate the crankshaft clockwise and align the timing marks to set the No. 1 cylinder's piston to TDC.
At this time, the timing marks of the camshaft sprocket and cylinder head cover should coincide with eachother and the dowel pin of the camshaft sprocket should be at the upper side.

1. Remove the crankshaft pulley and dirve belt.
2. Remove the timing belt cover.
3. Remove the auto tensioner.



KCHB014B



KCHB014C

NOTE

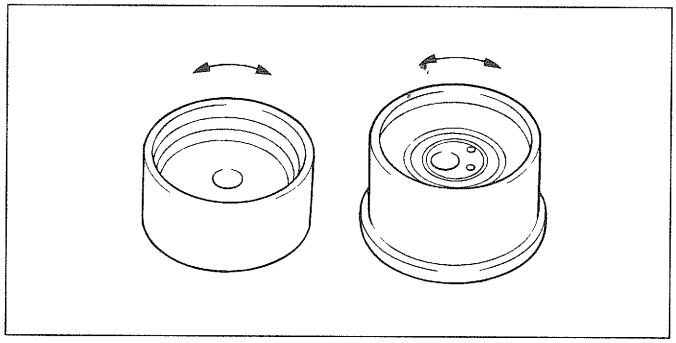
If the timing belt is reused, make an arrow mark indicating the turning direction (or the front of the engine) to make sure that the belt is reinstalled in the same direction as before.

4. Remove the timing belt.
5. Remove the camshaft sprockets.

INSPECTION ECHB9200

SPROCKETS, TENSIONER PULLEY AND IDLER PULLEY

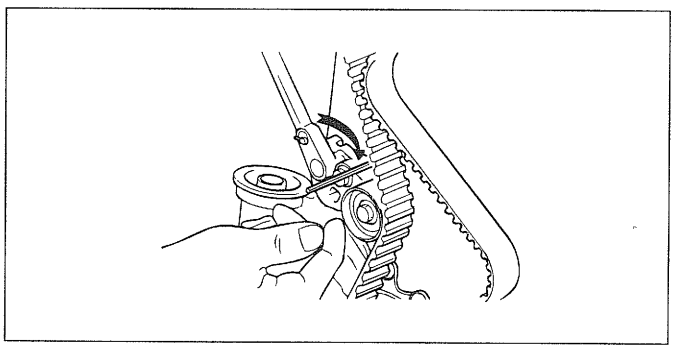
1. Check the camshaft sprocket, crankshaft sprocket, tensioner pulley and idler pulley for abnormal wear, cracks or damage. Replace if necessary.
2. Inspect the tensioner pulley and the idler pulley for easy and smooth rotation and check for play or noise. Replace if necessary.
3. Replace the pulley if there is a grease leak from it s bearing.



EOY025A

AUTO TENSIONER

1. Check the auto tensioner for leaking and replace if necessary.
2. Check the rod end for wear or damage and replace if necessary.

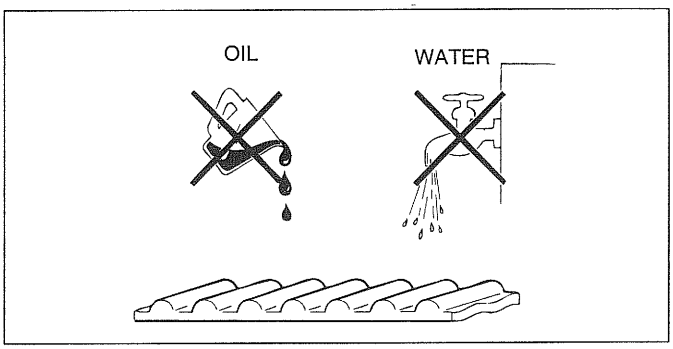


KCHB014C

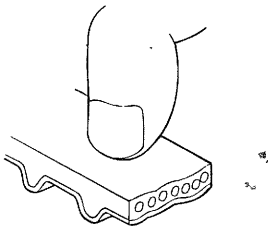
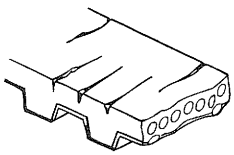
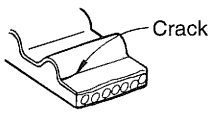
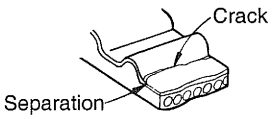
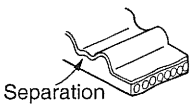
TIMING BELT

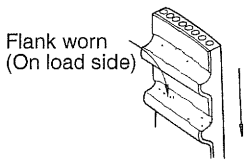
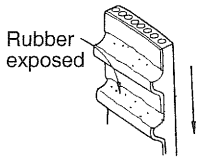
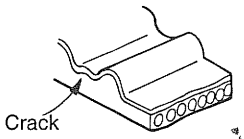
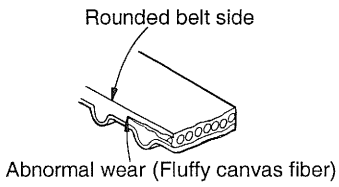
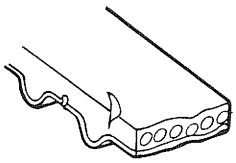
1. Check the belt for oil or dust deposit. Replace if necessary. Small deposits should be wiped away with a dry cloth or paper. Do not clean with solvent.

2. When the engine is overhauled or belt tension is adjusted, check the belt carefully. If any of the following flaws are evident, replace the belt with a new one.



ECA9200A

Description	Flaw conditions
1. Hardened back surface of rubber	Back surface is glossy, Non-elastic and so hard that, when your fingernail is pressed into it, no mark is produced.  ECA9200B
2. Cracked back surface of rubber	 ECA9200Y
3. Cracked or separating canvas	 ECA9200I  ECA9200J  ECA9200K
4. Badly worn out teeth (initial stage)	Tooth flank shows canvas on the load side (Fluffy canvas fibers, rubber changed into white color and unclear canvas texture)

Description	Flaw conditions
	 ECA9200C
5. Badly worn out teeth (last stage)	Tooth flank worn and rubber exposed on load side (tooth width reduced)  ECA9200D
6. Cracked tooth bottom	 ECA9200E
7. Missing tooth	 ECA9200F
8. Badly worn side of belt	 ECA9200G
9. Cracked side of belt	 ECA9200H

INSTALLATION ECHB9300

1. Install the crankshaft sprocket onto the crankshaft.

   ⚠ ***CAUTION***

   Pay attention to the direction of the flange. If it is installed in the wrong direction, a broken belt could result.

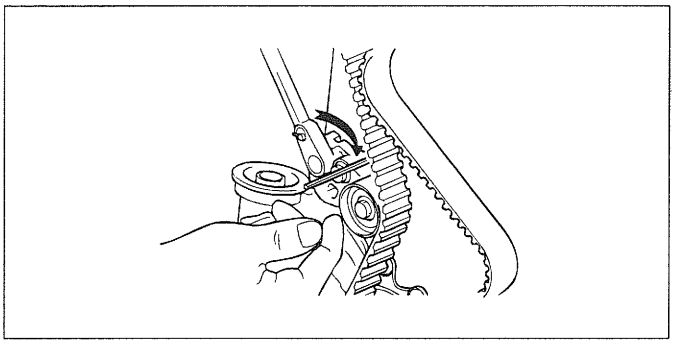
2. Install the special washer and sprocket bolt to the crankshaft and then tighten the sprocket bolt.

Tightening torque

Crankshaft sprocket bolt :

185 - 195 Nm (1850 - 1950 kg·cm, 136 - 144 lb.ft)

3. Install the auto tensioner.



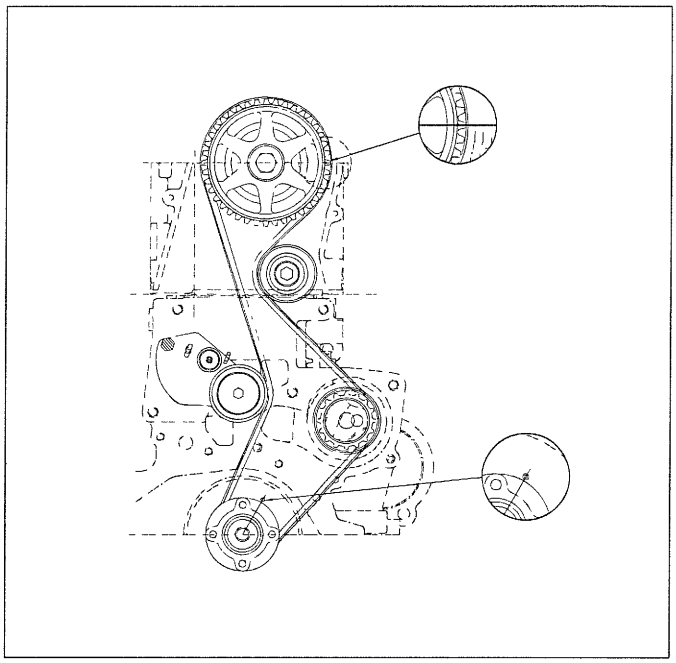
KCHB014C

TIMING BELT

1. Check timing mark.
   - Crankshaft side : Timing mark at crankshaft sprocket and timing pin at oil pump housing.
   - Camshaft side : Timing mark at camshaft sprocket and head.

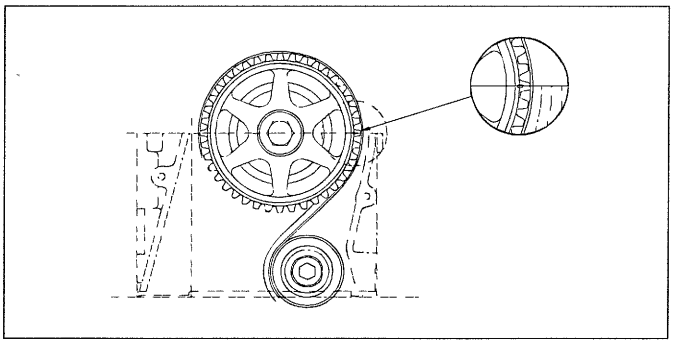
2. Install tensioner.

3. Install timing belt.



KCHB014B

4. Rotate engine more than 2 revelutions (Check timing mark).



KCHB014E

5. Tighten stop bolt.

FUEL SYSTEM

COMMON RAIL ACCUMULATOR FUEL-INJECTION SYSTEM FL-2
SYSTEM OVERVIEW FL-2
ELECTRONIC DIESEL CONTROL - EDC FL-31
START-ASSIST SYSTEMS FL-34
GENERAL FL-36
TROUBLESHOOTING PROCEDURE FL-60
EDC COMPONENT INSPECTION FL-75

COMMON RAIL ACCUMULATOR FUEL-INJECTION SYSTEM

SYSTEM OVERVIEW

FIELD OF APPLICATION

The in-line fuel-injection pump's main area of application is still in all sizes of commercial-vehicle diesel engines, stationary diesel engines, locomotives and ships. Injection pressures of up to approx. 1350 bar are used to generate output powers of up to about 160 kW per cylinder.
Over the years, a wide variety of different requirements, such as the installation of direct-injection (DI) engines in small delivery vans and passenger cars, have led to the development of various diesel fuel-injection systems which are aligned to the requirements of a particular application. Of major importance in these developments are not only the increase in specific power, but also the demand for reduced fuel consumption, and the call for lower noise and exhaust-gas emissions. Compared to conventional cam-driven systems, the Bosch "Common Rail" fuel-injection system for direct-injection (DI) diesel engines provides for considerably higher flexibility in the adaptation of the injection system to the engine, for instance:

- Extensive area of application (for passenger cars and light commercial vehicles with output powers of up to 30kW/cylinder, as well as for heavy-duty vehicles, locomotives, and ships with outputs of up to approx. 200kW/cylinder,
- High injection pressures of up to approx. 1400 bar.
- Variable start of injection,
- Possibility of pilot injection, main injection, and post injection,
- Matching of injection pressure to the operating mode.

FUNCTIONS

Pressure generation and fuel injection are completely decoupled from each other in the "Common Rail" accumulator injection system. The injection pressure is generated independent of engine speed and injected fuel quantity. The fuel is stored under pressure in the high-pressure accumulator (the "Rail") ready for injection. The injected fuel quantity is defined by the driver, and the start of injection and injection pressure are calculated by the ECU on the basis of the stored maps. The ECU then triggers the solenoid valves so that the injector (injection unit) at each engine cylinder injects accordingly. The ECU and sensor stages of such a CR fuel-injection system comprise:

- ECU,
- Crankshaft-speed sensor,
- Camshaft-speed sensor,
- Accelerator-pedal sensor,
- Boost-pressure sensor,
- Rail-pressure sensor,
- Coolant sensor and
- Air-mass meter.

Using the input signals from the above sensors, the ECU registers the driver's requirements (accelerator-pedal setting) and defines the instantaneous operating performance of the engine and the vehicle as a whole. It processes the signals which have been generated by the sensors and which it receives via data lines. On the basis of this information, it can then intervene with open and closed-loop controlling action at the vehicle and particularly at the engine. The engine speed is measured by the crankshaft-speed sensor, and the camshaft-speed sensor determines the firing sequence (phase length). The electrical signal generated across a potentiometer in the accelerator-pedal module informs the ECU about how far the driver has depressed the pedal, in other words about his (her) torque requirement.
The air-mass meter provides the ECU with data on the instantaneous air flow in order that combustion can be adapted so as to comply with the emissions regulations. Insofar as the engine is equipped with an exhaust-gas turbocharger and boost-pressure control, the boost-pressure sensor also measures boost-pressure. At low outside temperatures and with the engine cold, the ECU applies the data from the coolant-temperature and air-temperature sensors to adapt the setpoint values for start of injection, post injection, and further parameters to the particular operating conditions. Depending upon the vehicle in question, in order to comply with the increasing demands for safety and comfort, further sensors and data lines provide inputs to the ECU.
Fig. 1 shows an example of a 4-cylinder diesel engine fitted with a fuel-injection installation using the "Common Rail" accumulator injection system. Various components are shown.

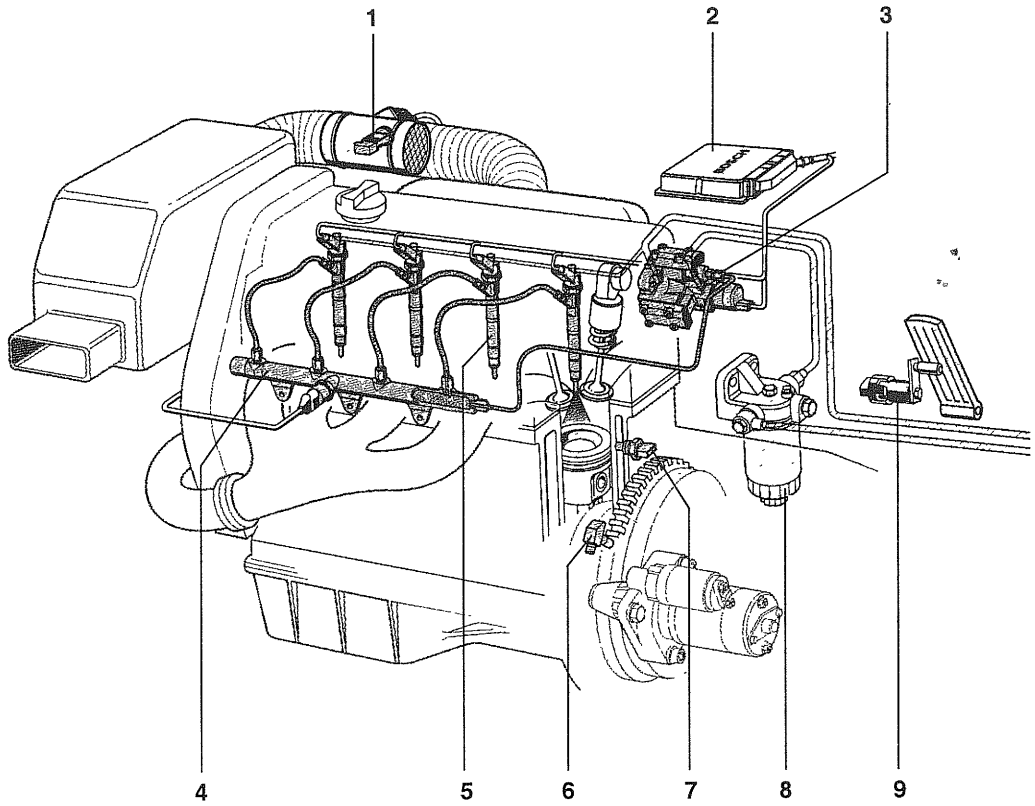
Basic functions

The basic functions control the injection of the diesel fuel at the right moment, in the right quantities, and with the correct injection pressure. They ensure that the diesel engine not only runs smoothly, but also economically.

Auxiliary functions

Auxiliary closed and open-loop control functions serve to improve both the exhaust-gas emission and fuel-consumption figures, or are used for increasing safety, comfort, and convenience. Examples here are Exhaust-Gas Recirculation (EGR), boost-pressure control, vehicle-speed control, and electronic immobilizer etc.
The CAN bus system permits the exchange of data with other electronic systems in the vehicle. During vehicle inspection in the workshop, a diagnosis interface permits evaluation of the stored system data.

[Fig. 1]



Common Rail accumulator injection system on a 4-cylinder diesel engine

1. Air-mass meter
2. ECU
3. High-pressure pump
4. High-pressure accumulator (rail)
5. Injectors
6. Crankshaft-speed sensor
7. Coolant-temperature sensor
8. Fuel filter
9. Accelerator-pedal sensor

NOTE
This drawing is not exactly same with real lay-out.

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INJECTION CHARACTERISTICS

CONVENTIONAL INJECTION CHARACTERISTICS

With conventional injection systems, using distributor and in-line injection pumps, fuel injection today comprises only the main injection phase - without pilot and post-injection phases (Fig. 1). On the solenoid-valve-controlled distributor pump though, developments are progressing towards the introduction of a pilot-injection phase. In conventional systems, pressure generation and the provision of the injected fuel quantity are coupled to each other by a cam and a pump plunger. This has the following effects upon the injection characteristics:

- The injection pressure increases together with increasing speed and injected fuel quantity
- During the actual injection process, the injection pressure increases and then drops again to the nozzle closing pressure a the end of injection

The consequences are as follows:

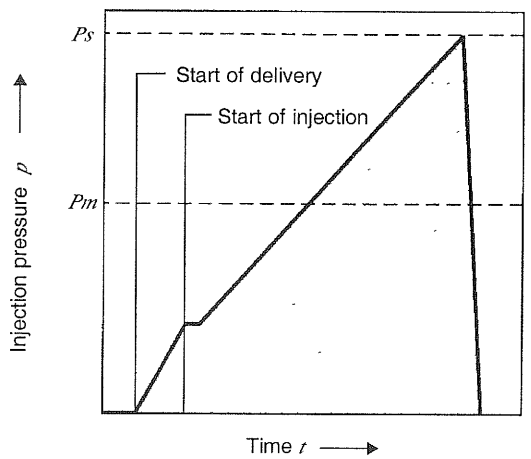
- Smaller injected fuel quantities are injected with lower pressures than larger injected fuel quantities (refer to Fig. 1)
- The peak pressure is more than double that of the mean injection pressure, and
- In line with the requirements for efficient combustion, the rate-of discharge curve is practically triangular.

The peak pressure is decisive for the mechanical loading of a fuel-injection pump's components and drive. On conventional fuel-injection systems it is decisive for the quality of the A/F mixture formation in the combustion chamber.

[Fig. 1]

Rate-of-discharge curve for conventional fuel injection

p_m Mean injection pressure, p_s Peak pressure.



INJECTION CHARACTERISTICS WITH COMMON RAIL

Compared to conventional injection characteristics, the following demands are made upon an ideal injection characteristic:

- Independently of each other, injected fuel quantity and injection pressure should be definable for each and every engine operating condition (provides more freedom for achieving ideal A/F mixture formation)
- At the beginning of the injection process, the injected fuel quantity should be as low as possible (that is, during the ignition lag between the start of injection and the start of combustion).

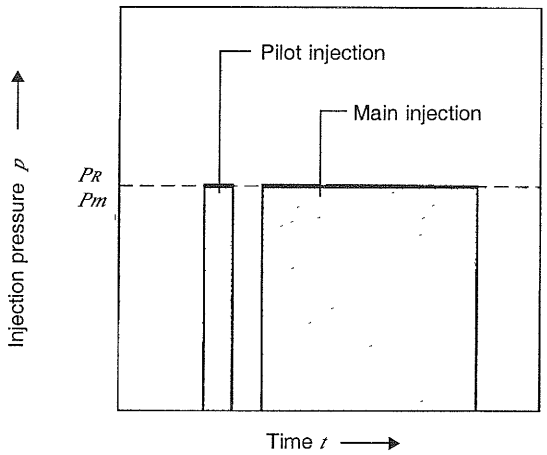
These requirements are complied with in the Common rail accumulator injection system with its pilot and main-injection features (Figs. 2 and 4).
The Common Rail system is a modular system, and essentially the following components are responsible for the injection characteristic:

- Solenoid-valve-controlled injectors which are screwed into the cylinder head,
- Pressure accumulator (rail), and
- High-pressure pump

[Fig. 2]

Rate-of-discharge curve for Common Rail fuel injection

p_m Mean injection pressure, p_R Rail pressure.



The following components also also required in order to operate the system:

- Electronic control unit (ECU),
- Crankshaft-speed sensor, and
- Camshaft-speed sensor (phases sensor).

For passenger-car systems, a radial-piston pump is used as the high-pressure pump for pressure generation. Pressure is generated independently of the injection process. The speed of the high-pressure pump is coupled directly to the engine speed with a non-variable transmission ratio. In comparison with conventional injection systems, the fact that delivery is practically uniform, means that not only is the Common Rail high-pressure pump much smaller, but also that its drive is not subject to such high pressure-loading peaks.
The injectors are connected to the rail by short lines and, essentially, comprise a nozzle, and a solenoid valve which is energized by the ECU to switch it on (start of injection). When the solenoid valve is switched off (de-energized) injection ceases. Presuming constant pressure, the injected fuel quantity is directly proportional to the length of time the solenoid valve is energized. It is completely independent of the engine or pump speed (time-controlled fuel injection).
The required high-speed solenoid switching is achieved by using high voltages and currents. This means that the solenoid-valve triggering stage in the ECU must be designed accordingly.
The start of injection is controlled by the angle-time control system of the EDC (Electronic Diesel Control). This uses a sensor on the crankshaft to register engine speed, and a sensor on the camshaft for phase detection (working cycle).

Pilot injection

Pilot injection can be advanced by up to 90° crankshaft (90°cks) referred to TDC. If the start of injection occurs less than 40°cks BTDC, fuel can be deposited on the surface of the piston and the cylinder walls, and can lead to unwanted dilution of the lube-oil. With pilot injection, a small amount of diesel fuel (1...4 mm^3) is injected into the cylinder to "precondition" the combustion chamber. Combustion efficiency can be improved as a result, and the following effects are achieved:

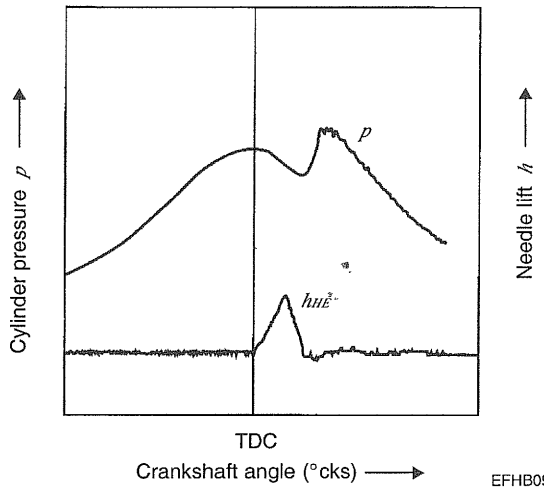
- The compression pressure is increased slightly due to pilot reaction and partial combustion, this in turn leads to
- The main-injection ignition delay being reduced, and
- A reduction of combustion-pressure rise and of the combustion-pressure peaks (softer combustion).

These effects reduce the combustion noise, the fuel consumption, and in many cases the exhaust-gas emissions as well. In the case of a rate-of-discharge curve without pilot injection (Fig. 3), in line with the compression only a slight, flat pressure rise is evident just before TDC, after which it peaks relatively sharply at the point of maximum pressure. The steep pressure increase together with the sharp peak contribute considerably to the diesel engine's combustion noise. As shown by the rate-of-discharge curve with pilot injection, (Fig. 4), pressure in the vicinity of TDC reaches a somewhat higher value, and the combustion-pressure increase is less rapid.
Since it reduces the ignition delay, pilot injection makes an indirect contribution to the generation of engine torque. The specific fuel consumption can increase or decrease as a function of the start of main injection and the time between the pilot and main injection sequences.

[Fig. 3]

Needle lift in the injector nozzle, and rate-of-discharge curve without pilot injection

h_{HE} Needle lift for main injection.



Main injection

The energy for the engine's output work comes from the main injection sequence. This means that essentially the main injection is responsible for the development of the engine's torque. With the Common Rail accumulator fuel-injection system, the injection pressure remains practically constant throughout the whole of the injection process.

Secondary injection

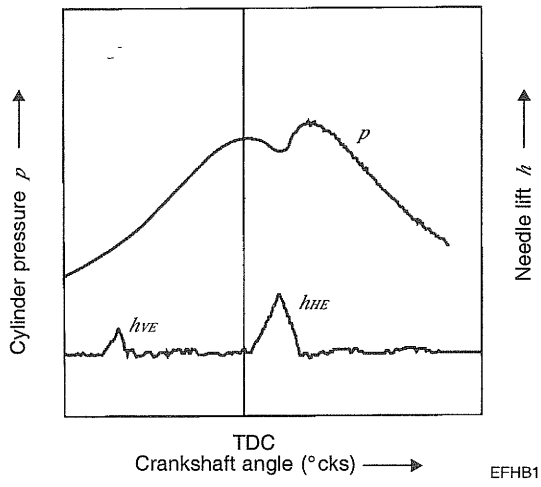
With certain versions of NOx catalytic converter, secondary injection can be applied for NOx combustion (reduction). It follows the main injection process and is timed to take place during the expansion or exhaust cycle up to 200°cks after TDC. Secondary injection introduces a precisely metered quantity of fuel to the exhaust gas.

In contrast to the pilot and main injection processes, the injected fuel does not combust but instead vaporises due to the residual heat in the exhaust gas. During the exhaust cycle, the resulting mixture of exhaust gas and fuel is forced out through the exhaust valves and into the exhaust-gas system. Part of the fuel though is returned for combustion via the EGR system and has the same effects as very advanced pilot injection. Provided suitable NOx catalytic converters are fitted, these utilise the fuel in the exhaust gas as a reduction agent to lower the NOx content in the exhaust gas.

[Fig. 4]

Needle lift in the injector nozzle, and rate-of-discharge curve with pilot injection

h_{VE} Needle lift for pilot injection.
h_{HE} Needle lift for main injection.



Since very late secondary injection leads to dilution of the engine lube oil, it must be approved by the engine manufacture.

EXHAUST-GAS REDUCTION

MIXTURE FORMATION AND COMBUSTION BEHAVIOR

Compared to SI engines, diesel engines burn low-volatility (high-boiling) fuel, and not only prepare the air/fuel mixture in the period between injection and start of combustion, but also during the actual combustion process. The result is a less homogenous mixture. The diesel engine always operates with excess air ($\lambda > 1$). Fuel consumption, and the emissions of soot, CO, and HC increase if there is insufficient excess air.
The A/F mixture formation is defined by the following parameters:

- Injection pressure,
- Rate of discharge (injection time),
- Spray distribution (number of spray jets, spray cross-section, spray direction),
- Start of injection,
- Air movement, and
- Air mass.

These quantities all have an effect upon the engine's emissions and fuel consumption. High combustion temperatures and high levels of oxygen concentration lead to increased NOx generation. Soot emissions rise due to lack of air and poor A/F mixture formation.

MEASURES AT THE ENGINE

The configuration of the combustion chamber and air-intake tract can have a positive effect upon the exhaust-gas emissions. If the air movement in the combustion chamber is carefully matched to the fuel jets leaving the nozzle, this promotes efficient mixing of air and fuel and thus complete combustion of the injected fuel. In addition, positive effects are achieved with a homogenous mixture of air and exhaust gas and a cooled EGR tract. Four-valve techniques and turbochargers with variable-turbine geometry (VTG) also contribute to lower emissions and higher power density.

EXHAUST-GAS RECIRCULATION (EGR)

Without EGR, NOx emissions are excessive from the emission-control legislation standpoint, whereas soot emissions are within limits. Exhaust-gas recirculation (EGR) is a method for reducing the emissions of NOx without drastically increasing the engine's soot output. This can be implemented very efficiently with the CR system thanks to the excellent A/F mixture formation resulting from the high injection pressures. With EGR, a portion of the exhaust gases are diverted into the intake tract during part-load operation. This not only reduces the oxygen content, but also the rate of combustion and the peak temperature at the flame front, with the result that NOx emissions drop. If too much exhaust gas is recirculated though (exceeding 40% of the intake air volume), the soot, CO, and HC emissions, as well as the fuel consumption rise due to the lack of oxygen.

INFLUENCE OF FUEL INJECTION

Start of injection, rate-of discharge curve, and atomization of the fuel also have an influence upon fuel consumption and upon exhaust-gas emissions.

Start of injection

Due to lower process temperatures, retarded fuel-injection reduces the NOx emissions. But if it is too far retarded, HC emissions and fuel consumption increase, as do soot emissions under high loading conditions. If the start of injection deviates by only 1°cks (crankshaft) from the desired value, NOx emissions can increase by as much as 5%. Whereas a deviation of 2°cks in the advance (early) direction can lead to a 10 bar increase in the cylinder peak pressure, a deviation of 2°cks in the retarded (late) direction can increase the exhaust-gas temperature by 20°C. Such high sensitivity demands utmost accuracy when adjusting the start of injection.

Rate-of-discharge curve

The rate-of discharge curve defines the variations in fuel mass flow during a single injection cycle (from start of injection till end of injection). The rate-of-discharge curve determines the mass of fuel delivered during the combustion lag (between start of injection and start of combustion). Furthermore, since it also influences the distribution of the fuel in the combustion chamber it also has an effect upon the efficiency of the air utilization. The rate-of-discharge curve must climb slowly in order that fuel injection during the combustion lag is kept to a minimum. This fuel, namely, combusts suddenly as soon as combustion is initiated with the attendant negative effects upon engine noise and NOx emissions. The rate-of-discharge curve must drop-off sharply in order to prevent poorly atomized fuel leading to high HC and soot emissions, and increased fuel consumption during the final phase of combustion.

Fuel atomization

Finely atomized fuel promotes the efficient mixing of air and fuel. It contributes to a reduction in HC and soot emissions. High injection pressure and optimal geometrical configuration of the nozzle injection orifices lead to good atomization. To prevent visible soot emission, the injected fuel quantity must be limited in accordance with the intake air quantity. This necessitates excess air in the order of at least 10...40% (λ=1.1 ...1.4).
Once the nozzle needle has closed, the fuel in the injection orifices can vaporize (in the case of sac-hole (blind-hole) nozzles the fuel vaporizes in the sac-hole volume) and in the process increase the HC emissions. This means that such (harmful) volumes must be kept to a minimum.

FUEL SYSTEM

The fuel system in a "Common Rail" fuel-injection system (Fig. 1) comprises a low-pressure stage for the low-pressure delivery of fuel, a high-pressure stage for the high-pressure delivery, and the ECU (11).

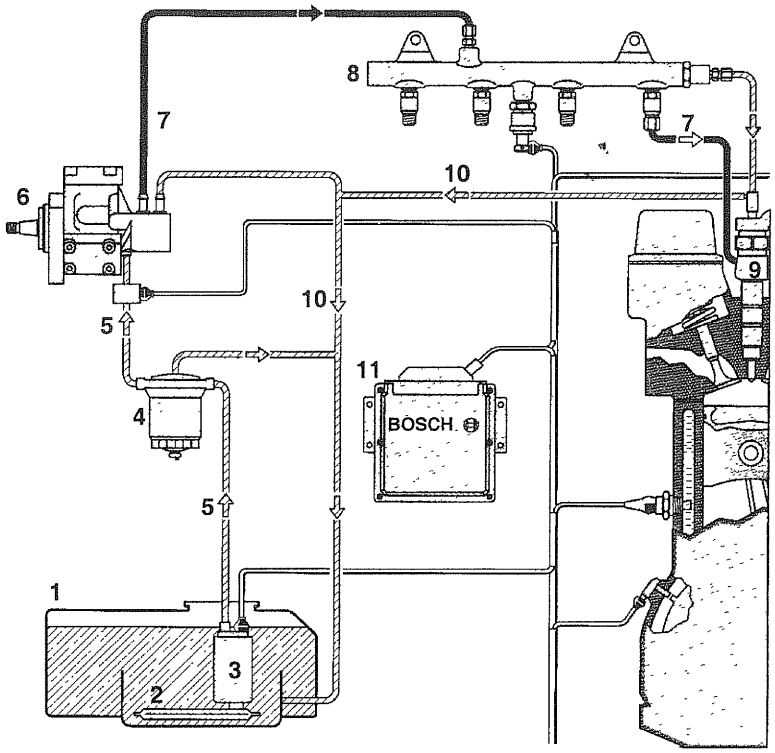
LOW-PRESSURE DELIVERY

The low-pressure stage of the Common Rail fuel system incorporates:
- Fuel tank with pre-filter,
- Presupply pump,
- Fuel filter, and
- Low-pressure fuel lines.

Fuel lines for the low-pressure stage

As an alternative to steel pipes, flame-inhibiting steel-braid-armoured flexible fuel lines can be used for the low-pressure stage. They must be routed so that they cannot be damaged mechanically, and fuel which has dripped or evaporated must not be able to accumulate, nor must it be able to ignite.
When the vehicle twists, or the engine moves etc., this must have no derogatory effects upon fuel-line function. All parts which carry fuel must be protected against the effects of heat. In the case of buses, fuel lines must not be located in the passenger compartment or in the driver's cab, nor may fuel be delivered by force of gravity.

[Fig. 1]



Fuel system for a Common Rail fuel-injection system

1. Fuel tank
2. Pre-filter
3. Presupply pump
4. Fuel filter
5. Low-pressure fuel lines
6. High-pressure pump
7. High-pressure fuel lines
8. Rail
9. Injector
10. Fuel-return line
11. ECU

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Low-pressure system components

Presupply pump

The presupply pump is either an electric fuel pump with pre-filter, or a gear-type fuel pump. The pump draws the fuel from the fuel tank and continually delivers the required quantity of fuel in the direction of the high-pressure pump.

Fuel filter

Inadequate filtering can lead to damage at the pump components, delivery valves, and injector nozzles. The fuel filter cleans the fuel before it reaches the high-pressure pump, and thereby prevents premature wear at the pump's sensitive components.

HIGH-PRESSURE DELIVERY

The high-pressure stage of the fuel system in a Common Rail installation comprises:
- High-pressure pump with pressure-control valve,
- High-pressure fuel lines,
- The rail as the high-pressure accumulator with rail-pressure sensor, pressure-limiting valve, and flow limiter, injectors, and
- Fuel-return lines.

High-pressure-system components

High-pressure pump

The high-pressure pump pressurises the fuel to a system pressure of up to 1,350bar. This pressurized fuel then passes through a high-pressure line and into the tubular high-pressure fuel accumulator (rail).

High-pressure accumulator (rail)

Even after an injector has taken fuel from the rail in order to inject it, the fuel pressure inside the rail remains practically constant. This is due to the accumulator effect arising from the fuel's inherent elasticity. Fuel pressure is measured by the rail-pressure sensor and maintained at the desired level by the pressure-control valve. It is the job of the pressure-limiter valve to limit the fuel pressure in the rail to maximum 1,500bar. The highly pressurized fuel is directed from the rail to the injectors by a flow limiter, which prevents excess fuel reaching the combustion chamber.

Injectors

The nozzles of these injectors open when the solenoid valve is triggered and permit the flow of fuel. They inject the fuel directly into the engine's combustion chamber. The excess fuel which was needed for opening the injector nozzles flows back to the tank through a collector line. The return fuel from the pressure-control valve and from the low-pressure stage is also led into this collector line together with the fuel used to lubricate the high-pressure pump.

Fuel lines in the high-pressure section

These fuel lines carry the high-pressure fuel. They must therefore be able to permanently withstand the maximum system pressure and, during the pauses in injection, the sometimes high-frequency pressure fluctuations which occur. They are therefore manufactured from steel tubing. Normally, they have an outside diameter of 6 mm and an internal diameter of 2.4 mm.
The injection lines between the rail and the injectors must all be of the same length. The differences in length between the rail and the individual injectors are compensated for by using slight or pronounced bends in the individual lengths of tubing. Nevertheless, the injection lines should be kept as short as possible.

DESIGN AND FUNCTION OF THE COMPONENTS

LOW-PRESSURE STAGE

The low-pressure stage (Fig. 1) provides enough fuel for the high-pressure section. The most important components are:

- Fuel tank,
- Pre-supply pump with prefilter,
- Low-pressure fuel lines for supply and return,
- Fuel filter and
- Low-pressure area of the high-pressure pump.

Pre-supply pump

It is the pre-supply pump's job to maintain an adequate supply of fuel to the high-pressure pump. This applies

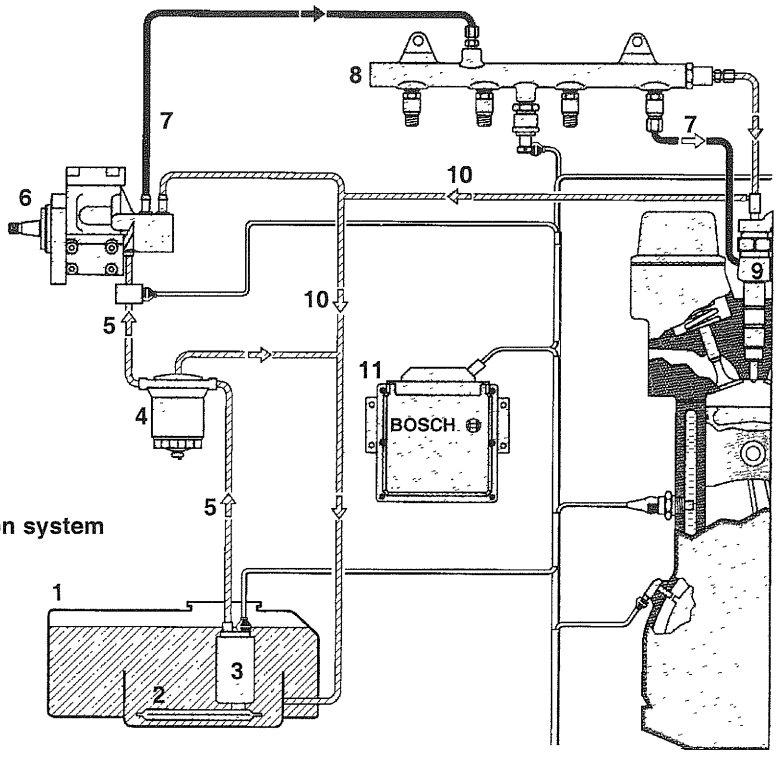
- In every operating state,
- At the necessary pressure, and
- Throughout the complete service life.

At present, there are two possible versions. An electric roller-cell fuel pump is the standard solution. An alternative is the mechanically driven gear-type fuel pump.

Electric fuel pump

The electric fuel pump is only used in passenger cars and light commercial vehicles. It is not only responsible for delivering the fuel to the high-pressure pump, but within the framework of system monitoring it must also interrupt the flow of fuel in case of an emergency.
Beginning with the engine cranking process, the electric fuel pump runs continuously independent of engine speed. This means that the pump permanently delivers fuel from the fuel tank, and through the filter to the high-pressure pump. Excess fuel can flow back to the tank through an overflow valve.
A safety circuit is provided to prevent the delivery of fuel should the ignition be on with the engine stopped.
Electric fuel pumps are available as in-line or in-tank versions. In-line fuel pumps are installed outside the tank in the fuel line between the tank and the fuel filter. They are attached to the vehicle's floor assembly. In-tank fuel-pump versions on the other hand are installed in the fuel tank itself using a special mounting. Apart from the electrical and hydraulic connections to the outside, this mounting usually incorporates a fuel strainer, a fuel-level indicator, and a swirl pot which acts as a fuel reservoir.

[Fig. 1]



Fuel system for a Common Rail fuel-injection system

1. Fuel tank
2. Pre-filter
3. Presupply pump
4. Fuel filter
5. Low-pressure fuel lines
6. High-pressure pump
7. High-pressure fuel lines
8. Rail
9. Injector
10. Fuel-return line
11. ECU

EFHB121A

An electric fuel pump comprises the three function elements:
- Pumping element,
- Electric motor, and
- End cover.

Fuel filter

Contaminants in the fuel can lead to damage at the pump components, delivery valves, and injection nozzles. This, therefore, necessitates the use of a fuel filter which is specifically aligned to the requirements of the particular injection system, otherwise faultless operation and a long service life cannot be guaranteed. Diesel fuel can contain water either in bound form (emulsion) or in free form (e.g. condensation of water due to temperature change). If this water enters the injection system, it can lead to damage as a result of corrosion.
Similar to other injection systems, the Common Rail also needs a fuel filter with water reservoir, from which the water must be drained at regular intervals. The increasing number of diesel engines used in passenger cars, has led to the demand for an automatic water warning device which indicates by means of a warning lamp when water must be drained (this is binding in those countries in which there is a high level of water in the fuel).

HIGH-PRESSURE STAGE

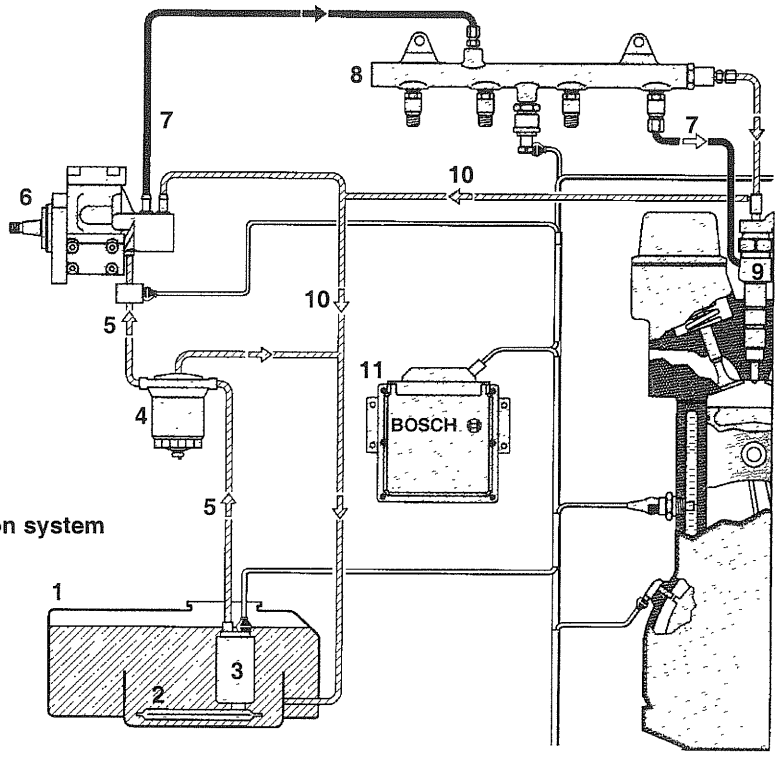
In addition to high-pressure generation, fuel distribution and fuel-metering also take place in the high-pressure stage (Fig. 1). The most important components are:
- High-pressure pump with element shutoff valve and pressure-control valve,
- High-pressure accumulator,
- Rail-pressure sensor,
- Pressure-limiter valve,
- Flow limiter and
- Injectors.

High-pressure pump

Assignments

The high-pressure pump (Figs. 7 and 8) is the interface between the low-pressure and the high-pressure stages. Under all operating conditions, it is responsible for providing adequate high-pressure fuel throughout the

[Fig. 1]



Fuel system for a Common Rail fuel-injection system

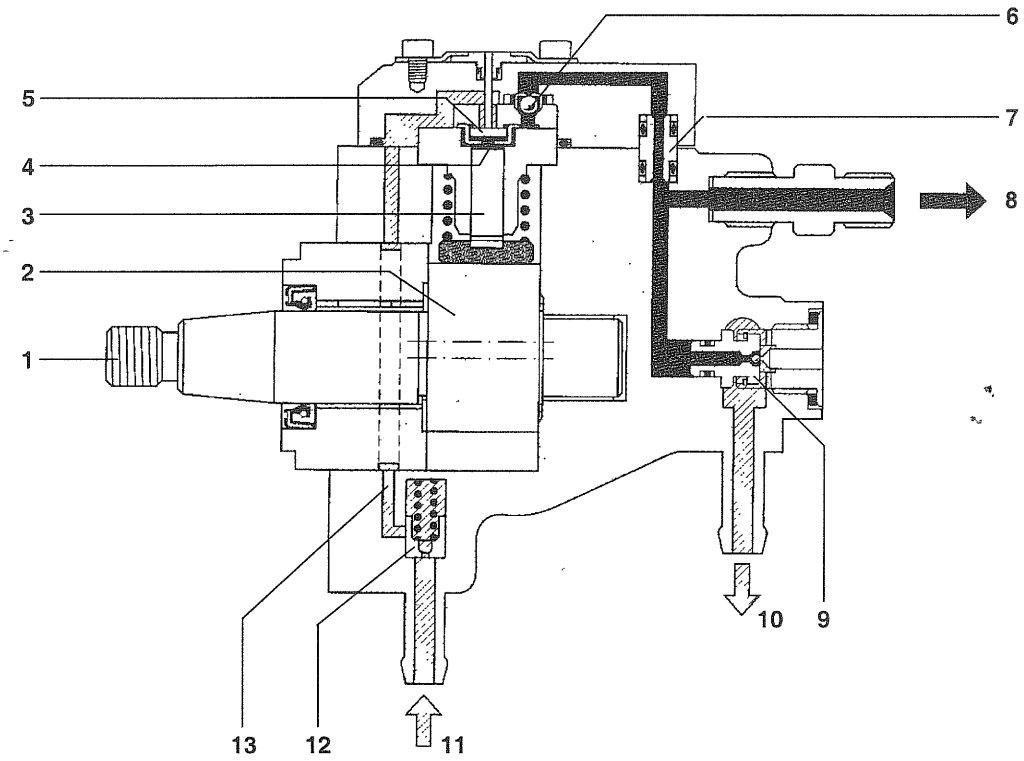
1. Fuel tank
2. Pre-filter
3. Presupply pump
4. Fuel filter
5. Low-pressure fuel lines
6. High-pressure pump
7. High-pressure fuel lines
8. Rail
9. Injector
10. Fuel-return line
11. ECU

EFHB121A

vehicle's complete service life. This also includes the provision of extra fuel as needed for rapid starting and for rapid build-up of pressure in the rail.

The high-pressure pump continually generates the system pressure as needed in the high-pressure accumulator (rail). This means therefore, that in contrast to conventional systems, the fuel does not have to be specially compressed for each individual injection process.

[Fig. 7]



High-pressure pump (schematic, longitudinal section)

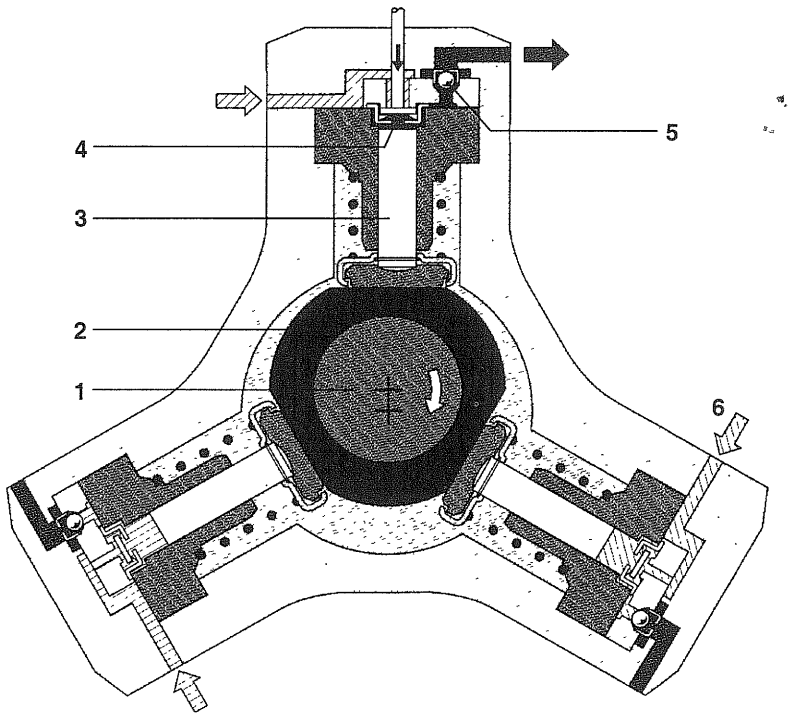
1. Driveshaft
2. Eccentric cam
3. Pumping element with pump plunger
4. Pumping-element chamber
5. Suction valve
6. Outlet valve
7. Seal
8. High-pressure connection to the rail
9. Ball valve
10. Fuel return
11. Fuel inlet from the presupply pump
12. Safety valve with throttle bore
13. Low-pressure passage to the pumping element

EFHB172A

Design and construction

The high-pressure pump is installed preferably at the same point on the diesel engine as a conventional distributor pump. It is driven by the engine (at half engine speed, but max. 3000 min^{-1}) through a coupling, gear-wheel, chain, or toothed belt, and lubricated by the diesel fuel which it pumps.
Depending on available space, a pressure-control valve is installed directly on the high-pressure pump or remote from it. Inside the high-pressure pump, the fuel is compressed with three radially arranged pump pistons which are at an angle of 120° to each other. Since three delivery stokes take place for every revolution, only low peak drive torques are generated so that the stress on the pump drive remains uniform. With 16Nm, the torque is only about 1/9 of that required to drive a comparable distributor pump. This means that Common Rail places less loading on the pump drive than is the case with conventional injection system. The power required to drive the pump climbs in proportion to the pressure set in the rail and to the pump's speed (delivery quantity). For a 2-liter engine turning at rated speed, and with a set pressure of 1,350 bar in the rail, the high-pressure pump requires 3.8kW presuming a mechanical efficiency of approx. 90%. The higher power demand (higher than theoretically necessary) results from the leak-fuel and control quantities at the injector, and from the fuel return through the pressure-control valve.

[Fig. 8]



High-pressure pump (schematic, cross-section)

1. Driveshaft
2. Eccentric cam
3. Pumping element with pump piston
4. Inlet valve
5. Outlet valve
6. Inlet

EFHB181A

Method of operation

Via a filter with water separator, the presupply pump pumps fuel from the tank to the high-pressure pump through the fuel inlet (Fig. 7) and the safety valve. It forces the fuel through the safety valve's throttle bore and into the high-pressure pump's lubrication and cooling circuit. The driveshaft with its eccentric cams moves the three pump plungers up and down in accordance with the shape of the cam.
As soon as the delivery pressure exceeds the safety valve's opening pressure (0.5 ... 1.5bar), the pre-supply pump can force fuel through the high-pressure pump's inlet valve into the pumping-element chamber whose pump piston is moving downwards (suction stroke). The inlet valve closes when the pump piston passes through BDC and, since it is impossible for the fuel in the pumping-element chamber to escape, it can now be compressed beyond the delivery pressure. The increasing pressure opens the outlet valve as soon as the rail pressure is reached, and the compressed fuel enters the high-pressure circuit.
The pump piston continues to deliver fuel until it reaches TDC (delivery stroke), after which the pressure collapses so that the outlet valve closes. The fuel remaining in the pumping-element chamber relaxes and the pump piston moves downwards again.
As soon as the pressure in the pumping-element chamber drops below the presupply-pump pressure, the inlet valve opens and the pumping process starts again.

Fuel-delivery rate

Since the high-pressure pump is designed for large delivery quantities, excess high-pressure fuel is delivered during idle and part-load operation. This excess fuel is returned to the tank via the pressure-control valve. The compressed fuel relaxes in the tank, and the energy is lost which was used for compressing the fuel in the first place. In addition to the unnecessary heating up of the fuel, overall efficiency is also reduced.
To a certain extent, this loss of efficiency can be compensated for by switching off one of the pumping elements.

Element switch-off:

When one of the pumping elements (Fig. 7) is switched off, this leads to a reduction of the amount of fuel which is pumped into the rail. Switch-off involves the suction valve (Fig. 7) remaining open permanently. When the solenoid valve of the pumping-element switchoff is triggered, a pin attached to its armature continually holds the inlet valve open. The result is that the fuel drawn into this pumping element cannot be compressed during the delivery stroke. No pressure is generated in the element chamber since the fuel flows back into the low-pressure passage again. With one of its pumping elements switched off when less power is needed, the high-pressure pump no longer delivers the fuel continuously but rather with brief interruptions in delivery.

Transmission ratio:

The high-pressure pump's delivery rate is proportional to its rotational speed. And this, in turn, is a function of the engine speed. During the injection-system application-engineering work on the engine, the transmission ratio is defined so that on the one hand the amount of excess fuel is not too high, and on the other, the fuel requirements can still be satisfied during WOT operation. Referred to the crankshaft, transmission ratios of 1:2 and 2:3 are possible.

High-pressure accumulator (rail)

Assignments

The high-pressure accumulator (the Rail in Fig. 10) stores the fuel at high pressure. At the same time, the pressure oscillations which are generated due to the high-pressure pump delivery and the injection of fuel are damped by the rail volume.
This high-pressure accumulator is common to all cylinders, hence its name "common rail". Even when large quantities of fuel are extracted, the common rail maintains its inner pressure practically constant. This ensures that the injection pressure remains constant from the moment the injector opens.

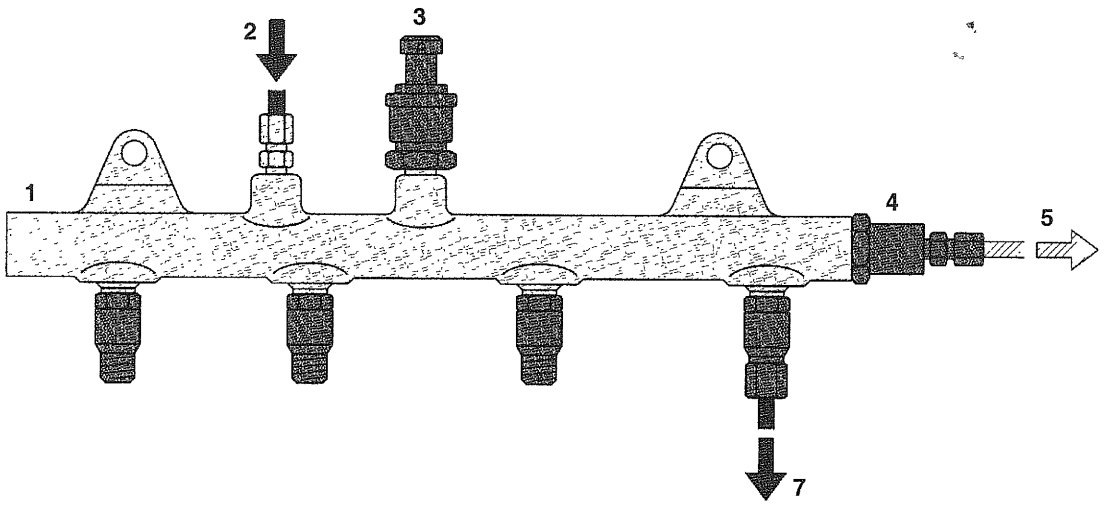
Design and construction

In order to comply with the wide variety of engine installation conditions, the rail with its flow limiters and the provisions for attaching rail-pressure sensor, pressure-control valve, and pressure-limiter valve is available in a number of different designs.

Function

The available rail volume is permanently filled with pressurized fuel. The compressibility of the fuel resulting from the high pressure is utilised to achieve the accumulator effect. When fuel leaves the rail for injection, the pressure in the high-pressure accumulator remains practically constant. Similarly, the pressure variations resulting from the pulsating fuel supply from the high-pressure pump are compensated for.

[Fig. 10]



High-pressure accumulator (rail)

1. Rail
2. Inlet from the high-pressure pump
3. Rail-pressure sensor
4. Return from the rail to the fuel tank
5. Line to the injector

EFHB211A

Rail-pressure sensor

Assignment

In order to output a voltage signal to the ECU which corresponds to the applied pressure, the rail-pressure sensor must measure the instantaneous pressure in the rail
- With adequate accuracy, and
- As quickly as possible

Design and construction

The rail-pressure sensor (Fig. 12) comprises the following components:
- An integrated sensor element welded to the pressure fitting,
- A printed-circuit board (pcb) with electrical evaluation circuit, and
- A sensor housing with electrical plug-in connection.

The fuel flows to the rail-pressure sensor through an opening in the rail, the end of which is sealed off by the sensor diaphragm. Pressurized fuel reaches the sensor's diaphragm through a blind hole. The sensor element (semiconductor device) for converting the pressure to an electric signal is mounted on this diaphragm. The signal generated by the sensor is inputted to an evaluation circuit which amplifies the measuring signal and sends it to the ECU.

Function

The rail-pressure sensor (Fig. 12) operates as follows: When the diaphragm's shape changes, the electrical resistance of the layers attached to the diaphragm also change. The change in shape (approx. 1 mm at 1500bar) which results from the buildup of system pressure, changes the electrical resistance and causes a voltage change across the 5V resistance bridge.

This voltage change is in the range 0 ... 70mV (depending upon the applied pressure) and is amplified by the evaluation circuit to 0.5 ... 4.5V.
The precise measurement of rail pressure is imperative for correct system functioning. This is one of the reasons for the very tight tolerances which apply to the rail-pressure sensor during pressure measurement. In the main operating range, the measuring accuracy is approx. ± 2% of full-scale reading. If the rail-pressure sensor should fail, the pressure-control valve is triggered "blind" using an emergency (limp-home) function and fixed values.

Pressure limiter valve

Assignment

The pressure limiter valve has the same job as an overpressure valve. In case of excessive pressure, the pressure limiter valve limits the rail pressure by opening an escape passage. The pressure limiter permits a short-time maximum rail pressure of 1500 bar.

Design and construction

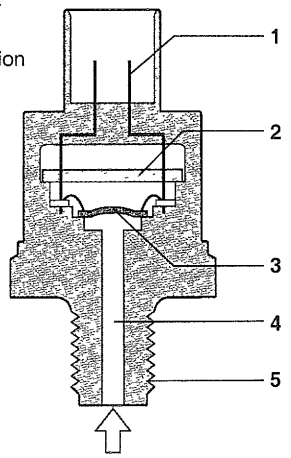
The pressure-limiter valve is a mechanical device comprising the following components:
- Housing with external thread for screwing to the rail,
- A connection to the fuel-tank return line,
- A movable plunger, and
- A spring.

At the connection end to the rail, the housing is provided with a passage which is closed by the cone-shaped end of the plunger coming up against the sealing seat inside the housing. At normal operating pressures (up to 1350bar), a spring forces the plunger against the seat and the rail remains closed. As soon as the maximum system pressure is exceeded, the plunger is forced up by the rail pressure against the force of the spring. The fuel under high pressure can now escape, whereby it flows through passages into the plunger's interior from where it is led through a collector line back to the fuel tank. When the valve opens. fuel leaves the rail so that the rail pressure drops.

[Fig. 12]

Rail-pressure sensor (schematic)

1. Electric connections
2. Evaluation circuit
3. Diaphragm with sensor element
4. High-pressure connection
5. Mounting thread



EFHB231A

Injector's

Assignment

The start of injection and the injected fuel quantity are adjusted by electrically triggered injectors. These injectors supersede the nozzle-and-holder assembly (nozzle and nozzle-holder).
Similar to the already existing nozzle-holder assemblies in direct-injection (DI) diesel engines, clamps are preferably used for installing the injectors in the cylinder head. This means that the Common Rail injectors can be installed in already existing DI diesel engines without major modifications to the cylinder head.

Design and construction

The injector (Fig. 16) can be sub-divided into a number of function blocks:
- The hole-type nozzle,
- The hydraulic servo-system, and
- The solenoid valve.

Referring to Fig. 16, fuel is fed from the high-pressure connection, to the nozzle through the passage, and to the control chamber through the feed orifice. The control chamber is connected to the fuel return via a bleed orifice which is opened by the solenoid valve.
With the bleed orifice closed, the hydraulic force applied to the valve control plunger exceeds that at the nozzle-needle pressure shoulder. As a result, the needle is forced into its seat and seals off the high-pressure passage from the combustion chamber.
When the injector's solenoid valve is triggered, the bleed orifice is opened. This leads to a drop in control-chamber pressure and, as a result, the hydraulic pressure on the plunger also drops. As soon as the hydraulic force drops below the force on the nozzle-needle pressure shoulder, the nozzle needle opens and fuel is injected through the spray holes into the combustion chamber. This indirect control of the nozzle needle using a hydraulic force-amplification system is applied because the forces which are necessary for opening the needle very quickly cannot be directly generated by the solenoid valve. The so-called control quantity needed for opening the nozzle needle is in addition to the fuel quantity which is actually injected, and it is led back to the fuel-return line via the control chamber's orifices.
In addition to the control quantity, fuel is also lost at the nozzle-needle and valve-plunger guides. These control and leak-off fuel quantities are returned to the fuel tank via the fuel return and the collector line to which overflow valve, high-pressure pump, and pressure-control valve and also connected.

Method of operation

The injector's operation can be subdivided into four operating states with the engine running and the high-pressure pump generating pressure:
- Injector closed (with high pressure applied),
- Injector opens (start of injection),
- Injector opened fully, and
- Injector closes (end of injection).

These operating states result from the distribution of the forces applied to the injector's components. With the engine at standstill and no pressure in the rail, the nozzle spring closes the injector.

Injector closed (at-rest status):

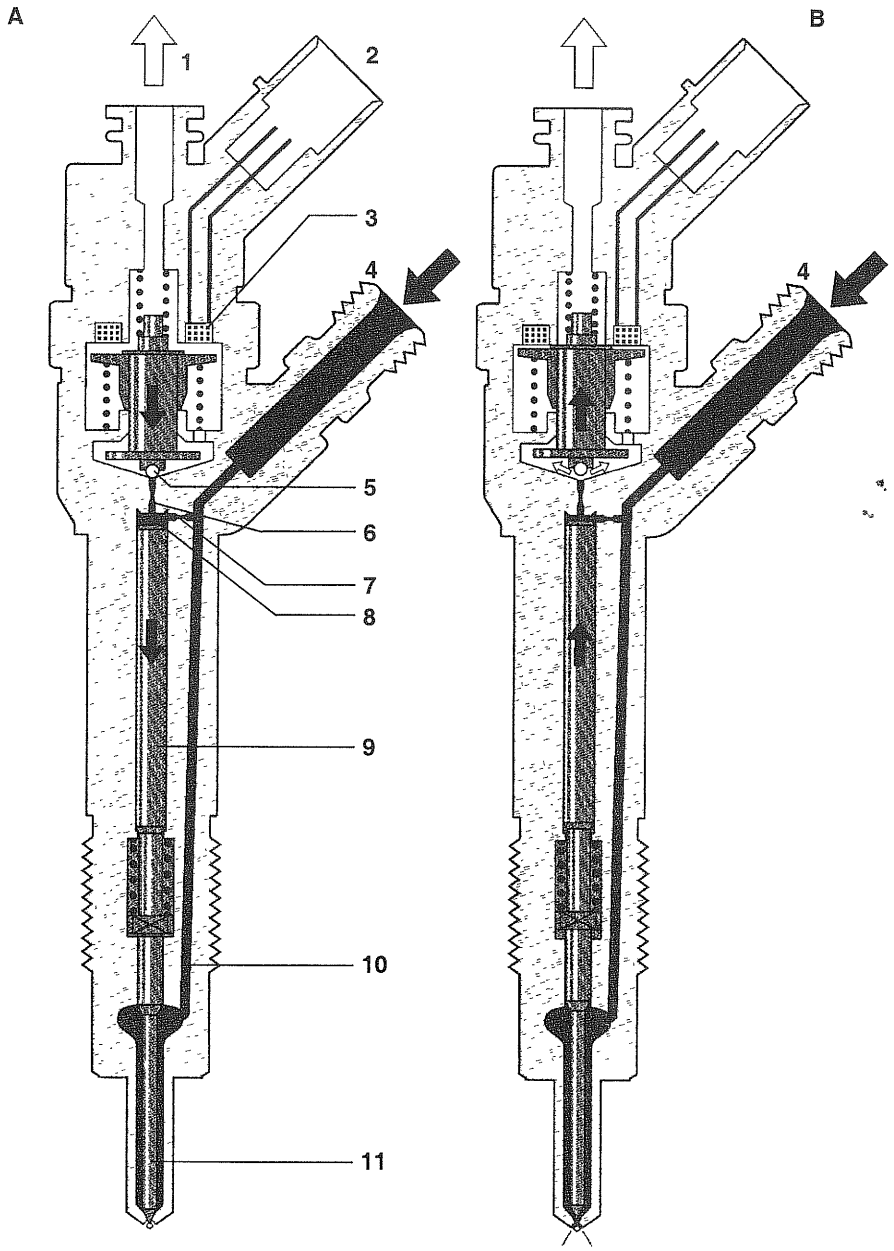
In the at-rest state, the solenoid valve is not energized and is therefore closed (Fig. 16a).
With the bleed orifice closed, the valve spring forces the armature's ball onto the bleed-orifice seat. The rail's high pressure builds up in the valve control chamber, and the same pressure is also present in the nozzle's chamber volume. The rail pressure applied at the control plunger's end face, together with the force of the nozzle spring, maintain the nozzle in the closed position against the opening forces applied to its pressure stage.

Injector opens (start of injection):

The injector is in its at-rest position. The solenoid valve is energized with the pickup current which serves to ensure that it opens quickly (Fig. 16b). The force exerted by the triggered solenoid now exceeds that of the valve spring and the armature opens the bleed orifice. Almost immediately, the high-level pick-up current is reduced to the lower holding current required for the electromagnet. This is possible due to the magnetic circuit's air gap now being smaller. When the bleed orifice opens, fuel can flow from the valve-control chamber into the cavity situated above it, and from there via the fuel return to the fuel tank, The bleed orifice prevents complete pressure balance, and the pressure in the valve control chamber sinks as a result. This leads to the pressure in the valve-control chamber being lower than that in the nozzle's chamber volume which is still at the same pressure level as the rail. The reduced pressure in the valve-control chamber causes a reduction in the force exerted on the control plunger, the nozzle needle opens as a result, and injection starts.

The nozzle needle's opening speed is determined by the difference in the flow rate through the bleed and feed orifices. The control plunger reaches its upper stop where it remains supported by a cushion of fuel which is generated by the flow of fuel between the bleed and feed orifices. The injector nozzle has now opened fully, and fuel is injected into the combustion chamber at a pressure almost equal to that in the fuel rail. Force distribution in the injector is similar to that during the opening phases.

[Fig. 16]



Injector (schematic)

A. Injector closed (at-rest status)
B. Injector opened (injection)
1. Fuel return
2. Electrical connection
3. Triggering element (solenoid valve)
4. Fuel inlet (high pressure) from the rail
5. Valve ball
6. Bleed orifice
7. Feed orifice
8. Valve control chamber
9. Valve control plunger
10. Feed passage to the nozzle
11. Nozzle needle

EFHB261A

Injector closes (end of injection):

As soon as the solenoid valve is no longer triggered, the valve spring forces the armature downwards and the ball closes the bleed orifice. The armature is a 2-piece design. Here, although the armature plate is guided by a driver shoulder in its downward movement, it can "overspring" with the return spring so that it exerts no downwards-acting forces on the armature and the ball. The closing of the bleed orifice leads to pressure buildup in the control chamber via the input from the feed orifice. This pressure is the same as that in the rail and exerts an increased force on the control plunger through its end face. This force, together with that of the spring, now exceeds the force exerted by the chamber volume and the nozzle needle closes.
The nozzle needle's closing speed is determined by the flow through the feed orifice. Injection ceases as soon as the nozzle needle comes up against its bottom stop again.

SYSTEM CONTROL USING EDC

SYSTEM BLOCKS

The Electronic Diesel Control (EDC) for Common Rail comprises three major system blocks:

1. Sensors and setpoint generators for registration of the operating conditions and the desired values. These convert a variety of physical parameters into electrical signals.
2. The ECU for generating the electrical output signals by processing the information using specified arithmetic operations (control algorithms)
3. Actuators to convert the ECU' s electrical output signals into mechanical parameters.

SENSORS (FIG. 12)

Crankshaft-speed sensor

The piston position in the combustion chamber is decisive in defining the start of injection. All the engine' s pistons are connected to the crankshaft by connecting rods (conrods). A sensor on the crankshaft can therefore provide information on the position of all the pistons. The rotational speed defines the number of crankshaft rotations per minute.
This important input variable is calculated in the ECU using the signal from the inductive crankshaft-speed sensor.

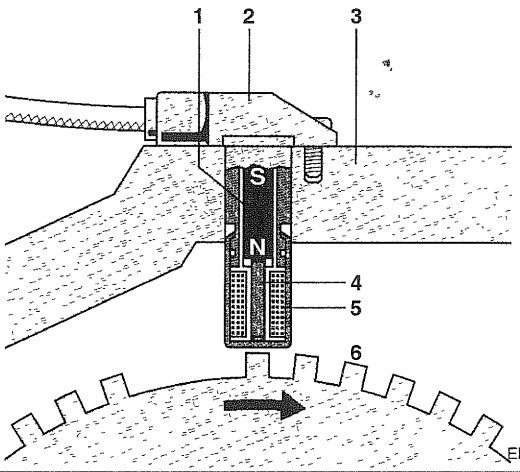
Signal generation

A 60-tooth ferromagnetic trigger wheel is attached to the crankshaft. On the actually used trigger wheel 2 teeth are missing. The large gap is allocated to a defined crankshaft position for cylinder 1.
The crankshaft-speed sensor registers the trigger wheel' s tooth sequence. It comprises a permanent magnet and a soft-iron core with a copper winding (Fig. 1). The magnetic flux in the sensor changes as the teeth and gaps pass by, and a sinusoidal AC voltage is generated the amplitude of which increases sharply in response to higher engine (crankshaft) speeds. Adequate amplitude is already available from speeds as low as 50 min^{-1}.

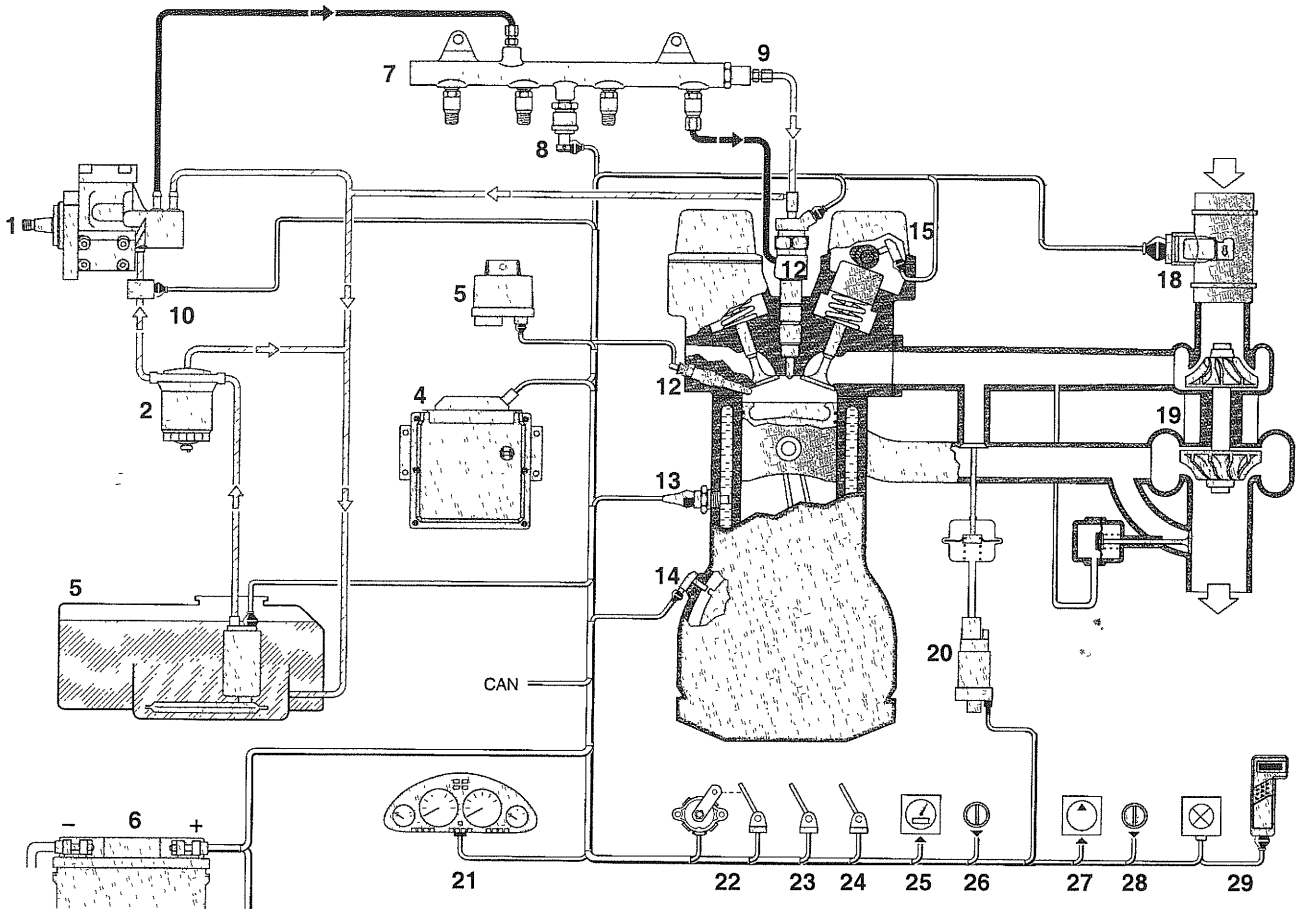
[Fig. 1]

Crankshaft-speed sensor

1. Permanent magnet
2. Housing
3. Engine crankcase
4. Shoft-iron core
5. Winding
6. Trigger wheel



[Fig. 12]



System overview of a Common Rail injection system and a variety of system components

1. High-pressure pump
2. Fuel filter
3. Fuel tank with preliminary filter and presupply pump
4. ECU
5. Glow control unit
6. Battery
7. High-pressure accumulator (rail)
8. Rail-pressure sensor
9. Pressure limiter valve
10. Fuel-temperature sensor
11. Injector
12. Sheathed-element glow plug
13. Coolant-temperature sensor
14. Crankshaft sensor
15. Camshaft sensor
16. Intake-air temperature sensor
17. Boost-pressure sensor (BPS)
18. Air-mass meter
19. Turbocharger
20. EGR positioner
21. Instrument panel with display for fuel consumption, engine speed etc.
22. Accelerator-pedal sensor
23. Brake contacts
24. Clutch switch
25. Road-speed sensor
26. Operator unit for vehicle-speed controller
27. Air-conditioner compressor
28. Air-conditioner operator unit
29. Diagnosis display with connection for diagnostic unit

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Camshaft-speed sensor

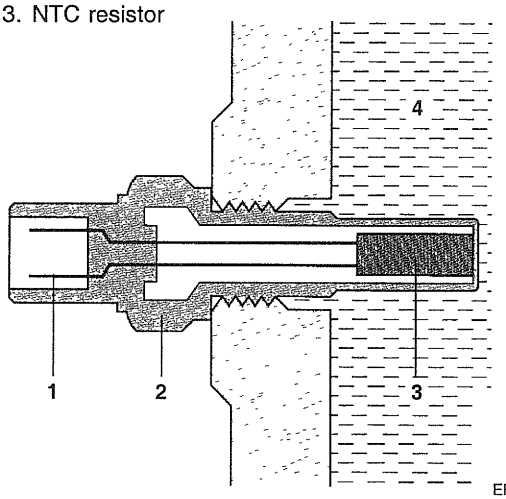
The camshaft controls the engine' s intake and exhaust valves. It turns at half the speed of the crankshaft. When a piston travels in the directions of TDC, the camshaft position determines whether it is in the compression phase with subsequent ignition, or in the exhaust phase. The information cannot be generated from the crankshaft position during the starting phase. During normal engine operation on the other hand, the information generated by the crankshaft sensor suffices to define the engine status. In other words, this means that if the camshaft sensor should fail while the vehicle is being driven, the ECU still receives information on the engine status from the crankshaft sensor.

The camshaft sensor utilises the Hall effect when establishing the camshaft position. A tooth of ferromagnetic material is attached to the camshaft and rotates with it. When this tooth passes the semiconductor wafers of the camshaft sensor, its magnetic field diverts the electrons in the semiconductor wafers at right angles to the direction of the current flowing through the wafers. This results in a brief voltage signal (Hall voltage) which informs the ECU that cylinder 1 has just entered the compression phase.

[Fig. 3]

Coolant-temperature sensor (schematic)

1. Electrical connections
2. Housing
3. NTC resistor



EFHB322A

Temperature sensors

Temperature sensors are installed at a number of different points:

- In the coolant circuit, to establish engine temperature by way of the coolant temperature (Fig. 3),
- In the intake manifold to measure the temperature of the intake air,
- In the engine lube oil to measure the oil temperature (optional), and
- In the fuel-return line to measure the fuel temperature (optional).

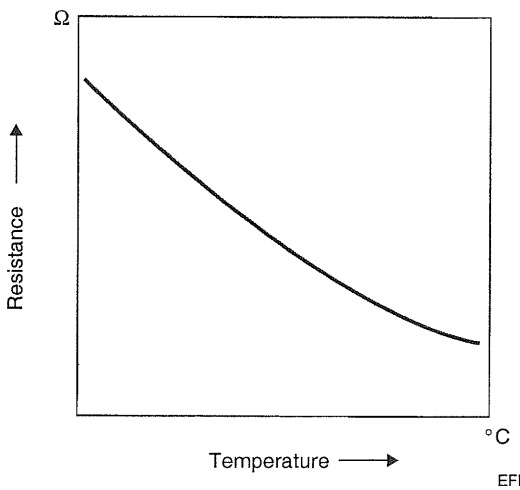
The sensors are equipped with a temperature-dependent resistor with a negative temperature coefficient (NTC) which is part of a voltage-divider circuit across which 5V are applied.
The voltage drop across the resistor is inputted into the ECU through an analog-to-digital converter (ADC) and is a measure for the temperature. A characteristic curve is stored in the ECU microcomputer which defines the temperature as a function of the given voltage value (Fig. 4).

Hot-film air-mass meter

Particularly during dynamic operation, precise compliance with the correct A/F ratio is imperative in order to comply with the exhaust-gas limits as stipulated by law. This necessitates the use of sensors which precisely register the air-mass flow actually being drawn in by the engine at a particular moment. This load sensor' s measuring accuracy must be completely independent of pulsation, reverse flow, EGR, variable camshaft control, and changes in the intake-air temperature.

[Fig. 4]

Characteristic curve of a temperature sensor (NTC)



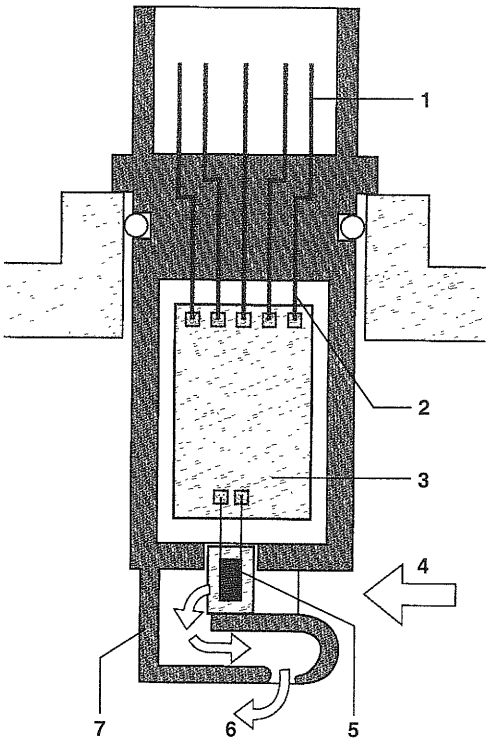
EFHB322A

A hot-film air-mass meter was selected as being most suitable for complying with the above stipulations. The hot-film principle is based on the transfer of heat from a heated sensor element to the air-mass flow (Fig. 5). A micromechanical measuring system is utilised which permits registration of the air-mass flow and detection of flow direction. Reverse flows are also detected in case of strongly pulsating air flow.
The micromechanical sensor element is located in the plug-in sensor' s flow passage (Fig. 5,). The plug-in sensor can be installed in the air filter or in a measuring tube in the engine' s air intake duct.

[Fig. 5]

Hot-film air-mass meter (schematic)

1. Electrical connections
2. Internal connections
3. Evaluation electronics (hybrid circuit)
4. Air inlet
5. Sensor element
6. Air outlet
7. Housing



EFHB331A

There are a variety of different-sized measuring tubes available, depending upon the maximum air throughput reqauired by the engine. The signal voltage curve, as a function of the air mass flow, is divided into signal ranges for forward flow and reverse flow. In order to increase measuring accuracy, the measuring signal is referred to a reference voltage outputted by the engine management. The characteristic curve has been designed so that during diagnosis in the workshop and open circuit conductor, for instance, can be detected with the help of the engine management.
A temperature sensor can be incorporated for measuring the intake-air temperature.

Accelerator-pedal sensor

In contrast to conventional distributor and in-line injection pumps, with EDC the driver' s acceleration input is no longer transmitted to the injection pump by Bowden cable or mechanical linkage, but is registered by an accelerator-pedal sensor and transmitted to the ECU (this is also known as drive-by wire).
A voltage is generated across the potentiometer in the accelerator-pedal sensor as a function of the accelerator-pedal setting. Using a programmed characteristic curve, the pedal' s position is then calculated from this voltage.

Boost-pressure sensor

The boost-pressure sensor (BPS) is pneumatically connected to the intake manifold and measures the intake manifold' s absolute pressure between 0.5 and 3 bar. The sensor is sub-divided into a pressure cell with two sensor elements, and a chamber for the evaluation circuit. The sensor elements and the evaluation circuit are mounted on a common ceramic substrate.
Each sensor element comprises a bell-shaped thick-film diaphragm, containing a reference volume with defined internal pressure. The diaphragm is displaced to a greater or lesser degree as a function of charge pressure.

Piezoresistive resistors are located on the diaphragm's surface whose resistance changes when mechanical stress is applied. These resistors are connected as a bridge so that when the diaphragm moves this causes a change in the bridge balance. This means that the bridge voltage is a measure for the boost pressure.
The evaluation circuit is responsible for amplifying the bridge voltage, compensating for temperature influences, and for linerization of the pressure characteristic. The evaluation circuit's output signal is inputted to the ECU where, with the help of a programmed characteristic curve, it is used for calculating the boost pressure.

ECU

Assignment and method of operation

The ECU evaluates the signals it receives from the external sensors and limits them to the permissible voltage level.
From this input data, and from stored characteristic maps, the ECU microprocessors calculate the injection times and the instants of injections, and convert these times to signal characteristics which are adapted to the movements of the engine pistons and crankshaft. The specified accuracy and the engine's high dynamic response demands high levels of computing power.
The output signals from the ECU microprocessors are used to trigger driver stages which provide adequate power for switching the actuators rail-pressuresure control and element switch-off. In addition, actuators for engine function are triggered (e.g. EGR actuator, boost-pressure actuator, and the relay for the electric fuel pump), as well as those for further auxiliary functions such as blower relay, auxilary-heater relays, glow relay, air-conditioner). The driver stages are proof against short-circuit and destruction due to brief electrical overloading. Errors of this type, and open-circuit or unplugged lines, are reported to the microprocessor. Diagnosis functions in the injector driver stages detect faulty signal characteristics, and in addition a number of the output signals are transferred via interfaces for use in other systems in the vehicle. And within the framework of a special safety concept, the ECU monitors the complete fuel-injection system.
Injector triggering places particularly heavy demands on the driver stages. In the injector, the current from the driver stage generates a magnetic force in the triggering element which is applied to the injector's high-pressure system. In order to ensure very tight tolerances, and high reproducibility of the injected fuel quantity, this coil must be triggered with steep current flanks. This necessitates high voltages being made available in the ECU.
A current control circuit divides the energisation time (injection time) into a pickup-current phase and a hold phase. It must operate so accurately that the injector guarantees reproducible injection under all operating conditions. In addition, it must reduce the power loss in the ECU and the injectors.

Operating conditions

High demands are made upon the ECU regarding
- The surrounding (ambient) temperatures (in normal cases from -40 ... +85° C),
- The resistance to fuels and lubricants etc.,
- The resistance to humidity, and
- Mechanical loading.

Very high demands are also made upon electromagnetic compatibility (EMC) and upon the radiation of HF interference signals.

Design and construction

The ECU has a metal housing. The sensors, the actuators, and power supply are connected to the ECU through a multi-pole plug-in connector.
The power components which directly trigger the actuators are integrated in the ECU in such a manner that they can efficiently dissipate their heat to the ECU housing. Both sealed and non-sealed versions of the ECU are available.

Operating-state control

In order that the engine operates with optimum combustion in every operating state, the ECU in each case calculates the appropriate injected fuel quantity. In the process, a number of parameters must be taken into account (Fig. 6).

Start quantity

For starting, the injected fuel quantity is calculated as a function of temperature and cranking speed. The start quantity is injected from the moment the starting switch is turned to "Start" (Fig. 6, Pos. A) until the engine has reached a given minimum speed. The driver has no influence upon the start quantity.

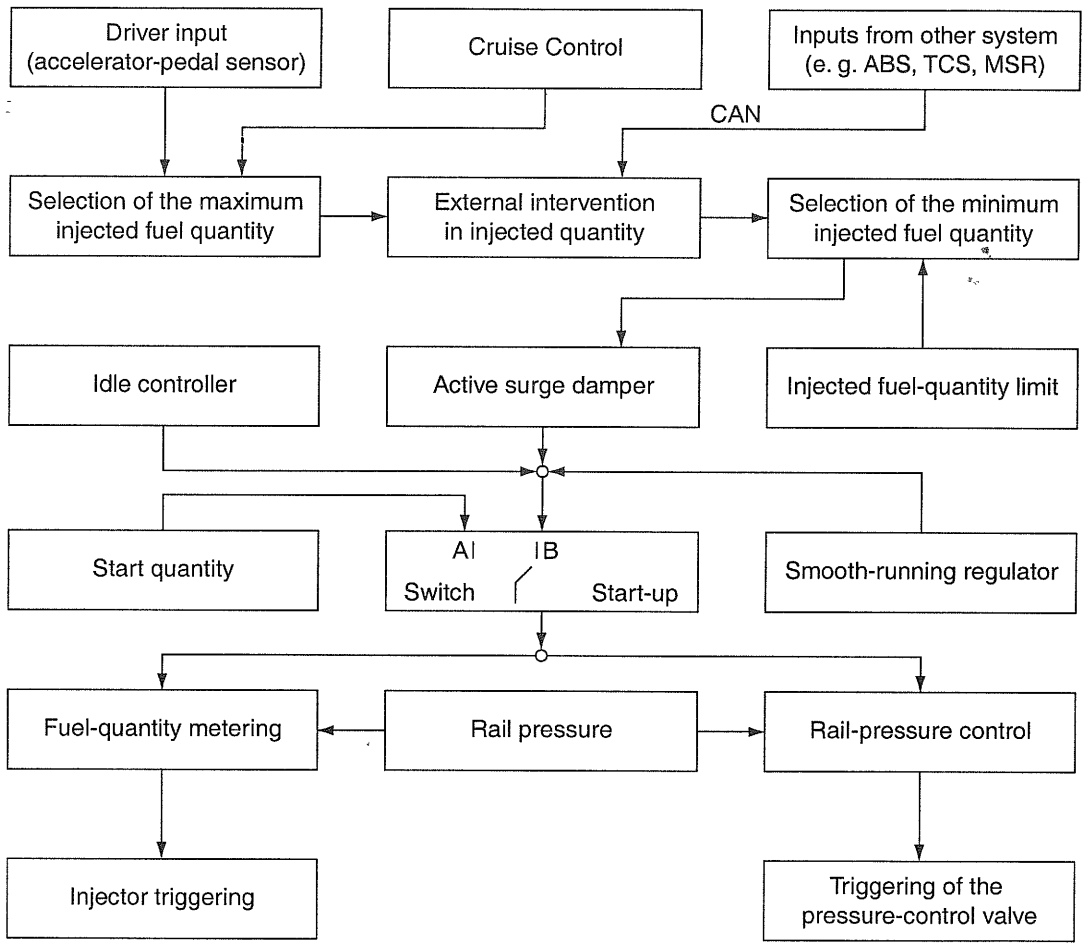
Drive mode

When the vehicle is being driven normally (Fig. 6, stating switch in Pos. B), the injected fuel quantity is calculated from the accelerator-pedal setting (accelerator-pedal sensor) and the engine speed. Calculation utilises the driving map so that the driver input and the engine O.P power are optimally matches to each other.

[Fig. 6]

Calculation in the ECU of the injected fuel quantity

Starting-switch position A : Start
Starting-switch position B : Drive mode



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Idle-speed control

At idle, fuel consumption depends for the most part on engine efficiency and idle speed. Since a considerable portion of a vehicle's fuel consumption in dense traffic conditions is attributable to this operating state, it is obvious that idle speed must be kept to a minimum. The idle speed though, must be set so that no matter what the operating conditions, it does not drop so far under load that the engine runs roughly or even stops. This applies for instance when the vehicle electrical system is loaded, when the air-conditioner is switched on, when a gear is engaged on an automatic transmission, or when the power steering is in operation. In order to regulate to the desired idle speed, the idle controller varies the injected fuel quantity until the actual engine speed equals the desired idle speed. Here, the desired idle speed and the control characteristic are influenced by the selected gear and by the engine temperature (coolant-temperature sensor). In addition to the external load moments must also be taken into account and compensated for by the idle-speed control. These change minimally but steadily throughout the vehicle's service life, as well as being highly dependent upon temperature.

Smooth-running control

Due to mechanical tolerance and ageing, there are differences in the torques generated by the engine's individual cylinders. This leads to rough or irregular running, particularly at idle. The smooth-running (cylinder-balancing) control measures the engine-speed changes every time a cylinder has "fired" and compares them with each other. The injected fuel quantity of reach cylinder is then adjusted in accordance with the measured differences in engine speed between the individual cylinders, so that each cylinder makes the same contribution to the torque generated by the engine. The smooth-running control is only operative in the lower engine-speed range.

Vehicle-speed controller

The vehicle-speed controller (Cruise Control) comes into operation when the vehicle is to be driven at a constant speed. It controls the vehicle speed to that inputted by the driver at the operator unit in the instrument panel.
The injected fuel quantity is increased or reduced until the actual speed equals the set speed. While the Cruise Control is in operation, the control process is interrupted if the driver depresses the clutch, or applies the brakes. If the accelerator pedal is pressed, the vehicle can be accelerated beyond the speed which has been set with the Cruise Control.

As soon as the accelerator pedal is released, the Cruise Control regulates the speed back down again to the previous set speed. Similarly, if the Cruise Control has been switched off, the driver only needs to press the reactivate key in order to again select the last speed which had been set.

Controlling the injected fuel quantity limit

There are a number of reasons why the fuel quantity desired by driver (or the maximum physically possible quantity) must not be injected.
These include:
- Excessive pollutant emissions,
- Excessive soot emissions,
- Mechanical overloading due to excessive torque or engine speed, or
- Thermal overload as a result of excessive coolant, lube-oil, or turbocharger temperature.

The limit for the injected fuel quantity is formed from a number of input variables, for instance intake air mass, engine speed, and coolant temperature.

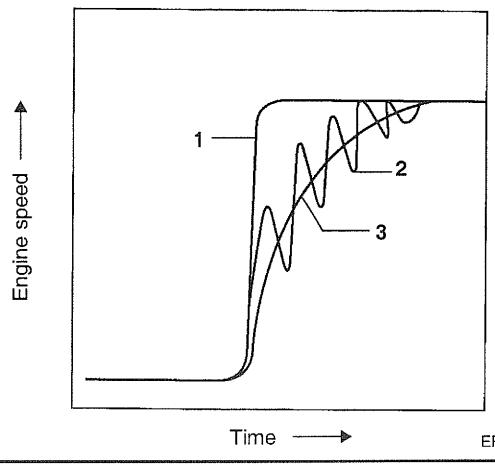
Active surge-damping control

When the accelerator pedal is abruptly depressed or released, this causes the injected fuel quantity to change rapidly with the result that there is also a rapid change in the torque developed by the engine. These abrupt load changes lead to the resilient engine mountings and the drivertrain generating bucking oscillations which result in fluctuations of engine speed (Fig. 7).

[Fig. 7]

Active surge damper

1. Sudden accelerator-pedal movement (driver input)
2. Engine-speed curve without active surge-damping control
3. With active surge-damping control



The active surge-damper reduces these periodic speed fluctuations by varying the injected fuel quantity at the same frequency as the periodic speed fluctuations:
Less fuel is injected when the speed increases, and more when it decreases.
This effectively damps the surge movements.

Engine switch off

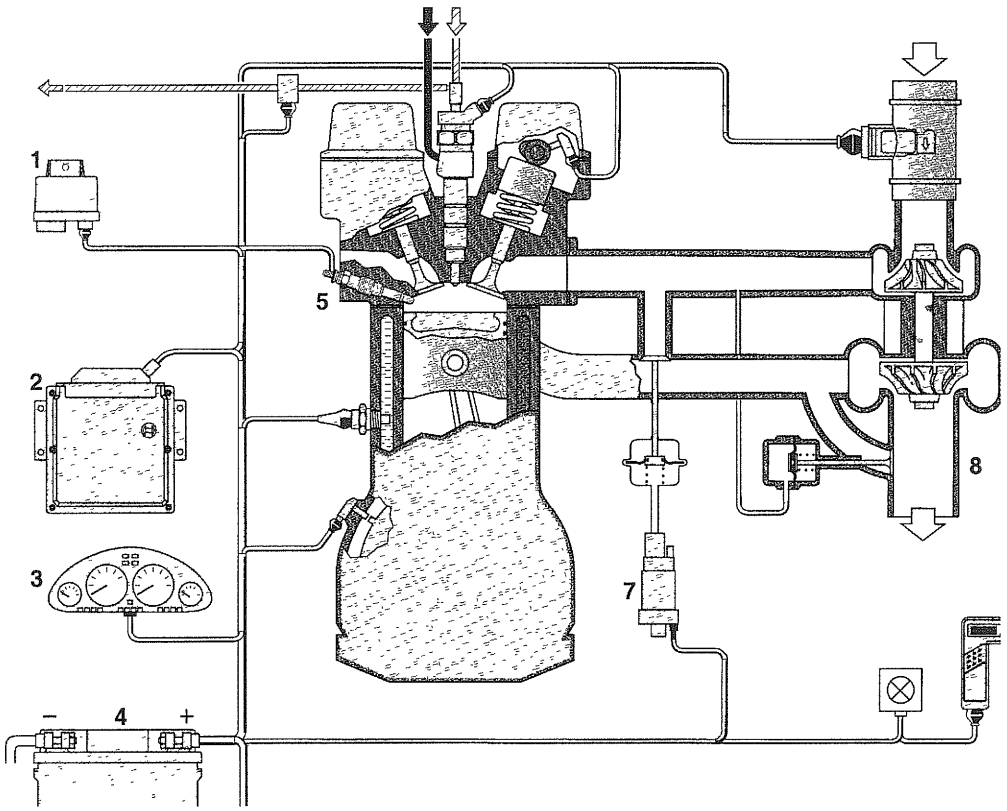
The diesel engine operates according to the "auto-ignition" principle. This means that it can only be switched off by interupting its supply of fuel.
In the case of the "Electronic Diesel Control (EDC)", the engine is switched off by ECU stipulating "injected fuel quantity zero". The system also features a number of additional (redundant) switch-off paths.

ACTUATORS (FIG.8)

Injector

Special injectors with hydraulic servo system and electrical triggering element (solenoid valve) are used with the Common Rail system in order to achieve efficient start of injection and precise injected fuel quantity. At the start of injection, a high pickup current is applied to the injector so that the solenoid valve opens quickly. As soon as the nozzle needle has travelled its complete stroke, and the nozzle has opened completely, the energizing current is reduced to a lower holding value. The injected fuel quantity is now defined by the injector opening time and the rail pressure. Injection is terminated when the solenoid valve is no longer triggered and closes as a result

[Fig. 8]



High-pressure pump (schematic, longitudinal section)

1. Glow control unit
2. ECU
3. Instrument panel with displays for fuel consumption, engine speed etc.
4. Battery
5. Glow plug
6. Injector
7. EGR positioner
8. Charge-pressure actuator
9. Vacuum pump
10. Turbocharger

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Pressure -control valve

The ECU uses the pressure-control valve to control the rail pressure. When the pressure-control valve is triggered, the energized electromagnet forces the armature up against the seal seat and the valve closes. The high-pressure and low-pressure side are sealed off from each other and the rail pressure increases.
In the non-energized mode, the electromagnet no longer exerts force on the armature and the pressure-control valve opens so that some of the fuel from the rail can flow back to the tank through a collector line. The rail pressure drops.
It is possible to vary the pressure by pulsing (pwm) the triggering current. The degree to which the pressure-control valve is opened or closed depends on the pulse rate (duty cycle).

Glow control unit

The glow control unit is responsible for ensuring efficient cold starting. It also shortens the warm-up period, a fact which is highly relevant for exhaust emissions. The preheating time is a function of the coolant temperature. The further glow phases during engine start or when the engine is actually running are determined by a number of parameters which include engine speed and injected fuel quantity. Glow control utilises a power relay.

INTEGRATED DIAGNOSIS

Sensor monitoring

For sensor monitoring, the integrated diagnosis facility checks whether they are being supplied with power, and whether their O/P signals are plausible (within the permitted range, e.g. temperature between -40 und 150° C). Where possible, the redundancy principle is applied for important signals. That is, in case of malfunction a switch is made to another similar signal.

Monitoring module

In addition to the microcontroller, the ECU also incorporates a monitoring module.
The ECU and the monitoring module monitor each other. If a malfunction is detected, either of them can switch off the injection independent of the other.

Malfunction detection

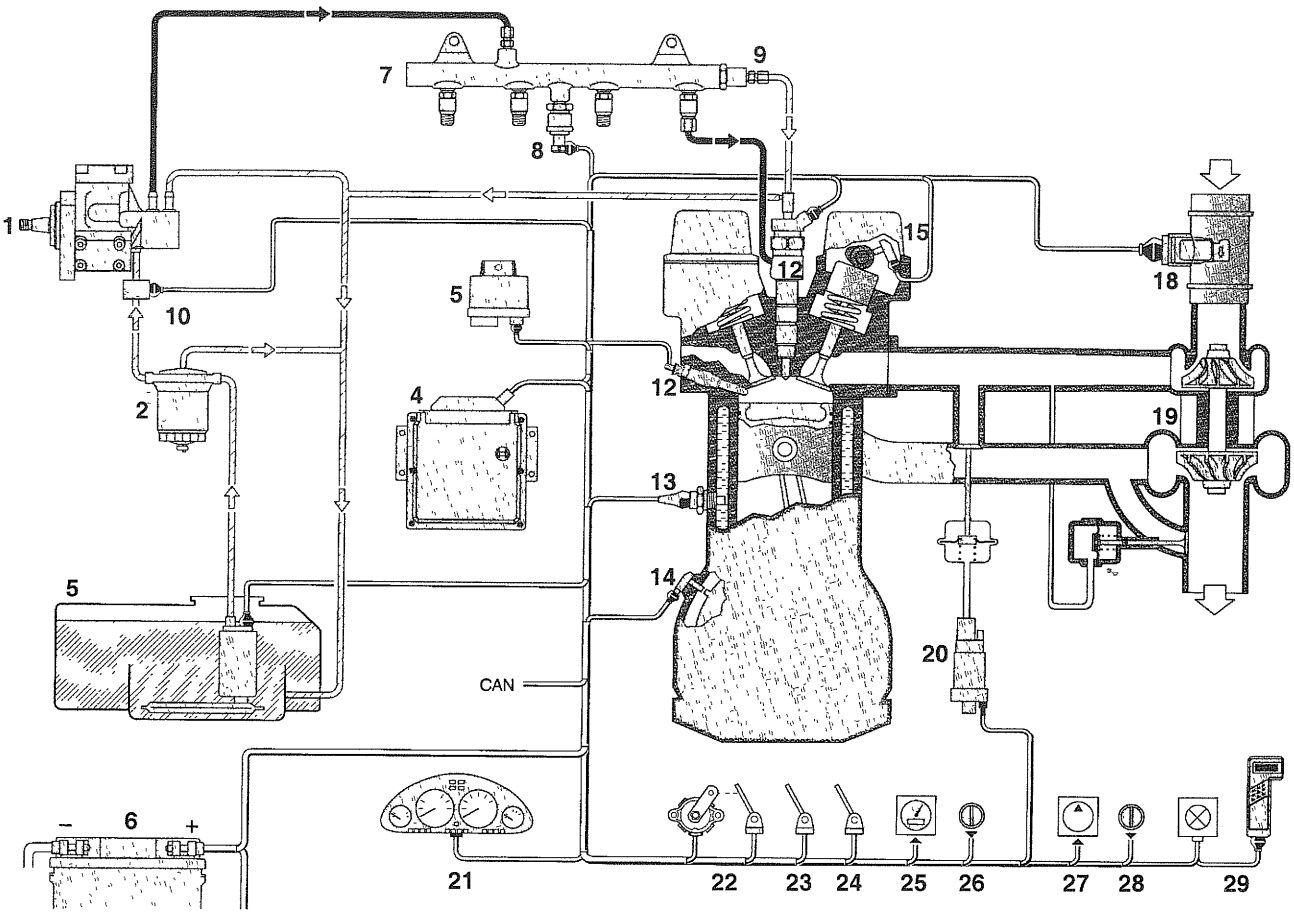
Malfunction detection is only possible within the monitoring range of a given sensor. A signal path is classified as faulty when an error is present for longer than a predefined period. In such cases, the error is stored in the ECU's error memory together with details of the environmental conditions which prevailed when the error/malfunction occurred (e.g. coolant temperature, engine speed etc.). For a large number of errors/malfunctions, it is possible for the "OK again" status to be established. Here, the signal path must be identified as intact for a defined period of time.

Error procedure

If a sensor' s permitted output-signal range is violated, a switch is made to a substitute value. This procedure is applied for the following input signals:
- Battery voltage,
- Coolant, air, and lube-oil temperature,
- Charge-air pressure,
- Atmospheric pressure and intake-air quantity.

In addition, in case of non-plausible signals from the accelerator-pedal sensor and/or the brakes, a substitute accelerator-pedal sensor signal is applied.

[Fig. 12]



System overview of a Common Rail injection system and a variety of system components

1. High-pressure pump
2. Fuel filter
3. Fuel tank with preliminary filter and presupply pump
4. ECU
5. Glow control unit
6. Battery
7. High-pressure accumulator (rail)
8. Rail-pressure sensor
9. Pressure limiter valve
10. Fuel-temperature sensor
11. Injector
12. Sheathed-element glow plug
13. Coolant-temperature sensor
14. Crankshaft sensor
15. Camshaft sensor
16. Intake-air temperature sensor
17. Boost-pressure sensor (BPS)
18. Air-mass meter
19. Turbocharger
20. EGR positioner
21. Instrument panel with display for fuel consumption, engine speed etc.
22. Accelerator-pedal sensor
23. Brake contacts
24. Clutch switch
25. Road-speed sensor
26. Operator unit for vehicle-speed controller
27. Air-conditioner compressor
28. Air-conditioner operator unit
29. Diagnosis display with connection for diagnostic unit

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ELECTRONIC DIESEL CONTROL - EDC

TECHNICAL REQUIREMENTS

The reduction of fuel consumption along with an increase in power output or torque, are the decisive factors behind present-day developments in the diesel fuel-injection field. In the past years this has led to an increase in the use of direct-injection (DI) diesel engines. Compared to prechamber or whirl-chamber engines, the so-called indirect-injection (IDI) engines, the DI engine operates with far higher injection pressures. This leads to improved mixture formation, and fuel combustion is more complete.
In the DI engine, the improved mixture formation and the fact that there are no overflow losses between prechamber/whirl chamber and the main combustion chamber results in a fuel-consumption reduction of 10...15% compared to the IDI engine.
In addition, modern-day engines are subject to more severe requirements with regard to exhaust-gas and noise emissions.
This has led to higher demands being made on the injection system and its control:

- High injection pressures,
- Structured rate-of-discharge curve,
- Variable start of injection,
- Pilot injection,
- Adaptation of injected fuel quantity, boost pressure, and injected fuel quantity to the given operating state,
- Temperature-dependent start quantity,
- Load-independent idle-speed control,
- Cruise control,
- Closed-loop-controlled exhaust-gas recirculation (EGR), and
- Reduced tolerances and higher accuracy throughout the vehicle' s useful life.

Conventional mechanical (flyweight) governors use a number of add-on devices to register the various operating conditions, and ensure that mixture formation is of high quality. Such governors, though, are restricted to simple open-loop control operations at the engine, and there are many important actuating variables which they cannot register at all or not quickly enough.

SYSTEM OVERVIEW

In the past years, the marked increase in the computing power of the micro-controllers available on the market has made it possible for the EDC (Electronic Diesel Control) to comply with the above-named stipulations.
In contrast to diesel-engined vehicles with conventional in-line or distributor injection pumps, the driver of an EDC controlled vehicle has no direct influence, for instance through the accelerator pedal and Bowden cable, upon the injected fuel quantity. On the contrary, the injected fuel quantity is defined by a variety of actuating variables, e.g. operating state driver input, pollutants emission, etc. This of course means that an extensive safety concept must be implemented that detects errors and malfunctions and, depending upon their severity, initiates appropriate countermeasures (e.g. limitation of torque, or emergency (limp-home) running in the idle-speed range) EDC also permits the exchange of data with other electronic systems in the vehicle (e.g. with the traction control system (TCS), and with the electronic transmission-shift control). This means that it can be integrated in the overall vehicle system.

EDC DATA PROCESSING

Input signals

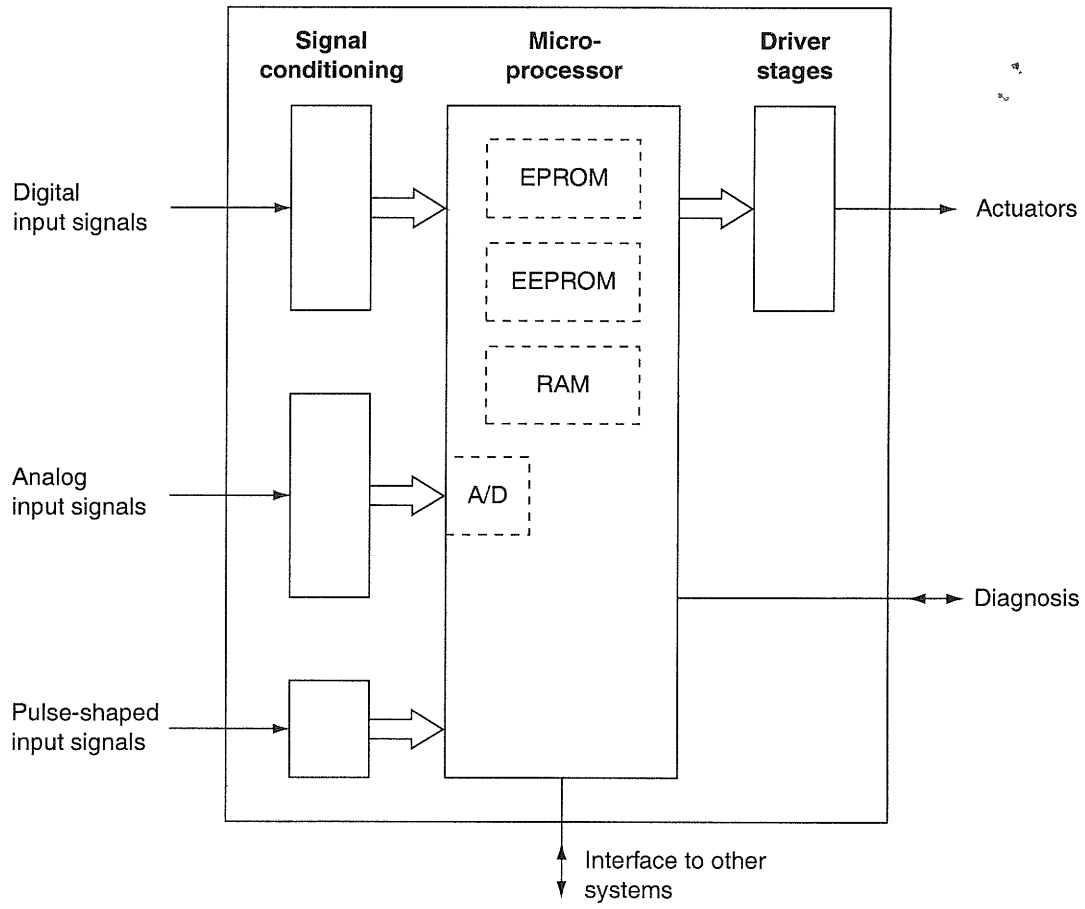
Together with the actuators, the sensors represent the interface between the vehicle and its data-processing unit the ECU.
The signals from the sensors are passed to the ECU (or to several ECU' s) via protective circuitry and, where necessary, via signal transducers and amplifiers (Fig. 1):

- Analog input signals (e.g. information from analog sensors on the quantity of air drawn in by the engine, engine and intake-air temperatures, battery voltage, etc.) are converted to digital values by an A/D converter in the ECU microprocessor.
- Digital input signals (e.g. On/Off switching signals, or digital sensor signals such as the rotational-speed pulses from a Hall sensor) acan be processed directly by the microprocessor.
- In order to suppress interference pulses, the pulse-shaped input signals from inductive sensors which carry information on engine speed and reference mark are conditioned by a special circuit in the ECU and converted to square-wave from.

Depending upon the level of integration, signal conditioning can take place completely or partially in the sensor. The operating conditions encountered at its installation point determine the sensor' s loading.

[Fig. 1]

Signal processing in the ECU



SIGNAL CONDITIONING

Protective circuitry is used to limit the incoming signals to a maximum voltage level. The effective signal is freed almost completely of superimposed interference signals by means of filtering, and is then amplified to match it to the ECU input voltage.

SIGNAL PRESSING IN THE ECU

The ECU microprocessors (Fig. 1) mostly process the input signals digitally, and therefore need a special program. This is stored in a Read Only Memory (ROM or Flash-EPROM).

In addition, engine-specific curves and engine-management maps are stored in a Flash-EPROM. Immobilizer data, calibration and manufacturing data, as well as data on errors/malfunctions which may have occurred during operation are stored in a non-volatile read/write memory (EEPROM).
Due to the large number of engine and equipment variants, the ECU' s are provided with a so-called variant code. Using this code, a selection of the maps stored in the Flash-EPROM takes place at the manufacturer or in the workshop, in order to provide the specific functions required for the vehicle variant in question. This selection is also stored in the EEPROM.
Other ECU variants are designed so that complete data sets can be programmed into the Flash-EPROM at the end of vehicle production. This reduces the number of different ECU types required by the vehicle manufacturer.

A volatile random access memory (RAM) is needed to store variable data such as calculations data and signal values. In order to function correctly, the RAM requires a permanent power supply. In other words, it loses its complete data stock when the ECU is switched off via the ignition switch or when the vehicle battery is disconnected. In such cases, the adaptation values (values which have been learnt regarding engine and operating conditions) would have to be re-established when the ECU is switched on again. To prevent this, the adaptation values are stored in an EEPROM and not in a RAM.

OUTPUT SIGNALS

With their output signals, the microprocessors trigger output stages which usually are powerful enough for direct connection to the actuators. The triggering of the individual actuators is dealt with in the particular system decription. These output stages are proof against short-circuit to ground or to battery voltage, as well as against destruction due to electrical overload. Such faults are recognized by the output stages and reported to the microprocessor. This also applies to conductor open-circuits.
In addition, a number of the output signals are transmitted through interfaces to other systems in the vehicle.

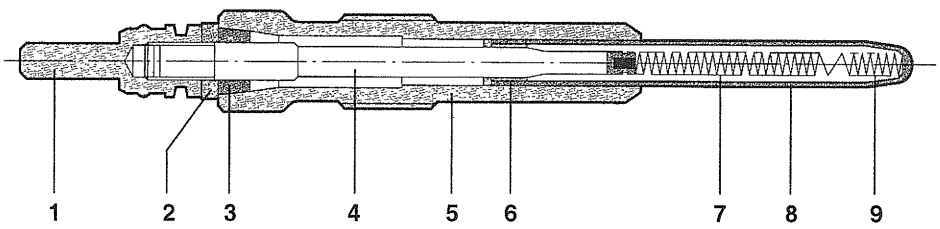
START-ASSIST SYSTEMS

Sin leakage and heat losses reduce the pressure and the temperature of the A/F mixture at the end of the compression stroke, the diesel engine is more difficult to start and the mixture more difficult to ignite than it is when hot. These facts make it particularly important that start-assist systems are used. The minimum starting temperature depends upon the engine type. Pre-chamber and swirl-chamber engines are equipped with a sheathed-element glow plug (GSK) in the auxiliary combustion chamber which functions as a "hot spot". On small direct-injection (DI) engines, this "hot spot" is located on the combustion chamber' s periphery. Large DI truck engines on the other hand have the alternative of using air preheating in the intake manifold (flame start) or special, easily ignitable fuel (Start Pilot) which is sprayed into the intake air. To day, the start-assist systems use sheathed-element glow plugs practically without exception.

SHEATHED-ELEMENT GLOW PLUG

The sheathed-element glow plug' s tubular heating element is so firmly pressed into the glow-plug shell that a gas-tight seal is formed. The element is a metal tube which is resistant to both corrosion and hot gases, and which contains a heater (glow) element embedded in magnesium-oxide powder (Fig. 1). This heater element comprises two series-connected resistors: the heater filament in the glow-tube tip, and the control filament. Whereas the heater filament maintains virtually constant electrical resistance regardless of temperature, the control filament is made of material with a positive temperature coefficient (PTC). On newer-generation glow plugs (GSK2), its resistance increases even more rapidly with rising temperature than was the case with the conventional S-RSK glow plug. This means that the newer GSK2 glow plugs are characterized by reaching the temperature needed for ignition far more quickly (850° C in 4s). They also feature a lower steady-state temperature (Fig. 2) which means that the glow plug' s temperature is limited to a non-critical level. The result is that the GSK2 glow plug can remain on for up to 3 minutes following engine start. This post-glow feature improves both the warm-up and run-up phases with considerable improvements in noise and exhaust-gas emissions.

[Fig. 1]



Sheathed-element glow plug GSK2

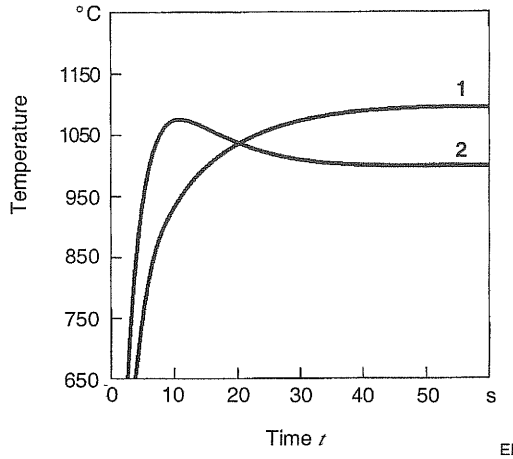
1. Electrical connector terminal
2. Insulating washer
3. Double gasket
4. Terminal pin
5. Glow-plug shell
6. Heater seal
7. Heater and control filament
8. Glow tube
9. Filling power

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[Fig. 2]

Sheathed-element glow plugs: Temperature-time diagram

1. S-RSK
2. GSK2



FLAME GLOW PLUG

The flame glow plug burns fuel to heat the intake air. Normally, the injection system' s supply pump delivers fuel to the flame plug through a solenoid valve. The flame plugs' s connection fitting is provided with a filter, and a metering device which permits passage of precisely the correct amount of fuel appropriate to the particular engine. This fuel then evaporates in an evaporator tube surrounding the tubular heating element and mixes with the intake air. The resulting mixture ignites on the 1000° C heating element at the flame-plug tip.

GLOW CONTROL UNIT

For triggering the glow plugs, glow control unit (GZS) is provided with a power relay and a number of electronic switching blocks. These, for instance, control the glow duration of the glow plugs, or have safety and monitoring functions. Using their diagnosis functions, more sophisticated glow control units are also able to recognise the failure of individual glow plugs and inform the driver accordingly. Multiple plugs are used as the control inputs to the ECU. In order to avoid voltage drops, the power supply to the glow plugs is through suitable threaded pins or plugs.

FUNCTIONAL SEQUENCE

The diesel engine' s glow plug and starter switch, which controls the preheat and starting sequence, functions in a similar manner to the ignition and starting switch on the spark-ignition (SI) engine. Switching to the "ignition on" position starts the preheating process and the glow-plug indicator lamp lights up. This extinguishes to indicate that the glow plugs are hot enough for the engine to start, and cranking can begin. In the following starting phase, the droplets of injected fuel ignite in the hot, compressed air. The heat released as a result leads to the initiation of the combustion process (Fig. 3).

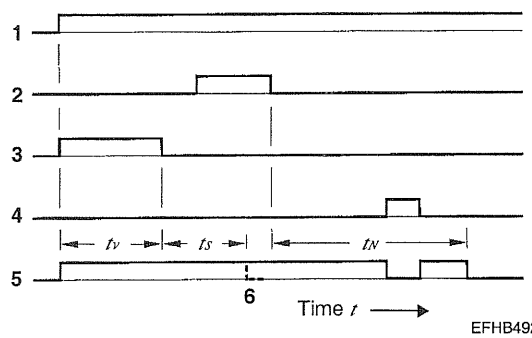
In the warm-up phase following a successful start, post-heating contributes to faultless engine running (no misfiring) and therefore to practically smokeless engine run-up and idle. At the same time, when the engine is cold, preheating reduces combustion noise. A glow-plug safety switchoff prevents battery discharge in case the engine cannot be started.

The glow-control unit can be coupled to the ECU of the Electronic Diesel Control (EDC) so that information available in the EDC control unit can be applied for optimum control of the glow plugs in accordance with the particular operating conditions. This is yet another possibility for reducing the levels of blue smoke and noise.

[Fig. 3]

Typical preheating sequence

1. Glow-plug and starter switch
2. Starter
3. Glow-plug indicator lamp
4. Load switch
5. Glow plugs
6. Self-sustained engine operation, t_V Pre-heating time, ts Ready to start, t_N Post-heating time



GENERAL

SPECIFICATION

Input sensors	
Mass air flow sensor	HFM5 (Hot Film Sensor)
Intake air temperature sensor	Thermistor type
Resistance	2.22 ~ 2.82kΩ at 20°C (68°F)
	0.299 ~ 0.357kΩ at 80°C (176°F)
Engine coolant temperature sensor	Thermistor type
Resistance	2.31 ~ 2.59kΩ at 20°C (68°F)
	0.314 ~ 0.331kΩ at 80°C (176°F)
Vehicle speed sensor	Hall effect type
Camshaft position sensor	Hall effect type
Crankshaft position sensor	Hall effect type
Accel position sensor	Variable resistor type
Fuel pressure sensor	Piezo electricity type
Fuel temperature sensor	Thermistor type
Resistance	2.27 ~ 2.73kΩ at 20°C (68°F)
	0.322 ~ 0.298kΩ at 80°C (176°F)
Fuel tank capacity	SM : 65 liter
	FO : 65 liter
	XD : 55 liter
Fuel filter	High pressure type
Fuel pump	Electrical, in-tank type
Driven by	Electric motor
Fuel pressure at high pressure side	1350 bar.
Injectors	Electromagnetic type

SEALANT

Engine coolant temperature sensor	LOCTITE 962T or equivalent

SERVICE STANDARD

Curb idle speed (rpm)	N-range	A/CON: OFF	750 ± 40	SM
		A/CON: ON	750 ± 40	
	N-range	A/CON: OFF	780 ± 40	FO
		A/CON: ON	780 ± 40	
	N-range	A/CON: OFF	750 ± 40	XD
		A/CON: ON	800 ± 40	

TIGHTENING TORQUES

Item	Nm	Kg.cm	lb.ft
Delivery pipe (Common Rail) installation	18 - 23	180 - 230	12.6 - 15.4
Engine coolant temperature sensor	20 - 40	200 - 400	14 - 29
Throttle body - nut flange	7 - 11	70 - 110	4.9 - 9.9
Throttle body - bolt flange	4 - 6	40 - 60	2.8 - 4.2
Fuel filter mounting bolts	9 - 14	90 - 140	6.5 - 10
Accelerator arm bracket bolts	8 - 12	80 - 120	5.8 - 8.7
Pipe from rail to Injector 1/2/3/4	18 - 22	180 - 220	12.6 - 15.4
Rail pressure sensor	33 - 37	330 - 370	23.1 - 25.9
Clamp bolt for Injector	25 - 29	250 - 290	17.5 - 20.3
Retaining bolt for high pressure pump	13 - 18	130 - 180	9.1 - 12.6
Flang bolt - EGR Sonenoid valve	7 - 11	70 - 110	4.9 - 7.7
Self locking nut - EGR valve gasket	25 - 30	250 - 300	17.5 - 21
Bolt - EGR pipe gasket	20 - 30	200 - 300	14 - 21
CMP sensor mounting bolt	4 - 6	40 - 60	2.8 - 4.2
High pressure pump - bolt	13 - 18	130 - 180	9.1 - 12.6
CKP - bolt	4 - 6	40 - 60	2.8 - 4.2
Oil pressure switch	15 - 26	150 - 260	10.5 - 18.2

TROUBLESHOOTING

FUEL INJECTION SYSTEM

Symptom	Probable cause	Remedy
Engine does not start	Cranking speed too low	Repair starting system or charge or replace battery so that engine cranks at a minimum of 150 rpm.
	No voltage at fuel cut-off solenoid on injection pump	Check for voltage with test light. If necessary, replace fuse or faulty wires.
	Fuel cut-off solenoid on injection pump loose or faulty	Tighten solenoid. Check that solenoid clicks when key is turned off and on. Replace faulty solenoid.
	No voltage at glow plug bus	If test light shows no voltage at bus with key at "ON" position, test relay and wiring.
	Glow plug faulty	Test and, if necessary, replace glow plug.
	Air in fuel system	Bleed fuel system.
	Injection pump not delivering fuel	If no fuel emerges from a loosenes injection pipe during cranking, check timing belt and fuel supply from filter.
	Injection pipes misconnected	Connect pipes in correct location
	Injection timing incorrect	Adjust injection timing.
	Faulty injection	Check and, if necessary, replace injectors.
	Engine mechanical faults, as described earlier under this heading	Test compression and, if necessary, repair engine.
	Faulty injection pump	Try to start engine with new pump installed. If necessary, replace pump permanently. Check and, if necessary, adjust the idle speed.
Idle speed incorrect of idle rough or irregular	Idle speed incorrectly adjusted	Check that accelerator lever on pump is not loose, then adjust accelerator cable.
	Accelerator control binding	Replace hose of secure with clamps, bleed air from system.
	Loose fuel hose between filter and injection pump	Tighten, if necessary, and repair.
	Air in fuel system	Bleed fuel system.

Symptom	Probable cause	Remedy
Idle speed incorrect of idle rough or irregular	Inadequate fuel supply owing to clogged fuel filter, or fuel return line and injection pipes leaking, dirty, kinked, or squeezed at connections	Inspect and, if necessary, replace lines and hoses or replace fuel filter
	Faulty injection	Check and, if necessary, repair or replace injection injectors.
	Injection timing incorrect	Adjust injection timing.
	Engine mechanical faults, as described earlier under this heading	Test compression and, if necessary, repair engine.
	Faulty injection pump	Try engine at idle with new pump installed. If necessary, replace pump permanently.
	Engine lugging in too high a gear	Observe correct shift speeds.
Smoky exhaust (black, blue or white)	Engine not reaching correct operating temperature	Check and, if necessary, replace cooling system thermostat.
	Maximum rpm incorrect	Check and, if necessary, replace injection pump.
	Faulty injection nozzles	Check and, if necessary, repair or replace injection nozzles.
	Injection timing incorrect	Adjust injection timing.
	Restricted exhaust system	Check exhaust system for dents and obstructions
	Engine mechanical faults, as described earlier under this heading	Test compression and, if necessary, repair engine.
	Faulty injection pump	Observe exhaust with new pump installed if necessary, replace pump permanently.
Poor power output, slow acceleration (speedometer accurate, clutch not slipping)	Injection pump accelerator lever loose or not reaching maximum rpm adjusting screw	Tighten lever, check that accelerator pedal travel is not restricted, then adjust accelerator cable.
	Maximum rpm incorrect	Check and, if necessary, replace injection pump.
	Air cleaner filter dirty	Clean or replace air cleaner filter.
	Inadequate fuel supply owing to clogged fuel filter, or fuel return line and injection pipes leaking, dirty, kinked, or squeezed at connections	Inspect and, if necessary, replace lines and hoses, replaced fuel filter.
	Air in fuel system	Bleed fuel system.

Symptom	Probable cause	Remedy
Poor power output, slow acceleration (speedometer accurate, clutch not slipping)	Ice or solidified wax in fuel lines. (winter time only)	Move car to a warm garage until ice or wax has become liquid, then bleed fuel system.
	Faulty injection nozzles	Check and, if necessary, repair or replace injection nozzles.
	Injection timing incorrect	Adjust injection timing.
	Engine mechanical faults, as described earlier under this heading	Test compression and, if necessary, repair engine.
	Faulty injection pump	Check acceleration and speed with new pump installed. If necessary, replace pump permanently.
Excessive fuel consumption	Air cleaner filter dirty	Clean or replace air cleaner filter
	Fuel leaks	Check and, if necessary, replace or tighten all pipes, hoses and connections.
	Return pipe and hose blocked	Check return line for kinks and dents. Replace faulty lines. If line is clogged, blow it out with compressed air, then bleed fuel system.
	Idle speed too fast or maximum rpm too high	Check and, if necessary, adjust idle speed or replace injection pump.
	Faulty injection nozzles	Check and, if necessary, repair or replace injection nozzles.
	Injection timing incorrect	Adjust injection timing.
	Engine mechanical faults, as described earlier under this heading	Test compression and, if necessary, repair engine.
	Faulty injection pump	Check fuel consumption with new pump installed, if unnecessary, replace pump permanently.

ENGINE CONTROL

Symptom	Probable cause	Remedy
Excessive accelerator pedal effort required (Incomplete pedal return included)	Rusty pedal arm	Clean and lubricate
	Incorrect routing	Ensure bending radius of 150mm or more and correct excessively bent portion
	Rusty cable	Replace
	Shift throttle cable	Lubricate link and shaft
Broken accelerator control cable	Binding cable end	Remove rust and burrs from cable end
	Incorrect perpendicularity of cable end mounting point	Correct ends on the lever side
	Incorrect perpendicularity between cable end and cable	Correct or replace parts
Engine does not stop	Faulty starting switch operation	Correct or replace part
	Broken harness between starting switch and fuel cut solenoid	Replace harness

TROUBLESHOOTING

Trouble condition	Probable cause	Remedy
Engine will not crank	Battery charge low	Charge or replace battery
	Battery cables loose, corroded or worn	Repair or replace cables
	Transaxle range switch faulty (Vehicle with automatic transaxle only)	Adjust or replace switch
	Fusible link blown	Replace fusible link
	Starter motor faulty	Repair starter motor
	Injector switch faulty	Replace Injectors
Engine cranks slowly	Battery charge low	Charge or replace battery
	Battery cables loose, corroded or worn	Repair or replace cables
	Starter motor faulty	Repair starter motor
Starter keeps running	Starter motor faulty	Repair starter motor
	Starter switch faulty	Replace ignition switch
Starter spins but engine will not crank	Short in wiring	Repair wiring
	Pinion gear teeth broken or starter motor faulty	Repair starter motor
	Ring gear teeth broken	Replace flywheel ring gear or torque converter

FUEL TANK AND FUEL LINE

Symptom	Probable cause	Remedy
Engine malfunctions due to insufficient fuel supply	Bent or kinked fuel pipe or hose	Repair or replace
	Clogged fuel pipe or hose	Clean or replace
	Clogged fuel filter of in-tank fuel filter	Replace
	Water in fuel filter	Replace the fuel filter or clean the fuel tank and fuel lines
	Dirty or rusted fuel tank interior	Clean or replace
	Malfunctioning fuel pump (Clogged filter in the pump)	Replace
When the fuel filter warning lamp illuminates	Water has accumulated in the fuel filter	Remove the water accumulated in the fuel filter as below - Unscrew the mounting bolt on the fuel filter and raise fuel filter up (for SM) - Loosen the drair plug at the bottem of the fuel filter - Tighten the drain plug when water no longer comes out

TROUBLESHOOTING GUIDE CHART

Trouble symtoms / Check items	Engine will not start	Engine shut off and then restart	Engine starts only with difficult	High idle no throttle take-up	Knocking on accel. (warm-up phases)	Vibration at idle	Reduced power	Engine does not run smothly, misfiring, knocking	Bucking
Self-diagnosis	1	1	1	1	1	1	1	1	1
Immobilizer	2								
Vehicle supply volt.	3		2					9	3
Main Relay	4	3	3					11	4
Fuse/plug wiring harness	5	2						8	2
Terminal 15	6	4	4					10	5
Crankshaft Position Sensor	7							12	
NO fuel	8								
Wrong fuel	9	5	7			2	4	3	
Lack of fuel								2	
Air in fuel system	10	6	8			3		4	
Low-pressure circuit(fuel)	11	7	13			4	5	7	
High-pressure circuit(fuel)	16	8	14			14	19	16	
Fuel filter	12		9			5	6	5	
Electric fuel pump	15		11					6	
Fuel pre-heater	13		10			6	7		
Pressure Regulator Valve	18	9	16			13		15	
Incorrect connection of injector	14		17		3	11		13	
Injector	17	10	19		4	10	18	14	
Mechanical componenet (compression, valve clearance...)	19		20				20	19	9
ECU defective	20								
TDC sensor			5						
Water Temp. Sensor			15		2		15		
Loss of coolant									
Glow-plug system			16						

Trouble symtoms / Check items	Engine will not start	Engine shut off and then restart	Engine starts only with difficult	High idle no throttle take-up	Knocking on accel. (warm-up phases)	Vibration at idle	Reduced power	Engine does not run smothly, misfiring, knocking	Bucking
Rail Pressure Sensor			18			12	17	17	
Accel. Position Sensor				2			8		
Mechanical fault in accel.				3			9		
EGR						7	10		
HFM5 (Air Flow Meter)						9	14		
Air filter clogged			12			8	3		
Vacuum system leaking							2		
Turbocharger defective							11		
Waste-gate valve connection							12		
Fuel Temp. Sensor							16		
Checking belt tension								18	
Clutch switch									6
Brake switch									7
Vehicle speed signal									8
Checking oil level									
Radiator fan									
Radiator defective or clogged									
IG switch defective									
AC compress. SW									
AC SW									
Plug contacts			6						
Connection between turbo. and In-mani. Leaking			6				13		

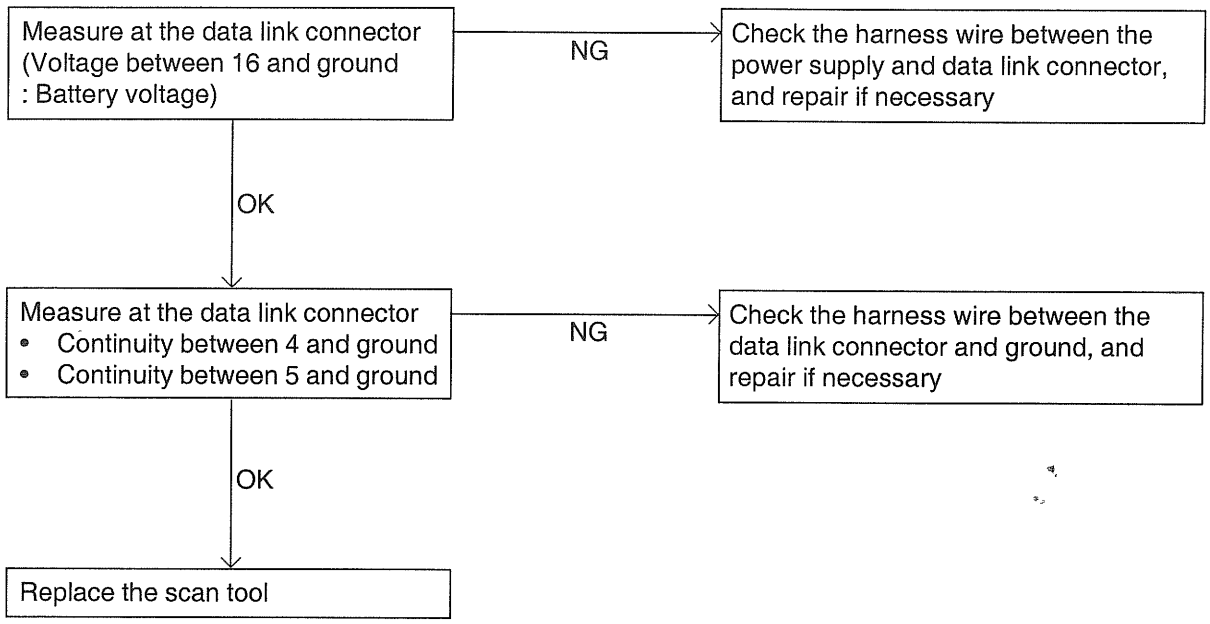
Trouble symtoms / Check items	Engine overrun, Accel.	White/Blue smoke	Clouds of black smoke	Engine overheating	Can not shut off with IG key	Diagnosis lamp not go out or flickers	AC cannot be switched on	RAD. Fan constantly in operation
Self-diagnosis	1	1	1	1	1	1	1	1
Immobilizer								
Vehicle supply volt.								
Main Relay								
Fuse/plug wiring harness					4	2	2	4
Terminal 15					3			
Crankshaft Position Sensor								
NO fuel								
Wrong fuel				2				
Lack of fuel								
Air in fuel system		3						
Low-pressure circuit(fuel)		6						
High-pressure circuit(fuel)	7							
Fuel filter		4						
Electric fuel pump								
Fuel pre-heater		5						
Pressure Regulator Valve	6							
Incorrect connection of injector								
Injector								
Mechanical componenet (compression, valve clearance...)			7	7				
ECU defective					5			
TDC sensor								
Water Temp. Sensor	8	2	6	3			5	3
Loss of coolant				6				
Glow-plug system								

Trouble symtoms / Check items	Engine overrun, Accel.	White/Blue smoke	Clouds of black smoke	Engine overheating	Can not shut off with IG key	Diagnosis lamp not go out or flickers	AC cannot be switched on	RAD. Fan constantly in operation
Rail Pressure Sensor								
Accel. Position Sensor	3						6	
Mechanical fault in accel.	2							
EGR			3					
HFM5 (Air Flow Meter)			5					
Air filter clogged			2					
Vacuum system leaking			4					
Turbocharger defective	4							
Waste-gate valve connection	5							
Fuel Temp. Sensor	9							
Checking belt tension								
Clutch switch								
Brake switch								
Vehicle speed signal								
Checking oil level		7						
Radiator fan				4				
Radiator defective or clogged				5				
IG switch defective					2			
AC compress. SW							4	2
AC SW							3	
Plug contacts								
Connection between turbo. and In-mani. Leaking								

TROUBLESHOOTING PROCEDURES

PROBLEM

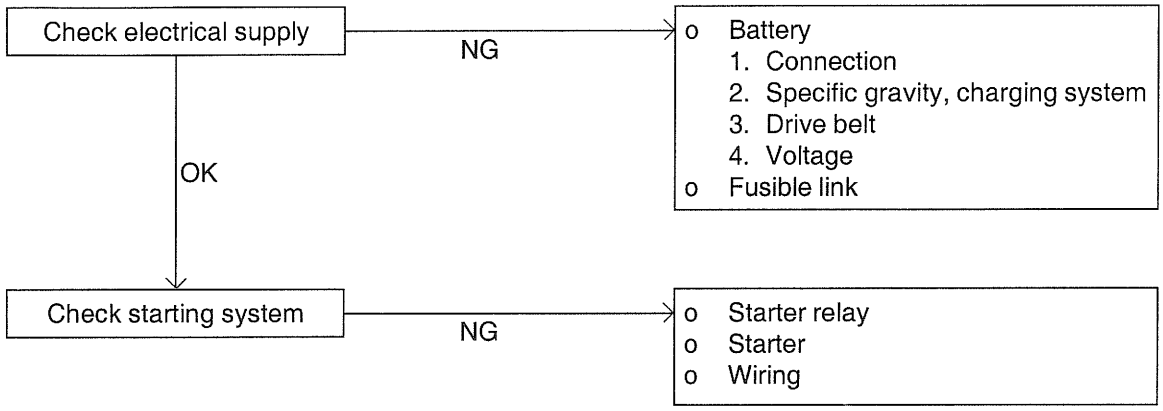
Communication with scan tool is not possible.
(Communication with all system is not possible)



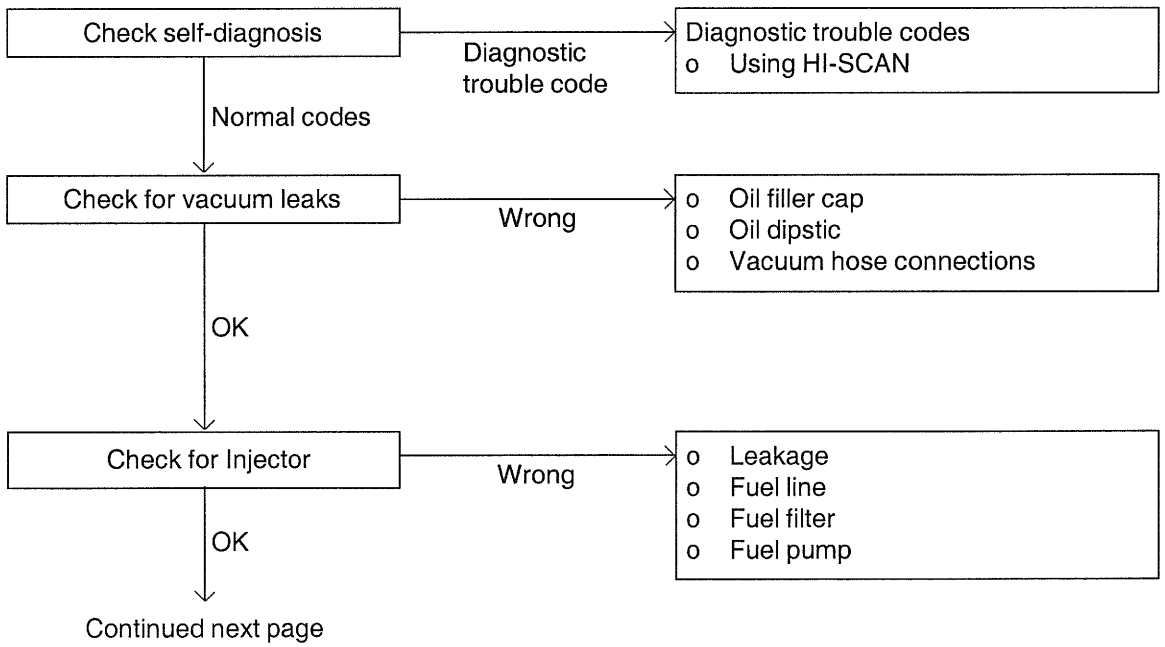
Scan tool communication with ECM is not possible

Comment	Probable cause
One of the following causes may be suspected. • No power supply to ECM • Defective ground circuit of ECM • Defective ECM • Improper communication line between ECM and scan tool	• Malfunction of ECM power supply circuit • Malfunction of the ECM • Open circuit between ECM and DLC

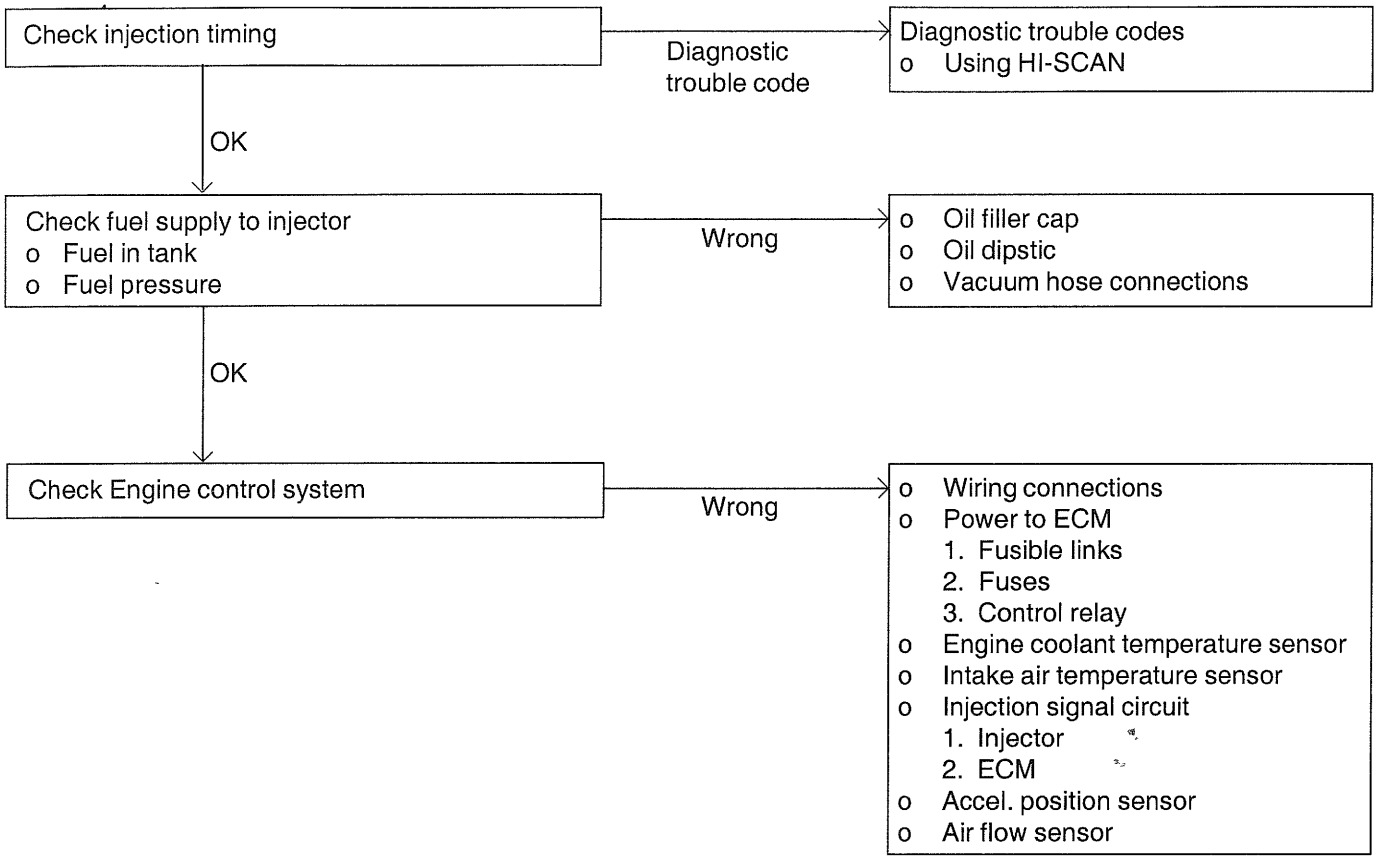
Engine will not start



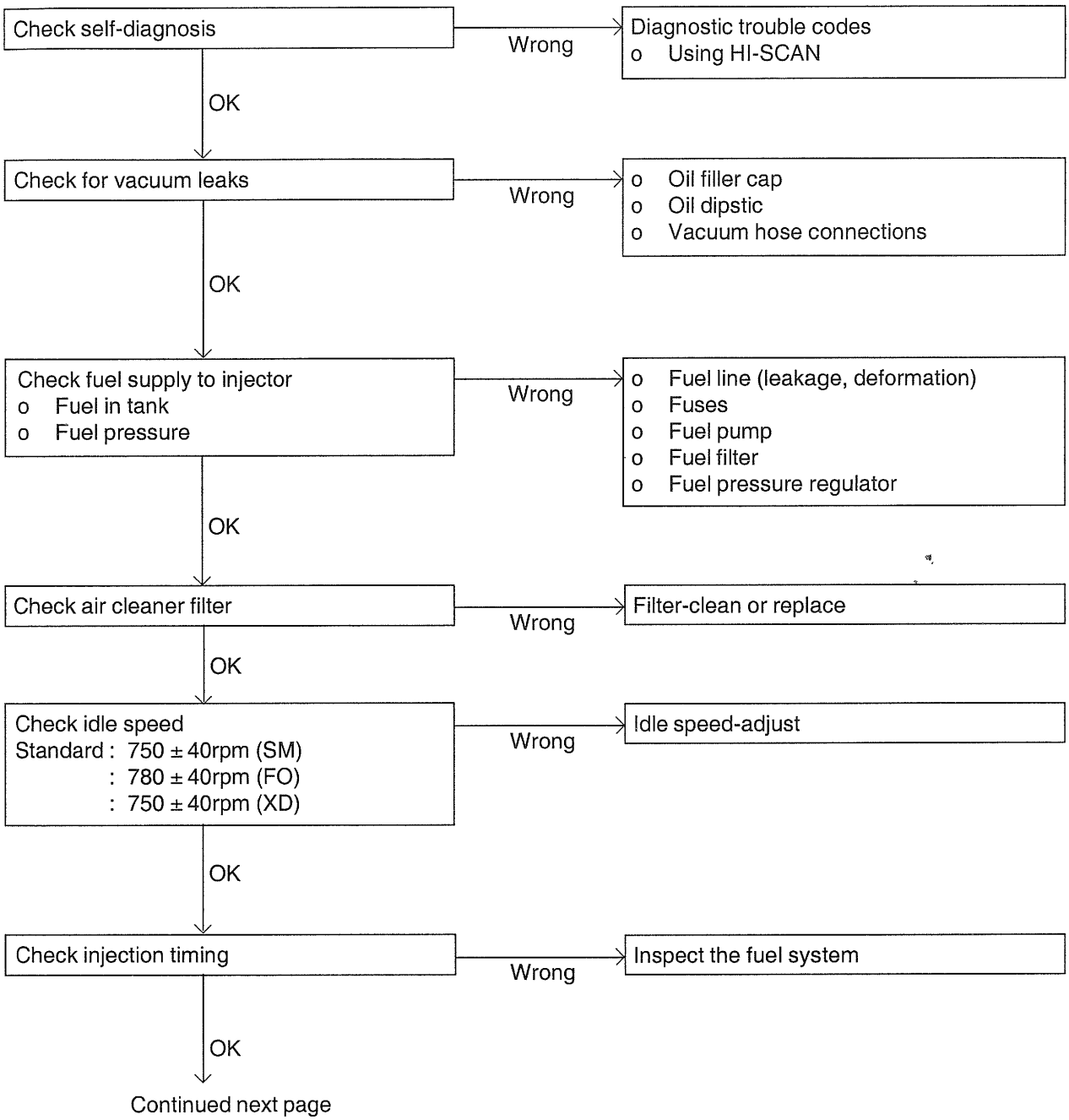
Hard to start (Cranks OK)



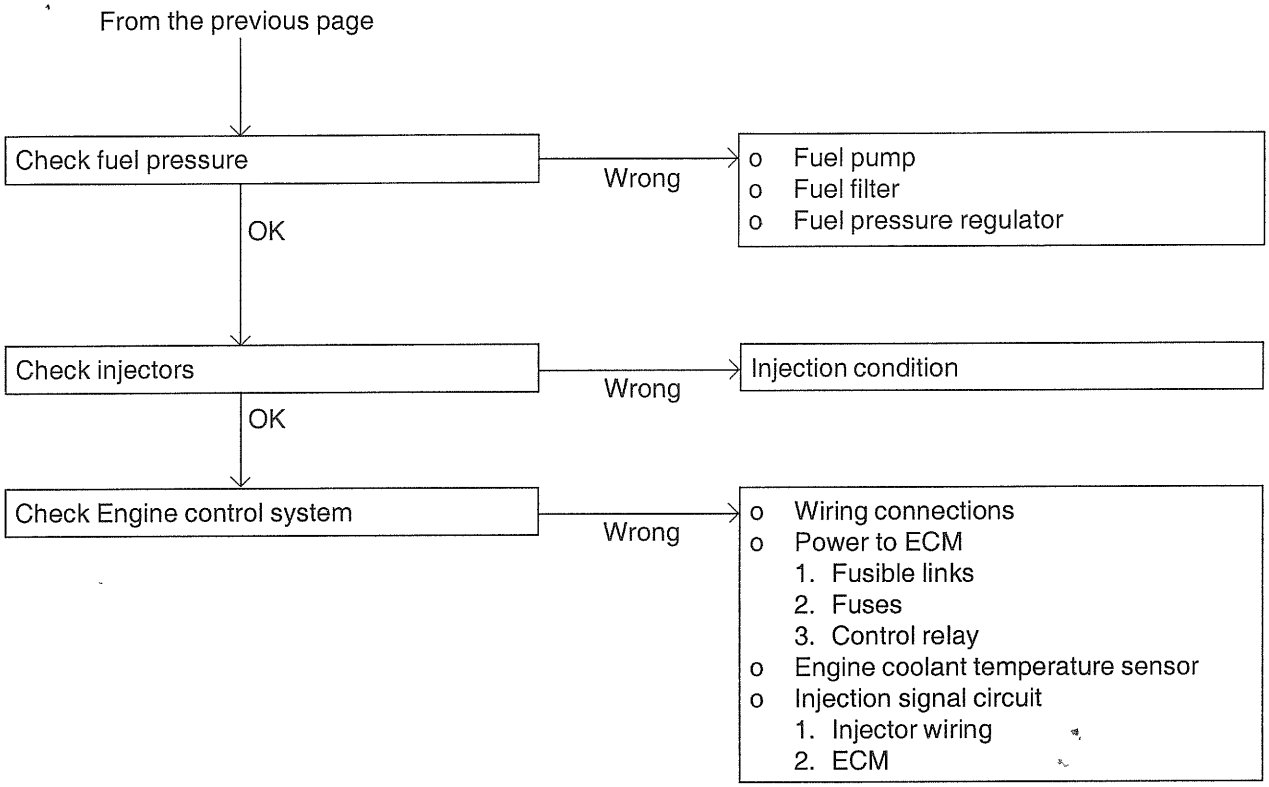
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Check injection timing
Diagnostic trouble code
Diagnostic trouble codes
o Using HI-SCAN
OK
Check fuel supply to injector
o Fuel in tank
o Fuel pressure
Wrong
o Oil filler cap
o Oil dipstic
o Vacuum hose connections
OK
Check Engine control system
Wrong
o Wiring connections
o Power to ECM
1. Fusible links
2. Fuses
3. Control relay
o Engine coolant temperature sensor
o Intake air temperature sensor
o Injection signal circuit
1. Injector
2. ECM
o Accel. position sensor
o Air flow sensor

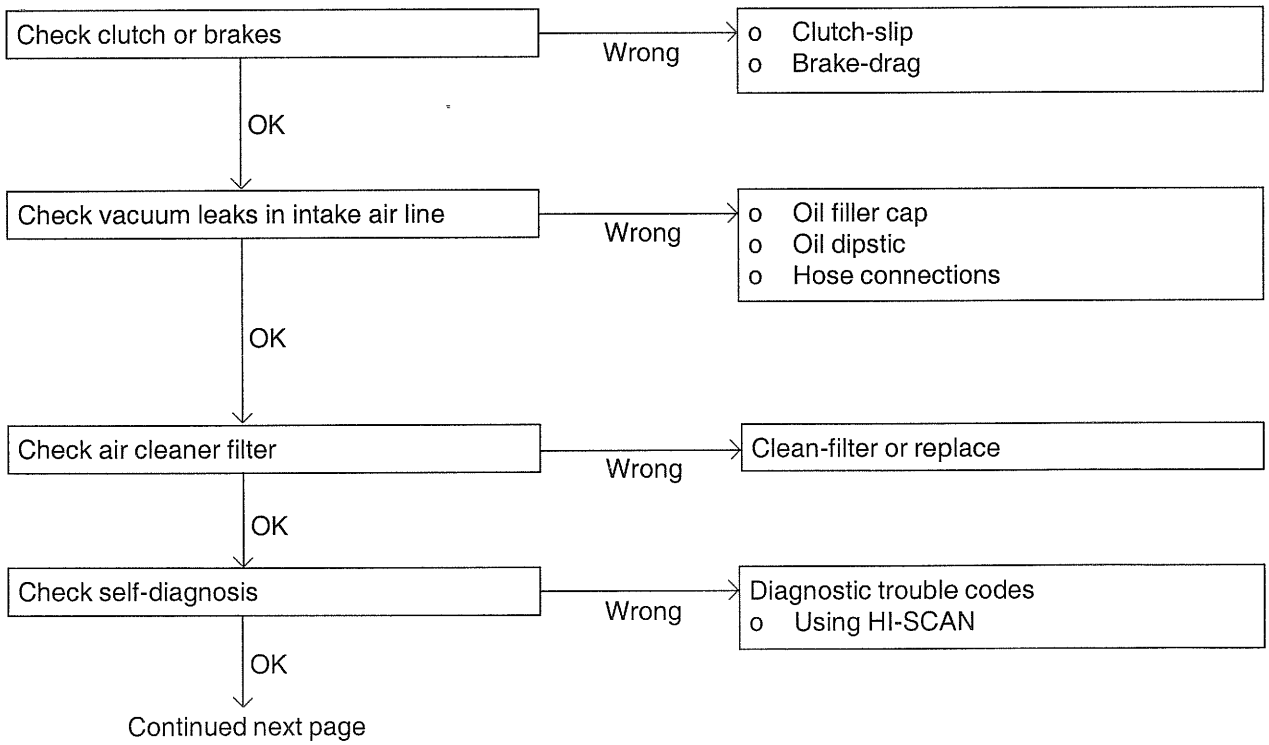
Rough idle or engine stalls

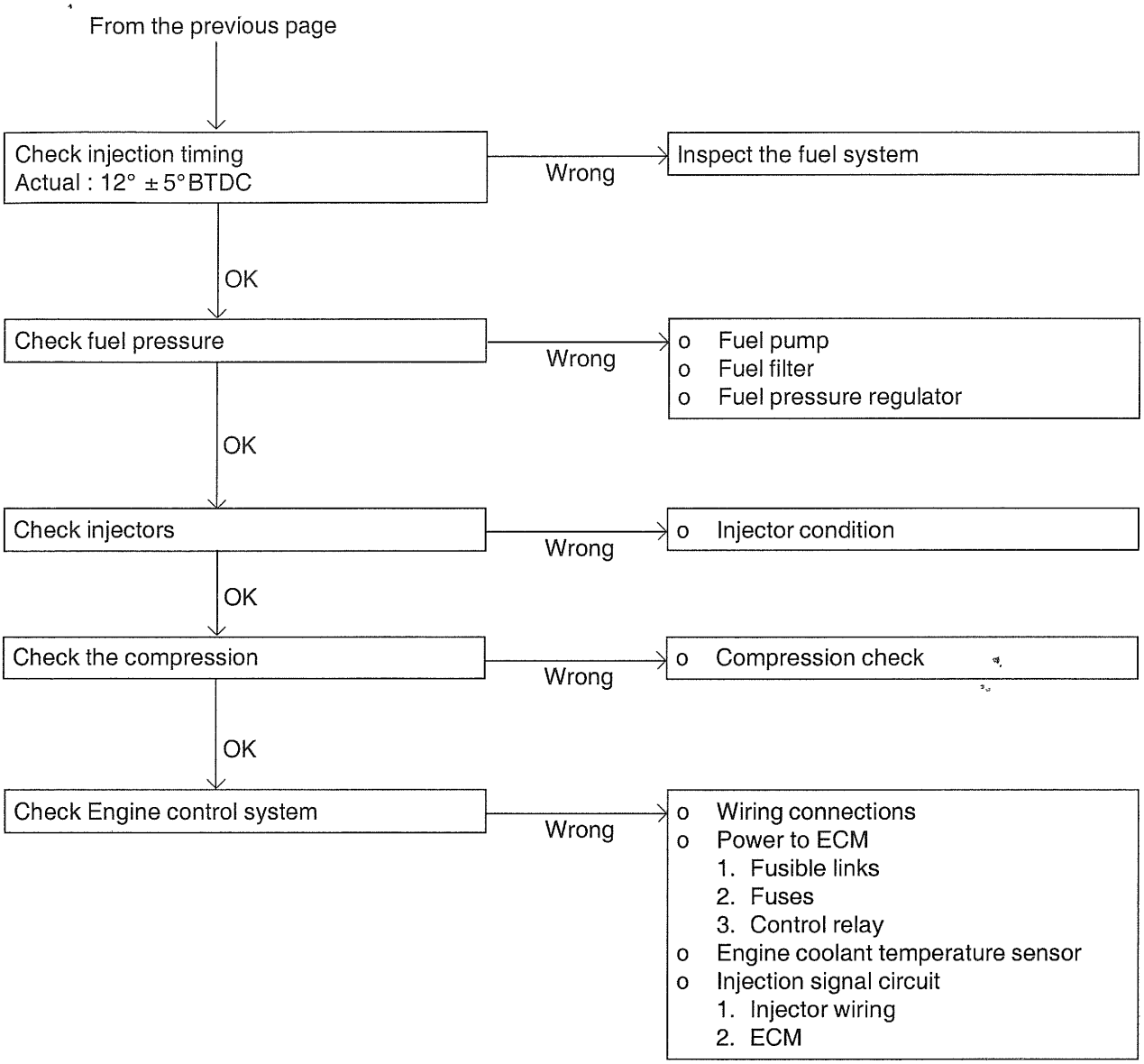


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Engine hesitates or accelerates poorly




From the previous page
Check injection timing
Actual : 12° ±5°BTDC
Wrong
Inspect the fuel system
OK
Check fuel pressure
Wrong
o Fuel pump
o Fuel filter
o Fuel pressure regulator
OK
Check injectors
Wrong
o Injector condition
OK
Check the compression
Wrong
o Compression check
OK
Check Engine control system
Wrong
o Wiring connections
o Power to ECM
1. Fusible links
2. Fuses
3. Control relay
o Engine coolant temperature sensor
o Injection signal circuit
1. Injector wiring
2. ECM

INSPECTION CHART FOR DIAGNOSTIC TROUBLE CODES

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P0601	**EEPROM and configuration**		
	Adjusting values (EEPROM) checksum	C020	Adjusting values (EEPROM) checksum
	EEPROM Communication	C019	Line open circuit
	EEPROM Writer error	C021	Code word incorrect or mission
	Different variation number	C021	Code word incorrect or mission
	Code word incorrect or missing	C021	Code word incorrect or mission
P0335	**Engine speed sensor (CKP)**		
	Dynamic plausibility	C004	Plausibility error
	Overspeed recognition	C002	Signal : SRC above upper limit
P0340	**Increment sensor (IAT)**		
	Flow quantity limiter switched on		
	Cam signal frequency too high	C002	Signal : SRC above upper limit
	IAT failure	C003	General error
	IAT dynamic inplausible	C004	Plausibility error
	Cam signal statically defect	C001	Signal : SRC below lower limit
	Main injection correction too late		
P1645	**Capacitor 1 voltage**		
	Booster voltage too high	C002	Signal : SRC above upper limit
	Booster voltage too low	C001	Signal : SRC below lower limit
P1647	**Threshold voltage**		
	Calculated booster voltage too high	C002	Signal : SRC above upper limit
	Calculated booster voltage too low	C001	Signal : SRC below lower limit
P0190	**Rail pressure sensor (RPS)**		
	Signal : SRC below lower limit	C001	Signal : SRC below lower limit
	Signal : SRC above upper limit	C002	Signal : SRC above upper limit
	Supply : SRC below lower or above upper limit	C003	General error
	Plausibility of I_DRV and P_Rail	C004	Plausibility error

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P1181	**Fuel pressure monitoring**		
	Maximum pressure exceeded	C005	Maximum pressure exceeded
	Minimum pressure at engine speed too low	C006	Minimum pressure at engine speed too low
	Set value DRV too high/leakage overrun	C007	Correcting value DRV too great/leakage overrun
	DBE jammed	C008	Actuator sticks
	Leakage	C009	Leakage
	Governor deviation at engine speed too high	C010	Governor deviation at engine speed too high
	Correcting variable too high	C011	Governor output too great
	Leakage flow while idling	C012	Leakage during low idle
P0560	**Battery voltage**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
	Rail pressure limited over UBAT	C004	Plausibility error
P0120	**Accelerator pedal sensor (APS 1)**		
	Signal : SRC below lower limit	C001	Signal : SRC below lower limit
	Signal : SRC above upper limit	C002	Signal : SRC above upper limit
	Supply : SRC above upper or below lower limit	C003	General error
	PWG plausibility with brake signal BRE	C004	Plausibility error
P0220	**Accelerator pedal sensor (APS 2)**		
	Signal : SRC below lower limit	C001	Signal : SRC below lower limit
	Signal : SRC above upper limit	C002	Signal : SRC above upper limit
	Supply : SRC above upper or below lower limit	C003	General error
	Implausibility potentiometer 1/2	C004	Plausibility error
P1639	**Monitoring ADC**		
	Dynamic ADC-RAM test failed	C004	Plausibility error
	Ground connection PGS failed	C002	Signal : SRC above upper limit
	Test voltage from ADC failed	C003	General error
P0115	**Water temperature sensor (ECT)**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
	Operation temperature not attained	C004	Plausibility error
P0180	**Fuel temperature sensor (ETS)**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P0110	**Air temperature sensor (IAT)**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
P1170	**Atmospheric pressure sensor (in ECU)**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
P0100	**Airmass meter (HFM)**		
	HFM5 signal : SRC below lower limit	C001	Signal : SRC below lower limit
	HFM5 signal : SRC above upper limit	C002	Signal : SRC above upper limit
	Supply : SRC above upper or below lower limit	C003	General error
	Plausibility offset drift HFM5 1ms	C004	Plausibility error
	Plausibility positive range	C004	Plausibility error
	Plausibility	C004	Plausibility error
P1526	**Sensor supply 1 voltage**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
P1526	**Sensor supply 2 voltage**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
P1569	**Current of pressure control valve IDV**		
	SRC below lower limit	C001	Signal : SRC below lower limit
	SRC above upper limit	C002	Signal : SRC above upper limit
P1638	**Microcontroller**		
	RECOVERY occured	C022	RECOVERY occured
	Redundant overrun monitoring	C023	Redundant overrun monitoring
	Gate array quantity stop	C024	Gate array quantity stop
	Gate array communication	C025	Gate array communication
	Gate array communication not debounced	C025	Gate array communication
P0500	**Vehicle speed signal (VSS)**		
	CAN data invalid	C003	General error
	SRC above upper limit	C002	Signal : SRC above upper limit
	PEC frequency too high	C002	Signal : SRC above upper limit
	FGG plausibility	C004	Plausibility error

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P0403	**Vacuum Modulator**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
	Positive governor deviation	C010	Governor deviation at engine speed too high
	Negative governor deviation	C010	Governor deviation at engine speed too high
	EGR flow check		
P1613	**Regulator**		
	Lower regulator limit	C001	Signal : SRC below lower limit
	Upper regulator limit	C002	Signal : SRC above upper limit
P1635	**Water heated relay**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1325	**Glow relay**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1629	**Glow indicator lamp**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P0230	**Electric fuel pump relay**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
	Plausibility after ignition off operation	C004	Plausibility error
P1180	**Rail pressure regulator**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
	Power stage error	C003	General error
P1622	**Air-condition relay**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1624	**Radiator cooling fan**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P1625	**A/C condensor fan**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1623	**ENG. CHK lamp**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P0703	**Brake switch**		
	Parity error in CAN-message		
	Plausibility with redundant contact after initialization	C004	Plausibility error
	Plausibility with redundant contact	C004	Plausibility error
P0704	**Clutch switch**		
	Plausibility	C004	Plausibility error
P1616	**Main relay**		
	Switch off too early	C004	Plausibility error
	Switch off too late	C004	Plausibility error
P1652	**IG-switch**		
	K15 plausibility after initialization	C004	Plausibility error
P0600	**CAN-Diagnosis error path NPL**		
	CAN NPL M1 TCU	C019	Line : open circuit
	CAN NPL M2 ABS	C019	Line : open circuit
	CAN NPL M3 receipt message 3	C019	Line : open circuit
	CAN NPL M4 receipt message 4	C019	Line : open circuit
	CAN NPL M3 receipt message 5	C019	Line : open circuit
	CAN NPL M4 receipt message 6	C019	Line : open circuit
	CAN NPL mute	C019	Line : open circuit
	CAN NPL bus	C019	Line : open circuit

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P0600	**CAN-Diagnosis error path ERF**		
	CAN ERF M1 TCU	C019	Line : open circuit
	CAN ERF M2 ABS	C019	Line : open circuit
	CAN ERF M3 receipt message 3	C019	Line : open circuit
	CAN ERF M4 receipt message 4	C019	Line : open circuit
	CAN ERF M5 receipt message 5	C019	Line : open circuit
	CAN ERF M6 receipt message 6	C019	Line : open circuit
	CAN ERF mute	C019	Line : open circuit
	CAN ERF bus	C019	Line : open circuit
P1609	**Immobilizer**		
	Immo Line faulty	C013	Immobilizer smartra error
	Invalid Tester request	C014	Immobilizer antenna error
	EEPROM faulty-non plausible VSP data	C015	IFZ does not respond
	Transponder faulty	C016	Start command at locked IFZ
	SMATRA faulty	C017	IFZ responds with wrong code
	Authentication not succesful	C026	Authentication not successful
	EEPROM faulty for KEY ID block & Immo data block	C027	EEPROM faulty for KEY ID block & IMMO data block
P1530	**Maximum vehicle speed limiting**		
	Negative governor deviation	C003	General error
P0204	**Injector #4**		
	Over current LS	C018	Line : short circuit
	Over current HS	C018	Line : short circuit
	Load drop	C019	Line : open circuit
	SL error		
P0203	**Injector #3**		
	Over current LS	C018	Line : short circuit
	Over current Hs	C018	Line : short circuit
	Load drop	C019	Line : open circuit
	SL error		
P0202	**Injector #2**		
	Over current LS	C018	Line : short circuit
	Over current HS	C018	Line : short circuit
	Load drop	C019	Line : open circuit
	SL error		

DTC No.	Fault Item and Description	Detailed Code	Meaning (could also be used for tester display)
P0201	**Injector #1**		
	Over current LS	C018	Line : short circuit
	Over current HS	C018	Line : short circuit
	Load drop	C019	Line : open circuit
	SL error		
P1653	**Error check after ignition off**		
	Error at shutoff via zero quantity		
	Error at shutoff via injector power stage (OFF)		
P1623	**MIL-CARB lamp**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1633	**Immobilizer status indicator lamp**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1634	**Cruise control indicator lamp**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit
P1660	**Cruise control switch**		
	Signal : SRC below lower limit	C001	Signal : SRC below lower limit
	Signal : SRC above upper limit	C002	Signal : SRC above upper limit
	Supply : SRC out of limits	C003	General error
	Plausibility	C004	Plausibility error
P1190	**Throttle plate actuator output**		
	Short circuit	C018	Line : short circuit
	Open circuit	C019	Line : open circuit

TROUBLESHOOTING PROCEDURE

GENERAL

1. Test drive: Test drive means a cantain driving cycle or pattern that includes the ambient conditions when a fault was occured. Before driving, erase the stored fault code with Hi-scan.

2. Limp home mode : ECU switches to limp home mode in the event of failure of the important input/output signals.
   The result is as follows.
   - Reduced power and lower maximum speed.
   - EGR function disabled.

3. Emergency shut off
   For safety reasons, ECU effects emergency shut off of the engine if the following system components fail.
   - Injectors
   - Engine speed sensor
   - Pressure regulator
   - Fuel leakage

4. Attention
   Never work on injection system with engine running or within 30 seconds after shutting off the engine. High pressure pump, rail, injectors and high pressure pipes are subjected to high pressure even after the engine has been switched off.

5. Safety measures
   If it is necessary to run the engine for certain test steps (ex. Call up the actual values at the actuator test), the test equipment is to be set up such that mechanic does not have to be within possible range of high pressure jets when performing test.
   People who are using pacemakers should not be closer than 30cm to ECU or wiring harness within the engine is running, since the high currents in the CR system produce considerable magnetic fields.

   • Acutuator test can be performed only if engine speed is "ZERO".

ECU : ENGINE CONTROL UNIT

1. Possible DTC
   1) P0601 (Perform and configuration)
   2) P1647(Threshold voltage)
   3) P1639 (Monitoring ADC)
   • CC-CODE: C002
   Check the ground connection from APS ground to ECU pin
   (APS pin #6 - ECU pin #79)
   (APM pin #5 - ECU pin#79)
   4) P1526 (Sensor supply voltage 1 for APS1, AFS)
   P1527 (Sensor supply voltage 2, APS2, RPS)
   * Check the short circuit of sensor supply line to GND or Bat. ECU should not be exchanged for these errors.
   5) P1569 (Actual current of pressure regulator valve)
   6) P1638 (Microcontroller)
   7) P1613 (Voltage regulator monitoring of voltage regulator in 2 different tests)

2. If these faults are encountered, cancel the fault memory and perform the test drive. Replace ECU if fault code is stored again.

ECU : CAPACITOR VOLTAGE 1

1. Possible DTC : P1645

   Capacitor in ECU charges for activating the injectors. First check the wiring of injectors to ECU. Rectify the additionally stored faults. Cancel the fault memory and perform the test drive.
   Replace ECU if fault code is stored again.

CKP : CRANKSHAFT POSITION SENSOR

1. Possible DTC :P0335

2. Actual value for evaluation : Engine warm > 80°C, aircondition off
   - Required idling speed

   SM: 750 ± 40 rpm (M/T, A/T)
   FO: 780 ± 40 rpm (M/T, A/T)
   XD: 750 ± 40 rpm (M/T, A/T)

   • CC-CODE
   - Substitute reaction is performed anyhow.
   - NOTE : When excessive engine oil is filled up, for instance 2 times of normal amount, engine can be run more than 6000rpm (i.e. dieseling) in this case error can be memorized but this should be neglected.
   1) C004 (Plausibility error)
      • This error is reduntant to DTC340 can occur only if DTC340 CC-Code C004 occurred.
      - Measure the signal rate between present engine speed(k) and previous engine speed(k-1). If the rate is out of the standard, it is detected as an error.

- Possible causes of trouble:
  1) Contact resistance
  2) CKP defective
  3) Metal abrasion or dirt at sensor
  4) Incorrect installation position or sensor loose
  5) Wheel - CKP sensor

3. Measure the resistance of sensor at the detached plug pin1 to pin 2

   650 - 1000Ω at 20°

4. Attach the plug.

5. Record the signal profile from pin1 to GND. Engine idling.
   Using oscillocope : CMP signal
   CKP signal

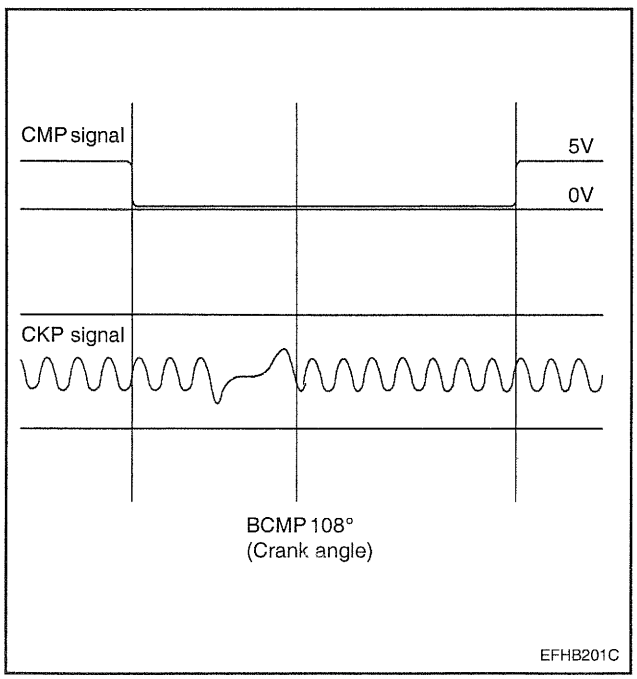
   Wiring check:

ECU	CKP
Pin 69	Pin 1
Pin 100	Pin 2
Pin 101	Pin 3

6. If wiring is OK and signal profile doesn't correspond to set value (Min. 1.65V), check the sensor for dirt (possibly abrasion or some metallic parts), proper installation position and tight fit.
   Measure the gap between sensor wheel and sensor:

   1 ± 0.5 mm

   Gap cannot be adjusted. Check the sensor wheel for damage.



CMP : TOP DEAD CENTER SENSOR

1. Possible DTC: P0340
   - CC-CODE
   1) C001 (Signal below the lower limit - No signal)
      - Possible causes of trouble:
      A. Open circuit. Broken line
      B. Short circuit to GND line
      C. CMP sensor defective
      E. Incorrect installation position or sensor loose
   2) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. CMP sensor defective
      B. Inteference on signal line from other component (Alternator, Injector lines)
   3) C003 (General error)
      - 2 time turns of camshaft signal are exceed the upper or lower window limit of camshaft set signal, then error is detected.
      - Possible causes of trouble:
      A. CMP sensor defective
      B. Incorrect installation position or sensor loose
      C. Air gap between sensor to sensing wheel is too wide
   4) C004 (Plausibility error)
      - When the limit between angular velocity of crankshaft signal sensing stubs and frequency multiplier of inner ECU is exceed the set value, error is detected.
      - Possible causes of trouble:
      A. Contact resistance
      B. CMP sensor defective
      C. Incorrect installation position or sensor loose
      D. Camshaft and crankshaft misarrangement
      E. Inteference on signal line from other component (Alternator, Injector lines)

2. Measure the supply voltage of sensor pin 3 to pin 1

   Set value : 8 - 15V

3. Use an oscilloscope to record signal profile from pin2 to GND. Engine idling.

   Set value : Square wave (5V)

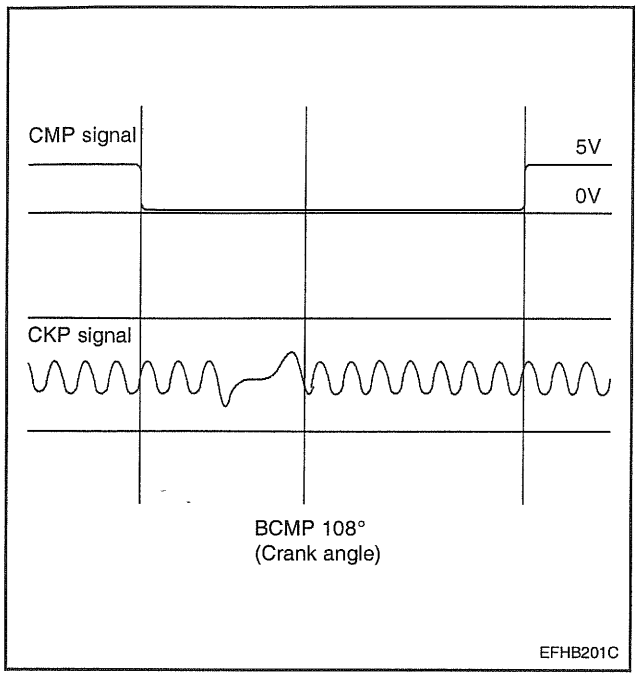
   CMP signal
   CKP signal

4. Check wiring if CMP sensor signal is not OK.

   Wiring check:

ECU	CMP
Pin 104	Pin 1
Pin 103	Pin 2
B (+)	Pin 3

5. Check the camshaft and crankshaft arrangement if applicable at the present of CKP and CMP signal.



RPS : RAIL PRESSURE SENSOR

1. Possible DTC: P0190
   Actual value for evaluation : Engine warm at approx. 80° C. Engine idling.

   Set value: 220 - 300 bar
   Typical value: 260 bar

   Rail pressure in limp home mode (fault state) :

   approx. 400 bar

   Vehicle can be driven in limp home mode.

   • CC-CODE
   1) C001 (Signal below the lower limit- No signal)
      - Possible causes of trouble:
      A. Open circuit, contact resistance, or short circuit to GND line
      B. RPS defective
      C. ECU - sensor supply voltage 2 : DTC1527
      C001
   1) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. Short circuit to Bat(+) line
      B. RPS defective
      C. ECU - sensor supply voltage 2 : DTC1527
      C002
   3) C003 (General error)
      Rail pressure sensor error is determined by comparison of rail pressure regulator operation current value to rail pressure sensor output.
      Possible causes of trouble:
      A. Short circuit to Bat(+) line or to GND
      B. ECU - sensor supply voltage 2 : DTC1527
      The CC-Code from this error reports the error source.

2. Measure the supply voltage of RPS with ignition on. Pin 3(+) to pin 1(-)

   Set value : 4.5V - 5.5V

3. Signal voltage measurement
   If supply voltage set value is attained, measure the voltage from pin 2 to GND with ignition on.

   Set value : Approx. 0.5V
   Engine idling set value : 1V
   Voltage increases with increasing pressure:
   Max. 4.5V

4. If set values are attained : Ignition off, pull off the plug of control unit and sensor. Then check the following wiring for open/ short circuit.

ECU	Sensor
Pin 90	Pin 3
Pin 91	Pin 2
Pin 92	Pin 1

5. If the signal voltage set value is not attained, replace RPS.

6. Note the followings
   1) Always renew the sealing washer (soft iron sealing ring) even if the old sensor is re-used
   2) When removing seal, take care not to damage sealing surface.
   3) When installing RPS, apply sealing washer with grease if necessary.

   4) **Tightening torque** : 35 ± 2Nm

      • Replace the faulty fuel rail assembly in case of new model vehicle within a year, or replace the faulty parts of vehicle of which model year is more than a year.

RAIL PRESSURE MONITORING

1. Possible DTC: P1181

2. Actual value for evaluation: Conform actual value of RPS

   • CC-CODE
   1) C005 (Max. pressure excceed)
      C008 (Actuator sticks in closed position)
      - Possible causes of trouble:

A. Rail pressure sensor (RPS) defective
B. Pressure regulator valve defective
C. Injectors defective
D. High pressure pump defective

2) C006 (Min.pressure at low engine speed)
C009 (Leakage), C010 (Governor deviation at high engine speed)
- Possible causes of trouble:
A. Rail pressure sensor (RPS) defective
B. Pressure regulator valve defective
C. Injectors defective
D. High pressure pump defective
E. Leakage

3. Any additionally stored faults are to be rectified first. Cancel the fault memory and then perform the test drive. Start by checking above-mentioned components if fault code is stored again.

4. Visually check the pipes, rail and connections for leakage.

5. Check the low pressure circuit.
- Possible causes of trouble: Leakage, fuel filter clogged, electric fuel pump
1) Connect the pressure gauge between fuel filter and high pressure pump. Ignition on. Fuel pump delivery for 30 seconds.

Pressure > 3.5 bar

Opening pressure at overflow valve of fuel filter is too high
Replacle the valve

Pressure < 1.5 bar

Block the hose between overflow valve and return flow collector

Pressure > 3.5 bar

Overflow valve defective

Pressure < 3.5 bar

Check the electric fuel pump

2) Connect the pressure gauge to the entire return fuel line toward the tank
Ignition on. (High pressure pump delivery)

Pressure < 1 bar : Return line clogged

3) Connect the pressure gauge to upstream of filter
Ignition on. (High pressure pump delivery)

Pressure > 2.8 bar : Filter or inlet clogged

6. Check the high pressure circuit
- Possible causes of trouble: Leakage, rail pressure sensor, regulator, injectors, high pressure pump
1) Visually inspect for leakage and check all connectors
2) Block the fuel return line of function block
3) Pull off the electric connector of all injectors. Connect the self-diagnosis tester (HI-SCAN)
4) Ignition on. Operate starting motor for 5 seconds

Actual value read out: Rail pressure
Actual value < 150 bar :
High pressure pump defective

BATTERY VOLTAGE

1. Possible DTC: P0560
- CC-CODE
1) C001 (Signal below the lower limit- No signal)
- Possible causes of trouble:
A. Open circuit in wiring / Short circuit to GND line
B. Contact resistance
C. Fuse defective
D. Plug contacts
E. Main relay
F. Battery defective
G. Alternator charge defective

2) C002 (Signal above the upper limit)
- Possible causes of trouble:
A. 24V battery connected
B. Alternator over-charging

3) C004 (Plausibility error)
- Possible causes of trouble:
A. Rail pressure sensor defective
B. Pressure regulator valve defective
C. Battery defective

2. Check ECU plug and wiring plug contact condition.
3. After ignition on, check the supply voltage of ECU pin 4 to GND and of ECU pin 5 to GND.

Set value: 8 - 15V

4. If set value is not attained, check the main relay of pin 30 to GND.

Set value: 8 - 15V

5. If set value is not attained, check fuses.

6. Measure the supply voltage of ECU pin 13 to GND

Set value: 8 - 15V

7. Check GND wires from ECU pin 1,2,3 for open and short circuit.
8. Check the battery voltage
9. Check the alternator charge condition

APS : ACCELERATION POSITION SENSOR 1

1. Possible DTC: P0120 (Accel position sensor 1)

   Actual value for evaluation : Ignition on

   Idle set value: 0%
   Full throttle : 100%

   - CC-CODE
   1) C001 (Signal below the lower limit- No signal)
      - Possible causes of trouble:
      A. Short circuit to GND line
      B. APS defective
      C. ECU defective (Sensor supply voltage): DTC P1526 C001
   2) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. Short circuit to Bat line
      B. APS defective
      C. ECU defective (Sensor supply voltage): DTC P1526 C002
   3) C003 (General error)
      Possible causes of trouble:
      - Possible causes of trouble:
      A. ECU defective (Sensor supply voltage): DTC P1526
   4) C004 (Plausibility error with brake signal)
      When depressing accel pedal (not at idle), brake switch signal is shown "ON" for a certain time, error is detected.
      - Possible causes of trouble:
      A. Brake switch defective
      B. APS defective
      C. ECU defective (Sensor supply voltage); DTC P1526

2. Check the sensor supply voltage with ignition on.
   Sensor 1: Pin 2(+) and pin 3(-), Sensor 2 : Pin 1 (+) and pin 5(-) (with APM)

   Set value : 4.5 - 5.5V

   Sensor 1: Pin 4(+) and pin 5(-), Sensor 2 : Pin 1 (+) and pin 6(-) (with APM)

   Set value : 4.5 - 5.5V

3. If set value is not attained: Ignition off. ECU and sensor plug off. Check wiring for short or open circuit. Check the following wiring.
   1) With APS (XD/FO/SM-RHD)

ECU	APS 1
Pin 76	Pin 5
Pin 77	Pin 2
Pin 78	Pin 4

   2) With APM (LC/FC/SM-LHD)

ECU	APS 2
Pin 76	Pin 3
Pin 77	Pin 4
Pin 78	Pin 2

4. If connecting leads are OK, measure the signal voltage of sensor.
   1) With APM
      - Sensor 1:

      Pin 4(+) and pin 3(-) set value
      At idle : 0.6 - 0.9V
      At full throttle : 3.6 - 4.6 V

   2) With APS
      - Sensor 1:

      Pin 2(+) and pin 5(-) set value
      At idle : 0.6 - 0.9V
      At full throttle : 3.6 - 4.6 V

APS : ACCELERATION POSITION SENSOR 2

1. Possible DTC: P0220 (Accel position sensor 2)
2. Actual value for evaluation : Ignition on

   Idle set value: 0%
   Full throttle : 100%

   - CC-CODE
   1) C001 (Signal below the lower limit- No signal)
      - Possible causes of trouble:
      A. Short circuit to GND line
      B. APS defective
      C. ECU defective (Sensor supply voltage): DTC P1527 C001
   2) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. Short circuit to Bat line
      B. APS defective

C. ECU defective (Sensor supply voltage): DTC P1527 C002

3) C003 (General error)
APS sensor operation power error (ECU)
- Possible causes of trouble:
A. ECU defective (Sensor supply voltage): DTC P1527

4) C003 (Plausibility error with brake signal)
When comperative value between accel pedal sensor signal and accel pedal sensor signal 2 exceed the set deviation, error is detected.
- Possible causes of trouble:
A. APS defective
B. ECU defective (Sensor supply voltage): DTC P1527

3. Check the voltage supply of sensors with ignition on
Sensor 1: Pin 2(+) and pin 3(-), Sensor 2 : Pin 1 (+) and pin 5(-) (with APM)

Set value : 4.5 - 5.5 V

Sensor 1: Pin 4(+) and pin 5(-), Sensor 2 : Pin 1 (+) and pin 6(-) (with APS)

Set value : 4.5 - 5.5V

4. If set value is not attained: Ignition off. ECU and sensor plug off.
Check wiring for short or open circuit.
Check the following wiring.

1) With APS (XD/FO/SM-RHD)

ECU	APS 1
Pin 79	Pin 6
Pin 80	Pin 3
Pin 80	Pin 1

2) With APM (LC/FC/SM-LHD)

ECU	APS 1
Pin 79	Pin 6
Pin 80	Pin 5
Pin 81	Pin 1

If connecting leads are OK, measure the signal voltage of sensor.

1) With APM

Sensor2: Pin 6(+) and pin 5(-) set value
At idle : 0.25 - 0.6V
At full throttle : 1.6 - 2.5 V

2) With APS

Sensor2: Pin 3(+) and pin 6(-) set value
At idle : 0.25 -0.6V
At full throttle : 1.6 - 2.5 V

WTS : WATER TEMPERATURE SENSOR

1. Possible DTC: P0115
Actual value for evaluation: Set value, approx. 80°C (with engine warm)
Evaluation display:
A temperature reading < -40°C indicates an open circuit in the signal line
A temperature reading > 120°C indicates a short circuit to GND in the signal line

NOTE
Radiator fan starts up if temperature sensor is defective or plug pulled off.

- CC-CODE

1) C001 (Signal below the lower limit- No signal)
- Possible causes of trouble:
A. Short circuit to GND line
B. Contact resistance
C. WTS defective
D. ECU defective

2) C002 (Signal above the upper limit)
- Possible causes of trouble:
A. Short circuit to Bat(+) line, open circuit in wiring
B. WTS defective
C. ECU defective

3) C004 (Plausibility error)
After ignition on, cooling water temperature is not arrived at the set value within set time, error is detected.
- Possible causes of trouble:
A. Contact resistance
B. WTS defective
C. ECU defective
D. Thermostat defective

2. Measure the resistance of sensor at pin 1 (+) and pin 3 (-)

Set value at 0 - 40 : 1.1 - 5.8 kΩ
Set value at 60 - 100 : 180 - 590Ω

3. Repeat the measurement directly at sensor if set values are not attained.

4. If set values are attained at sensor, check wiring from ECU pin 84 and pin 85 to sensor.

FTS : FUEL TEMPERATURE SENSOR

1. Possible DTC: P0180
   * CC-CODE
   1) C001 (Signal below the lower limit- No signal)
      - Possible causes of trouble:
      A. Short circuit to GND line
      B. Contact resistance
      C. FTS defective
      D. ECU defective
   2) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. Short circuit to Bat(+) line, Open circuit in wiring
      B. WTS defective
      C. ECU defective

2. Measure the resistance of sensor at pin 1 (+) and pin 2 (-)

   Set value at 0 - 40°C : 1 - 7 kΩ
   Set value at 70 - 90°C : 390 - 240Ω

3. Repeat the measurement directly at sensor if set values are not attained.
   If set values are attained at sensor, check wiring from ECU pin 82 and pin 83 to sensor

ATS : AIR TEMPERATURE SENSOR

1. Possible DTC: P0110 (Air temperature sensor)

   Air temperature sensor is integrated into HFM5.
   Actual value for evaluation: Set value., Ambient temperature
   Evaluation display:

   A temperature reading < -40°C indicates an open circuit in the signal line
   A temperature reading > 120°C indicates a short circuit to GND in the signal line

   • CC-CODE
   1) C001 (Signal below the lower limit- No signal)
      - Possible causes of trouble:
      A. Short circuit to GND line
      B. Contact resistance
      C. HFM5 defective
      D. ECU defective
   2) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. Short circuit to Bat line, Open circuit in wiring
      B. ATS in HFM5 defective
      C. ECU defective

2. Measure the resistance of temperature sensor at the detached ECU plug.

   Set value at 0 - 30°C : 1.5 - 6kΩ
   Set value at approx. 50°C : 750 - 920kΩ

3. If set values are not attained , repeat the measurement at temperature sensor in air flow sensor pin 1 to pin 3.
   If set values are attained at sensor, check wiring from ECU pin 86 to sensor pin 1 and ECU pin 88 to sensor pin 3

4. Replace HFM5 if set value is not attained at air temperature sensor

APS : ATMOSPHERIC PRESSURE SENSOR

1. Possible DTC: P1170

   Set value :
   Atmospheric pressure tolerance : +/- 30hPa

   Possible actual value : approx. 1000hPa at sea level

   NOTE
   Atmospheric pressure sensor is located in ECU

   • CC-CODE
   1) C001 (Signal below the lower limit- No signal), C002 (Signal above the upper limit)
   Possible causes of trouble: Defective atmospheric pressure sensor in ECU

2. Call up the actual values

3. Cancel the fault memory and perform the test drive

4. Replace ECU if fault memory cannnot be cancelled or if fault is set again.

HFM5 (AIR FLOW SENSOR)

1. Possible DTC: P0100 (Air flow sensor)

   Actual value for evaluation: Engine idling, or enine warm at approx.80°C

   Set value:
   450 - 510 mg/stroke (without EGR)
   280 - 360mg/stroke (without EGR)

   • CC-CODE
   1) C001 (Signal below the lower limit- No signal)
      - Possible causes of trouble:
      A. Short circuit to GND line or Open circuit in wiring
      B. Contact resistance
      C. HFM5 defective
      D. ECU defective (Sensor supply voltage) : DTC P1526 C001
   2) C002 (Signal above the upper limit)
      - Possible causes of trouble:
      A. Short circuit to GND line or Open circuit in wiring
      B. HFM5 defective

C. ECU defective (Sensor supply voltage) : DTC P1526 C002

3) C003 (General error)
Sensor operation power (from ECU) error
- Possible causes of trouble:
A. Open circuit in wiring / short circuit
B. ECU defective (Sensor supply voltage)

2. Check the HFM5 supply voltage

Pin 2 - GND / Pin 2 - Pin 3 : 8 - 15V
Pin 4 - GND / Pin 4 - Pin 3 : 4.5 - 5.5V

3. If set values are not attained : Ignition off, pull off ECU plug.
Check the following wiring

ECU	Sensor
Pin 97	Pin 2, Pin 4
Pin 89	Pin 5
Pin 88	Pin 3

4. Measure the signal voltage of sensors if connecting leads are OK.

5. Measure the voltage of plug pin 5 to pin 3 at idle.

Set value (engine warm) : 1.7 - 2.2 V
Throttle burst set value : Voltage increases

6. Replace HFM5 if signal voltage set values are not attained.

VEHICLE SPEED SIGNAL

1. Possible DTC: P0500

- CC-CODE
1) C001 (Signal below the lower limit- No signal)
- Possible causes of trouble:
A. Interference from other component
B. Vehicle speed sensor defective
2) C004 (Plausibility error)
While injection fuel and engine rpm is supported by above the upper limit, if vehicle speed is below the set value error is detected.
- Possible causes of trouble:
A. Clutch switch defective
B. Vehicle speed sensor defective

2. Check wiring between ECU pin 49 and vehicle speed sensor.

SOLENOID VALVE FOR EGR VALVE

1. Possible DTC : P0403
- CC-CODE
1) When feedback governing exceeds the set value in comparison of aim value with the actual value.
- Possible causes of trouble:
A. Solenoid valve sticks
B. Vacuum source/ pipe/ hose
2) C018 (Line : Short circuit)
- Possible causes of trouble:
A. Short circuit to Bat line, Open circuit in wiring
3) C019 (Line : Open circuit)
- Possible causes of trouble:
A. Short circuit to GND line

2. Check wiring between ECU pin 16 and solenoid valve.

3. Check wiring between supply voltage line and solenoid valve.

4. Check for leaks in vacuum hose to EGR valve and solenoid valve.

5. Pull off the plug of solenoid valve, measure the resistance of solenoid valve.

Set value : 14 - 17Ω

6. Measure the frequency of control voltage :

300 Hz

7. Check whether vacuum is provided by vacuum source.
Check mode : Keep engine at 1500rpm for 20 seconds and then conduct the measurement as it is.

Set value > 650 mmHg

8. Pull off the vacuum hose from EGR valve.
Check for presence of vacuum.

9. Check the mechanical components of solenoid valve if vacuum is present but engine speed does not change.

10. If valve stick is in closed position or C019 occurs, then black smoke arises.

ADDITIONAL WATER HEATER

1. Possible DTC: P1635

   • CC-CODE
   1) C018 (Line : Short circuit)
      - Possible causes of trouble:
      A. Short circuit to Bat line, Open circuit in wiring
      B. Fuse defective
      C. Open circuit. Contact resistance
      D. Additional water heater relay defective
   2) C019 (Line : Open circuit)
      - Possible causes of trouble:
      A. Short circuit to Bat line, Open circuit in wiring
      B. Fuse defective
      C. Contact resistance
      D. Additional water heater relay defective

2. Measure the voltage at relay pin 85 to GND.

   Set value :
   8 - 15V (OFF)
   0V(ON)

3. Check the additional water heater relay wiring

4. Measure the supply voltage at relay pin. 87 to GND.

   Set value : 8 - 15V

5. Check the additional water heater relay wiring

6. Check wiring between ECU pin 23 and additional water heater relay.

7. If wiring and fuse is OK, replace the additional water heater relay.

   NOTE :
   FO vehicle of which mounting combustive heater reveals the above trouble code normally. So please ignore the code.

GLOW RELAY AND GOLW LAMP

1. Possible DTC: P1325 (Glow relay) P1329 (Glow indicator lamp)

   • CC-CODE
   1) C018 (Line : Short circuit)
      - Possible causes of trouble:
      A. Short circuit to Bat line, open circuit
      B. Fuse defective
      C. Contact resistance
      D. Glow time control
      E. Glow plug indicator lamp
   3) C019 (Line : Open circuit)
      - Possible causes of trouble:
      A. Short circuit to GND line
      B. Fuse defective
      C. Contact resistance
      D. Glow time control
      E. Glow plug indicator lamp

   NOTE
   Golw plug idicator lamp lights briefly for self test when Ignition switch is turned on.

2. Activate the lamp by way of actuator diagnosis
   If check lamp does not flash: Check the fuse
   Check glow lamp wiring

3. Activate the lamp by way of actuator diagnosis
   If relay is not switched : Check the fuse
   Measure the supply voltage at relay pin. 2 to GND.

   Set value : 8 - 15V

   Check glow lamp wiring
   Measure the supply voltage at relay pin. 3 to GND.

   Set value : 8 - 15V

   Check glow lamp wiring.

4. If wiring and fuse is OK, replace the glow relay.

5. After replace the glow relay, perform the test again.

EFP : ELECTRIC FUEL PUMP

1. Possible DTC: P0230
   • CC-CODE
   1) C004 (Plausibility error)
      After run mode or fuel cut off mode, if rail pressure does not drop below the set value within set time, error is deteced.
      - Possible causes of trouble:
      A. Contact resistance
      B. EFP relay defective
      C. EFP defective
   2) C018 (Line : Short circuit)
      - Possible causes of trouble:
      A. Short circuit to Bat line, open circuit in wiring
      B. EFP relay defective
      C. EFP defective
   3) C019 (Line : Open circuit)
      When EFP runs for a second or longer and ignition switch is turned on :
      Line to EFP relay was short circuit to GND
      Measure the sensor resistance of pin 1 (+) and pin 2 (-)
      - Possible causes of trouble:
      A. Short circuit to Bat line, Open circuit in wiring
      B. Contact resistance

C. EFP relay defective
D. EFP defective
E. ECU power stage short circuited

2. EFP runs for approx. 1 second after switching on ignition. (Delivery noise can be heard)

3. Check the fuse in engine compartment if EFP does not run.

4. Ignition off. Check wiring between ECU pin 24 and EFP relay pin 86.
Jump pin 30 and pin 87 at relay frame with fused measurement lead.
Ignition on. EFP must run for apporx. 1 second.

5. Replace the relay if EFP runs.

6. Check the supply voltage of EFP.
Voltage is applied to EFP for approx. 1 second when ignition switch is turned on.

Set value : 8 - 15V

7. Replacle the EFP if set value is attained

PRV : PRESSUE REGULATOR VALVE

1. Possible DTC: P1180
Feature: Depending on the rail pressure to be set, PRV is actuated by ECU with a PWM (Pulse with modulated).

2. When PRV is replaced

Tightening torque : 5 ± 1Nm

* Replace the faulty fuel rail assembly in case of new model vehicle within a year, or replace the faulty parts of vehicle of which model year is more than a year.

• CC-CODE
1) C003 (General error)
After run mode or fuel cut off mode, if rail pressure does not drop below the set value within set time, error is deteced.
- Possible causes of trouble:
A. Short circuit
B. Contact resistance
C. PRS defective
D. EFP relay continuously active
E. Pressure regulator valve defective
F. High pressure pump
G. ECU
2) C018 (Line : Short circuit)
- Possible causes of trouble:
A. Short circuit to Bat line, Open circuit in wiring
B. WTS defective
3) C019 (Line : Open circuit)
- Possible causes of trouble:
A. Short circuit to GND line, Open circuit

3. Pull off PRV plug
Check wiring between ECU pin 108, pin 109 and PRV.

4. Measure the resistance of PRV

Approx. set value : 2.3 ± 0.23Ω

5. Check RPS if preceding test is OK.

6. Examine the system for leaks if rail pressure sensor is OK.

7. Check the high pressure circuit
1) Visually inspect for leakage and check all connectors.
2) Block the fuel return line of the function block.
3) Pull off the electirc connector from all injectors and connect the self diagnosis tester (HI-SCAN).
4) Ignition on, and operate starting motor for 5 seconds.
- Actual value read out : Rail pressure
- Actual value < 100 bar : High pressure pump defective or air in the system

A/C COMPRESSOR RELAY

1. Possible DTC : P1622

• CC-CODE
1) C018 (Line : Short circuit)
- Possible causes of trouble:
A. Short circuit to Bat line
B. A/C compressor relay defective
2) C019 (Line : Open circuit)
- Possible causes of trouble:
A. Short circuit to GND line, Open circuit
B. A/C compressor relay defective
C. Pressure switch defective
D. A/C compressor magnetic clutch

2. Ignition on
Measure the voltage at compressor relay (A/C compressor) pin 86 to GND.

Set value : 8 - 15V

3. If set value is not attained , check the fuse

4. Measure the voltage at compressor relay (A/C compressor) pin 30 to GND.

Set value : 8 - 15V

If set value is not attained, check the supply voltage.

5. Check wiring from compressor relay pin 87 to plug of compressor.
Check wiring between relay pin 85 to ECU pin 21.

6. Check wiring between pressure switch to ECU pin 51, pin 52.

7. Check A/C compressor magnetic clutch if proceeding tests do not reveal the cause of trouble.

COOLING FAN

1. Possible DTC : P1624 P1625

- CC-CODE

1) C018 (Line : Short circuit)
   - Possible causes of trouble:
   A. Short circuit to Bat line
   B. Fuse defective
   C. Relay defective
   D. Resistance continuity defective
   E. Fan motors defective
2) C019 (Line : Open circuit)
   - Possible causes of trouble:
   A. Short circuit to GND line, Open circuit
   B. Fuse defective
   C. Relay defective
   D. Series resistors defective
   E. Fan motors defective

The fan relays are in 3 kinds
The first relay (FAN 1): Speed 1 (both fans)
The second and thrid relays : Speed 2 (each fan)

Fan speed 1:
Measure the supply voltage at relay pin 85 to the ground with ignition on.

Set value : 8 - 15 V

Check the fuse, if set value is not attained.
Ignition off.
Check wiring between ECU pin 20 and relay pin 85 if wiring is OK, check the relay.

2. Measure the series resistances.

3. If fans do not start up despite actuation, check the fuse.

4. Measure the resistance of wiring between relay pin 87 and GND.

5. Fan speed 2
Additional checks.
Measure the supply voltage of relays pin 85 to GND with ignition on.

Set value : 5 - 15V

---

6. Ignition off
Check wiring of relays pin 86 to ECU PIN 19.
Check wiring of relays pin 87 to GND.

ENGINE CHECK LAMP

1. Possible DTC :P1623

- CC-CODE

1) C018 (Line : Short circuit)
   - Possible causes of trouble:
   A. Short circuit to Bat line
2) C019 (Line : Open circuit)
   - Possible causes of trouble:
   A. Short circuit to GND line, Open circuit

2. Perform the actuator diagnosis.

3. If lamp does not flash, measure the supply voltage at engine check lamp to GND with ignition on.

Set value : 8 - 15V

---

4. Check the fuse if set value is not attained.

Check the actuation lead of fault lamp.
Check wiring between engine check lamp and ECU pin 110 for open circuit and short circuit.
Lamp is defective if all preceding tests are OK.

BRAKE SWITCH

1. C004 (Plausibility error)

- CC-CODE

1) C004 (Plausibility error)
   After ignition on, brake signal 1, and signal 2 are different each other, error is detected.

Without being concerned with brake signal 1, if only brake signal 2 is turned on continuously for set time, error is detected.
- Possible causes of trouble:
A. Open circuit in wiring , Short circuit
B. Fuse defective
C. Poor connection
D. Switch defective

Brake switch 1
Measure the supply voltage at switch pin 2 to GND with ignition on.

Set value : 8 - 15V

Check the fuse if set value is not attained.

2. Ignition off
Measure the supply voltage at the detached plug.
Depress the brake.

3. Check wiring between switch pin 1 and ECU pin 59.

Brake switch 2 (Redundant brake switch)
Measure the supply voltage at switch pin 4 to GND with ignition on.

Set value : 8 - 15V

Check the fuse if set value is not attained.

5. Ignition off
Measure the resistance of switch at the detached plug.
Depress the brake.

6. Check wiring between switch pin 3 and ECU pin 4.

CLUTCH SWITCH

* MT vehicle Only

1. Possible DTC: P704

- CC-CODE
1) C004 (Plausibility error)
Without changing of clutch signal, if vehicle speed is above the set value , error is detected.
- Possible causes of trouble:
A. Open circuit in wiring, Short circuit
B. Fuse defective
C. Poor connection
D. Switch defective

Measure the voltage at switch pin (ECU side) to GND with ignition on.

Set value : 8 - 15V

3. Check wiring if set value is not attained.
Ignition off
Measure the resistance of switch at the detached plug.

Set value : ---- > 1 MΩ

Depress the clutch pedal.

Set value : 0 - 1Ω

4. Check wiring between switch and ECU pin 61.

5. Clutch disengage
Clutch engage // Signal on

MAIN RELAY

1. Possible DTC: P1616

- CC-CODE
1) C004 (Plausibility error)
Without changing of ignition switch position "ON" → "OFF", If main relay is turned off, error is detected.
Before ECU is shut off, if ignition switch and main relay are turned off, error is detected
- Possible causes of trouble:
A. Open circuit in wiring, Short circuit
B. Contact resistance
C. Fuse defective
D. Main relay defective

2. After ignition on, check the supply voltage of ECU pin 4 to GND and ECU pin 5 to GND.

Set value : 8 - 15V

3. If set value is not attained , check wiring an fuses.

4. If wiring and fuses are OK, replace the main relay.

IGNITION SWITCH

1. Possible DTC : P1652
- CC-CODE
1) C004 (Plausibility error)
After ignition off, if ignition switch signal keeps "OFF" continuously, error is detected.
- Possible causes of trouble:
A. Open circuit in wiring, Short circuit
B. Contact resistance
C. Fuse defective
D. Switch defective

2. Measure the voltage at switch from ECU pin 58 to GND with ignition on.

Set value : 8 - 15V

Check wiring and fuse if set value is not attained.
Ignition off
Measure the resistance of switch at the detached plug.

MAXIMUM VEHICLE SPEED LIMITATION

1. Possible DTC: P1530

   1) C003 (General error)
   In comparision of maximum vehicle speed set value with actual vehicle speed , if it exceeds set value, error is detected.
   - Possible causes of trouble:
   A. Vehicle speed sensor defective
   B. ECU defective

2. Check wiring between ECU pin 49 and vehicle speed sensor.

INJECTOR

1. Possible DTC: P0201 (Sylinder #1 Injector)
   P0202 (Sylinder #2 Injector)
   P0203 (Sylinder #3 Injector)
   P0204 (Sylinder #4 Injector)

   • CC-CODE
   1) C018 (Line : Short circuit)
   Engine can be severely damaged due to continuous fuel injection.
   - Possible causes of trouble:
   A. Short circuit of high side line to Bat
   B. Shrot circuit of low side line to GND
   C. Injectors
   D. Injector voltage (ECU)
   2) C019 (Line : Open circuit)
   - Possible causes of trouble:
   A. High side line or low side line broken
   B. Contact resistance
   C. Injectors
   D. Injector voltage (ECU)

2. Ignition off. Check wiring between ECU and injectors.

	Injector 1	ECU	Injector 2	ECU
Pin NO.	1	114	1	121
Pin NO.	2	117	2	118

	Injector 3	ECU	Injector 4	ECU
Pin NO.	1	120	1	119
Pin NO.	2	118	2	117

Measure the resistance of injectors with plug disconnected.

Set value : 0.3 - 0.6 ohm (at room temperature)

3. Check the actuation of injectors with clip- on ammeter of Motortester.
Clip-on ammeter must satisfy the following conditions.

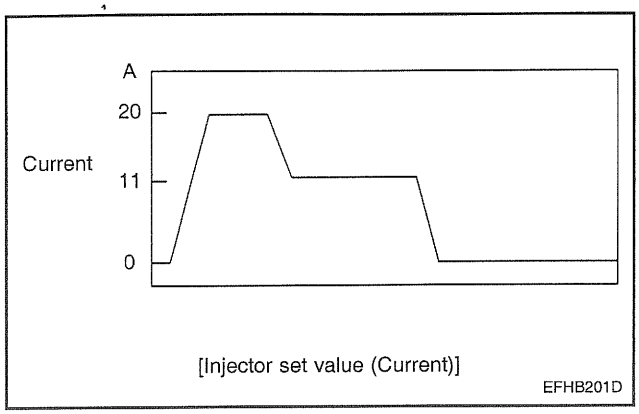
Measuring range >25A
Bandwidth >100 kHz

4. Attach the plug to injector
Fasten clip-on ammeter around lead to pin 2 of corresponding injector.
Allow the engine to idle. Set value : Refer to the following Fig. Injector set value(current) on next page.

NOTE
1) Length of holding current phase (Max. 12A) is governed by engine speed, injection time, and changes on acceleration.
2) The first current curve shows the pre-injection.

5. Check whether injector injects fuel. To do so, pull off the injector plug in each case and connect to replacement injector.
If change to engine running results, injector is injecting.
If no change to engine running results injector is not injecting.

This test cannot however establish whether an injetor is injecting correct quantity.
If necessary, all injectors have to be replaced.



[Injector set value (Current)]

EFHB201D

AFTER RUN TEST

1. After run test conditions
   1) Ignition switch : "ON" → "OFF".
   2) Engine rpm is within set value.
   3) Actual vehicle speed is below the set value.
   4) Rail pressure sensor and vehicle speed sensor is OK.

2. Possible DTC: P1653
   - When energizing time is "0" after run test mode, if engine rpm is not below the set value within set time , error is detected.
   - When injector power stage is shut off, if engine rpm is not below the set time within set time, error is detected.
   - Possible causes of trouble:
     A. Open circuit in wiring, or Short circuit
     B. Poor connection
     C. ECU

   Several tests are implemented in ECU after switching off the Ignition.
   This fault entry occurs if ECU detects any faults during these tests.

3. Start by rectifying any other stored faults.

   Then cancel the fault memory and perform the test drive.

4. Measure the supply voltage at ECU pin 114 (Cylinder #1 injector), pin 119 (Cylinder # 4 injector) to ECU Pin 117 and ECU pin 120 (Cylinder # 3 injector), pin 121 (Cylinder # 2 injector) to ECU Pin 118 with ignition off.

   Set value : 0 V

   Check wiring if set value is not attained.

5. If wiring is OK , replace ECU.

REMOVAL AND INSTALLATION OF INJECTOR

ATTENTION

1) **Fuel system is subject to extremely high pressure (1350 bar).**
2) **Never perform any work on injection system with engine running or within 30 seconds after stopping the engine.**
3) **Always pay attention to safety precautions.**
4) **Ensure the absolute cleanliness.**
5) **Never remove the injectors.**

1. Removal
   1) Disconnect the negative battery (-) terminal.
   2) Pull off the injector electric connector.
   3) Unfasten the high pressure pipe at rail and injector.
   4) Press in clip to back leak rail by hand and pull out back leak rail.
   5) Attach the connection of back leak rail. Never fit without clip.
   6) Remove the copper sealing ring.

2. Before re-installing injector, clean the cylinder head bore and sealing surface.
   1) Insert the brush.
   2) Clean the sealing surface and blow out.

3. Installaion
   1) Insert a new copper sealing ring (if necessary, apply small quantity of grease to bond it to injector).
   2) Install the injector (do not touch the nozzle tip) and sliding clamp with clamp bolt.
   3) Screw the clamp bolt .

      Tightening torque : 2.7 ± 0.2 kg· m

   4) Install the high pressure pipes.

      Tightening torque : 1.8 - 2.3 kg· m

      * When mounting the high pressure pipes, fix the hexagon component of high pressure fuel injection parts not to squeeze heavily the high pressure fuel injection parts.

   5) Attach the connection of back leak rail. Never fit without clip.
   6) Check the tightness of back leak rail by tugging it.
   7) Attach the electric connector.
   8) Re-connect the negative battery(-) terminal.
   9) Start the engine and check the high pressure circuit for leaks.

4. Read out the fault memory and cancel the faults stemming from the detached injector plug.

HIGH PRESSURE PUMP

ATTENTION

1) **Fuel system is subject to extremely high pressure (1350 bar).**
2) **Never perform any work on injection system with engine running or within 30 seconds after stopping the engine.**
3) **Always pay attention to safety precautions.**
4) **Ensure the absolute cleanliness.**

INSTALLATION

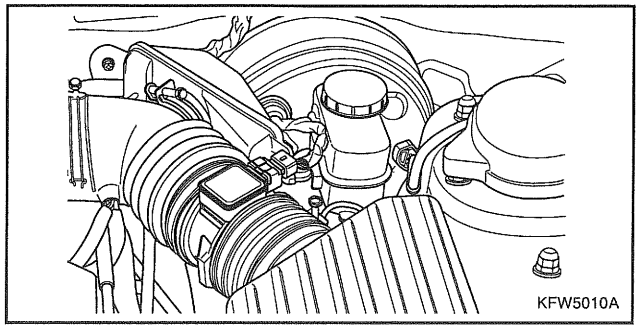
1) **Insert the coupling into the pump**
2) **Lightly apply the grease to O-ring and install the pump in cylinder head. At this time, turn the pump until the shaft stub of the pump engages the camshaft.**
3) **Apply the medium- strength screw locking compound to the bolt threads**
4) **Install the retaining bolts with washers and tighten to**

1.3 - 1.8 kg· m

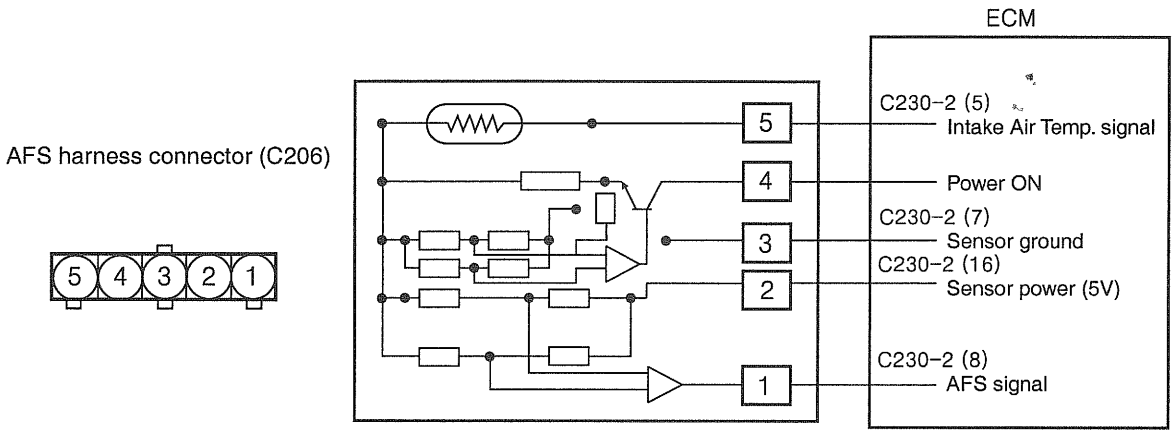
EDC COMPONENT INSPECTION

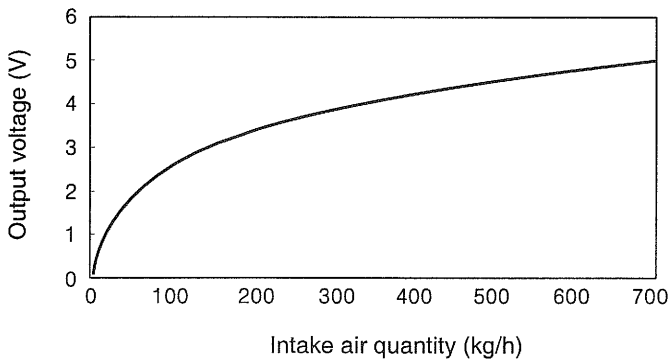
AIR FLOW SENSOR (AFS)

AFS uses the features of sensor heater, after HOT FILM units calculate the intake air quantity, then send the signal to ECM.
ECM decides the fuel quantity and ignition timing, and recognizes uphills and helps fuel quantity and overrun airconditioner compensation, idle speed actuator AFS might be combined to measure the intake air temperature.



[CIRCUIT DIAGRAM]

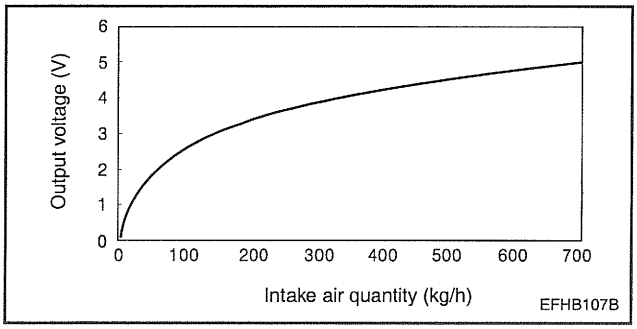




EFHB106B / EFHB107B

[HOT FILM AFS OUTPUT FEATURES]

Air quantity (kg/h)	Output voltage (V)
8	1.248 - 1.265
10	1.318 - 1.339
15	1.474 - 1.500
30	1.820 - 1.856
60	2.302 - 2.347



TEST PROCEDURE

- o Engine state : Operating
- o Fault code : P0100

YES

- o Check wiring and ECM for poor connection.
- o Connection is OK?

NO → o Repair wire or connector.

YES

- o Check the AFS.
- o Is it OK?

NO → o Repair sensor.

YES

- o Cancel the stored error code.
- o Is there still existing error code after rechecking?

YES

- o Replace the ECM.

TROUBLESHOOTING HINTS

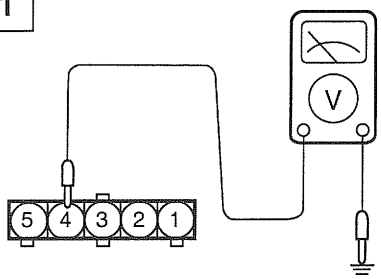
1. If engine is intermittently starting, after starting the engine, shake AFS harness up. Inspect the contact troubles of AFS connetor, if engine stops.
2. When Ignition switch is turned on, if AFS output voltage is not "0" (engine stops), inspect the malfunction of AFS and ECM.
3. Even though AFS output voltage is abnormal, if engine is at idle ,inspect the following conditions.
   1) Chect the poor attachment of airflow, cut air duct, and air cleaner filter branched from AFS.
   2) Bad combustion in the cylinder or fault injector.
4. Even it no AFS malfunction occurs, check the mounting direction of AFS.

NOTE

1. **In case of new vehicle (mileage : below 500km) AFS air quantity is above approx.10%.**
2. **Use correct digital voltmeter.**
3. **Before inspection, warming up the engine till the engine coolant temperature is up to 80~90°C.**

AFS HARNESS INSPECTION PROCEDURES

1



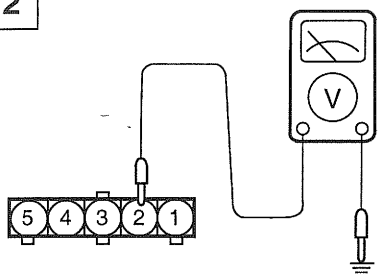
Measure the power supply voltage
- o Connector : Disconnected
- o Ignition switch : ON
- o Voltage(V) : Battery voltage

OK ⇨ 2

NG ⇨ Repair the harness

EFHB108B

2



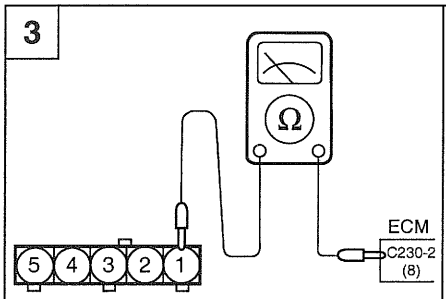
Measure the sensor power voltage
- o Connector : Disconnected
- o Ignition switch : ON
- o Voltage(V) : 4.8 - 5.3V

OK ⇨ 3

NG ⇨ Repair the harness

EFHB109B

3



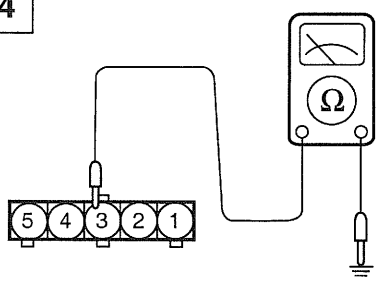
Check for a short wiring, or a short circuit between AFS and ECM harness
- o Connector : Disconnected

OK ⇨ 4

NG ⇨ Repair the harness

EFHB110B

4



Check for continuity of the ground sensor
- o Connector : Disconnected

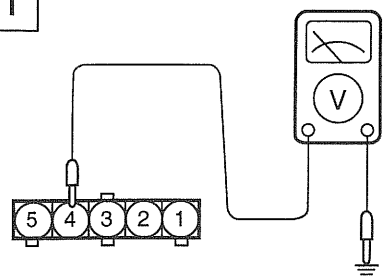
OK ⇨ **END !**

NG ⇨ Repair the harness

EFHB111B

INTAKE AIR TEMPERATURE SENSOR HARNESS INSPECTION PROCEDURE

1



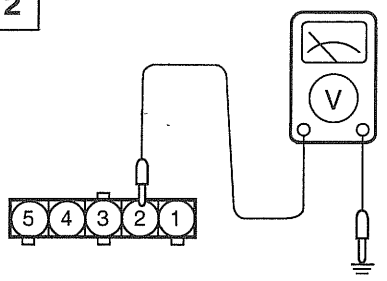
Measure the power supply voltage
- Connector : Disconnected
- Ignition switch : ON
- Voltage(V) : Battery voltage

OK ⇒ 2

NG ⇒ Repair the harness

EFHB108B

2



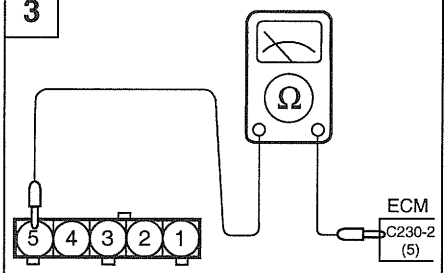
Measure the sensor power voltage
- Connector : Disconnected
- Ignition switch : ON
- Voltage(V) : 4.8 - 5.3V

OK ⇒ 3

NG ⇒ Repair the harness

EFHB109B

3



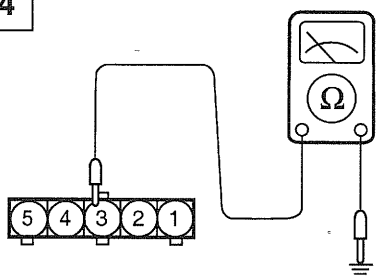
Check for a short wiring, or a short circuit between ECM and intake air temperature sensor
- Connector : Disconnected

OK ⇒ 4

NG ⇒ Repair the harness

EFHB114B

4



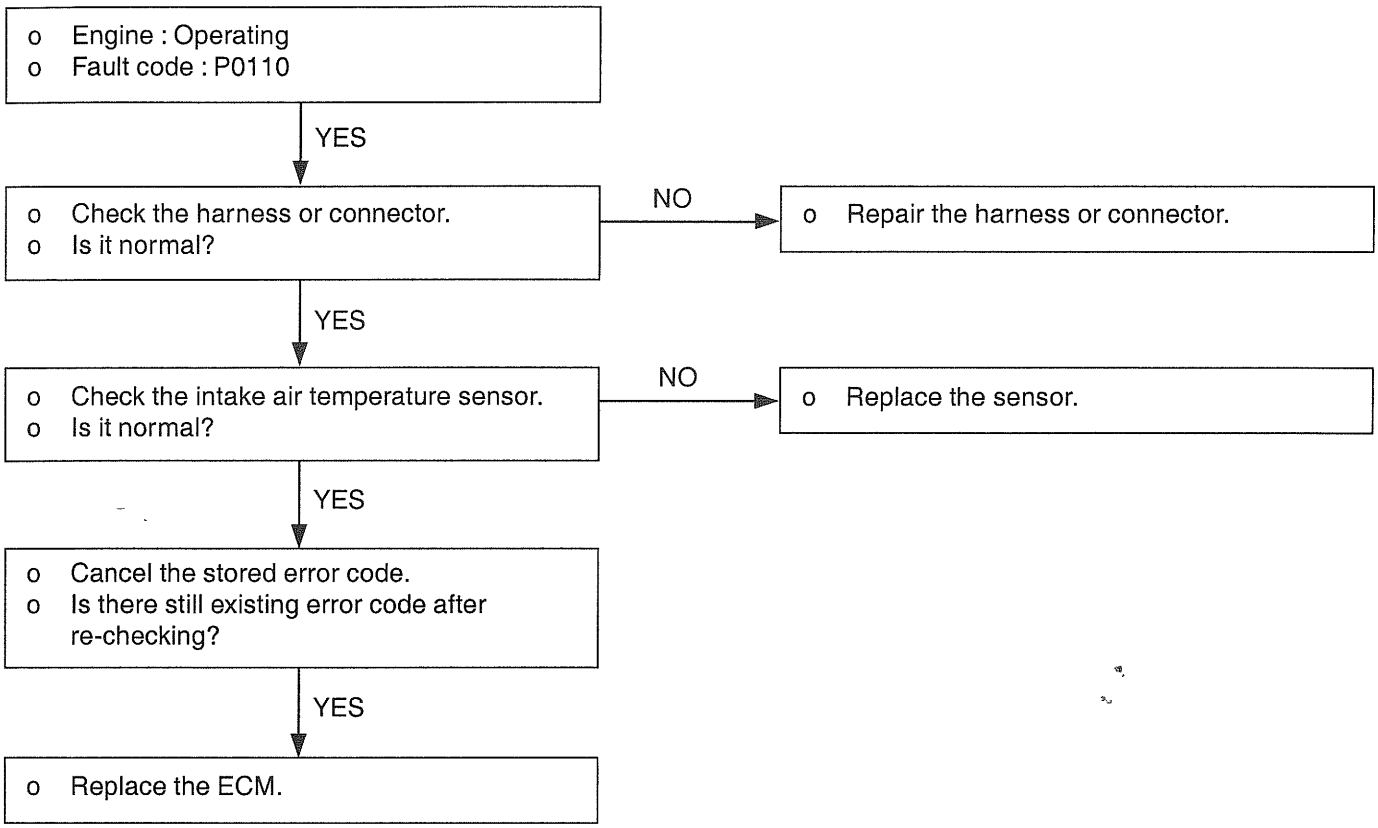
Check for continuity of the ground sensor
- Connector : Disconnected

OK ⇒ END !

NG ⇒ Repair the harness

EFHB111B

TEST PROCEDURE (INTAKE AIR TEMPERATURE SENSOR)



SENSOR INSPECTION

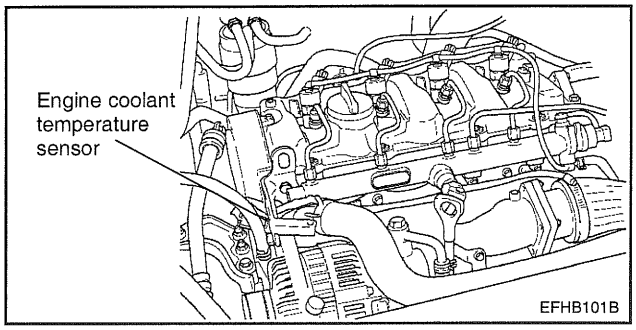
1. Inspect the resistance of sensor using a multi-tester.
2. Measure the resistance between intake air temperature sensor and terminal.

CONDITION	TEMPERATURE (°C)	RESISTANCE (kΩ)
Ignition switch ON	0	5.12 - 5.89
	20	2.29 - 2.55
	40	1.09 - 1.24
	80	0.31 - 0.37

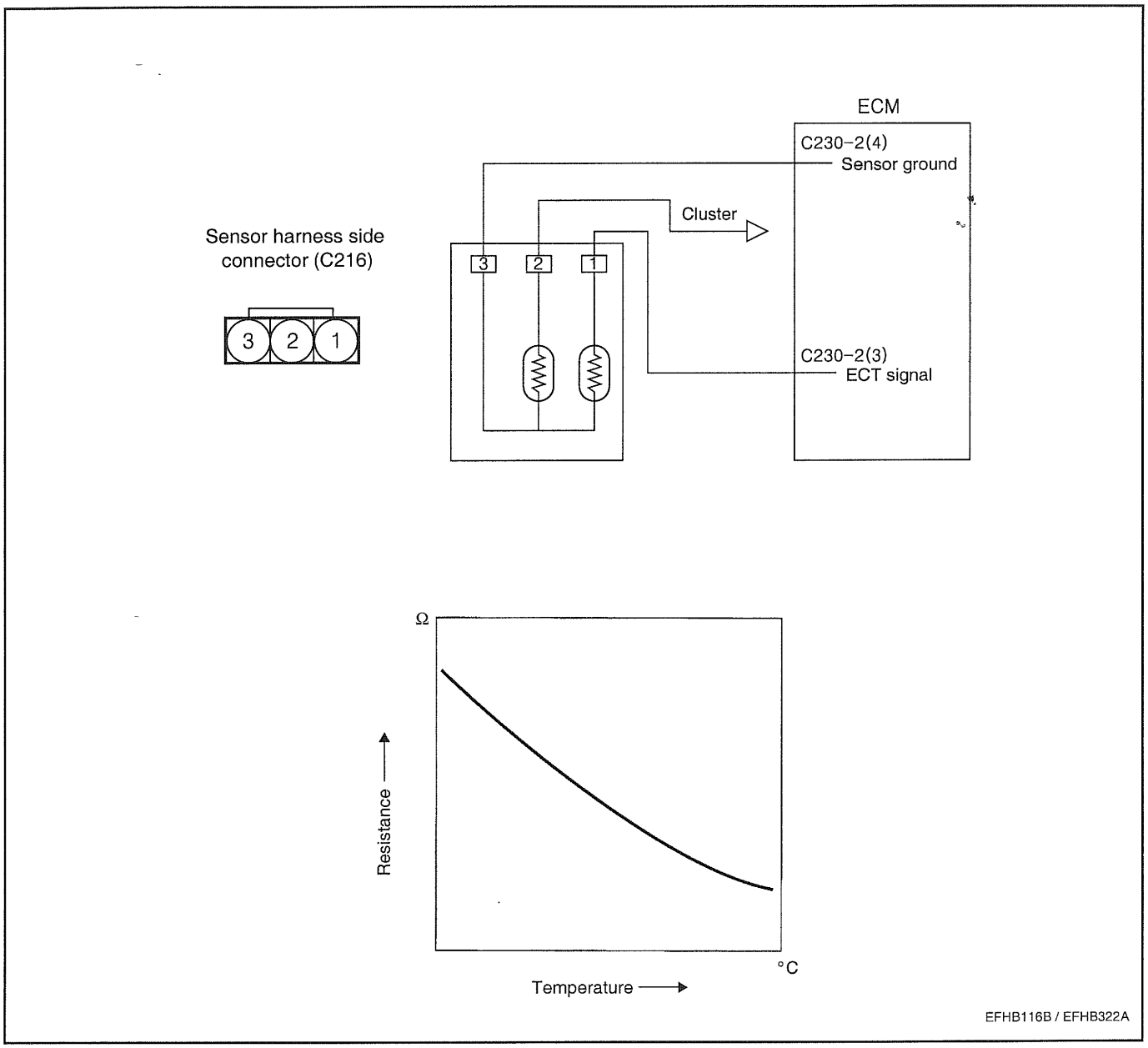
3. If resistance value is out of standard, replace the intake air temperature sensor assembly.

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

The engine coolant temperature sensor located in the engine coolant passage of the cylinder head. It detects the engine coolant teperature and relays signals to the ECU. It employs a thermistor, which is sensitive to changes in temperature. The electric resistance of a thermistor decreases in response to temperature rise. The ECU judges engine coolant temperture by the sensor output voltage and provides optimum fuel enrichment when the engine is cold.



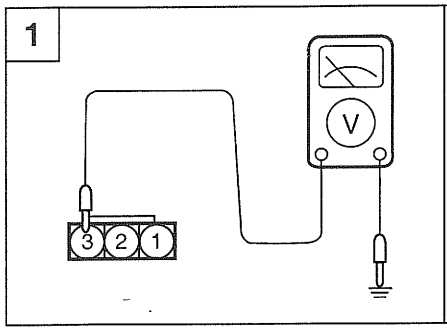
[CIRCUIT DIAGRAM]



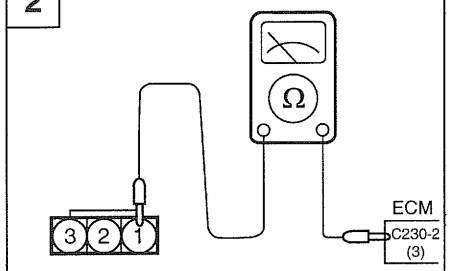
TROUBLESHOOTING HINTS

When idling speed is not appropriate or blacksmoke arises it is likely to be a defect of engine coolant temperature sensor.

HARNESS INSPECTION PROCEDURES

1 	Check for continuity of the ground sensor o Connector : Disconnected	OK ⇒	2
		NG ⇒	Repair the harness

EFHB117B

2 	Check for a short wiring or a short circuit between ECM and ECT sensor o ECM Connector : Disconnected o ECT sensor Connector : Disconnected	OK ⇒	END !
		NG ⇒	Repair the harness

EFHB118B

SENSOR INSPECTION

USING HI-SCAN

Check item	Data display	Check conditions	Coolant temp.	Set value (HI-SCAN)
Engine coolant temperature sensor	Sensor temperature	• Ignition switch : ON or engine running	-20°C	-20°C
			0°C	0°C
			20°C	20°C
			40°C	40°C
			80°C	80°C

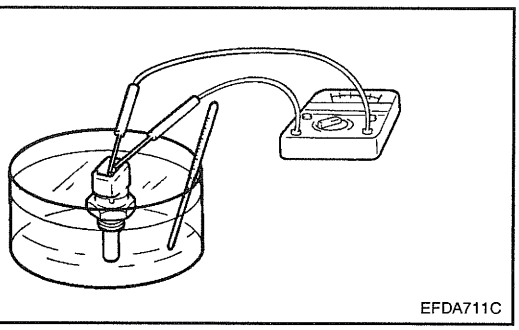
USING MULTITESTER

1. Remove the engine coolant temperature sensor from the engine coolant passage of the cylinder head.
2. With the temperature sensing portion of the engine coolant temperature sensor immersed in hot water, check resistance.
   1) ECT sensor

Temperature (°C)	Resistance (kΩ)
-20	14.13 ~ 16.83
0	5.790
20	2.31 ~ 2.59
40	1.148
60	0.586
80	0.322

   2) Gauge unit

Temperature (°C)	Resistance (Ω)
60	125
85	42.6 ~ 54.2
110	22.1 ~ 26.2
125	15.2



3. If the resistance deviates from the standard value greatly, replace the sensor.

INSTALLATION

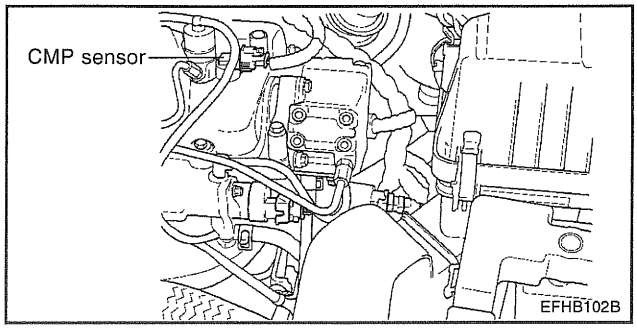
1. Apply sealant LOCTITE 962T or equivalent to threaded portion.
2. Install engine coolant temperature sensor and tighten it to specified torque.

Tightening torque : 2.0 ~ 4.0kg· m

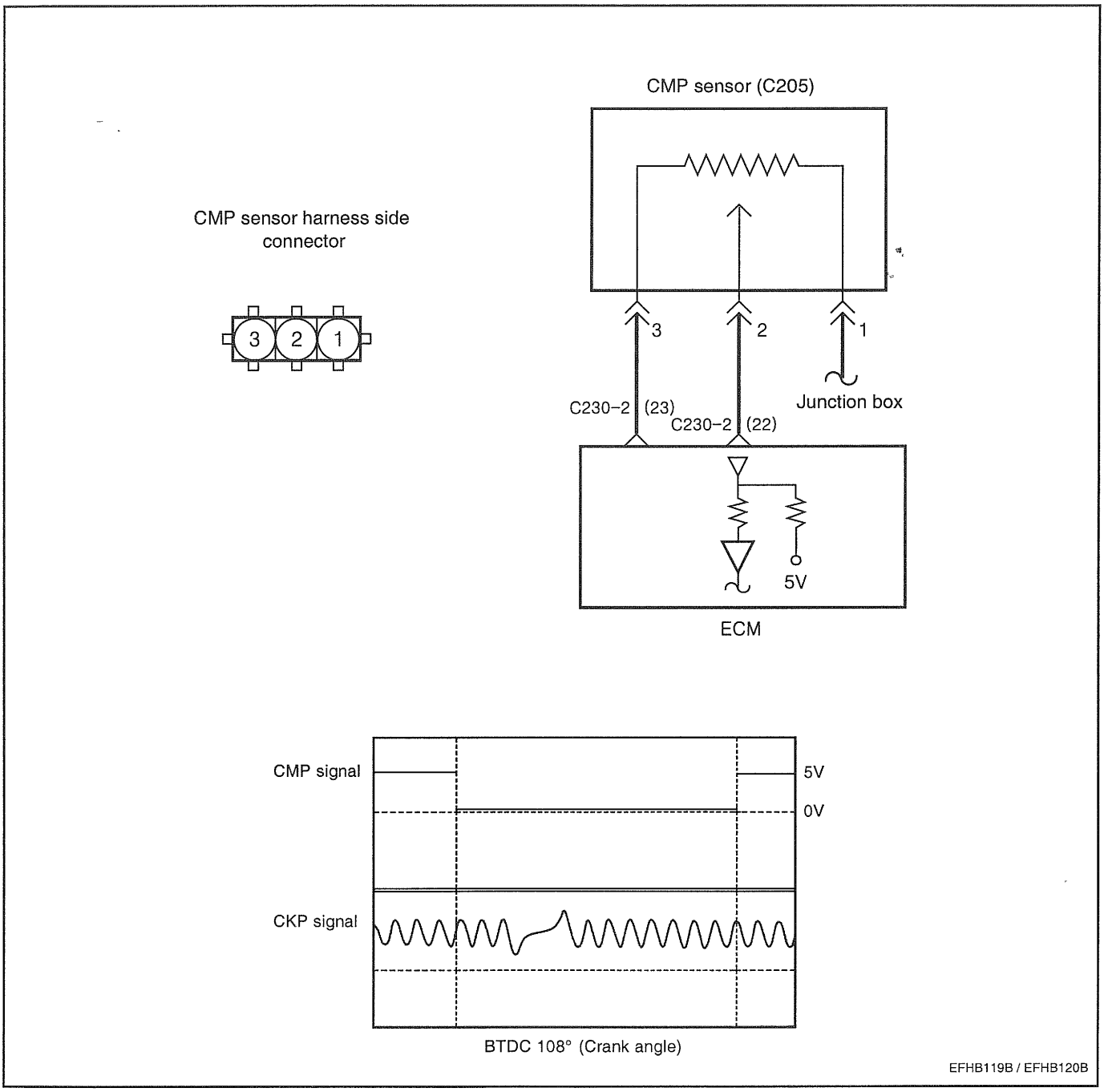
3. Connect the harness connector securely.

CAMSHAFT POSITION SENSOR (CMP)

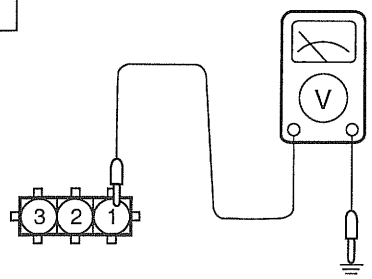
CMP senses the CMP(Camshaft Position Sensor) point of NO.1,4 cylinder on its compression stroke. Its signal is fed to ECM to be used to determine the sequence of fuel injection.
Crank angular sesor senses the crank angular of each cylinder, and input the pulse signal to ECM. Its signal is fed to ECM to be used to determine the engine speed and adjust the fuel injection timing and ignition timing.



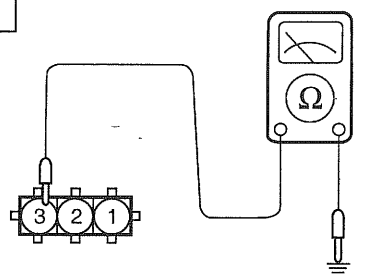
[CIRCUIT DIAGRAM]



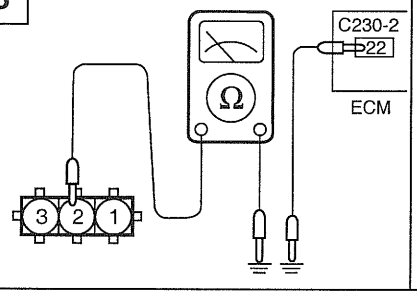
HARNESS INSPECTION PROCEDURES

1		Measure the power supply voltage o Connector : Disconnected o Ignition switch : ON o Voltage(V) : Battery voltage	OK ⇒ 2 NG ⇒ Repair the harness

EFHB121B

2		Check for continuity of the ground sensor o Connector : Disconnected	OK ⇒ 3 NG ⇒ Repair the harness

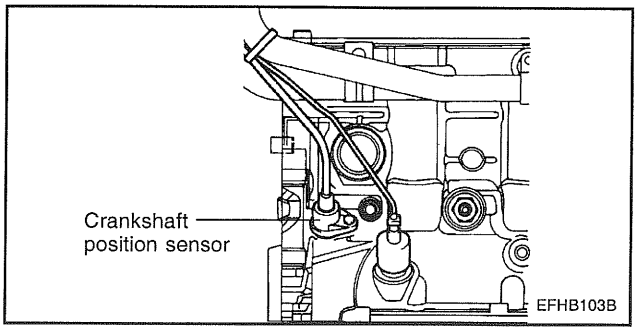
EFHB122B

3		Check for a short wiring or a short circuit to ground between TDC sensor and ECM. o Connector : Disconnected	OK ⇒ END ! NG ⇒ Repair the harness

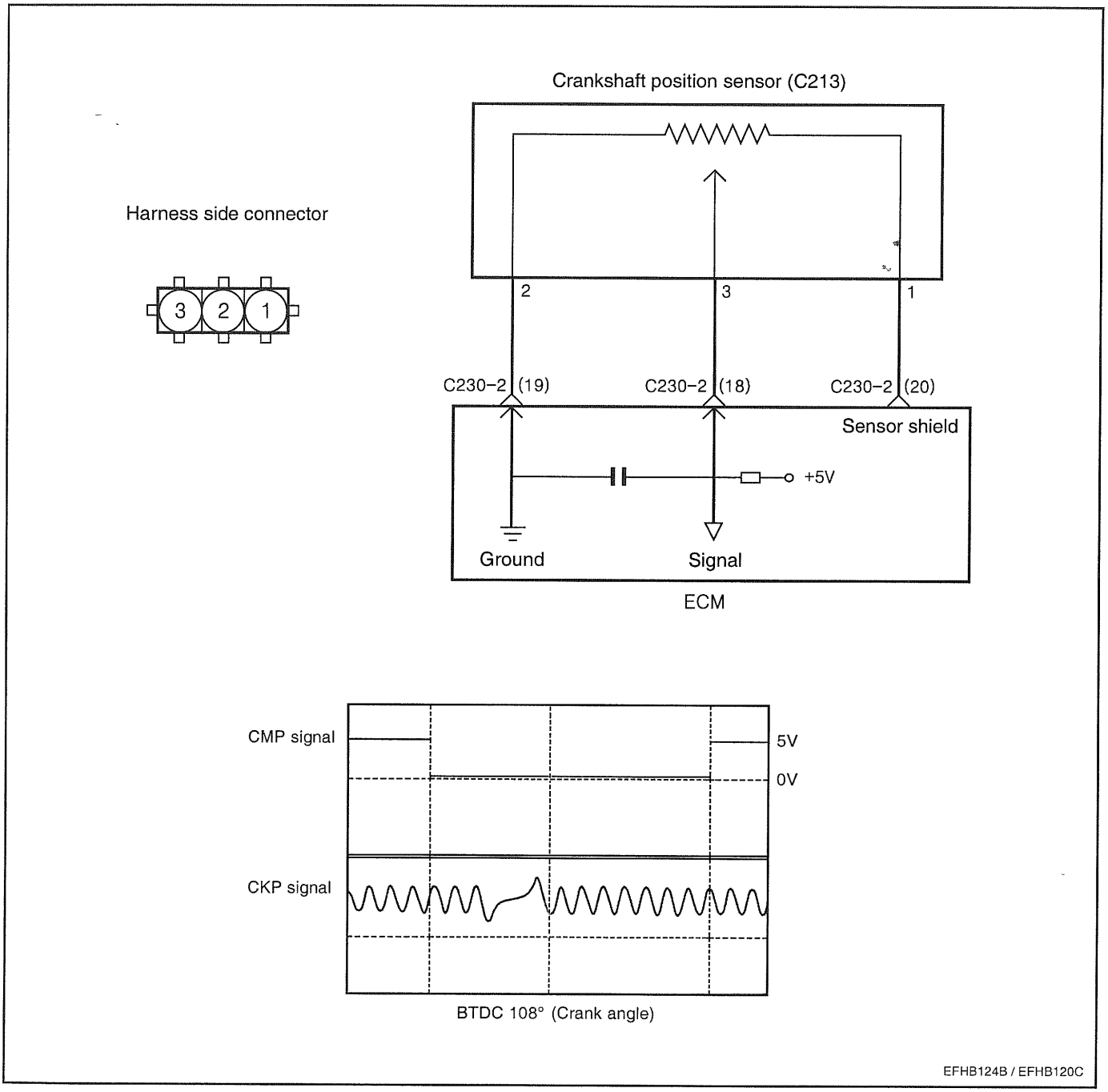
EFHB123B

CRANKSHAFT POSITION SENSOR (CKP)

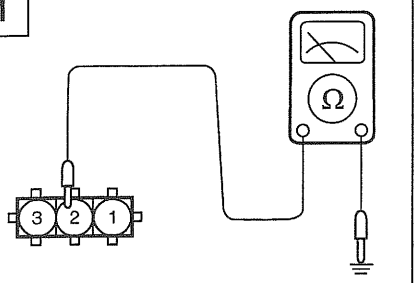
Piston position on combustion chamber is the substantial to define the starting of injection timing. All engine pistons are connected to crankshaft by connecting rod. Sensor on crankshaft can supply the informations concerning all piston positions, revolution speed is defined by revolutin per minute of crankshaft. Prior input variable is determined at ECM by using signal from induced crankshaft speed sensor.



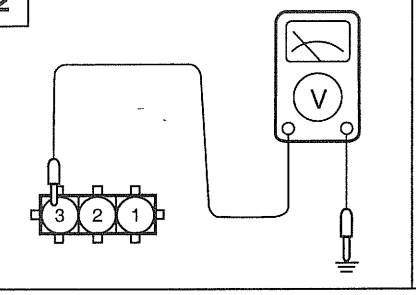
[CIRCUIT DIAGRAM]



HARNESS INSPECTION PROCEDURES

1 	Check for continuity of the ground sensor o Connector : Disconnected	OK ⇒	2
		NG ⇒	Repair the harness

EFHB125B

2 	Measure the power supply voltage o Connector : Disconnected o Ignition switch : ON o Voltage(V) : 4.8 - 5.2V	OK ⇒	END !
		NG ⇒	Repair the harness

EFHB126B

SENSOR INSPECTION

1. Remove the crankshaft position sensor connector.
2. Measure the resistance between terminal NO.1 and NO.2.

Standard value : 0.65 ~ 1.00kΩ

3. If the resistance deviates from the standard value greatly, replace the sensor.

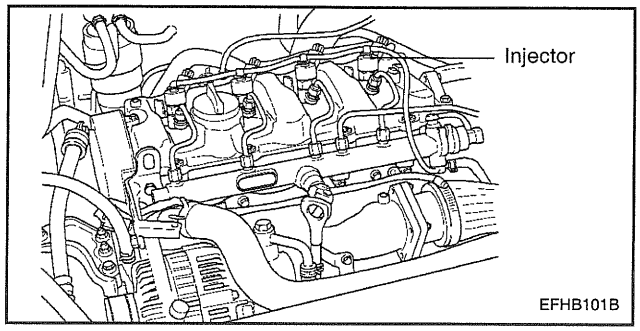
Clearance between crankshaft position sensor and CKP wheel : 0.5 ~ 1.5mm

4. Install the sensor observing the specified torque.

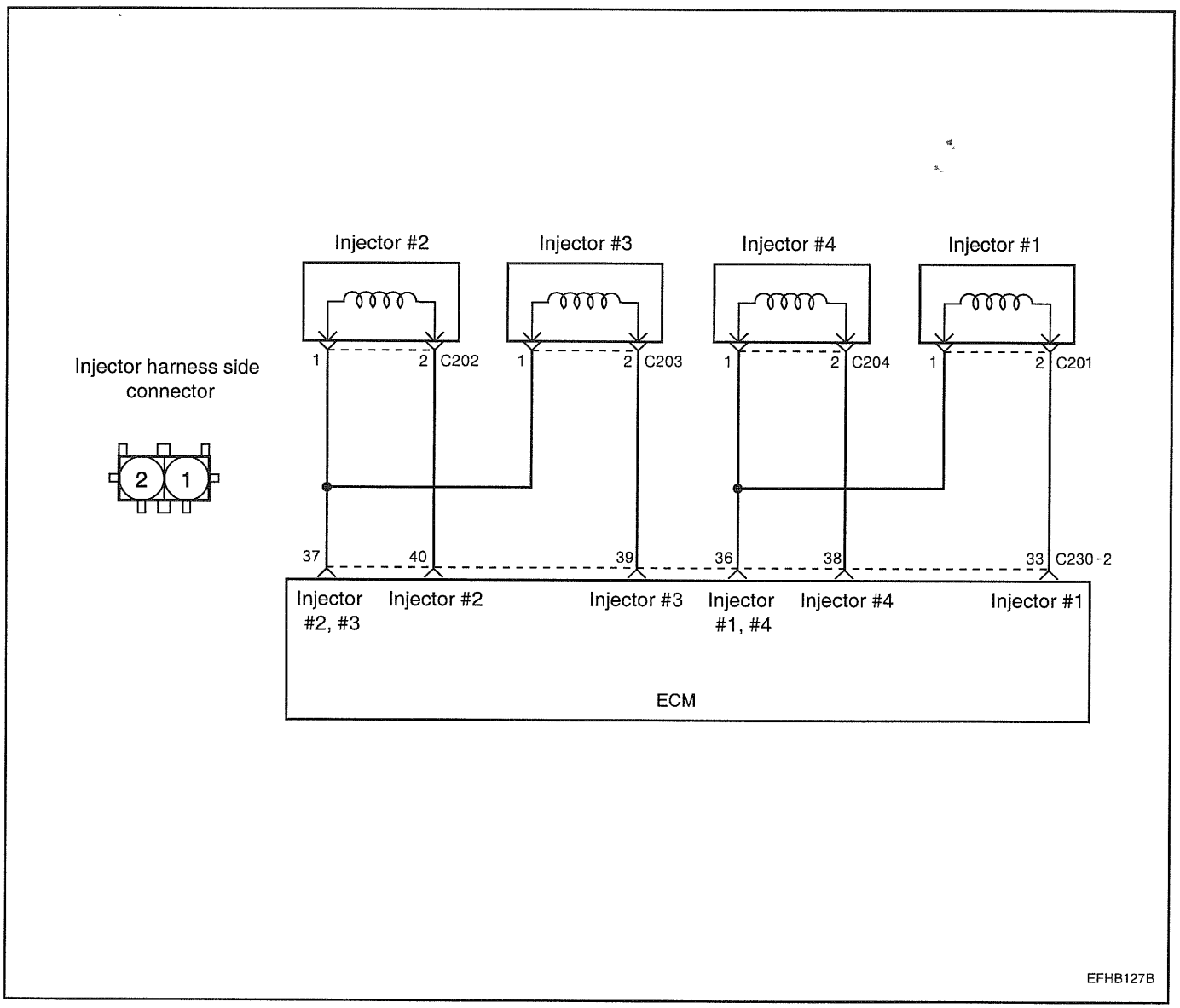
Specified torque : 0.4 ~ 0.6kg· m

INJECTOR

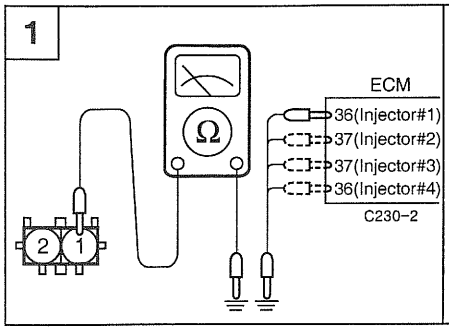
Special injectors with hydraulic servo-system and electrical triggering element (solenoid valve) are used with the Common Rail system in order to achieve efficient start of injection and precise injected fuel quantity. At the start of injection, a high pickup current is applied to the injector so that the solenoid valve opens quickly. As soon as the nozzle needle has travelled its complete stroke, and the nozzle has opened completely, the energizing current is reduced to a lower holding value. The injected fuel quantity is now defined by the injector opening time and the rail pressure. Injection is terminated when the solenoid valve is no longer triggered and closes as a result.



[CIRCUIT DIAGRAM]



HARNESS INSPECTION PROCEDURES

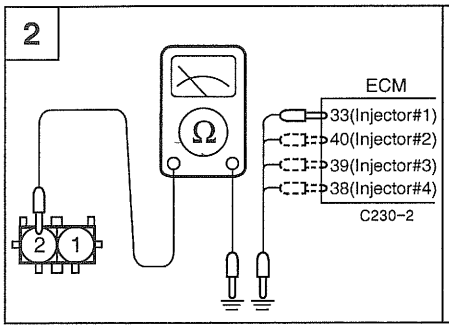


Check for an open-circuit, or a short-circuit between ECM and injector
- o ECM Connector : Disconnected
- o Injector connector : Disconnected
- o Ignition switch : OFF

OK ⇒ 2

NG ⇒ Repair the harness

EFHB128B



Check for an open-circuit, or a short circuit between ECM and injector
- o ECM Connector : Disconnected
- o Injector connector : Disconnected
- o Ignition switch : OFF

OK ⇒ END !

NG ⇒ Repair the harness

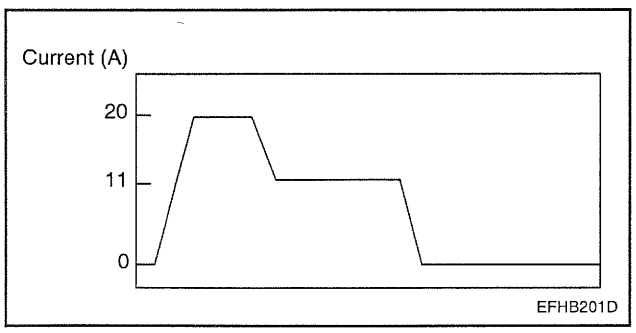
EFHB128C

INJECTOR OPERATION INSPECTION

1. Using a clip-on ammeter of motor tester, check actuation of injector. Clip-on ammeter must satisty the following conditions.

   Measuring range > 25A
   Bandwidth > 100kHz

2. Attach the plug to the injector. Fasten clip-on ammeter around lead to pin.2 of corresponding injector. Allow engine to be at idle.
   Refer to the set value(current) as following figure.



NOTE
1. **Length of holding current phase (max.12A) is governed by engine speed, injection time and changes on velocity.**
2. **The first current curve shows the pre-injection.**

3. Check the injector for injecting of fuel. As checking procedure, detach the injector plug from each boxes and connect to replaced injector.

   If change to enine running results, injector is injecting. If no change to engine running results, injector is not injecting.

   This test cannot however establish whether an injector is injecting an correct quantity.
   If necessary, all injectors have to be replaced.

AFTER RUN TEST

1. After run test
   1) Ignition switch : ON → OFF.
   2) Engine rpm is within set value.
   3) Actual vehicle speed is below set value.
   4) Rail pressure sensor and vehicle speed sensor have no error.

2. Possible DTC:P1653
   1) When energizing time is "0" at after run test mode, if engine rpm is not below the set value within set time, error is detected.
   2) When injector power stage is shut off, if engine rpm is not below set value within set time, error is detected.
   3) Possible causes of trouble
      - Open circuit in wiring or short circuit
      - Poor connection
      - ECM

   Several tests are implemented in the ECM after switching off the ignition. This fault entry occurs if ECM detects and faults during these tests.

3. Start by rectifying any other stored faults. Then cancel the fault memory and perform the test drive.

4. Measure the supply voltage at ECM pin 33(Cylinder #1 Injector), pin 38(Cylinder #4 Injector) to pin 36 and pin 39(Cylinder #3 Injector), pin 40(Cylinder #2 Injector) to pin 37 with ignition OFF.

   Set value : 0V

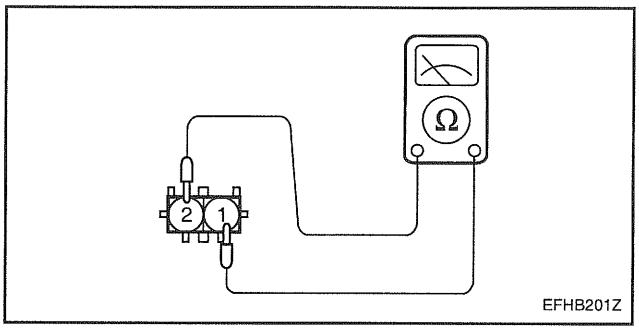
5. Check wiring if set value is not attained. If wiring is OK, replace the ECM.

MEASURE THE RESISTANCE BETWEEN TERMINALS

1. Detach the connector from injector.

2. Measure the resistance between terminals.

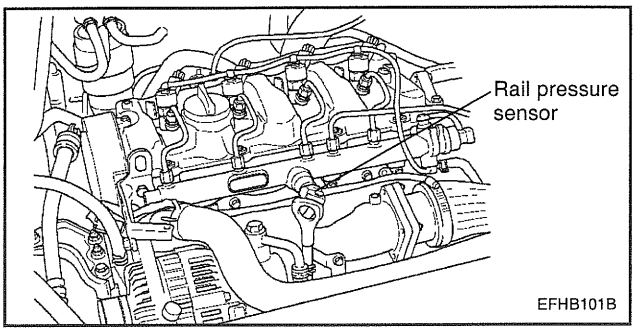
   Specified value : 0.3 ~ 0.6Ω (at 20°C)



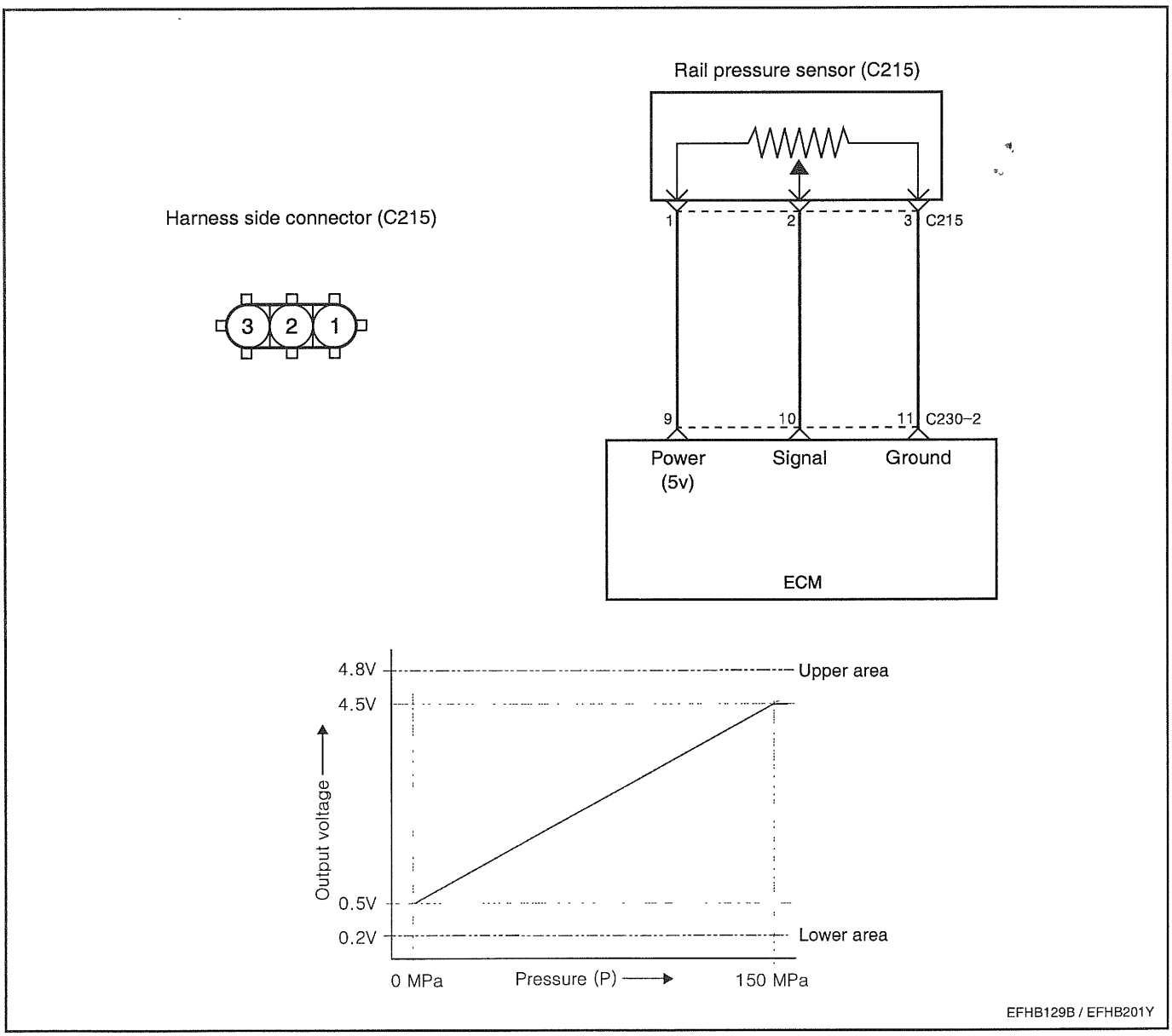
3. Connect the connector to the injector.

RAIL PRESSURE SENSOR (RPS)

In order to output a voltage signal to the ECM which corresponds to the applied pressure, the rail-pressure sensor must measure the instantaneous pressure in the rail.
The fuel flows to the rail-pressure sensor through an opening in the rail, the end of which is sealed off by the sensor diaphragm. Pressurized fuel reaches the sensor's diaphragm through a blind hole. The sensor element (semiconductor device) for converting the pressure to an electric signal is mounted on this diaphragm. The signal generated by the sensor is inputted to an evaluation circuit which amplifies the measuring signal and sends it to the ECM.



[CIRCUIT DIAGRAM]



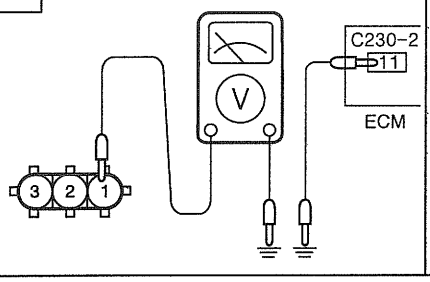
SENSOR INSPECTION

USING HI-SCAN

Check item	Data display	Check conditions	Set value	Standard value
Rail pressure sensor	Rail pressure value	Engine at idle	220 - 300bar	260bar

HARNESS INSPECTION PROCEDURES

1



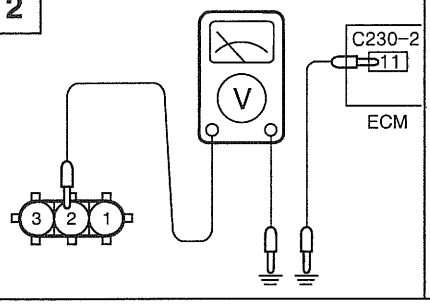
Measure the power supply voltage
- o Connector : Disconnected
- o Ignition switch : ON
- o Voltage(V) : 4.5 - 5.5V

OK ⇒ 2

NG ⇒ Repair the harness

EFHB130B

2



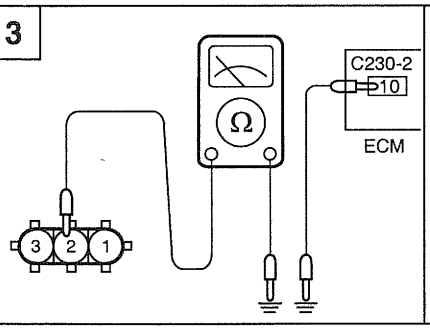
Measure the voltage of RPS harness side connector #2 terminal to the ground with ignition on.
- o Set value : 0.5V
- o Engine idling set value : 1V
- o Voltage increases with inereasing pressure : Max. 4.5V

OK ⇒ 3

NG ⇒ Repair the harness

EFHB131B

3



Check for an open circuit, or a short circuit between ECM and rail pressure sensor.
- o Connector : Disconnected
- o Ignition switch : OFF

OK ⇒ END !

NG ⇒ Repair the harness

EFHB131C

SENSOR REPLACEMENT

1. Replace the RPS if signal voltage exceeds the set value.

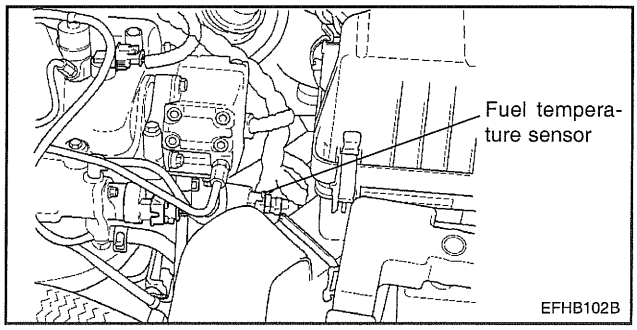
2. Note the followings.
   1) Always renew the sealing washer (soft iron sealing ring) even if old sensor is re-used.
   2) When removing seal, take care not to damage sealing surface.
   3) When installing RPS, provide the sealing washer with grease if necessary.
   4) Tightening torque is 35 ± 2 Nm.

NOTE

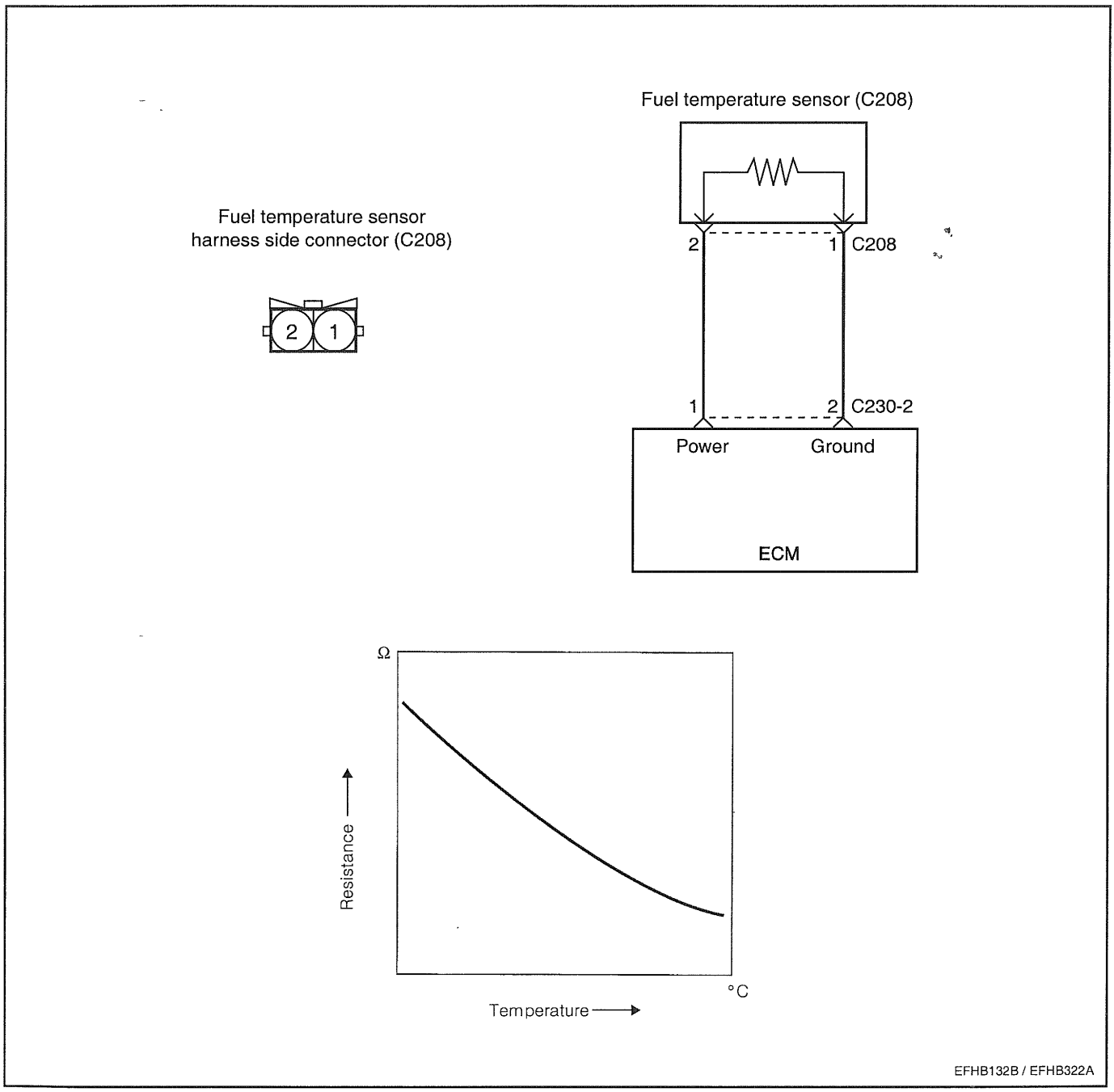
Replace the faulty fuel rail assembly in case of new model vehicle within a year, or replace the faulty parts of vehicle of which model year is more than a year.

FUEL TEMPERATURE SENSOR (FTS)

The fuel temperature sensor is equipped with a temperature-dependent resistor with a negative temperature coefficient (NTC) which is part of a voltage-divider circuit across which 5V are applied.
The voltage drop across the resistor is inputted into the ECM through an analog-to-digital converter (ADC) and is a measure for the temperature. A characteristic curve is stored in the ECM microcomputer which defines the temperature as a function of the given voltage value.



[CIRCUIT DIAGRAM]



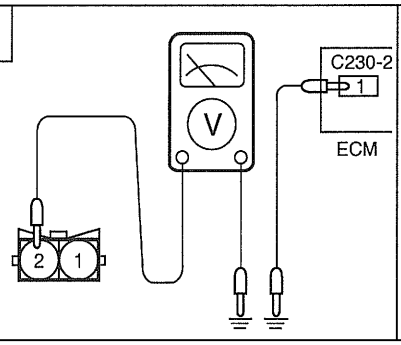
SENSOR INSPECTION

USING VOLTMETER

Check item	Output data	Check condition	Fuel temperature (°C)	Resistance (kΩ)
Fuel temperature sensor	Fuel temperature	Ignition switch : ON or START	-30	22.22 ~ 31.78
			-20	13.24 ~ 18.10
			0	5.18 ~ 6.60
			20	2.27 ~ 2.73
			40	1.059 ~ 1.281
			60	0.538 ~ 0.650
			80	0.322 ~ 0.298
			100	0.185 ~ 0.167
			120	0.097 ~ 0.127

HARNESS INSPECTION PROCEDURES

1



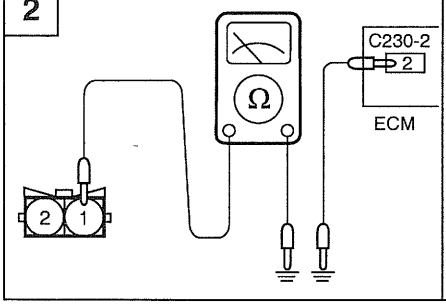
Measure the supply voltage
- o Connector : Disconnected
- o Ignition switch : ON
- o Voltage : 4.8 - 5.2V

OK ⇒ 2

NG ⇒ Repair the harness

EFHB133B

2



Check for an open circuit, or a short circuit to the ground between ECM and fuel temperature sensor.
- o ECM Connector : Disconnected
- o Fuel temperature sensor connector : Disconnected

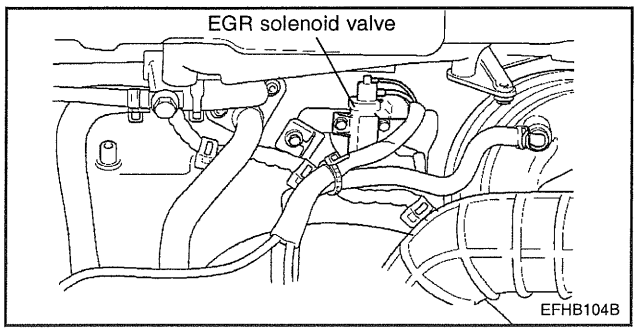
OK ⇒ END !

NG ⇒ Repair the harness

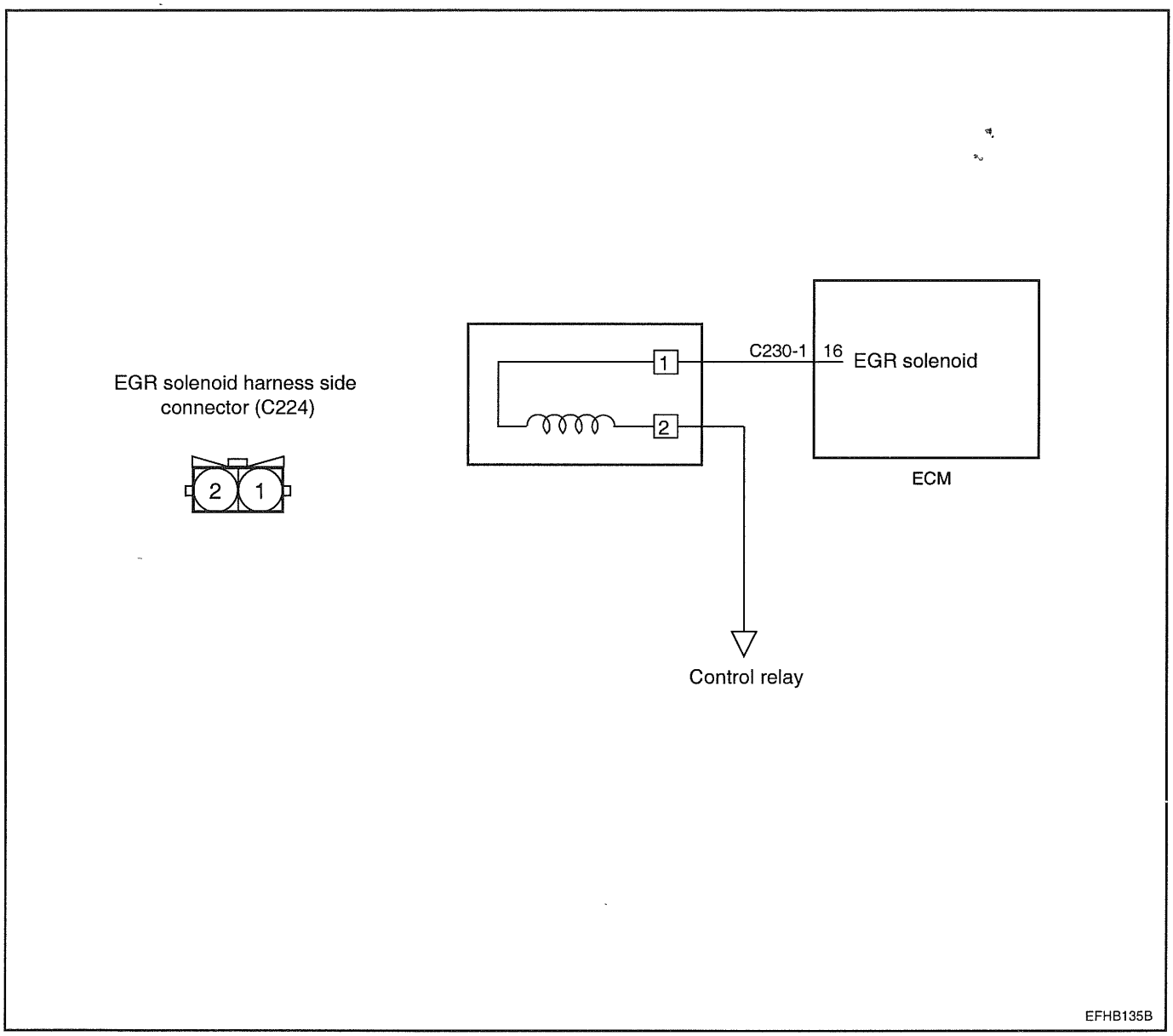
EFHB134B

EGR SOLENOID VALVE

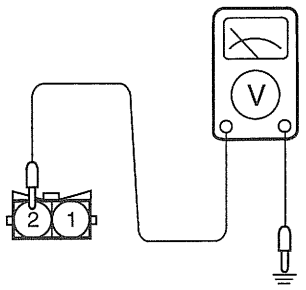
With exhaust-gas recirculation (EGR) a portion of the exhaust gas is led into the engine's intake tract. Up to a certain degree, an increasing portion of the residual exhaust gas content has a positive effect upon energy conversion and therefore upon the exhaust-gas emissions. Depending upon the engine's operating point, the air/gas mass drawn into the cylinders can be composed of up to 40% exhaust gas.
For ECM control, the actual drawn-in fresh-air mass is measured and compared at each operating point with the air-mass setpoint value. Using the signal generated by the control circuit, the EGR valve opens so that exhaust gas can flow into the intake tract.



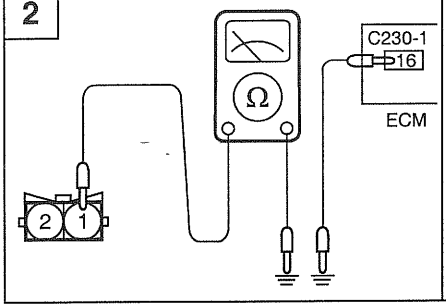
[CIRCUIT DIAGRAM]



HARNESS INSPECTION PROCEDURES

1 	Measure the supply voltage o Connector : Disconnected o Ignition switch : ON o Voltage(V) : Battery voltage	OK ⇨ NG ⇨	2 Repair the harness

EFHB136B

2 	Check for an open circuit, or a short circuit to the ground between ECM and EGR solenoid valve. o Connector : Disconnected	OK ⇨ NG ⇨	END ! Repair the harness

EFHB137B

EGR SOLENOID VALVE INSPECTION

USING HI-SCAN

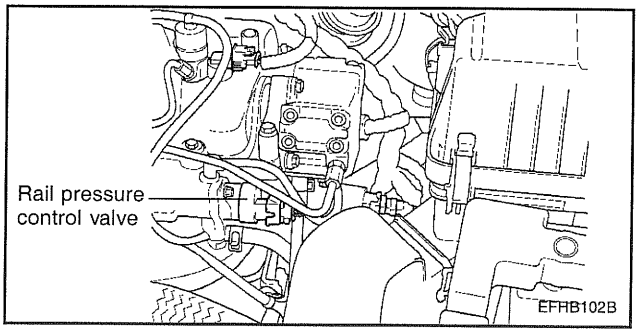
Check item	Check condition	Engine condition	Standard value
EGR solenoid valve	solenoid valve OFF → ON	Ignition switch : ON	Check the sound for proper operation

USING VOLTMETER

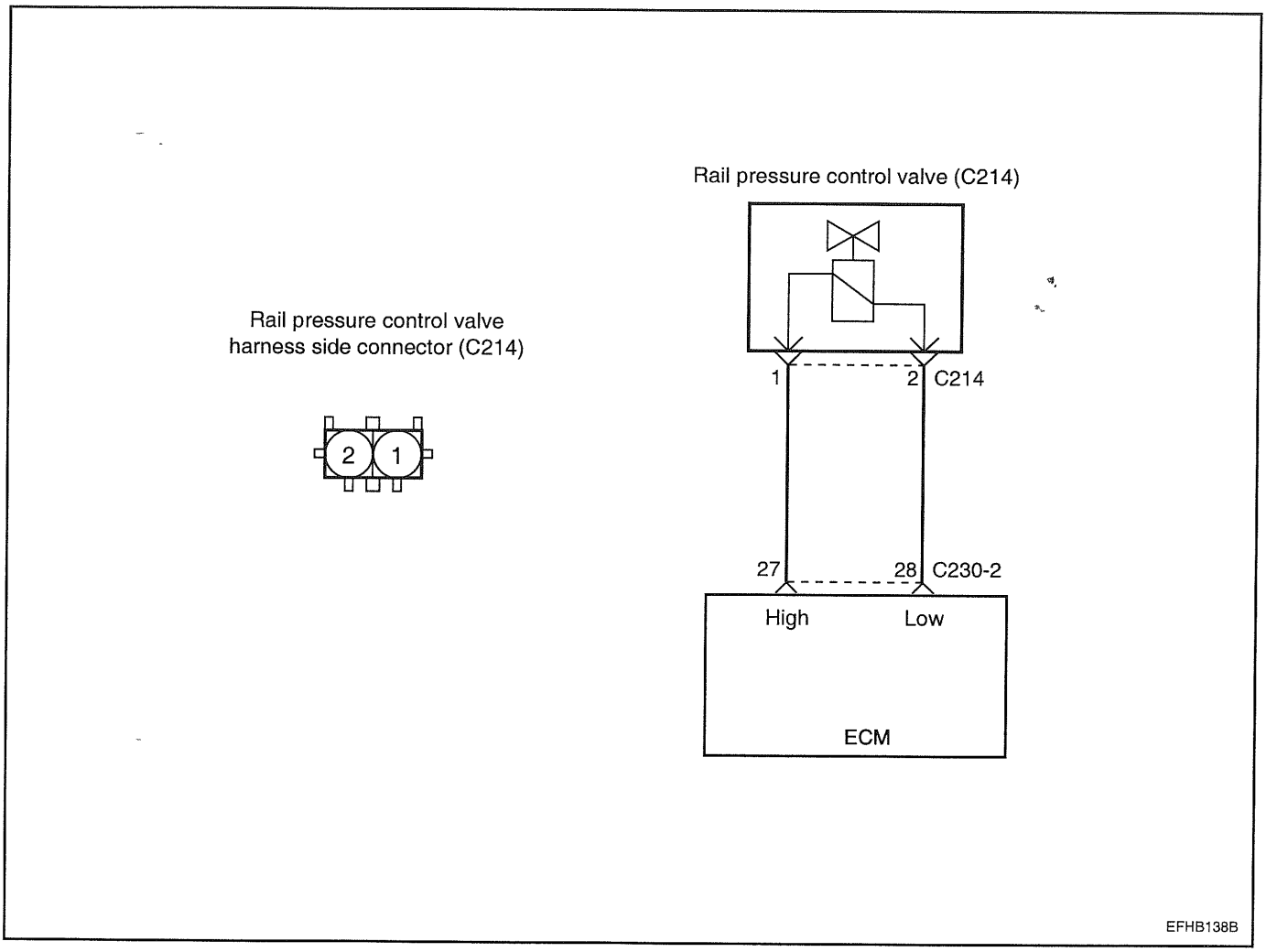
Check item	Specified value
EGR solenoid valve resistance	14 ~ 17Ω

RAIL PRESSURE CONTROL VALVE

The rail pressure-control valve sets the correct pressure in the rail as a function of engine loading, and maintains it at this level.
If the rail pressure is excessive, the pressure-control valve opens and a portion of the fuel returns from the rail to the fuel tank via a collector line.
If the rail pressure is too low, the pressure-control valve closes and seals off the high-pressure stage from the low-pressure stage.



[CIRCUIT DIAGRAM]

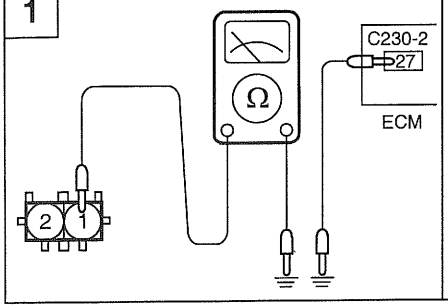


TROUBLESHOOTING HINTS

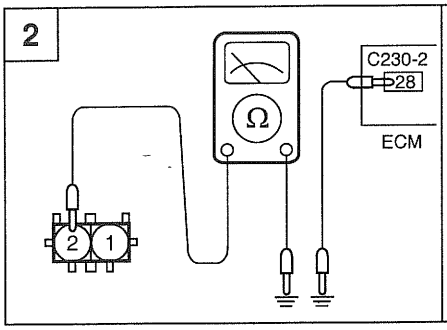
At after run test mode or fuel cut mode, if within set time engine rpm is not dropped below the lower set value, error is detected.

The reasons are short circuit, connecting resistance, faulty rail pressure sensor, continuity of fuel pump relay, faulty rail pressure control valve, defective high pressure pump, ECM fault, etc.

HARNESS INSPECTION PROCEDURES

1 	Check for an open circuit, or a short circuit to the ground between ECM and pressure control valve. o Connector : Disconnected	OK ⇨	2
		NG ⇨	Repair the harness

EFHB139B

2 	Check for an open circuit, or a short circuit to the ground between ECM and pressure control valve. o Connector : Disconnected	OK ⇨	END !
		NG ⇨	Repair the harness

EFHB140B

RAIL RPRESSURE CONTROL VALVE INSPECTION

USING VOLTMETER

Check item	Set value (Ω)
Rail pressure control valve resistance	2.07 ~ 2.53Ω

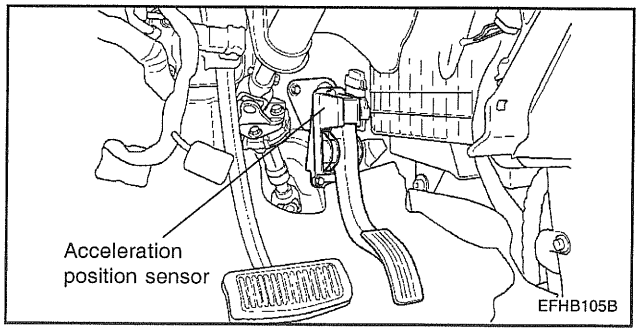
RAIL PRESSURE CONTROL VALVE REPLACEMENT

1. Replace the rail pressure control valve if signal voltage exceeds the set value.
2. Tightening torque for this replacement is 5 ± 1Nm.

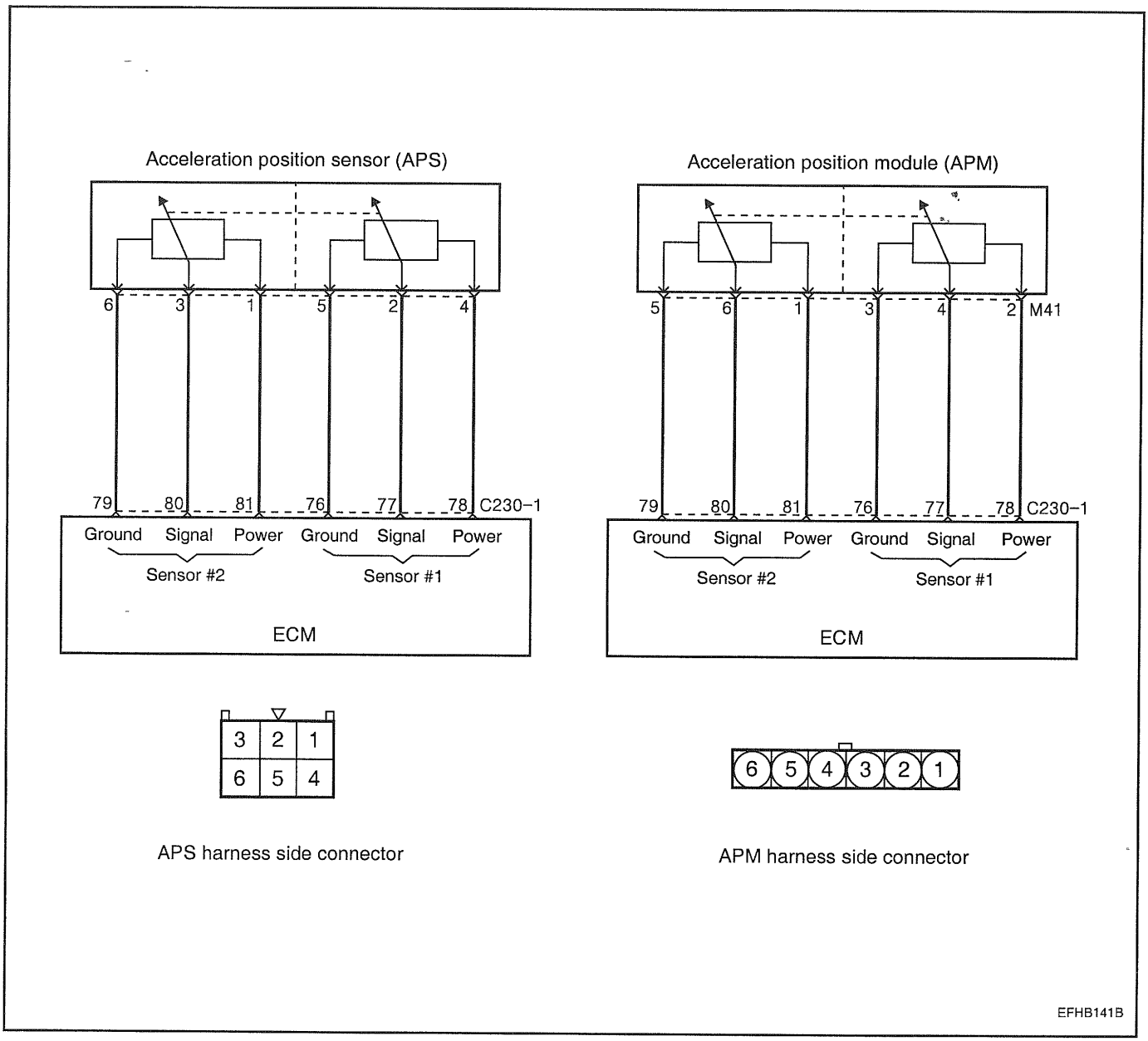
NOTE
Replace the faulty fuel rail assembly in case of new model vehicle within a year, or replace the faulty parts of vehicle of which model year is more than a year.

ACCELERATION POSITION SENSOR (APS)

In contrast to conventional distributor and in-line injection pumps, with EDC the driver's acceleration input is no longer transmitted to the injection pump by Bowden cable or mechanical linkage, but is registered by an acceleration position sensor and transmitted to the ECM (this is also known as drive-by-wire).
A voltage is generated across the potentiometer in the acceleration position sensor as a function of the accelerator-pedal setting. Using a programmed characteristic curve, the pedal's position is then calculated from this voltage.



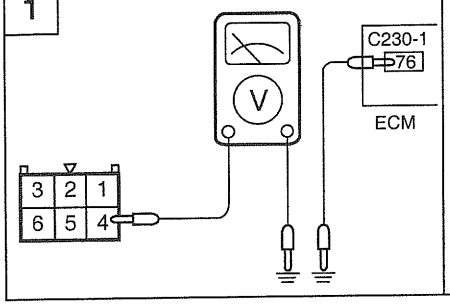
[CIRCUIT DIAGRAM]



HARNESS INSPECTION PROCEDURES

1. APPLYING ACCELERATION POSITION SENSOR (APS)

1



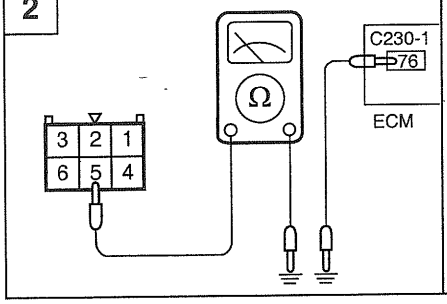
Measure the sensor supply voltage
- o Connector : Disconnected
- o Ignition switch : ON
- o Voltage(V) : 4.5 - 5.5V

OK ⇨ **2**

NG ⇨ Repair the harness

EFHB142B

2



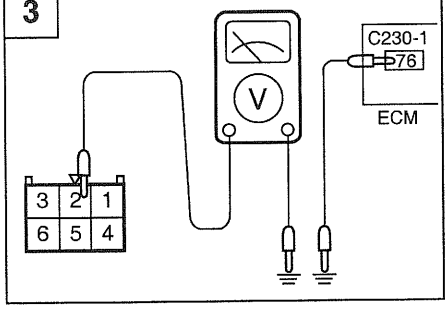
Check for an open circuit, or a short circuit between ECM and acceleration position sensor
- o Connector : Disconnected
- o Ignition switch : OFF

OK ⇨ **3**

NG ⇨ Repair the harness

EFHB143B

3



If contact lead is OK, measure the sensor signal voltage
- o at idle : 0.6 - 0.9V
- o at full throttle : 3.6 - 4.6V

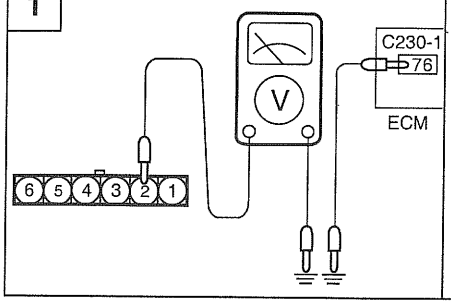
OK ⇨ **END !**

NG ⇨ Repair the harness

EFHB144B

2. APPLYING ACCELERATION POSITION MODULE (APM)

1



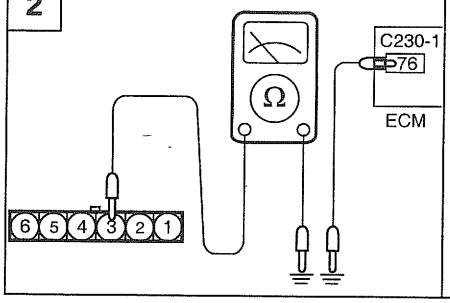
Measure the sensor supply voltage
- o Connector : Disconnected
- o Ignition switch : ON
- o Voltage(V) : 4.5 - 5.5V

OK ⇒ **2**

NG ⇒ Repair the harness

EFHB145B

2



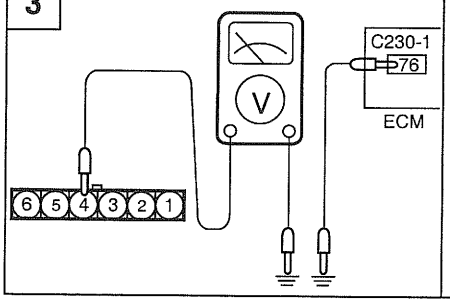
Check for an open circuit, or a short circuit between ECM and acceleration position sensor
- o Connector : Disconnected
- o Ignition switch : OFF

OK ⇒ **3**

NG ⇒ Repair the harness

EFHB146B

3



If contact lead is OK, measure the sensor signal voltage
- o at idle : 0.6 - 0.9V
- o at full throttle : 3.6 - 4.6V

OK ⇒ **END !**

NG ⇒ Repair the harness

EFHB147B

SCHEMATIC DIAGRAMS

TRAJET

FUSE & RELAY INFORMATION SD-2
ENGINE CONTROL SYSTEM SD-8
FUEL FILTER HEATING SYSTEM SD-14
COMPONENT LOCATION SD-16
CONNECTOR CONFIGURATION SD-19

SANTA FE

FUSE & RELAY INFORMATION SD-22
ENGINE CONTROL SYSTEM SD-28
FUEL FILTER HEATING SYSTEM SD-34
COMPONENT LOCATION SD-36
CONNECTOR CONFIGURATION SD-39

ELANTRA

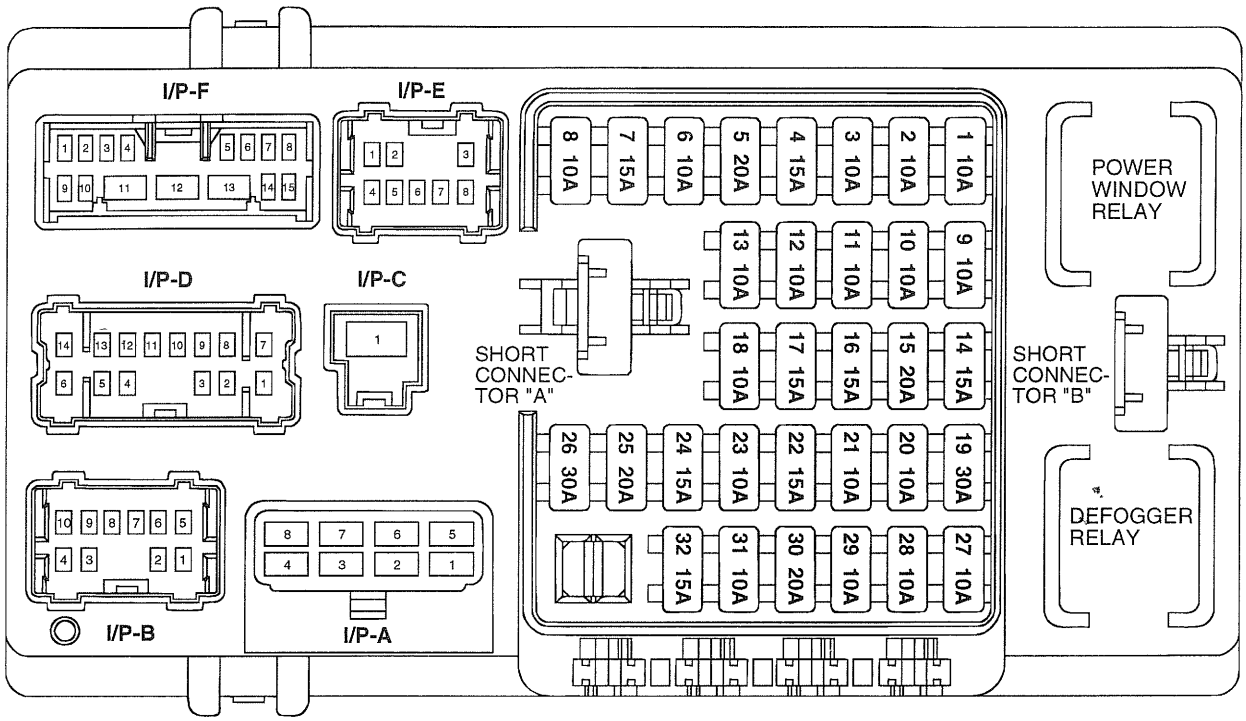
FUSE & RELAY INFORMATION SD-42
ENGINE CONTROL SYSTEM SD-48
FUEL FILTER HEATING SYSTEM SD-54
COMPONENT LOCATION SD-56
CONNECTOR CONFIGURATION SD-59

FUSE AND RELAY INFORMATION

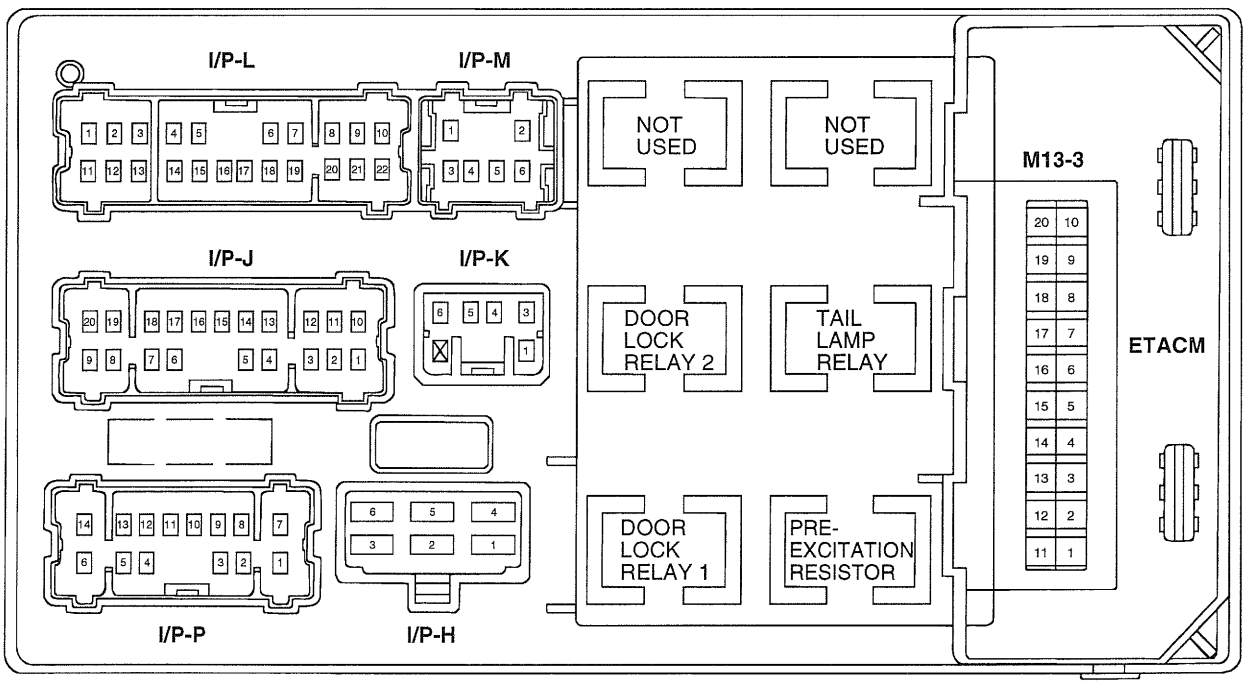
PASSENGER COMPARTMENT JUNCTION BLOCK

LAYOUT

<FRONT>



<REAR>



E2DB001A

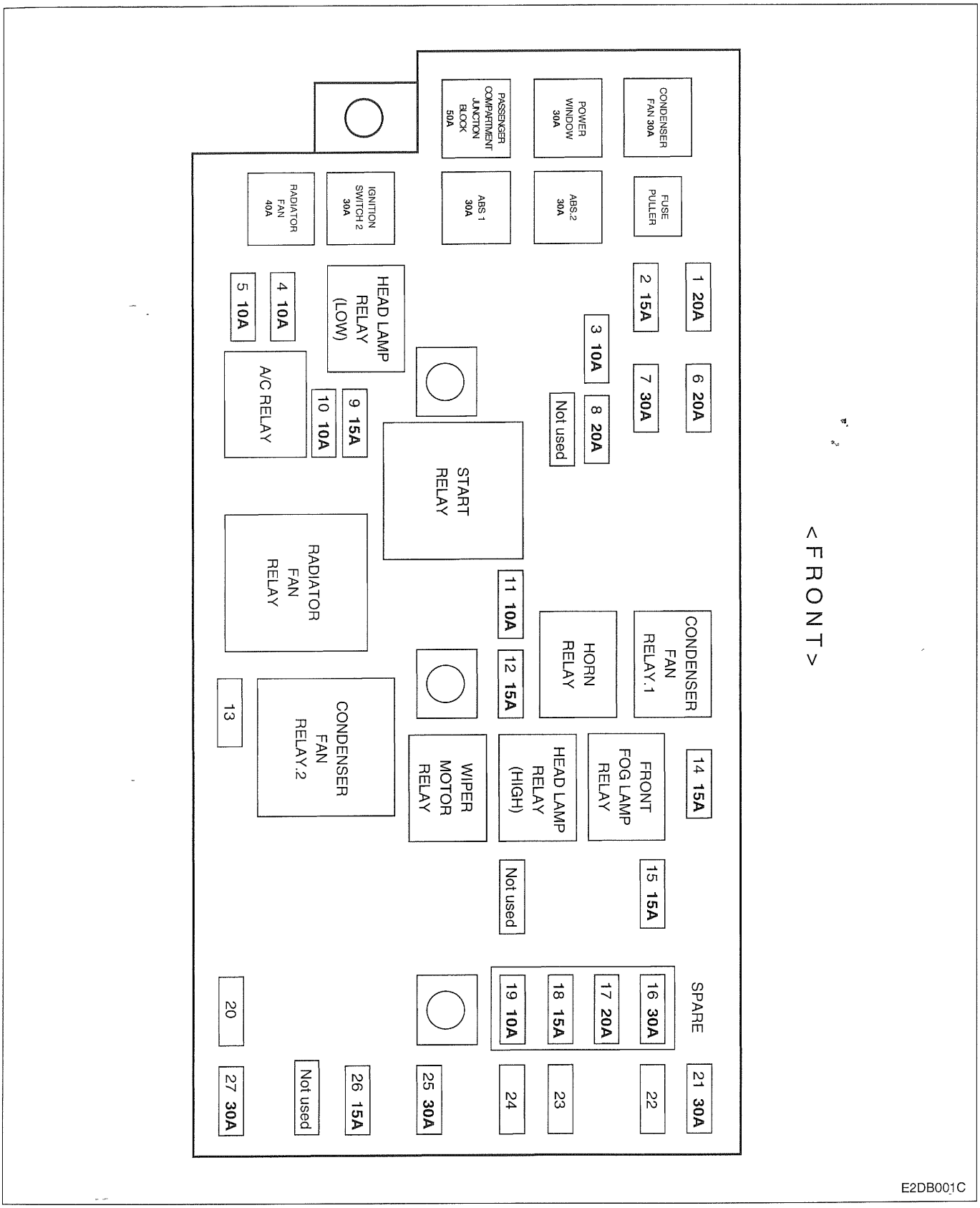
CIRCUIT

FUSE	Amperages(A)	Circuit protected
1	10A	Immobilizer, Instrument cluster
2	10A	AIR BAG Indicator
3	10A	Hazard switch
4	15A	SRS controls
5	20A	Power outlet
6	10A	Audio, Power outside mirror folding
7	15A	Cigarette lighter
8	10A	Seat belt tension reducer
9	10A	Rear window & outside mirror defogger
10	10A	A/C controls
11	10A	Auto lights, Engine controls, Vehicle speed sensor, Back-up lamps
12	10A	Audio, A/C controls, clock
13	10A	Courtesy lamps, Door lamps
14	15A	Power door locks
15	20A	Speaker
16	15A	Sunroof, overhead console lamp
17	15A	Immobilizer
18	10A	Rear fog lamp
19	30A	Rear window & Outside mirror defogger
20	10A	Short connector 'B', Illumination lamps, Exterior lamps (RH)
21	10A	A/C controls, Sunroof, ETACM
22	15A	Rear blower & A/C controls
23	10A	Hazard relay
24	15A	Stop lamps
25	20A	Front wiper & Washer
26	30A	Engine compartment junction block (Ignition coil fuse, ABS fuse)
27	10A	Starting, Automatic transaxle range controls, B/Alarm relay
28	10A	Exterior lamps (LH)
29	10A	Fuel filter heating
30	20A	Seat warmer
31	10A	HLLD
32	15A	Rear wiper & Washer

E2DB001B

ENGINE COMPARTMENT JUNCTION BLOCK

LAYOUT



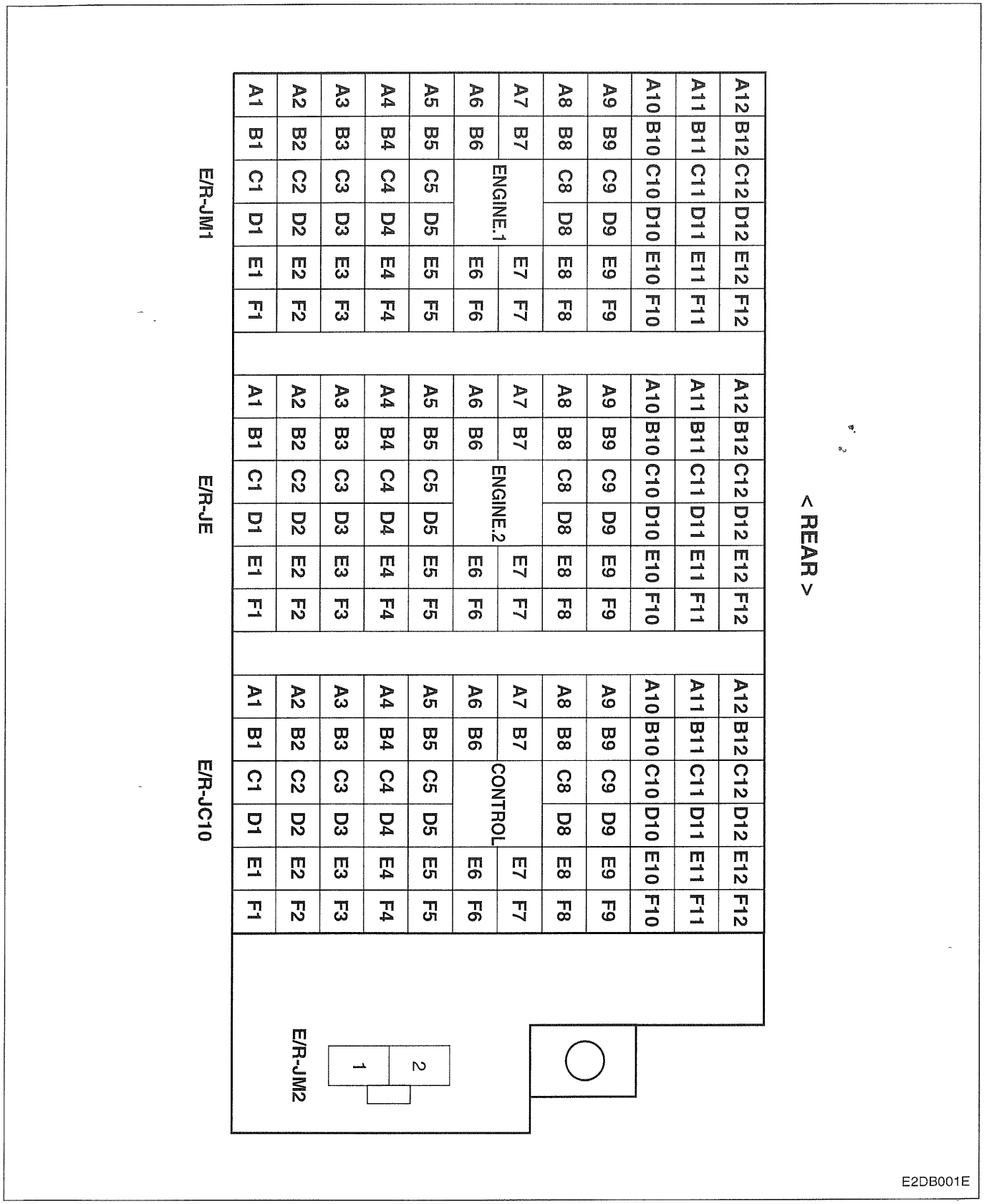
E2DB001C

FUSE & FUSIBLE

Description	FUSE	Amperages (A)	LABEL	Circuit protected
FUSE	1	20A	FUEL PUMP	Fuel pump relay
	2	15A	HEAD LAMP (LOW)	Head lamps (LOW)
	3	10A	ABS	ABS controls
	4	10A	FUEL INJECTOR	Injector controls
	5	10A	A/C COMPRESSOR	A/Con controls
	6	20A	ATM	Automatic transaxle controls
	7	30A	MAIN RELAY	Engine control relay
	8	20A	ECM/ IGNITION COIL	ECM/ Ignition coil control
	9	15A	OXYGEN SENSOR	Oxygen sensor
	10	10A	ECU	ECM, Fuel pump relay control
	11	10A	HORN	Horns
	12	15A	HEAD LAMP (HIGH)	Head lamps (HI)
	13			Not used
	14	15A	DRL	DRL control
	15	15A	FRONT FOG LAMP	Fog lamps
	16	30A	SPARE FUSE	Not used
	17	20A	SPARE FUSE	Not used
	18	15A	SPARE FUSE	Not used
	19	10A	SPARE FUSE	Not used
	20	30A	BLOWER	Blower controls
	21	30A	IGNITION SWITCH-1	Power controls (Acc, IG1)
	22			Not used
	23			Not used
	24			Not used
	25	30A	POWER FUSE-1	Passenger compartment fuse details (Fuse 22, 23, 24)
	26	15A	EGR	ECM, EGR actuator, Glow relay, Fuel pump relay
	27	30A		Not used
FUSIBLE LINK		30A	CONDENSER FAN	Condenser fan relay
		30A	POWER WINDOW	Power windows
		30A	IGNITION SWITCH-2	Power controls (IG2, Start)
		50A	POWER-2	Passenger compartment fuse details
		30A/30A	ABS-1/2	ABS controls
		40A	RADIATOR FAN	Radiator fan relay

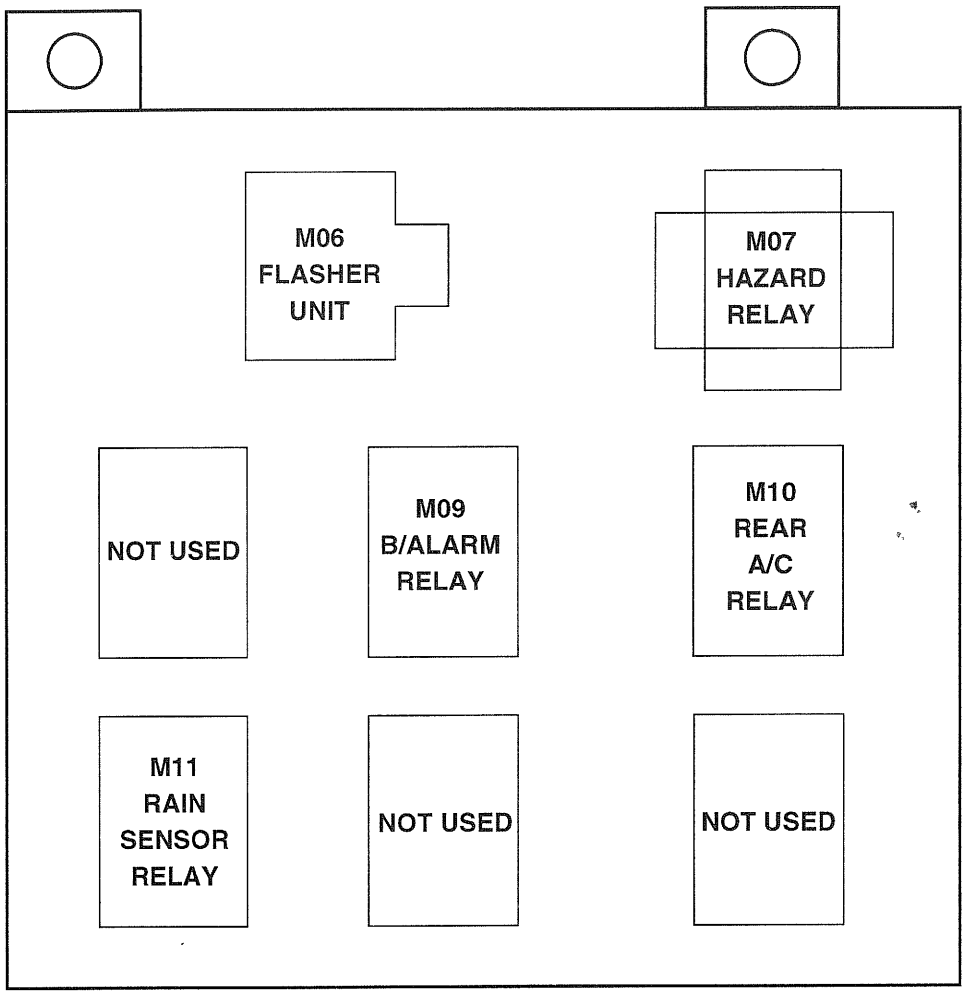
E2DB001D

LAYOUT


< REAR >
E/R-JM1
E/R-JE
E/R-JC10
E/R-JM2
ENGINE.1
ENGINE.2
CONTROL
1
2
E2DB001E

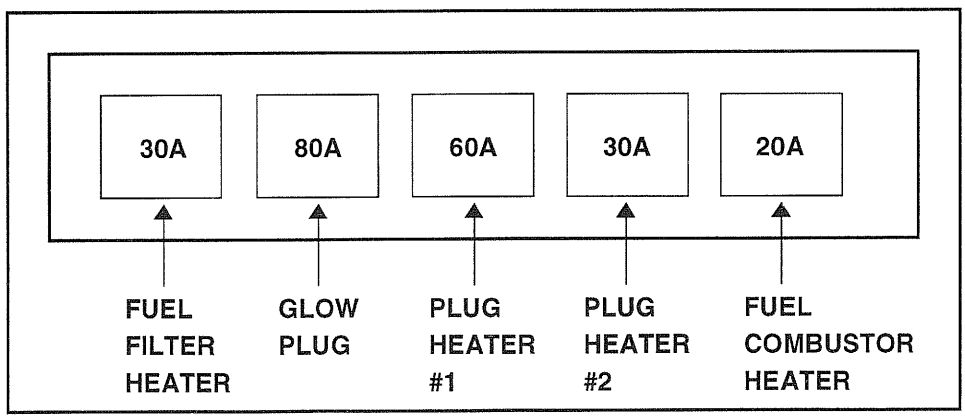
LAYOUT

RELAY BOX



E2DB001F

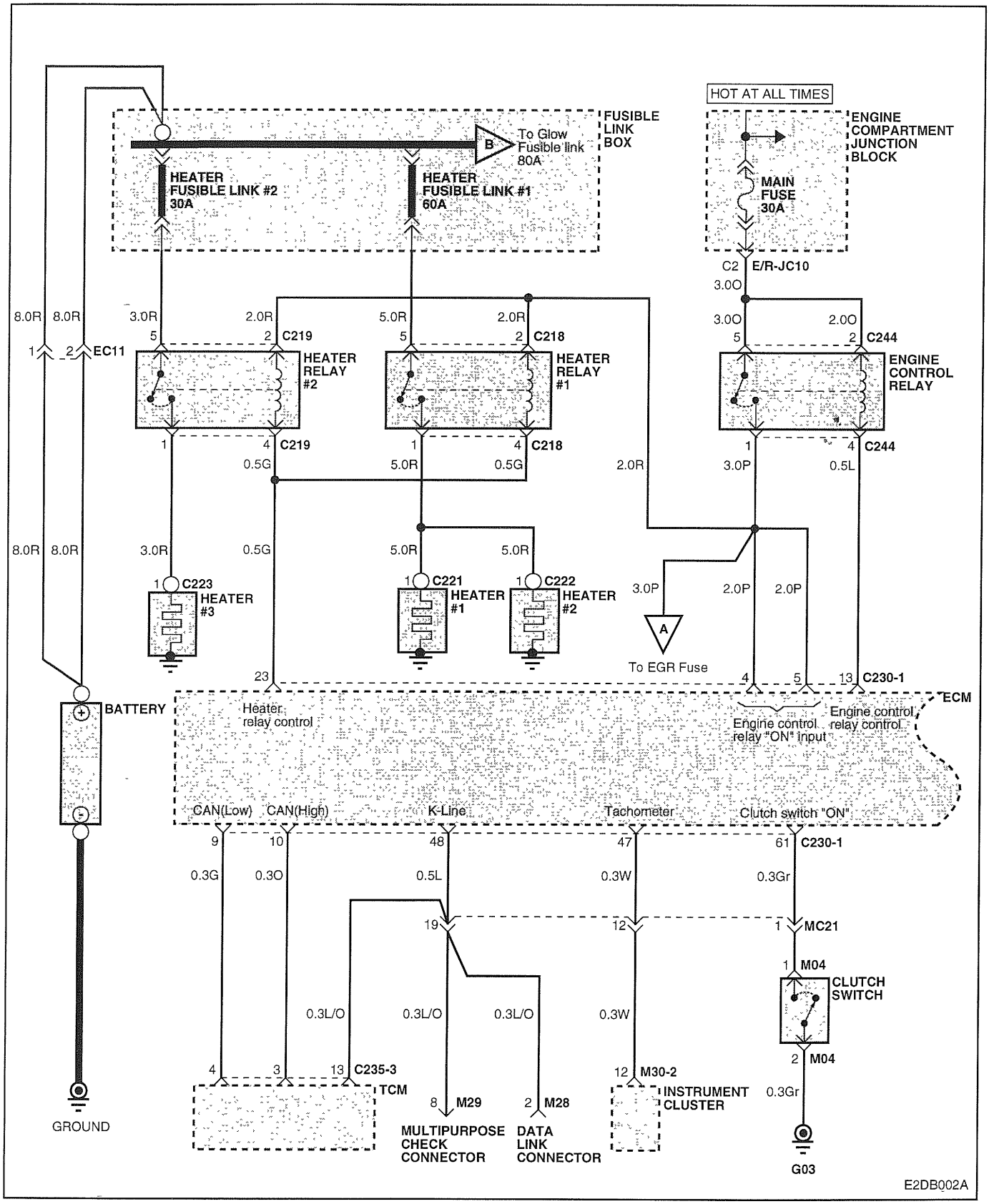
FUSIBLE LINK BOX



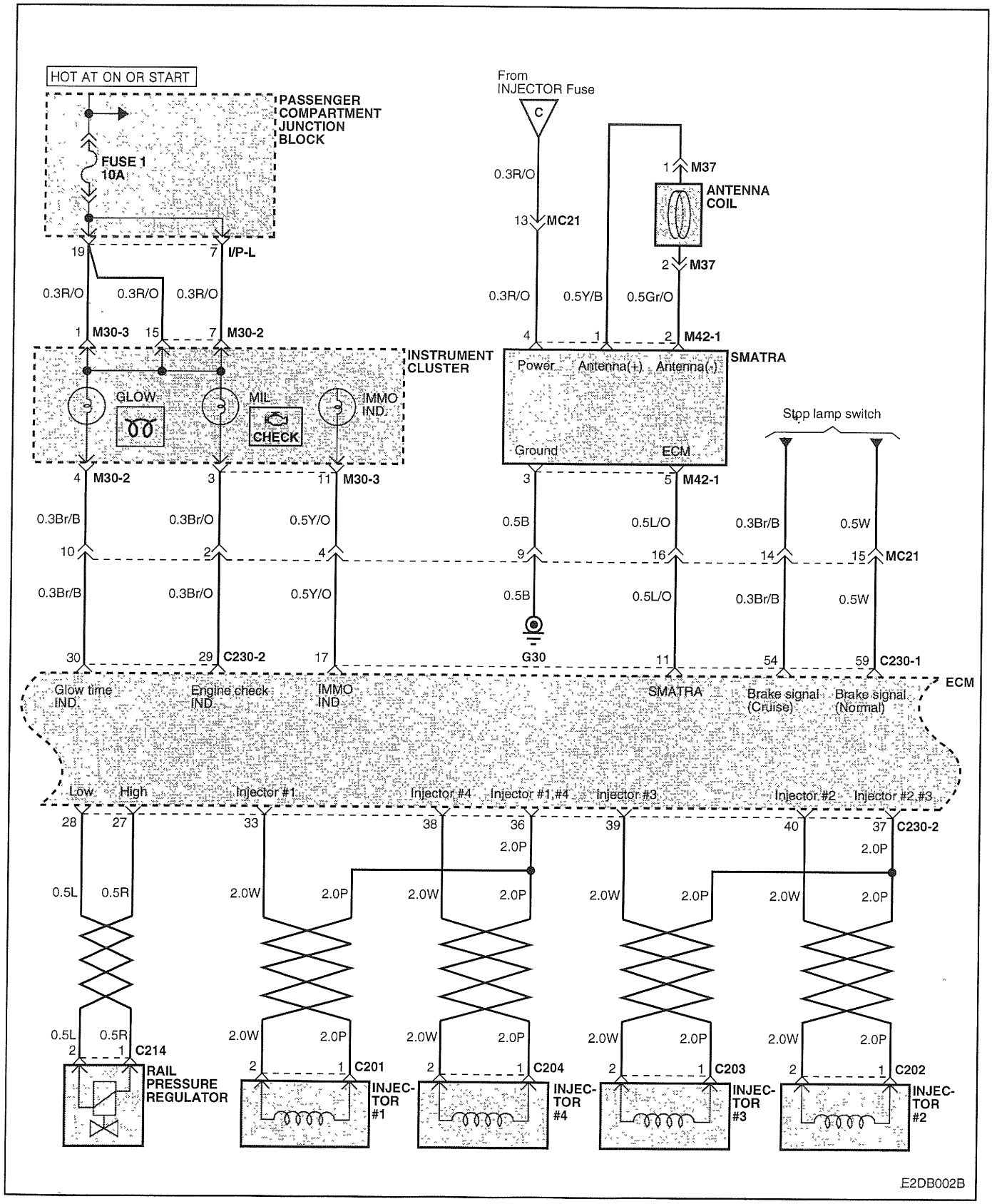
E2DB001G

ENGINE CONTROL SYSTEM

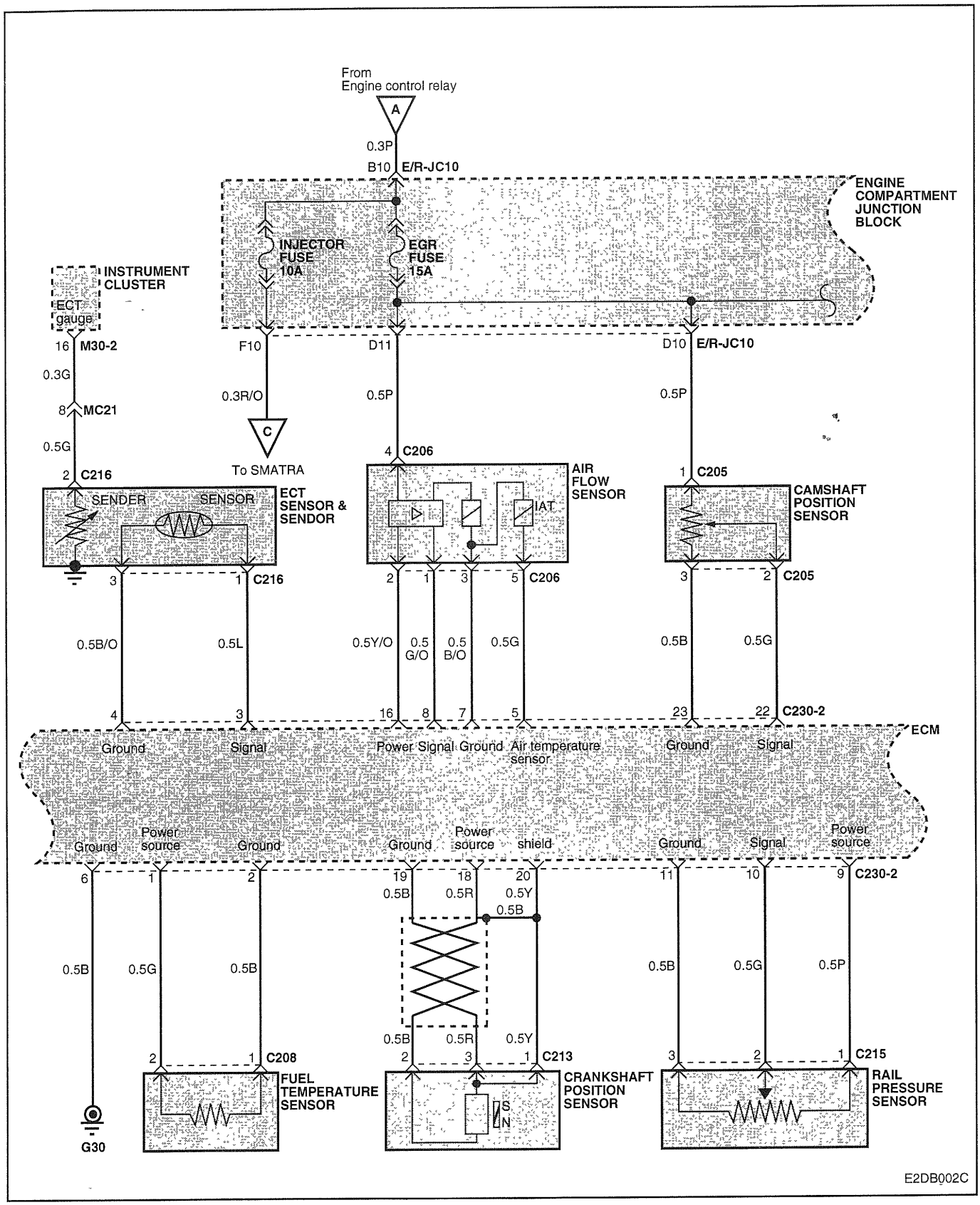
ENGINE CONTROL SYSTEM (1)



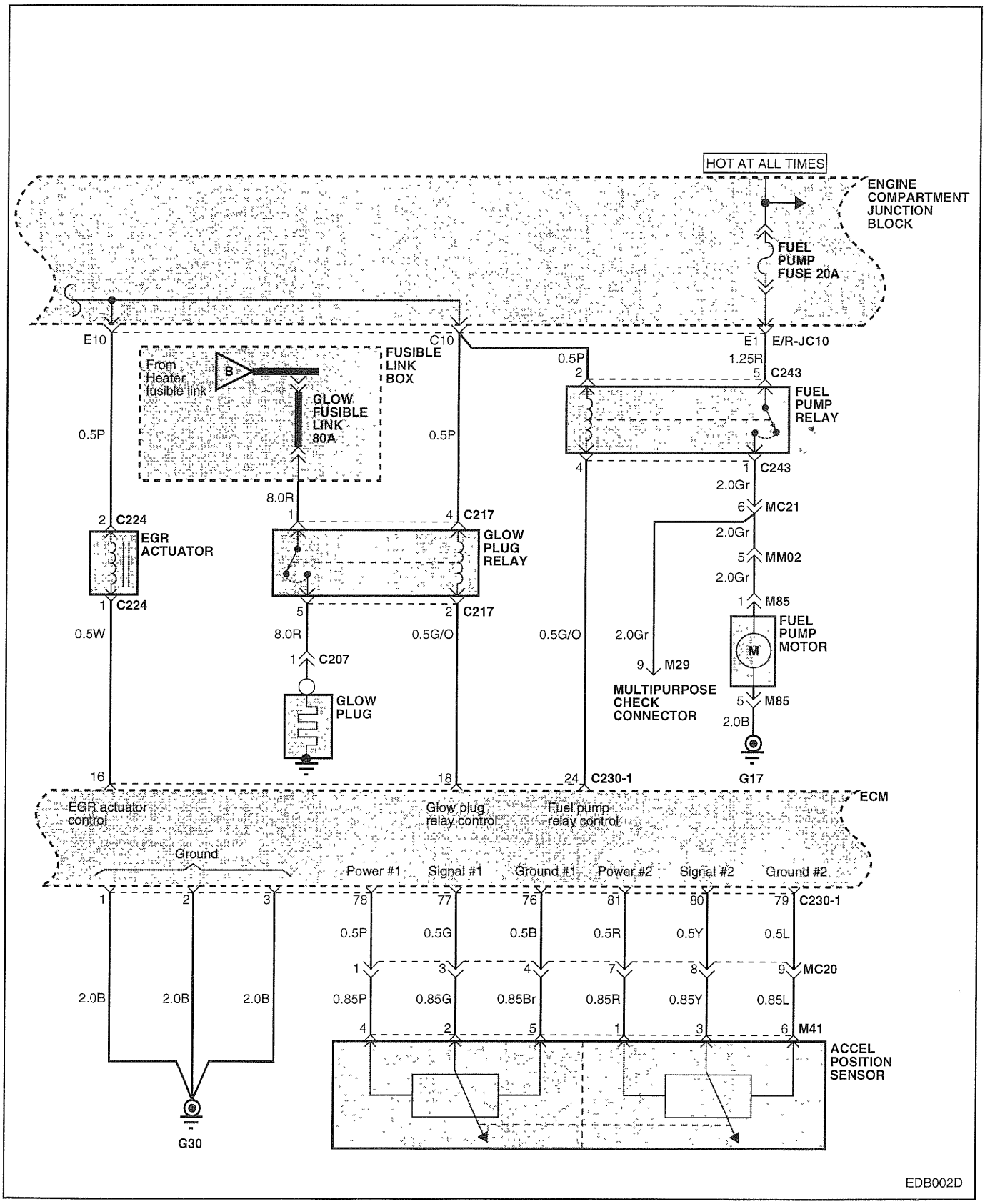
ENGINE CONTROL SYSTEM (2)



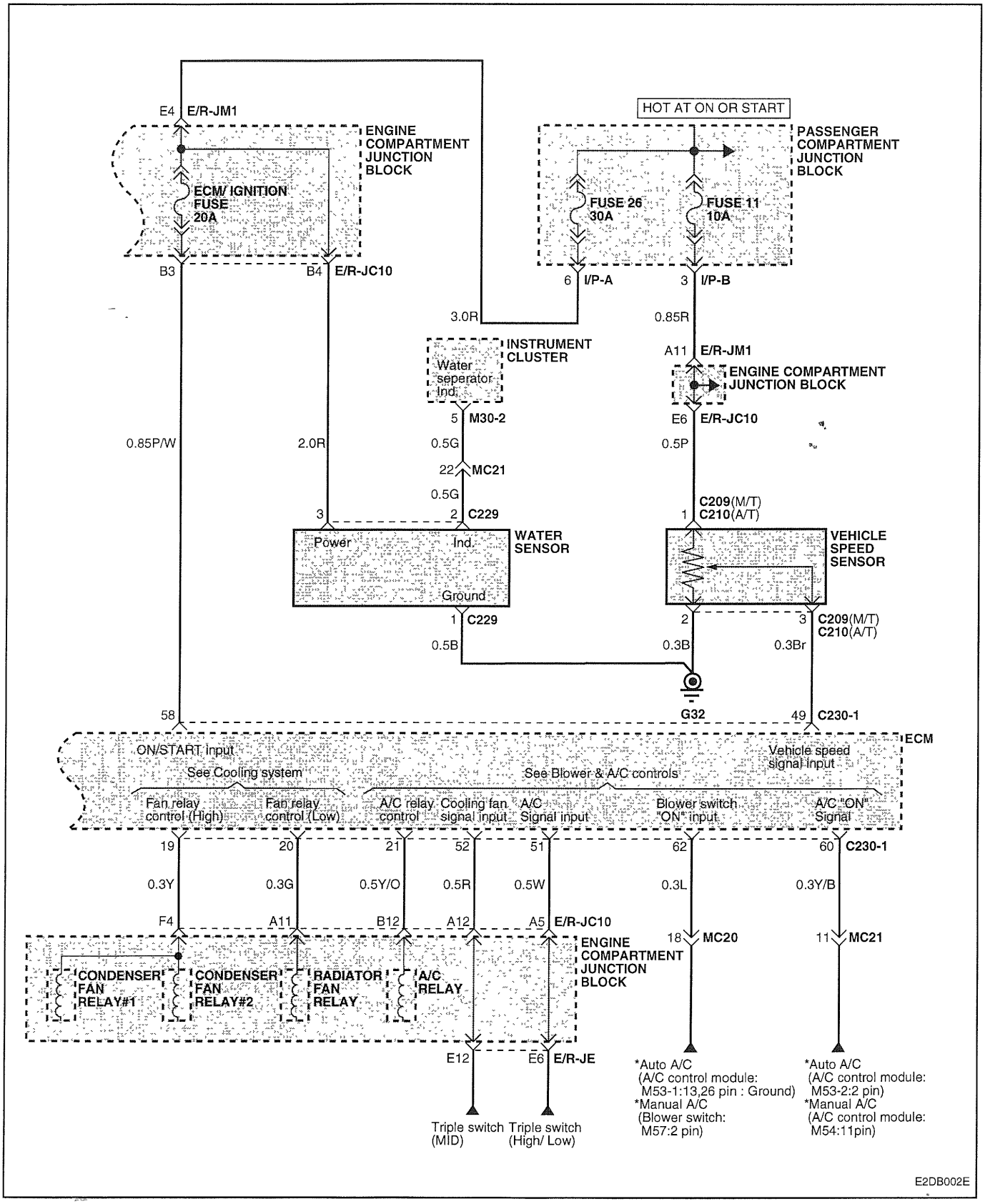
ENGINE CONTROL SYSTEM (3)



ENGINE CONTROL SYSTEM (4)



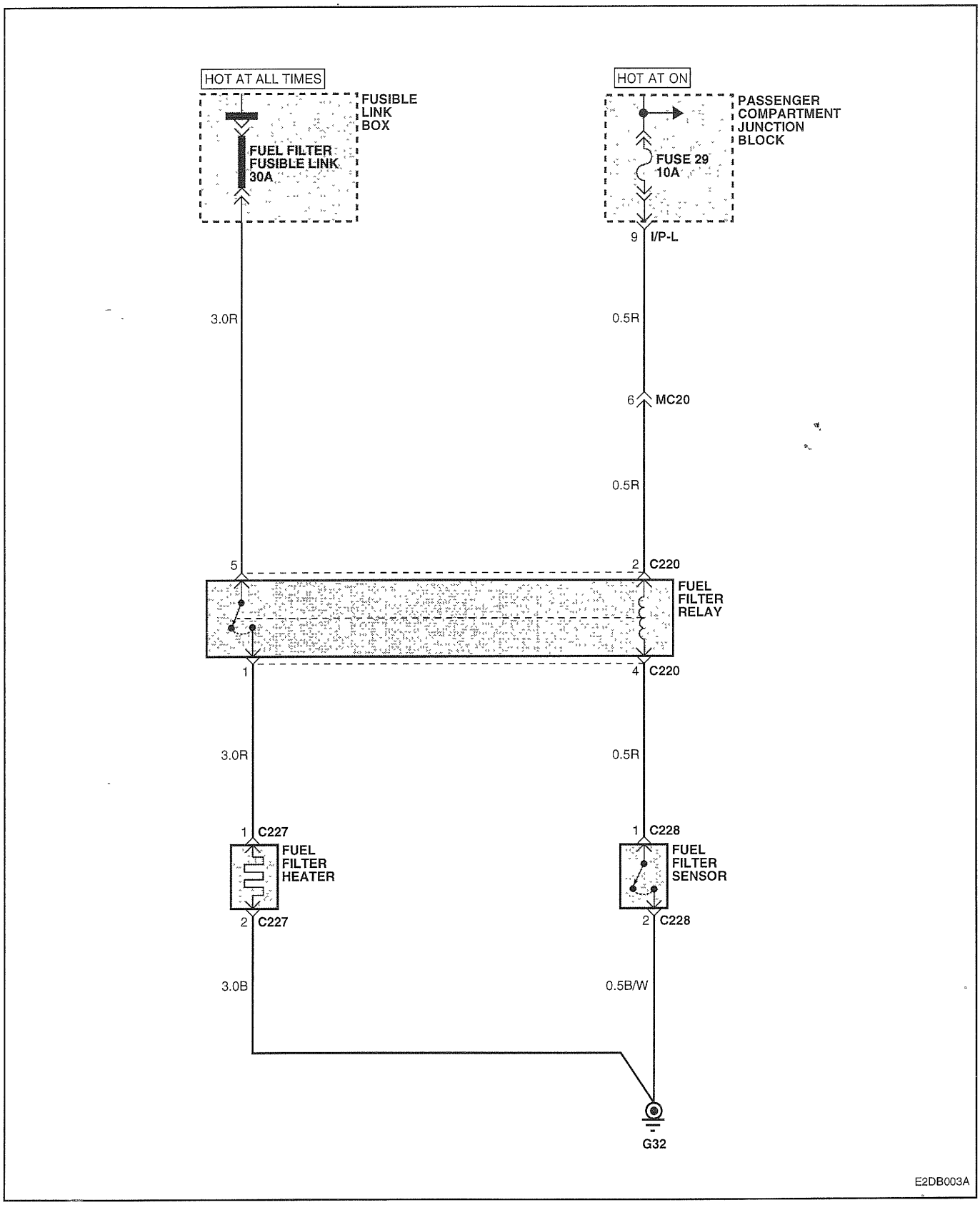
ENGINE CONTROL SYSTEM (5)



COMPONENT LOCATION INDEX

Components		Location reference-page
C201	Injector #1	SD-16
C202	Injector #2	SD-16
C203	Injector #3	SD-16
C204	Injector #4	SD-16
C205	Camshaft position sensor	SD-16
C206	Air flow sensor	SD-16
C207	Glow plug	SD-16
C208	Fuel temperature sensor	SD-16
C209	Vehicle speed sensor (M/T)	SD-16
C210	Vehicle speed sensor (A/T)	SD-16
C213	Crankshaft position sensor	SD-16
C214	Rail pressure regulator	SD-16
C215	Rail pressure sensor	SD-16
C216	ECT sensor & sender	SD-16
C217	Glow plug relay	SD-17
C218	Heater relay #1	SD-17
C219	Heater relay #2	SD-17
C221	Heater #1	SD-17
C222	Heater #2	SD-17
C223	Heater #3	SD-17
C224	EGR actuator	SD-17
C229	Water sensor	SD-17
C230-1	ECM	SD-17
C230-2	ECM	SD-17
C235-3	TCM	SD-17
C243	Fuel pump relay	SD-17
C244	Engine control relay	SD-17
M28	Data link connector	SD-18
M29	Multipurpose check connector	SD-18
M41	Accel position sensor	SD-18
Connectors		
E/R-JC10		SD-18
E/R-JE		SD-18
E/R-JM1		SD-18
MC20		SD-18
MC21		SD-18
Grounds		
G30		SD-18

FUEL FILTER HEATING SYSTEM

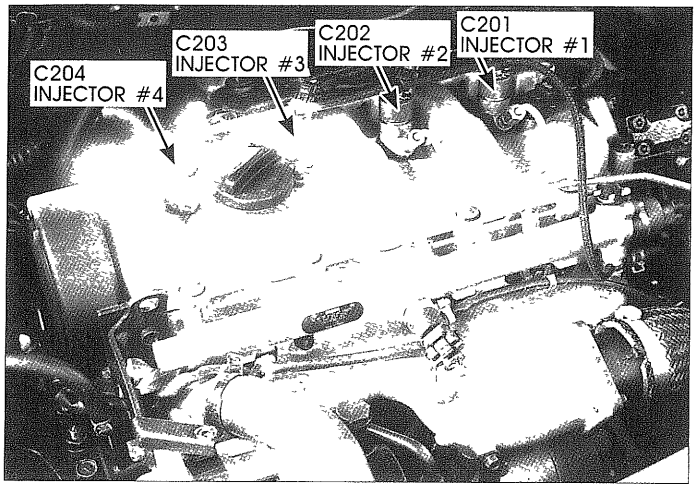


COMPONENT LOCATION INDEX

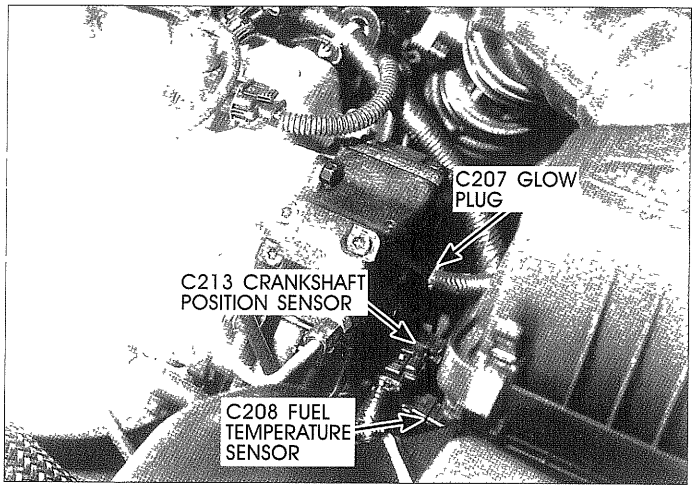
Components		Location reference-page
C220	Fuel filter relay	SD-17
C227	Fuel filter heater	SD-17
C228	Fuel filter sensor	SD-17
Connectors		
MC20		SD-18

COMPONENT LOCATION

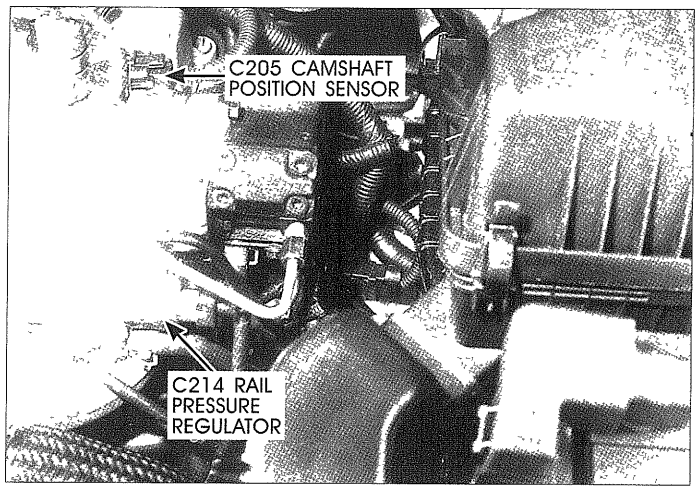
COMPONENT LOCATION(1)



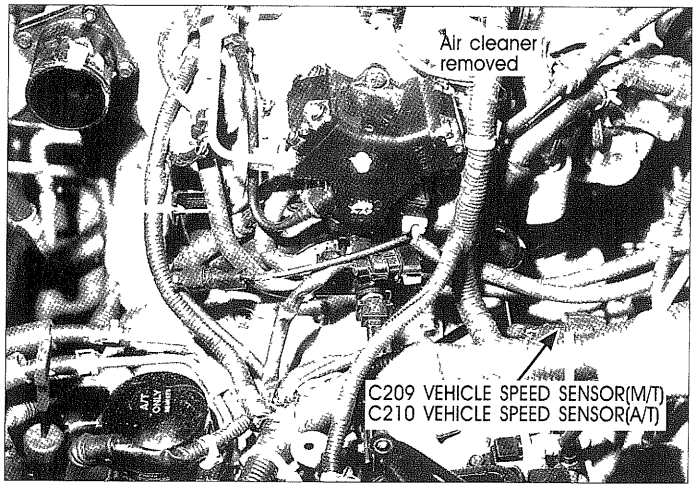
C201,C202,C203,C204 E3DA001A



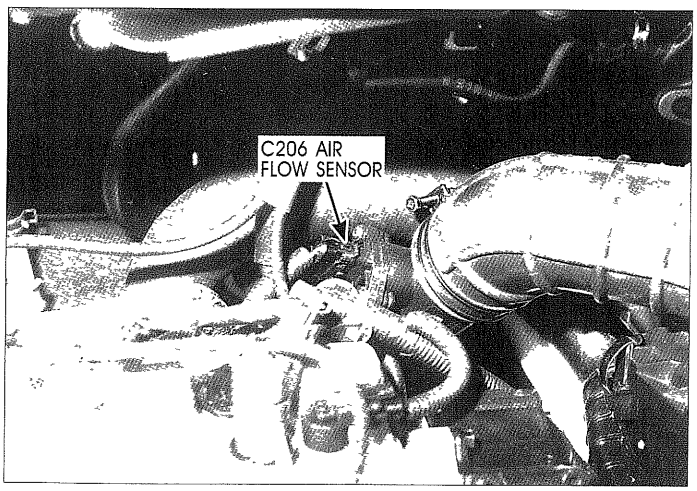
C207,C208,C213 E3DA001D



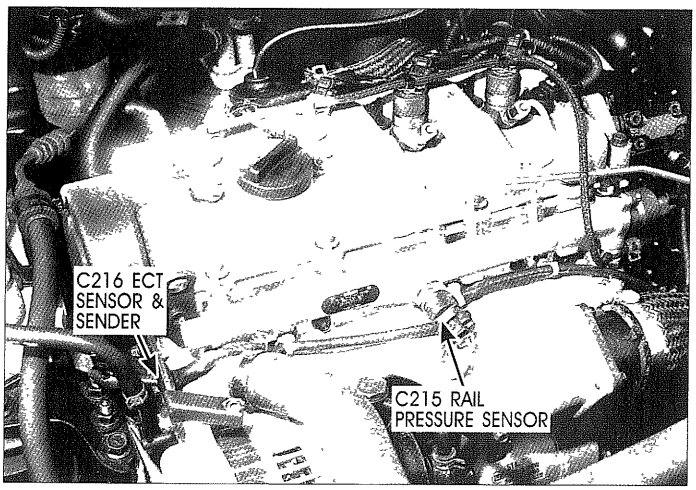
C205,C214 E3DA001B



C209,C210 E3DA001E

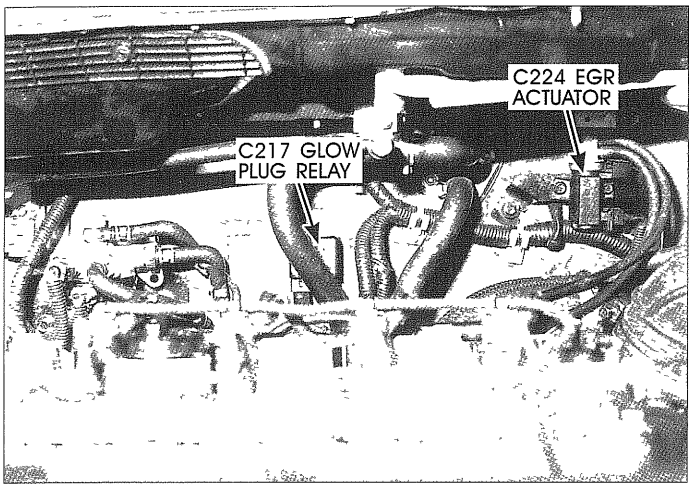


C206 E3DA001C

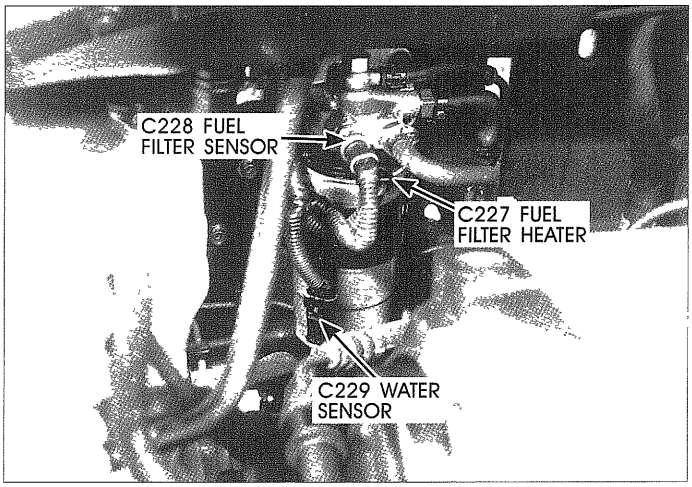


C215,C216 E3DA001F

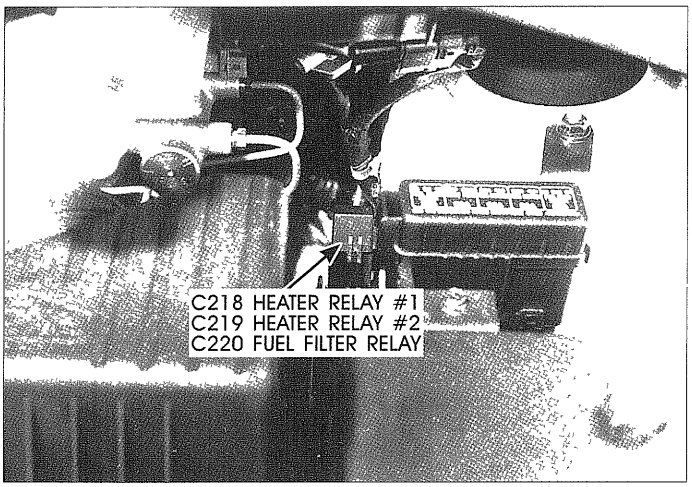
COMPONENT LOCATION(2)



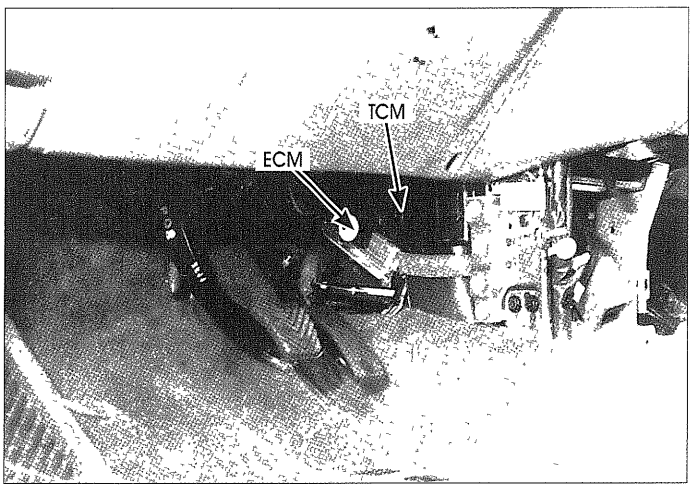
C217,C224 E3DA001G



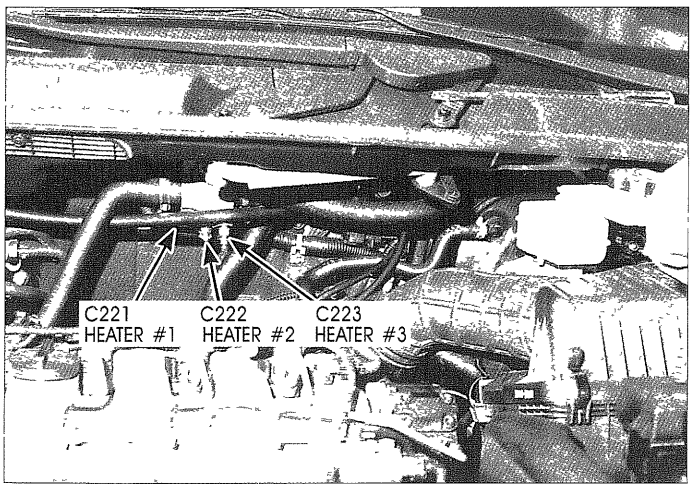
C227,C228,C229 E3DA001K



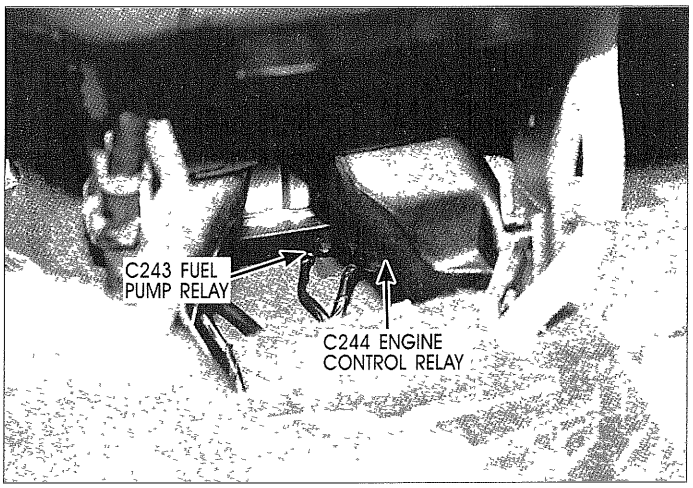
C218,C219,C220 E3DA001H



C230-1,C230-2,C235-1,C235-2,C235-3 E3DA001L

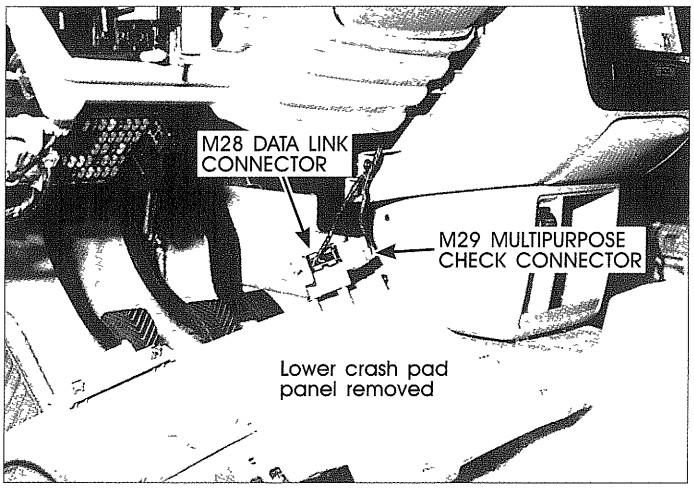


C221,C222,C223 E3DA001J

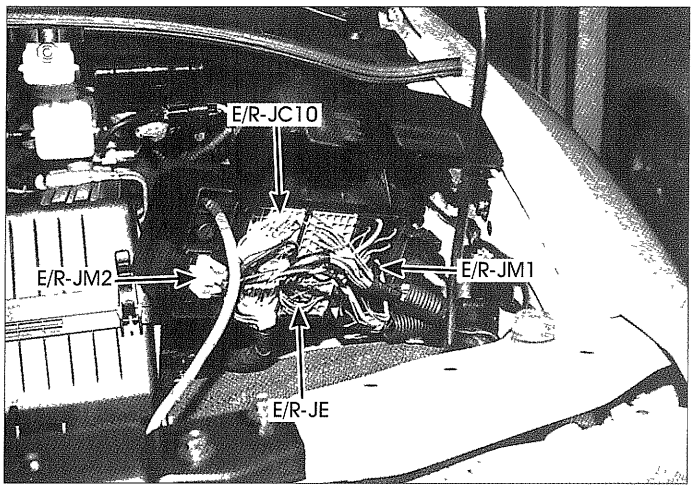


C243,C244 E3DA001M

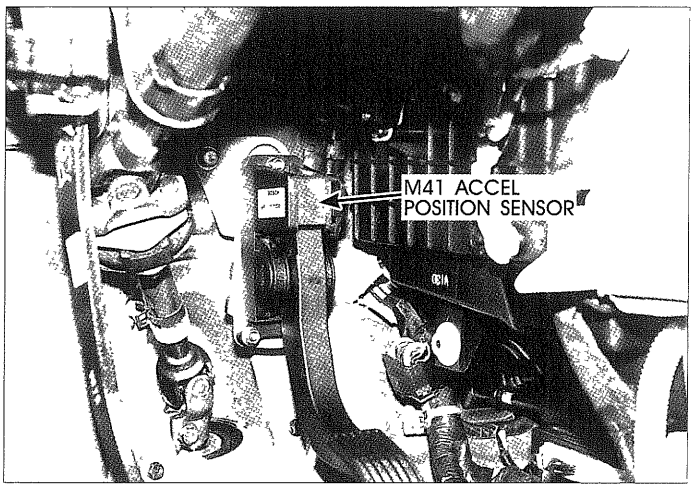
COMPONENT LOCATION(3)



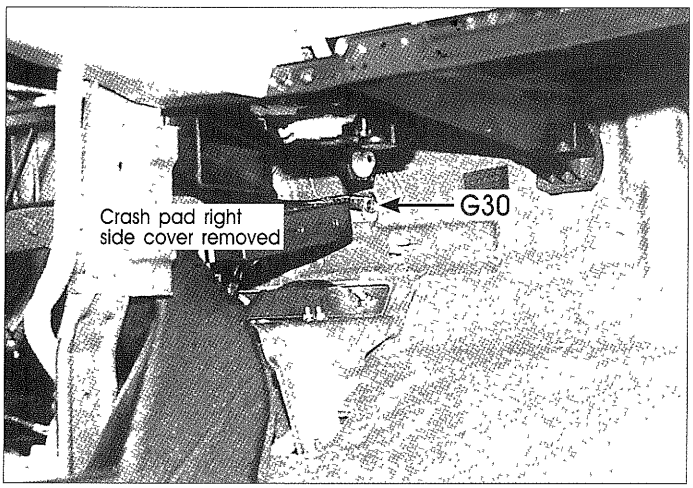
M28,M29 E3DA001N



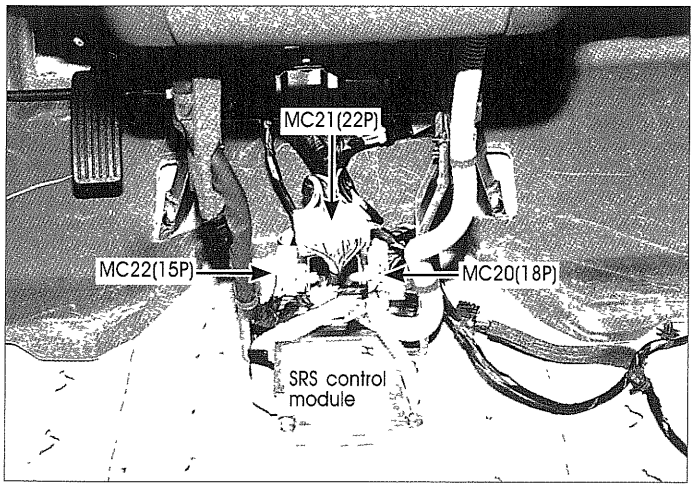
E/R-JC10,E/R-JE,E/R-JM1,E/R-JM2 E3DA001R



M41 E3DA001P



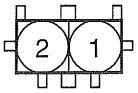
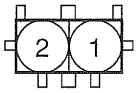
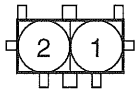
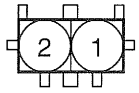
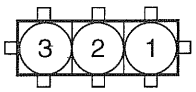
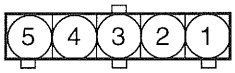
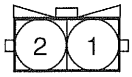
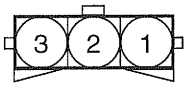
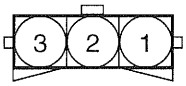
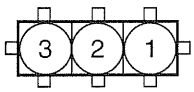
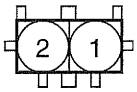
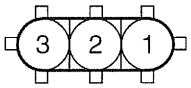
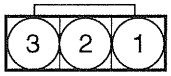
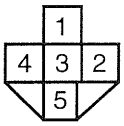
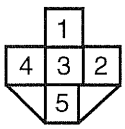
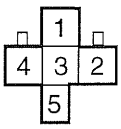
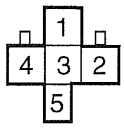
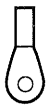
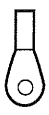
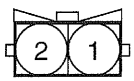
G30 E3DA001S



MC20,MC21,MC22 E3DA001Q

CONNECTOR CONFIGURATION

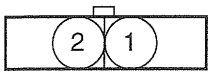
CONNECTOR CONFIGURATION (1)

C201  CR02F121	**C202**  CR02F121	**C203**  CR02F121	**C204**  CR02F121
C205  CR03F082	**C206**  CR05F032	**C207**  CR01F039	**C208**  CR02F041
C209  CR03F029	**C210**  CR03F029	**BLANK**	**C213**  CR03F082
C214  CR02F121	**C215**  CR03F084	**C216**  CR03F071	**C217**  CR05F031
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E2DB004A

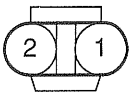
CONNECTOR CONFIGURATION (2)

C227



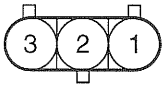
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C228



CR02F123

C229



CR03F083

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C230-1

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	5	4
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	3	
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62		
63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	2	1

CR81F002

C230-2

40	39	38	32	31	30	29	28	27	26	25
37		36	24	23	22	21	20	19	18	17
			16	15	14	13	12	11	10	9
35	34	33	8	7	6	5	4	3	2	1

CR40F003

C235-1

13	12	11	10	9	8	7	6	5	4	3	2	1
26	25	24	23	22	21	20	19	18	17	16	15	14

CR26F006

C235-2

8	7	6	5	4	3	2	1
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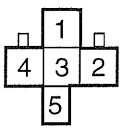
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C235-3

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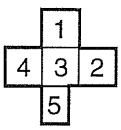
CR22F004

C243



CR05F022

C244



CR05F007

E/R-JC10

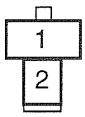
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A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A
B	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B
C	C1	C2	C3	C4	C5			C8	C9	C10	C11	C12	C
D	D1	D2	D3	D4	D5			D8	D9	D10	D11	D12	D
E	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E
F	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F
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CR68F001

E2DB004B

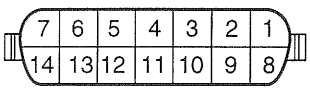
CONNECTOR CONFIGURATION (3)

M04



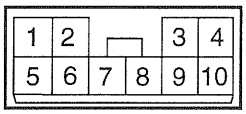
CR02F051

M28



CR14F021

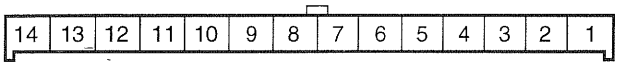
M29



CR10M003

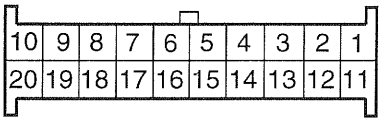
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M30-1



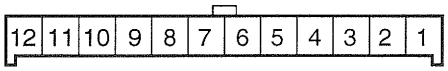
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M30-2



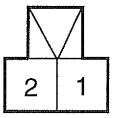
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M30-3



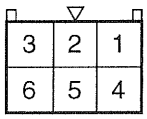
CR12F001

M37



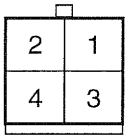
CR02F011

M41



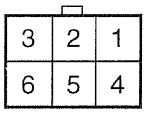
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M44



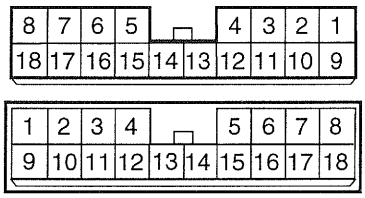
CR04F016

M57



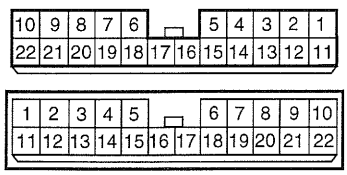
CR06F002

MC20



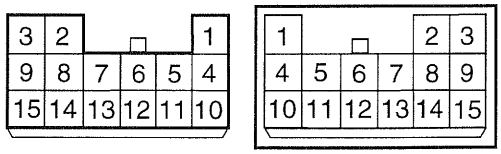
CR18B005

MC21



CR22B006

MC22



CR15B002

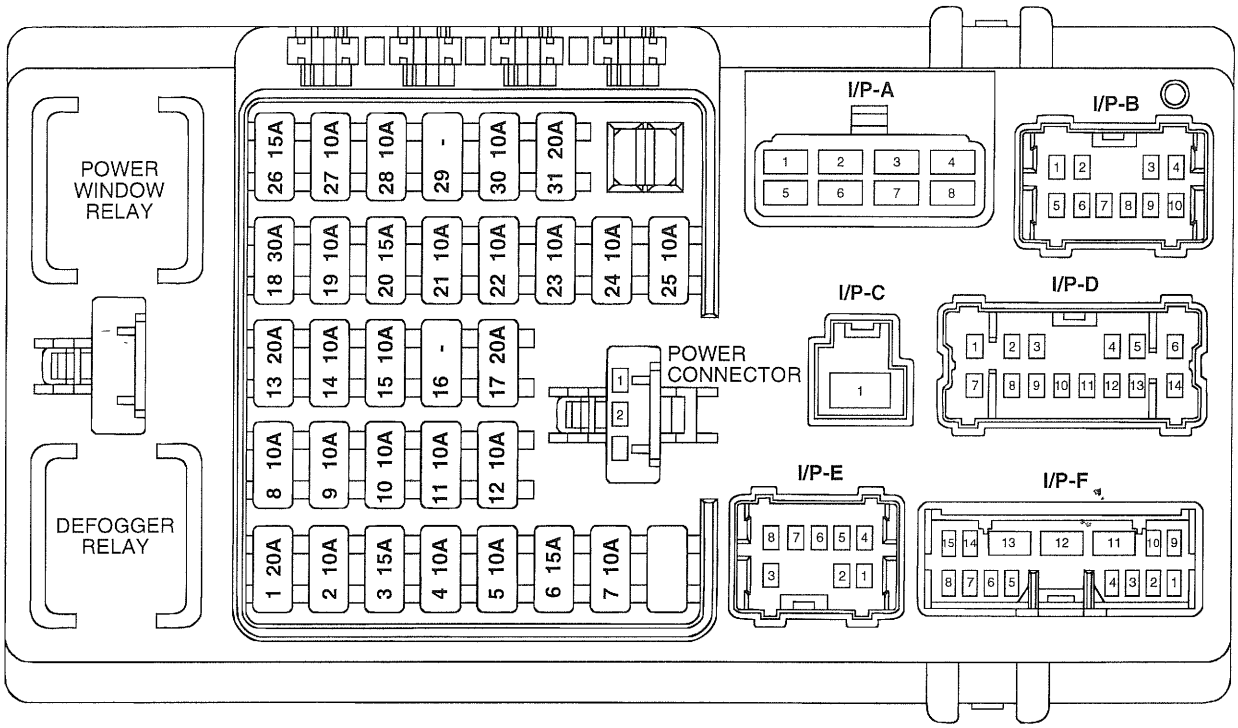
E2DB004C

FUSE AND RELAY INFORMATION

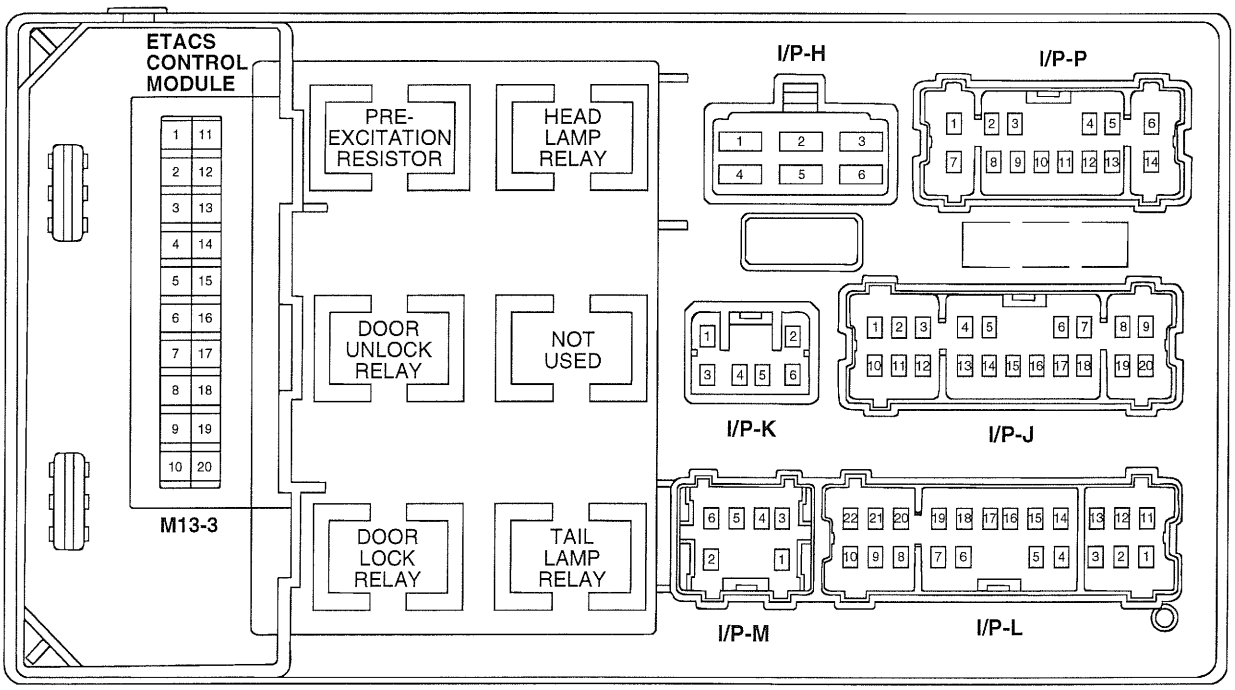
PASSENGER COMPARTMENT JUNCTION BLOCK (LAYOUT)

LAYOUT

< FRONT >



< BACK SIDE >



E2DB007A

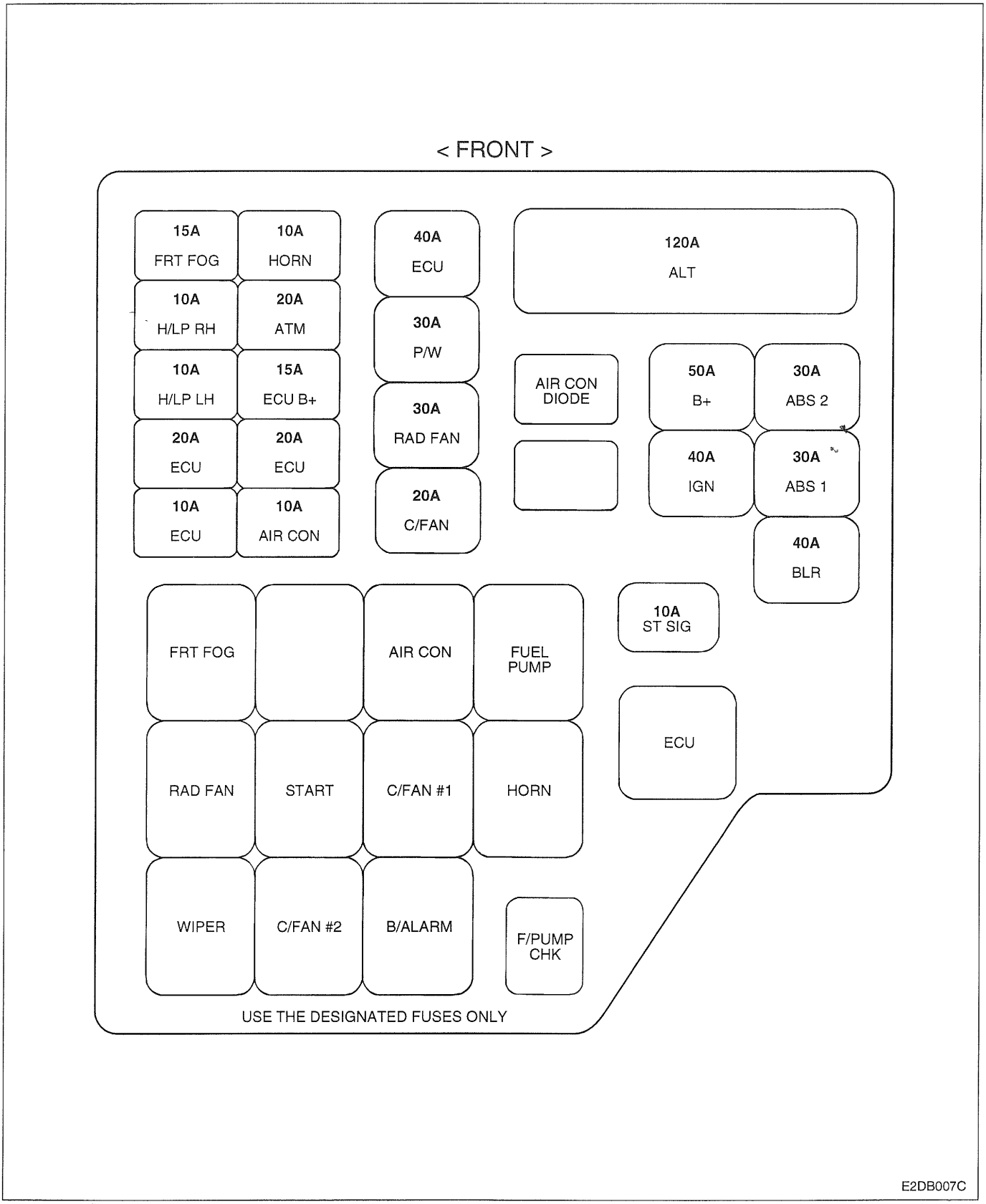
CIRCUIT

FUSE	Amperages(A)	Circuit protected
1	20A	Cigarette lighter & Power outlet
2	10A	Audio
3	15A	Clock, Power outlet, Seat belt tension reducer solenoid
4	10A	Fuel filter heating
5	10A	Head lamps
6	15A	Seat warmer
7	10A	Rear wiper & Washer
8	10A	Rear window defogger, Power outside mirrors
9	10A	A/C controls, Sunroof relay
10	10A	Rear fog lamp relay
11	10A	Courtesy lamps, Instrument cluster
12	10A	ETACS, Clock, Audio, Multimeter, Siren
13	20A	Speaker
14	10A	Stop lamps, Data link connector, Multipurpose check connector
15	10A	Hazard lamps, Immobilizer control module
16	25A	Power seat
17	20A	Sunroof relay
18	30A	Rear window defogger
19	10A	ETACS, Charging, Multimeter, Instrument cluster
20	15A	SRS controls
21	10A	ECM
22	10A	Instrument cluster
23	10A	ABS controls
24	10A	Hazard switch
25	10A	TCM, Automatic transaxle range controls, Vehicle speed sensor
26	20A	Power door locks
27	10A	Turn &Hazard lamps, Tail & License lamps
28	10A	Turn & Hazard lamps, Fog lamps, Illuminations
29		Not used
30	10A	Radiator fan relay, Condenser fan relay
31	20A	Front wiper & Washer

E2DB007B

ENGINE COMPARTMENT JUNCTION BLOCK

LAYOUT

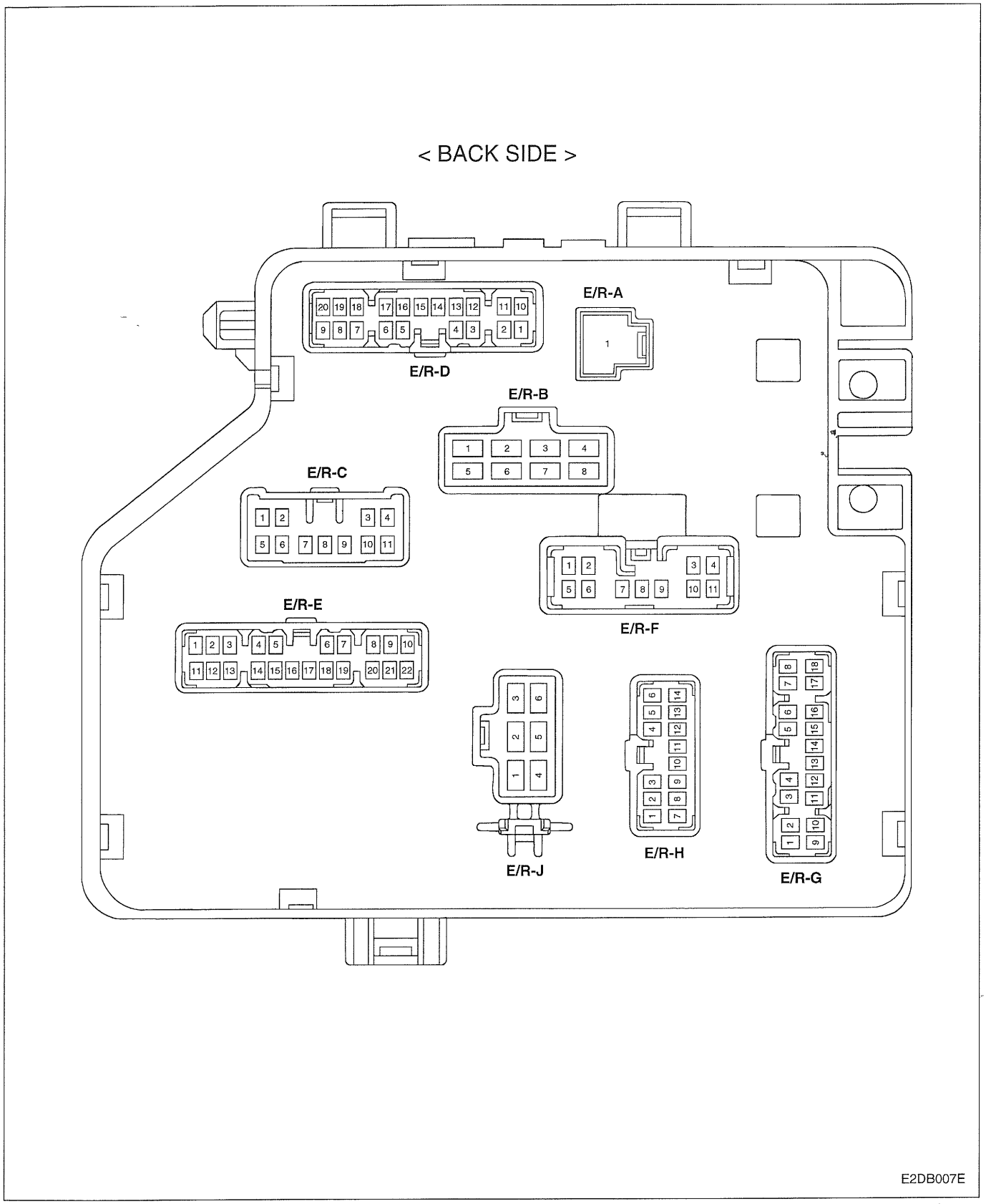


FUSE & FUSIBLE LINK

Description	LABEL	Amperages(A)	Circuit protected
FUSIBLE LINK	ALT	120A	Generator
	B+	50A	Tail lamp relay, Fuse 11-17, power connector
	IGN	40A	Starting, Ignition switch
	BLR	40A	A/C fuse, blower relay
	ABS.1	30A	ABS control, air bleeding connector
	ABS.2	30A	ABS control, air bleeding connector
	ECU	40A	Engine control relay
	P/W	30A	Power windows
	RAD FAN	30A	Radiator fan relay
	C/FAN	20A	Condenser fan relay
FUSE	FRT FOG	15A	Fog lamps
	H/LP(LH)	10A	Left head lamps, Instrument cluster
	H/LP(RH)	10A	Right head lamps
	ECU #1	20A	Ignition coil, oxygen sensor
	ECU #2	20A	Injectors
	ECU #3	10A	ECM
	ECU(B+)	15A	Fuel pump relay, ECM generator
	ATM	20A	Automatic transaxle controls, TCM
	HORN	10A	Horns
	AIR CON	10A	A/C relay, A/C switch
	ST SIG	10A	ECM, Cruise controls

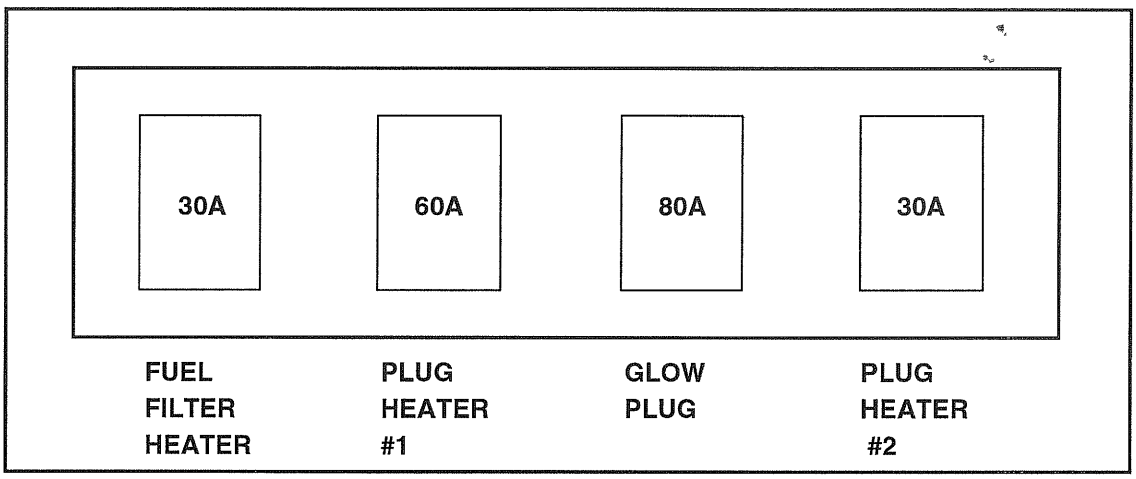
E2DB007D

LAYOUT



FUSIBLE LINK BOX

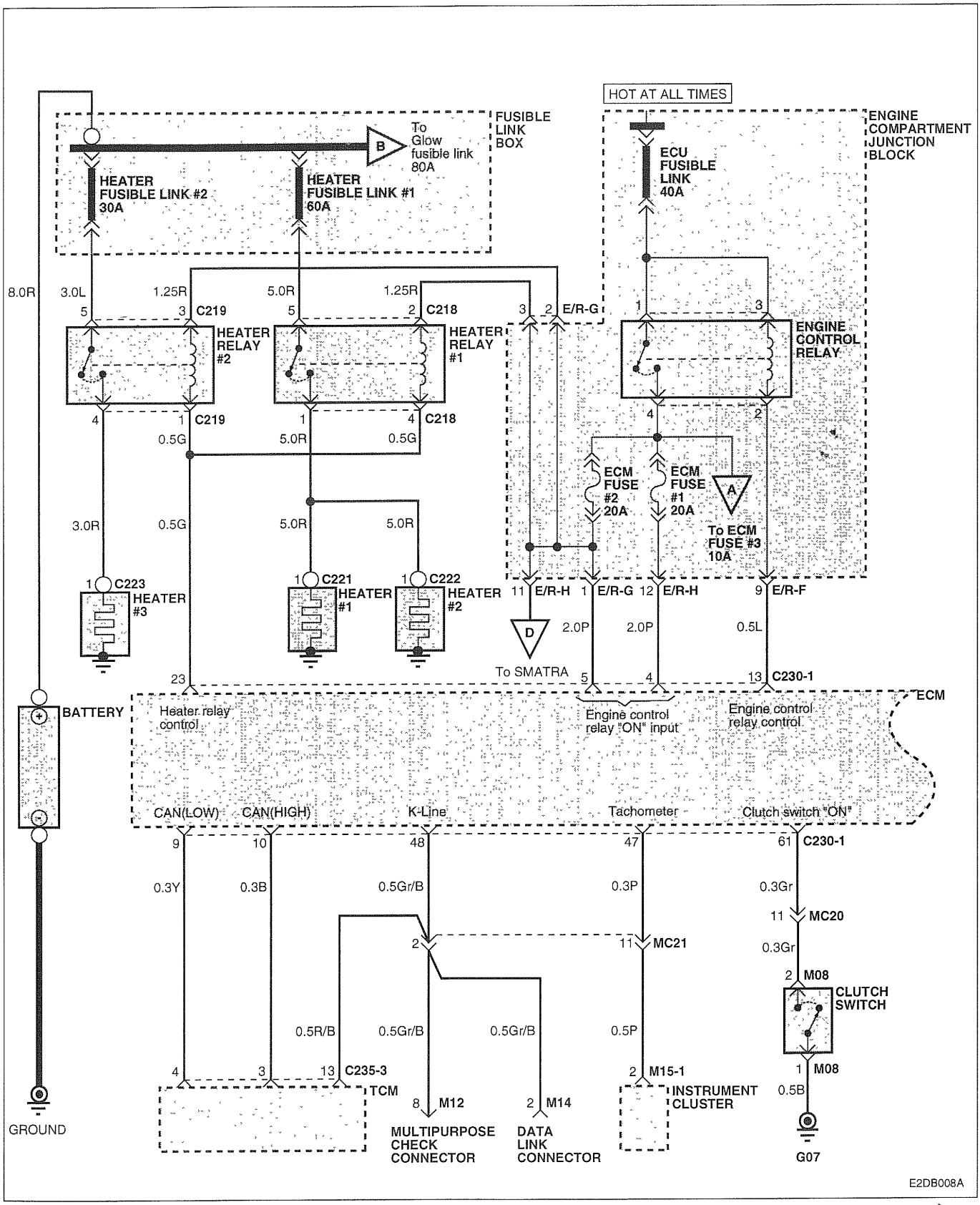
LAYOUT



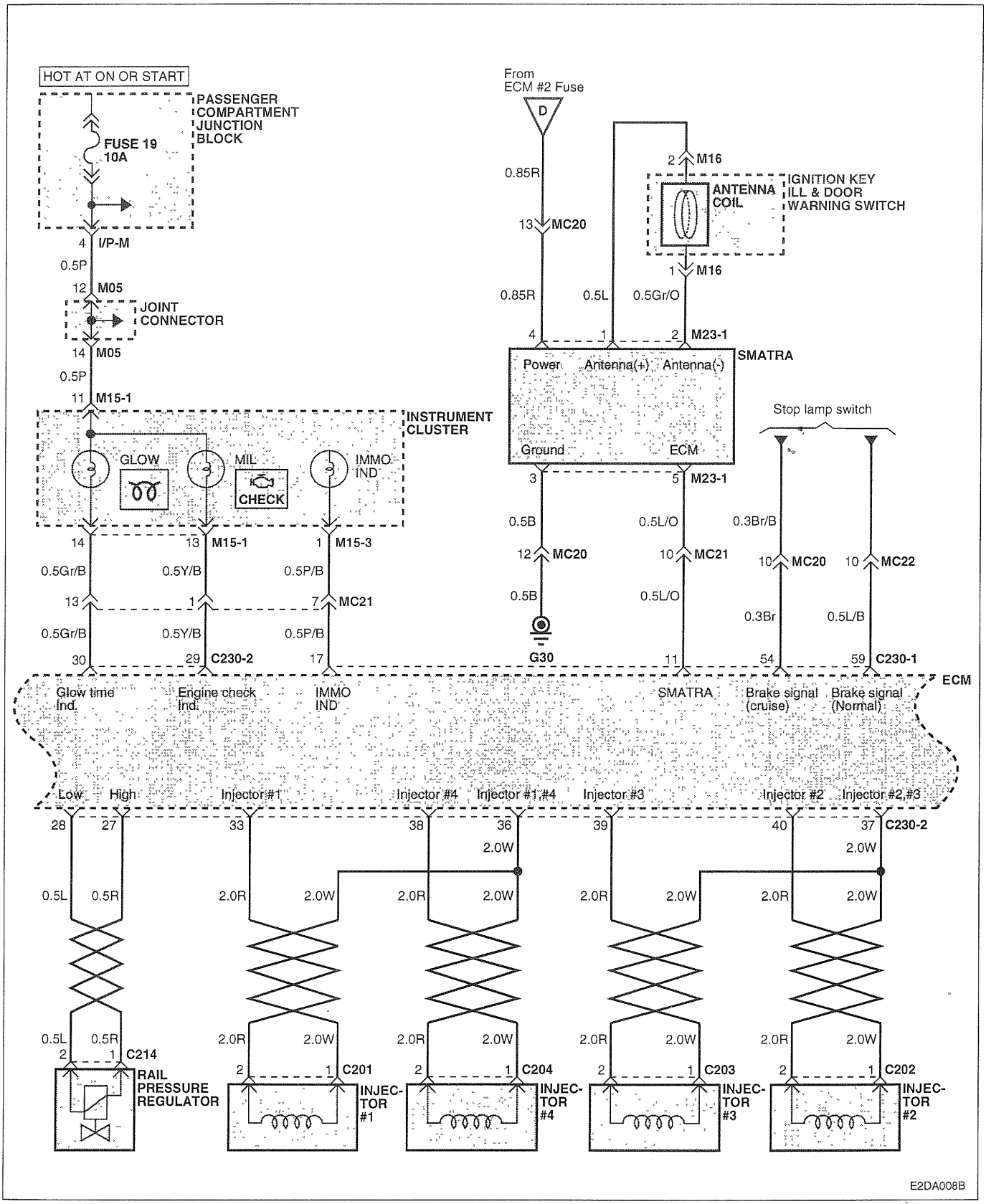
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ENGINE CONTROL SYSTEM

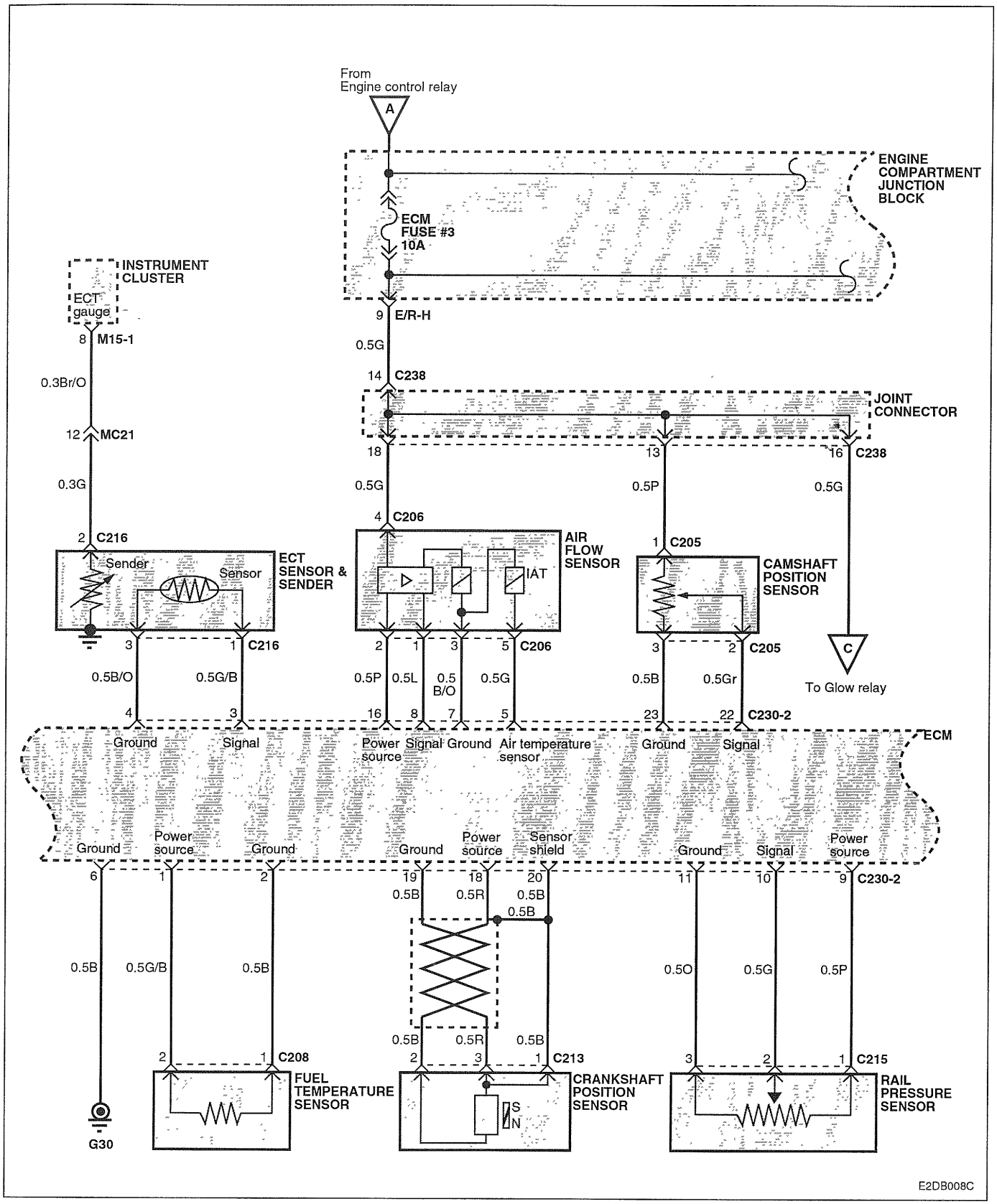
ENGINE CONTROL SYSTEM (1)



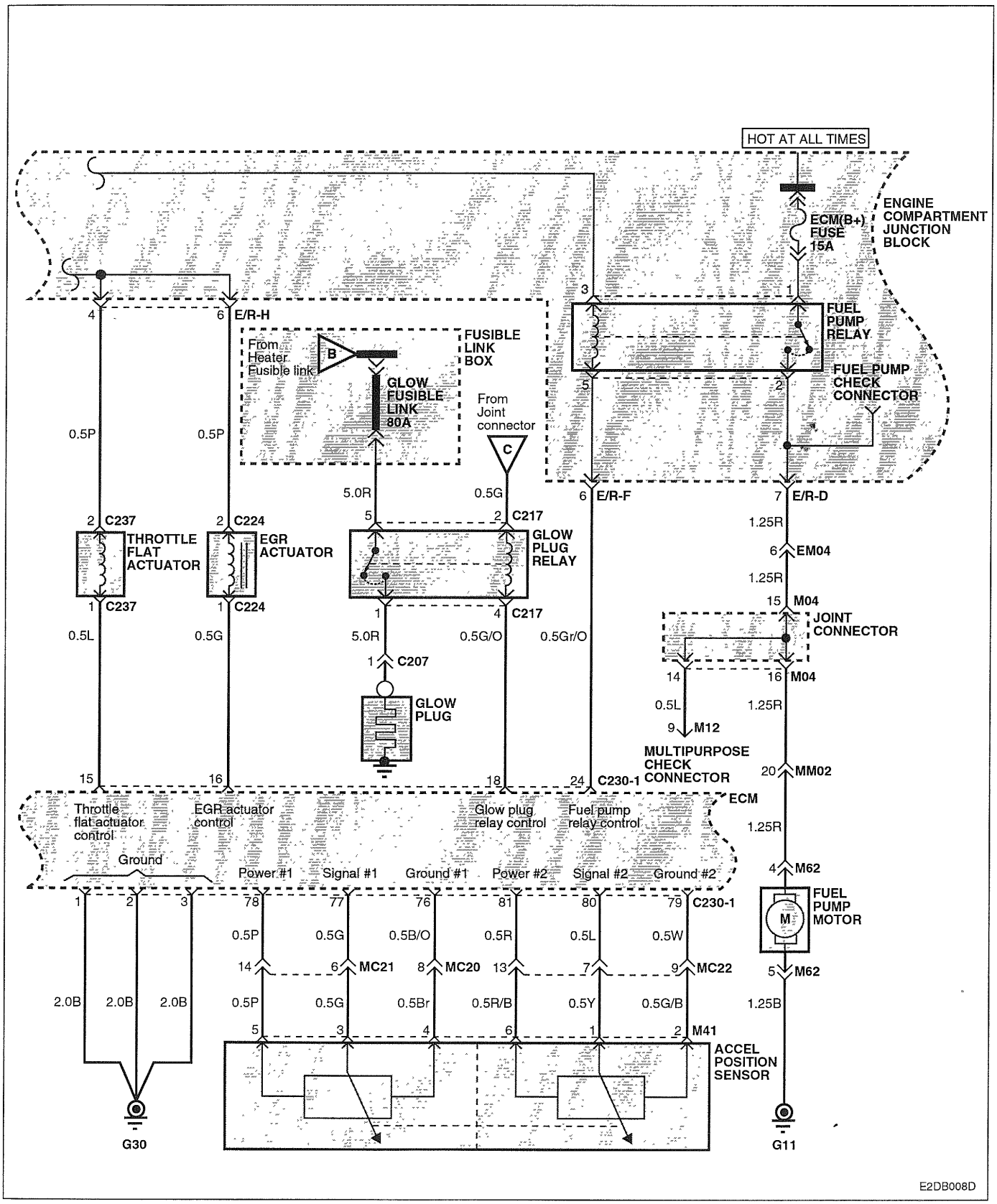
ENGINE CONTROL SYSTEM (2)



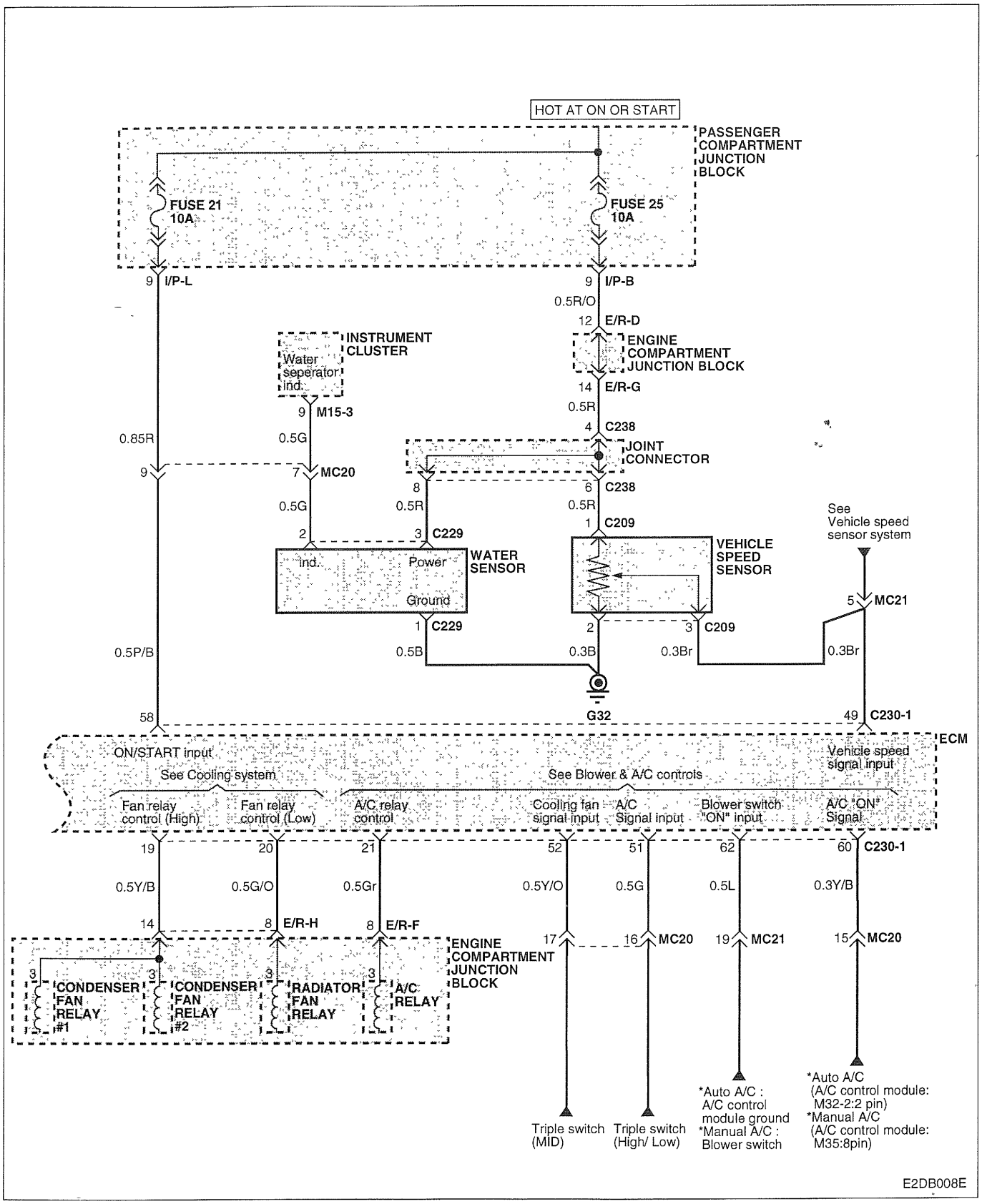
ENGINE CONTROL SYSTEM (3)



ENGINE CONTROL SYSTEM (4)



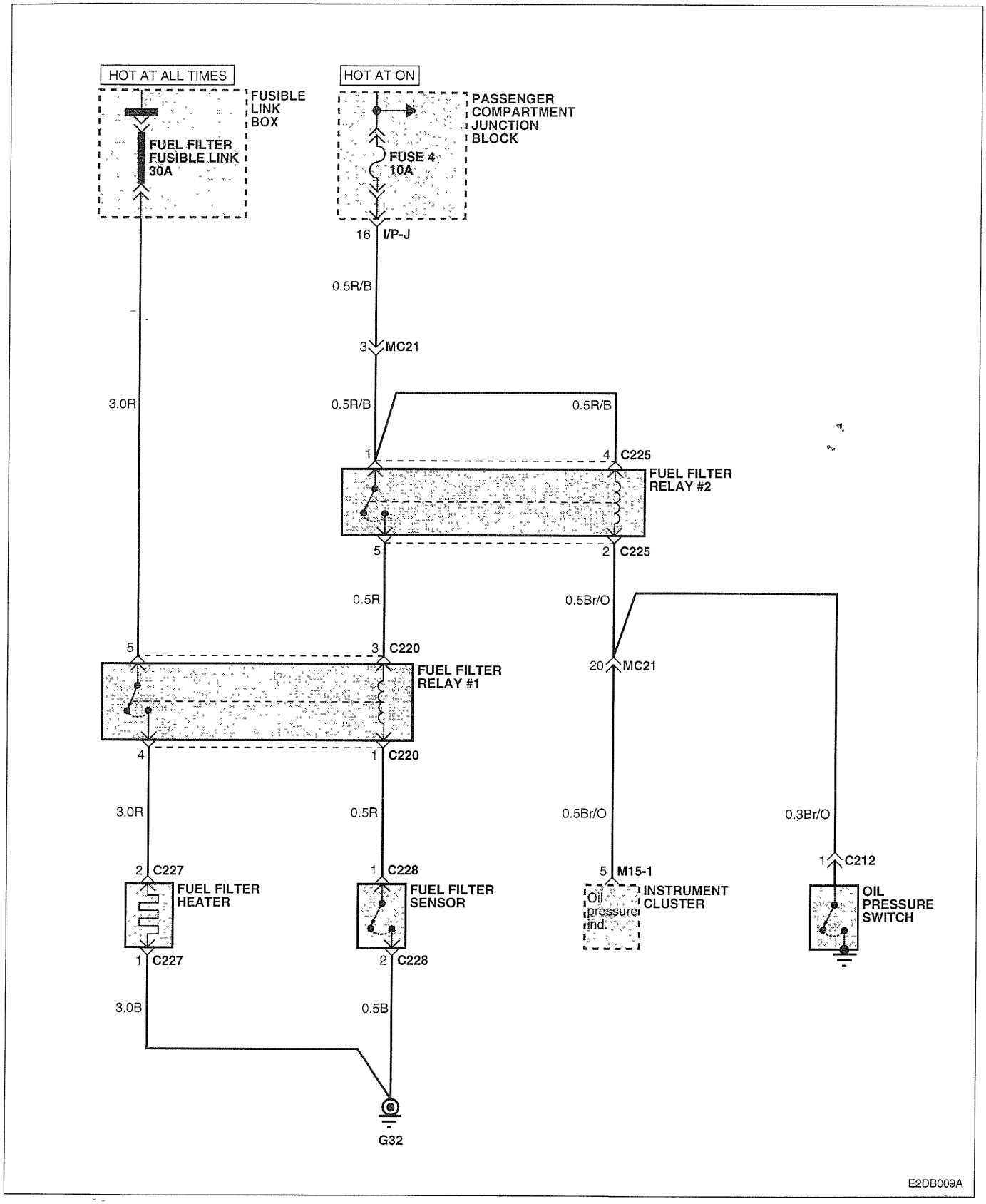
ENGINE CONTROL SYSTEM (5)



COMPONENT LOCATION INDEX

Components		Location reference-page
C201	Injector #1	SD-36
C202	Injector #2	SD-36
C203	Injector #3	SD-36
C204	Injector #4	SD-36
C205	Camshaft position sensor	SD-36
C206	Air flow sensor	SD-36
C207	Glow plug	SD-36
C208	Fuel temperature sensor	SD-36
C209	Vehicle speed snesor	SD-36
C213	Crankshaft position sensor	SD-36
C214	Rail pressure regulator	SD-36
C215	Rail pressure sensor	SD-36
C216	ECT sensor & sender	SD-36
C217	Glow plug relay	SD-37
C218	Heater relay #1	SD-37
C219	Heater relay #2	SD-37
C221	Heater #1	SD-37
C222	Heater #2	SD-37
C223	Heater #3	SD-37
C224	EGR actuator	SD-37
C229	Water sensor	SD-37
C230-1	ECM	SD-37
C230-2	ECM	SD-37
C235-3	TCM	SD-37
M12	Multipurpose check connector	SD-38
M14	Data link connector	SD-38
M41	Accel position sensor	SD-38
Connectors		
E/R-F		SD-38
E/R-G		SD-38
E/R-H		SD-38
MC20		SD-38
MC21		SD-38
MC22		SD-38
Grounds		
G30		SD-38
G32		SD-38

FUEL FILTER HEATING SYSTEM

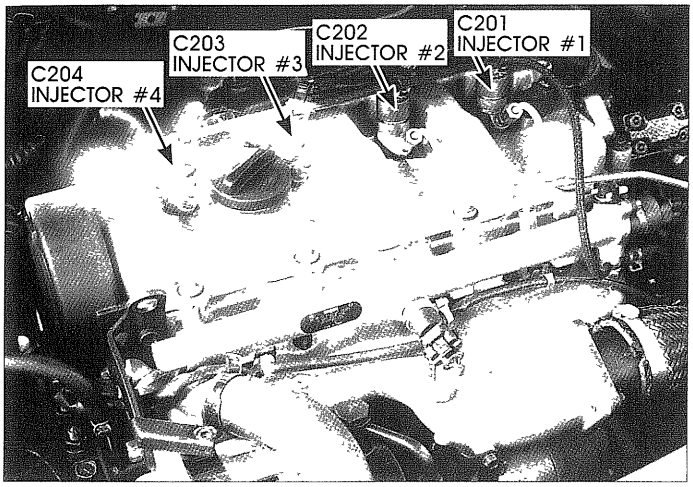


COMPONENT LOCATION INDEX

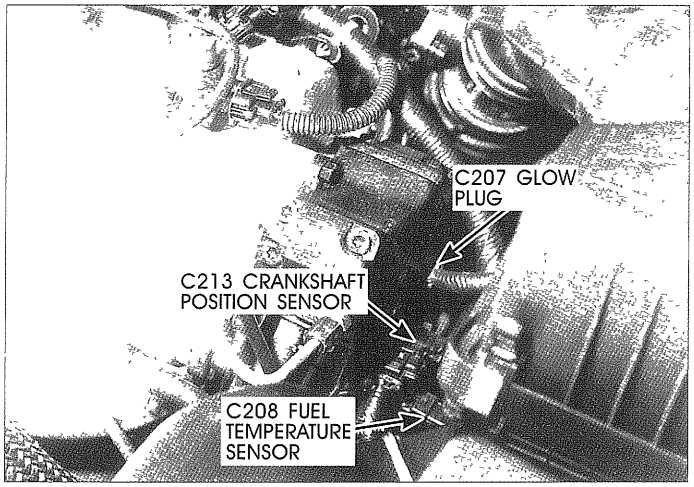
Components		Location reference-page
C220	Fuel filter relay #1	SD-37
C225	Fuel filter relay #2	SD-37
C227	Fuel filter heater	SD-37
C228	Fuel filter sensor	SD-37
Connectors		
MC21		SD-38
Grounds		
G32		SD-38

COMPONENT LOCATION

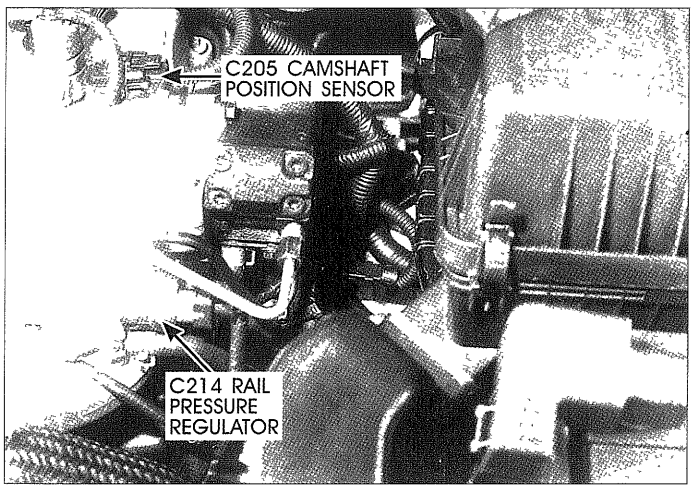
COMPONENT LOCATION(1)



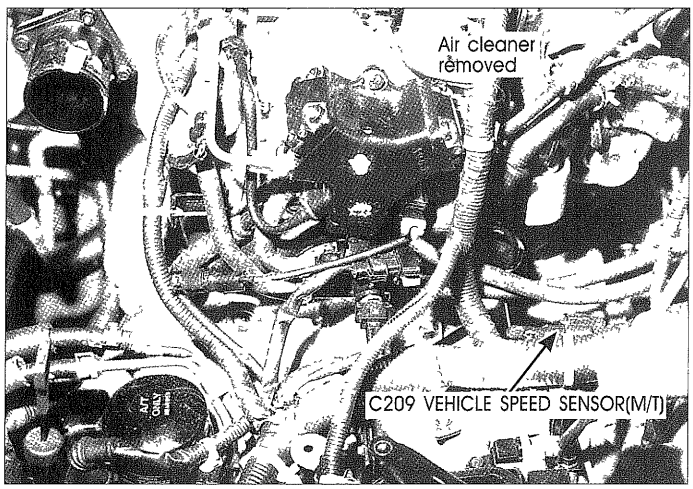
C201,C202,C203,C204 E3DA001T



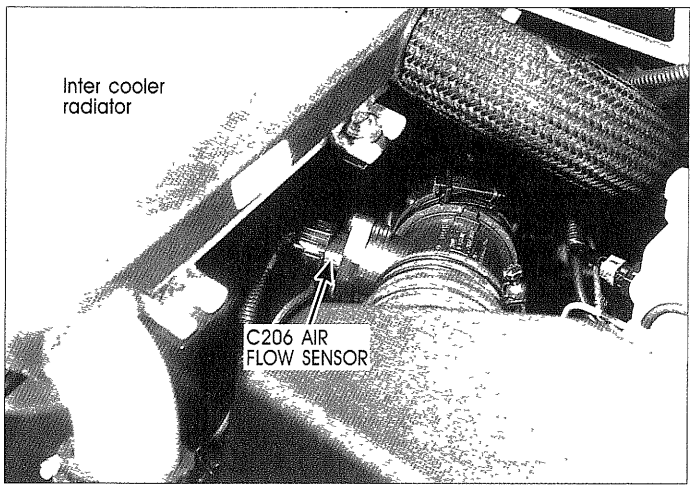
C207,C208,C213 E3DA001W



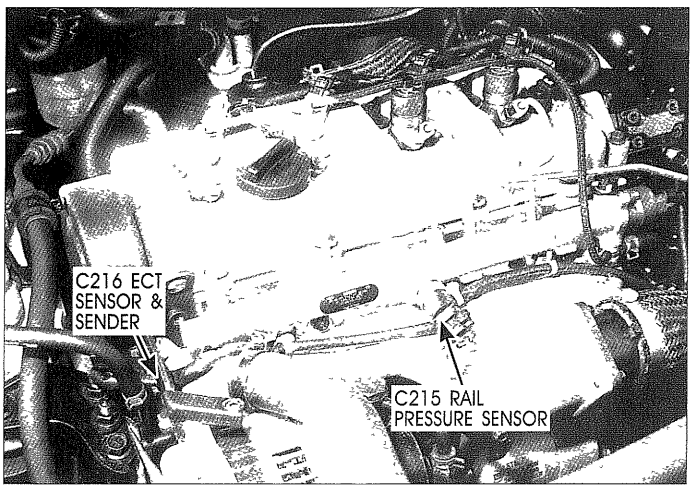
C205,C214 E3DA001U



C209 E3DA001X

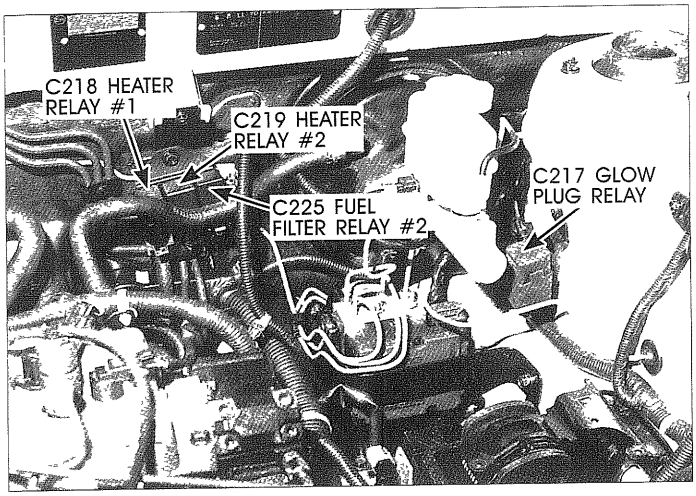


C206 E3DA001V

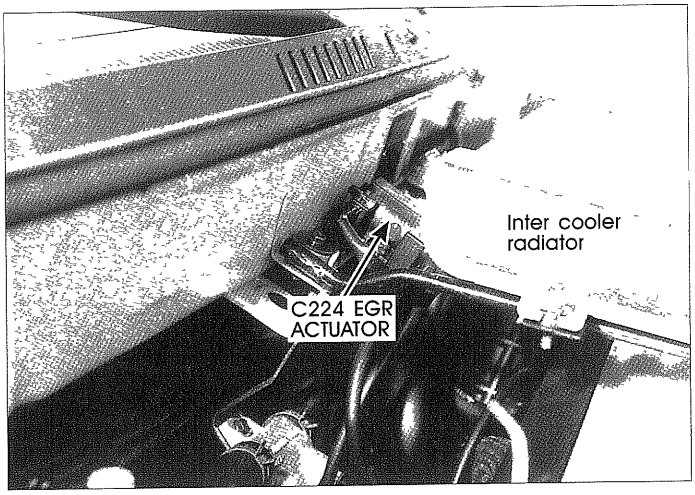


C215,C216 E3DA001Y

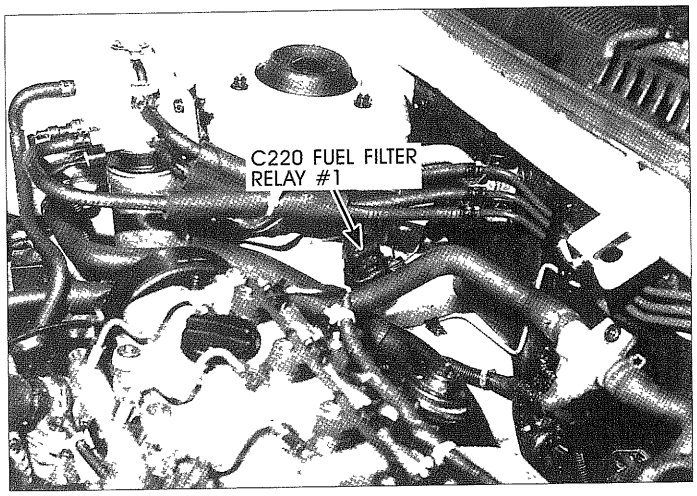
COMPONENT LOCATION(2)



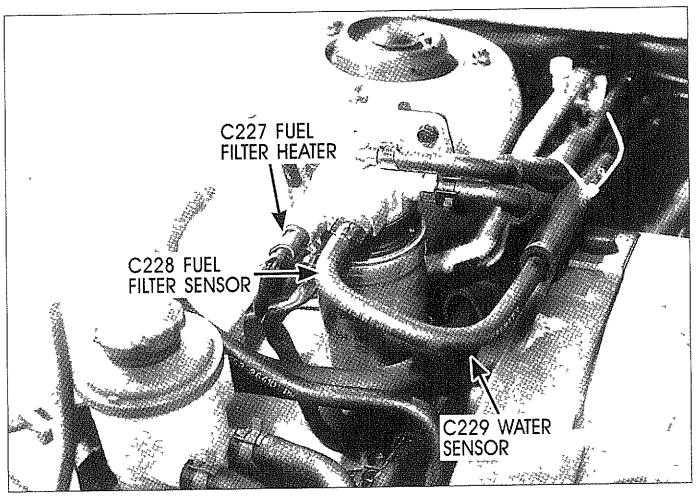
C217,C218,C219,C225 E3DA001Z



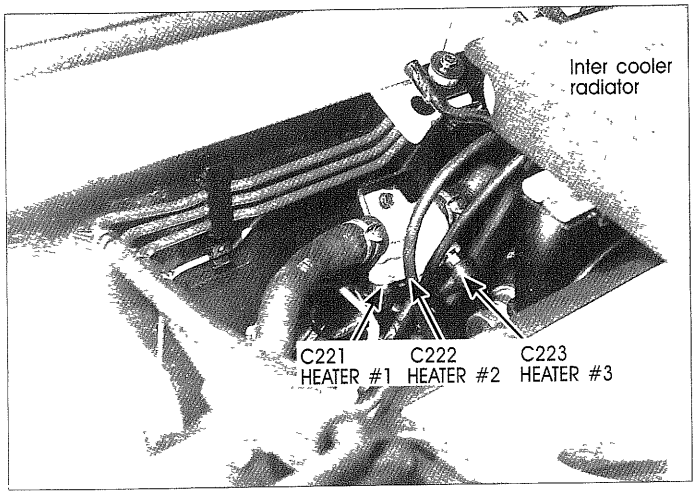
C224 E3DA002C



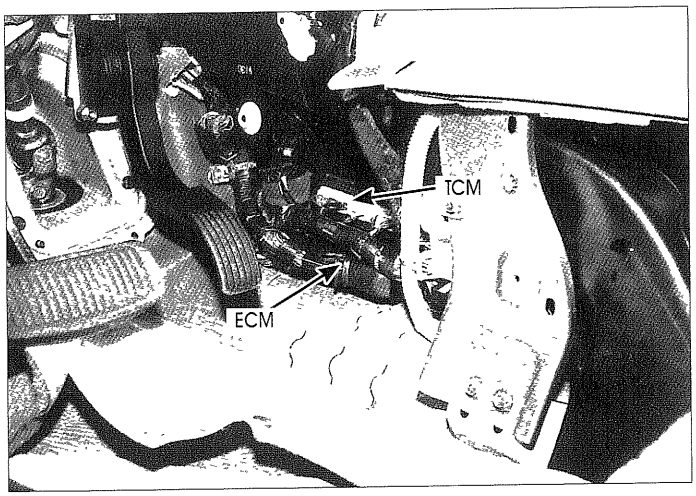
C220 E3DA002A



C227,C228,C229 E3DA002D

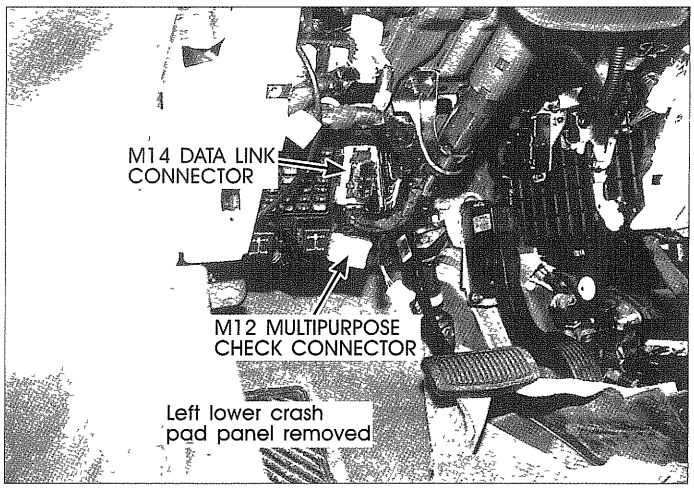


C221,C222,C223 E3DA002B

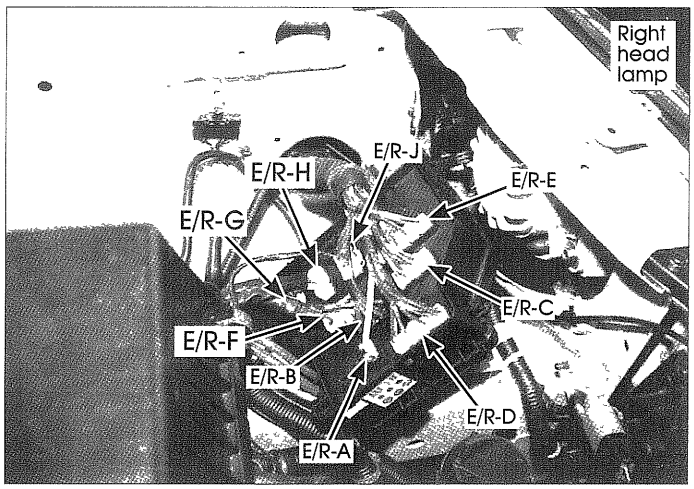


C230-1,C230-2,C235-1,C235-2,C235-3 E3DA002E

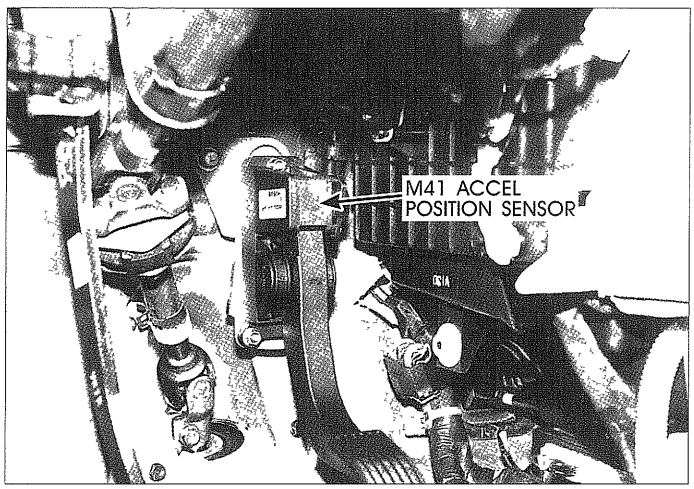
COMPONENT LOCATION(3)



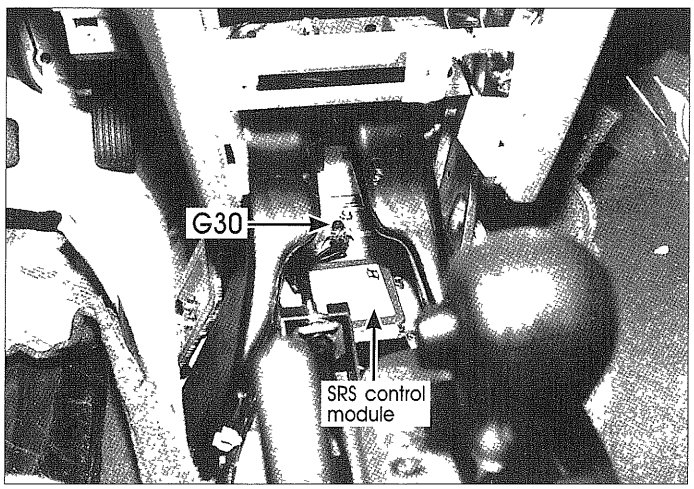
M12,M14 E3DA002F



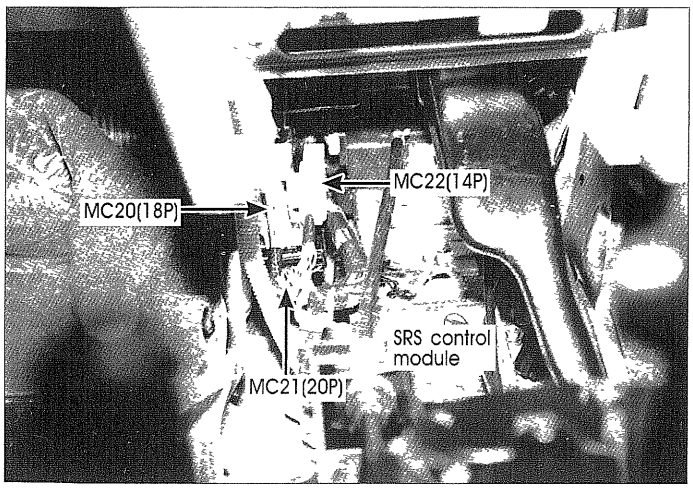
E/R-F,E/R-G,E/R-H E3DA002J



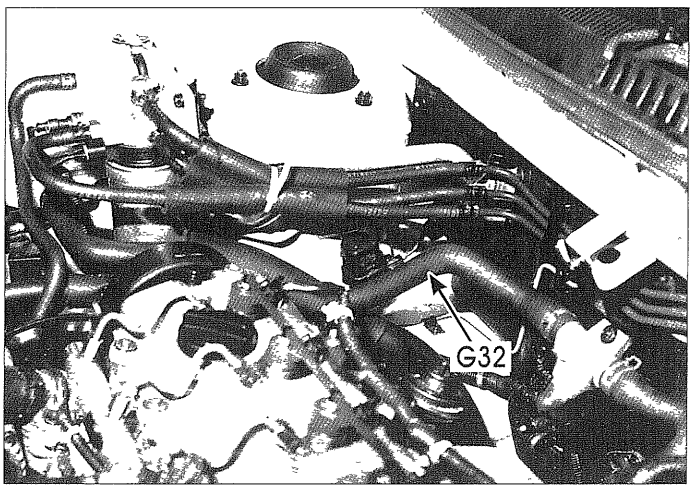
M41 E3DA002G



G30 E3DA002K



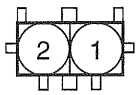
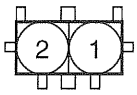
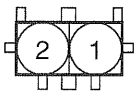
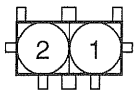
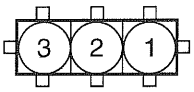
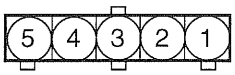
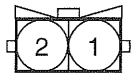
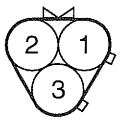
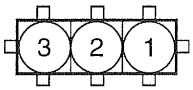
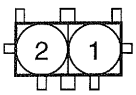
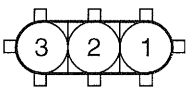
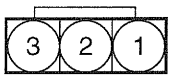
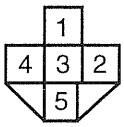
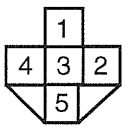
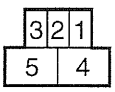
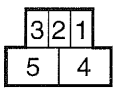
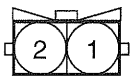
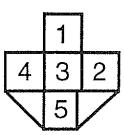
MC20,MC21,MC22 E3DA002H



G32 E3DA002L

CONNECTOR CONFIGURATION

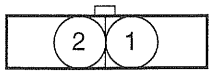
CONNECTOR CONFIGURATION (1)

C201  CR02F121	**C202**  CR02F121	**C203**  CR02F121	**C204**  CR02F121
C205  CR03F082	**C206**  CR05F032	**C207**  CR01F039	**C208**  CR02F041
C209  CR03F020	**BLANK**	**BLANK**	**C213**  CR03F082
C214  CR02F121	**C215**  CR03F084	**C216**  CR03F071	**C217**  CR05F031
C218  CR05F031	**C219**  CR05F003	**C220**  CR05F003	**C221**  CR01F002
C222  CR01F002	**C223**  CR02F002	**C224**  CR02F041	**C225**  CR05F031

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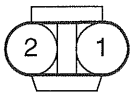
CONNECTOR CONFIGURATION (2)

C227



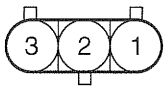
CR02F122

C228



CR02F123

C229



CR03F083

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C230-1

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	5	4
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	3	
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62		
63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	2	1

CR81F002

C230-2

40	39	38	32	31	30	29	28	27	26	25
37		36	24	23	22	21	20	19	18	17
			16	15	14	13	12	11	10	9
35	34	33	8	7	6	5	4	3	2	1

CR40F003

C235-1

13	12	11	10	9	8	7	6	5	4	3	2	1
26	25	24	23	22	21	20	19	18	17	16	15	14

CR26F006

C235-2

8	7	6	5	4	3	2	1
16	15	14	13	12	11	10	9

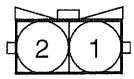
CR16F016

C235-3

11	10	9	8	7	6	5	4	3	2	1
22	21	20	19	18	17	16	15	14	13	12

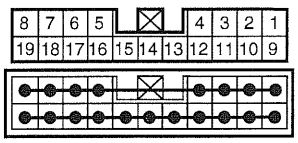
CR22F004

C237



CR02F041

C238



CR19B005

E/R-F

4	3					2	1
11	10	9	8	7	6	5	

CR11F005

E/R-G

8	7	6	5			4	3	2	1
18	17	16	15	14	13	12	11	10	9

CR18F001

E/R-H

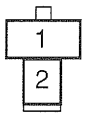
6	5	4			3	2	1
14	13	12	11	10	9	8	7

CR14F019

K2DA005B

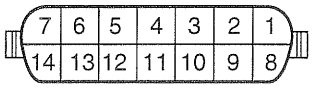
CONNECTOR CONFIGURATION (3)

M04



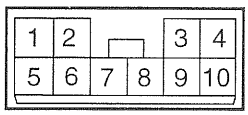
CR02F051

M28



CR14F021

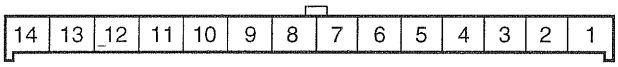
M29



CR10M003

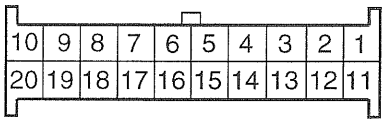
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M30-1



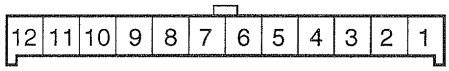
CR14F007

M30-2



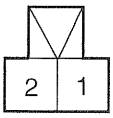
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M30-3



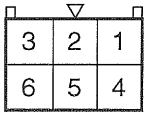
CR12F001

M37



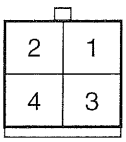
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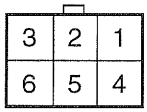
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M44



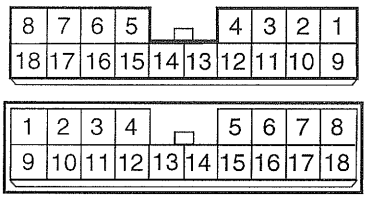
CR04F016

M57



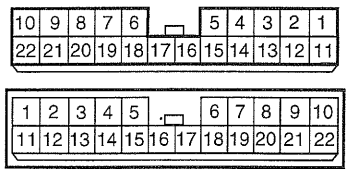
CR06F002

MC20



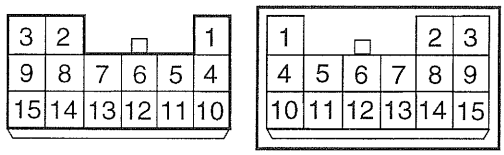
CR18B005

MC21



CR22B006

MC22



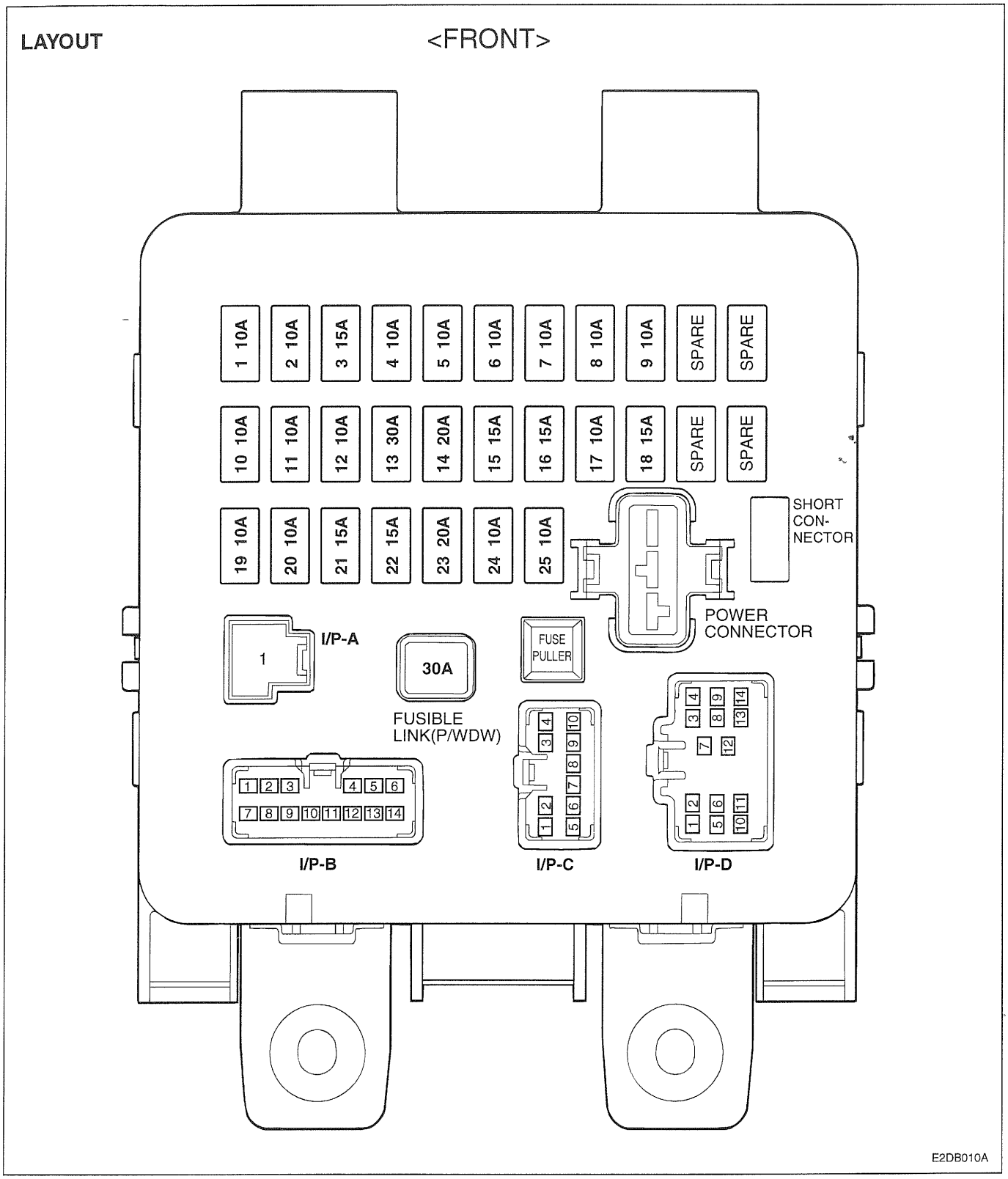
CR15B002

K2DA005C

FUSE AND RELAY INFORMATION

PASSENGER COMPARTMENT JUNCTION BLOCK

LAYOUT

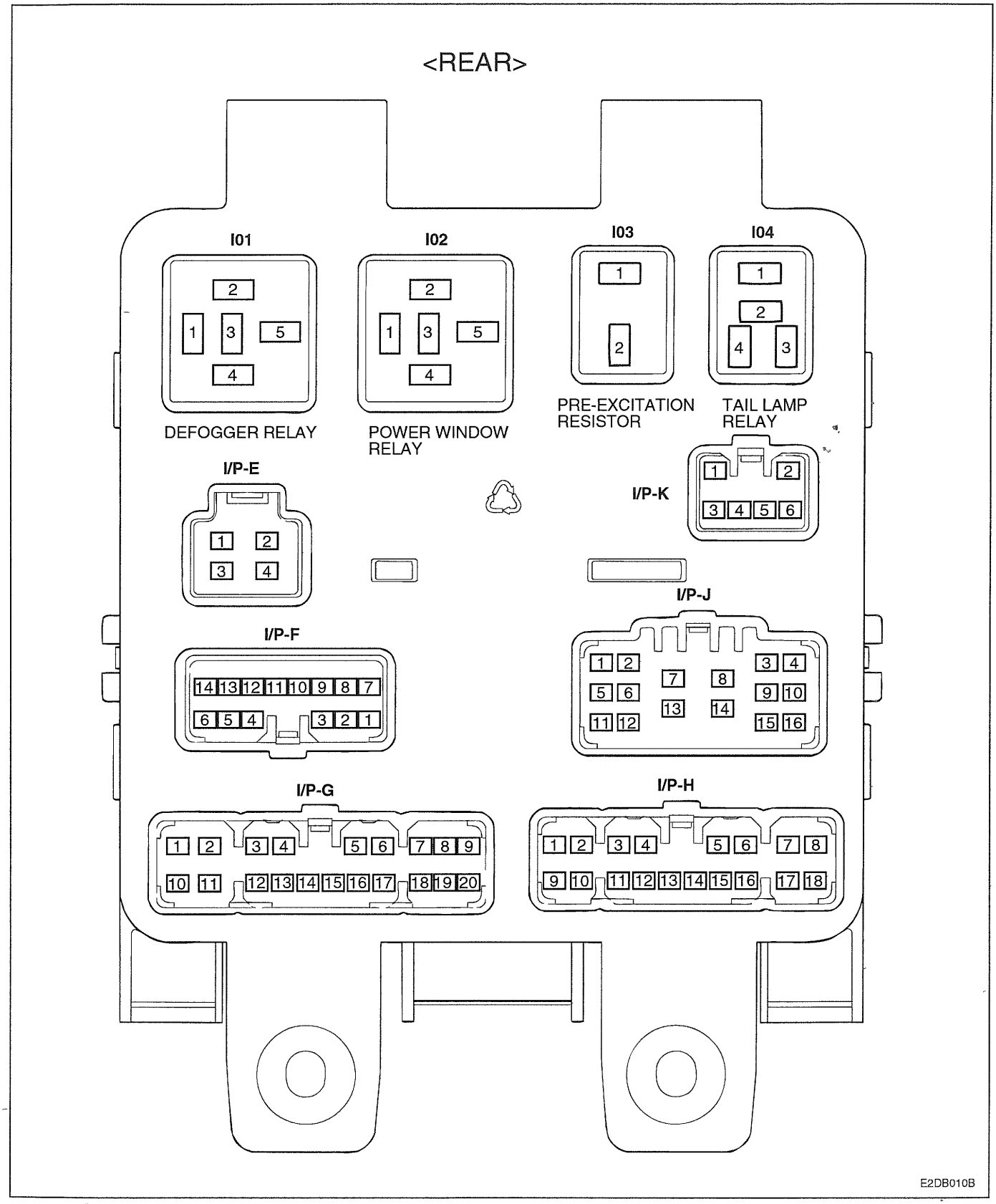


CIRCUIT

Description	NO.	Amperages	Circuit Protected
FUSE	1	10A	Hazard switch, Transaxle range switch, Back-up lamp switch
	2	10A	Pre-excitation resistor, Instrument cluster, ETACM, TACM, DRL module, Generator
	3	15A	SRS control
	4	10A	Hazard relay, ECM, Siren
	5	10A	Blower relay, Blower motor
	6	10A	Short connector, Illumination lamps, Head lamp, Head lamp washer
	7	10A	Head lamp, Exterior lamps
	8	10A	B/Alarm relay, Transaxle range switch, Starting
	9	10A	Digital clock, Power outside mirror switch, Audio
	10	10A	Cruise control, ECM, TCM, Vehicle speed
	11	10A	ABS control
	12	10A	Instrument cluster
	13	30A	Defogger relay
	14	20A	Power antenna
	15	15A	Door lock control module, Left front door lock actuator, sunroof
	16	15A	Stop lamp switch, Power window relay
	17	10A	Rear window & outside mirror defogger
	18	15A	Cigarette lighter
	19	10A	Rear fog lamp relay
	20	10A	Fuel filter heating
	21	15A	Rear wiper & washer
	22	15A	Front wiper & washer
	23	20A	Seat warmer
	24	10A	A/C control module, Blower relay, ETACM, TACM, Sunroof relay
	25	10A	Door lamps, Instrument cluster, Data link connector, Multipurpose check connector, Room lamps, ETACM, TACM, Audio, A/C control, Power connector
Fusible Link	P/WDW	30A	Power window relay

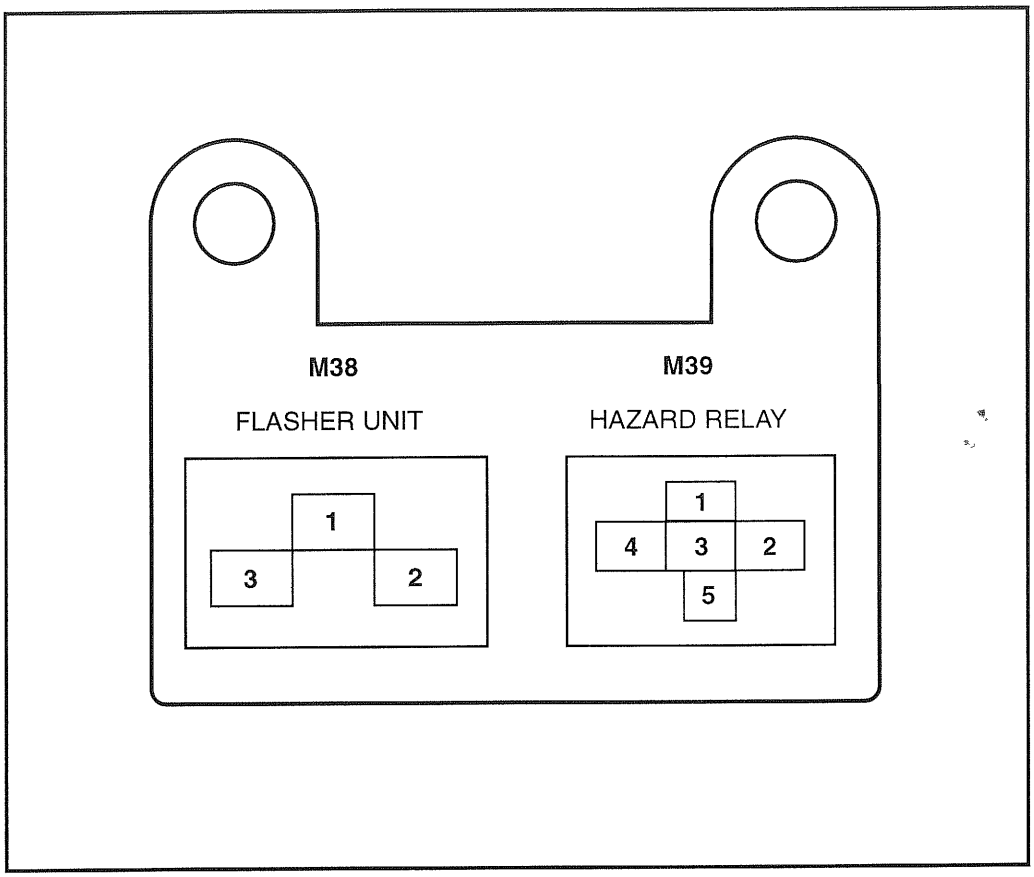
E2DB010E

LAYOUT


<REAR>
I01
I02
I03
I04
DEFOGGER RELAY
POWER WINDOW RELAY
PRE-EXCITATION RESISTOR
TAIL LAMP RELAY
I/P-E
I/P-K
I/P-J
I/P-F
I/P-G
I/P-H
E2DB010B

PASSENGER COMPARTMENT RELAY BOX

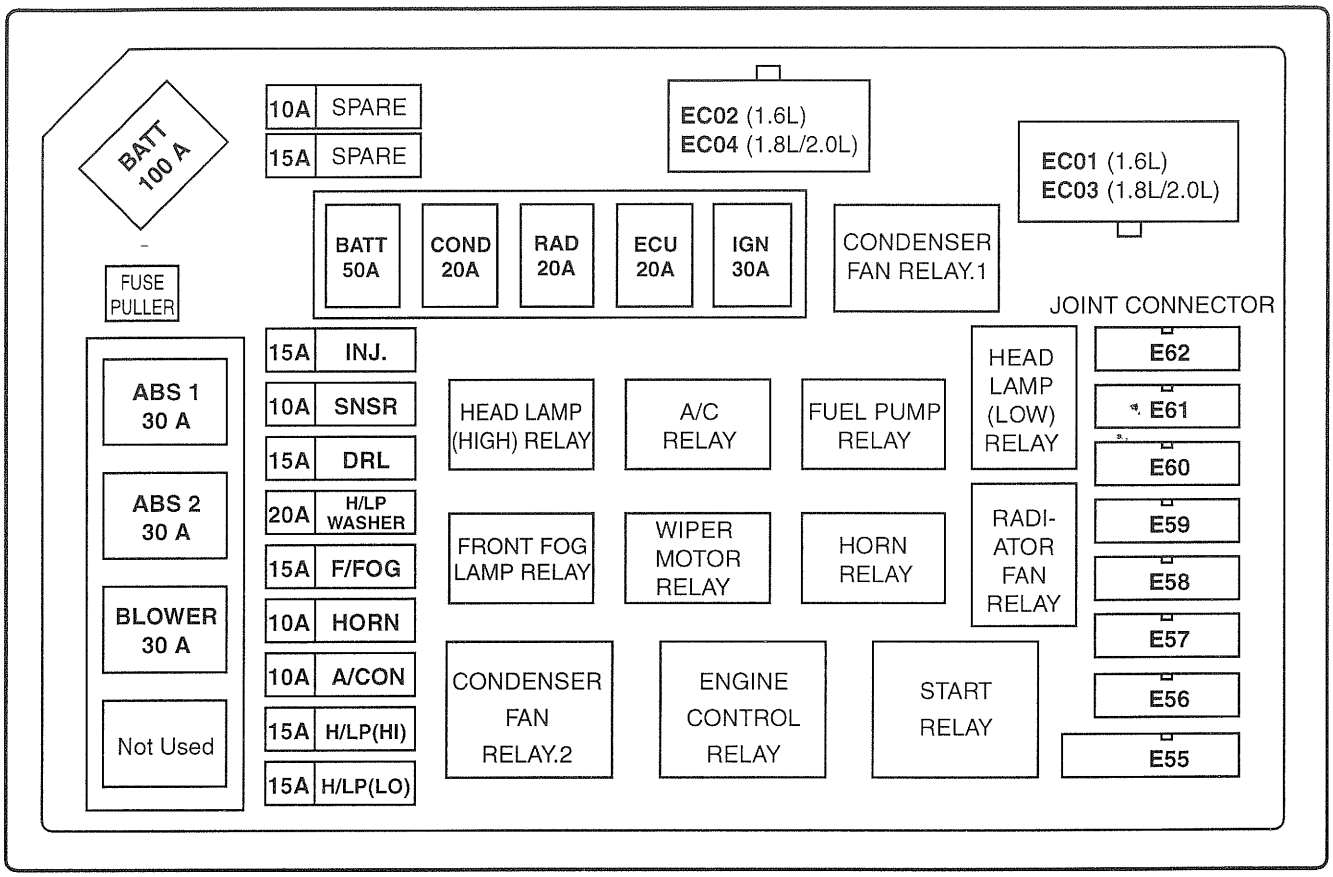
LAYOUT



E2DB010C

ENGINE COMPARTMENT RELAY AND FUSE BOX

LAYOUT



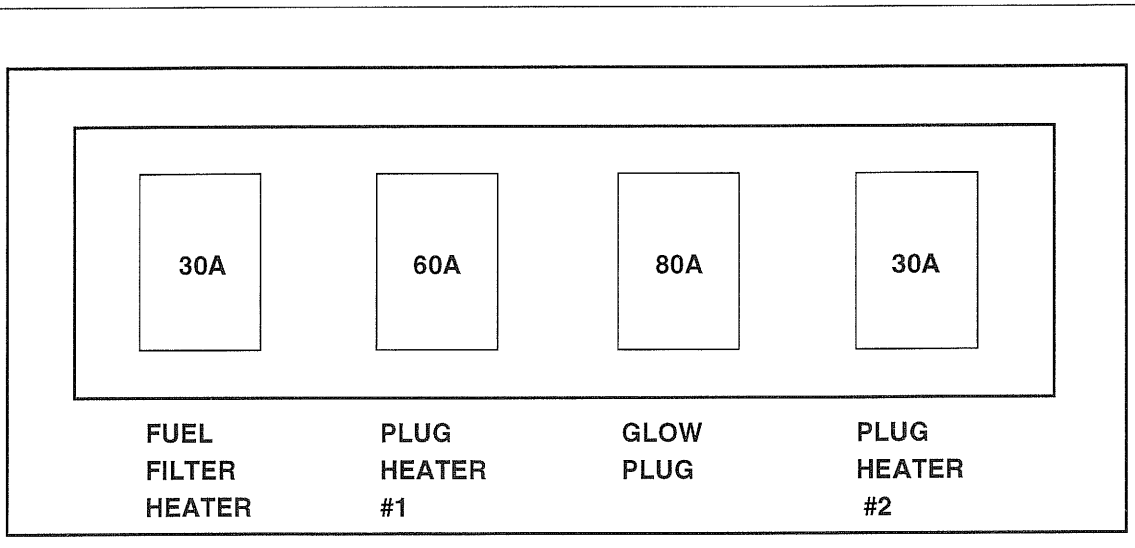
E2DB010D

CIRCUIT

Description		Amperages	Circuit Protected
Fusible Link	BATT	100A	Generator
	BATT	50A	Fusible link(P/WDW), Tail lamp relay, Power connector, Fuse (4,13,14,15,16)
	COND	20A	Condenser fan relay.1
	RAD	20A	Radiator fan relay
	ECU	20A	Generator, Engine control relay, Fuel pump relay, ECM
	IGN	30A	Ignition switch, Start relay
	ABS.1	30A	ABS control
	ABS.2	30A	ABS control
	BLOWER	30A	Blower relay
FUSE	INJ.	15A	Injectors, Idle speed actuator, CMP, Canister purge valve
	SNSR	10A	ECM, Heated oxygen sensor, SMATRA
	DRL	15A	DRL control
	H/LP WASHER	20A	Head lamp washer
	F/FOG	15A	Front fog lamp relay
	HORN	10A	Horn relay, TCM
	A/CON	10A	A/C relay
	H/LP(HI)	15A	Head lamp relay (High)
	H/LP(LO)	15A	Head lamp relay (Low)

E2DB010F

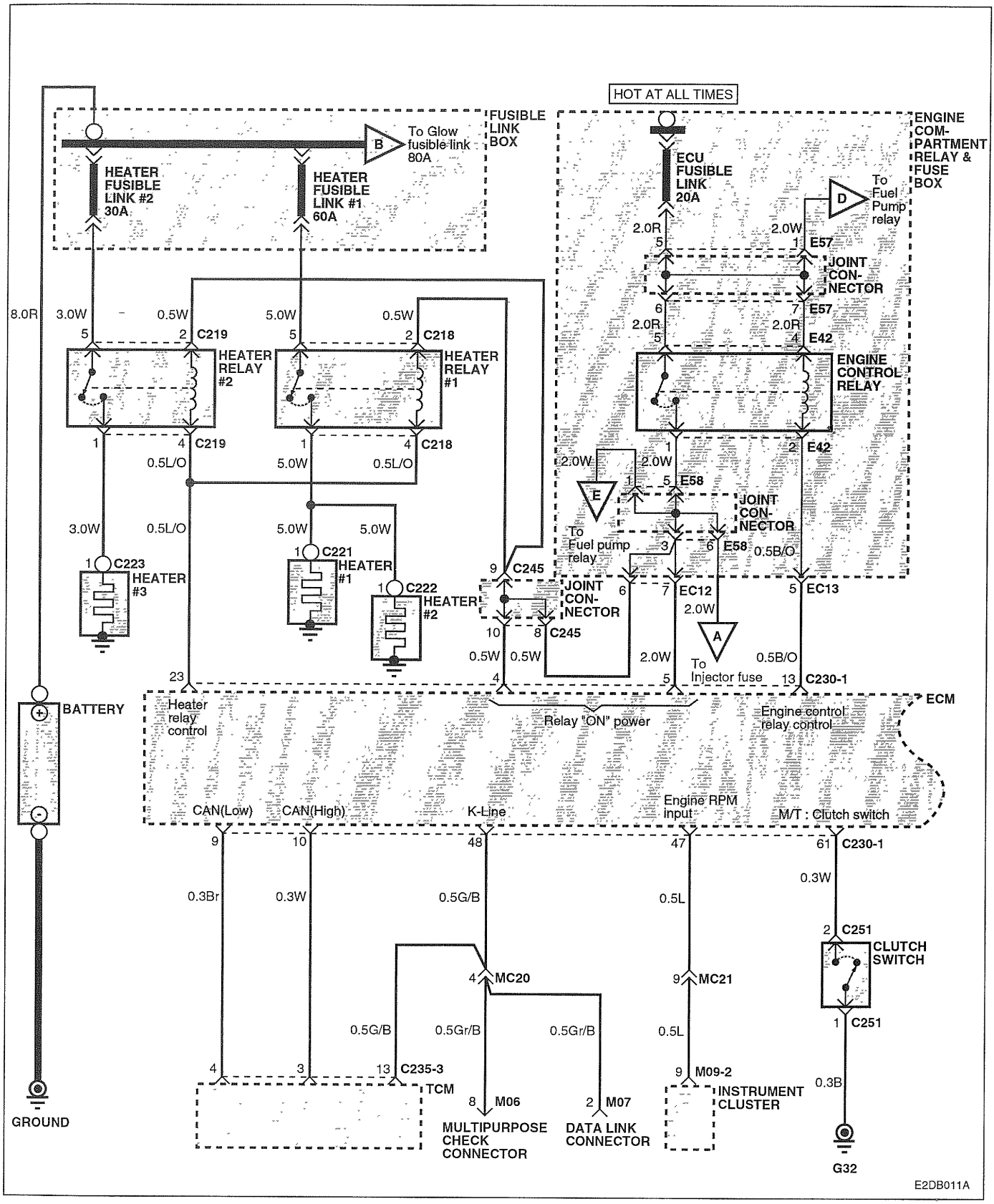
FUSIBLE LINK BOX



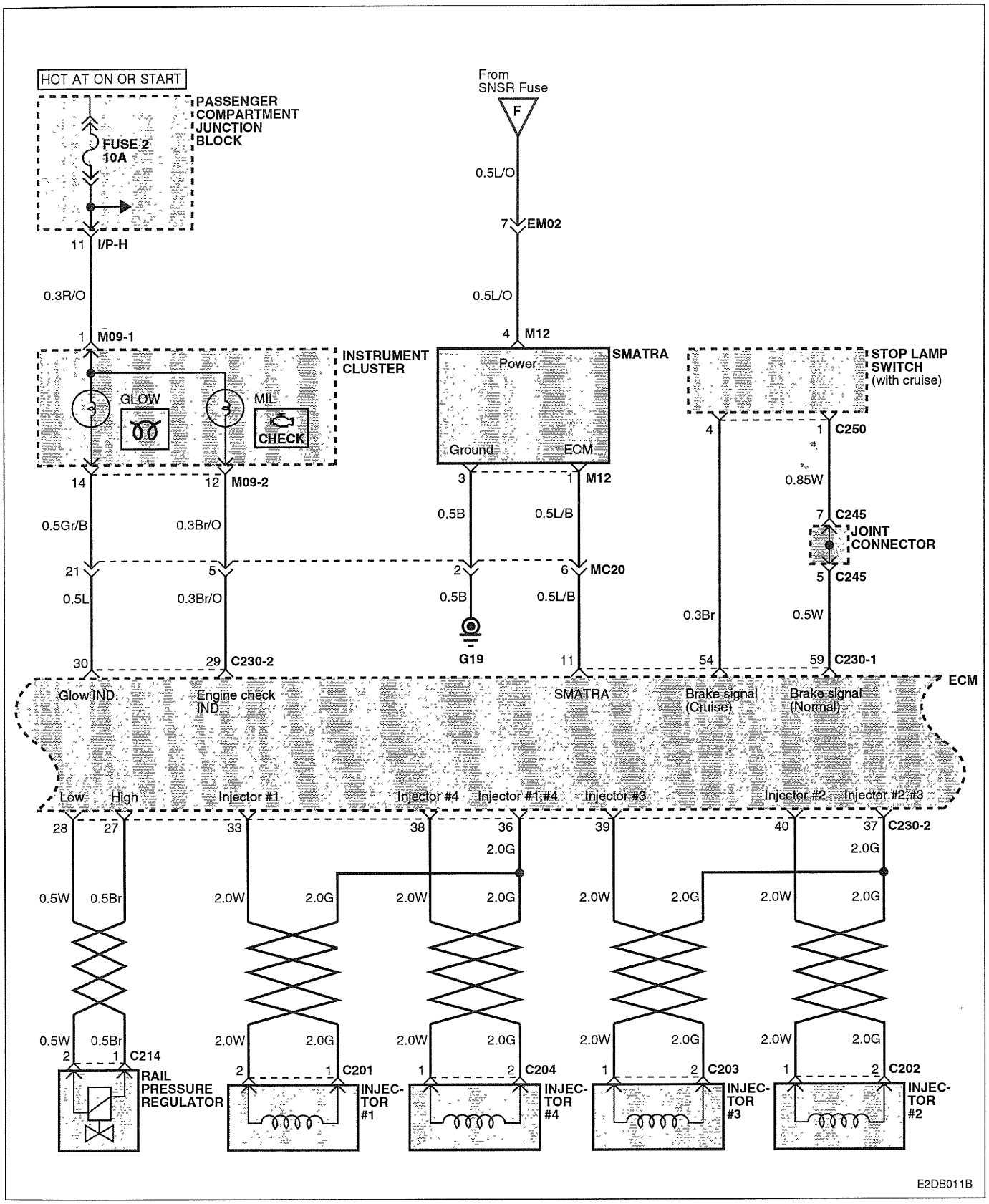
E2DB007F

ENGINE CONTROL SYSTEM

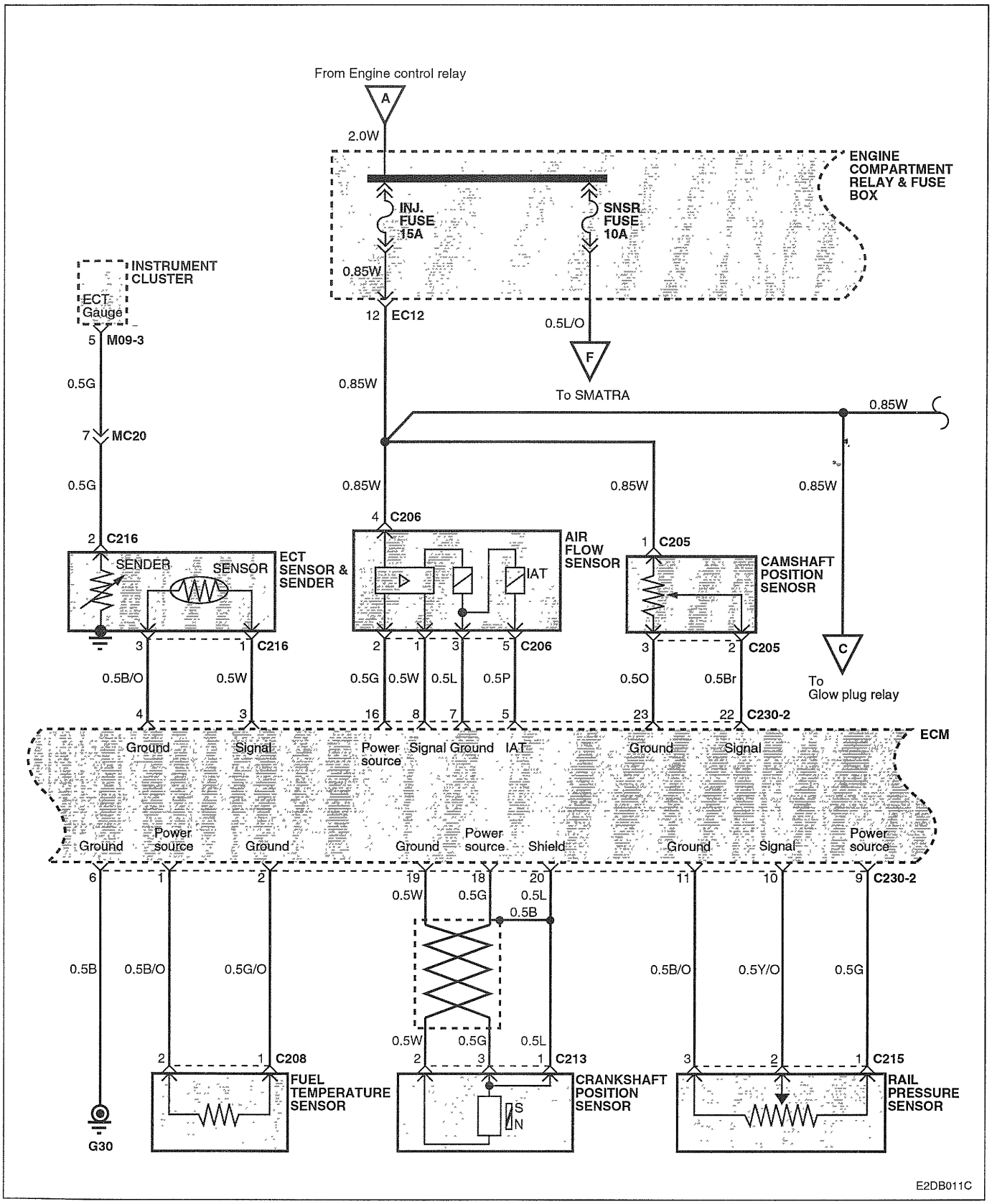
ENGINE CONTROL SYSTEM (1)



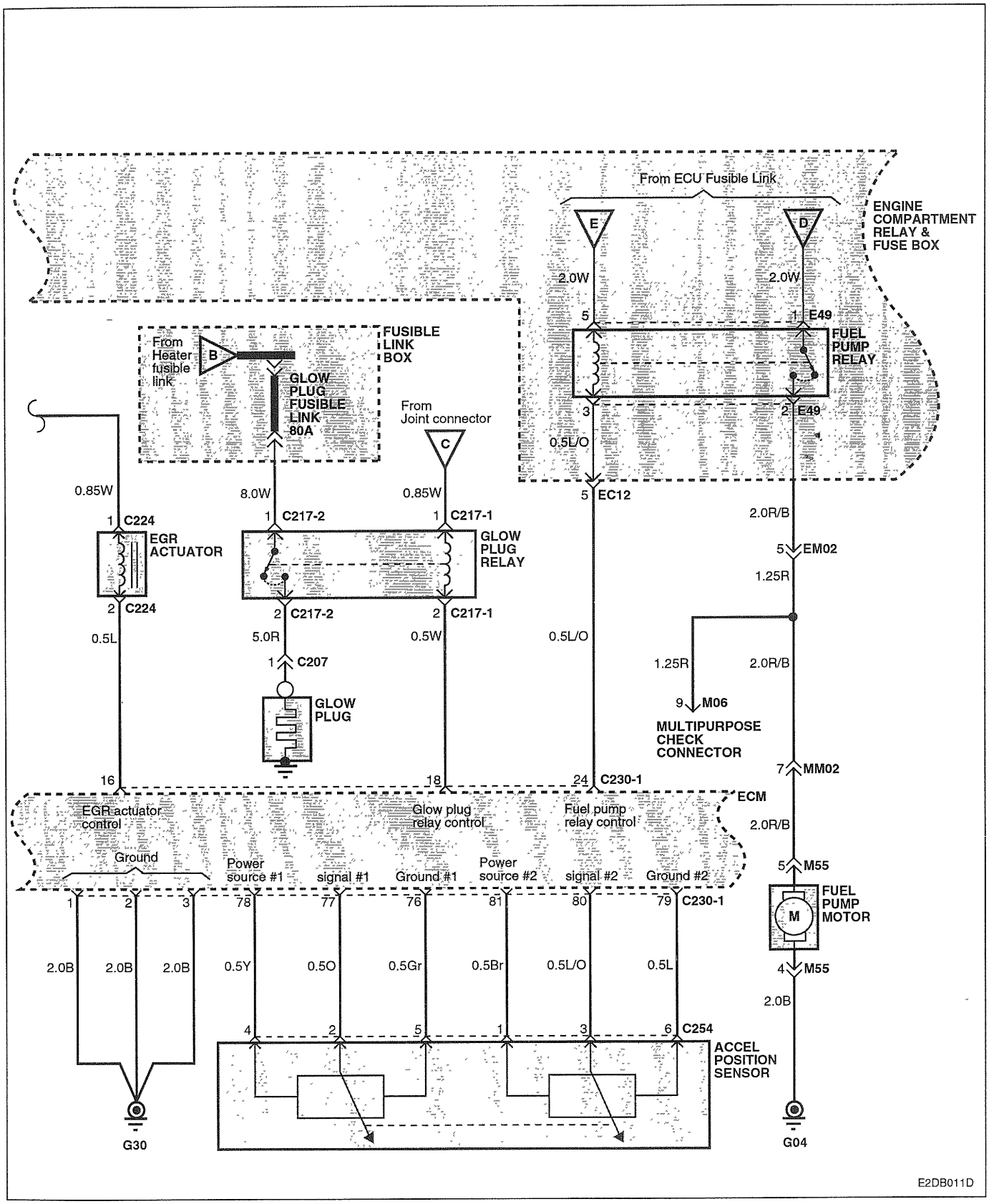
ENGINE CONTROL SYSTEM (2)



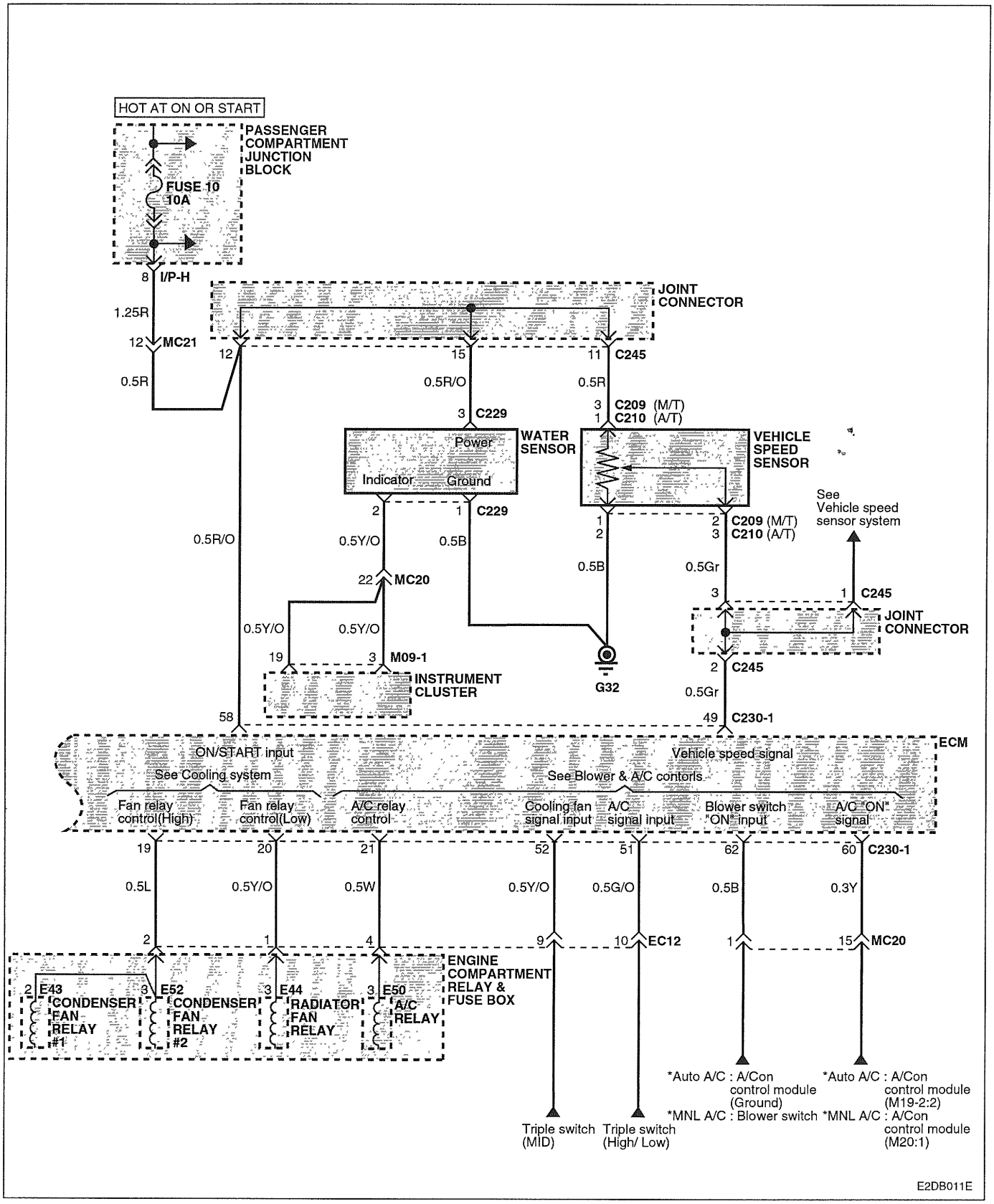
ENGINE CONTROL SYSTEM (3)



ENGINE CONTROL SYSTEM (4)



ENGINE CONTROL SYSTEM (5)

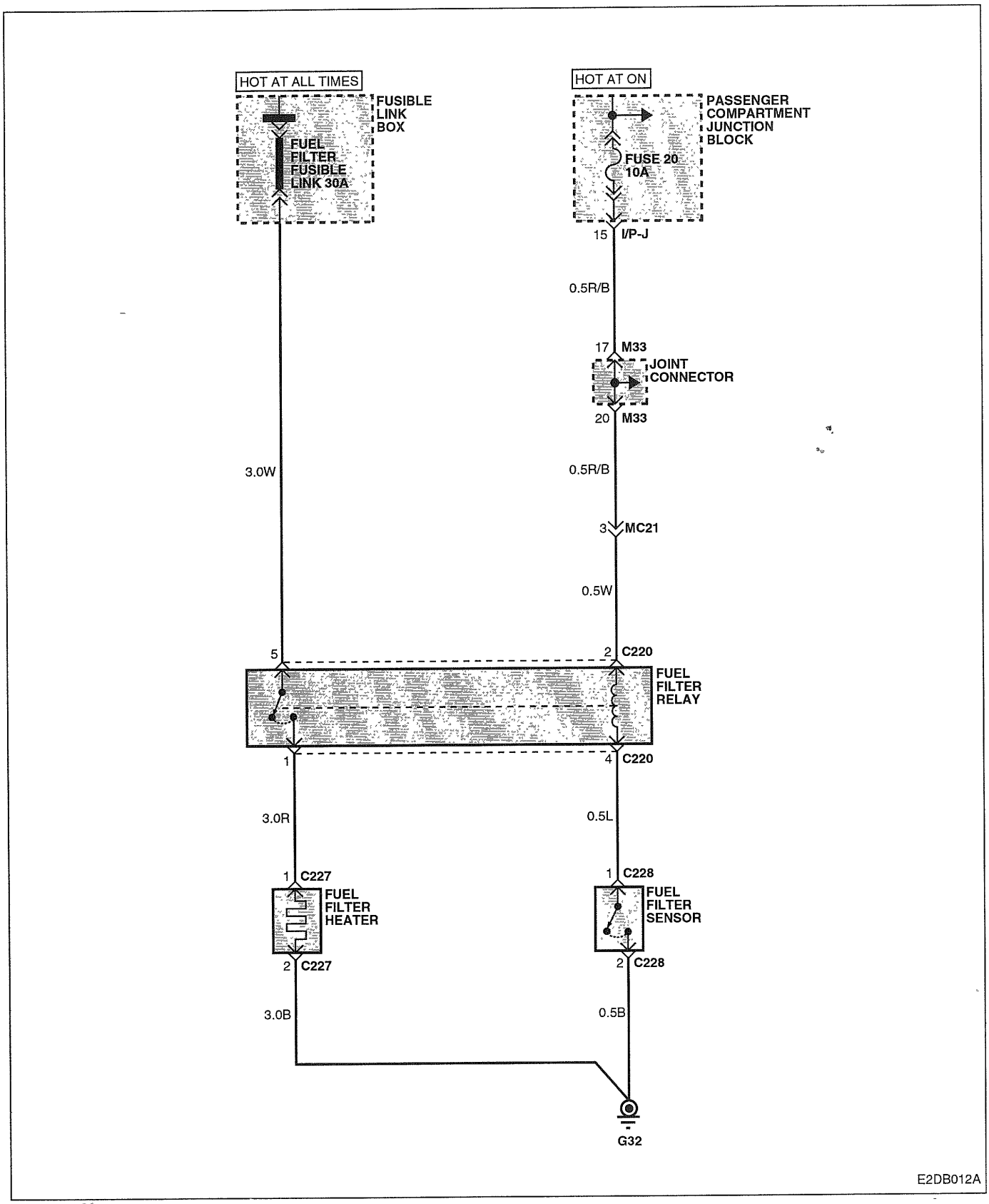


COMPONENT LOCATION INDEX

Components		Location reference-page
C201	Injector #1	SD-56
C202	Injector #2	SD-56
C203	Injector #3	SD-56
C204	Injector #4	SD-56
C205	Camshaft position sensor	SD-56
C206	Air flow sensor	SD-56
C207	Glow plug	SD-56
C208	Fuel temperature sensor	SD-56
C209	Vehicle speed snesor	SD-56
C213	Crankshaft position sensor	SD-56
C214	Rail pressure regulator	SD-56
C215	Rail pressure sensor	SD-56
C216	ECT sensor & sender	SD-56
C217-1	Glow plug relay	SD-57
C217-2	Glow plug relay	SD-57
C218	Heater relay #1	SD-57
C219	Heater relay #2	SD-57
C221	Heater #1	SD-57
C222	Heater #2	SD-57
C223	Heater #3	SD-57
C224	EGR actuator	SD-57
C229	Water sensor	SD-57
C230-1	ECM	SD-57
C230-2	ECM	SD-57
C235-3	TCM	SD-57
C254	Accel position sensor	SD-57
M06	Multipurpose check connector	SD-57
M07	Data link connector	SD-57

Connectors	
EC12	SD-58
MC20	SD-58
MC21	SD-58
MM02	SD-58

FUEL FILTER HEATING SYSTEM

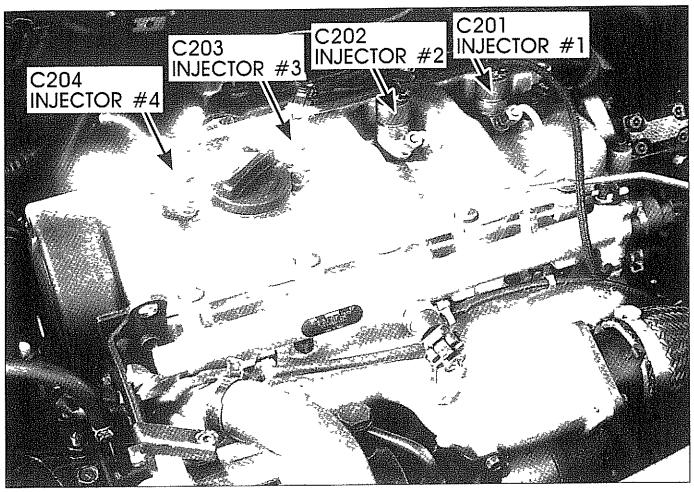


COMPONENT LOCATION INDEX

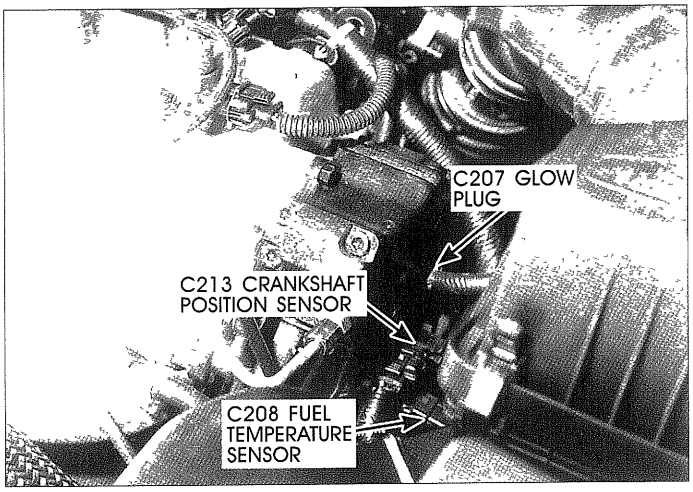
Components		Location reference-page
C220	Fuel filter relay	SD-57
C227	Fuel filter heater	SD-57
C228	Fuel filter sensor	SD-57
Connectors		
I/P-J		SD-58
MC21		SD-58

COMPONENT LOCATION

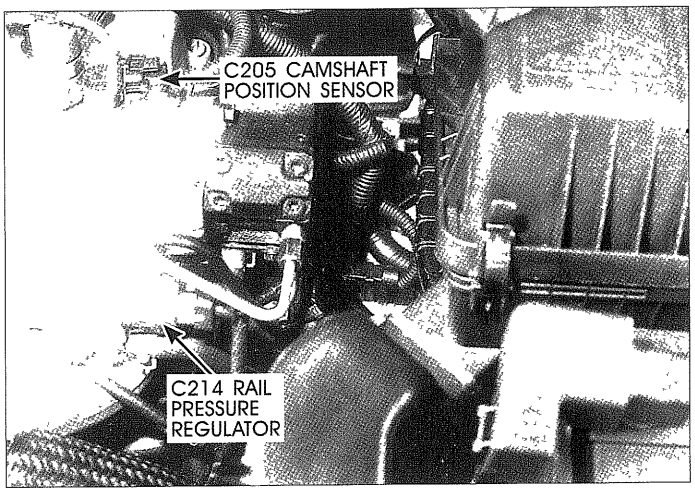
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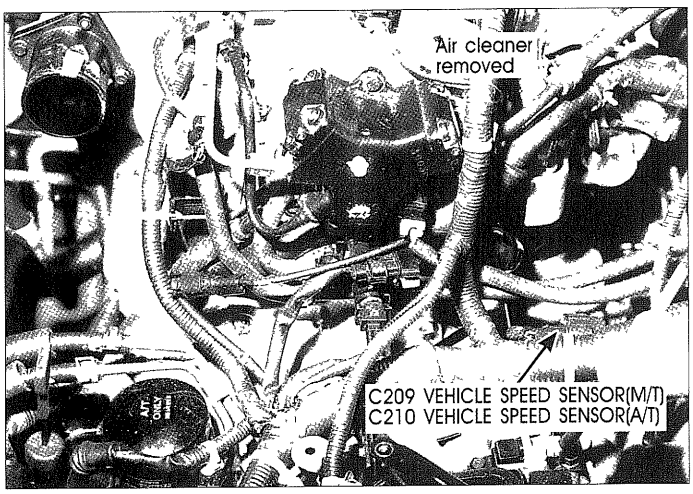
C201,C202,C203,C204 E3DA002M



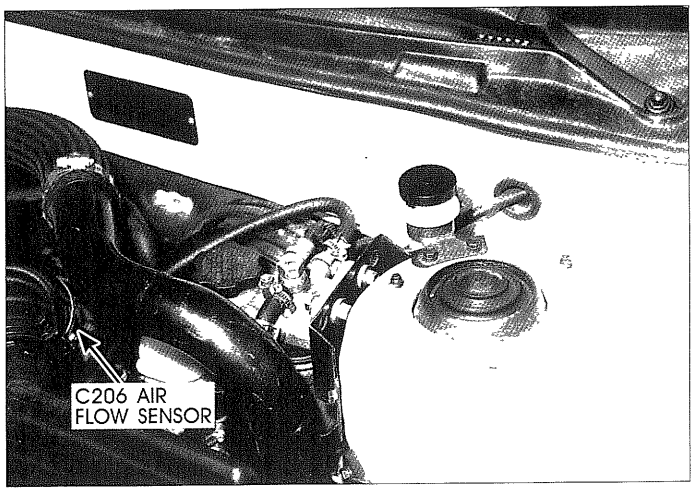
C207,C208,C213 E3DA002P



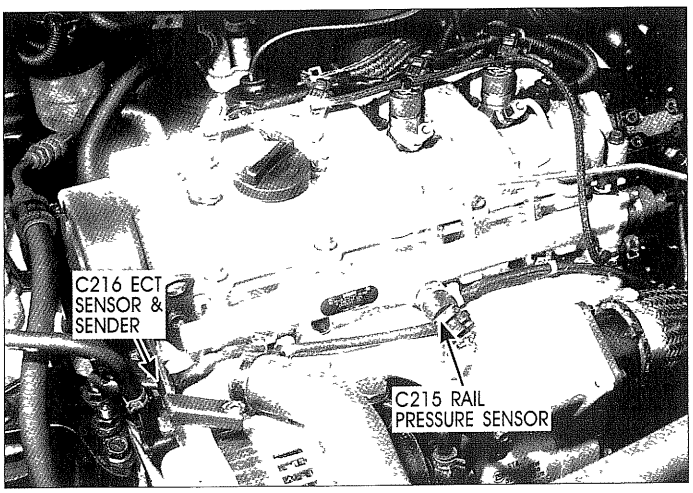
C205,C214 E3DA002N



C209,C210 E3DA002Q

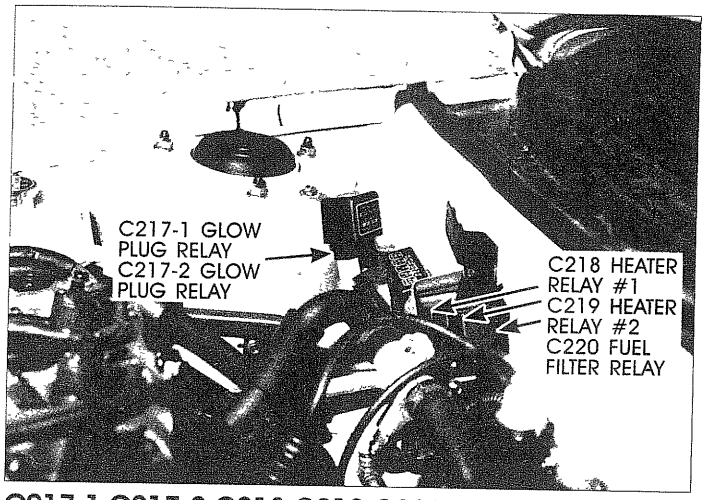


C206 E3DA002O

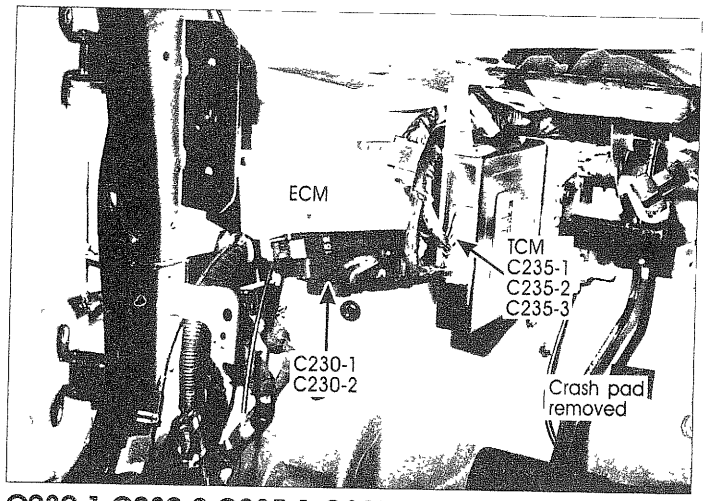


C215,C216 E3DA002R

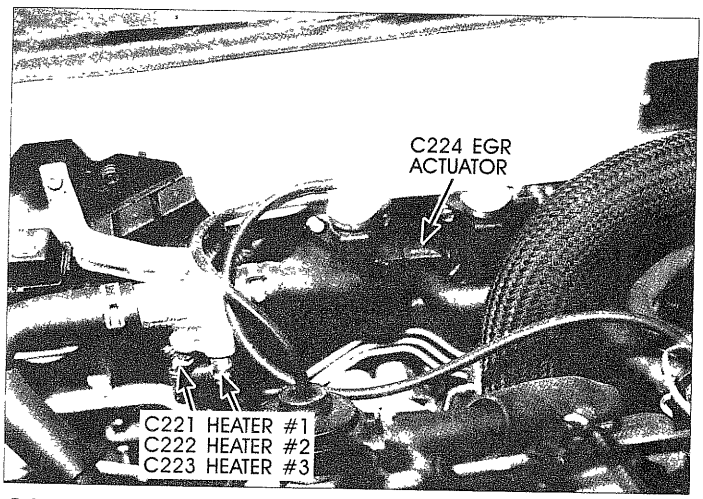
COMPONENT LOCATION(2)



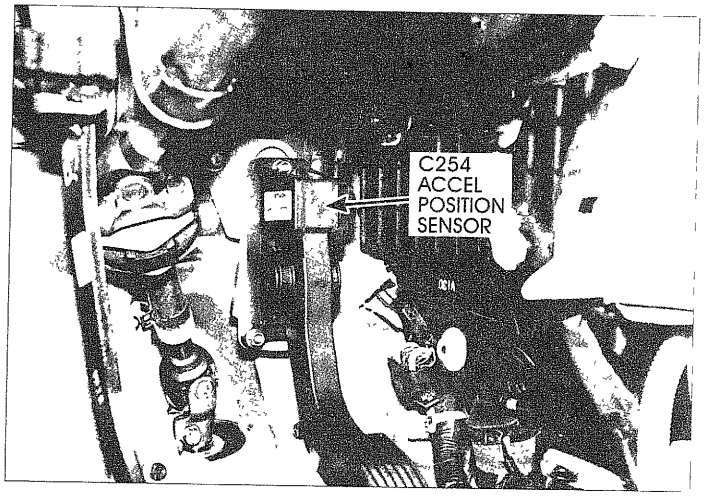
C217-1,C217-2,C218,C219,C220 E3DA002S



C230-1,C230-2,C235-1,C235-2,C235-3 E3DA002V



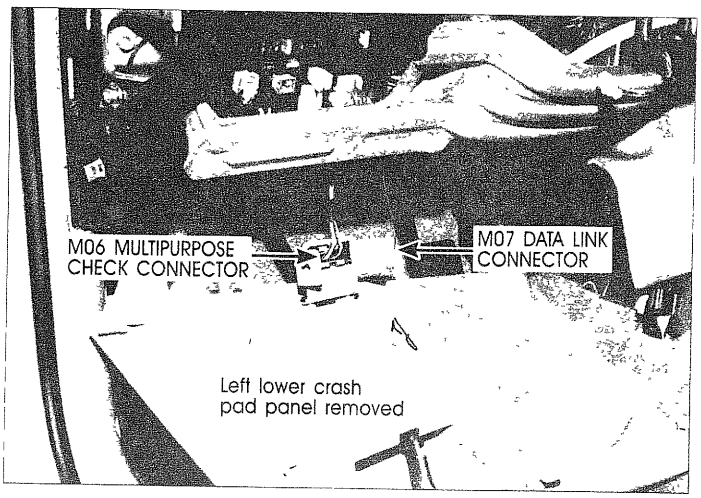
C221,C222,C223,C224 E3DA002T



C254 E3DA002W

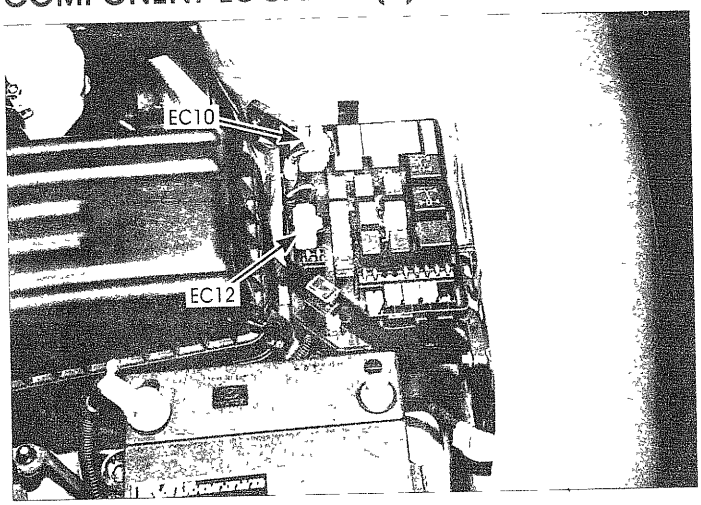


C227,C228,C229 E3DA002U

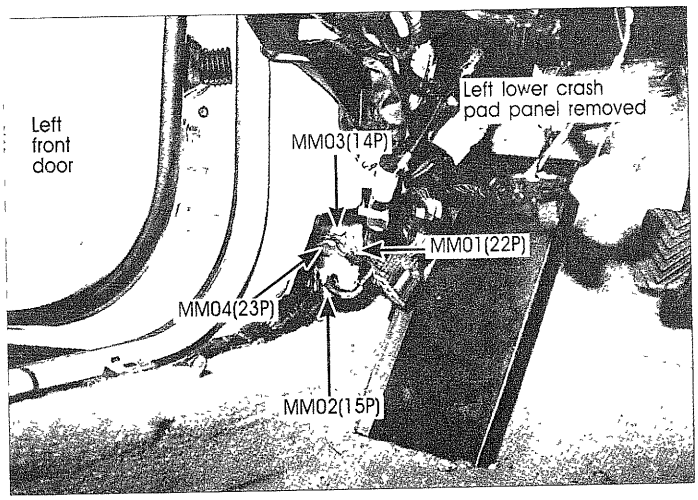


M06,M07 E3DA002X

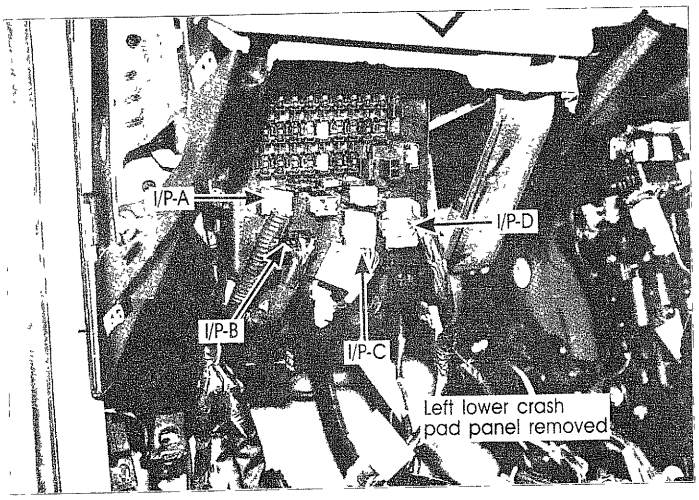
COMPONENT LOCATION(3)



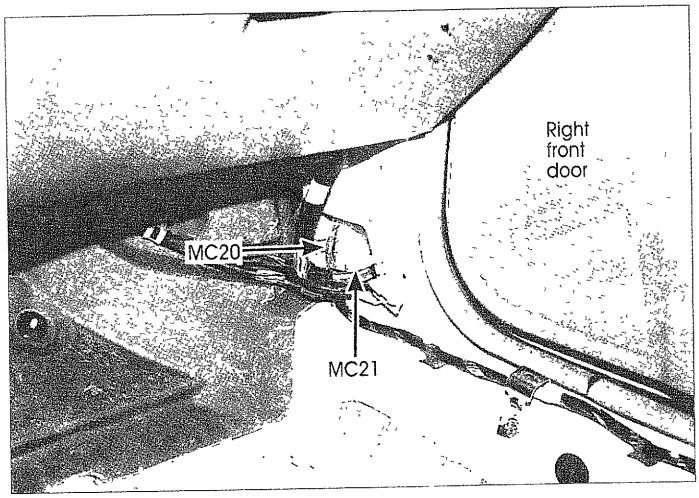
EC10,EC12 E3DA002Y



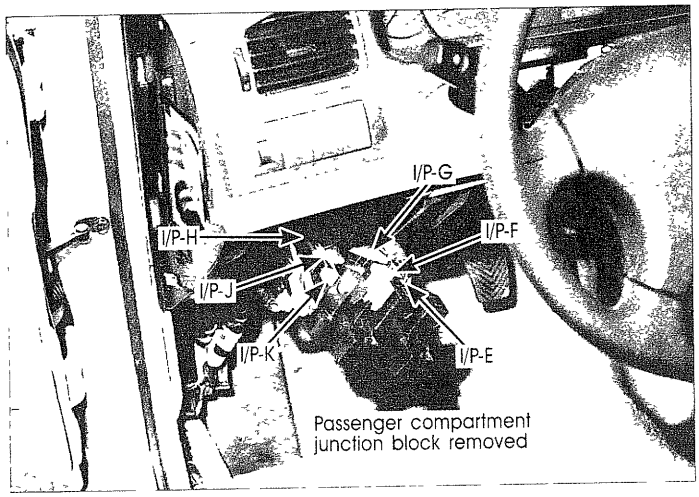
MM01,MM02,MM03,MM04 E3DA003B



I/P-A,B,C,D E3DA002Z



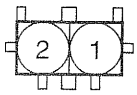
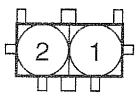
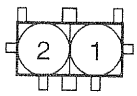
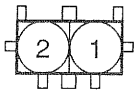
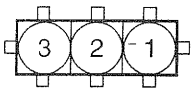
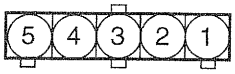
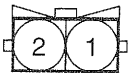
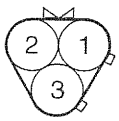
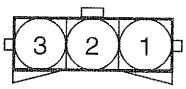
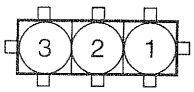
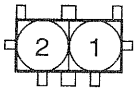
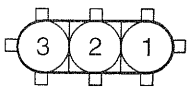
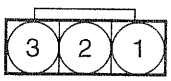
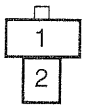
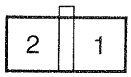
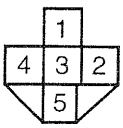
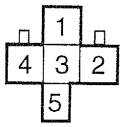
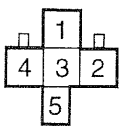
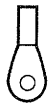
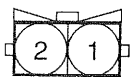
MC20,MC21 E3DA003C



I/P-E,F,G,H,J,K E3DA003A

CONNECTOR CONFIGURATION

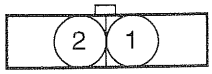
CONNECTOR CONFIGURATION (1)

C201  CR02F121	C202  CR02F121	C203  CR02F121	C204  CR02F121
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C209  CR03F020	C210  CR03F029	C213  CR03F082	C214  CR02F121
C215  CR03F084	C216  CR03F071	C217-1  CR02F012	C217-2  CR02F125
C218  CR05F031	C219  CR05F022	C220  CR05F022	C221  CR01F002
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E2DB013A

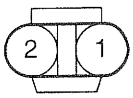
CONNECTOR CONFIGURATION (2)

C227



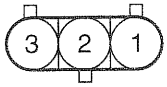
CR02F122

C228



CR02F123

C229



CR03F083

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C230-1

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	5	4
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	3	
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62		
63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	2	1

CR81F002

C230-2

40	39	38	32	31	30	29	28	27	26	25
37		36	24	23	22	21	20	19	18	17
			16	15	14	13	12	11	10	9
35	34	33	8	7	6	5	4	3	2	1

CR40F003

C235-1

13	12	11	10	9	8	7	6	5	4	3	2	1
26	25	24	23	22	21	20	19	18	17	16	15	14

CR26F006

C235-2

8	7	6	5	4	3	2	1
16	15	14	13	12	11	10	9

CR16F016

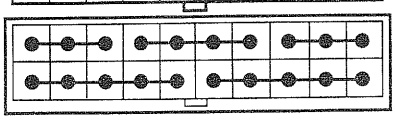
C235-3

11	10	9	8	7	6	5	4	3	2	1	
22	21	20	19	18	17	16	15	14	13	12	

CR22F004

C245

10	9	8	7	6	5	4	3	2	1
20	19	18	17	16	15	14	13	12	11



CR20F031

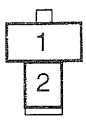
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C250

2	1
4	3

CR04F016

C251



CR02F051

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C254

3	2	1
6	5	4

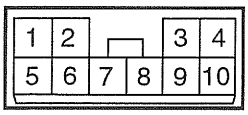
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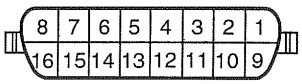
CONNECTOR CONFIGURATION (3)

M06



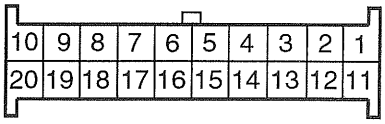
CR10M003

M07



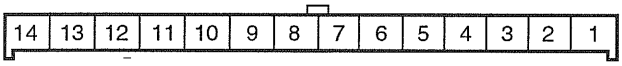
CR16F022

M09-1



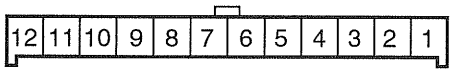
CR20F020

M09-2



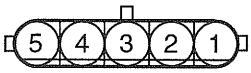
CR14F007

M09-3



CR12F001

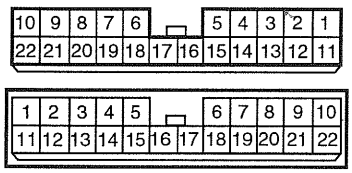
M55



CR05F027

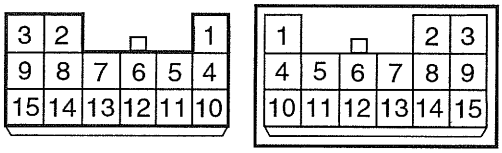
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MC20



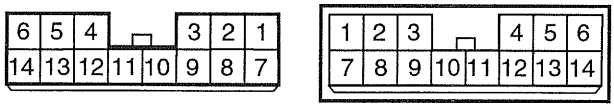
CR22B006

MC21



CR15B002

MC22



CR14B011

E2DB013C