ENGINE GENERAL

0000-00

INDEX

GENERAL

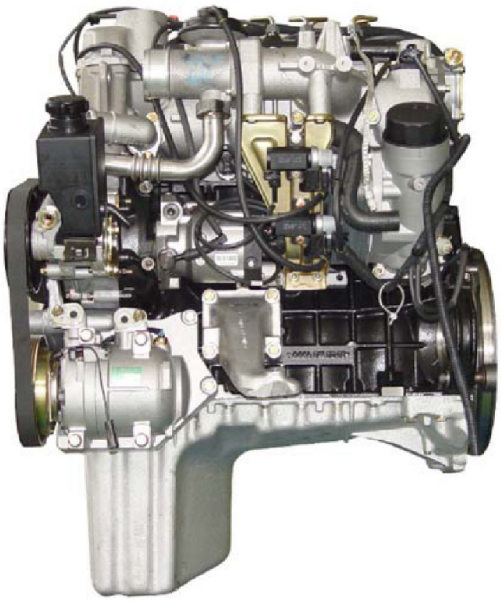
ENGINE GENERAL

0000-00

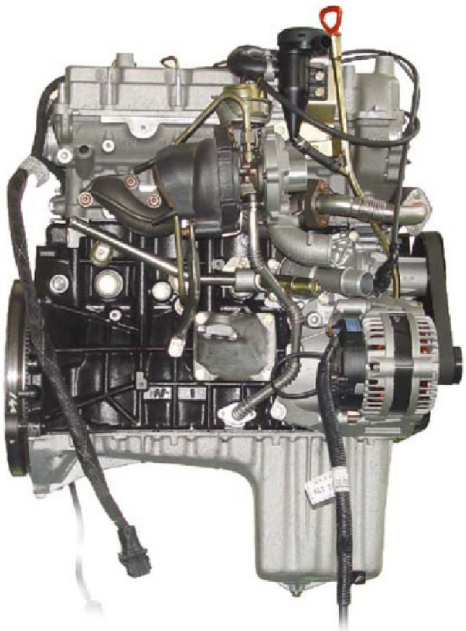
GENERAL

1. ENGINE ASSEMBLY LAYOUT

1) LH SIDE VIEW

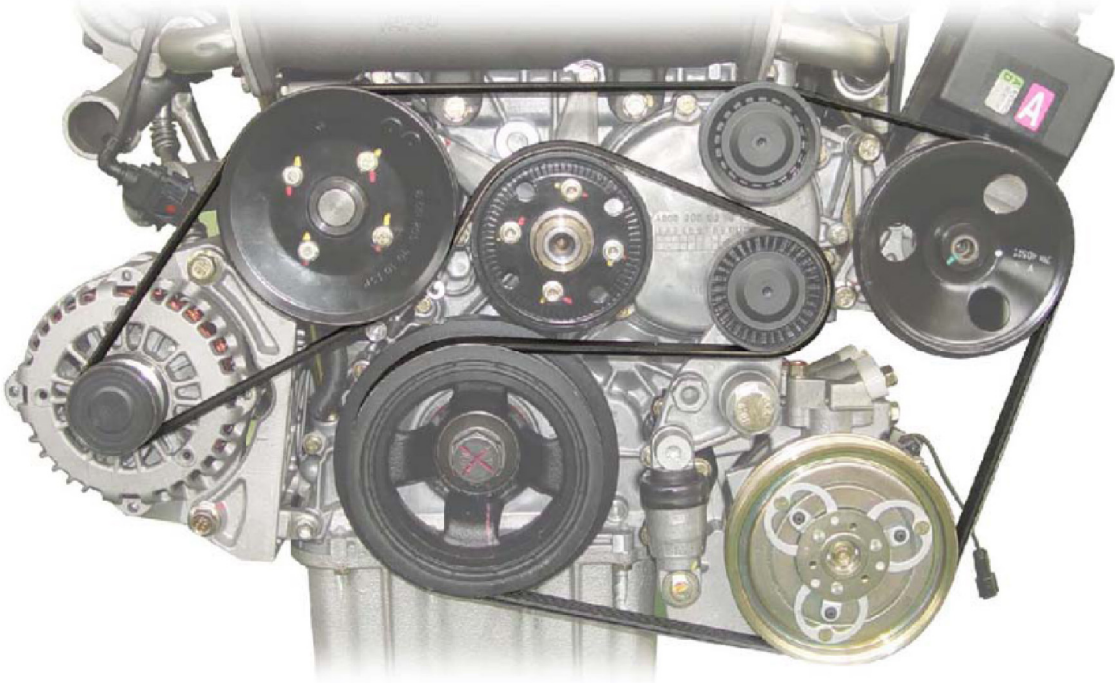


2) RH SIDE VIEW



3) FRONT VIEW

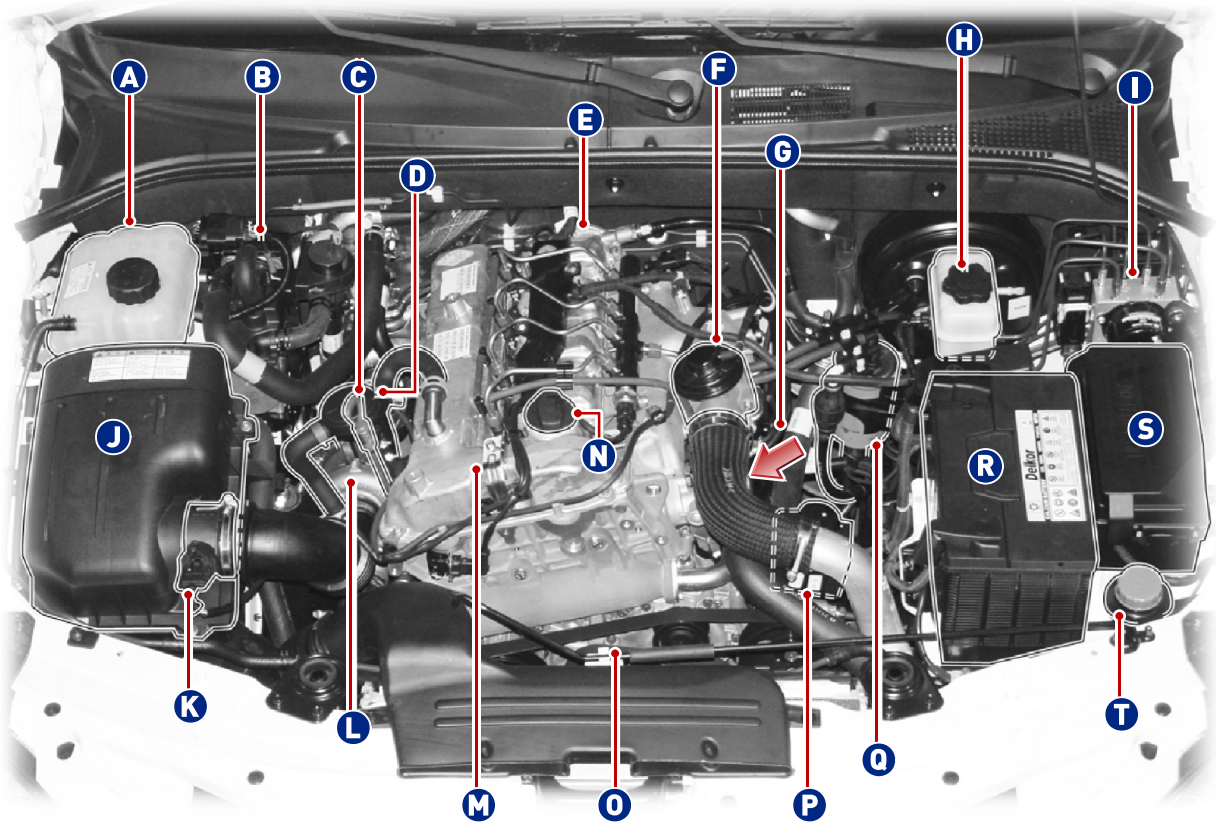
4) FAN BELT



Modification basis	
Application basis	
Affected VIN	

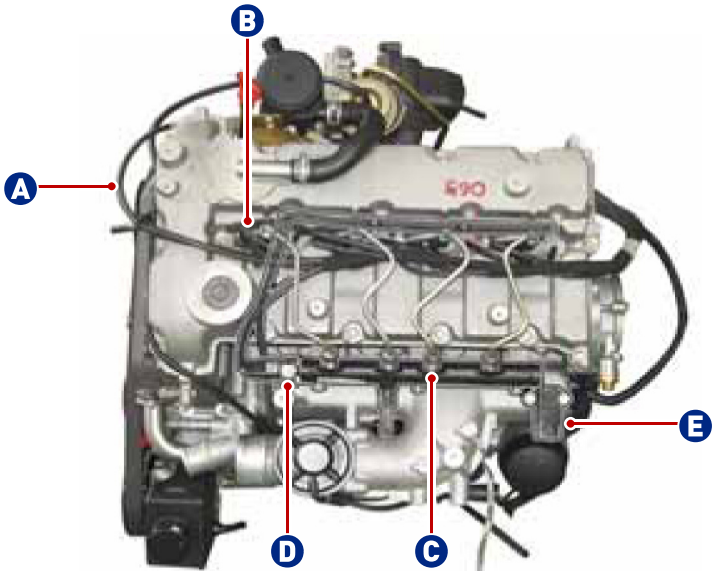
2. ENGINE CONTROLS LAYOUT

1) ECU Related Componets



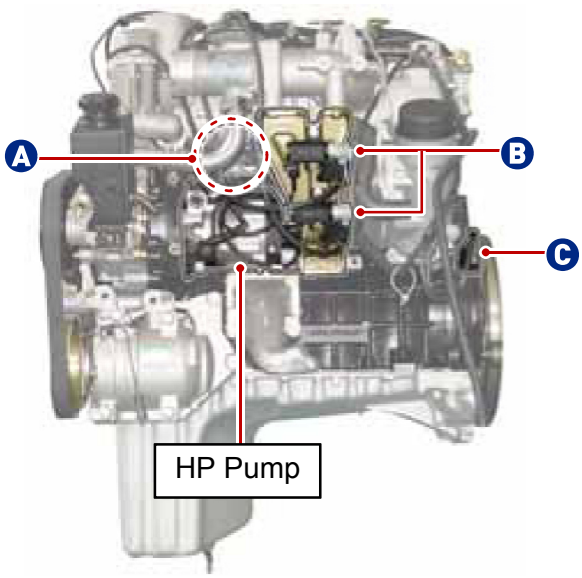
NO.	FUNCTION	NO.	FUNCTION
A	Coolant reservoir	K	HFM sensor
B	FFH	L	VGT turbo charger
C	Engine oil dipstick	M	Engine
D	Oil separator(PCV valve)	N	Engine oil filler cap
E	Vacuum pump	O	PWM electric fan & fan shroud
F	EGR valve	P	Power steering oil reservoir
G	Vacuum modulator	Q	Fuel filter & priming pump
H	Brake fluid reservoir	R	Battery
I	ABS/ESP modulator	S	Fuse box
J	Air cleaner assembly	T	Washer fluid reservoir

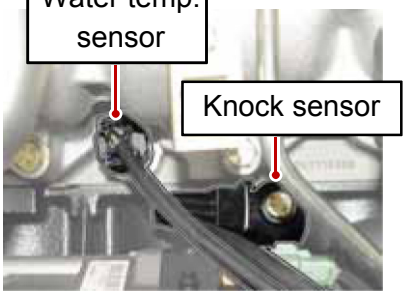
2) Engine And Sensors



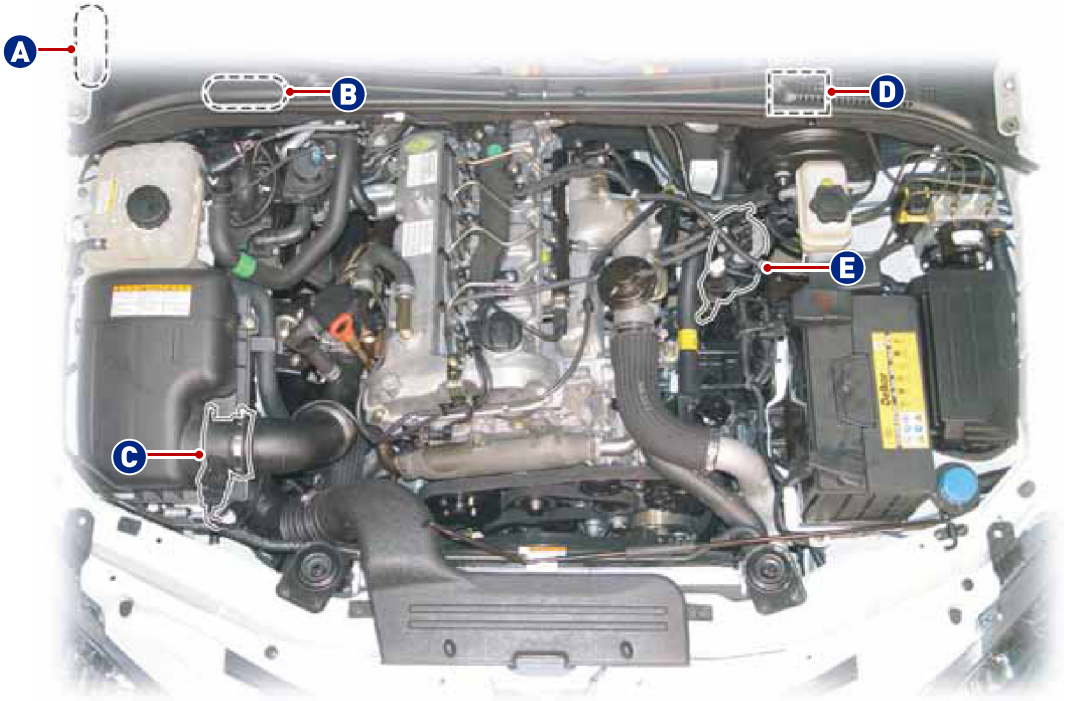
Camshaft Position Sensor	Injector	Glow Plug
A 	B 	B 
Common Rail	**Fuel Pressure Sensor (Common Rail)**	**Booster Pressure Sensor**
C 	D 	E 

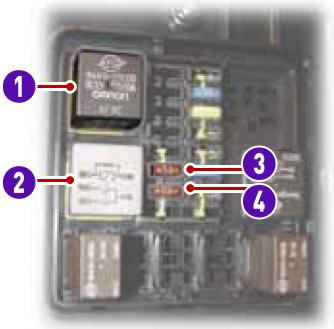
Modification basis	
Application basis	
Affected VIN	



Knock Sensor (1 EA) & Water Temperature Sensor	Vacuum Modulator	Crankshaft Position Sensor
A 	B 	C 

3) Engine Accessories Related to ECU

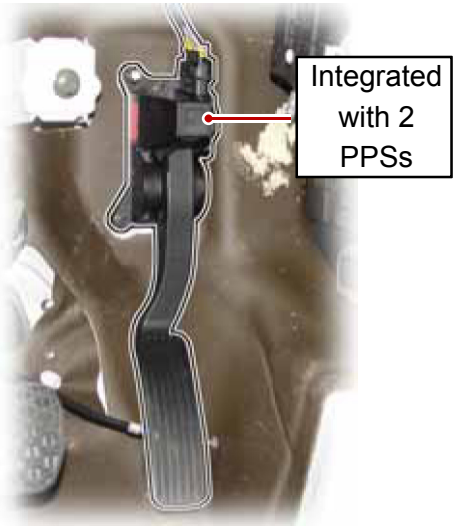
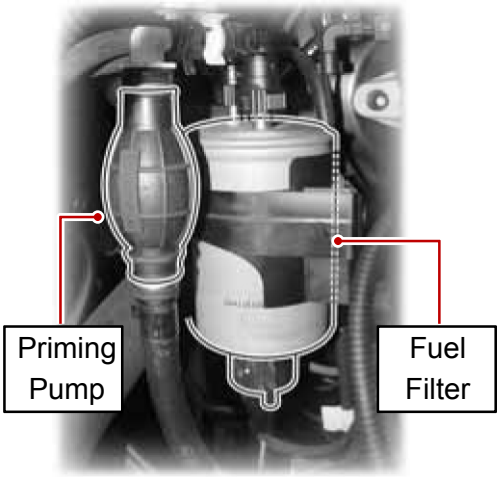


A IP Interior Fuse Box (Passenger Side)	
 1. Engine ECU main relay 2. Hazard warning lamp 3. VGT & EGR vacuum modulators, HFM 4. HP pumpIMV	Installed 

B Engine ECU	B Mounting Location
	

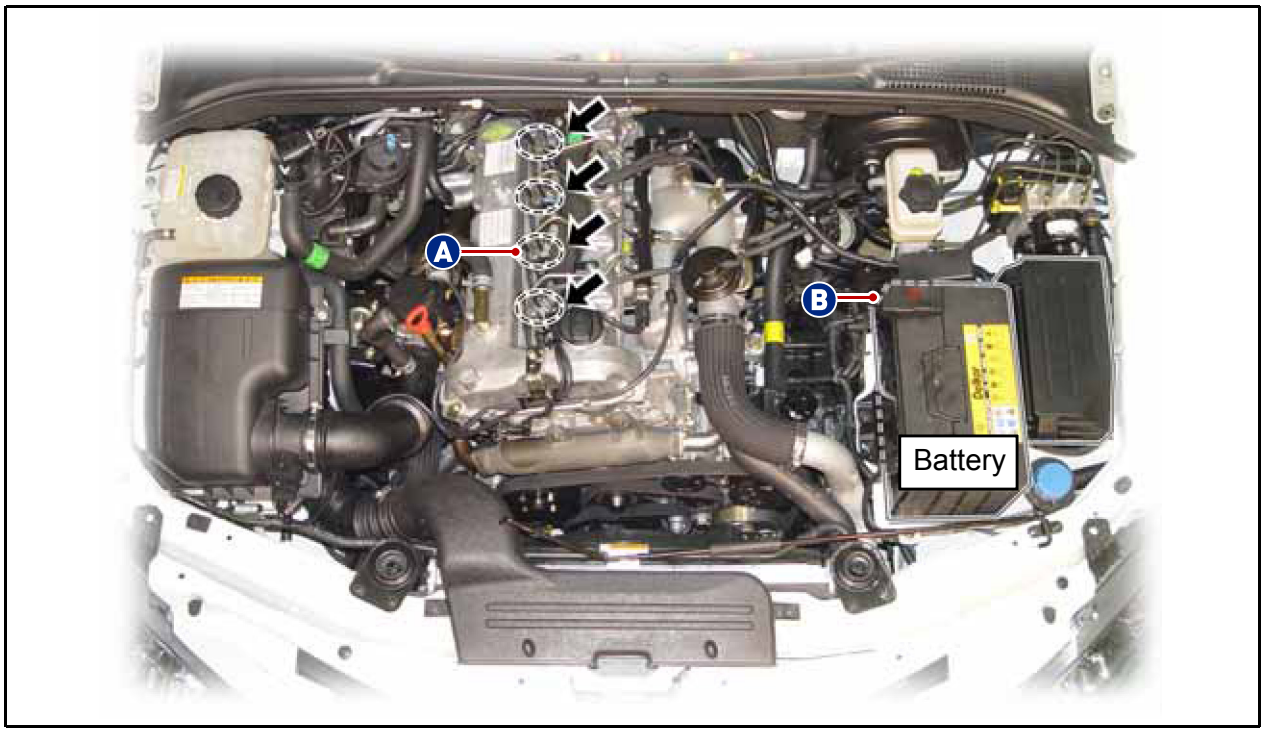
Modification basis	
Application basis	
Affected VIN	

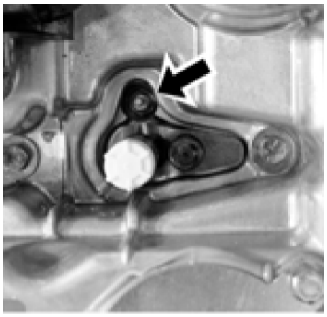
C HFM Sensor	
	

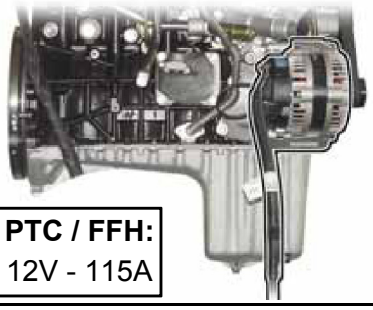
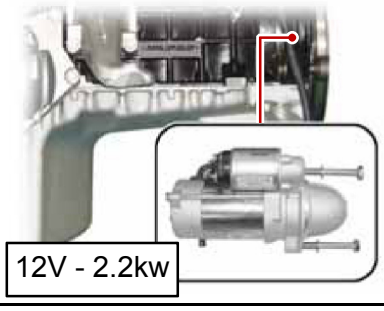
D Accelerator Pedal Module	E Fuel Filter Sensor
	

Service Interval (Fuel Filter)	
EU Only	Replace every 30,000 km (Draining water from fuel filter: whenever replacing the engine oil)
General	Replace every 25,000 km (Draining water from fuel filter: whenever replacing the engine oil)

3. ELECTRICAL COMPONENTS AND PREHEATING SYSTEM

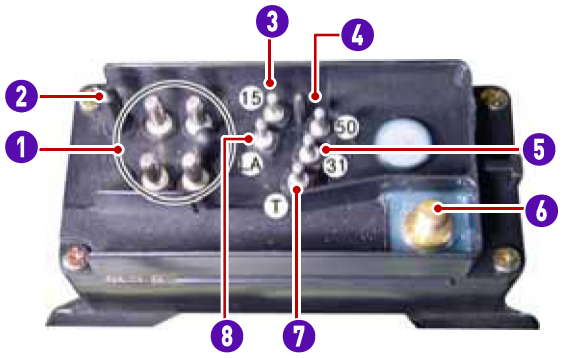


A Glow Plug		Preheat Warning Lamp (Cluster)
		

Alternator	Starter motor	Engine compartment fuse box
		

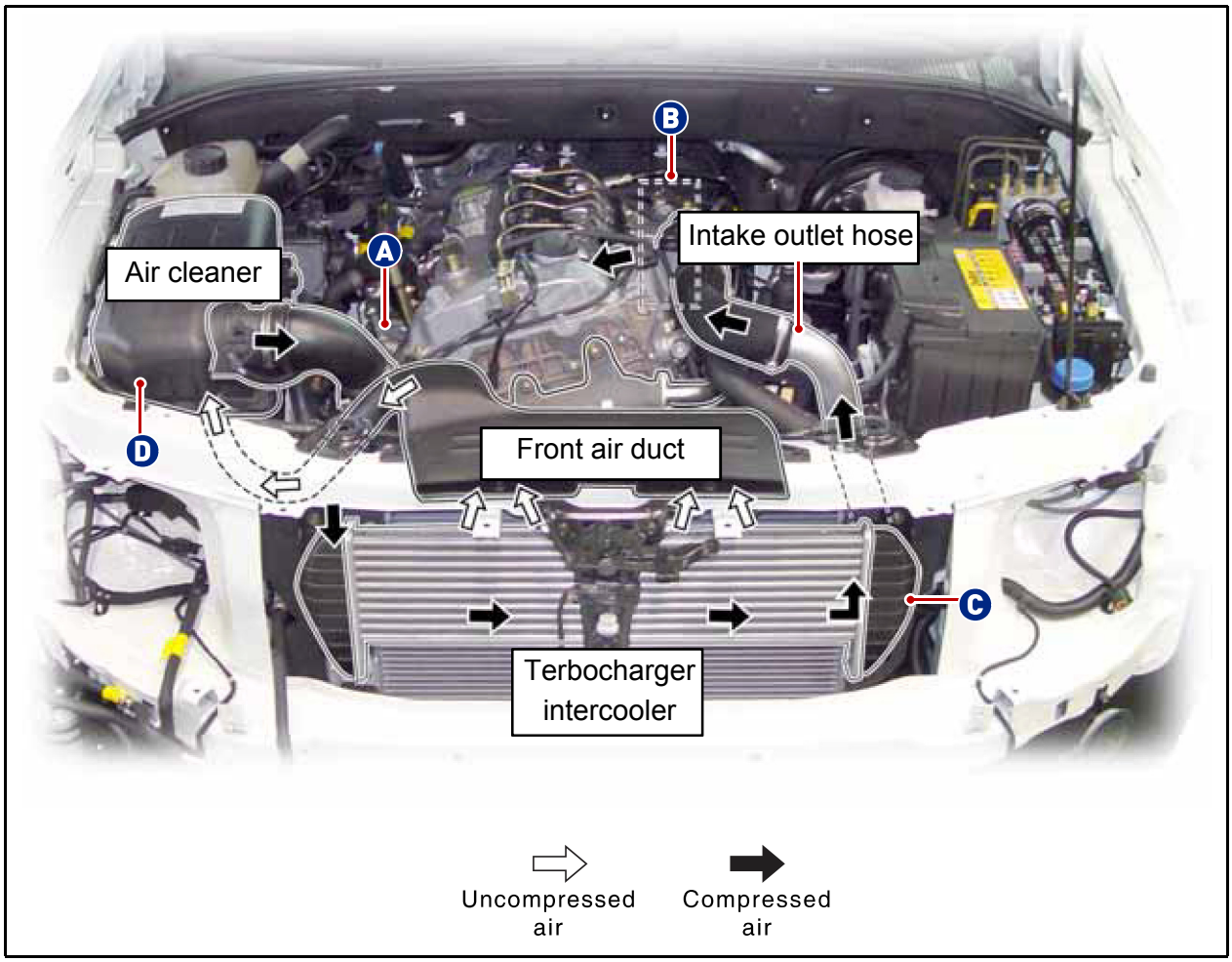
Modification basis	
Application basis	
Affected VIN	

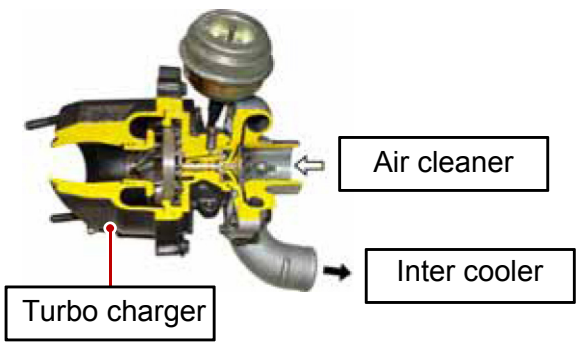
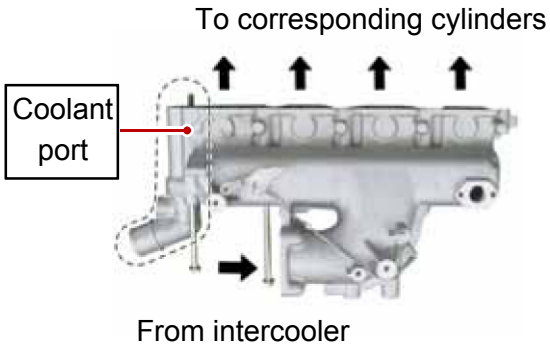
B Preheat Control Unit



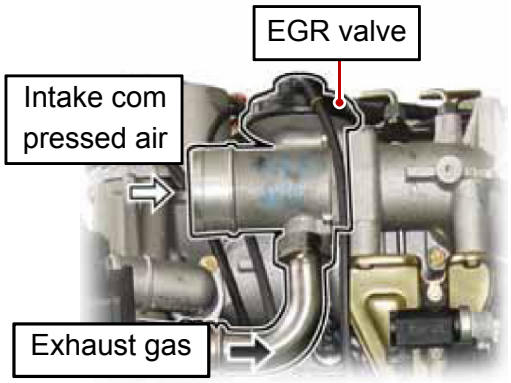
NO.	FUNCTION
1	Glow plug terminal (#1 ~ #4)
2	No G5 for 4 cylinders (Without D20DT)
3	IG1 power supply terminal
4	Glow plug control signal (ECU113)
5	Ground terminal
6	Battery main wire
7	Preheat completion transmit terminal : No use for vehicle without remote engine start
8	K-line (ECU 34)

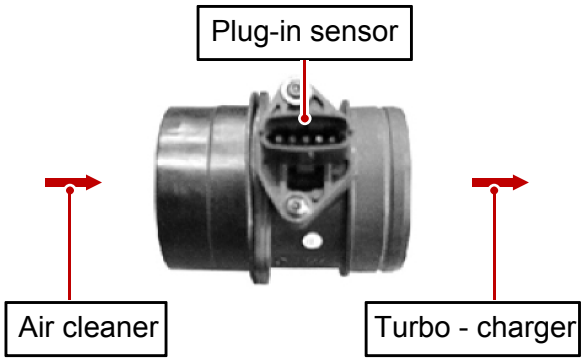
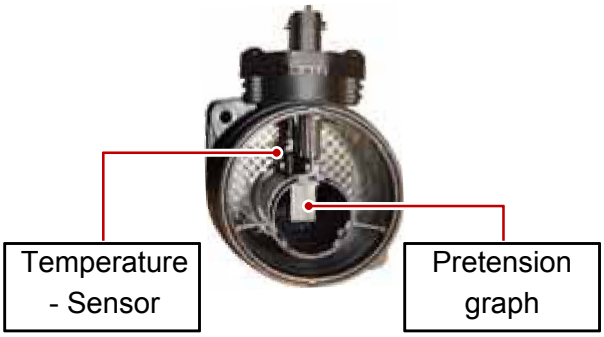
4. INTAKE SYSTEM LAYOUT



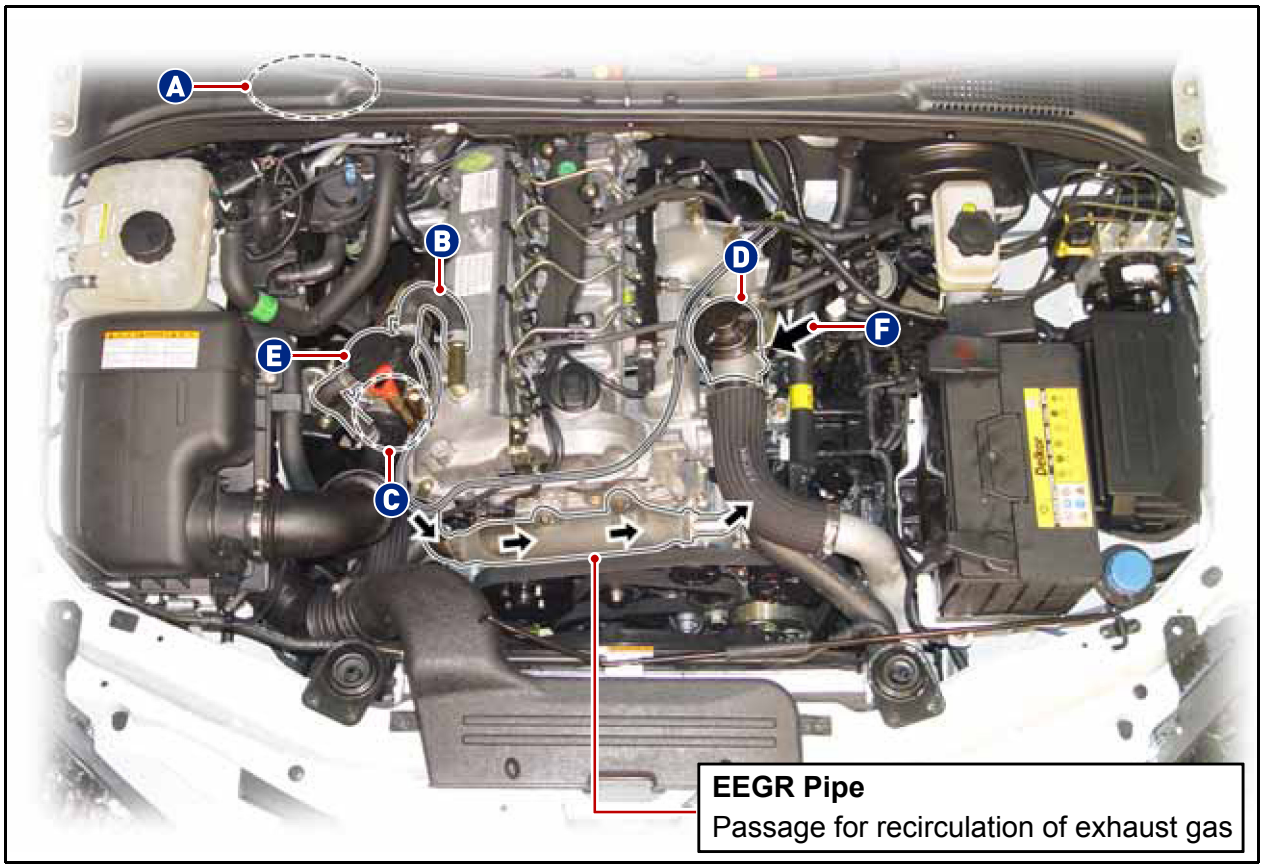
A Supplying Compressed Air with Turbocharger's Operation	B Intake Manifold
	

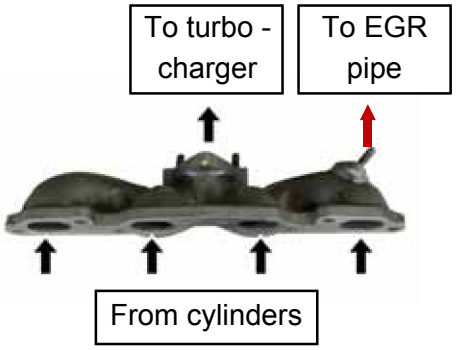
Modification basis	
Application basis	
Affected VIN	

Recirculation of Exhaust Gas when EGR Valve Operates	C Turbocharger Intercooler
	

D HFM Sensor	
	

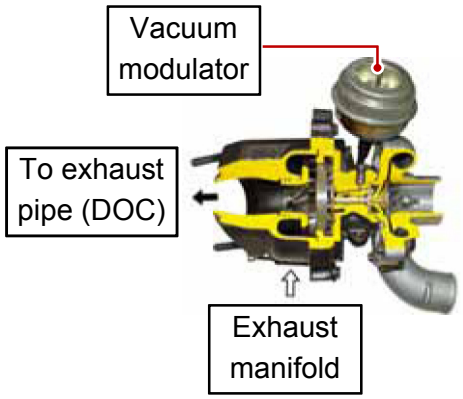
5. EXHAUST SYSTEM LAYOUT



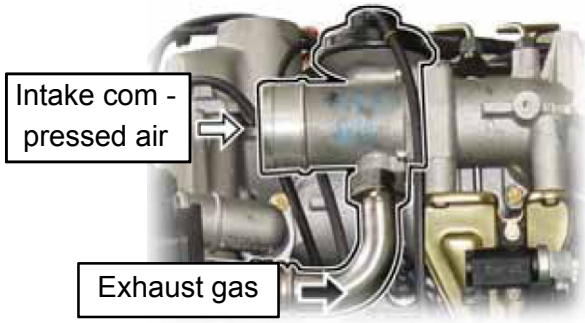
A DOC (Diesel Catalytic Converter)	B Exhaust Manifold
	

Modification basis	
Application basis	
Affected VIN	

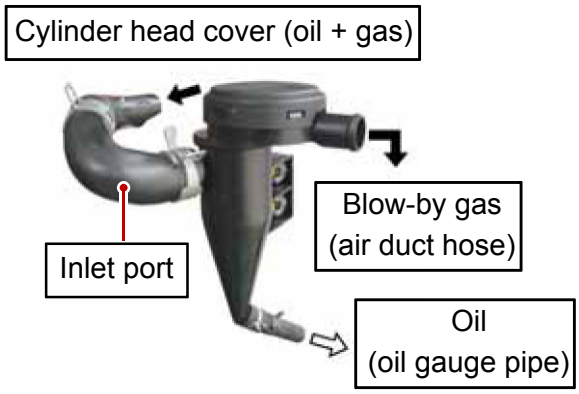
C VGT Turbocharger



D EGR Valved

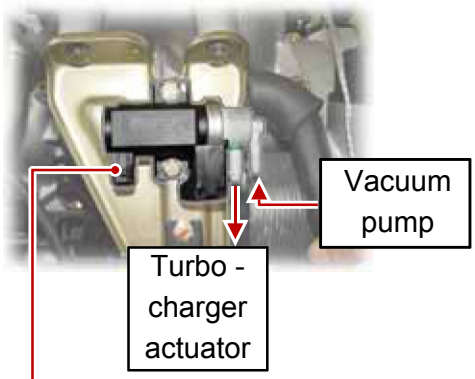


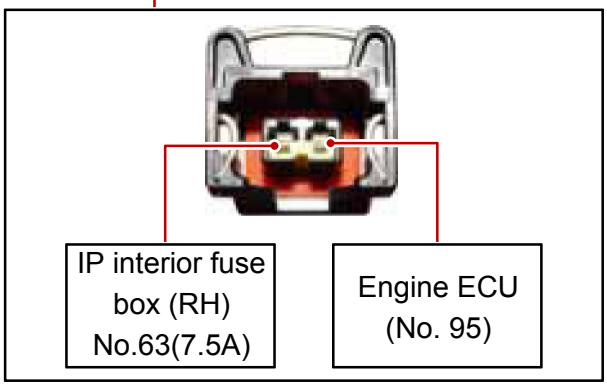
E PCV Oil Separator



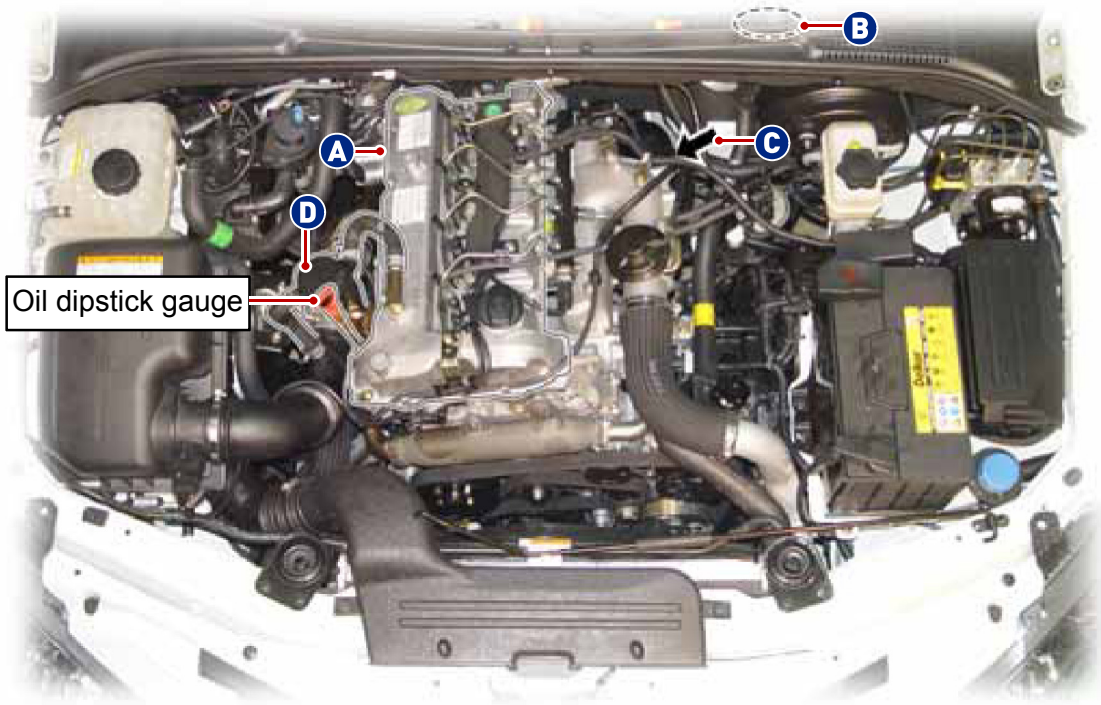
The first separation will happen when blow-by gas passes through baffle plates in cylinder head cover. Then oil and gas will be separated due to cyclone effect after entering the oil separator inlet port.
Separated oil returns to oil pan via oil drain port and the gas will be burnt again after entering the combustion chamber through air duct hose via PCV valve that opens/closes due to pressure differences between the intake side and crankcase.

F Turbocharger Vacuum Modulator





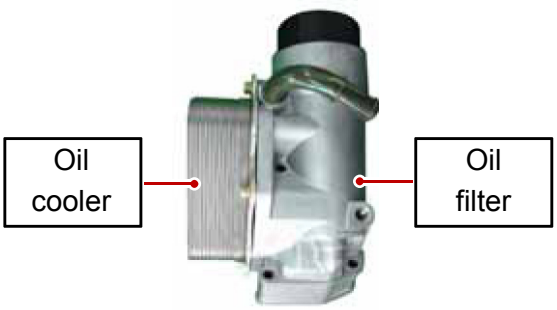
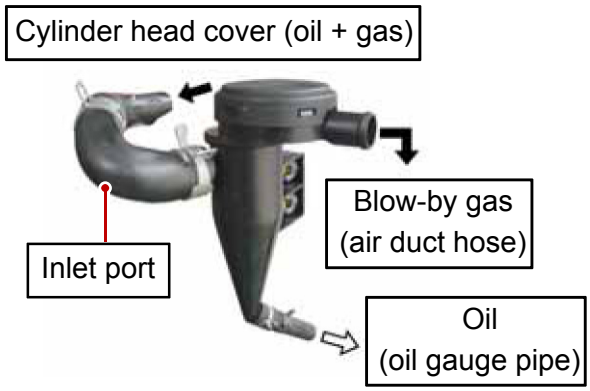
6. LUBRICATION SYSTEM LAYOUT



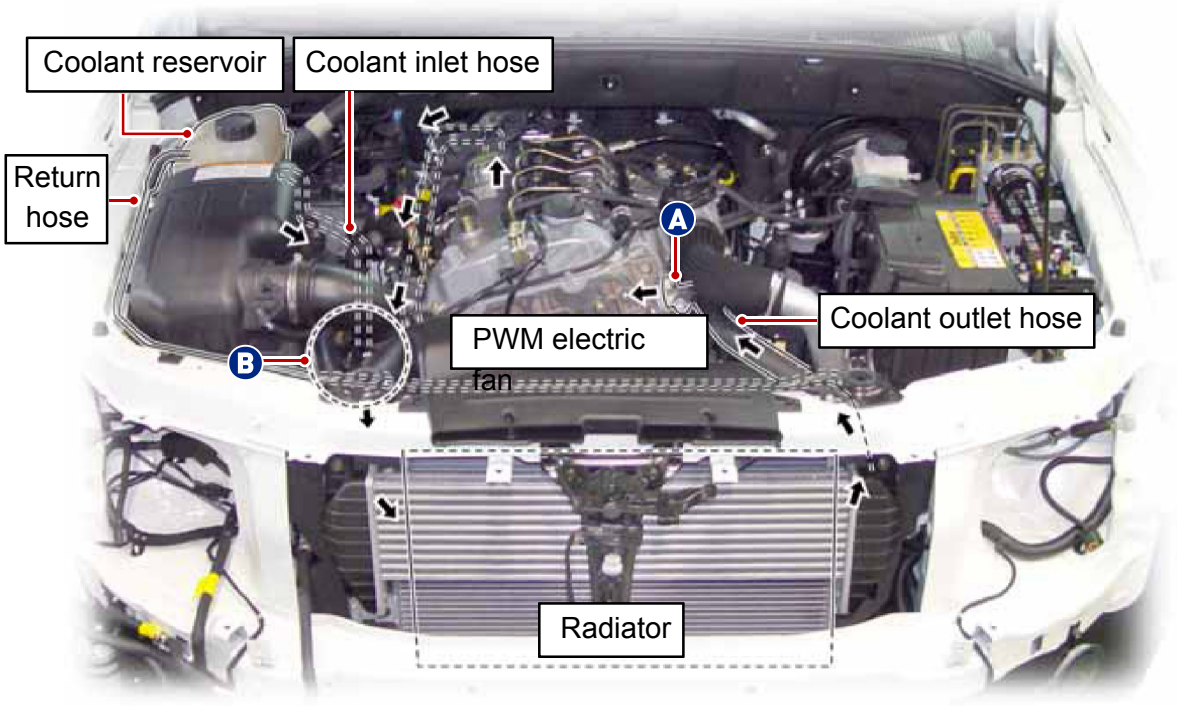
Cylinder Head Cover A	Oil Pressure Warning Lamp (Cluster) B
	

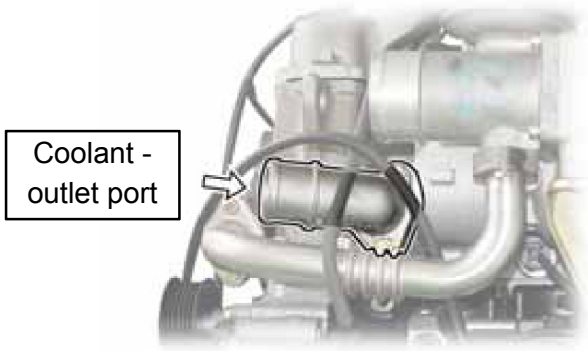
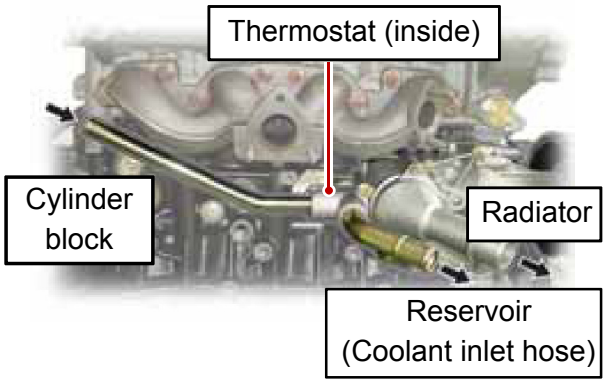
Oil Pan and Baffle Plate (Integrated Type)	Oil Strainer
	

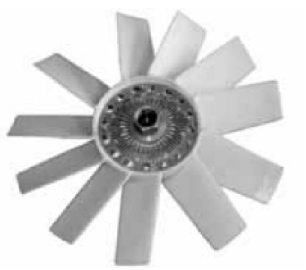
Modification basis	
Application basis	
Affected VIN	

Ⓒ Oil Filter & Oil Cooler	Ⓓ PCV Oil Separator
	 The first separation will happen when blow-by gas passes through baffle plates in cylinder head cover. Then oil and gas will be separated due to cyclone effect after entering the oil separator inlet port. Separated oil returns to oil pan via oil drain port and the gas will be burnt again after entering the combustion chamber through air duct hose via PCV valve that opens/closes due to pressure differences between the intake side and crankcase.

7. COOLING SYSTEM LAYOUT

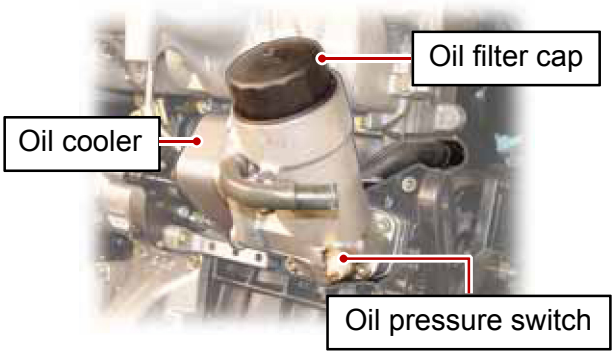


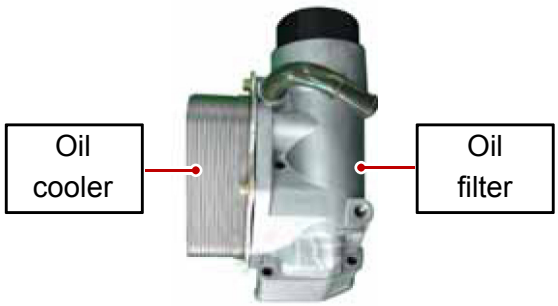
A Coolant Port	B Water Pump & Pipe
	

Radiator Assembly	Cooling Fan and Fan Clutch
	

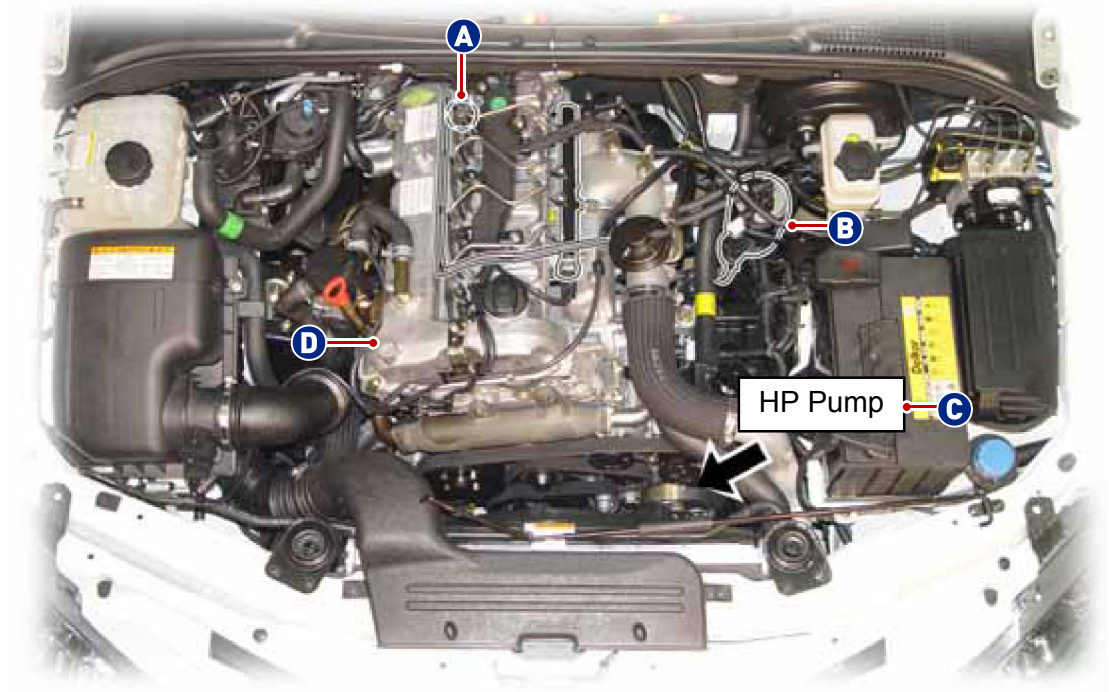
Modification basis	
Application basis	
Affected VIN	

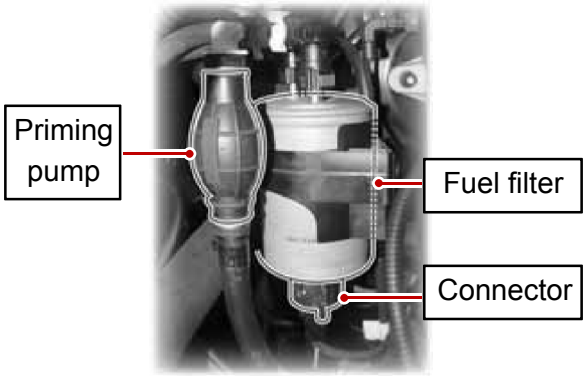
Engine Oil Filter & Cooler



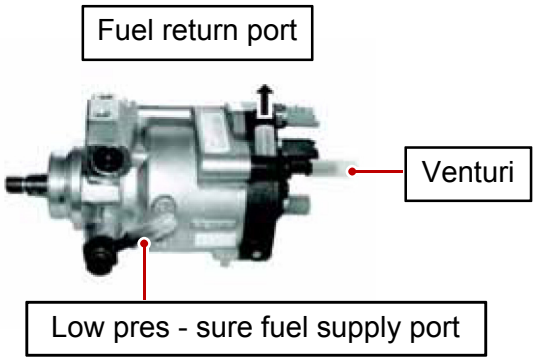


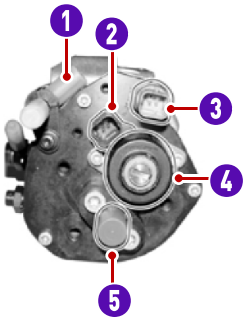
8. FUEL SYSTEM LAYOUT



A Injector		B Fuel Filter & Priming Pump
		

C HP Pump

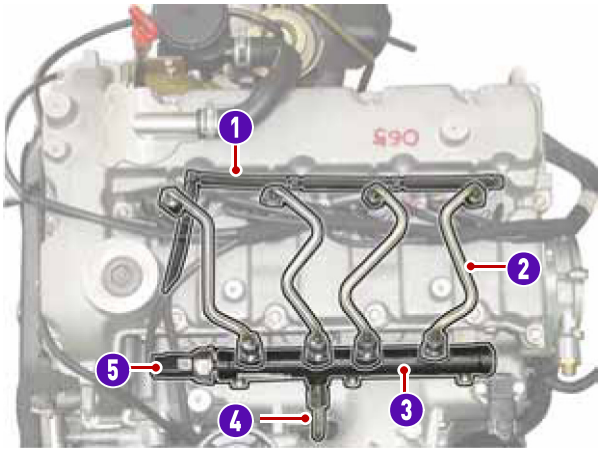




1. Fuel return port
2. Fuel tempera - ture sensor
3. IMV connector
4. IMV valve
5. High pres - sure fuel supply port

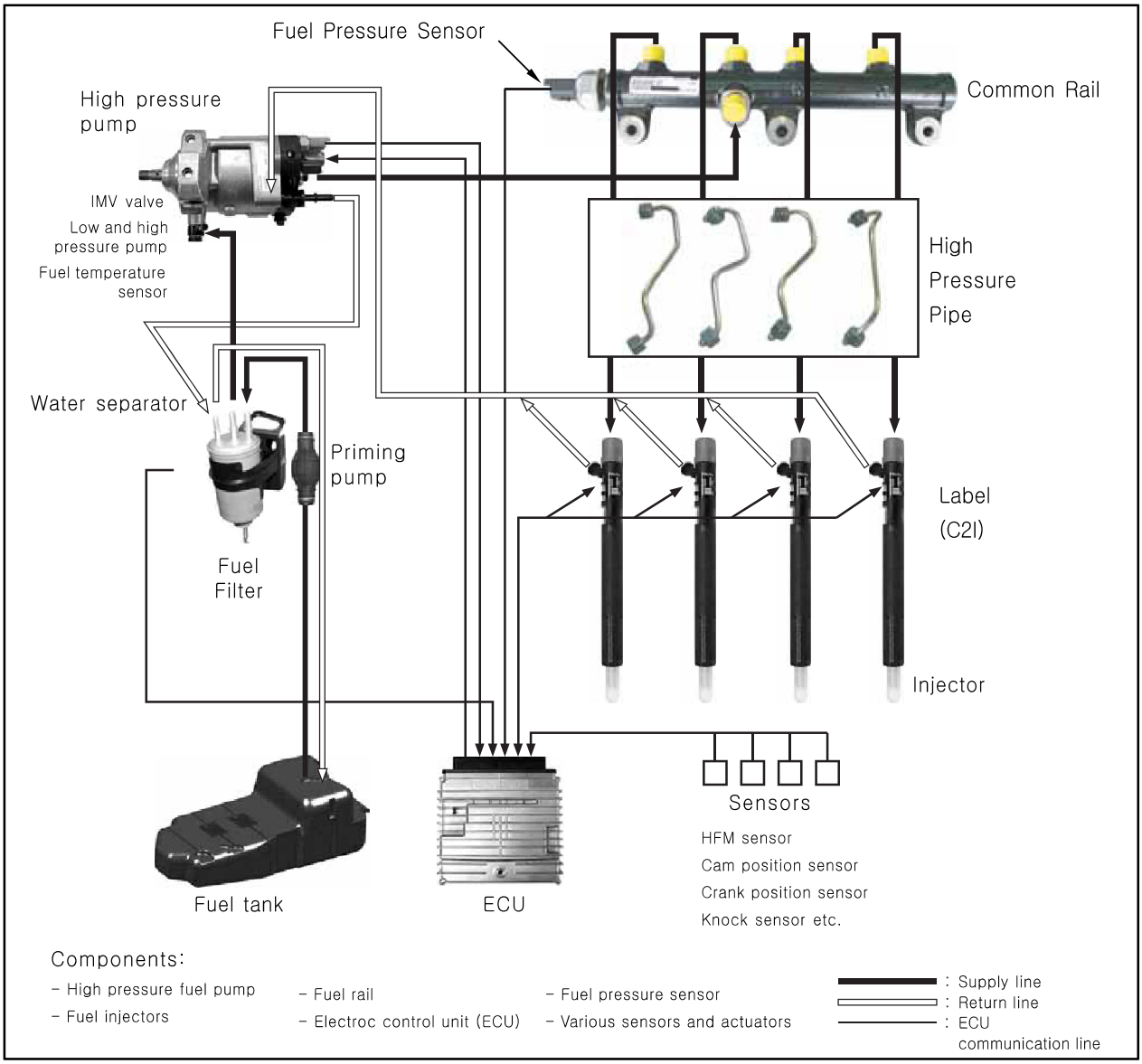
Modification basis	
Application basis	
Affected VIN	

D Cylinder Head



1. Fuel return hose
2. Fuel pipe
3. Common rail
4. High pressure fuel pipe
5. Fuel rail pressure sensor

9. FUEL SUPPLY SYSTEM



According to input signals from various sensors, engine ECU calculates driver's demand (position of the accelerator pedal) and then controls overall operating performance of engine and vehicle on that time.

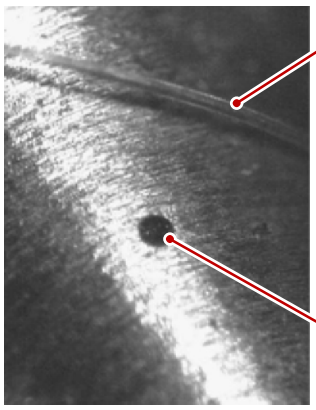
ECU receives signals from sensors via data line and then performs effective engine air-fuel ratio controls based on those signals. Engine speed is measured by crankshaft speed (position) sensor and camshaft speed (position) sensor determines injection order and ECU detects driver's pedal position (driver's demand) through electrical signal that is generated by variable resistance changes in accelerator pedal sensor. Air flow (hot film) sensor detects intake air volume and sends the signals to ECU. Especially, the engine ECU controls the air-fuel ratio by recognizing instant air volume changes from air flow sensor to decrease the emissions (EGR valve control). Furthermore, ECU uses signals from coolant temperature sensor and air temperature sensor, booster pressure sensor and barometric sensor as compensation signal to respond to injection starting, pilot injection set values, various operations and variables.

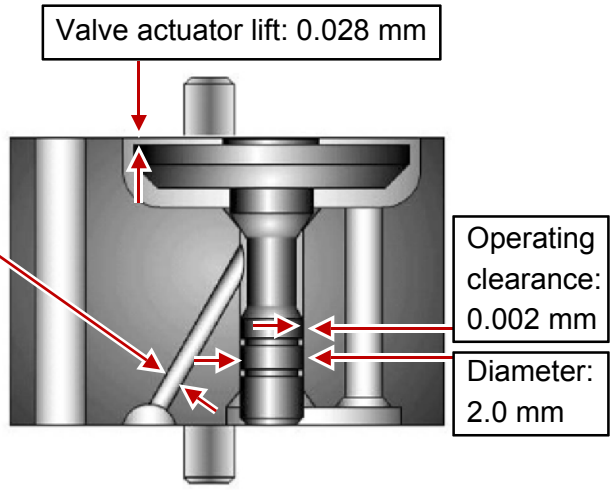
Modification basis	
Application basis	
Affected VIN	

10. CLEANNESS

1) CLEANNESS OF DI ENGINE FUEL SYSTEM AND SERVICE PROCEDURES

The fuel system for DI engine consists of transfer (low pressure) line and high pressure line. Its highest pressure reaches over 1600 bar. Some components in injector and HP pump are machined at the micrometer 100 μm of preciseness. The pressure regulation and injector operation are done by electric source from engine ECU. Accordingly, if the internal valve is stucked due to foreign materials, injector remains open. Even in this case, the HP pump still operates to supply high pressurized fuel. This increases the pressure to combustion chamber (over 250 bar) and may cause fatal damage to engine.
You can compare the thickness of injector nozzle hole and hair as shown in below figure (left side). The right side figure shows the clearance between internal operating elements.





The core elements of fuel system has very high preciseness that is easily affected by dust or very small foreign material. Therefore, make sure to keep the preliminary works and job procedures in next pages. If not, lots of system problems and claims may arise.

2) Job Procedures

1. Always keep the workshop and lift clean (especially, from dust).
2. Always keep the tools clean (from oil or foreign materials).
3. Wear a clean vinyl apron to prevent the fuzz, dust and foreign materials from getting into fuel system.
   Wash your hands and do not wear working gloves.
4. Follow the below procedures before starting service works for fuel system.

Carefully listen the symptoms and problems from customer.

↓

Visually check the leaks and vehicle appearance on the wiring harnesses and connectors in engine compartment.

↓

Perform the diagnosis proceee with SCAN-100
(refer to "DI10 DIAGNOSIS" section in this manual).

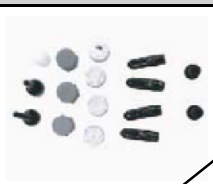
↓

Locate the fault. If the cause is from fuel system (from priming pump to injector, including return line), follow the step 1 through step 3 above.

5. If the problem is from HP pump, fuel supply line or injector, prepare the clean special tools and sealing caps to perform the diagnosis for DI engine fuel system in "DIAGNOSIS" section in this manual. At this point, thoroughly clean the related area in engine compartment.

CAUTION

- Clean the engine compartment before starting service works.

Tool kit for high pressure line	Took kit for low pressure line	Removal tool box and cap kits
		 

Modification basis	
Application basis	
Affected VIN	

6. Follow the job procedures. If you find a defective component, replace it with new one.

Disconnect the negative battery cable.

↓

For safety reasons: check pressure is low before opening the HP systems (pipes)

↓

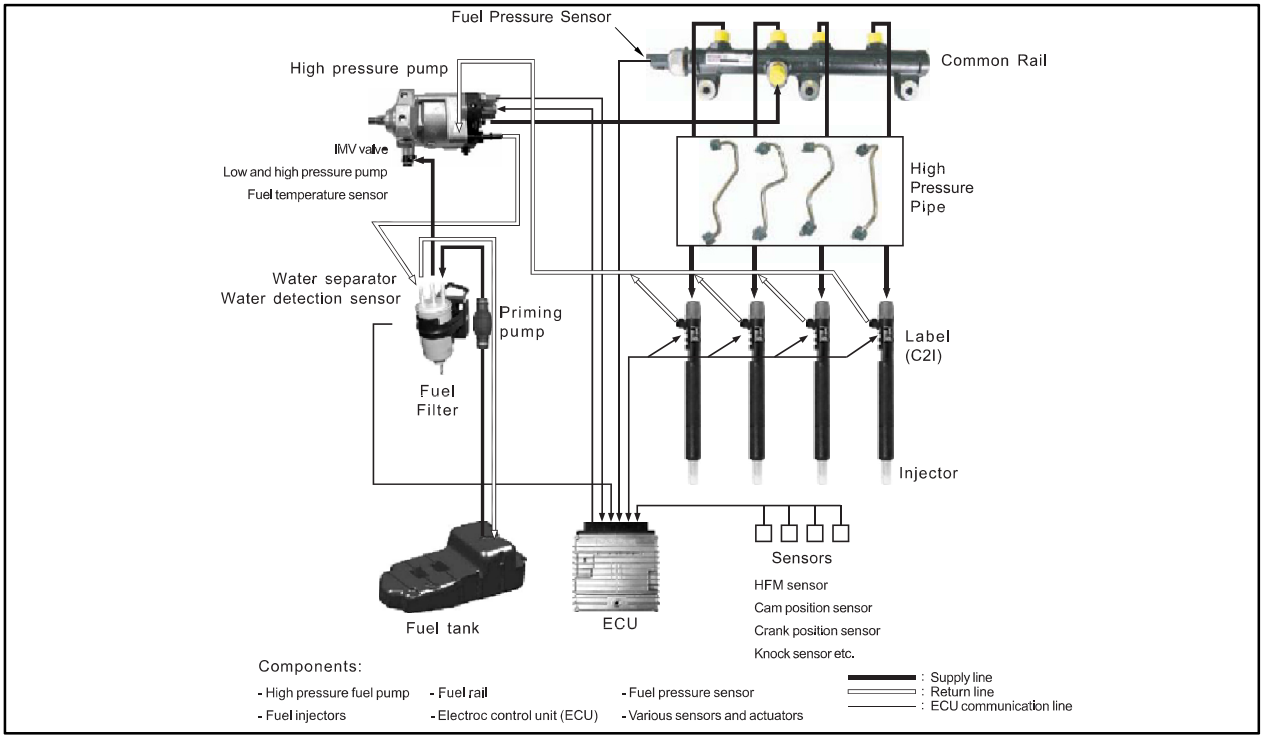
Use special tools and torque wrench to perform the correct works.

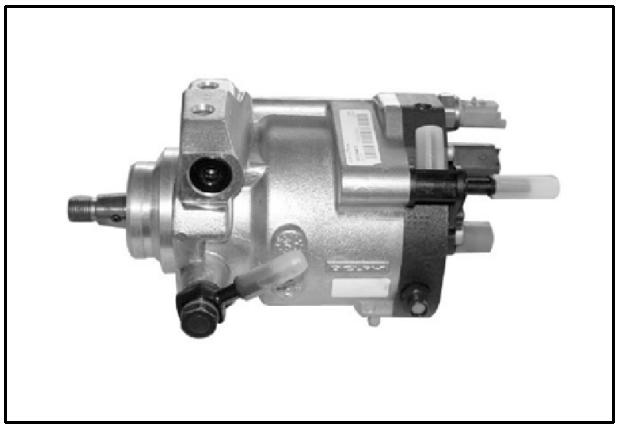
Once disconnected, the fuel pipes between HP pump and fuel rail and between fuel rail and each injector should be replaced with new ones. The pipes should be tightened tospecified tightening torques during installation. Over or under torques out of specified range may cause damages and leaks at connections. Once installed, the pipes have been deformed according to the force during installtion, therefore they are not reusable.

The copper washer on injector should be replaced with new one. The injector holder bolt should be tightened to specified tightening torque as well. If not, the injection point may be deviated from correct position, and it may cause engine disorder.

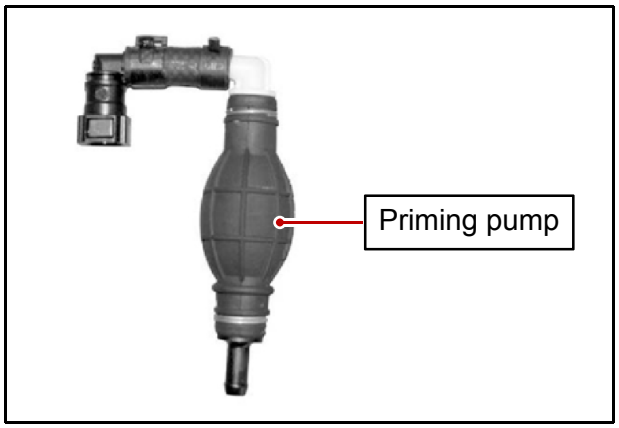
↓

Plug the disconnected parts with sealing caps, and remove the caps immediately before replacing the components.





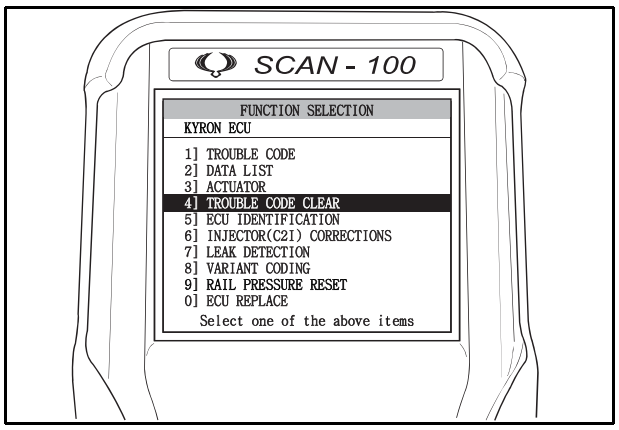
7. Plug the removed components with clean and undamaged sealing caps and store it into the box to keep the conditions when it was installed.
8. Clear the high pressure offset value by SCAN-100 after replacing the high pressure pump.



9. To supply the fuel to transfer line of HP pump press the priming pump until it becomes hard.

CAUTION

- Do not crank engine before having filled pump.



10. Check the installed components again and connect the negative battery cable. Start the engine and check the operating status.
11. With SCAN-100, check if there are current faults and erase the history faults.

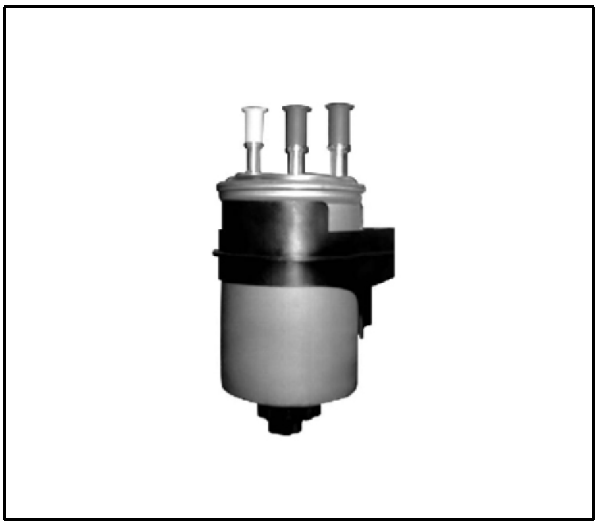
Modification basis	
Application basis	
Affected VIN	

3) DI Engine and Its Expected Problems and Remedies Can be Caused by Water in Fuel

▶ **System Supplement Against Paraffin Separation.**

In case of Diesel fuel, paraffin, one of the elements, can be separated from fuel during winter and then can stick on the fuel filter blocking fuel flow and causing difficult starting finally. Oil companies supply summer fuel and winter fuel by differentiating mixing ratio of kerosene and other elements by region and season. However, above phenomenon can be happened if stations have poor facilities or sell improper fuel for the season.
In case of DI engine, purity of fuel is very important factor to keep internal preciseness of HP pump and injector.
Accordingly, more dense mesh than conventional fuel filter is used. To prevent fuel filter internal clogging due to paraffin separation, SYMC is using fuel line that high pressure and temperature fuel injected by injector returns through fuel filter to have an effect of built-in heater (see fuel system).

▶ **System Supplement And Remedy Against Water In Fuel**



As mentioned above, some gas stations supply fuel with excessive than specified water. In the conventional IDI engine, excessive water in the fuel only causes dropping engine power or engine hunting. However, fuel system in the DI engine consists of precise components so water in the fuel can cause malfunctions of HP pump due to poor lubrication of pump caused by poor coating film during high speed pumping and bacterization (under long period parking). To prevent problems can be caused by excessive water in fuel, water separator is installed inside of fuel filter. When fuel is passing filter, water that has relatively bigger specific gravity is accumulated on the bottom of the filter.

If water in the separator on the fuel filter exceeds a certain level, it will be supplied to HP pump with fuel, so the engine ECU turns on warning light on the meter cluster and buzzer if water level is higher than a certain level.
Due to engine layout, a customer cannot easily drain water from fuel filter directly, so if a customer checks in to change engine oil, be sure to perform water drain from fuel filter.
(See fuel system for details.)

11. MAINTENANCE AND REPAIR

1) Maintenance And Lubrication

▶ Normal Vehicle Use

The maintenance instructions contained in the maintenance schedule are based on the assumption that the vehicle will be used for the following reasons:

1. To carry passengers and cargo within the limitation of the tire inflation prassure. Refer to "Wheels and Tire" in section 4H.
2. To be driven on reasonable road surfaces and within legal operating limits.

▶ Explanation of Scheduled Maintenance Services

The services listed in the maintenance schedule are further explained below. When the following maintenance services are performed, make sure all the parts are replaced
and all the necessary repairs are done before driving the vehicle. Always use the proper fluid and lubricants.

▷ Engine Oil and Oil Filter Change

Always use above the API SH grade or recommended engine oil.

▷ Engine Oil Viscosity

Engine oil viscosity (thickness) has an effect on fuel economy and cold weather operation. Lower viscosity engine oils can provide better fuel economy and cold weather performance however, higher temperature weather conditions require higher viscosity engine oils for satisfactory lubrication. Using oils of any viscosity other than those viscosities recommended could result in engine damage.

▷ Cooling System Service

Drain, flush and refill the system with new coolant. Refer to "Recommended Fluids And Lubricants" in this section.

Modification basis	
Application basis	
Affected VIN	

▷ **Spark Plug Wire Replacement**

Clean wires and inspect them for burns, cracks or other damage. Check the wire boot fit at the Distributor and at the spark plugs. Replace the wires as needed.

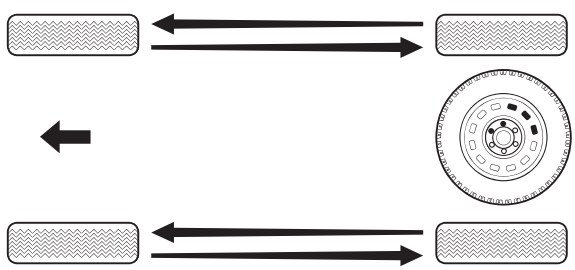
▷ **Brake System Service**

Check the disc brake pads or the drum brake linings.
Check the pad and the lining thickness carefully.

▷ **Tire and Wheel Inspection and Rotation**

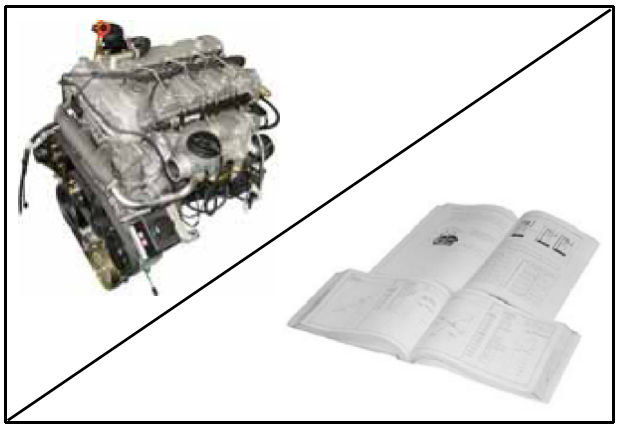
Check the tires for abnormal wear or damage. To equalize wear and obtain maximum tire life, rotate the tires. If irregular or premature wear exists, check the wheel alignment and check for damaged wheels. While the tires and wheels are removed, inspect the brakes.

Tire Rotation (Left-hand Drive Type)



12. GUIDELINES FOR SERVICE WORK SAFETY

1) General



To maintain and operate the vehicle under optimum state by performing safe service works, the service works should be done by following correct methods and procedures.
Accordingly, the purpose of this manual is to prevent differences that can be caused by personal working method, skill, ways and service procedures and to allow prompt/correct service works.

▶ **Note, Notice**

While using this manual, there are a lot of Note or Notice having below meaning.

CAUTION

- Note means detailed description of supplementary information on work procedure or skill.

CAUTION

- Notice means precautions on tool/device or part damages or personal injuries that can occur during service works.

However, above references and cautions cannot be inclusive measures, so should have habits of taking concerns and cautions based on common senses.

Modification basis	
Application basis	
Affected VIN	

2) Cautions on Inspection/Service

CAUTION

- During service works, be sure to observe below general items for your safety.
  - For service works, be sure to disconnect battery negative (-) terminal if not starting and inspection.
  - While inspecting vehicle and replacing various consumable parts, be sure to take caution not to damage vehicle and injure people.
  - Engine and transmission may be hot enough to burn you. So inspect related locations when they cooled down enough.
  - If engine is running, keep your clothing, tools, hair and hands away from moving parts.
  - Even when the ignition key is turned off and positioned to LOCK, electrical fan can be operated while working on near around electrical fan or radiator grille if air conditioner or coolant temperature rises.
  - Every oil can cause skin trouble. Immediately wash out with soap if contacted.
  - Painted surface of the body can be damaged if spilled over with oil or anti-freeze.
  - Never go under vehicle if supported only with jack.
  - Never near the battery and fuel related system to flames that can cause fire like cigarette.
  - Never disconnect or connect battery terminal or other electrical equipment if ignition key is turned on.
  - While connecting the battery terminals, be cautious of polarities (+, -) not to be confused.
  - There are high voltage and currency on the battery and vehicle wires. So there can be fire if short-circuited.
  - Do not park while running the engine in an enclosed area like garage. There can be toxication with CO, so make sufficient ventilation.
  - The electrical fan works electrically. So the fan can be operated unexpectedly during working causing injuries if the ignition key is not in LOCK position. Be sure to check whether ignition key is in LOCK position before work.
  - Be careful not to touch hot components like catalytic converter, muffler and exhaust pipe when the engine is running or just stopped. They may burn you badly.

3) Guidelines on Engine Service

To prevent personal injuries and vehicle damages that can be caused by mistakes during engine and unit inspection/repair and to secure optimum engine performance and safety after service works, basic cautions and service work guidelines that can be easily forgotten during engine service works are described in.

▶ Cautions before service works

1. Before work on engine and each electrical equipment, be sure to disconnect battery negative (-) terminal.
2. Before service works, be sure to prepare the works by cleaning and aligning work areas.
3. Always position the ignition switch to OFF if not required. If not, there can be electrical equipment damages or personal injuries due to short-circuit or ground by mistake.
4. There should be no leak from fuel injection system (HP pump, fuel hose, high pressure pipe) of the D20DT & D27DT engine. So they should be protected from foreign materials. While removing the engine, do not position the jack and others under the oil pan or
5. engine. To secure the safety, use only safety hook on the engine.

▶ Engine and accessories

Engine has a lot of precise portions so tightening torque should be correct during disassembly/assembly and removal/installation and service work should be done in clean ways during disassembly/assembly.
Maintaining working area clean and cautious service administration is essential element of service works while working on the engine and each section of the vehicle.
So the mechanics should well aware of it.

1. While removing the engine, related parts (bolts, gaskets, etc.) should be aligned as a group.
2. While disassembling/assembling internal components of the engine, well aware of disassembly/assembly section in this manual and clean each component with engine oil and then coat with oil before installation.
3. While removing engine, drain engine oil, coolant and fuel in fuel system to prevent leakage.
4. During service work of removal/installation, be sure to check each connected portions to engine not to make interference.

Modification basis	
Application basis	
Affected VIN	

▶ Fuel and lubrication system

Painted surface of the body can be damaged or rubber products (hoes) can be corroded if engine oil and fuel are spilled over. If spilled over engine, foreign materials in air can be accumulated on the engine damaging fuel system.

1. If work on the fluid system such as fuel and oil, working area should be well ventilated and mechanic should not smoke.
2. Gasket or seal on the fuel/lubrication system should be replaced with new and bolts and nuts should be tightened as specified.
3. After removal/installation works, be sure to check whether there is leak on the connecting section.

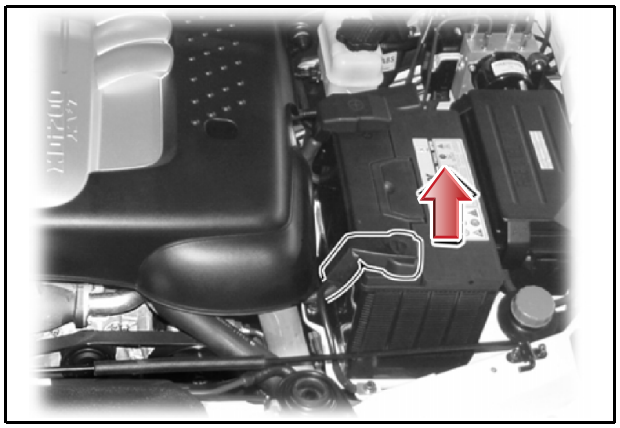
If fine dust or foreign material enters into DI engine's fuel system, there can be serious damages between HP pump and injectors. So, be sure to cover removed fuel system components with cap and protect removed parts not to be contaminated with dirt. (Refer to cleanness in this manual while working on DI engine fuel system)

▶ Electrical equipment

Electrical equipment should be handled more carefully.
Currently, the engine is equipped with a lot of electrical equipments so there can be engine performance drops, incomplete combustion and other abnormals due to short and poor contact. Mechanics should well aware of vehicle's electrical equipment.

1. If have to work on the electrical equipment, be sure to disconnect battery negative (-) terminal and position the ignition switch to off if not required.
2. When replacing electrical equipment, use the same genuine part and be sure to check whether ground or connecting portions are correctly connected during installation.
   If ground or connecting portion is loosened, there can be vehicle fire or personal injury.

13. DURING SERVICE WORK FOR INSPECTION



1. Before lifting up the vehicle with lift, correctly support the lifting points and lift up.
2. When using a jack, park the vehicle on the level ground and block front and rear wheels. Position the jack under the frame and lift up the vehicle and then support with chassis stand before service work.
3. Before service work, be sure to disconnect battery negative (-) terminal to prevent damages by bad wire and short.

4. If service from interior of the vehicle, use protection cover to prevent damage and contamination of seat and floor.
5. Brake fluid and anti-freeze can damage painted surface of body. So carefully handle them during service work.

6. Use recommended and specified tools to increase efficiency of service work.
7. Use only genuine spare parts.

Modification basis	
Application basis	
Affected VIN	

8. Never reuse cotter pin, gasket, O-ring, oil seal, lock washer and self-locking nut. Replace them with new.
   If reused, normal functions cannot be maintained.
9. Align the disassembled parts in clean according to disassembling order and group for easy assembling.
10. According to installing positions, the bolts and nuts have different hardness and design. So be careful not to mix removed bolts and nuts each other and align them according installing positions.
11. To inspect and assemble, clean the parts.
12. Securely clean the parts that related with oil not to be affected by viscosity of oil.
13. Coat oil or grease on the driving and sliding surfaces before installing parts.
14. Use sealer or gasket to prevent leakage if necessary.
15. Damaged or not, never reuse removed gasket.
    Replace with new and cautious on installing directions.
16. Tighten every bolt and nut with specified torque.
17. When service work is completed, check finally whether the work is performed properly or the problem is solved.
18. If work on the fuel line between priming pump and injector (including return line), be sure to cover the removed parts with cap and be careful not to expose the connecting passage and removed parts to external foreign materials or dust. (Refer to cleanness.)
19. If remove high pressure fuel supply pipe between HP pump and fuel rail and high pressure fuel pipe between fuel rail and each injector, be sure to replace them with new.

14. DURING SERVICE WORK FOR ELECTRIC DEVICES

CAUTION

- Be careful not to modify or alter electrical system and electrical device.
  Or there can be vehicle fire or serious damage.

1. Be sure to disconnect battery negative (-) terminal during every service work. Before disconnecting battery negative (-) terminal, turn off ignition key.
2. Replace with specified capacity of fuse if there is bad, blown or short circuited fuse. If use electrical wire or steel wire other than fuse, there can be damages on the various electrical systems. If replaced with over-capacity fuse, there can be damages on the related electrical device and fire.
3. Every wire on the vehicle should be fastened securely not to be loosened with fixing clip.
4. If wires go through edges, protect them with tape or other materials not to be damaged.
5. Carefully install the wires not to be damaged during installation/removal of parts due to interference.
6. Be careful not to throw or drop each sensor or relay.
7. Securely connect each connector until hear a "click" sound.

1) Lifting Positions

▶ 4-post lift

As illustrated, position the vehicle on the 4-post lift securely and block the front and rear of each tire not to move during working.

CAUTION

- During lifting, be sure to check whether vehicle is empty.
  - · Board-on lift connection device installed in front of vehicle should be positioned in front of sill locating under the front door.
  - · Install lift connecting device on the edge of front and rear of board-on lift.

WARNING

- · Be sure to use attachment during lifting to prevent the lift from contacting with body floor.
- · While lifting the vehicle, widen the lift floor as far as possible to stabilize between vehicle front and rear.
  When fixing the lift floor, be careful not to contact with brake tube and fuel lines.

▶ Safety jack and safety stand

If lift up the vehicle with safety jack and stand, should be more careful during works.

WARNING

- · Never be under the vehicle if supported with only jack. If have to be under the vehicle, be sure to use safety block.
- · Use wheel block in front and rear of every wheel.

Modification basis	
Application basis	
Affected VIN	

15. OWNER INSPECTIONS AND SERVICES

1) While Operating The Vehicle

▶ Horn Operation

Blow the horn occasionally to make sure it works. Check all the button locations.

▶ Brake System Operation

Be alert for abnormal sounds, increased brake pedal travel or repeated puling to one side when braking. Also, if the brake warning light goes on, or flashes, something may be wrong with part of the brake system.

▶ Exhaust System Operation

Be alert to any changes in the sound of the system or the smell of the fumes. These are signs that the system may be leaking or overheating. Have the system inspected and repaired immediately.

▶ Tires, Wheels and Alignment Operation

Be alert to any vibration of the steering wheel or the seats at normal highway speeds. This may mean a wheel needs to be balanced. Also, a pull right or left on a straight, level road may show the need for a tire pressure adjustment or a wheel alignment.

▶ Steering System Operation

Be alert to changes in the steering action. An inspection is needed when the steering wheel is hard to turn or has too much free play, or is unusual sounds are noticed when turning or parking.s.

▶ Headlamp Aim

Take note of the light pattern occasionally. Adjust the headlights if the beams seem improperly aimed.

2) At Each Fuel Fill

A fluid loss in any (except windshield washer) system may indicate a problem. Have the system inspected and repaired immediately.

▶ **Engine Oil Level**

Check the oil level and add oil if necessary. The best time to check the engine oil level is when the oil is warm.

1. After stopping the engine, wait a few minutes for the oil to drain back to the oil pan.
2. Pull out the oil level indicator (dip stick).
3. Wipe it clean, and push the oil level indicator back down all the way.
4. Pull out the oil level indicator and look at the oil level on it.
   Add oil, if needed, to keep the oil level above the lower mark. Avoid overfilling the engine, since this may cause engine damage.
5. Add oil, if needed, to keep the oil level above the lower mark. Avoid overfilling the engine, since this may cause engine damage.
6. Push the indicator all the way back down into the engine after taking the reading.

If you check the oil level when the oil is cold, do not run the engine first. The cold oil will not drain back to the pan fast enough to give a true oil level reading.

▶ **Engine Coolant Level and Condition**

Check the coolant level in the coolant reservoir tank and add coolant if necessary. Inspect the coolant. Replace dirty or rusty coolant.

▶ **Windshield Washer Fluid Level**

Check the washer fluid level in the reservoir. Add fluid if necessary.

3) At Least Twice A Month

Tire And Wheel Inspection and Pressure Check Check the tire for abnormal wear or damage. Also check for damaged wheels. Check the tire pressure when the tires are cold (check the spare also, unless it is a stowaway).
Maintain the recommended pressures. Refer to "Wheels and Tire" is in section 4H.

4) At Least Monthly

▶ **Lamp Operation**

Check the operation of the license plate lamp, the headlamps (including the high beams), the parking lamps, the fog lamps, the taillamp, the brake lamps, the turn signals, the backup lamps and the hazard warning flasher.

▶ **Fluid Leak Check**

Periodically inspect the surface beneath the vehicle for water, oil, fuel or other fluids, after the vehicle has been parked for a while. Water dripping from the air conditioning system after use is normal. If you notice fuel leaks or fumes, find the cause and correct it at once.

Modification basis	
Application basis	
Affected VIN	

5) At Least Twice A Year

▶ Power Steering System Reservoir Level

Check the power steering fluid level. Keep the power steering fluid at the proper level. Refer to Section 4G, Power Steering System.

▶ Brake Master Cylinder Reservoir Level

Check the fluid and keep it at the proper level. A low fluid level can indicate worn disc brake pads which may need to be serviced. Check the breather hole in the reservoir cover to be free from dirt and check for an open passage.

▶ Weather-Strip Lubrication

Apply a thin film silicone grease using a clean cloth..

6) Each Time The Oil Is Changed

▶ Brake System Inspection

This inspection should be done when the wheels are removed for rotation. Inspect the lines and the hoses for proper hookup, binding, leaks, cracks, chafing, etc. Inspect the disc brake pads for wear. Inspect the rotors for surface condition. Inspect other brake parts, the parking brake, etc., at the same time. Inspect the brakes more often if habit or conditions result in frequent braking.

▶ Steering, Suspension and Front Drive Axle Boot And Seal Inspection

Inspect the front and rear suspension and the steering system for damaged, loose or missing parts, signs of wear or lack of lubrication. Inspect the power steering line and the hoses for proper hookup, binding, leaks, cracks, chafing, etc. Clean and inspect the drive axle boot and seals for damage, tears or leakage. Replace the seals if necessary.

▶ Exhaust System Inspection

Inspect the complete system (including the catalytic converter if equipped). Inspect the body near the exhaust system. Look for broken, damaged, missing, or out-ofposition parts as well as open seams, holes, loose connections, or other conditions which could cause heat buildup in the floor pan or could let exhaust fumes seep into the trunk or passenger compartment.

▶ Drain the Water from Fuel Filter

When the water level inside water separator in fuel filter exceeds a certain level, water separator warning light comes on and buzzer sounds. Also, the driving force of the vehicle decreases.
If these conditions occur, immediately drain the water from fuel filter & water separator.

▶ Hood Latch Operation

When opening the hood, note the operation of the secondary latch. It should keep the hood from opening all the way when the primary latch is released. The hood must close firmly.

7) At Least Annually

▶ Lap and Shoulder Belts Condition and Operation

Inspect the belt system including: the webbing, the buckles, the latch plates, the retractor, the guide loops and the anchors.

▶ Movable Head Restraint Operation

On vehicles with movable head restraints, the restraints must stay in the desired position.

▶ Spare Tire and Jack Storage

Be alert to rattles in the rear of the vehicle. The spare tire, all the jacking equipment, and the tools must be securely stowed at all times. Oil the jack ratchet or the screw mechanism after each use.

▶ Key Lock Service

Lubricate the key lock cylinder.

▶ Body Lubrication Service

Lubricate all the body door hinges including the hood, the fuel door, the rear compartment hinges and the latches, the glove box and the console doors, and any folding seat hardware.

▶ Underbody Flushing

Flushing the underbody will remove any corrosive materials used for ice and snow removal and dust control. At least every spring clean the underbody. First, loosen the sediment packed in closed areas of the vehicle. Then flush the underbody with plain water.

▶ Engine Cooling System

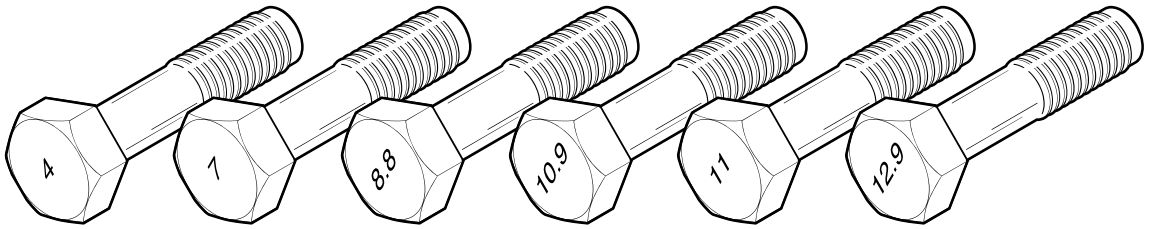
Inspect the coolant and freeze protection fluid. If the fluid is dirty or rusty, drain, flush and refill the engine cooling system with new coolant. Keep the coolant at the proper mixture in order to ensure proper freeze protection, corrosion protection and engine operating temperature. Inspect the hoses. Replace the cracked, swollen, or deteriorated hoses. Tighten the clamps.
Clean the outside of the radiator and the air conditioning condenser. Wash the filler cap and the neck. Pressure test the cooling system and the cap in order to help ensure proper operation.

Modification basis	
Application basis	
Affected VIN	

16. STANDARD BOLTS SPECIFICATIONS

Bolt*	Torque (Nm / lb-in)					
	Standard			Limit		
	4T	7T	9T	4T	7T	9T
M3 ×0.5	0.5 Nm (4.5 lb-in)	0.9 Nm (8 lb-in)	1.3 Nm (12 lb-in)	0.7 Nm (6.3 lb-in)	1.2 Nm (11 lb-in)	17 Nm (15 lb-in)
M4 ×0.7	1.2 Nm (11 lb-in)	2.0 Nm (18 lb-in)	3.0 Nm (27 lb-in)	1.6 Nm (14 lb-in)	2.6 Nm (23 lb-in)	4.0 Nm (36 lb-in)
M5 ×0.8	2.4 Nm (22 lb-in)	4.0 Nm (36 lb-in)	5.6 Nm (50 lb-in)	3.1 Nm (28 lb-in)	5.2 Nm (47 lb-in)	7.6 Nm (68 lb-in)
M6 ×1.0	4.0 Nm (36 lb-in)	6.7 Nm (60 lb-in)	9.7 Nm (87 lb-in)	5.4 Nm (49 lb-in)	9.0 Nm (81 lb-in)	12.7 Nm (114 lb-in)
M8 ×1.25	8.6 Nm (77 lb-in)	15.7 Nm (12 lb-in)	22.5 Nm (17 lb-in)	12.7 Nm (9 lb-in)	20.6 Nm (15.2 lb-in)	30.4 Nm (22 lb-in)
M10 ×1.25	18.6 Nm (14 lb-in)	32.3 Nm (24 lb-in)	46.0 Nm (34 lb-in)	25.5 Nm (19 lb-in)	42.1 Nm (31 lb-in)	60.8 Nm (31 lb-in)
M10 ×1.5	18.6 Nm (14 lb-in)	30.4 Nm (22 lb-in)	44.1 Nm (33 lb-in)	24.5 Nm (18 lb-in)	41.2 Nm (30 lb-in)	58.8 Nm (44 lb-in)
M12 ×1.25	34.3 Nm (25 lb-in)	56.8 Nm (42 lb-in)	82.3 Nm (61 lb-in)	45.0 Nm (33 lb-in)	75.5 Nm (56 lb-in)	107.8 Nm (80 lb-in)
M12 ×1.75	32.3 Nm (24 lb-in)	53.9 Nm (40 lb-in)	77.4 Nm (57 lb-in)	43.1 Nm (32 lb-in)	71.5 Nm (53 lb-in)	98.0 Nm (73 lb-in)
M14 ×1.5	54.0 Nm (40 lb-in)	89.2 Nm (66 lb-in)	127.4 Nm (94 lb-in)	71.6 Nm (53 lb-in)	117.6 Nm (87 lb-in)	166.6 Nm (123 lb-in)
M16 ×1.5	81.3 Nm (60 lb-in)	107.8 Nm (80 lb-in)	196.0 Nm (145 lb-in)	107.8 Nm (80 lb-in)	186.2 Nm (138 lb-in)	264.6 Nm (196 lb-in)
M18 ×1.5	117.6 Nm (87 lb-in)	196.0 Nm (145 lb-in)	284.2 Nm (210 lb-in)	156.8 Nm (116 lb-in)	264.6 Nm (196 lb-in)	372.4 Nm (276 lb-in)
M20 ×1.5	166.6Nm (123 lb-in)	274.4 Nm (203 lb-in)	392.0 Nm (290 lb-in)	215.6 Nm (160 lb-in)	362.6 Nm (268 lb-in)	519.4 Nm (384 lb-in)
M22 ×0.5	225.4Nm (167 lb-in)	372.4 Nm (276 lb-in)	529.2 Nm (392 lb-in)	294.0 Nm (218 lb-in)	490.0 Nm (362 lb-in)	705.6 Nm (522 lb-in)
M24 ×1.5	284.2 Nm (210 lb-in)	480.2 Nm (355 lb-in)	686.0 Nm (508 lb-in)	382.2 Nm (283 lb-in)	637.0 Nm (471 lb-in)	921.2 Nm (682 lb-in)
M24 ×2.0	274.4 Nm (203 lb-in)	460.6 Nm (341 lb-in)	666.4 Nm (493 lb-in)	372.4 Nm (276 lb-in)	617.4 Nm (457 lb-in)	891.8 Nm (660 lb-in)

*Diameter X pitch in millimeters



1. Metric bolt strength is embossed on the head of each bolt. The strength of bolt can be classified as 4T, 7T, 8.8T, 10.9T, 11T and 12.9T in general.
2. Observe standard tightening torque during bolt tightening works and can adjust torque to be proper within 15 % if necessary. Try not to over max.
   allowable tightening torque if not required to do so.
3. Determine extra proper tightening torque if tightens with washer or packing.
4. If tightens bolts on the below materials, be sure to determine the proper torque.
   1) Aluminum alloy: Tighten to 80 % of above torque table.
   2) Plastics: Tighten to 20 % of above torque table.

Modification basis	
Application basis	
Affected VIN	

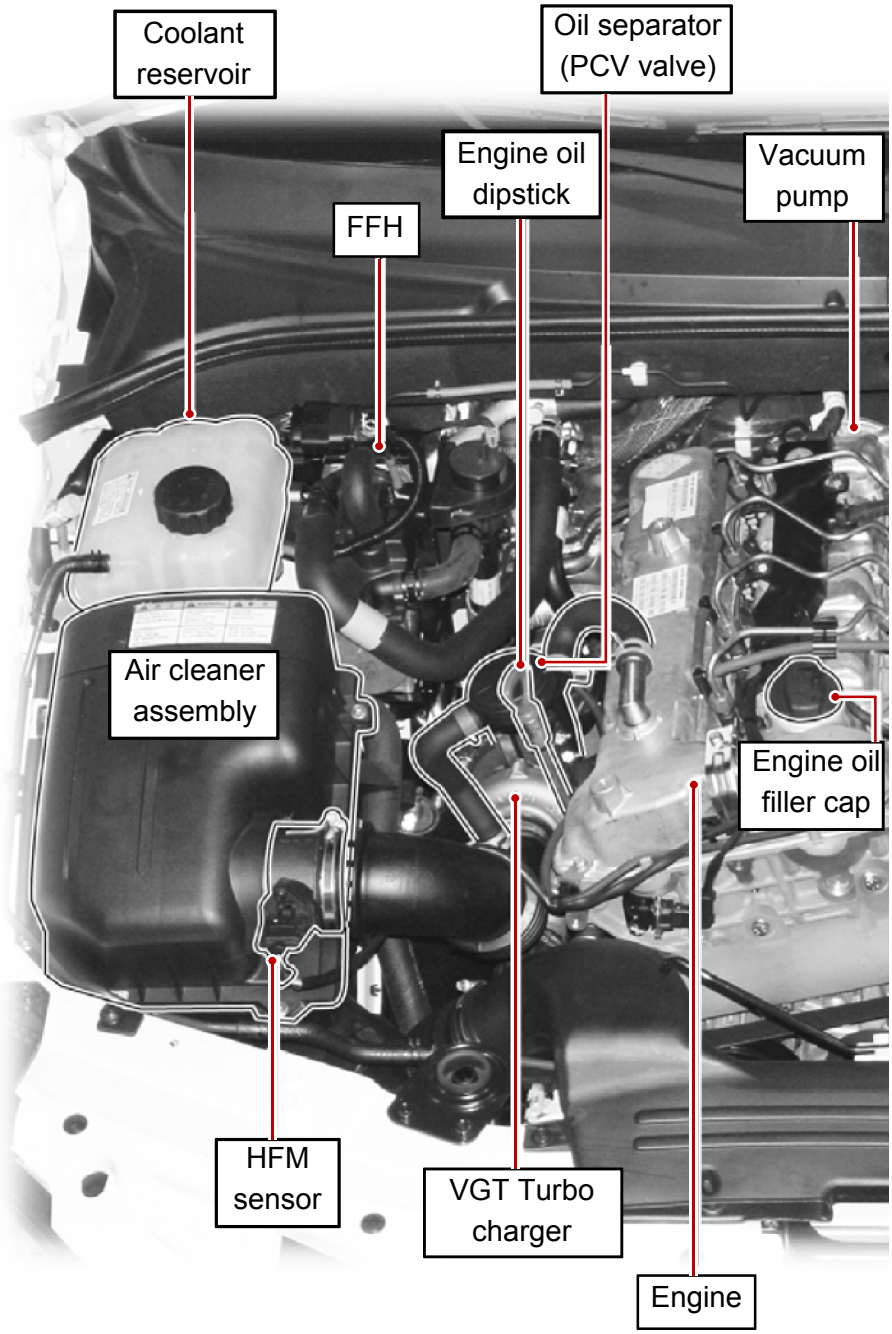
ENGINE ASSEMBLY

1212-01

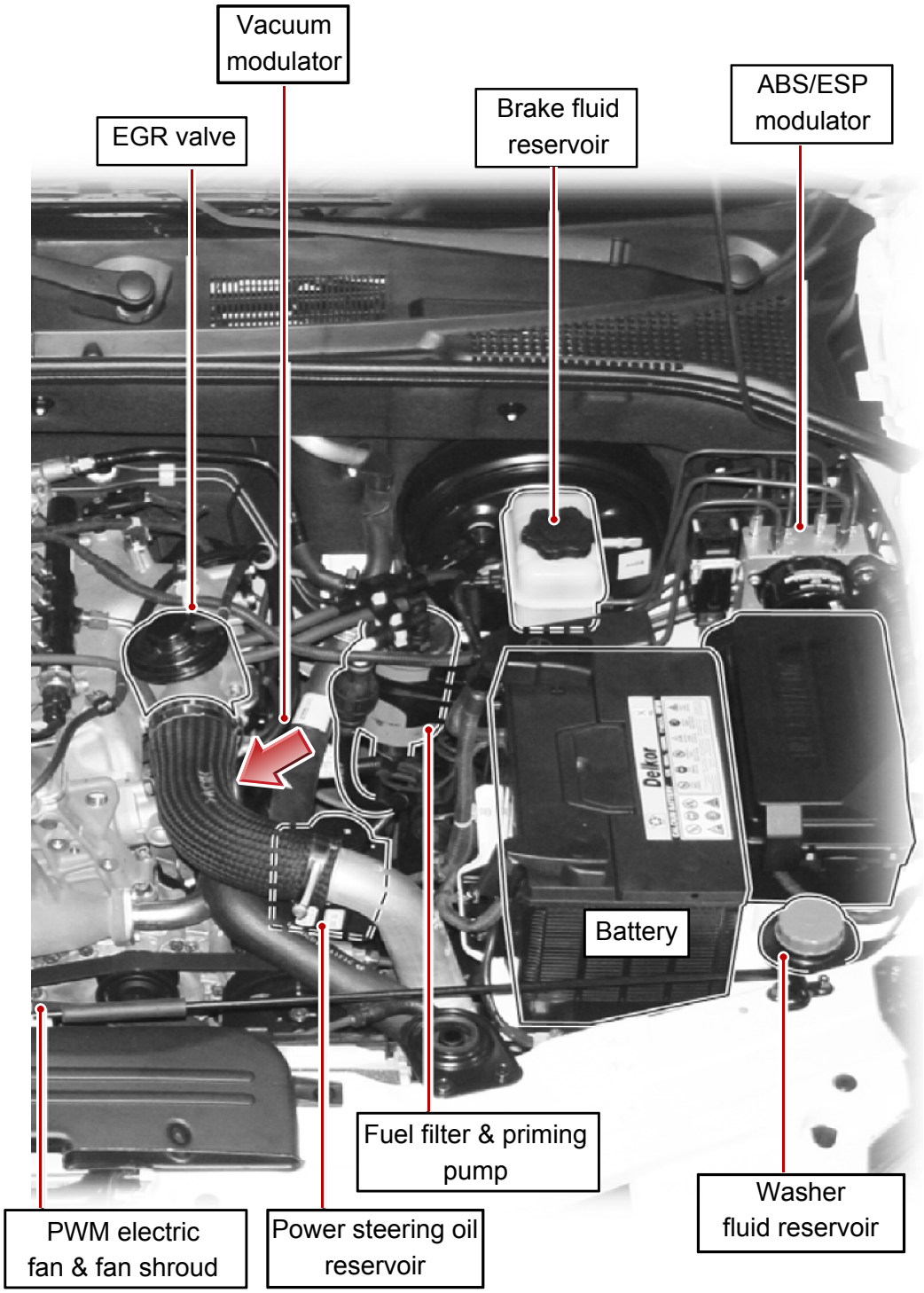
GENERAL

1. MAJOR COMPONENTS IN ENGINE AND ENGINE COMPARTMENT

The advanced electronically controlled D20DT engine that has high pressure fuel system has been introduced to this vehicle. It satisfies the strict emission regulation and provides improved output and maximum torque.

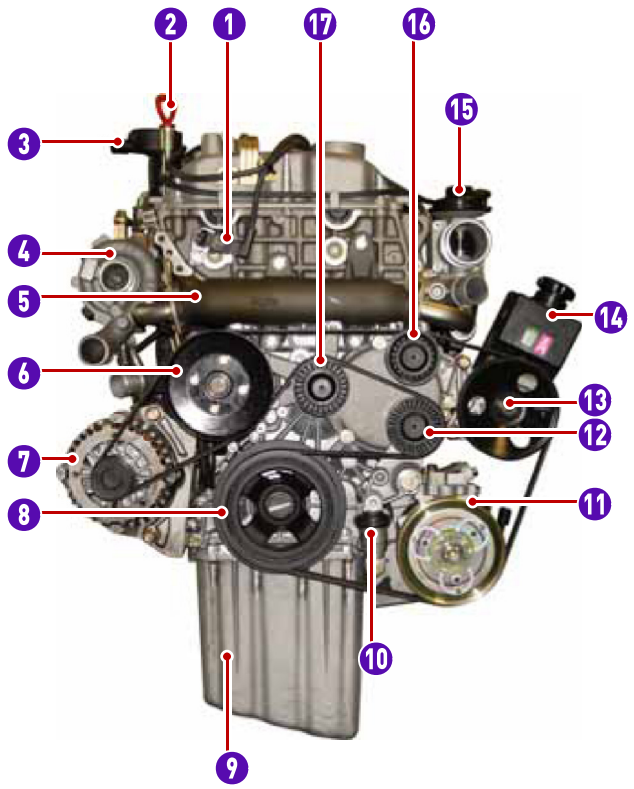


Modification basis	
Application basis	
Affected VIN	


Vacuum modulator
EGR valve
Brake fluid reservoir
ABS/ESP modulator
Battery
Fuel filter & priming pump
Washer fluid reservoir
PWM electric fan & fan shroud
Power steering oil reservoir

1) Engine Structure

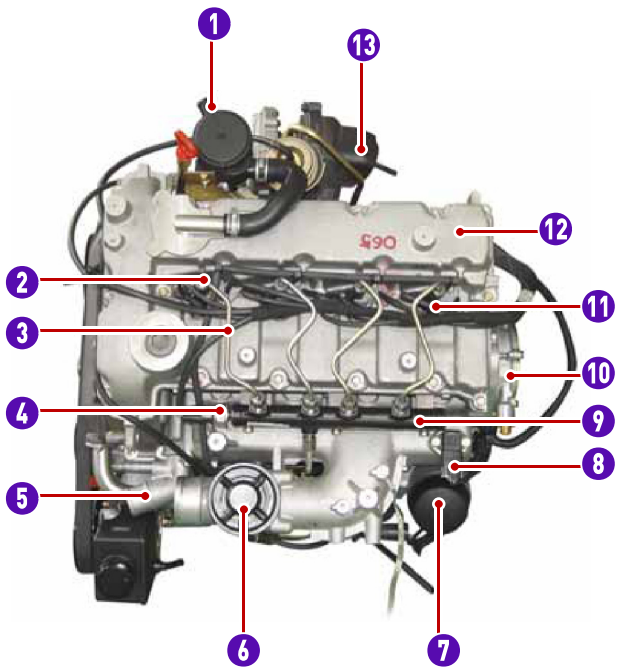
Front View



1	Cam position sensor Tightening torque 12 ± 1.7 Nm
2	Oil dipstick gauge
3	Oil separator (with PCV)
4	VGT Turbo charger
5	EGR pipe
6	Water pump pulley
7	Alternator
8	Crankshaft pulley
9	Oil pan
10	Auto tensioner
11	Air conditioner compressor
12	Auto tensioner pulley
13	Power steering pump pulley
14	Power steering pump
15	EGR valve
16	Idle pulley
17	Viscos clutch pulley

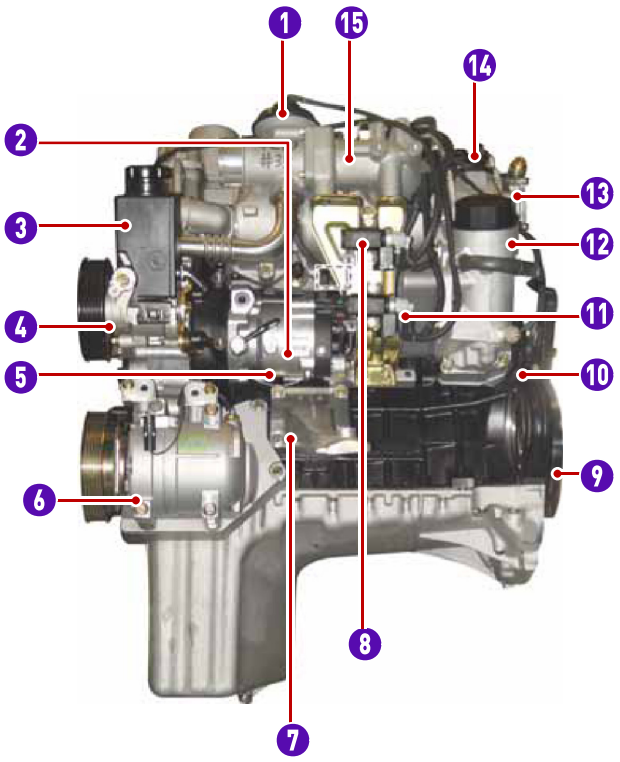
Modification basis	
Application basis	
Affected VIN	

Top View



1	Oil separator
2	Injector cover (10 ± 1.0 Nm → 180 + 20°)
3	Oil pipe (40 ± 4.0 Nm)
4	Fuel pressure sensor
5	Water outlet port
6	EGR valve
7	Oil filler
8	Booster pressure sensor Tightening torque 10 ± 1.0 Nm
9	Common rail (25 ± 2.5 Nm)
10	Vacuum pump (10 ± 1.0 Nm)
11	Glow plug (15 ± 3 Nm)
12	Cylinder head cover
13	VGT Turbo charger

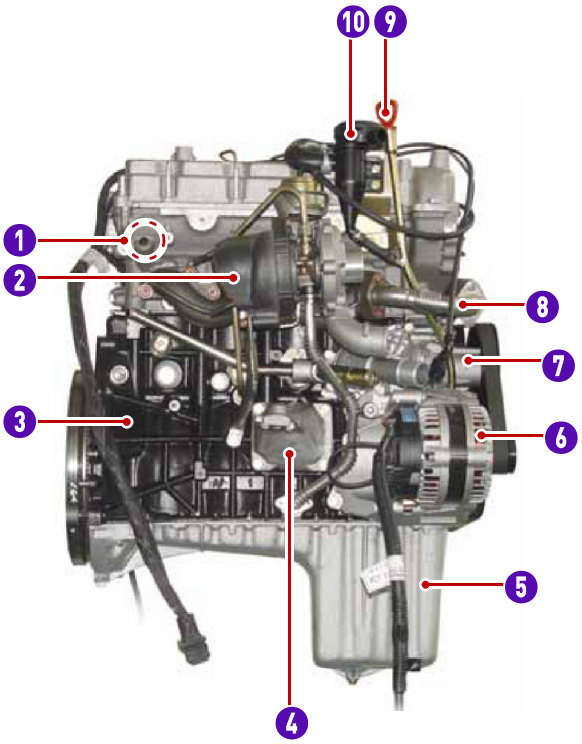
Right Side View



1	EGR valve
2	Knock sensor 20 ± 2.6 Nm
3	Power steering pump oil reservoir
4	Power steering pump
5	HP pump assembly
6	Air conditioner compressor
7	Engine mounting bracket
8	Vacuum modulator for VGT turbocharger actuator
9	Flywheel
10	Crank position sensor Tightening torque 0.8 ± 0.4 Nm Gap: 0.7 ~ 1.5 mm
11	Vacuum modulator for EGR valve
12	Oil filter & oil cooler
13	Vacuum pump
14	Booster pressure sensor
15	Intake manifold

Modification basis	
Application basis	
Affected VIN	

Left Side View



1	Cylinder head jack valve screw
2	VGT Turbo charger assembly
3	Cylinder block assembly
4	Engine mounting bracket
5	Oil pan
6	Alternator
7	Water pump
8	EGR pipe
9	Oil dipstick gauge
10	Oil separator (with PCV)

2. SPECIFICATIONS AND PERFORMANCE CURVE

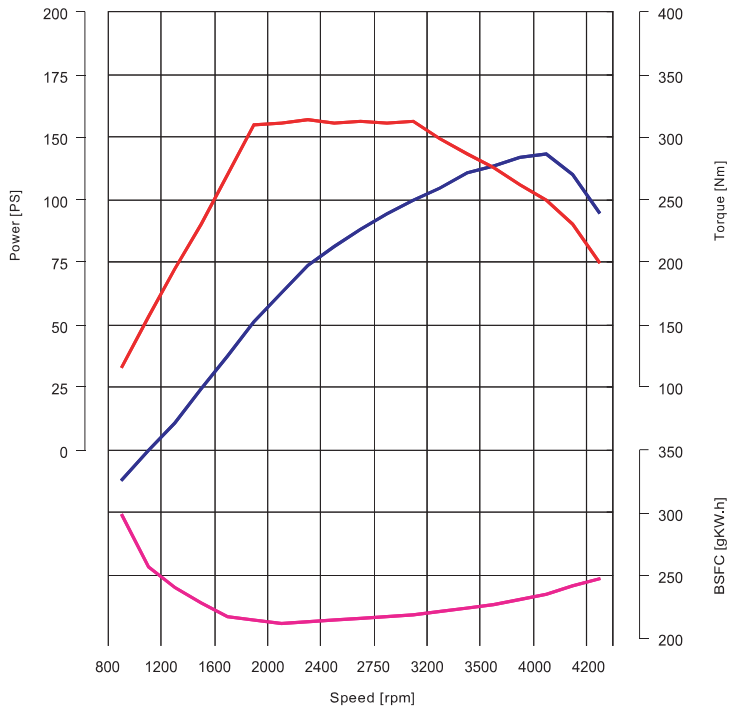
1) Specifications

Description			D20DT
Engine	Type/Number of cylinders		D20DT/4-cylinder
Cylinder	Inner diameter (mm)		86.2
	Stroke (mm)		85.6
Displacement (cc)			1998
Compression ratio			17.5: 1
Maximum output (ps/rpm)			141/4,000
Maximum torque (Nm/rpm)			310/1,800 ~ 2,750
Idle speed	For Manual Transmission		780 ± 50 rpm
	For Automatic Transmission		780 ± 50 rpm
Valve	Intake	Opens (BTDC)	9°
		Closes (ABDC)	26°
	Exhaust	Opens (BBDC)	38°
		Closes (ATDC)	16°
Camshaft	Type		DOHC
Fuel system	Fuel type		Low sulfur diesel
	Fuel pump type		Vane pump in HP pump
	Fuel supply pressure		HP pump inlet port: max. 400 mbar HP pump outlet port (with IMV fully open): over 1,050 bar
	Water separation in fuel filter		at every 10,000 km
	Fuel tank capacity (ℓ)		75
Lubrication system	Oil specification		SAE 10W40, 5W40 (MB Sheet 229.1, 229.3 approved oil)
	Lubrication type		Forced delivery
	Oil filter type		Full flow, filter element type
	Oil capacity (ℓ)		≒ 7.5
Cooling system	Cooling type		Water cooling type
	Cooling fan operation type		Belt operated type
	Thermostat (Fully Open: 100°C)	Opening temperature (°C)	85
		Type	WAX pellet type
	Coolant capacity (ℓ)		≒ 11.5

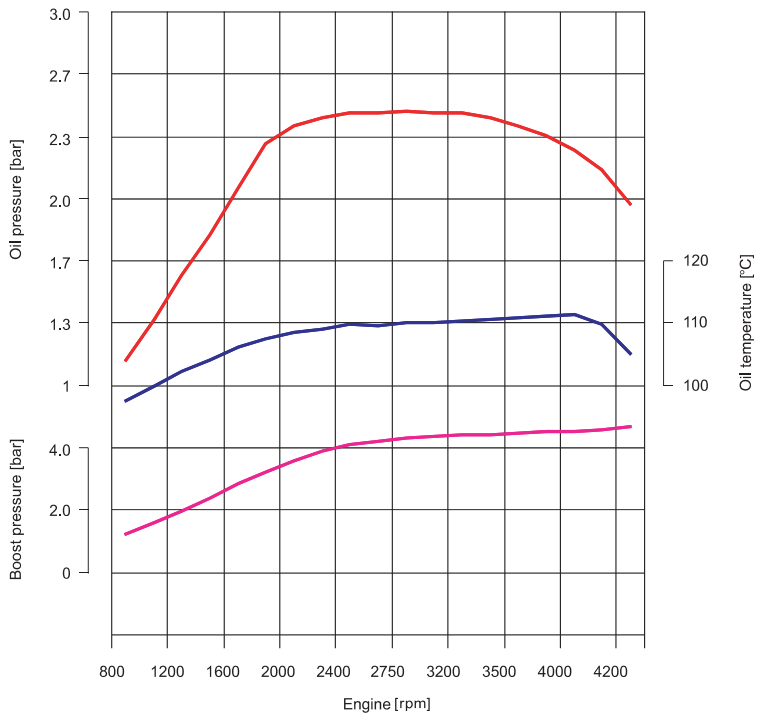
Modification basis	
Application basis	
Affected VIN	

2) Engine Performance Curve

(1) Output and Torque



(2) Oil Temperature/Pressure and Boost Pressure



3. TIGHTENING TORQUE

NO.	Name	Size	Quantity	Tightening Torque (Nm)
1	Main bearing cap	M11 x 67	10	55 ± 5 120° ± 10°
2	Connecting rod cap	M9 x 51	8	40 ± 5 90° ± 10°
3	Rear cover	M6 x 20	6	10 ± 1
4	Oil pump	M8 x 35SOC	3	25 ± 2.5
5	T.G.C. C	M6 x 40	6	10 ± 1
		M6 x 60	3	10 ± 1
		M6 x 70	2	10 ± 1
6	Flywheel	M10 x 22	8	45 ± 5 90° ± 10°
7	Crankshaft hub	M20 x 85	1	200 180° ± 10°
8	Oil pan	M6 x 20	20	10 ± 1
		M6 x 35	3	10 ± 1
		M6 x 85	3	10 ± 1
		M8 x 40	4	25 ± 2.5
9	High pressure pump mounting bolt	M8 x 55	3	25 ± 2.5
10	High pressure pump main nut (intershaft)	M14 x 1.5	1	65 ± 5
11	Cylinder head	M8 x 25	2	25 ± 2.5
		M8 x 50	2	
		M10 x 158	1	85 ± 5
		M10 x 177	9	270° + 10°
12	Camshaft sprocket (Intake)	M11 x 40	1	25 ± 2.5
13	Camshaft sprocket (Exhaust)			90° ± 10°
14	Chain tensioner	M24	1	65 ± 5
15	Auto tensioner	M12 x 90 (UP)	1	82 ± 6
		M8 x 45 (LOWER)	1	32 ± 3
16	Water pump assembly	M6 x 50	7	10 ± 1
17	Water pump pulley	M6 x 10	4	10 ± 1
18	Hot water inlet pipe assembly	M6 x 12	2	10 ± 1
19	Alternator bracket	M8 x 80	1	25 ± 2.5
		M8 x 34	2	25 ± 2.5
		M8 x 30	2	25 ± 2.5
20	Alternator	M10 x 90	1	46 ± 4.6
		M10 x 116	1	46 ± 4.6

Modification basis	
Application basis	
Affected VIN	

NO.	Name	Size	Quantity	Tightening Torque (Nm)
20	Air conditioner compressor bracket assembly	M8 x 25	1	25 ± 2.5
		M8 x 60	3	25 ± 2.5
22	Air conditioner compressor sub bracket assembly	M6 x 16	1	10 ± 1.0
		M8 x 20	1	25 ± 2.5
23	Intake manifold	M8 x 50	5	25 ± 2.5
		M8 x 133	5	25 ± 2.5
24	Acoustic cover bracket	M6 x 16	2	25 ± 2.5
		M8 x 105	1	25 ± 2.5
25	Knock sensor	M8 x 28	1	20 ± 2.6
26	Camshaft position sensor	M8 x 14	1	12 ± 1.7
27	Booster pressure sensor	M6 x 20	2	10 ± 1.0
28	Exhaust manifold stud bolt	M8 x 46	8	15 ± 1.5
		M8 x 35	2	15 ± 1.5
29	Exhauster manifold nut	M8	8	40 ± 4.0
30	Turbo charger assembly	M8	3	25 ± 2.5
31	Turbocharger hollow bolt	M10 x 1.0	1	18 ± 1.8
32	Turbocharger oil feed pipe	M16 (Cylinder block side)	1	25 ± 2.5
33	Turbocharger support bar (nut)	M8	1	23 ± 2.3
34	Turbocharger support bar (bolt)	M8 x 20	1	25 ± 2.5
35	Turbocharger return pipe	M6 x 16 (T/C side)	2	10 ± 1.0
		M6 x 16 (Cylinder block side)	2	10 ± 1.0
36	EGR valve assembly	M6 x 25	4	10 ± 1.0
37	EGR-LH pipe nut	M8	2	35 ± 3.5
38	EGR-RH pipe nut	M6 x 16	2	10 ± 1.0
39	EGR center bolt	M6 x 16	4	10 ± 1.0
40	EGR center pipe	M8 x 25	2	25 ± 2.5
		M8 x 30	2	25 ± 2.5
41	Glow plug	M5	5	15 ± 3.0
42	Vacuum pump	M6 x 20	3	10 ± 1.0
		M6 x 25	5	10 ± 1.0
43	Cooling fan bracket assembly	M6 x 55	1	10 ± 1.0
		M6 x 85	3	10 ± 1.0
44	Cylinder head cover	M6 x 35	18	10 ± 1.0
45	Vacuum modulator	M6 x 16	4	10 ± 1.0
46	Oil dipstick tube	M6 x 16	1	10 ± 1.0
47	Oil filter assembly	M8 x 35	1	25 ± 2.5
		M8 x 55	2	25 ± 2.5
		M8 x 125	1	25 ± 2.5

NO.	Name	Size	Quantity	Tightening Torque (Nm)
48	Fuel rail assembly	M8 x 35	2	25 ± 2.5
49	Injector	M6 x 60	4	10 ± 1.0 180° + 20°
50	Fuel pipe clip (H-C)	M14	2	40 ± 4.0
51	Fuel pipe clip (C-I)	M14	8	40 ± 4.0
52	Crankshaft position sensor	M6 x 14	1	0.8 ± 0.4
		GAP	-	0.7 ± 1.5 mm
53	Power steering pump	M8 x 100	2	25 ± 2.5
54	Head screw plug	-	1	25 ± 2.5
55	Cam shaft cap bolt	M8 x 60	20	25 ± 2.5
56	Piston topping	-	-	0.765 ~ 1.055 mm
57	Connecting rod end play	-	-	0.500 ~ 1.500 mm
58	Cam shaft end play	-	-	0.100 ~ 0.350 mm
59	Crank shaft end play	-	-	0.100 ~ 0.254 mm

Modification basis	
Application basis	
Affected VIN	

ENGINE FUEL SYSTEM

1881-01

GENERAL

1. CAUTIONS FOR DI ENGINE

This chapter describes the cautions for DI engine equipped vehicle. This includes the water separation from engine, warning lights, symptoms when engine malfunctioning, causes and actions.

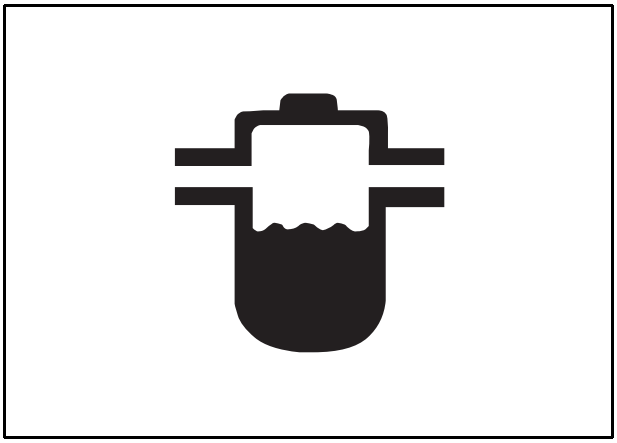
1) DI Engine

Comparatively conventional diesel engines, DI engine controls the fuel injection and timing electrically, delivers high power and reduces less emission.

2) System Safety Mode

When a severe failure has been occurred in a vehicle, the system safety mode is activated to protect the system. It reduces the driving force, restricts the engine speed (rpm) and stops engine operation. Refer to "Diagnosis" section in this manual.

3) Water Separator Warning Light



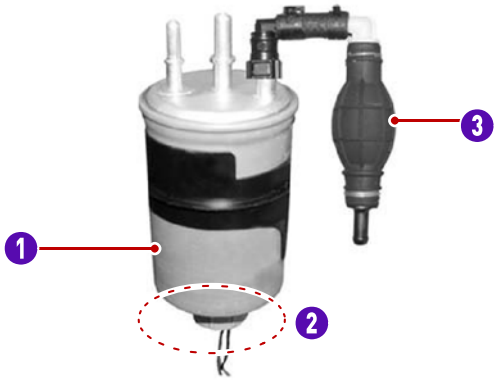
When the water level inside water separator in fuel filter exceeds a certain level (approx. 39 cc), this warning light comes on and buzzer sounds.
Also, the driving force of the vehicle decreases (torque reduction). If these conditions occur, immediately drain the water from fuel filter.
For the draining procedures, please refer to "How to drain the water from fuel filter" section.

4) Priming Pump

The priming pump installed in fuel pump is the device to fill the fuel into the fuel filter. When the vehicle is under the conditions as below, press the priming pump until it becomes rigid before starting the engine.

5) Conditions for Using Priming Pump

- After run out of fuel
- After draining the water from fuel separator
- After replacing the fuel filter

Fuel Filter and Water Separator	
	

1. Fuel filter
2. Water drain plug(water separating operation:every 10,000km)
3. Priming pump

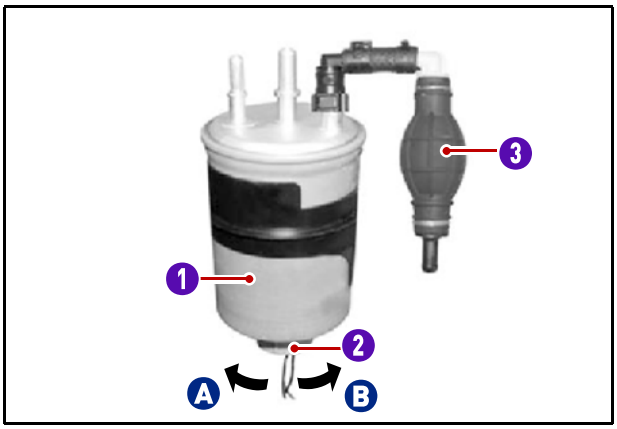
CAUTION

- When replaced the fuel filter or drained the water from fuel filter, press the priming pump until it becomes rigid before starting the engine.
- The water drain from fuel filter should be performed whenever changing the engine oil.

Modification basis	
Application basis	
Affected VIN	

6) Draining the Water From Fuel Filter

1. Place the water container under the fuel filter.



2. Turn the drain plug (2) to "A" direction to drain the water.
3. Wait until a certain amount of fuel gets out from the port, then turn the drain plug to "B" direction to tighten it.

CAUTION

- Be careful not to be injured by surrounding equipment during the working procedures.

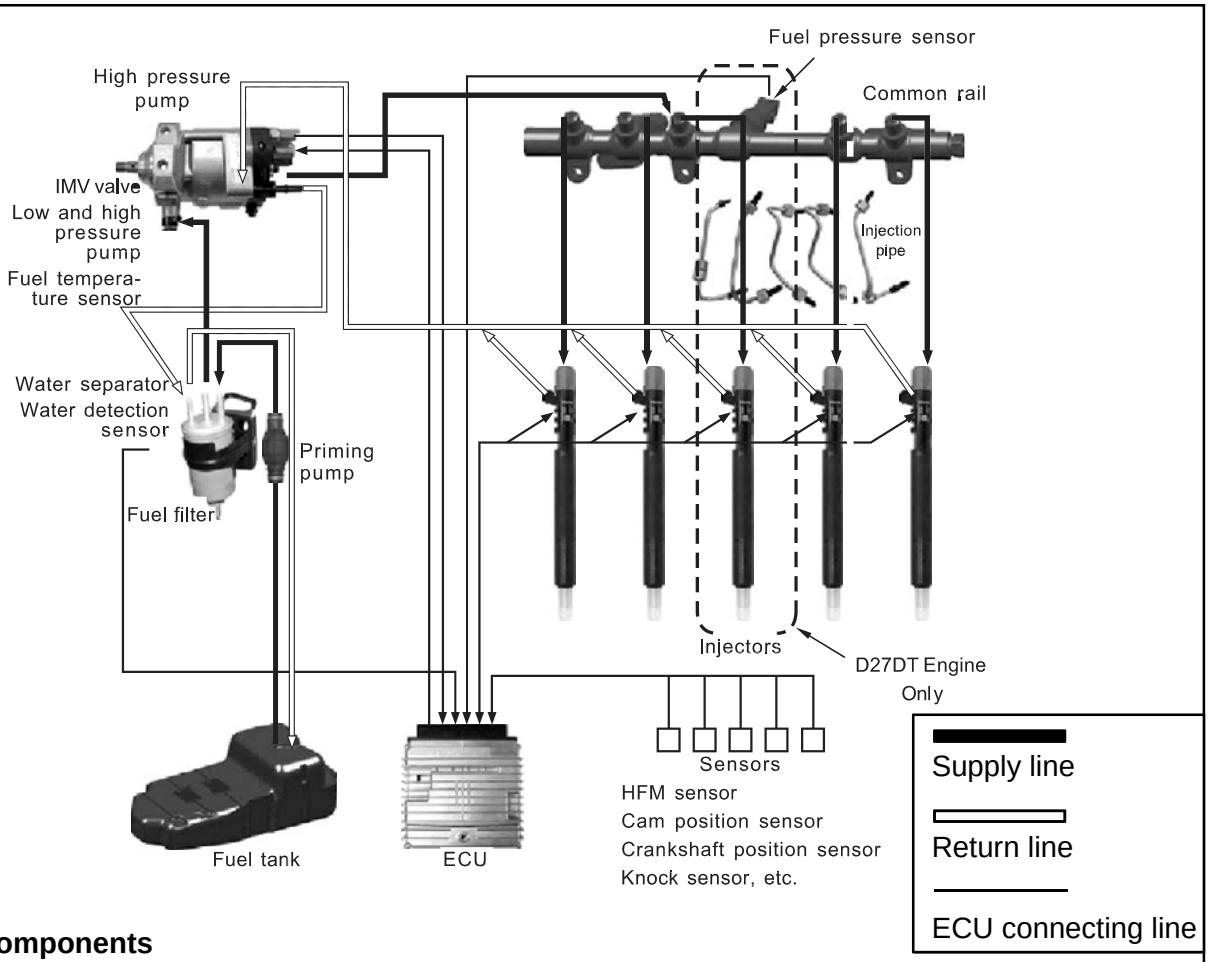
4. Press the priming pump until it becomes rigid.
5. Start the engine and check the conditions.

CAUTION

- If the priming pump is not properly operated, air may get into the fuel line. It may cause starting problem or fuel system problem. Make sure to perform the job in step 4.

OVERVIEW AND OPERATION PROCESS

1. ELECTRONIC CONTROL OF FUEL SYSTEM



Components

- High pressure fuel pump
- Fuel rail
- Fuel pressure sensor
- Fuel injectors
- Electronic control unit(ECU)
- Various sensors and actuators

According to input signals from various sensors, engine ECU calculates driver's demand (position of the accelerator pedal) and then controls overall operating performance of engine and vehicle on that time.

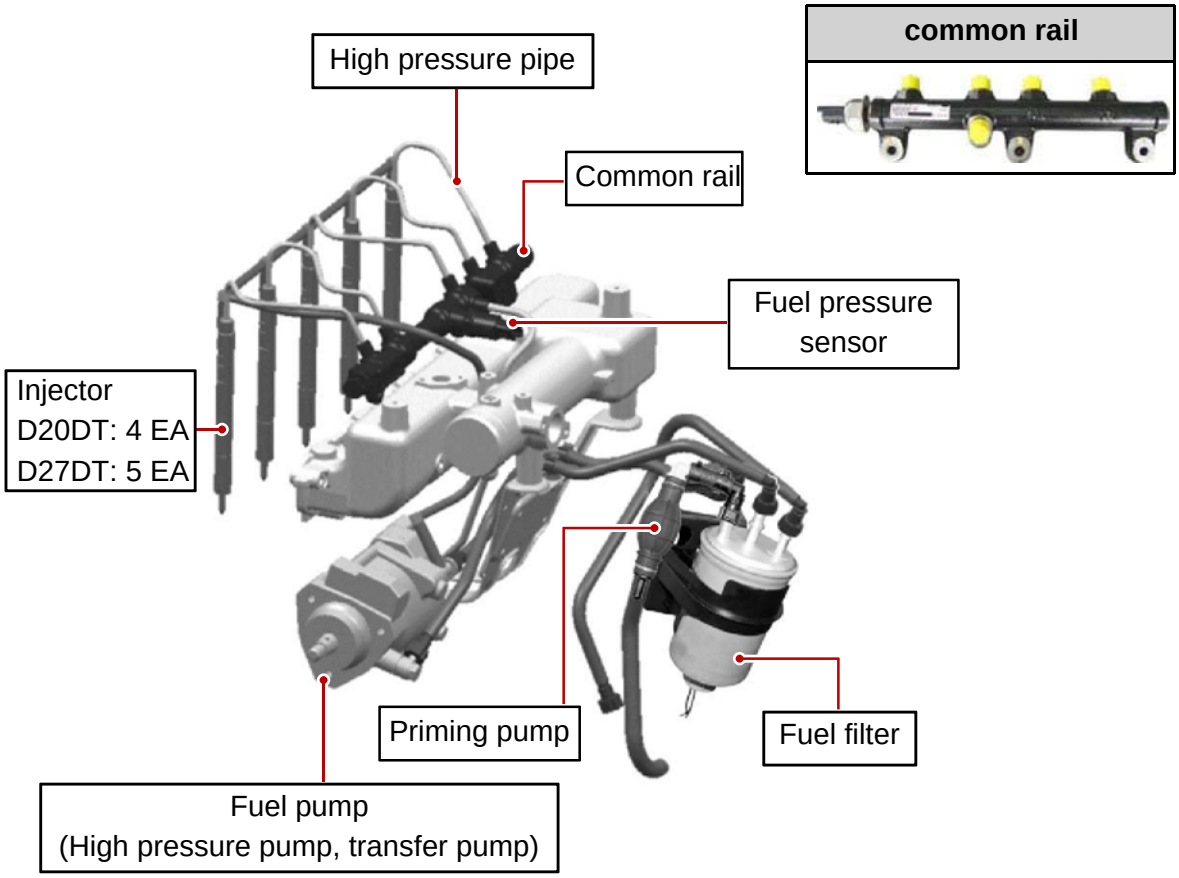
ECU receives signals from sensors via data line and then performs effective engine air-fuel ratio controls based on those signals. Engine speed is measured by crankshaft speed (position) sensor and camshaft speed (position) sensor determines injection order and ECU detects driver's pedal position (driver's demand) through electrical signal that is generated by variable resistance changes in accelerator pedal sensor. Air flow (hot film) sensor detects intake air volume and sends the signals to ECU. Especially, the engine ECU controls the air-fuel ratio by recognizing instant air volume changes from air flow sensor to decrease the emissions (EGR valve control). Furthermore, ECU uses signals from coolant temperature sensor and air temperature sensor, booster pressure sensor and atmospheric pressure sensor as compensation signal to respond to injection starting, pilot injection set values, various operations and variables.

Modification basis	
Application basis	
Affected VIN	

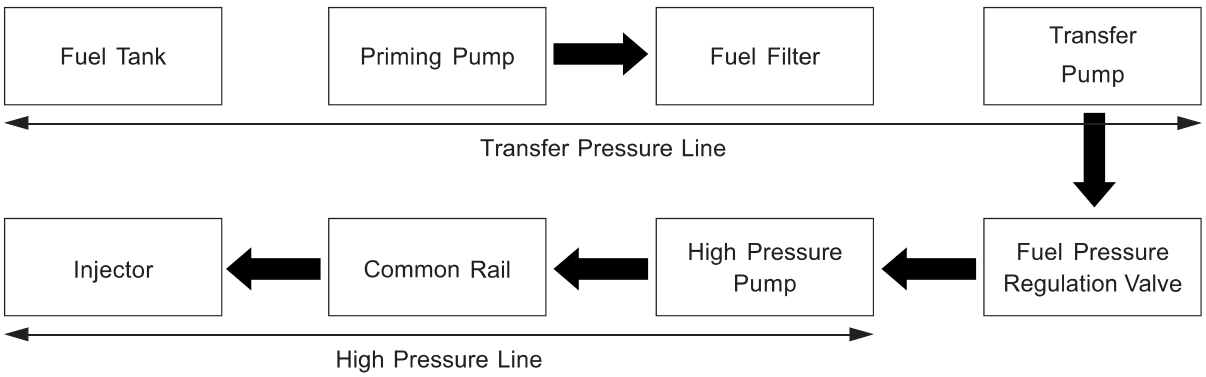
2. COMPOSITION OF FUEL SYSTEM

Components in fuel system are designed to generate and distribute high pressure, and they are controlled electronically by engine ECU. Accordingly, fuel system is completely different from injection pump type fuel supply system on the conventional Diesel engine. The fuel injection system in common rail engine is composed of transfer pressure section that transfers fuel in low pressure, high pressure section that transfers fuel in high pressure and ECU control section.

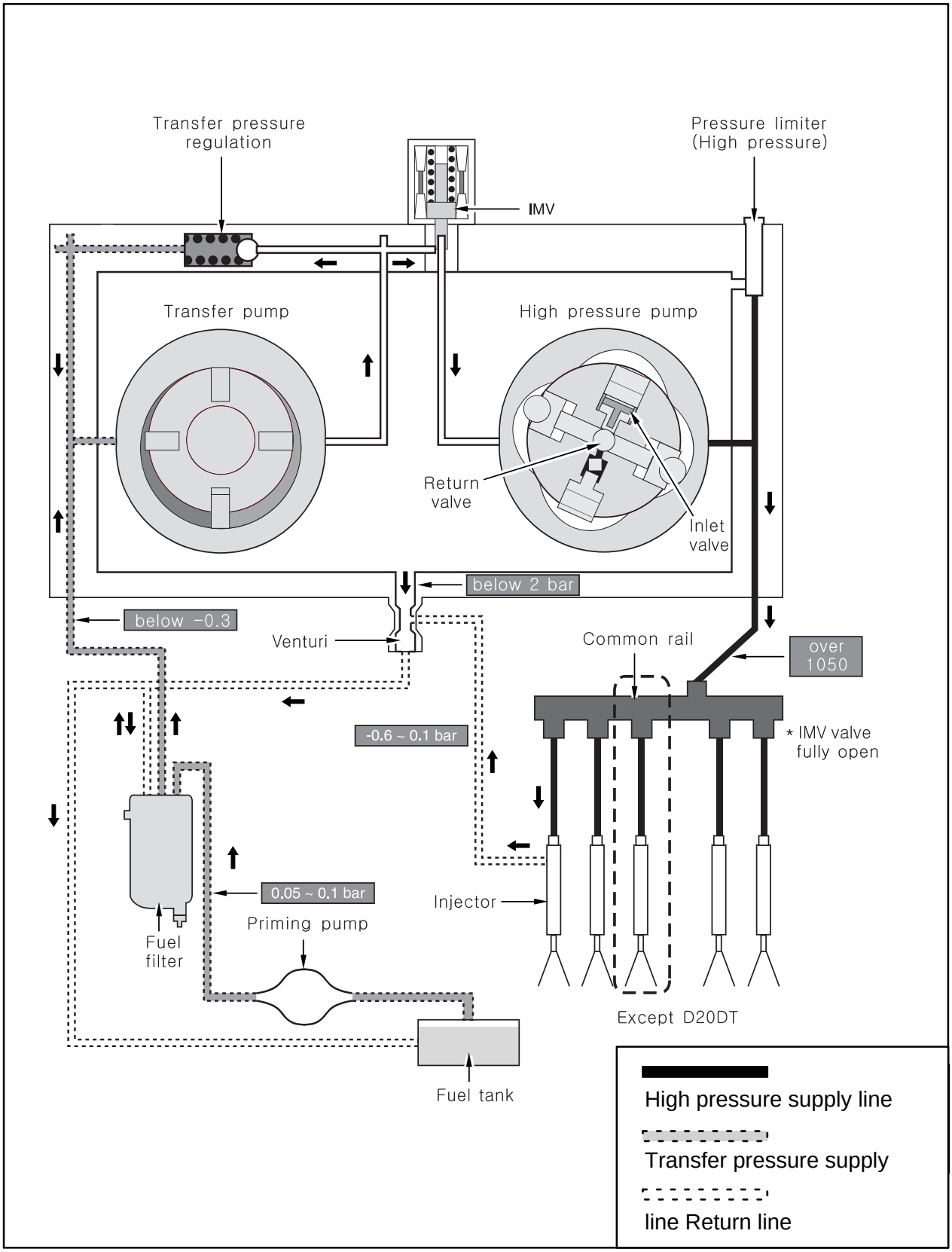
Fuel Line System



Fuel route



3. HYDRAULIC CYCLE IN FUEL LINE (TRANSFER AND HIGH PRESSURE LINE)



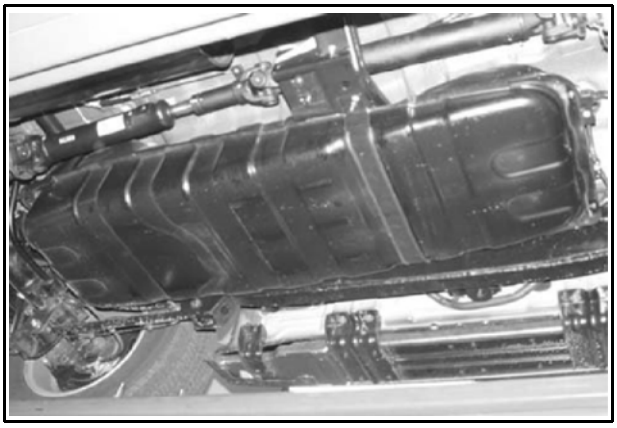
Modification basis	
Application basis	
Affected VIN	

4. COMPONENTS OF LOW PRESSURE TRANSFER LINE

Low pressure stage is to supply sufficient fuel to high pressure section and components are as below.

- Fuel tank (including strainer)
- Hand priming pump
- Fuel filter
- Transfer pump
- Other low pressure fuel hoses

1) Fuel Tank



Fuel tank is made of anti-corrosion material and its allowable pressure is 2 times of operating pressure (more than min. 0.3 bar).
It has protective cap and safety valve to prevent excessive pressure building. Also, to supply fuel smoothly, it has structure to prevent fuel from leaking in shocks, slopes and corners and.

2) Priming Pump

If fuel runs out during driving or air gets into fuel line after fuel filter replacement, it may cause poor engine starting or damage to each component. Therefore, the hand priming pump is installed to bleed air from transfer line.
When the vehicle is under the conditions as below, press the priming pump until it becomes rigid before starting the engine.

- After run out of fuel
- After draining the water from fuel separator
- After replacing the fuel filter

Press the priming pump until it becomes rigid before starting the engine.

3) Fuel Filter

It requires more purified fuel supply than conventional diesel engine. If there are foreign materials in the fuel, fuel system including pump components, delivery valve and injector nozzles may be damaged.
Fuel filter purifies fuel before it reaches to high pressure pump to help proper operations in high pressure pump.
And more, it separates water from fuel to prevent water from getting into FIE system (high pressure line).

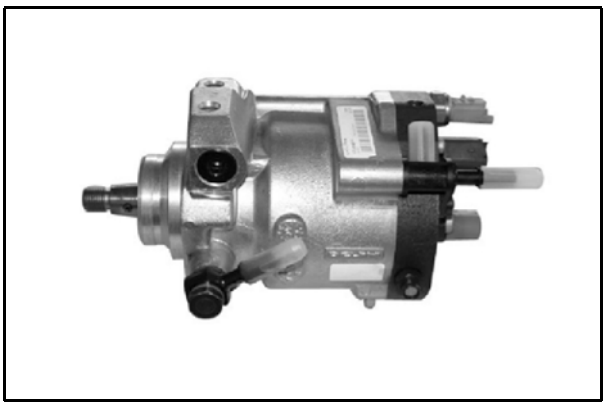
Modification basis	
Application basis	
Affected VIN	

5. COMPONENTS OF HIGH PRESSURE TRANSFER LINE

In the high pressure section, sufficient fuel pressure that injectors requires will be generated and stored. The components are as below:

- High pressure pump
- Rail pressure sensor
- Pressure limit valve
- Common rail
- High pressure pipe
- Injector
- Fuel pressure regulating valve (IMV)

1) High Pressure Pump



This is plunger pump that generates high pressure and driven by crankshaft with timing chain. The high pressure pump increases system pressure of fuel to approx. 1,600 bar and this compressed fuel is transferred to high pressure accumulator (common rail) in tube through high pressure line.

2) Common Rail

It stores fuel transferred from high pressure pump and also stores actual high pressure of fuel. Even though the injectors inject fuel from the rail, the fuel pressure in the rail is maintained to a specific value. It is because the effect of accumulator is increased by unique elasticity of fuel. Fuel pressure is measured by rail pressure sensor.
And the fuel pressure regulating valve (IMV, Inlet Metering Valve) included in high pressure pump housing keeps pressure to a desired level.

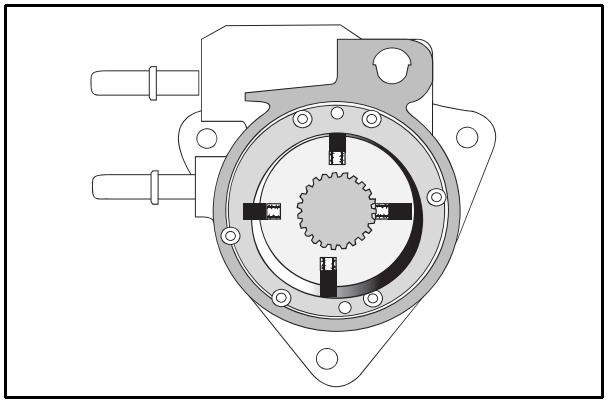
3) High Pressure Pipe (Fuel Pipe)

Fuel line transfers high pressure fuel. Accordingly, it is made of steel to endure intermittent high frequency pressure changes that occur under maximum system pressure and injection stops. Injection lines between rail and injectors are all in the same length; it means the lengths between the rail and each injector are the same and the differences in length are compensated by each bending.

4) Injectors

The fuel injection device is composed of electrical solenoid valve, needle and nozzle and controlled by engine ECU. The injector nozzle opens when solenoid valve is activated to directly inject the fuel into combustion chamber in engine. When injector nozzle is open, remaining fuel after injection returns to fuel tank through return line.
Pressure limit valve, fuel returned by low pressure and fuel used for high pressure pump lubrication also return to fuel tank through return line.

5) Transfer Pump



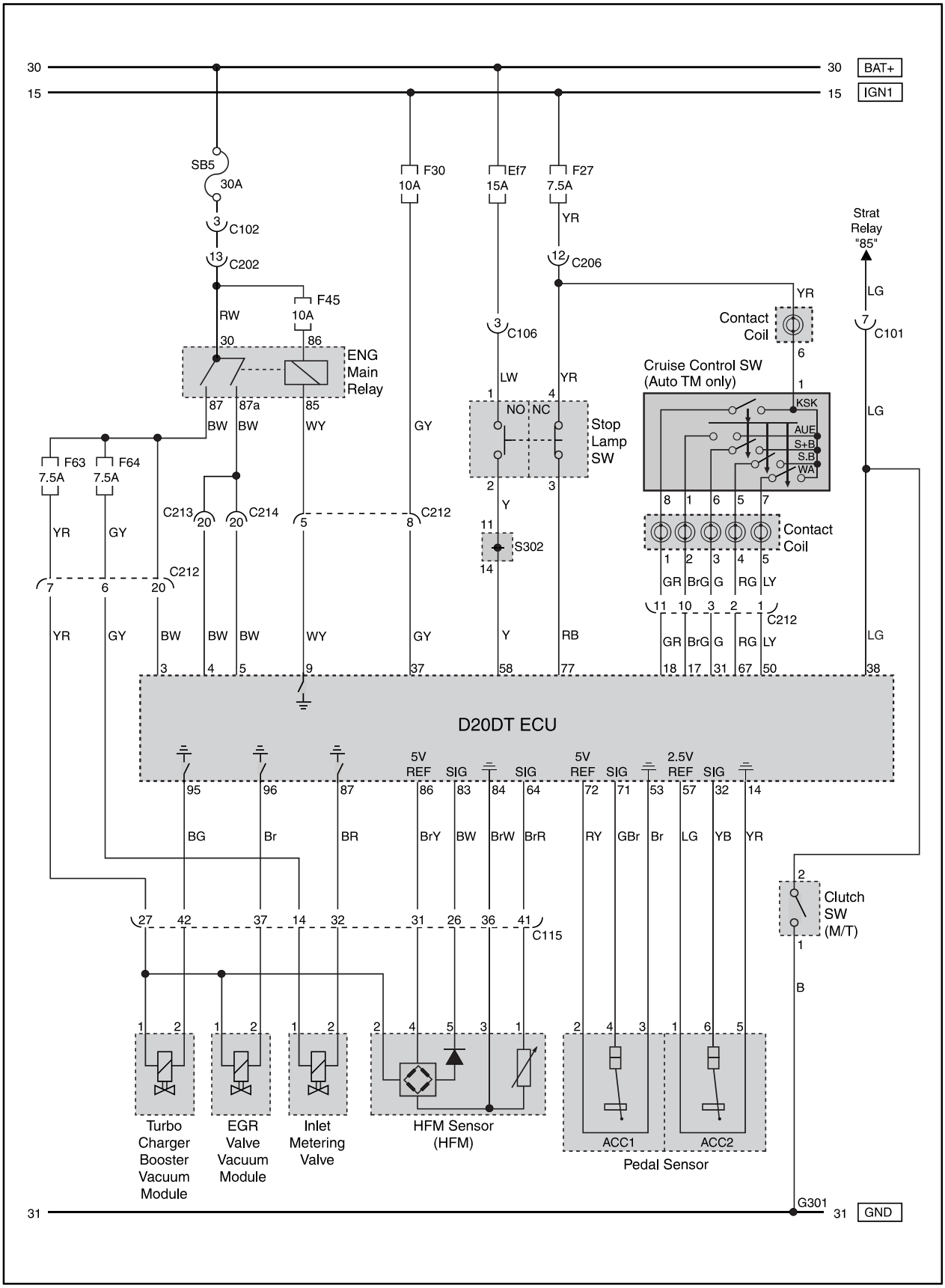
The transfer pump is included in the housing of the high pressure pump. The transfer pump is the volumetric blade type pump. To deliver the continuously required fuel volume, the pump transfers fuel from the fuel tank to high pressure pump.

6) Fuel Filter Replacement

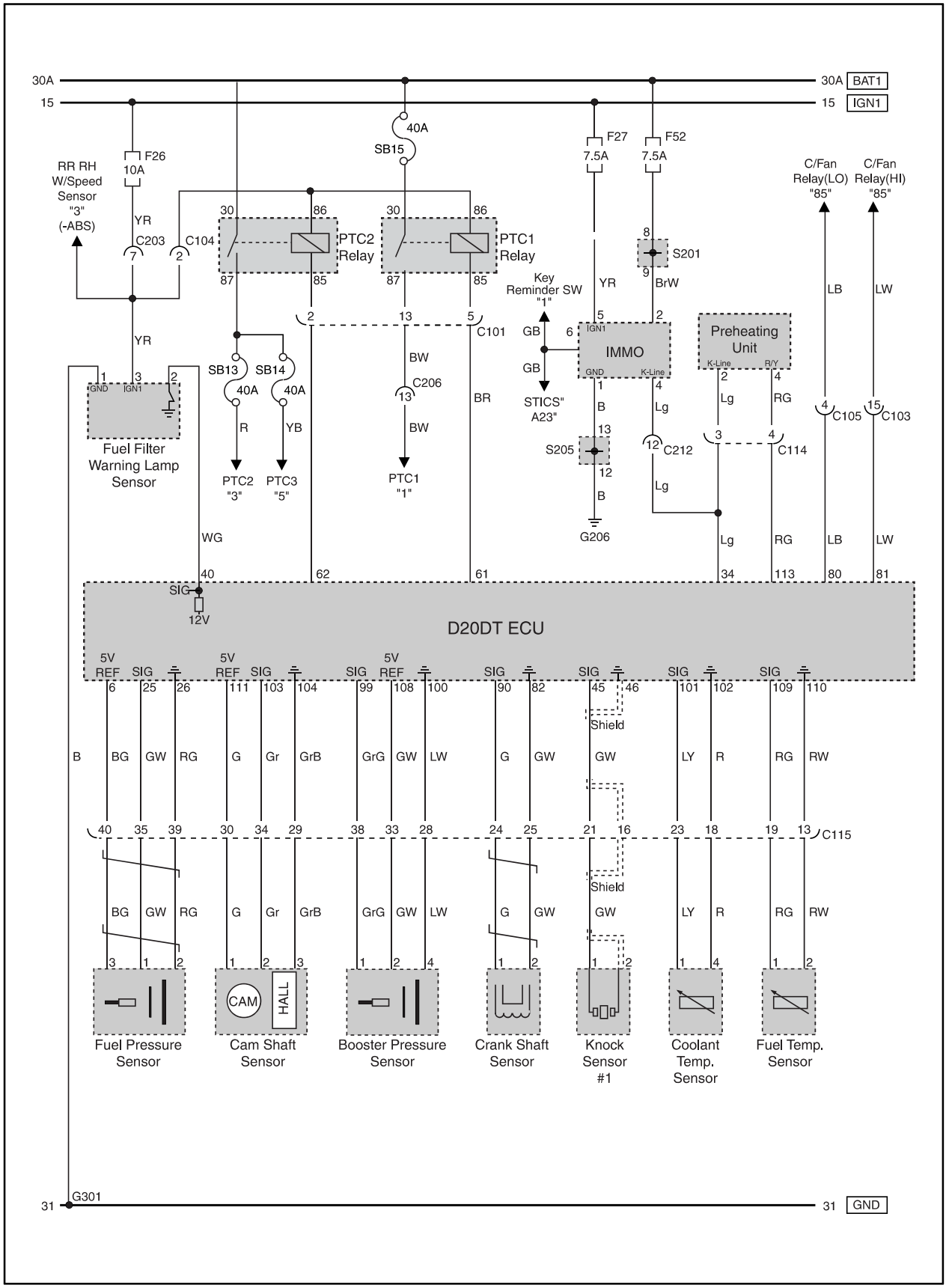
- Fuel filter change interval: every 30,000 km
- Water separation interval: every 10,000 km (same with engine oil change interval)
- Never reuse the removed fuel filter

Modification basis	
Application basis	
Affected VIN	

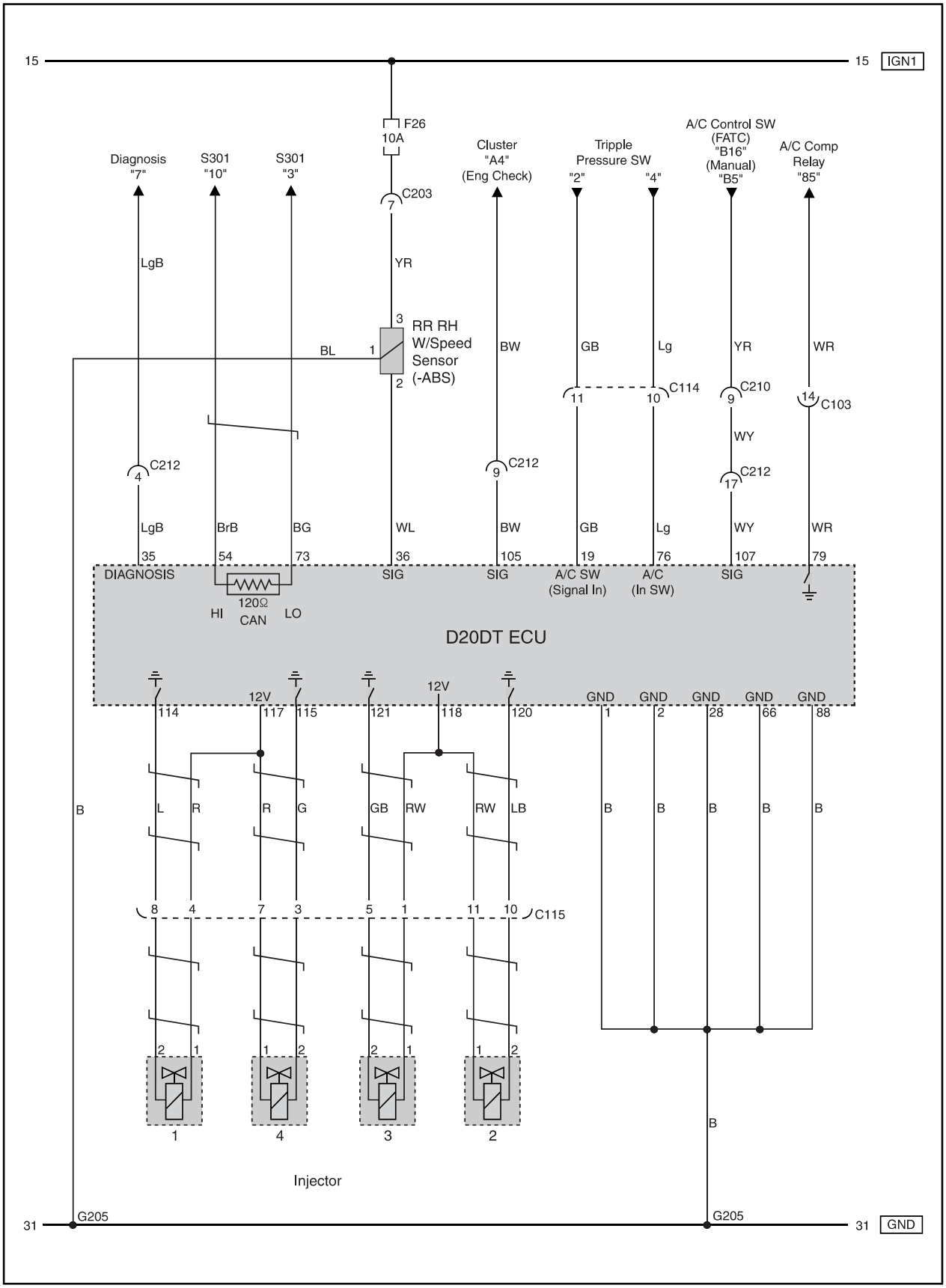
6. CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	



Modification basis	
Application basis	
Affected VIN	



Modification basis	
Application basis	
Affected VIN	

Memo

ENGINE INTAKE SYSTEM

2321-01

GENERAL

1. ENGINE INTAKE SPECIFICATIONS

1) Specifications

Element Type	Dry-Element Type
Service Interval	- Initial cleaning: 5,000 km, Clean or change every 10,000 km as required. However, change every 30,000 km. - If the vehicle is operated under severe condition (short distance driving, extensive ldling or driving in dusty condition): More frequent maintenance is required.

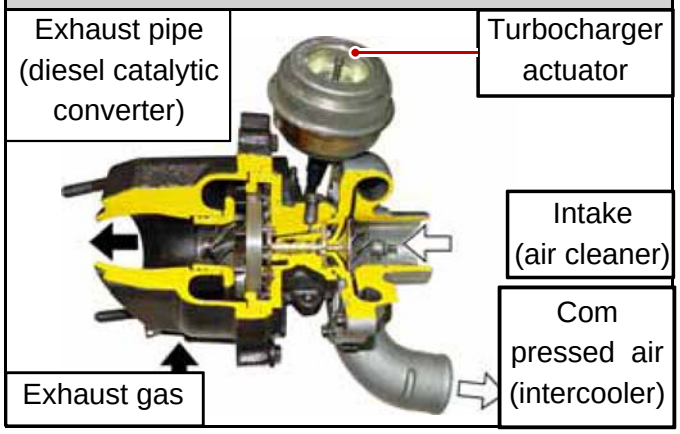
OVERVIEW AND OPERATION PROCESS

1. INTAKE SYSTEM LAYOUT

1) Work Flow of Intake System

Air Cleaner → HFM Sensor → VGT Turbo-charger → Inter-cooler → Intake Manifold → Combus-tion Chamber in Engine

VGT Turbocharger

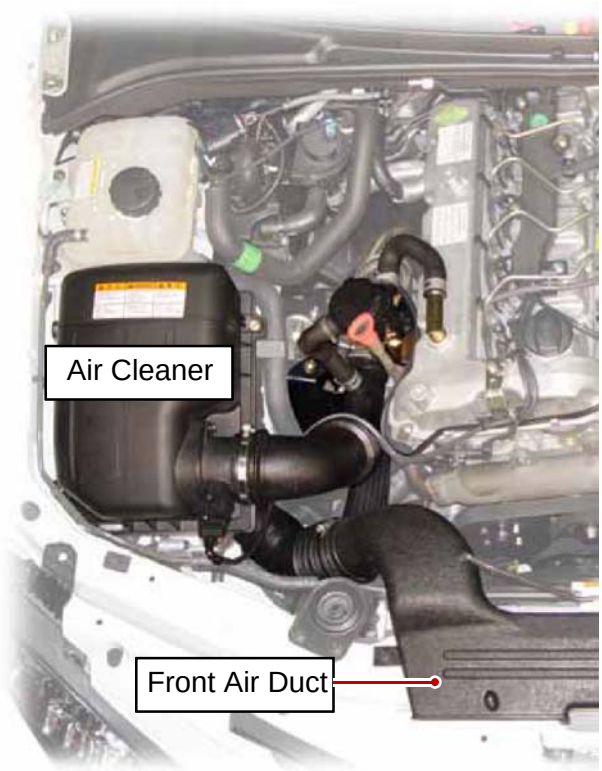


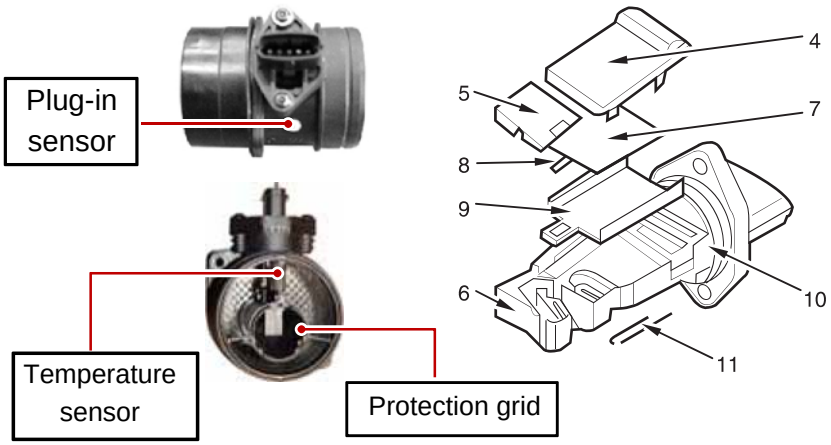
HFM Sensor

The HFM sensor is installed in the air intake passage between the air cleaner and the intake manifold. It measures the air volume supplied to the combustion chamber and the air temperature.

Major Functions

- It controls the EGR feedback.
- It controls the pressure control valve for the turbocharger booster.

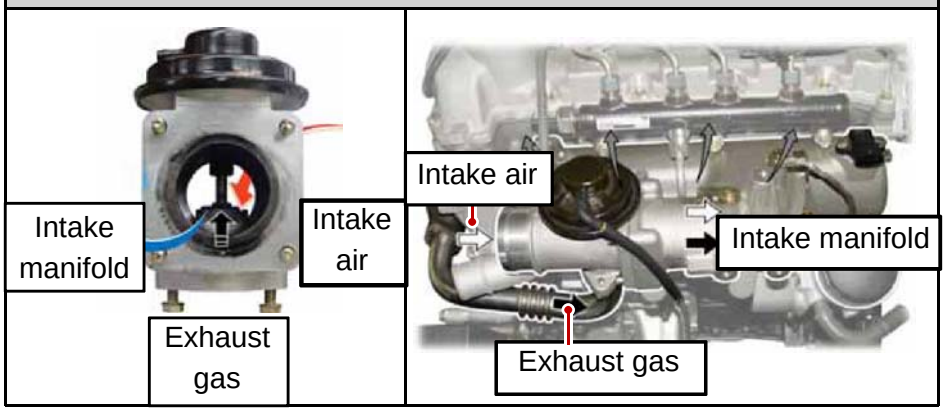




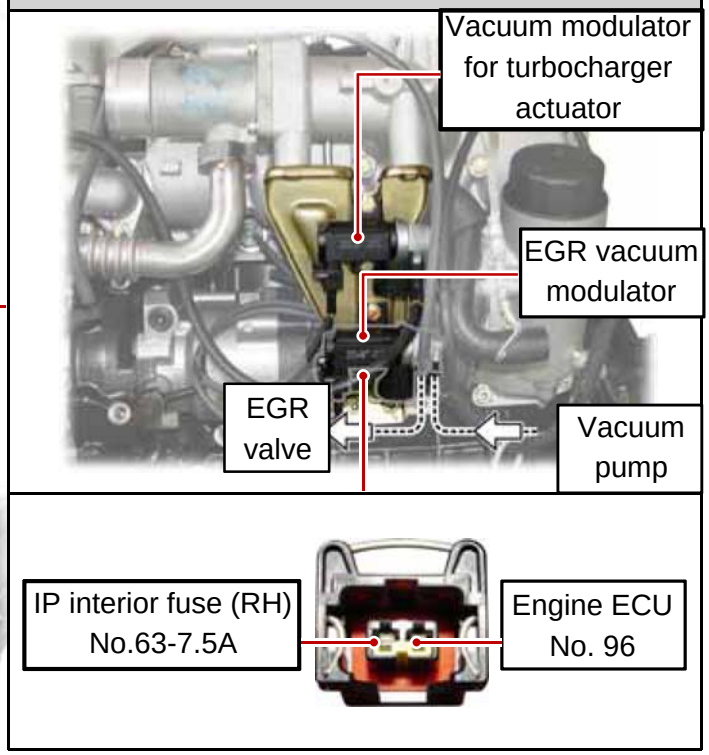
1. Plug-in sensor
2. Cylinder housing
3. Protection grid
4. Hybrid cover
5. Measuring duct cover
6. Housing
7. Hybrid
8. Sensor
9. Mounting plate
10. O-ring
11. Temperature sensor

Modification basis	
Application basis	
Affected VIN	

EGR Valve and Its Location
(* For details, refer to "EGR" section.)



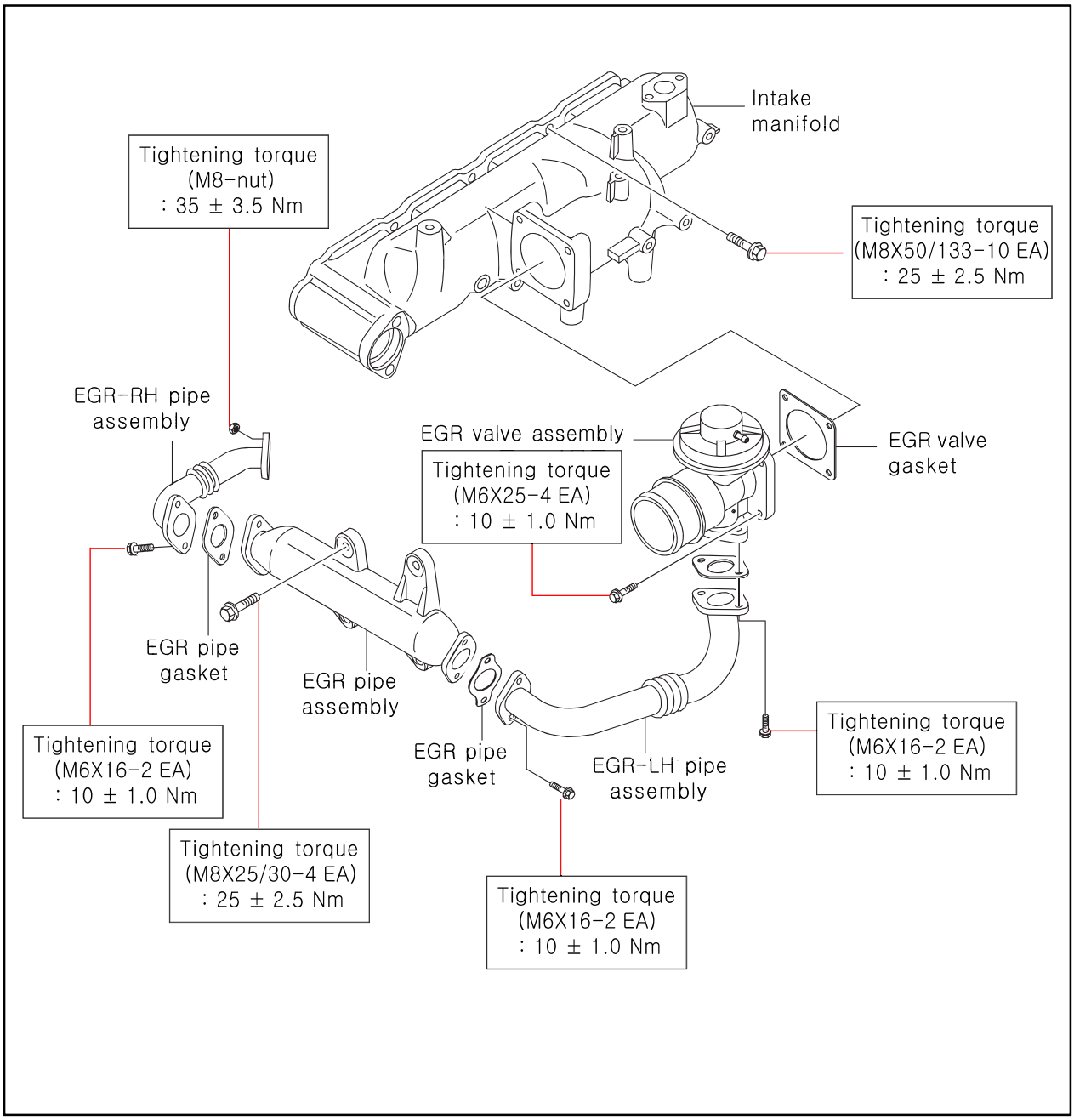
Vacuum Modulator



Turbocharger Intercooler

The charging efficiency may be lowered or the knocking may happen as the intake air is heated and the density of air is lowered. The intercooler is the device which cools the supercharged air.

2) Layout



Modification basis	
Application basis	
Affected VIN	

3) Components

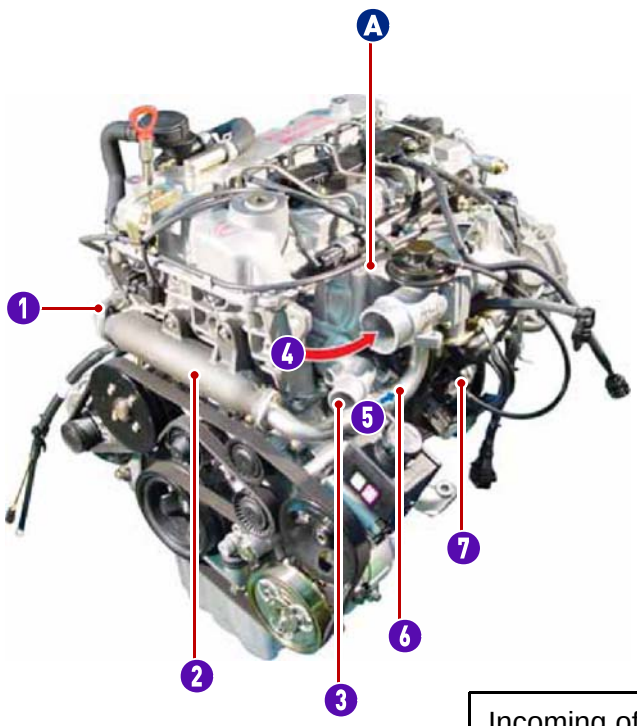
(1) Intake Manifold Assembly

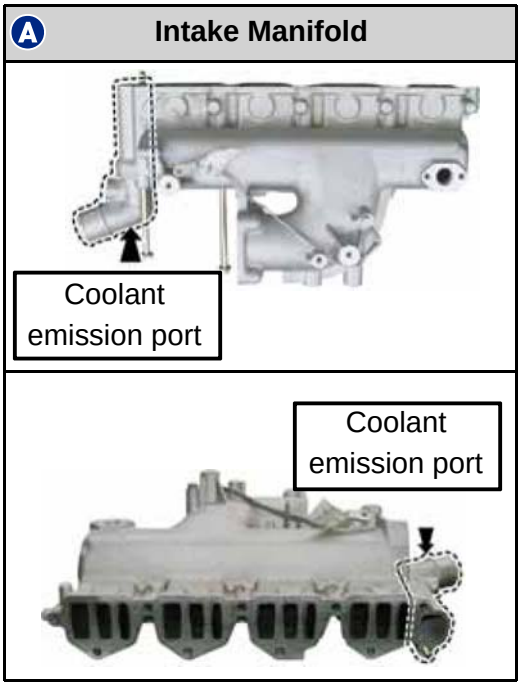
The intake manifold assembly is built for the optimized mixture of the EGR gas in the intake chamber when the compressed air in the turbocharger is sent to the intake port. The intake port is composed of the dual port (tangential and helical port) which increases the swirl ratio in mid/low operating range, improves acceleration/fuel consumption and decreases particle materials. However, there are some differences in the form of the EGR valve and 4-cylinder engine.

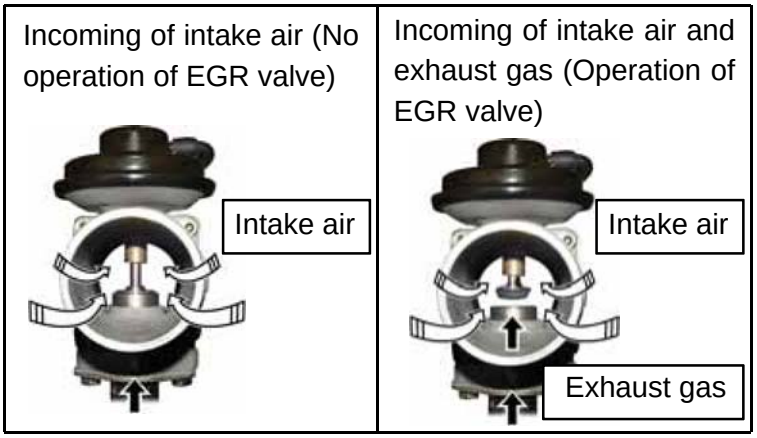
CAUTION

- The inlet port and coolant outlet port is integrated together. Therefore, be careful not to let the residual coolant in the manifold enter the inlet port when removing the intake manifold. Also, replace the gasket with a new one and tighten it to the specified torque (25 ± 2.5 Nm).

The SUS + Rubber coating is applied to the intake manifold gasket to prevent the air leakage and optimize the sealing effect.







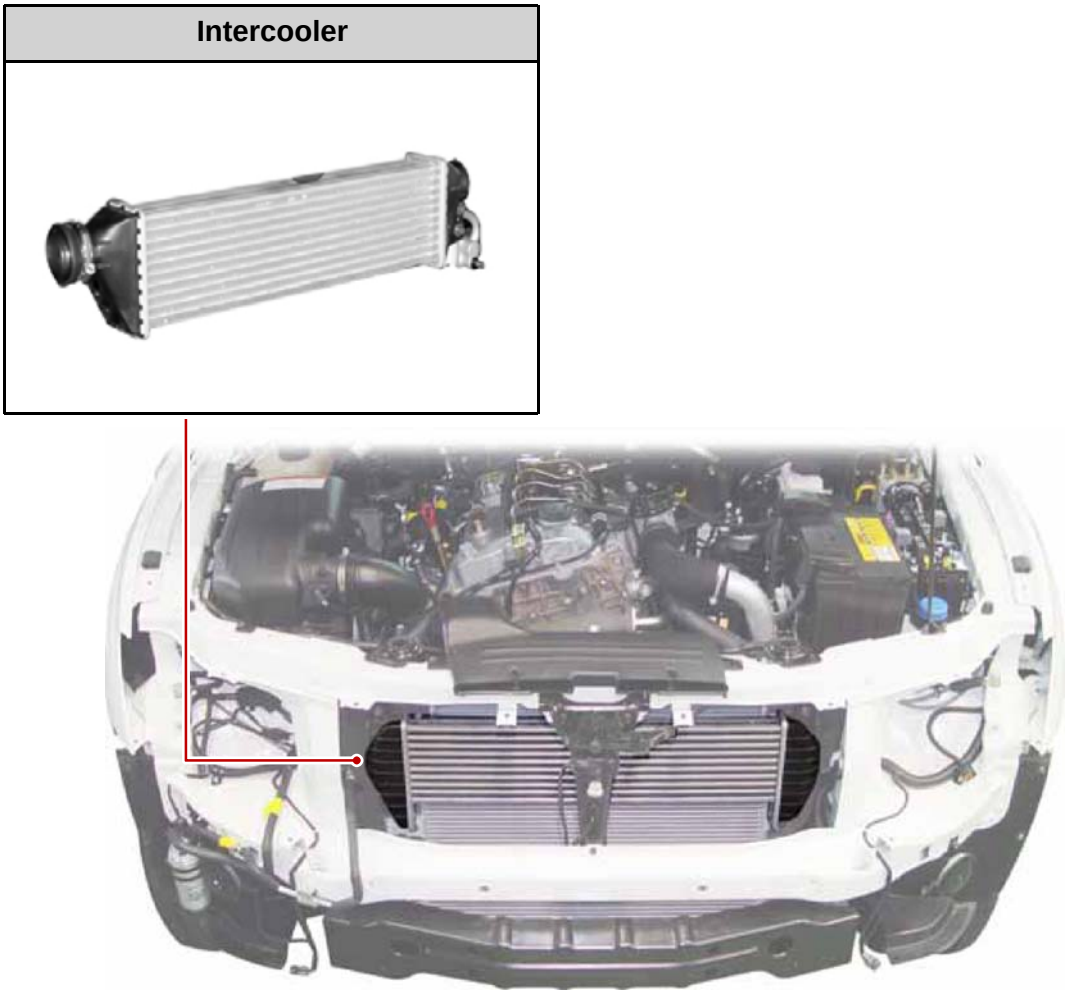
1. EGR pipe (RH)	5. Exhaust gas
2. EGR pipe (center)	6. EGR pipe (LH)
3. Coolant emission port	7. Vacuum modulator to the EGR valve
4. Intake air (intercooler)	

Modification basis	
Application basis	
Affected VIN	

(2) Turbocharger Intercooler Assembly

The turbocharger is designed to improve the engine power by introducing more air (oxygen) into the engine.
However, the intake air is heated during the compression process in the turbocharger compressor and the density is lowered.
The intercooler is the device which cools (50 ~ 60°C) the air entering the engine from high temperature (100 ~ 110°C) to maintain the turbocharging efficiency.
Thus, more air is entered the cylinder than the engine only with the turbocharger to give more power.

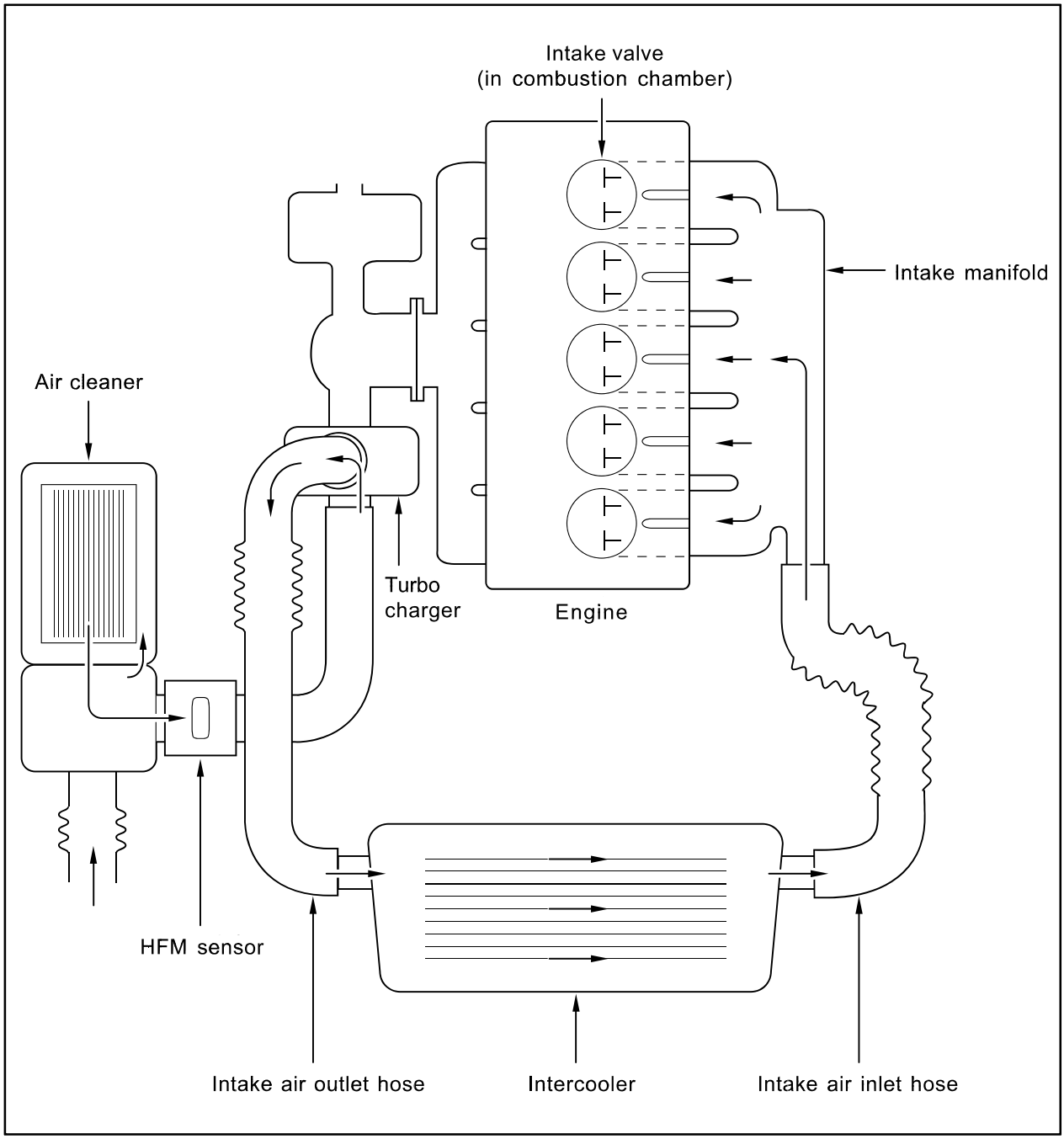
Intercooler



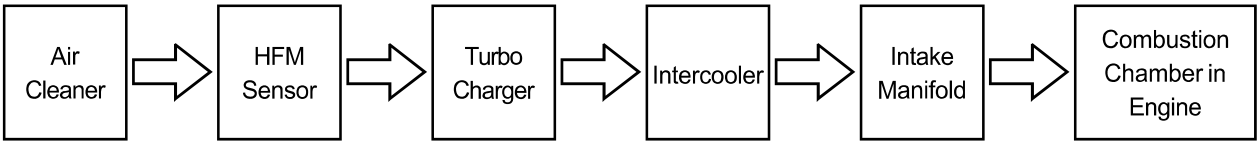
CAUTION

- For removal and installation procedures, refer to the "Cooling system" section in DI engine service manual.

2. AIR FLOWS



1) Work Flow of Intake System



Modification basis	
Application basis	
Affected VIN	

ENGINE EXHAUST SYSTEM

1913-01

GENERAL

1. INSPECTION BEFORE DIAGNOSIS

The base of making diagnosis on the EGR related system is the inspection on the connections of the vacuum hoses in related system as the first priority.When abnormal condition occurs with the EGR system, the basic approach is, as described in prior sentence, making detail inspections of vacuum circuits of each system before connecting the scan tool or vacuum tester. It is necessary to manually check on the connections if there are any slacks or loose circuits even if the visual inspection shows vacuum hose as being connected. If there are not any problems then the next inspection area is the connections of the system connectors. Most problems with the occurrence of system malfunction are from conditions of vacuum line and connector connections and the causes from the malfunction of mechanical mechanism is actually very few.

For example, when there are no problems with basic components, let's assume that there is a vehicle having vacuum leak from connection slack in the vacuum line between EGR vacuum modulator and EGR valve. This vehicle, due to the driving condition or, according to the circumstances, smog or other conditions, could create customer's complaint and by connecting the scanning device could display as the malfunction of the EGR valve's potentiometer.

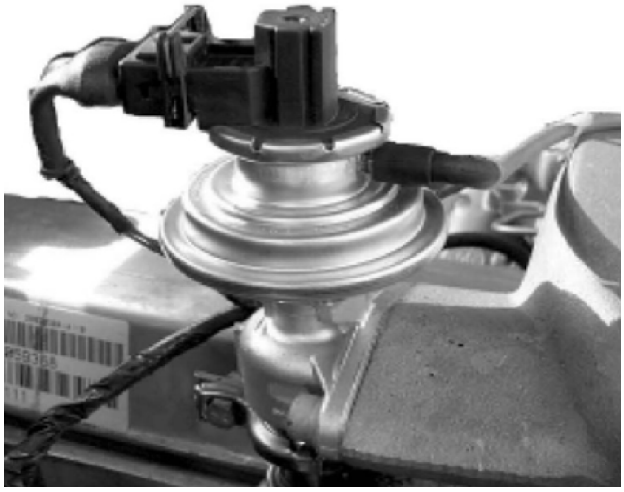
As previously explained, this car has a separate controller to control the HUBER EGR and, in accordance with various input element, the controller controls EGR valve by regulating the force of vacuum being applied to the EGR valve through PWM control. At this time, the controller has to receive feedback whether the EGR valve operates correctly according to the value sent to the EGR modulator and this role is performed by the EGR potentiometer located at top section of the EGR valve.

In other word, the controller sent correct output value to the EGR vacuum modulator but, due to the leakage of vacuum, signal of required value can not be received from the EGR potentiometer causing to display as malfunction of related parts.

As a reference, the EGR valve of diesel vehicle (DI Engine) controlling from the engine ECU to EGR system has different shape than the HUBER EGR valve because the EGR valve's operation signal in the DI engine is performed by the HFM sensor instead of the EGR potentiometer.

This principle is that when the EGR valve opens up to flow exhaust gas into the intake unit the amount of fresh air, comparatively, will be reduced. The DI engine ECU receives feedback signal of change in amount of air being passed through the HFM sensor according to the opening amount of the EGR valve.

▶ HUBER EGR System for IDI Engine (Including the EGR Valve Potentiometer)



The other big difference between the HUBER EGR and EGR controller for DI engine is that from two vacuum modulator, one is same as being the modulator for EGR valve whereas the HUBER EGR system's the other modulator controls ALDA of injection pump and the DI engine's the other modulator controls waist gate of the turbo charger.

This difference is in accordance with the difference in fuel injection method where the IDI engine has mechanical injection system and DI engine is capable of making electronically controlled fuel injection.

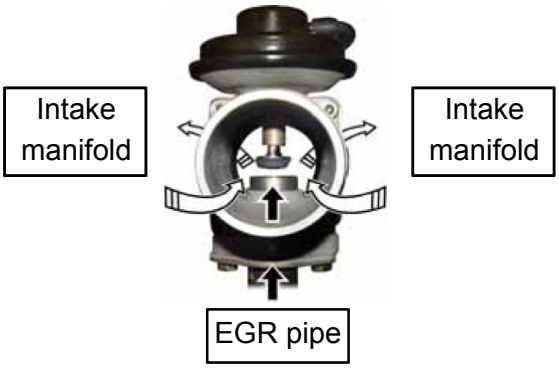
In other word, to reduce the amount of the fuel injection in no-load rapid acceleration mode, the IDI engine's HUBER EGR utilizes solenoid valve to disconnect the connection circuit between intake manifold and ALDA causing negative pressure to occur in the vacuum modulator to reduce the amount of fuel injection. When DI engine, basing input signal from the related sensors such as acceleration pedal sensor and engine RPM, recognizes that current mode is the no-load rapid acceleration mode it reduces the amount of fuel injection by sending short electrical signal to the injector. Therefore, disregarding the modulator for the EGR valve in DI engine, one must keep in mind that the other modulator is used to control the booster pressure valve in turbo charger.

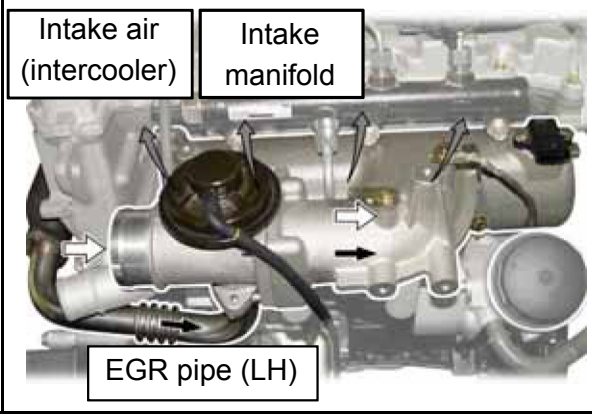
Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATION PROCESS

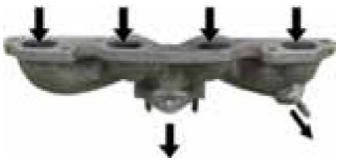
1. EXHAUST SYSTEM LAYOUT

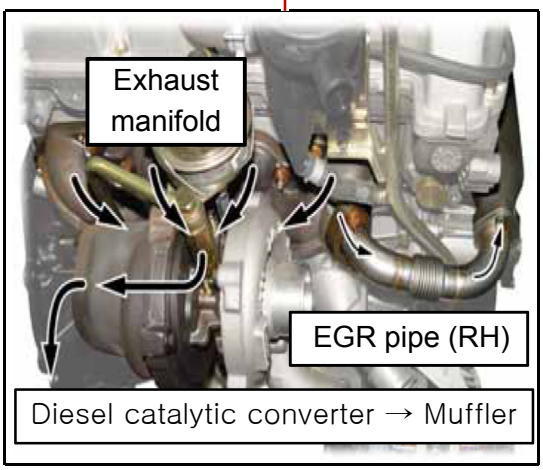
EGR Valve and Installation Location





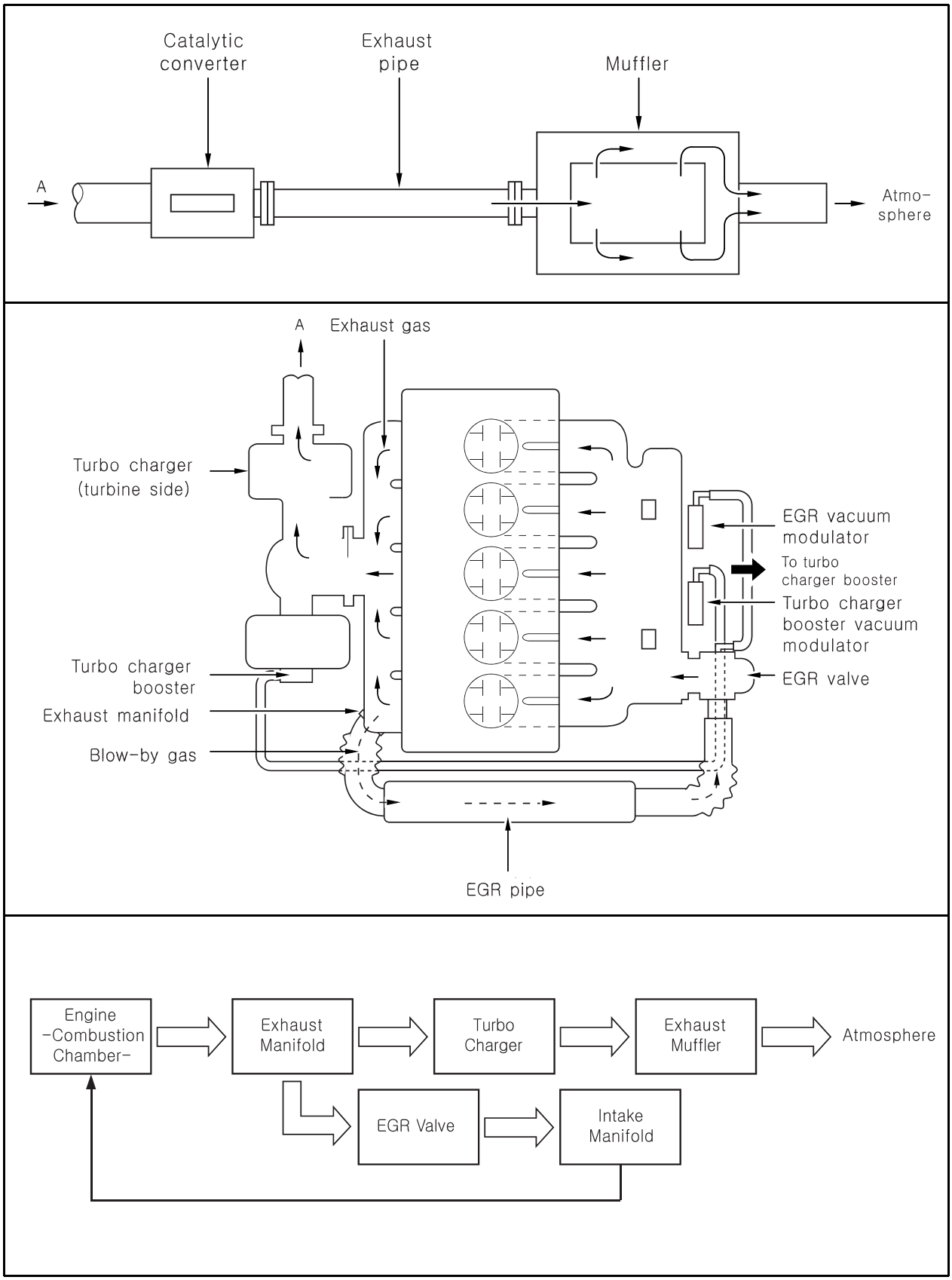
Exhaust Manifold





Modification basis	
Application basis	
Affected VIN	

2) Exhaust Gas Flows



Modification basis	
Application basis	
Affected VIN	

LUBRICATION SYSTEM

1533-01

GENERAL

1. SPECIFICATIONS

Engine oil	Specification	Approved by MB Sheet 229.1 or 229.3 Viscosity: See MB Sheet 224.1
	Capacity	6.8 ~ 8.3 liter
	Service interval	Initial change: 5,000 km, Change every 10,000 km or 12 months (Frequently check the oil level and add if needed. And, every 5,000 km or 6 months under severe conditions)
Engine oil filter		Same interval with engine oil
Oil relief valve opening pressure		5.8 ± 0.3 bar

▶ **Severe Condition:**
- When most trips include extended idling and/or frequent low-speed operation as in stop-and-go traffic.
- When most trips are less than 6 km (Operating when outside temperatures remain below freezing and whenmost trips are less than 16 km)
- When operating in dusty, sandy and salty areas
- In hilly or moutainous terrain
- When doing frequent trailer towing

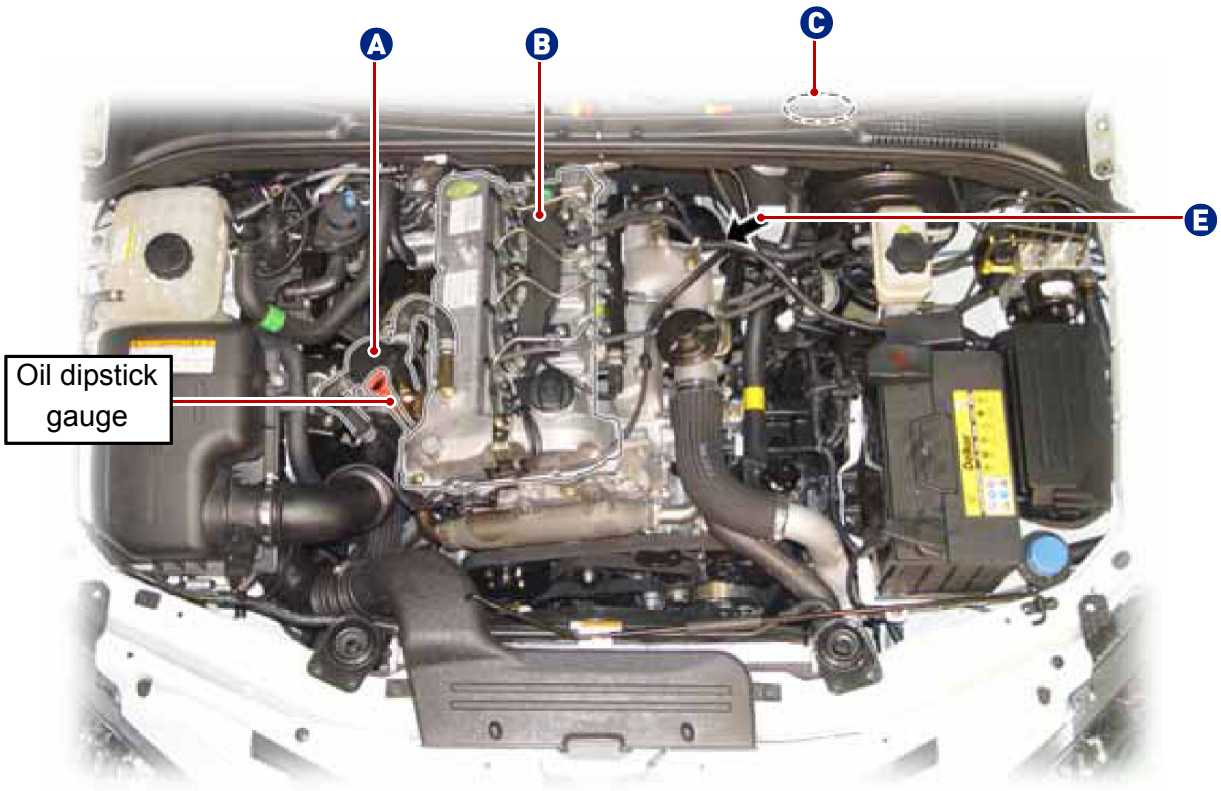
2. OIL PRESSURE SWITCH

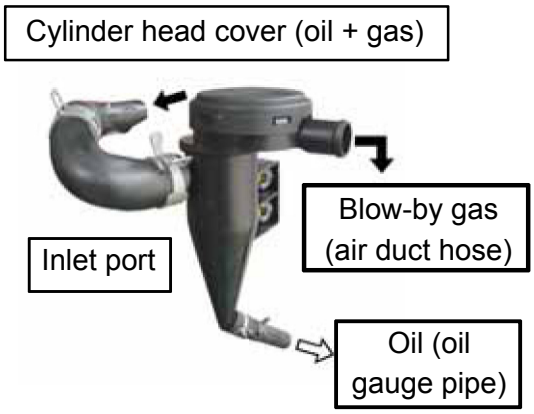
- Operating temperature: −40 ~ 140°C
- Operating pressure: 0.3 ~ 0.55 bar
- Permissible pressure: 10 bar

OVERVIEW AND PERATION PROCESS

1. LAYOUT AND OVERVIEW

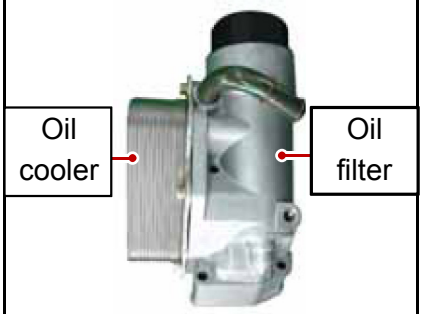
1) Lubrication System



A PCV Oil Separator	
The first separation will happen when blowby gas passes through baffle plates in cylinder head cover. Then oil and gas will be separated due to cyclone effect after entering the oil separator inlet port. Separated oil returns to oil pan via oil drain port and the gas will be burnt again after entering the combustion chamber through air duct hose via PCV valve that opens/closes due to pressure differences between the intake side and crankcase.	

Modification basis	
Application basis	
Affected VIN	

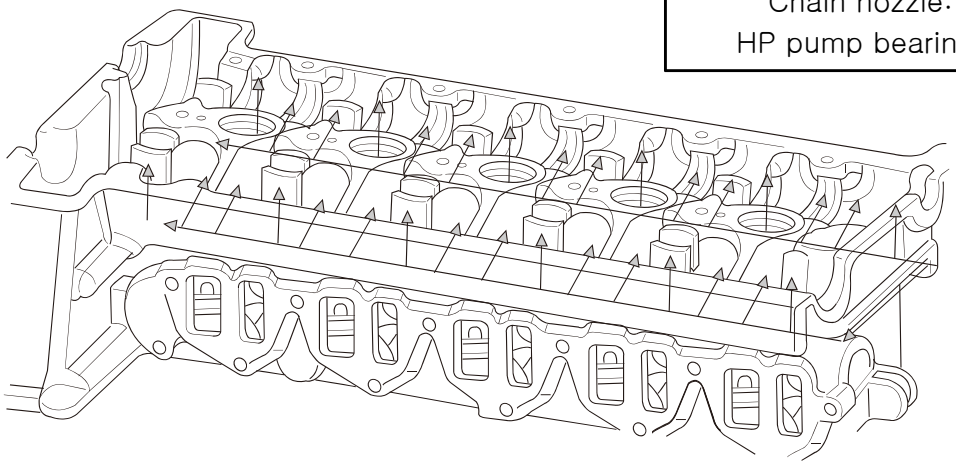
Cylinder Head Cover B	Oil pressure Warning Lamp (Cluster) C
	

Oil Pan and Baffle Plate (Integrated Type)	Oil Strainer	Oil Filter & Oil Cooler E
		

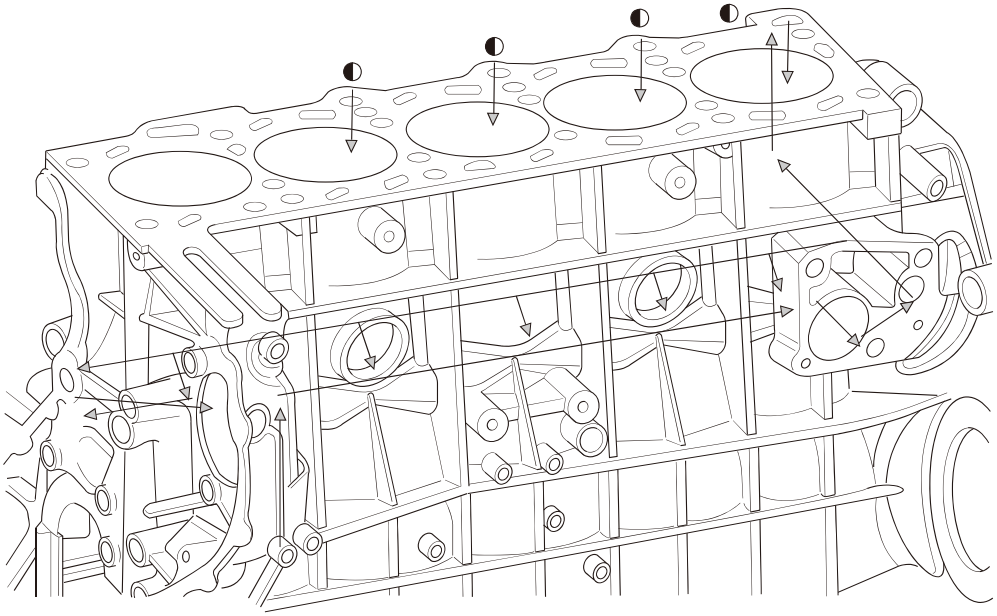
2) Lubrication System Layout

Cylinder Head

Main oil gallery: ϕ 16
Hole to cylinder head: ϕ 9
Main bearing hole: ϕ 7
Chain and injection pump: ϕ 7
Return hole: ϕ 14
Chain nozzle: ϕ 1
HP pump bearing: ϕ 6

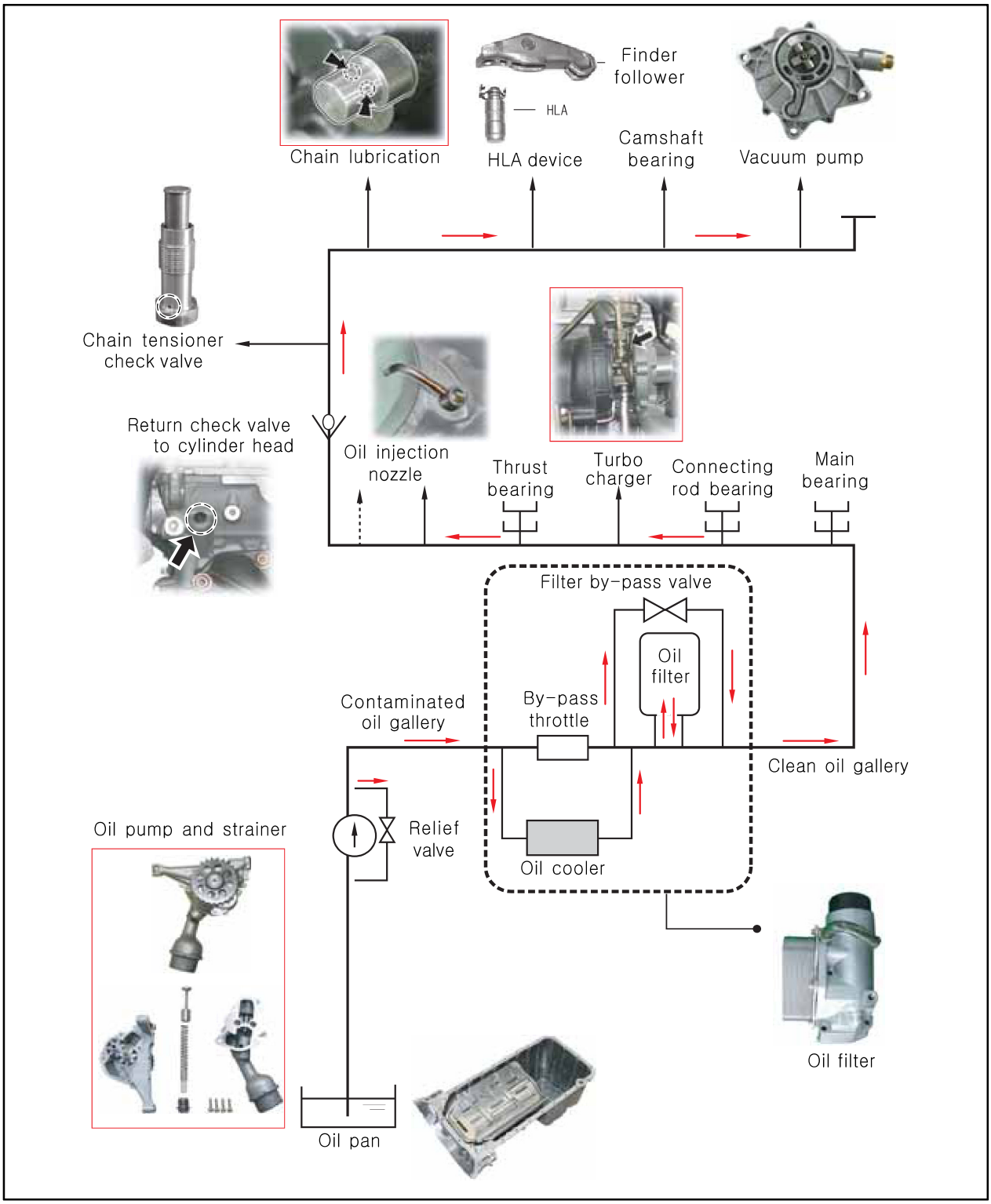


Cylinder Block



Modification basis	
Application basis	
Affected VIN	

2. LUBRICATION DIAGRAM



- Opening pressure of by-pass valve in oil filter: 3 ± 0.4 bar
- To prevent instant oil shortage after stopping the engine, the return check valve is installed in oil supply line of cylinder head

Modification basis	
Application basis	
Affected VIN	

ENGINE COOLING SYSTEM

9210-05

GENERAL

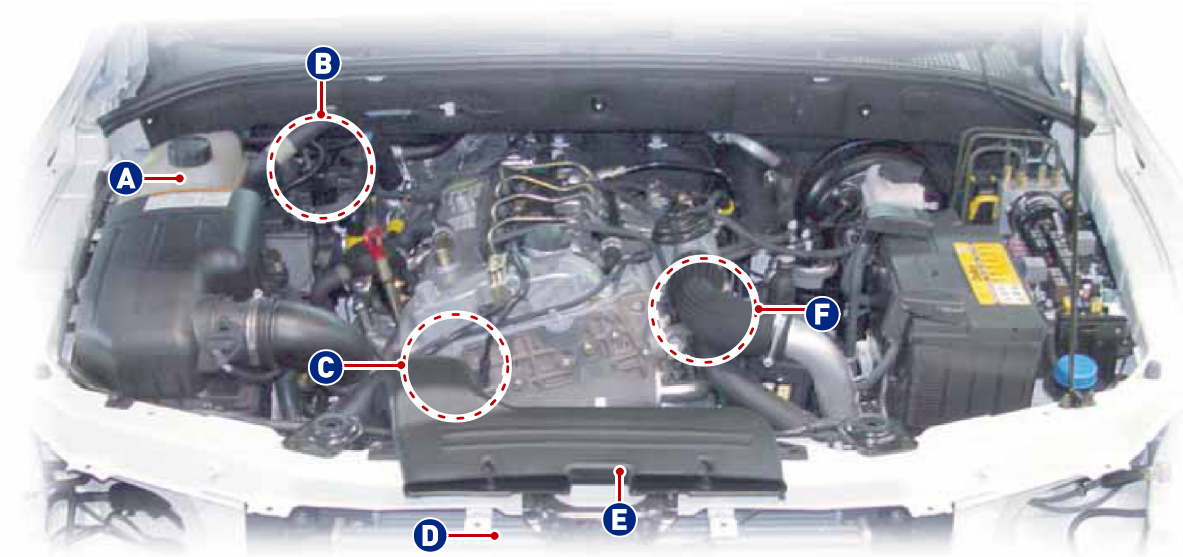
1. ENGINE COOLING SPECIFICATIONS

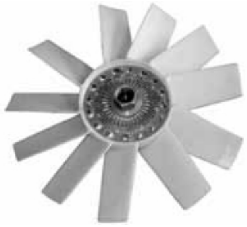
Descriptio n		Unit	Specificatio n
Cooling system	Type	-	Water cooling forced circulation
Coolant	Capacity	ℓ	11.3
Thermostat	Type	-	Wax pellet type
	Initial opening temperature	°C	85
	Fully opening temperature	°C	100
	Fully closing temperature	°C	83
	Stroke	mm	min. 8
Cooling fan	Blades		5
	Diameter	mm	320 (2)
	Low speed ON temp	°C	91
	Low speed OFF temp	°C	88
	High speed ON temp	°C	95
	High speed OFF temp	°C	92
	High speed ON temp. (By A/C pressure)	psi	270
Coolant reservoir	Pressure valve opening pressure	Kg/cm^2	1.2 ~ 1.5
	Vacuum valve opening pressure	Kg/cm^2	0.1
Water pump	Type	-	Centrifugal
	Impeller diameter	mm	72.3
	Impeller blades		10
Radiator	Type	-	Down-flow
	Core width	mm	701
	Core height	mm	372
	Core thickness	mm	18
	Minimum radiation capability	Kcal/h	45,000
Coolant temperature sensor	Resistance (at 20°C)	KΩ	3.33 ~ 3.78
	Resistance (at 80°C)	KΩ	0.32 ~ 0.35
Anti-freeze agent	Type	–	ALUTEC-P78
	Mixture ratio (water and anti-freeze)	–	50 : 50

OVERVIEW AND OPERATION PROCESS

1. COMPONENTS ENGINE COOLING

Coolant Reservoir	FFH	Water Pump
A 	B 	C 

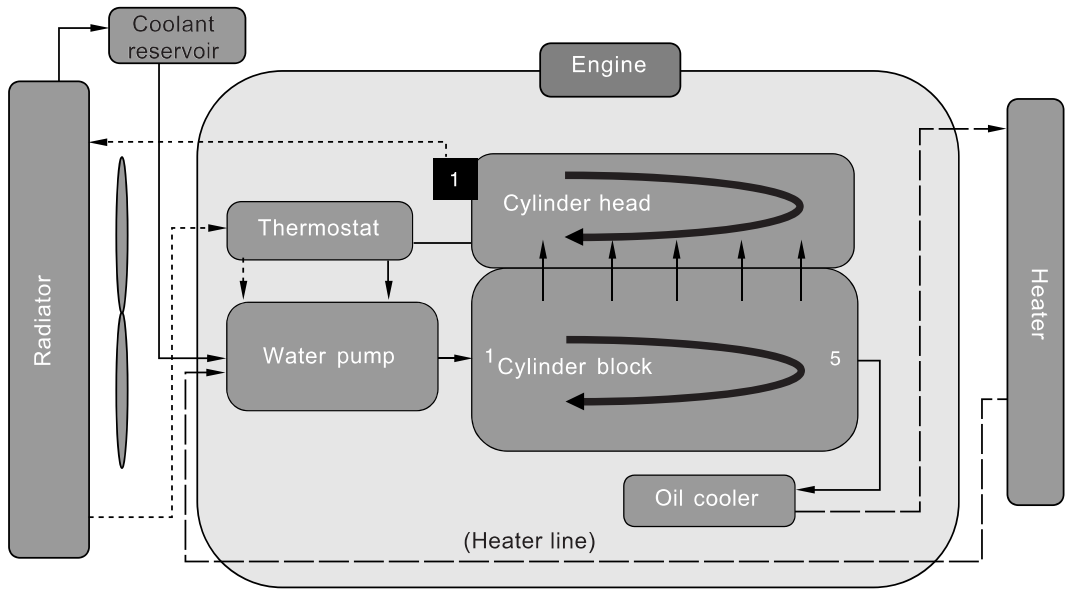


Radiator Assembly	Cooling Fan and Fan Clutch	Coolant Temperature Sensor
D 	E 	F 

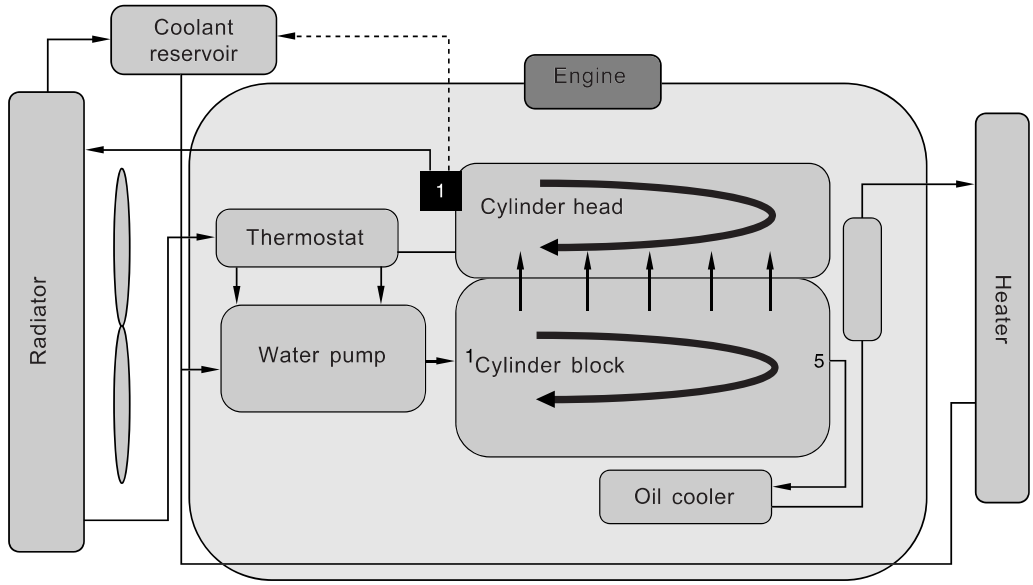
Modification basis	
Application basis	
Affected VIN	

2. COOLING SYSTEM FLOW

PTC Engine Coolant Flows

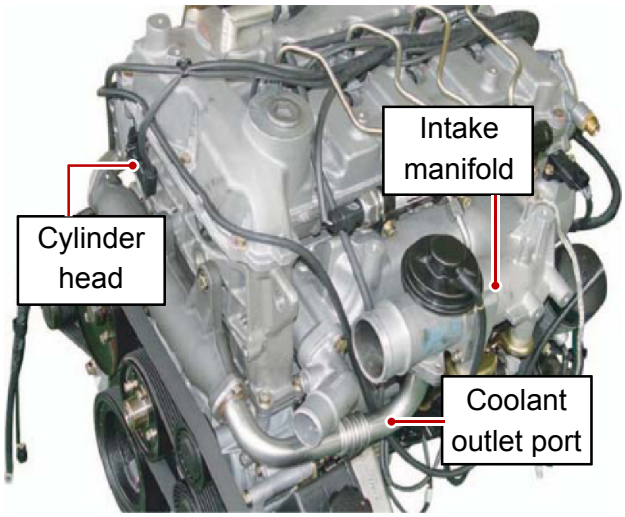


FFH Engine Coolant Flows

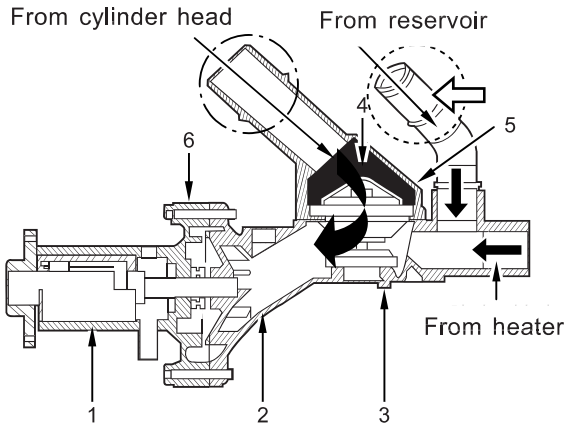


- Cylinder block side
  - · Block #5 → Oil cooler → Heater → Heater water pump inlet pipe → Water pump
- Cylinder head side
  - · Cylinder head → Coolant outlet port (intake #1) → Radiator → Water pump

3. FUNCTION DESCRIPTION OF COOLING SYSTEM



- Cylinder head coolant outlet port is integrated into intake manifold. (in front of cylinder #1)
  - · Improved shape and gasket material to prevent coolant from leaking



- In OM 600 engine, coolant inflows through the heater line rear section (cylinder #4 and #5) of cylinder head.
  However, in D27DT engine, coolant inflows from cylinder block through oil cooler (refer to coolant flows layout in previous page).
  - · It prevents cooling efficiency from decreasing due to coolant separation between cylinder #4 and #5.
- In OM 600 engine, the cooling fan is installed with water pump, however, in case of D27DT engine, it is connected to water pump with an additional pulley.

Modification basis	
Application basis	
Affected VIN	

ENGINE ELECTRICAL SYSTEM

1461-01

GENERAL

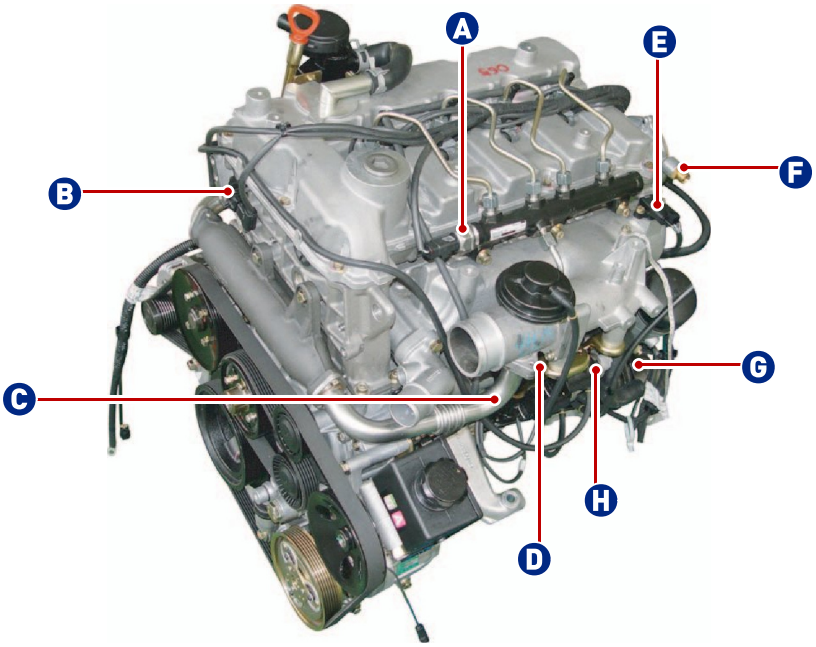
1.SPECIFICATIONS OF ENGINE ELECTRIC

Descriptio			Unit	pecificatio n
Starter	Type		-	WP220
	Output power		Kw	2.2
	No load test □ 12 volts		A	160
	Drive pinion speed at no load		rpm	4500
	Drive pinion speed at load		rpm/A	1700/430
	Brush length		mm	18
	Armature diameter		mm	55
	Armature run-out		mm	0.1
	Segment groove depth		mm	21.7
Alternator	Type		-	CS128D
	Output voltage / current		V/A	PTC equipped vehicle: 12V-140A FFH equipped vehicle: 12V-115A
	Regulator type		-	←
	Regulating voltage		V	14.6
	Brush	Length	mm	12.5
		Quantity	-	2
		Wear limit	mm	7
Battery	Type		-	M F
	Capacity		AH	12V - 90AH
Glow plug	Reserved capatity		RC	160
	Type		-	Seized type
	Rated voltage		-	11.5
	Circuit connection		-	Parallel
	Preheating time		sec	Max. 60 (at -35°C)

OVERVIEW AND OPERATION PROCESS

1. COMPONENTS OF ELECTRIC IN ENGINE

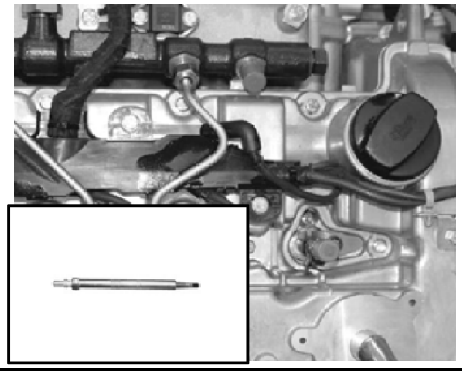
Fuel Pressure Sensor	Camshaft Position Sensor	Coolant Temperature Sensor	Fuel Temperature Sensor
A 	B 	C 	D 

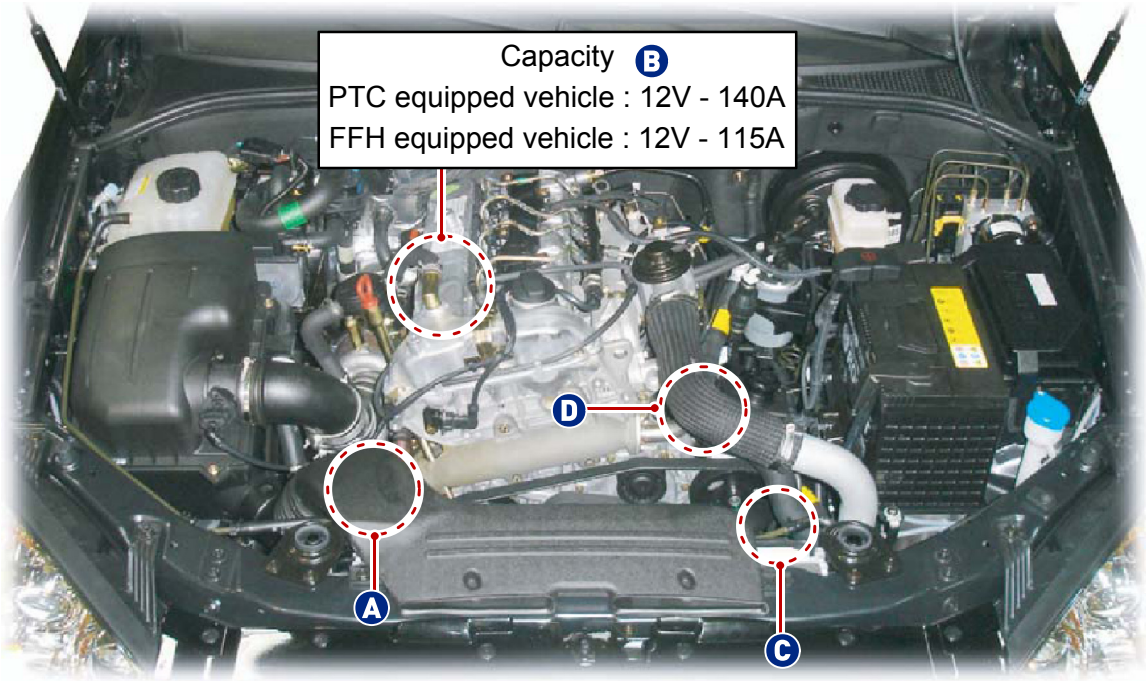


Booster Pressure Sensor	Oil Pressure Switch	Crankshaft Position Sensor	Knock Sensor (1 EA)
E 	F 	G 	H 

Modification basis	
Application basis	
Affected VIN	

2. COMPONENTS OF ELECTRIC DEVICES IN ENGINE

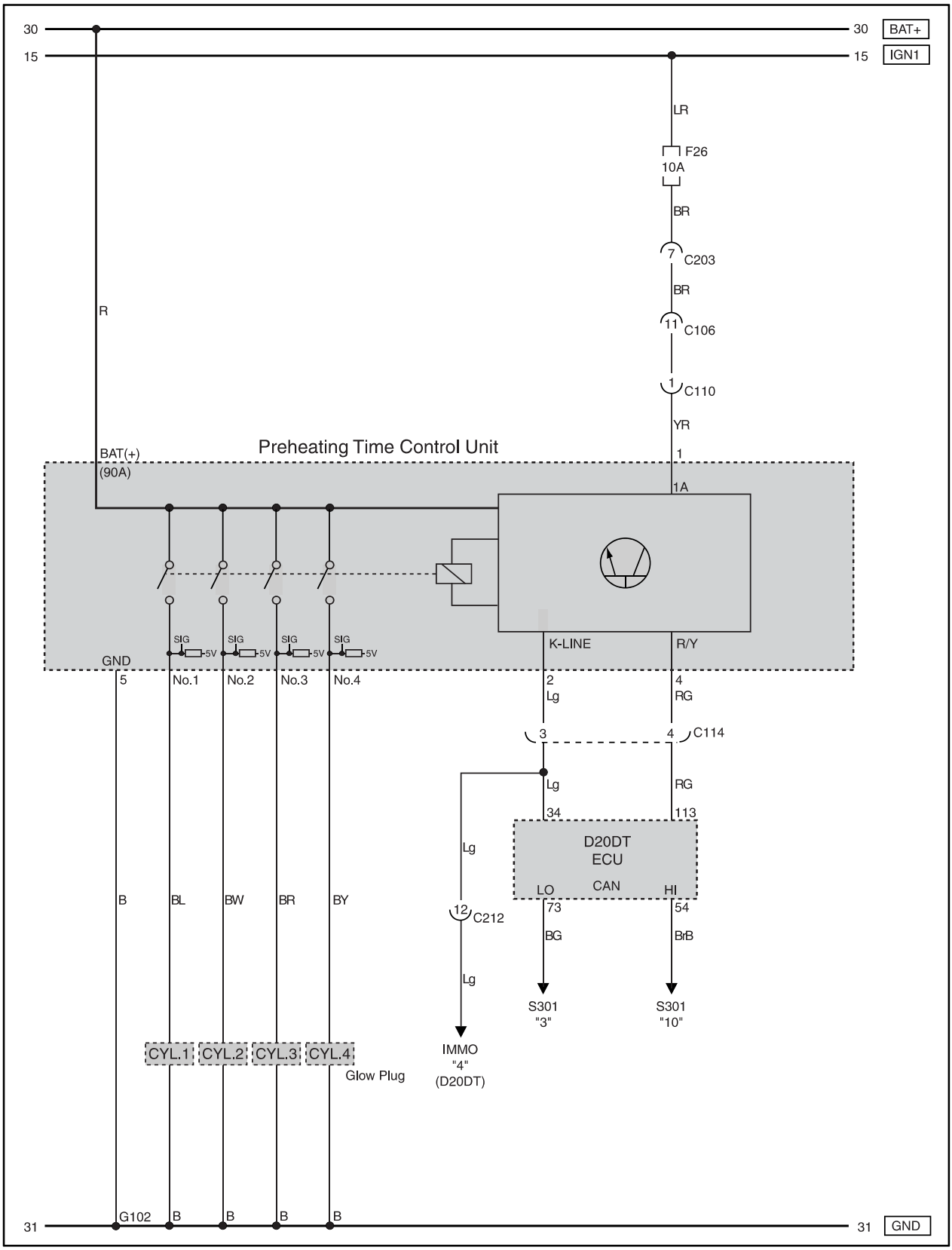
Alternator	Glow Plug
A 	B 



Air Conditioner Compressor	Starter
C 	D 

3. CIRCUIT DIAGRAM OF PREHEATING SYSTEM

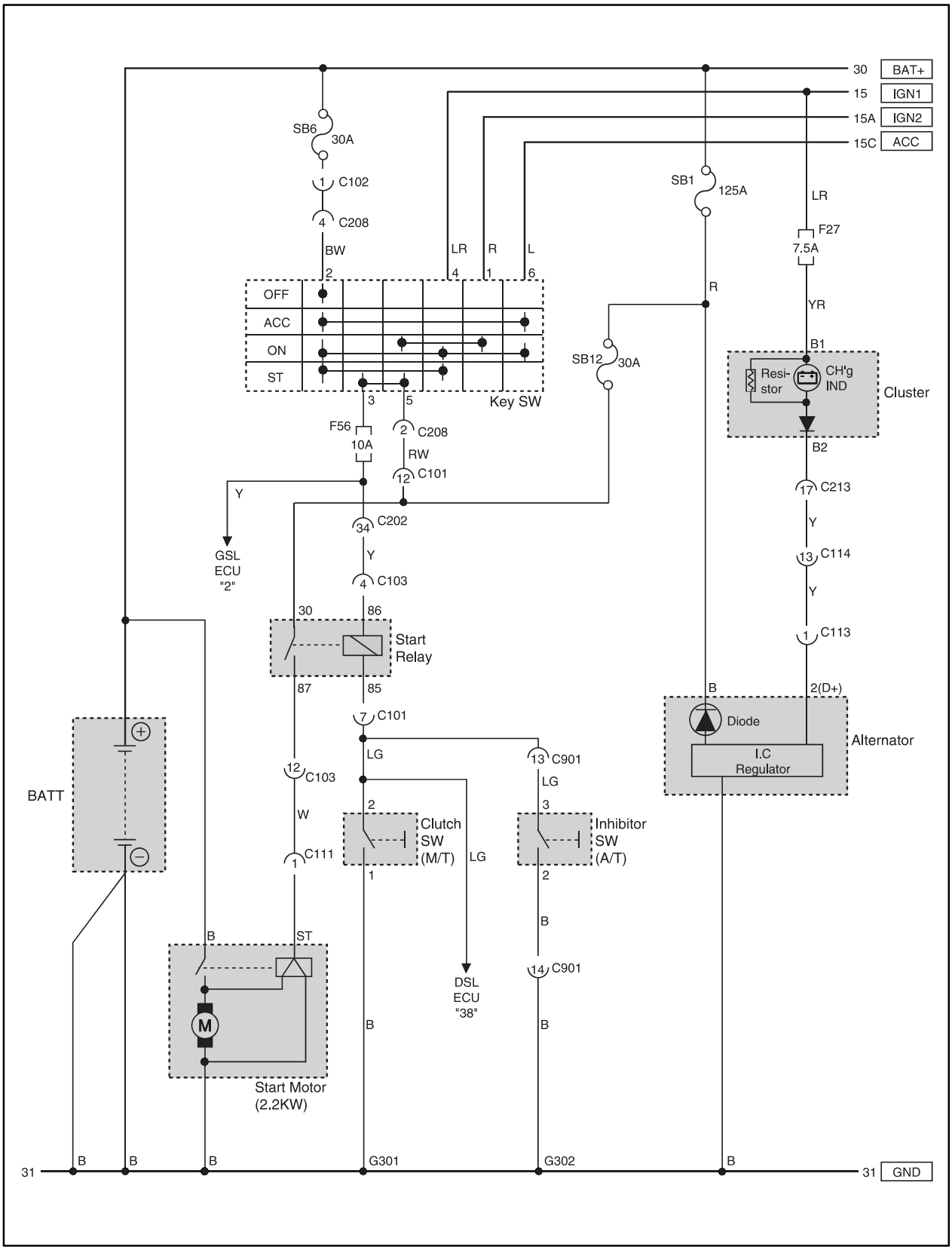
1) Preheating



Modification basis	
Application basis	
Affected VIN	

4. CIRCUIT DIAGRAM OF STARTING AND ALTERNATOR

1) Starting & Charging



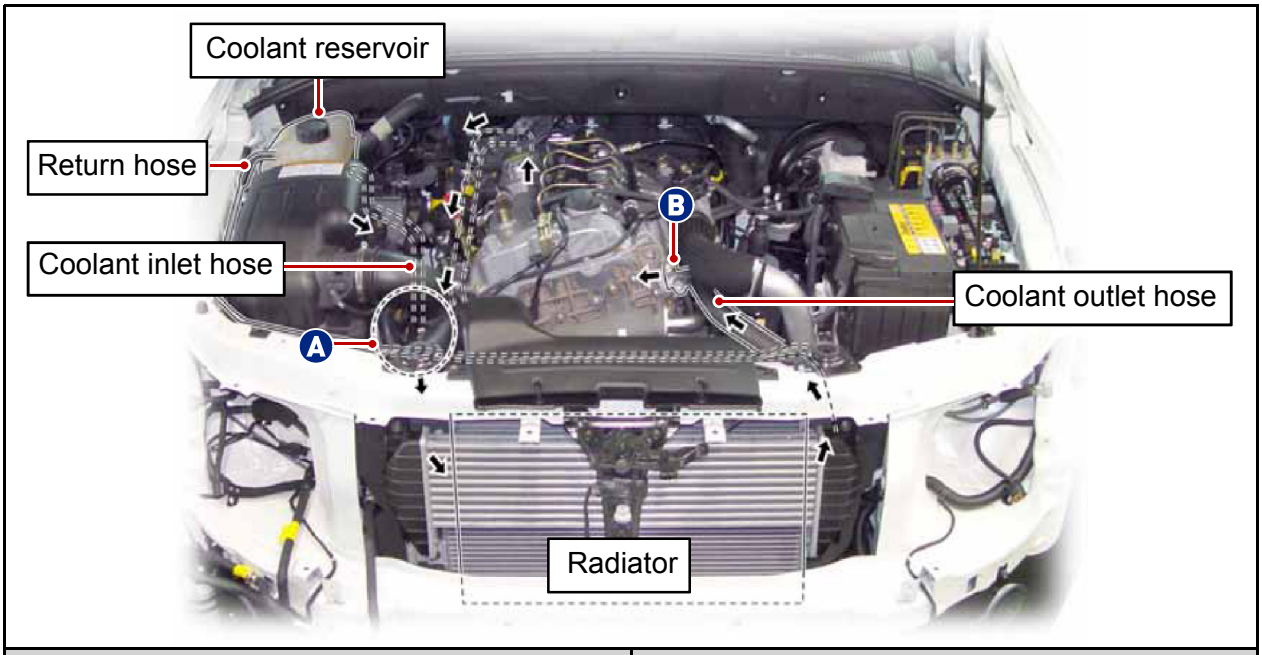
Modification basis	
Application basis	
Affected VIN	

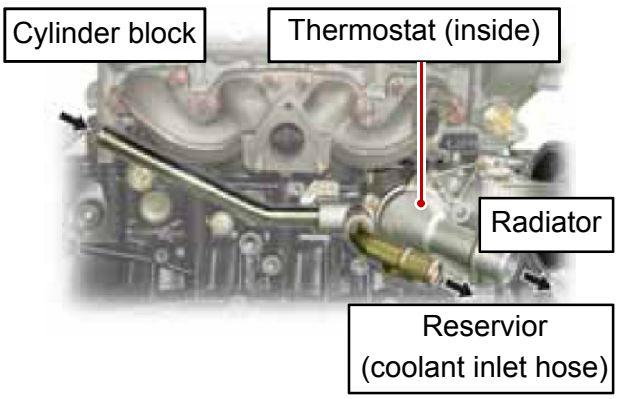
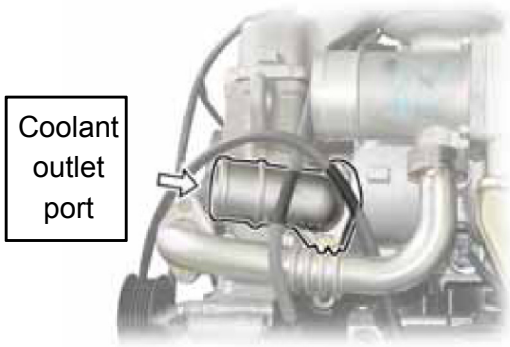
EGINE CONTROL SYSTEM

1491-01

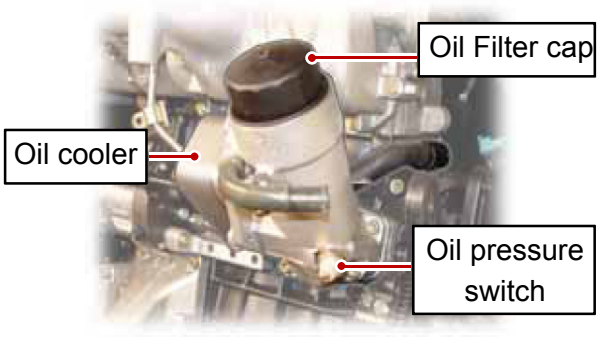
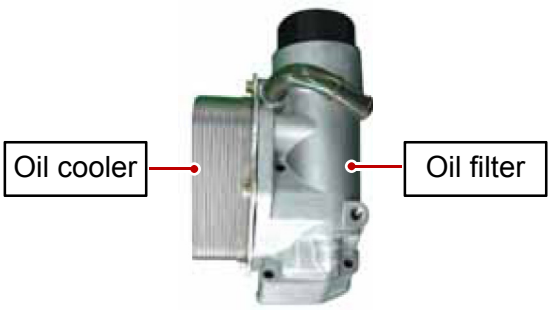
GENERAL

1. ENGINE ECU AND OTHER COMPONENTS



A Water Pump and Pipe	B Coolant Port
	

Engine Oil Filter and Cooler

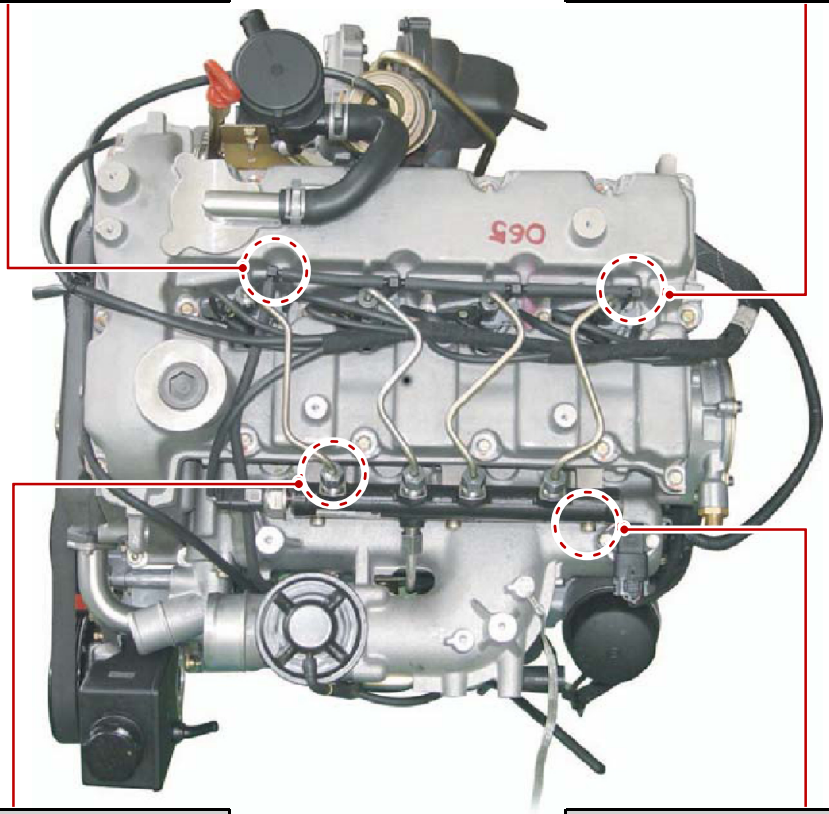
	

Modification basis	
Application basis	
Affected VIN	

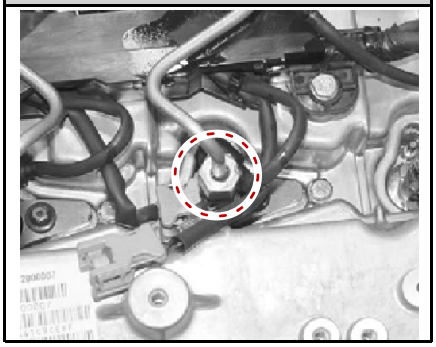
2. TOP VIEW

Fuel Pressure Sensor

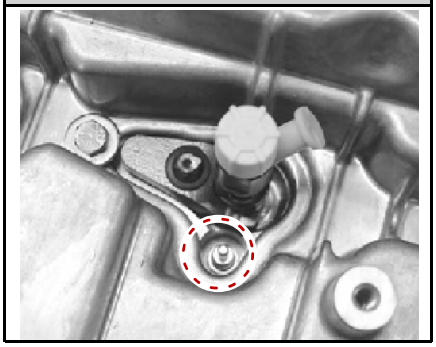
Booster Pressure Sensor



Injectors (4 EA)

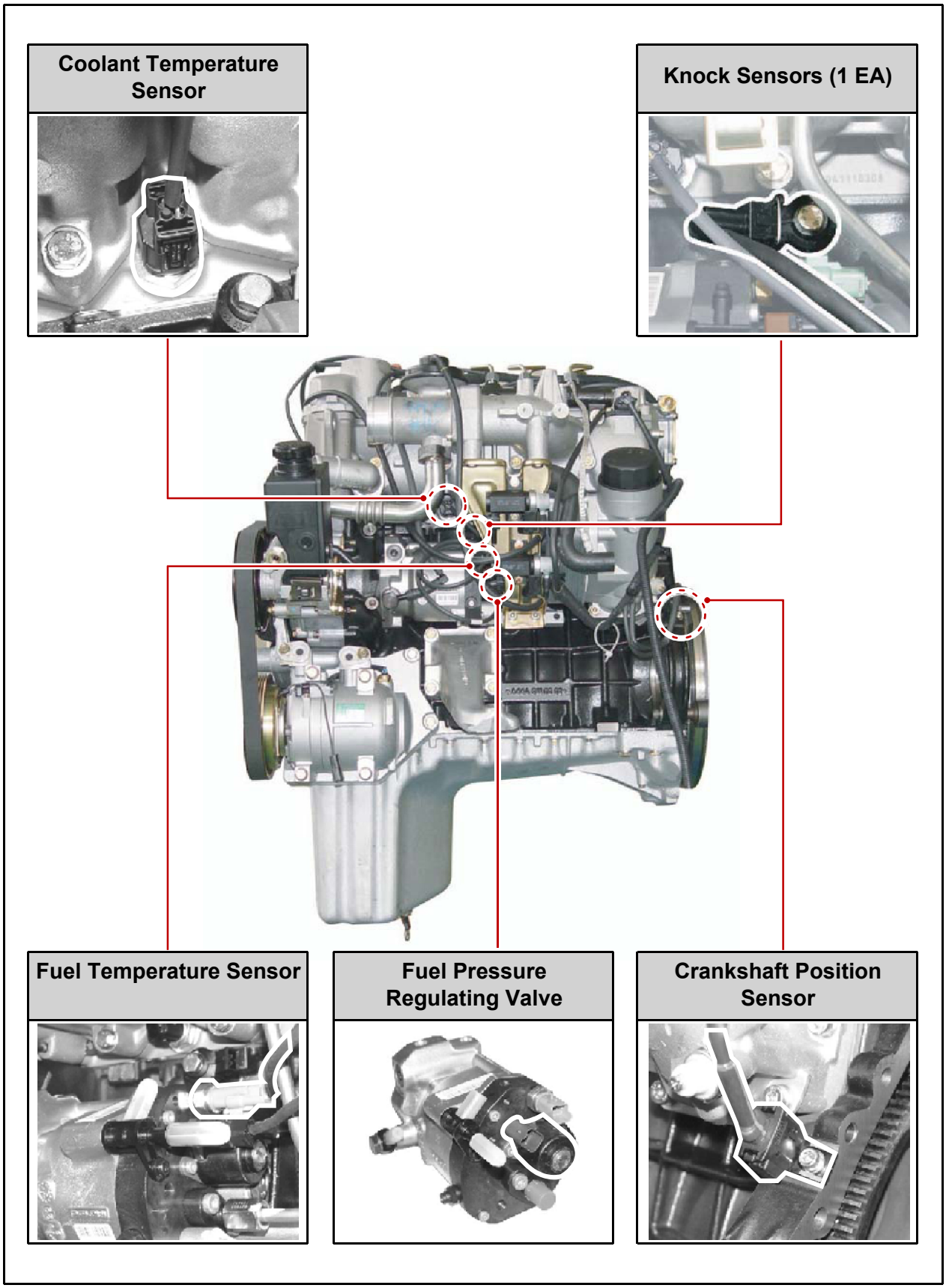


Glow Plugs (4 EA)



Modification basis	
Application basis	
Affected VIN	

3. SIDE VIEW


Coolant Temperature Sensor
Knock Sensors (1 EA)
Fuel Temperature Sensor
Fuel Pressure Regulating Valve
Crankshaft Position Sensor

OVERVIEW AND OPERATION PROCESS

1. ECU INPUTS/OUTPUTS

Inputs		Control		Output
Booster pressure sensor Atmospheric pressure sensor (Built-in ECU) Air flow sensor (HFM) Coolant temperature sensor Fuel temperature sensor Fuel pressure sensor Fuel filter water sensor Knock sensor crankshaft position sensor camshaft position sensor Accelerator sensor Vehicle speed sensor Switch input signal (IG, brake, clutch, A/C signal, A/C compressor)	→	E C U	→	Injector EGR system Fuel pressure regulating valve (IMV) Electrical fan control (Low/High-speed) A/C compressor relay Glow plug relay Immobilizer Warning lights (Water warning light, glow plug indicator light, engine warning light) Preheater (auxiliary heater) K - line CAN communication Self-diagnosis

Modification basis	
Application basis	
Affected VIN	

2. STRUCTURE AND FUNCTION OF ECU

1) Function of ECU

ECU receives and analyzes signals from various sensors and then modifies those signals into permissible voltage levels and analyzes to control respective actuators.
ECU microprocessor calculates injection period and injection timing proper for engine piston speed and crankshaft angle based on input data and stored specific map to control the engine power and emission gas.
Output signal of the ECU microprocessor drives pressure control valve to control the rail pressure and activates injector solenoid valve to control the fuel injection period and injection timing; so controls various actuators in response to engine changes. Auxiliary function of ECU has adopted to reduce emission gas, improve fuel economy and enhance safety, comforts and conveniences. For example, there are EGR, booster pressure control, autocruise (export only) and immobilizer and adopted CAN communication to exchange data among electrical systems (automatic T/M and brake system) in the vehicle fluently. And Scanner can be used to diagnose vehicle status and defectives.
Operating temperature range of ECU is normally -40 ~ +85°C and protected from factors like oil, water and electromagnetism and there should be no mechanical shocks.
To control the fuel volume precisely under repeated injections, high current should be applied instantly so there is injector drive circuit in the ECU to generate necessary current during injector drive stages.
Current control circuit divides current applying time (injection time) into full-in-current-phase and hold-current-phase and then the injectors should work very correctly under every working condition.

3. CONTROL FUNCTION OF ECU

▶ **Controls by operating stages**

- To make optimum combustion under every operating stage, ECU should calculate proper injection volume in each stage by considering various factors.

▶ **Starting injection volume control**

- During initial starting, injecting fuel volume will be calculated by function of temperature and engine cranking speed.
  Starting injection continues from when the ignition switch is turned to ignition position to till the engine reaches to allowable minimum speed.

▶ **Driving mode control**

- If the vehicle runs normally, fuel injection volume will be calculated by accelerator pedal travel and engine rpm and the drive map will be used to match the drivers inputs with optimum engine power.

4. FUEL PRESSURE CONTROL

1) Fuel Pressure Control Elements

Pressure control consists of 2 principle modules.

- Determines rail pressure according to engine operating conditions.
- Controls IMV to make the rail pressure to reach to the required value.

Pressure in the fuel rail is determined according to engine speed and load on the engine. The aim is to adapt the injection pressure to the engine's requirements.

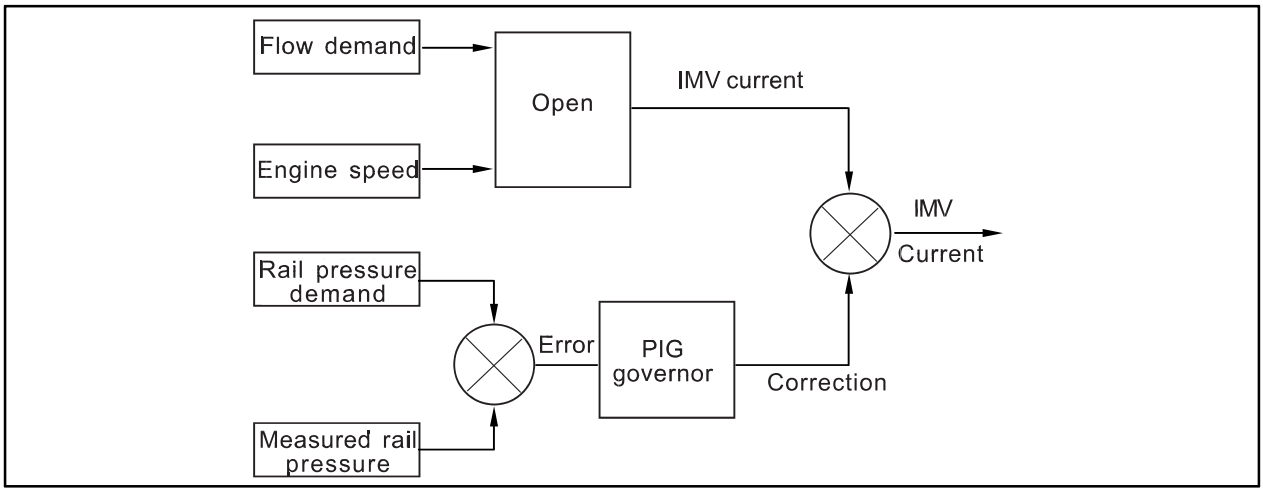
- When engine speed and load are high
  - · The degree of turbulence is very great and the fuel can be injected at very high pressure in order to optimize combustion.
- When engine speed and load are low
  - · The degree of turbulence is low. If injection pressure is too high, the nozzle's penetration will be excessive and part of the fuel will be sprayed directly onto the sides of the cylinder, causing incomplete combustion. So there occurs smoke and damages engine durability.

Fuel pressure is corrected according to air temperature, coolant temperature and atmospheric pressure and to take account of the added ignition time caused by cold running or by high altitude driving. A special pressure demand is necessary in order to obtain the additional flow required during starts. This demand is determined according to injected fuel and coolant temperature.

2) Fuel Pressure Control

Rail pressure is controlled by closed loop regulation of IMV. A mapping system - open loop - determines the current which needs to be sent to the actuator in order to obtain the flow demanded by the ECU. The closed loop will correct the current value depending on the difference between the pressure demand and the pressure measured.

- If the pressure is lower than the demand, current is reduced so that the fuel sent to the high pressure pump is increased.
- If the pressure is higher than the demand, current is increased so that the fuel sent to the high pressure pump is reduced.



Modification basis	
Application basis	
Affected VIN	

5. FUEL INJECTION CONTROL

1) Fuel Injection Control

Injection control is used in order to determine the characteristics of the pulse which is sent to the injectors.

Injection control consists as below.

- Injection timing
- Injection volume
- Translating fuel injection timing and injection volume into values which can be interpreted by the injector driver.
  - a reference tooth (CTP)
  - the delay between this tooth and the start of the pulse (Toff)
  - the pulse time (Ton)

▶ **Main injection timing control**

The pulse necessary for the main injection is determined as a function of the engine speed and of the injected flow.

The elements are:

- A first correction is made according to the air and coolant temperatures.
  This correction makes it possible to adapt the timing to the operating temperature of the engine. When the engine is warm, the timing can be retarded to reduce the combustion temperature and polluting emissions (NOx). When the engine is cold, the timing advance must be sufficient to allow the combustion to begin correctly.
- A second correction is made according to the atmospheric pressure.
  This correction is used to adapt the timing advance as a function of the atmospheric pressure and therefore the altitude.
- A third correction is made according to the coolant temperature and the time which has passed since starting.
  This correction allows the injection timing advance to be increased while the engine is warming up (initial 30 seconds). The purpose of this correction is to reduce the misfiring and instabilities which are liable to occur after a cold start.
- A fourth correction is made according to the pressure error.
  This correction is used to reduce the injection timing advance when the pressure in the rail is higher than the pressure demand.
- A fifth correction is made according to the rate of EGR.
  This correction is used to correct the injection timing advance as a function of the rate of exhaust gas recirculation.
  When the EGR rate increases, the injection timing advance must in fact be increased in order to compensate for the fall in termperature in the cylinder.

During starting, the injection timing must be retarded in order to position the start of combustion close to the TDC.

To do this, special mapping is used to determine the injection timing advance as a function of the engine speed and of the water temperature. This requirement only concerns the starting phase, since once the engine has started the system must re-use the mapping and the corrections described previously.

▶ Pilot injection timing control

The pilot injection timing is determined as a function of the engine speed and of the total flow.
The elements are:

- A first correction is made according to the air and coolant temperatures.
  This correction allows the pilot injection timing to be adapted to the operating temperature of the engine.
- A second correction is made according to the atmospheric pressure.
  This correction is used to adapt the pilot injection timing as a function of the atmospheric pressure and therefore the altitude.

During the starting phase, the pilot injection timing is determined as a function of the engine speed and of the coolant temperature.

Modification basis	
Application basis	
Affected VIN	

6. FUEL FLOW CONTROL

1) Main Flow Control

The main flow represents the amount of fuel injected into the cylinder during the main injection. The pilot flow represents the amount of fuel injected during the pilot injection.
The total fuel injected during 1 cycle (main flow + pilot flow) is determined in the following manner.
: The driver's demand is compared with the value of the minimum flow determined by the idle speed controller.

- When the driver depress the pedal, it is his demand which is taken into account by the system in order to determine the fuel injected.
- When the driver release the pedal, the idle speed controller takes over to determine the minimum fuel which must be injected into the cylinder to prevent the enigne from stalling.

It is therefore the greater of these 2 values which is retained by the system. This value is then compared with the lower flow limit determined by the ASR trajectory control system. As soon as the injected fuel becomes lower than the flow limit determined by the ASR trajectory control system, the antagonistic torque (engine brake) transmitted to the drive wheels exceeds the adherence capacity of the vehicle and there is therefore a risk of the drive wheels locking. The system thus chooses the greater of these 2 values (main flow & pilot flow) in order to prevent any loss of control of the vehicle during a sharp deceleration.
This value is then compared with the flow limit determined by the cruise control. As soon as the injected fuel becomes lower than the flow limit determined by the cruise control, the vehicle's speed falls below the value required by the driver. The system therefore chooses the greater of these 2 values in order to maintain the speed at the required level.
This valve is then compared with the flow limit determined by the flow limitation strategy. This strategy allows the flow to be limited as a function of the operating conditions of the engine. The system therefore chooses the smaller of these 2 values in order to protect the engine. This value is then compared with the fuel limit determined by the ASR trajectory control system.
As soon as the injected fuel becomes higher than the fuel limit determined by the ASR trajectory control system, the engine torque transmitted to the wheels exceeds the adhesion capacity of the vehicle and there is a risk of the drive wheels skidding. The system therefore chooses the smaller of the two values in order to avoid any loss of control of the vehicle during accelerations.

The anti-oscillation strategy makes it possible to compensate for fluctuations in engine speed during transient conditions. This strategy leads to a fuel correction which is added to the total fuel of each cylinder. The correction is determined before each injection as a function of the instantaneous engine speed.

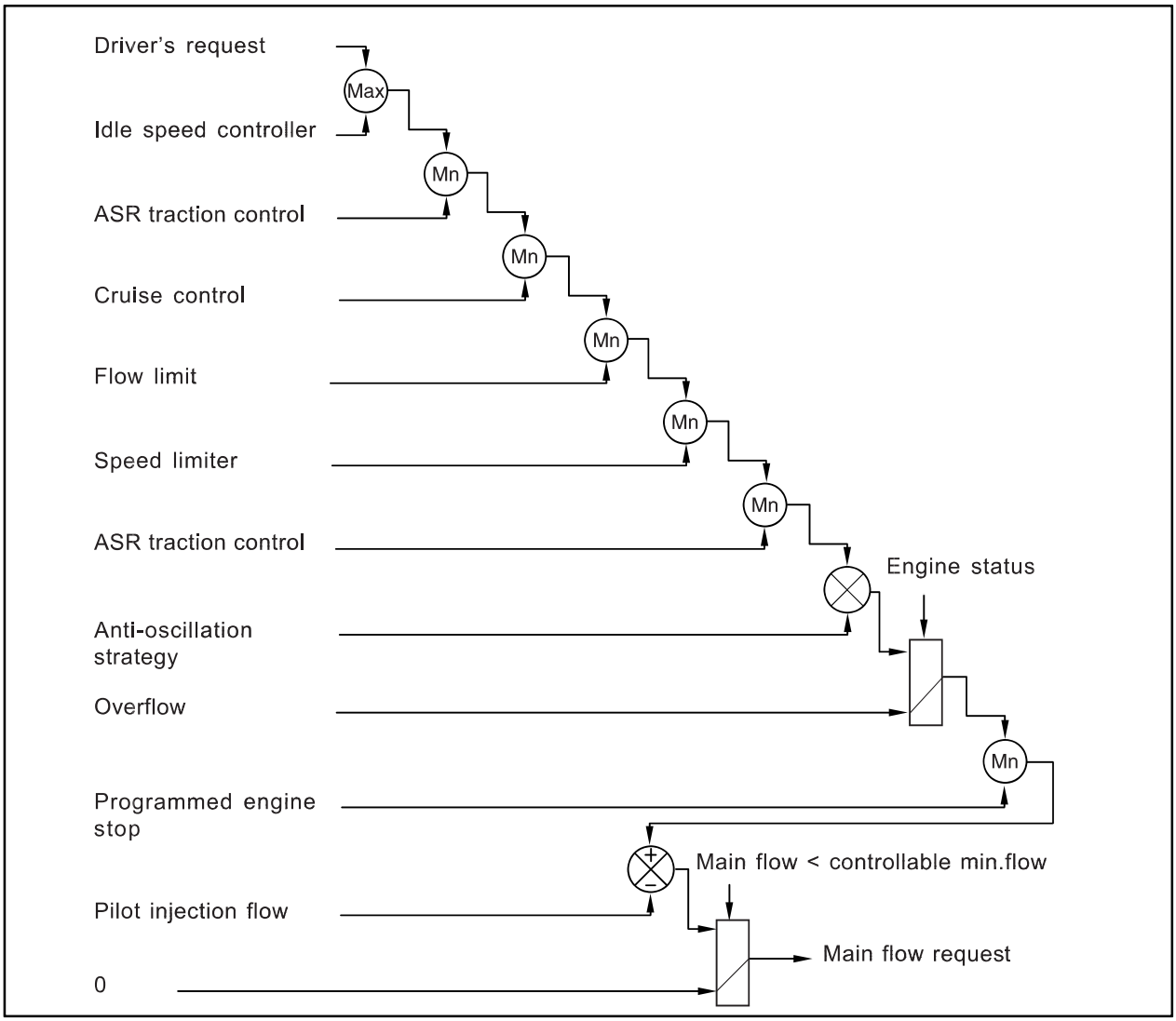
A switch makes it possible to change over from the supercharge fuel to the total fuel according to the state of the engine.

- Until the stating phase has finished, the system uses the supercharged fuel.
- Once the engine changes to normal operation, the system uses the total fuel.

The main fuel is obtained by subtracting the pilot injection fuel from the total fuel.
A mapping determines the minimum fuel which can control an injector as a function of the rail pressure. As soon as the main fuel falls below this value, the fuel demand changes to 0 because in any case the injector is not capable of injecting the quantity demand.

Modification basis	
Application basis	
Affected VIN	

2) Driver Demand



The driver demand is the translation of the pedal position into the fuel demand. It is calculated as a function of the pedal position and of the engine speed. The driver demand is filtered in order to limit the hesitations caused by rapid changes of the pedal position. A mapping determines the maximum fuel which can be injected as a function of the driver demand and the rail pressure. Since the flow is proportional to the injection time and to the square root of the injection pressure, it is necessary to limit the flow according to the pressure in order to avoid extending the injection for too long into the engine cycle. The system compares the driver demand with this limit and chooses the smaller of the 2 values. The driver demand is then corrected according to the coolant temperature. This correction is added to the driver demand.

3) Idle Speed Controller

The idle speed controller consists of 2 principal modules:

- The first module determines the required idle speed according to:
  - · The operating conditions of the engine (coolant temperature, gear engaged)
  - · Any activation of the electrical consumers (power steering, air conditioning, others)
  - · The battery voltage
  - · The presence of any faults liable to interface with the rail pressure control or the injection control. In this case, the accelerated idle speed is activated to prevent the engine from stalling when operating in degraded mode.
  - · It is possible to increase or to reduce the required idle speed with the aid of the diagnostic tool.
- The second module is responsible for providing closed loop control of the engine's idle speed by adapting the minimum fuel according to the difference between the required idle speed and the engine speed.

4) Flow Limitation

The flow limitation strategy is based on the following strategies:

- The flow limitation depending on the filling of the engine with air is determined according to the engine speed and the air flow. This limitation allows smoke emissions to be reduced during stabilized running.
- The flow limitation depending on the atmospheric pressure is determined according to the engine speed and the atmospheric pressure. It allows smoke emissions to be reduced when driving at altitude.
- The full load flow curve is determined according to the gear engaged and the engine speed. It allows the maximum torque delivered by the engine to be limited.
- A performance limitation is introduced if faults liable to upset the rail pressure control or the injection control are detected by the system. In this case, and depending on the gravity of the fault, the system activates:
  - · Reduced fuel logic 1: Guarantees 75 % of the performance without limiting the engine speed.
  - · Reduced fuel logic 2: Guarantees 50 % of the performance with the engine speed limited to 3,000 rpm.
  - · Reduce fuel logic 3: Limits the engine speed to 2,000 rpm.

The system chooses the lowest of all these values.

A correction depending on the coolant temperature is added to the flow limitation. This correction makes it possible to reduce the mechanical stresses while the engine is warming up. The correction is determined according to the coolant temperature, the engine speed and the time which has passed since starting.

▶ **Superchager Flow Demand**

The supercharge flow is calculated according to the engine speed and the coolant temperature. A correction depending on the air temperature and the atmospheric pressure is made in order to increase the supercharge flow during cold starts. It is possible to alter the supercharge flow value by adding a flow offset with the aid of the diagnostic tool.

Modification basis	
Application basis	
Affected VIN	

5) Pilot Flow Control

The pilot flow represents the amount of fuel injected into the cylinder during the pilot injection. This amount is determined according to the engine speed and the total flow.

- A first correction is made according to the air and water temperature.
  This correction allows the pilot flow to be adapted to the operating temperature of the engine. When the engine is warm, the ignition time decreases because the end-of-compression temperature is higher. The pilot flow can therefore be reduced because there is obviously less combustion noise when the engine is warm.
- A second correction is made according to the atmospheric pressure.

This correction is used to adapt the pilot flow according to the atmospheric pressure and therefore the altitude.

During starting, the pilot flow is determined on the basis of the engine speed and the coolant temperature.

6) Cylinder Balancing Strategy

▶ **Balancing of the point to point flows**

The pulse of each injector is corrected according to the difference in instantaneous speed measured between 2 successive injectors.

- The instantaneous speeds on two successive injections are first calculated.
- The difference between these two instantaneous speeds is then calculated.
- Finally, the time to be added to the main injection pulse for the different injectors is determined. For each injector, this time is calculated according to the initial offset of the injector and the instantaneous speed difference.

▶ **Detection of an injector which has stuck closed**

The cylinder balancing strategy also allows the detection of an injector which has stuck closed. The difference in instantaneous speed between 2 successive injections then exceeds a predefined threshold. In this case, a fault is signaled by the system.

7) Accelerometer Strategy

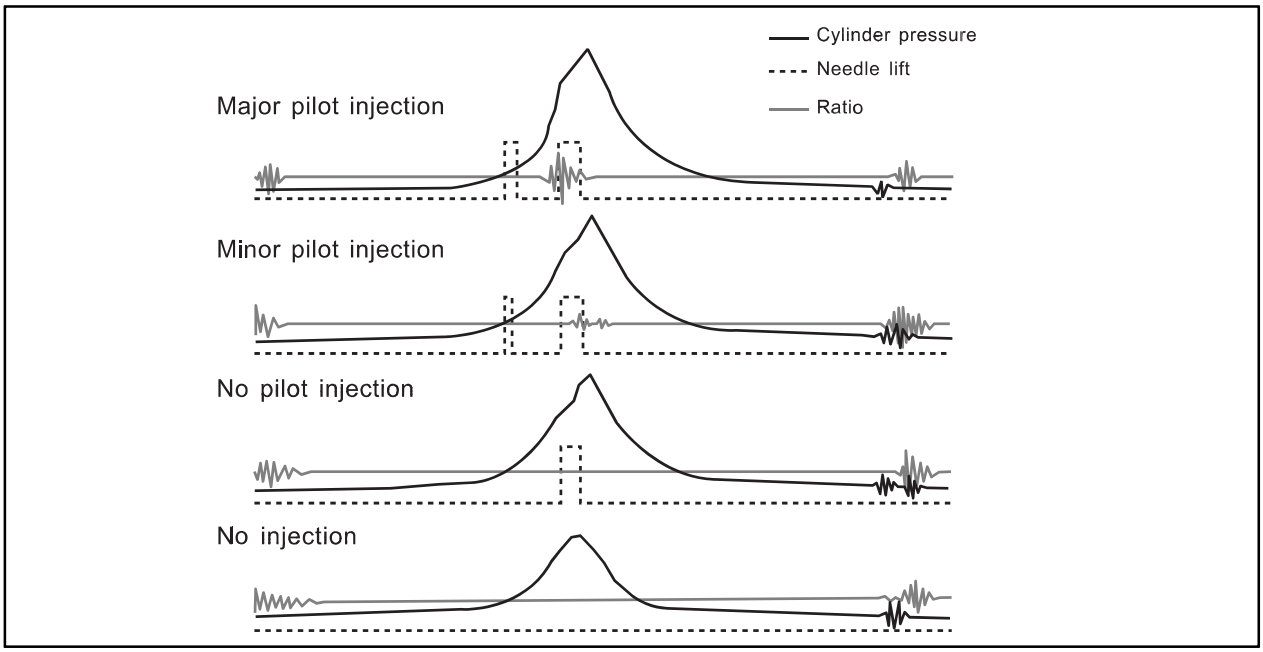
▶ **Resetting the pilot injection**

The accelerometer is used to reset the pilot injection flow in closed loop for each injector. This method allows the correction of any injector deviations over a period of time. The principle of use of the accelerometer is based on the detection of the combustion noises.

The sensor is positioned in such a way as to receive the maximum signal for all the cylinders. The raw signals from the accelerometer are processed to obtain a variable which quantifies the intensity of the combustion. This variable, known as the ratio, consists of the ratio between the intensity of the background noise and the combustion noise.

- A first window is used to establish the background noise level of the accelerometer signal for each cylinder. This window must therefore be positioned at a moment when there cannot be any combustion.
- The second window is used to measure the intensity of the pilot combustion. Its position is such that only the combustion noises produced by the pilot injection are measured . It is therefore placed just before the main injection.

The accelerometer does not allow any evaluation of the quantity injected. However, the pulse value will be measured when the injector starts injection and this pulse value is called the MDP (Minimum Drive Pulse). On the basis of this information, it is possible to efficiently correct the pilot flows. The pilot injection resetting principle therefore consists of determining the MDP, in other words the pulse corresponding to the start of the increase in value of the ratio (increase of vibration due to fuel combustion).



This is done periodically under certain operating conditions. When the resetting is finished, the new minimum pulse value replaces the value obtained during the previous resetting. The first MDP value is provided by the C2I. Each resetting then allows the closed loop of the MDP to be updated according to the deviation of the injector.

Modification basis	
Application basis	
Affected VIN	

▶ Detection of leaks in the cylinders

The accelerometer is also used to detect any injector which may have stuck open. The detection principle is based on monitoring the ratio. If there is a leak in the cylinder, the accumulated fuel self-ignites as soon as the temperature and pressure conditions are favorable (high engine speed, high load and small leak).

This combustion is set off at about 20 degrees before TDC and before main injection.

The ratio therefore increases considerably in the detection window. It is this increase which allows the leaks to be detected. The threshold beyond which a fault is signaled is a percentage of the maximum possible value of the ratio.

Because of the severity of the recovery process (engine shut-down), the etection must be extremely robust.

An increase in the ratio can be the consequence of various causes:

- Pilot injection too strong
- Main combustion offset
- Fuel leak in the cylinder

If the ratio becomes too high, the strategy initially restricts the pilot injection flow and retards the main injection. If the ratio remains high despite these interventions, this shows that a real leak is present, a fault is signaled and the engine is shut down.

▶ Detection of an accelerometer fault

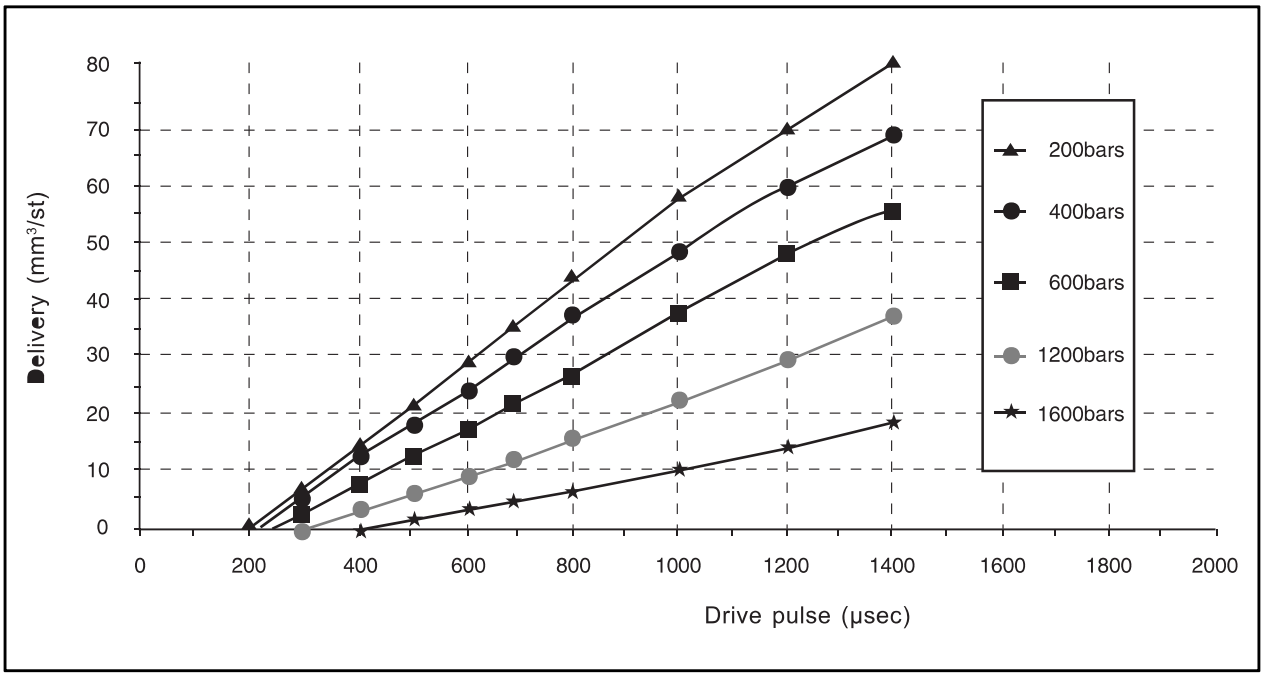
This strategy permits the detection of a fault in the sensor or in the wiring loom connecting the sensor to the ECU.

It is based on detection of the combustion. When the engine is idling, the detection window is set too low for the combustion caused by the main injection. If the ratio increases, this shows that the accelerometer is working properly, but otherwise a fault is signaled to indicate a sensor failure. The recovery modes associated with this fault consist of inhibition of the pilot injection and discharge through the injectors.

7. INDIVIDUAL INJECTOR CALIBRATION (C2I)

Injected fuel is proportional to square root of injection time and rail pressure.

It is function between pulse and rail pressure and fuel injection curve is called injector characteristics curve having the following shape.



Common rail injectors are very accurate components. They are able to inject fuel delivery between 0.5 to 100 mg/str under pressure varying from 150 to 1600 bar.

This high level of accuracy requires very low machining tolerances (few ㎛).

Nevertheless, due to the machining dispersion, the loss of charge through the functional orifices, the friction between moving parts and electromagnetic field level are different from one injector to the other. So, the difference of fuel delivery for the same pressure and the same pulse can reach 5 mg/str from one injector to the other. It is impossible to control efficiently the engine with such a dispersion between the different injectors. It is necessary to add a correction that allows injecting the demanded fuel delivery whatever the initial hydraulic characteristics of the injector is. The method consists in correcting the pulse that is applied to the injector with an offset that depends on the initial hydraulic map of the injector. So, the pulse should be corrected according to characteristics of each injector.

Modification basis	
Application basis	
Affected VIN	

C2I is composed of models on these characteristics of injectors.
C2I consists of 16-digit composed of numbers from 1 to 9 and alphabets from A to F. ECU remembers C2I, characteristics of each injector, to make the most optimal fuel injection.

- When replacing the injector, C2I code on the top of new injector should be input into ECU because the ECU is remembering the injector's C2I value. If C2I is not input, engine power drops and occurs irregular combustion.
- When ECU is replaced, C2I code of every injector should be input. If not, cannot accelerate the vehicle even when the accelerator pedal is depressed.

※ For coding of C2I, refer to "Diagnosis" section

8. MINIMUM DRIVE PULSE (MDP) LEARNING

When the pulse value that the injector starts injection is measured, it is called mininum drive pulse (MDP). Through MDP controls, can correct pilot injections effectively. Pilot injection volume is very small, 1 ~ 2 mm/str, so precise control of the injector can be difficult if it gets old. So there needs MDP learning to control the very small volume precisely through learning according to getting older injectors.

1) Learning Conditions

Coolant temperature	> 75°C
Vehicle speed	> 50 Km/h (over 5 seconds)
Intake manifold pressure	> 0.7 bar
Engine speed	> 2,500 rpm
Battery voltage	10 V < MDP < 16 V
Fuel temperature	0 < fuel temperature < 80 °C
Initial MDP learning on each injector	5 seconds

2) Trouble Codes

Trouble code	Descriptio n	Diagnosis
P1171	Fault MDP learning on injector No. 1	• Check each injector
P1172	Fault MDP learning on injector No. 2	
P1173	Fault MDP learning on injector No. 3	
P1174	Fault MDP learning on injector No. 4	
P1175	Fault MDP learning on injector No. 5	

Modification basis	
Application basis	
Affected VIN	

CRUISE CONTROL SYSTEM

8510-23

OVERVIEW AND OPERATION PROCESS

1. CRUISE CONTROL SWITCH

The purpose of the cruise control system is to automatically maintain a vehicle speed set by the driver, without depressing the accelerator pedal. The cruise control switch is located under the right side of the steering wheel, and when this switch is operating "AUTO CRUISE" lamp comes on.

The minimum speed for setting the cruise control system is 36 km/h (22.37 mph). Pay constant attention to the distance between the vehicles and the traffic conditions when using the cruise control system.

CAUTION

The cruise control system is a supplementary system, which helps the driver to drive the vehicle at a desired speed without using the accelerator pedal under the traffic condition where the vehicle-to-vehicle distance meets the legal requirement.

Modification basis	
Application basis	
Affected VIN	

1) When To Use

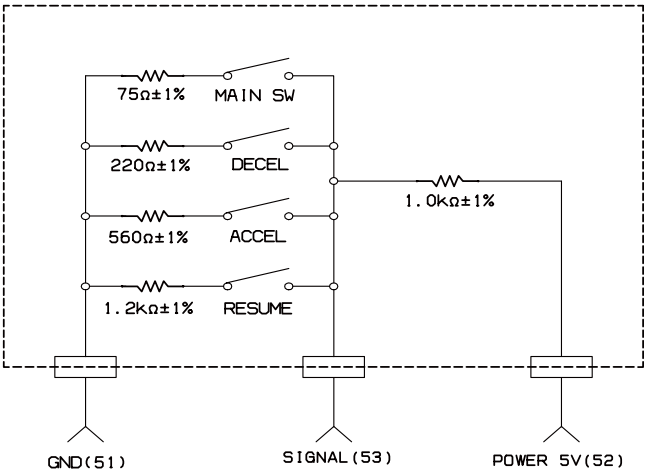
Use the cruise control system only when (a) the traffic is not jammed, (b) driving on motorways or highways where there is no sudden change in the driving condition due to traffic lights, pedestrian, etc.

WARNING

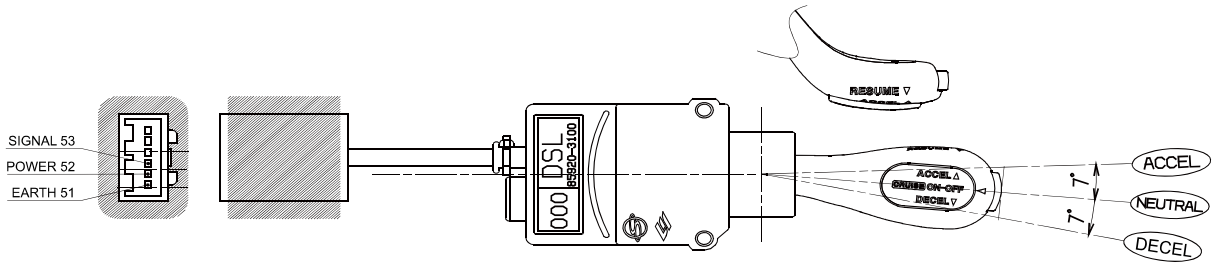
Use the cruise control system only when driving on motorways or highways. Do not use the cruise control system where the road conditions are as follows:
- When there is strong wind or cross wind.
- Heavy traffic.
- Slippery roads or steep decline.

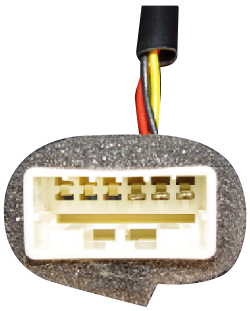
Modification basis	
Application basis	
Affected VIN	

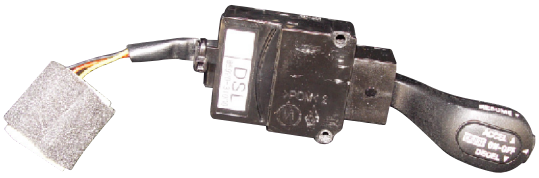
2. CIRCUIT DIAGRAM



1) Configuration







Modification basis	
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3. HOW TO OPERATE CRUISE CONTROL SWITCH

1) How To Set Speed

1. To operate the cruise control system, accelerate the vehicle to the speed within the specified range below with depressing the accelerator pedal.
   - Cruise control operating range: between 36 km/h (22.37 mph) and 150 km/h (93.207 mph)
2. When the desired speed is reached, which should be within the above range, push up the cruise control switch lever to ACCEL side (upwards arrow), or push down the switch lever to DECEL side (downwards arrow).
   And then release the accelerator pedal slowly.
3. Now the vehicle is cruised by this system with the set speed. You don't need to use the accelerator pedal.
4. Refer to the following pages for details of operation.

CAUTION

Never use the cruise control system until you get used to it.
Improper use or not fully aware of this function could result in collision and/or personal injuries.

Modification basis	
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2) Accelerating with the Cruise Control System

(1) While the cruise control system is running

1. To increase the set speed, push up the cruise control switch lever to ACCEL side and hold it until the desired speed is reached without depressing the accelerator pedal.
2. When the desired speed is set, release the switch lever.

(2) When the cruise control system is not running

To increase the speed with the cruise control system while the system is not running, follow the procedures below.

1. Accelerate the vehicle to more than 36 km/h (22.37 mph) using the accelerator pedal. Push up the cruise control switch lever to ACCEL side and hold it.
2. When the desired speed is reached, release the accelerator pedal and the switch lever.

(3) Tap-up while the cruise control system is running

To increase the vehicle speed in stages while the cruise control system is running, follow the procedures below.

1. Push up the cruise control switch lever to ACCEL side for less than 0.5 second per one switching while the cruise control system is running; the speed increases each time by 1.3 km/h (0.81 mph).
2. For example, if you want to increase the speed 13 km/h (81 mph) more than the previous set speed, tap up the switch lever to ACCEL side ten times without using the accelerator pedal.

3) Decelerating with the Cruise Control System

(1) While the cruise control system is running

1. To decrease the set speed, push down the cruise control switch lever to DECEL side and hold it until the desired speed is reached without depressing the brake pedal.
   But the cruise control system cannot maintain the cruise function at less than 34 km/h (21.13 mph).
2. When the desired speed is set, release the switch lever.

(2) When the cruise control system is not running

To decrease the speed with the cruise control system while the system is not running, follow the procedures below.

1. Push down the cruise control switch lever to DECEL side and hold it until the desired speed is reached while the vehicle speed is over 36 km/h (22.37 mph).
2. When the desired speed is reached, release the switch lever.
3. But the cruise control system cannot maintain the cruise function at less than 34 km/h (21.13 mph).

(3) Tap-down while the cruise control system is running

To decrease the vehicle speed in stages while the cruise control system is running, follow the below procedures.

1. Push down the cruise control switch lever to DECEL side for less than 0.5 second per one switching while the cruise control system is running; the speed decreases each time by 1.0 km/h (0.62 mph).
2. For example, if you want to decrease the speed 10 km/h (62 mph) lower than the previous set speed, tap down the switch lever to DECEL side ten times without using the brake pedal.

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4) Recovery of Set Speed (RESUME)

Even if the cruise control is cancelled, the previous set cruise speed can be recovered by operating the cruise control switch lever like below:
- Pull the switch lever in the arrow direction shown in the illustration.
This RESUME function works only when the vehicle speed is more than 36 km/h (22.37 mph) without using the accelerator or brake pedal.

CAUTION
But the driver should know the previous set speed to react to the changed vehicle speed properly. If the vehicle speed increases abruptly, depress the brake pedal to adjust the vehicle speed properly.

5) Normal Cancellation of the Cruise Control(OFF ↔ ON)

The cruise control system will be cancelled when the button on the side of the switch is pressed, or when one of the following conditions is met:

1. When the brake pedal is depressed or ESP is activated.
2. When the vehicle speed is less than 34 km/h (21.13 mph).
3. When the parking brake is applied while driving.
4. When the clutch pedal is depressed for shifting (M/T only).

CAUTION

Put the cruise control switch lever in the neutral position when not using the cruise control system.

(1) Abnormal Cancellation of the Cruise Control

1. When the rapid deceleration or acceleration occurs.
2. When the cruise control lever is faulty.
3. When the brake switch is malfunctioning or has an open circuit.

When the cruise control function is cancelled abnormally or intermittent problems occur, stop the vehicle and turn off the ignition switch and remove the key to reset the system. After a while, turn on the ignition switch again to operate the cruise control system.

CAUTION

- Do not move the shift lever to Neutral position while driving with the cruise control turned on. Otherwise, it may result in system malfunction or accidents.
- Always be prepared to use the brake or accelerator pedal for safe driving while the cruise control system is running.
- The actual speed can be different from the set speed momentarily when driving on a uphill or downhill. So, it is recommended to disable the cruise control function on a uphill or downhill. hen driving on a steep hill use the engine brake and foot brake properly to protect the vehicle system and for a safe driving.
- Ensure that the braking distance is maintained and use the brake pedal if needed.

Modification basis	
Application basis	
Affected VIN	