

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN

Audi
5000
Volkswagen
Dasher
Rabbit
Pickup

As the vane pump rotor turns, centrifugal force holds the vanes against the walls of the pump's pressure chamber. The off-center design of the rotor and pressure chamber squeezes trapped fuel between vanes and forces it out the delivery port. Vane pressure is 42.7-99.6 psi (3-7 kg/cm²).

DESCRIPTION

Diesel fuel injection systems consist of the fuel tank, fuel filter, distributor-type injection pump, glow plugs, throttle pintle injection nozzles and a centrifugal governor. See Fig. 1.

A vane-type fuel pump, built into the injection pump, supplies fuel from tank to fuel filter to injection pump. See Fig. 2. Injection pump supplies fuel to nozzles under high pressure, according to the firing sequence (1-3-4-2 on Volkswagen and 1-2-4-5-3 on Audi). Excess fuel is returned to fuel tank by return lines.

SYSTEM COMPONENTS

FUEL INJECTION PUMP

The Bosch single plunger mechanical pump consists of a low-pressure, vane-type fuel pump, a high-pressure distributor plunger injection pump, a centrifugal governor, an injection timing mechanism, and an electrical fuel shut-off solenoid. See Fig. 1.

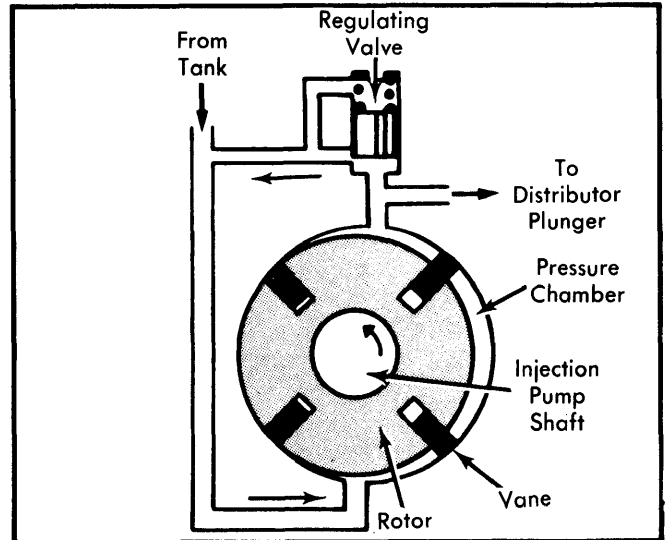


Fig. 2 Vane-Type Fuel Pump Components

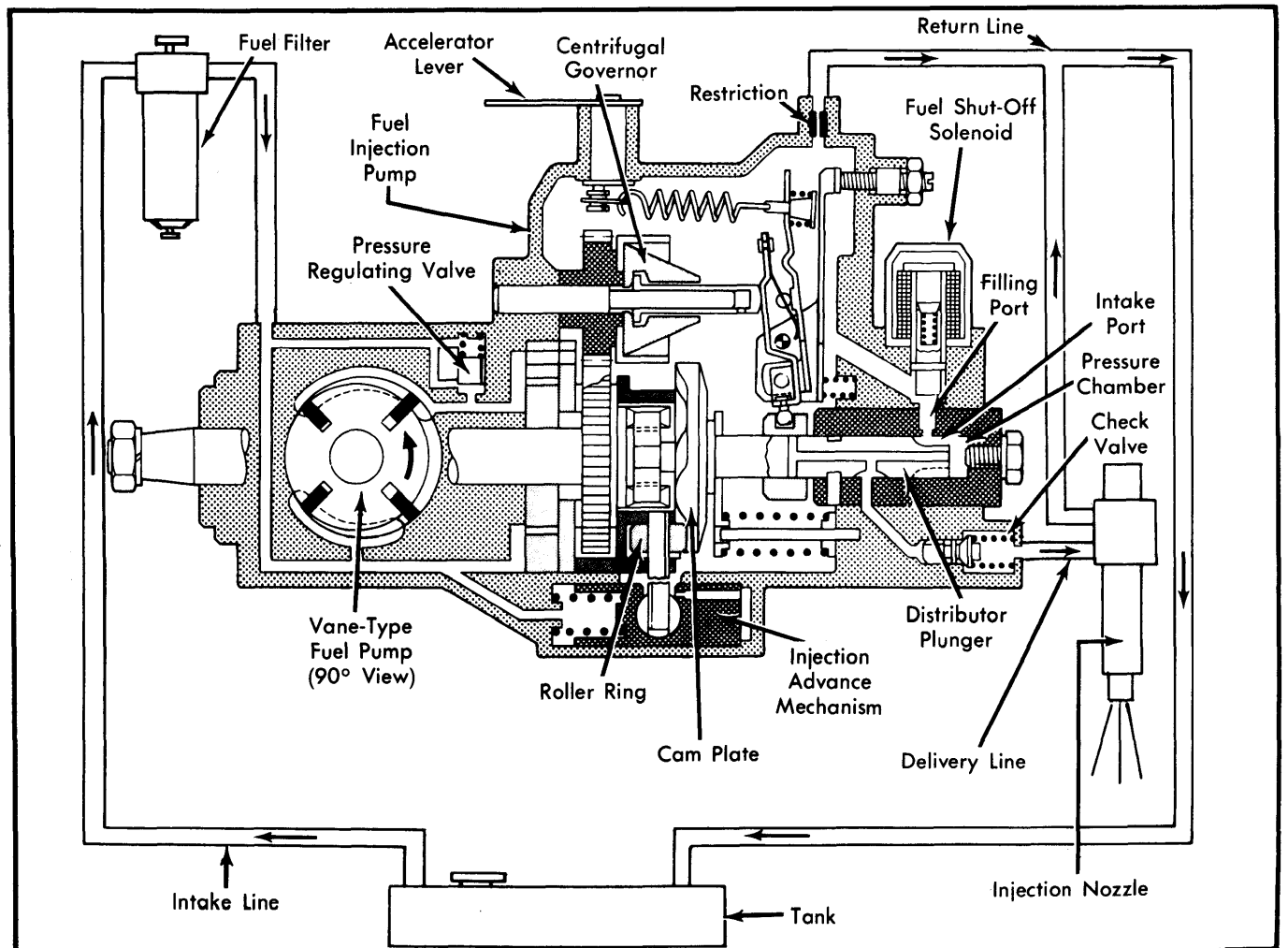


Fig. 1 Diesel Fuel Supply System

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

The vane pump is driven by the camshaft at one-half engine speed. See Fig. 2. It lubricates all moving parts of the injection pump with diesel fuel, supplies fuel to the distributor plunger for pressurization and use by injection nozzles, and controls injection timing advance mechanism. The injection pump drive shaft turns the vane pump, distributor plunger and cam plate as a unit.

Springs hold the cam plate and distributor plunger against stationary rollers. See Figs. 1 and 3. This causes the plunger to move back and forth in its cylinder as it also turns. Whenever an intake port in the plunger becomes aligned with a filling port in the pump body, fuel from the vane pump fills the pressure chamber.

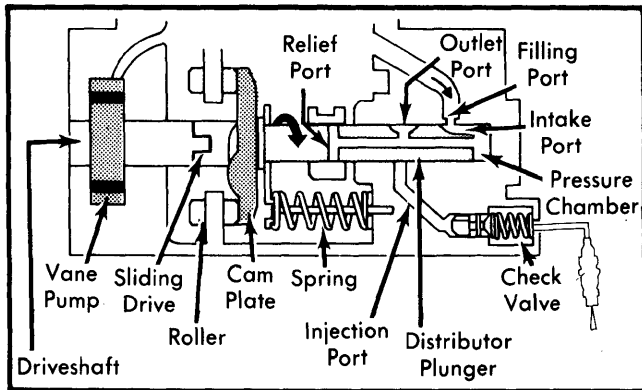


Fig. 3 Operation of Distributor Plunger

As the plunger turns, the intake port is covered and fuel is trapped in the pressure chamber. As the cam plate and rollers push against the plunger, fuel is pressurized to approximately 1800 psi (126 kg/cm²). As the plunger continues to turn, the single outlet port in the plunger becomes aligned with one of the 4 or 5 injection ports in the pump body. This pressurized fuel opens the check valve and supplies high pressure fuel to the appropriate injection nozzle.

An injection timing mechanism is located on the lower side of the injection pump. See Fig. 4. As engine speed increases, stroke time becomes shorter and injection time becomes longer. Burning must therefore begin sooner to ensure peak combustion pressures still occur at the most efficient point after TDC.

As engine speed increases, fuel pressure from the vane pump also increases, pushing the hydraulic piston to the side against

its spring. This causes the roller housing to turn slightly as the peg is moved. Since the cam plate is turning in the opposite direction, the ramps on the cam plate engage the roller sooner.

For cold start and warm-up periods, a lever and cam act against the hydraulic piston, advancing injection timing approximately 5°. See Fig. 4. This provides more time for fuel to burn, improving performance and preventing black exhaust smoke during cold start and warm-up periods.

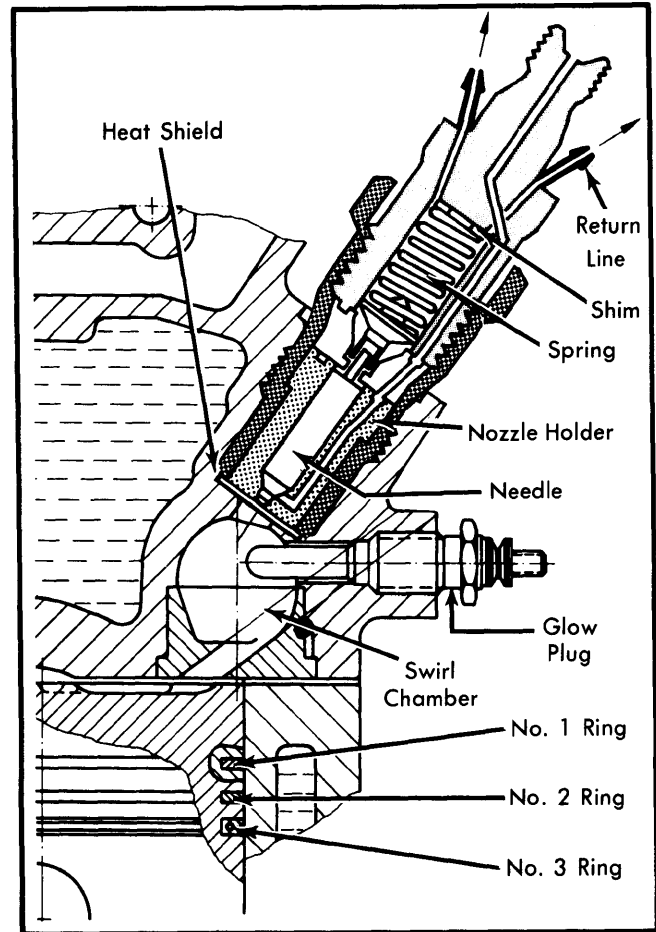


Fig. 5 Cutaway View Showing Relationship of Injection Nozzle, Glow Plug & Swirl Chamber to Piston

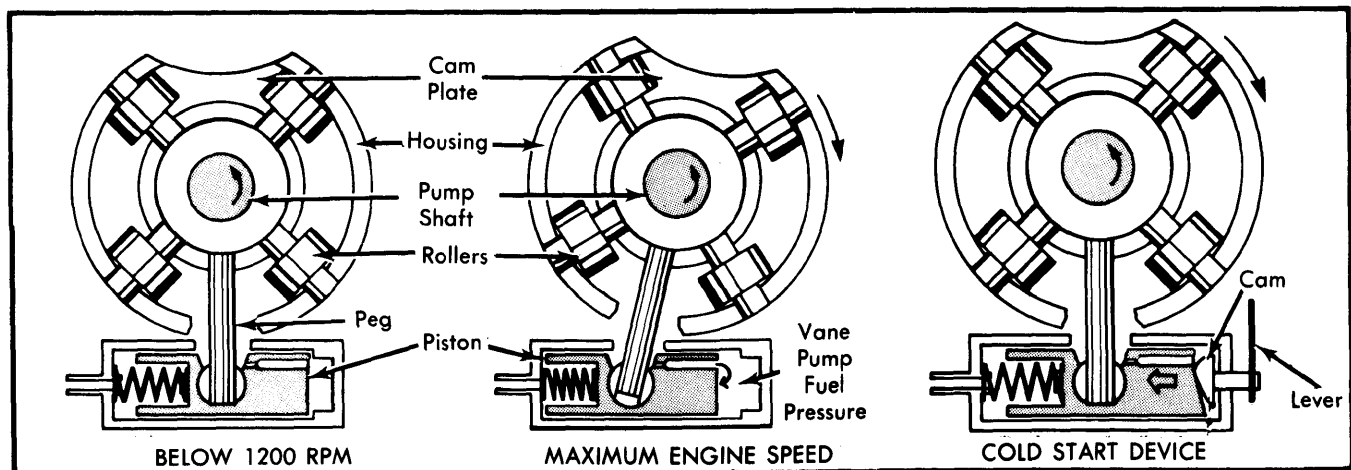


Fig. 4 Injection Timing Mechanism & Cold Start Device

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

INJECTION NOZZLES

Bosch DNOSD 193 injection nozzles, mounted in KDA SD 27/4 sockets, inject fuel at 1706-1850 psi (120-130 kg/cm²). See Fig. 5.

A pressurized mist of fuel is injected into a round swirl chamber. Fuel swirls around the chamber, mixing with hot air, compressed at a 23:1 ratio. Heat shields protect each injector.

Combustion begins in rich swirl chamber, continues on through a small passageway and into a leaner main chamber. As peak cylinder pressures build in swirl chamber, rather than main chamber, loads on connecting rods and crankshaft are reduced.

GLOW PLUGS

During cold starts, glow plugs are used to preheat swirl chambers. See Fig. 5. When current is applied, glow plugs become red hot. A temperature sensor connected to a time circuit in a relay controls pre-heating time.

To start a cold engine, pull out cold start knob to left of steering column (Volkswagen only). Turn ignition switch to glow plug position (No. 2). When light goes out, crank the engine. At below freezing temperatures, depress accelerator pedal while cranking. About 2 minutes after engine starts, push cold start knob in fully. When starting a warm engine, do not use glow plugs.

NOTE – Cold starting device of Audi 5000 is automatically controlled by engine coolant passing over a thermostat. When engine is cold, thermostat pulls on advance lever advancing injection timing.

FUEL FILTER

The fuel filter allows unrestricted flow of fuel from the tank to the injection pump, but stops any dirt or water. A replaceable element, similar to an oil filter cartridge, threads onto a removable flange. See Fig. 6.

To drain water from filter, open vent screw on top of filter flange. If there is no vent screw, remove fuel return line at injection pump. Remove flange mounting nuts and lift filter. Open water drain on bottom of filter. Drain until clean fuel runs out. Close water drain and vent screw (or reattach return line).

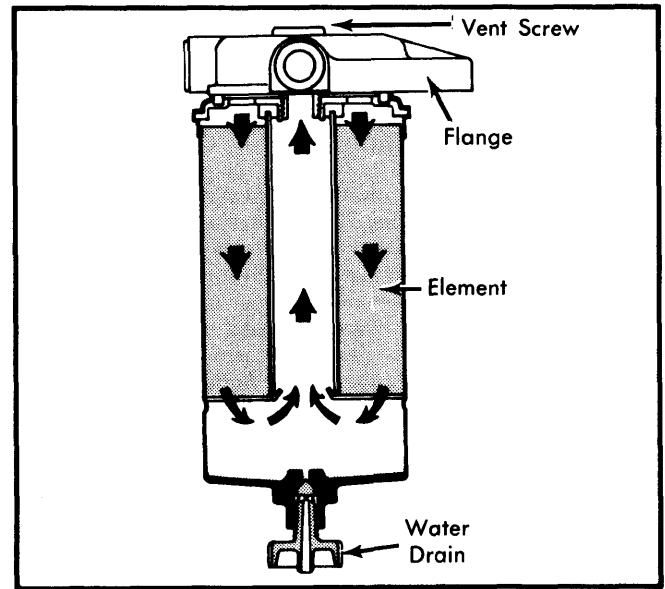


Fig. 6 Components of Fuel Filter

CENTRIFUGAL GOVERNOR

The amount of fuel injected is controlled by changing the injection cut-off point according to engine speed and load conditions. The cut-off point is controlled by the position of the metering sleeve around the distributor plunger. The sleeve normally covers a relief port in the plunger. Uncovering the port, stops injection.

The position of the metering sleeve is controlled by linkage connected to the centrifugal governor and accelerator pedal. See Fig. 7. When engine is starting, leaf spring presses starting lever to left, so metering sleeve moves right. Injection lasts longer, as the plunger must move further before uncovering the relief port. More fuel is supplied during starting.

At idle speed, governor weights are partly expanded. The governor sleeve moves to the right, starting lever is pushed against control lever, and metering sleeve moves to the left. The distributor plunger moves only a short distance before relief port is uncovered, stopping injection. A small amount of fuel is supplied at idle.

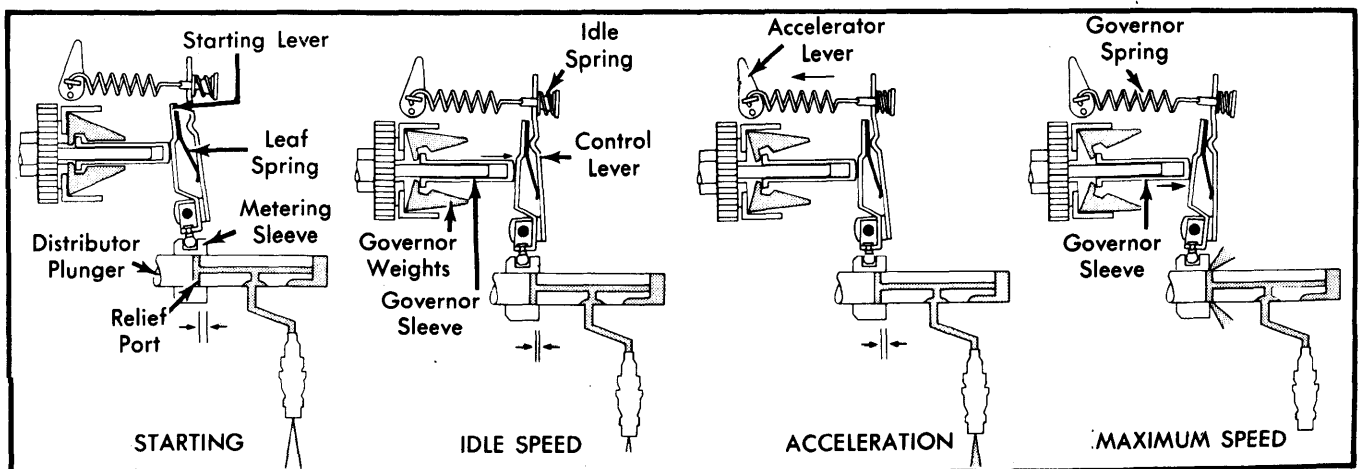


Fig. 7 Operation of Injection Pump Centrifugal Governor

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

During acceleration, the control lever is pulled to the left by accelerator pedal linkage. The metering sleeve is moved to the right so that more fuel is injected before relief port is exposed. Engine speed increases until governor movement neutralizes the effect of the pedal linkage.

At maximum speed, the governor is spinning with enough centrifugal force for governor sleeve to act against the governor spring, stretching it, and forcing control lever to the right. The metering sleeve moves to the left uncovering relief port at the beginning of each distributor plunger stroke. There is no pressure for injection until engine speed drops and metering sleeve moves to the right again. This acts as a speed limiter, causing the engine performance to "flatten out".

SERVICING COMPONENTS

FUEL INJECTION PUMP

NOTE — When working on an injection system, keep all components clean. Clean injection line unions before loosening.

Removal — 1) If injection pump is faulty, it must be replaced. Special test equipment and service tools are necessary for making repairs. For Audi vehicles, continue to step 2). For Volkswagen vehicles, proceed to step 3).

2) For Audi vehicles, remove vacuum pump pulley and drive belt and injection pump drive belt cover. Set crankshaft at TDC for No. 1 cylinder and align marks on flywheel and clutch housing and injection pump sprocket and mounting plate. Install special tool (2064) to lock injection pump sprocket securely. Lock vacuum pump belt pulley and injection pump drive sprocket with special tool (3036). See Fig. 8. Loosen and remove retaining bolt and remove drive sprocket and drive belt. Proceed to step 4).

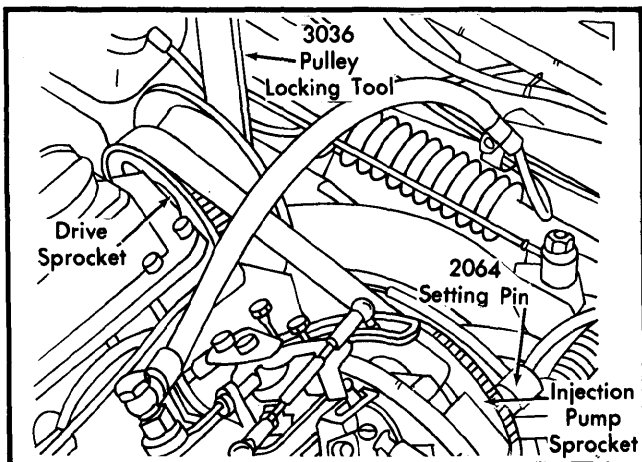


Fig. 8 Locking Injection Pump and Vacuum Pump Pulleys (Audi)

3) For Volkswagen vehicles, turn engine to TDC on No. 1 cylinder. Lock camshaft with special setting bar (2065). See Fig. 9. Remove drive belt. Proceed to step 4).

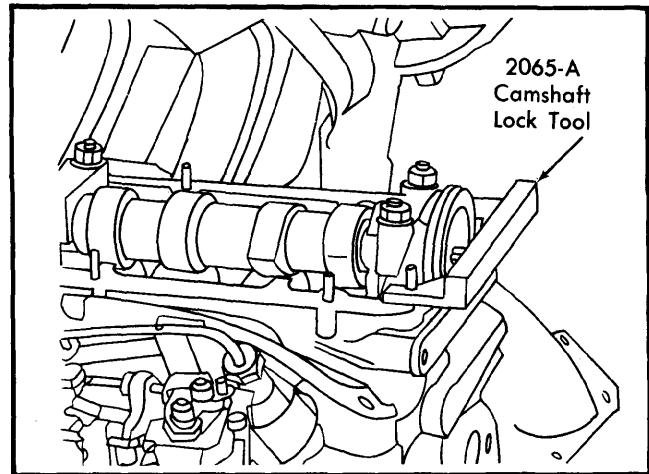


Fig. 9 Camshaft Locking Tool Installation (Volkswagen Shown)

4) Loosen injection pump sprocket retaining nut approximately one turn. On Audi vehicles, remove special tool (2064) from sprocket.

5) Attach puller (VW203b for Volkswagen; 3032 for Audi) to injection pump sprocket and apply light tension to puller. See Fig. 10. Tap lightly on puller spindle head until sprocket loosens from pump shaft.

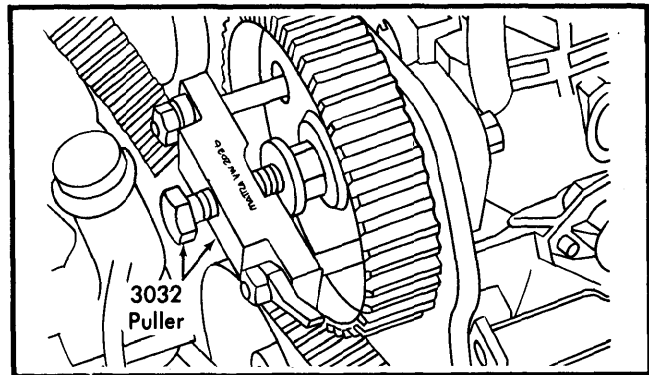


Fig. 10 Fuel Injection Pump Gear Removal (Audi Shown)

6) Remove puller and nut and remove sprocket by hand. Disconnect all fuel pipes from pump. Cover unions with clean cloth. Disconnect wire from fuel shut-off solenoid and detach accelerator cable. Remove pump mounting bolts. Support and remove pump.

Installation — 1) Install pump, aligning marks on pump and mounting plate. See Fig. 11. For Volkswagen vehicles, install injection pump sprocket. Tighten pump mounting bolts and fuel pipes to 18 ft. lbs. (2.5 mkg) and pump sprocket to 33 ft. lbs. (4.5 mkg). Adjust injection pump/valve timing and injection timing.

2) On Audi vehicles, align rear support so it contacts cylinder block and injection pump free of tension. Tighten support mounting bolts. Install injection pump sprocket and turn it until marks on sprocket and mounting plate are in line.

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

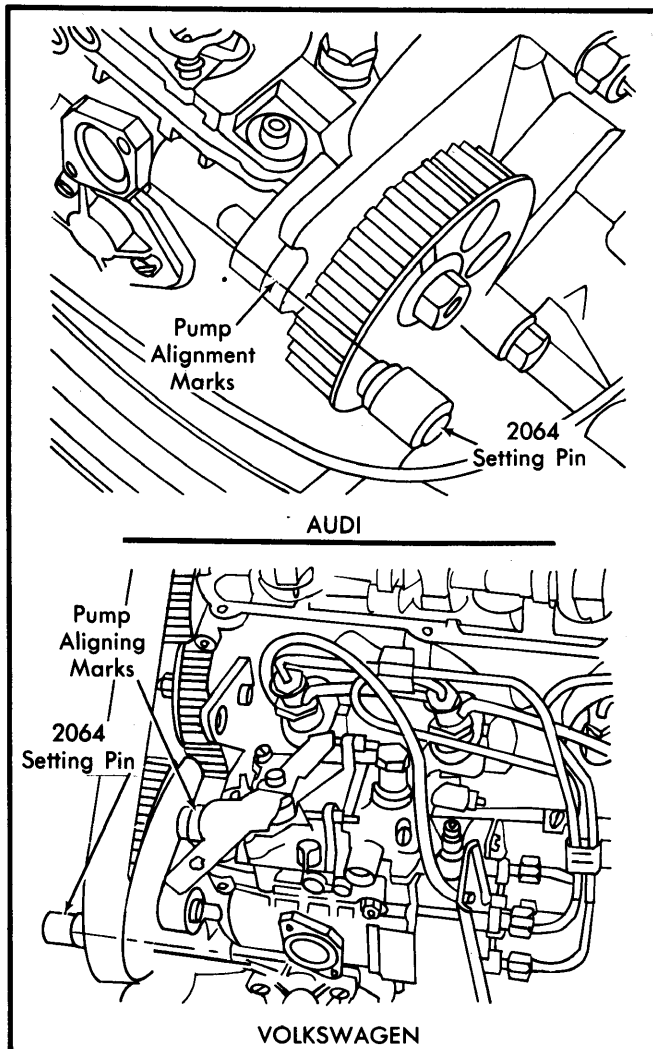


Fig. 11 Aligning Reference Marks on Injection Pump

3) Lock pump with special tool (2064) and tighten retaining nut to 33 ft. lbs. (4.5 mkg). Install drive belt and injection pump drive sprocket. Tighten drive sprocket retaining bolt so that sprocket can still be turned by hand. Check drive belt tension with VW 210 scale. Value should register 12-13 on scale.

4) If not, adjust drive belt tension by loosening bolts and moving mounting plate with pump. Check if TDC mark on flywheel is still aligned with reference mark. Tighten injection pump drive sprocket using special tool (3036), tightening bolt to 72 ft. lbs. (9.95 mkg). Remove special tool (2064). Check injection pump/valve timing and injection timing.

5) Reinstall fuel pipes, drive belt cover, and vacuum pump pulley and drive belt. Reattach accelerator cable and wire to fuel shut-off solenoid.

INJECTION NOZZLES

Injection nozzle problems usually are accompanied by knocking in one or more cylinders, engine overheating, loss of power or performance, black exhaust smoke and increased fuel consumption. To locate and correct faulty injectors, proceed as follows:

1) Loosen line unions on each injection nozzle, one at a time with engine running at fast idle. If engine speed remains constant with line removed, that nozzle is defective.

2) To remove nozzle, detach injector line. Use special tool (US 2775) to remove injection nozzles. To install, insert new heat shield with recess pointing upward. Tighten nozzles to 51 ft. lbs. (7.0 mkg) and lines to 18 ft. lbs. (2.5 mkg). Bleeding is not necessary.

FUEL FILTER

Service is limited to replacing filter at proper interval and draining water, when present. Bleeding is not required.

ADJUSTMENTS

ACCELERATOR CABLE

Place accelerator pedal in full throttle position. Adjust cable with nuts until pump lever contacts stop free of strain. See Fig. 12. Be sure ball pin on pump lever is pointing upward and touching end of elongated hole. Accelerator cable should be attached at upper hole in bracket. See Fig. 13.

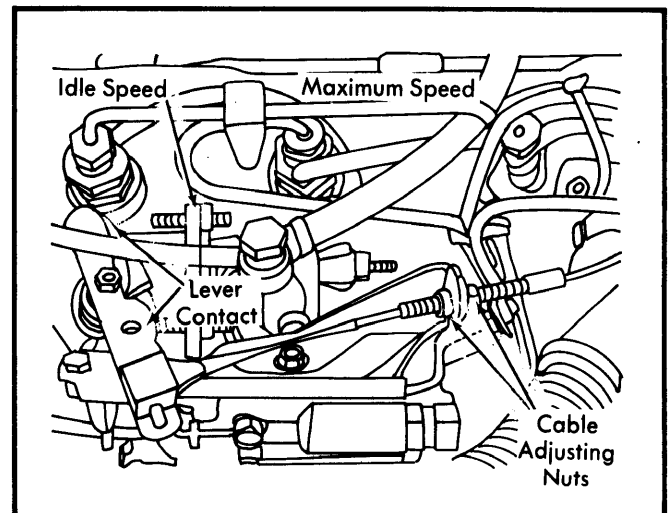


Fig. 12 Adjusting Points for Accelerator Cable

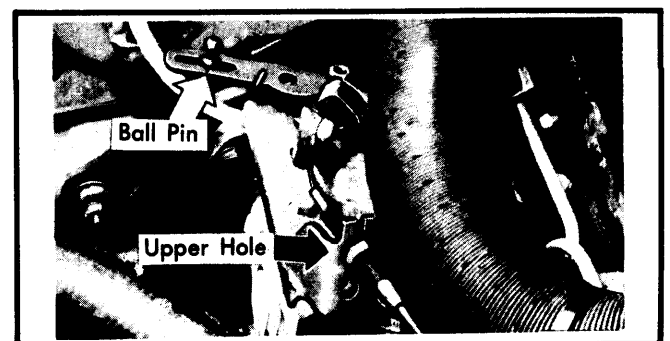


Fig. 13 Accelerator Cable Attaching Points

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

COLD STARTING CABLE

On Volkswagen vehicles, insert washer onto cable and install cable into bracket with rubber bushing. See Fig. 14. Insert cable into pin. Install lock washer and move lever as far as possible in direction of arrow. Pull cable tight and secure pin with clamping screw.

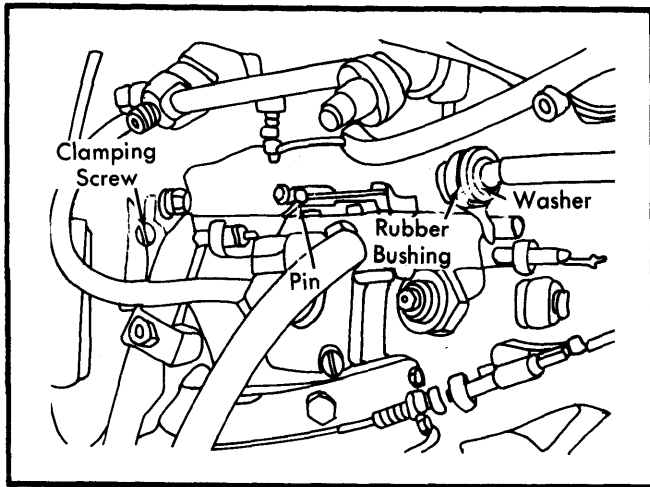


Fig. 14 Adjusting Cold Starting Cable

INJECTION PUMP TIMING

Audi (Engine Removed) – 1) Set engine to TDC on No. 1 cylinder. Adjust special tool (2068/A) to 125.5 reference mark (white arrow), left notch of vernier scale. See Fig. 15. Screw tool in as shown.

NOTE – Before starting timing procedure, check valve timing and drive belt tension. On Volkswagen engines, be sure cold start knob is pushed fully inward.

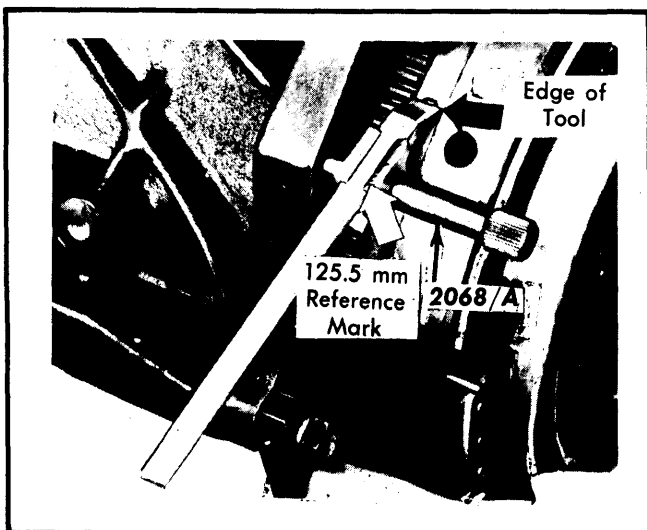


Fig. 15 Adjusting No. 1 Cylinder to TDC With Engine Removed (Audi Shown)

2) Turn crankshaft until TDC mark on flywheel is aligned with edge of special tool (2068/A) at black arrow and marks on injection pump sprocket align with mounting plate.

Audi (Engine Installed) – 1) Set crankshaft to TDC on No. 1 cylinder and align marks on flywheel and clutch housing and injection pump sprocket and mounting plate.

2) Loosen cold start device cable by loosening screw No. 1 and turning clamp 90°. See Fig. 16. Do not loosen screw No. 2.

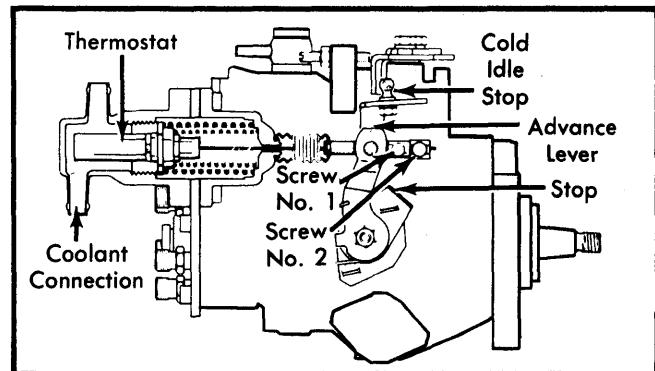


Fig. 16 Loosening Cold Start Device Screw No. 1

All Models – 1) Remove plug from injection pump cover. Install adaptor and dial indicator (2066) in place of plug. See Fig. 17. Preload indicator (0-0.118" or 0-3 mm) to .097" (2.5 mm).

2) Turn engine slowly counterclockwise until dial indicator needle stops moving. Zero indicator. Turn engine clockwise until TDC mark on flywheel is aligned with reference mark. Check dial indicator reading against specifications.

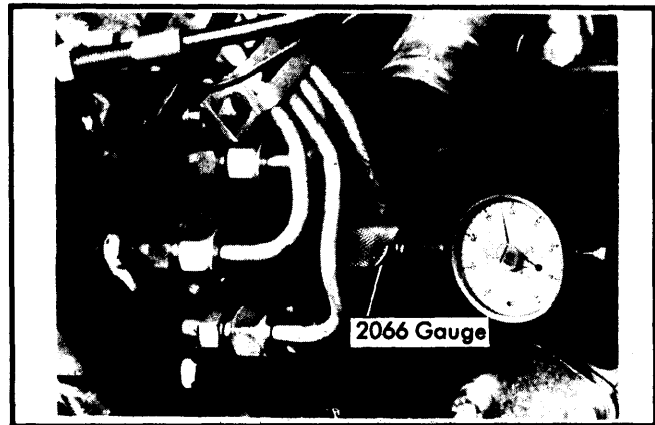


Fig. 17 Preloading Injection Pump With Dial Indicator (2066)

3) If necessary, loosen bolts on mounting plate and support. Set lift to specifications by turning pump and retightening bolts. Recheck dial indicator reading against specifications.

4) On Audi vehicles, turn clamp on cold start device back 90° to original setting and tighten screw No. 1.

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

Injection Pump Timing Specifications

Application	Dial Indicator Reading
Audi033" (.85 mm)
Volkswagen	
Rabbit ^①045" (1.15 mm)
All Others035" (.88 mm)

① — Only those models with yellow paint mark on pump advance cover.

MEASURING ENGINE SPEED

When measuring engine speed use the VW 1324 senser with Volkswagen vehicles or VW 1367 tester or Siemens 451 with Audi. Use Bosch Dwell-Tach (EFAW 166C) or the Sun Dwell-Tach (TDT-12) as an alternate.

IDLE SPEED

Audi — 1) Warm engine to normal operating temperature (oil temperature of 122-158°F or 50-70°C). Turn idle speed control knob on instrument panel counterclockwise to stop.

2) Connect VW 1367 tester or use Siemens 451 according to instructions. Adjust speed to 720-880 RPM by loosening lock nut, and turning adjusting screw in to raise idle speed and out to lower idle speed. Retighten lock nut. See Fig. 18.

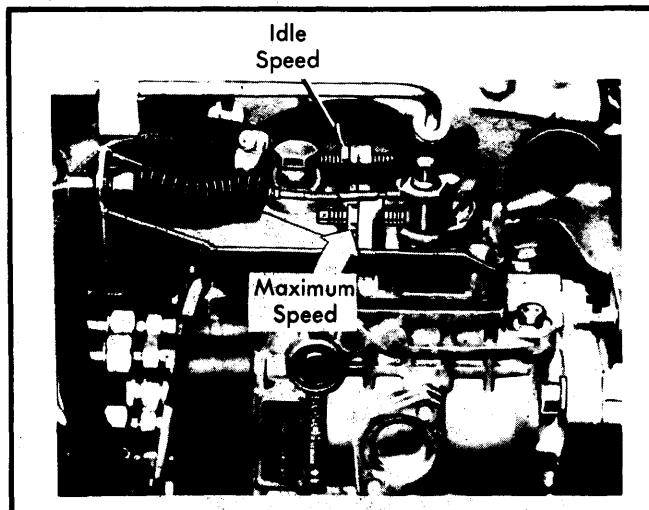


Fig. 18. Adjusting Idle and Maximum Speeds (Audi Vehicles)

Volkswagen — 1) Warm engine to normal operating temperature (oil temperature of 122-158°F or 50-70°C). Adjust idle speed to 770-870 RPM.

2) To adjust, loosen lock nut and turn screw in to raise idle speed and out to lower it. See Fig. 19. Retighten lock nut with paint.

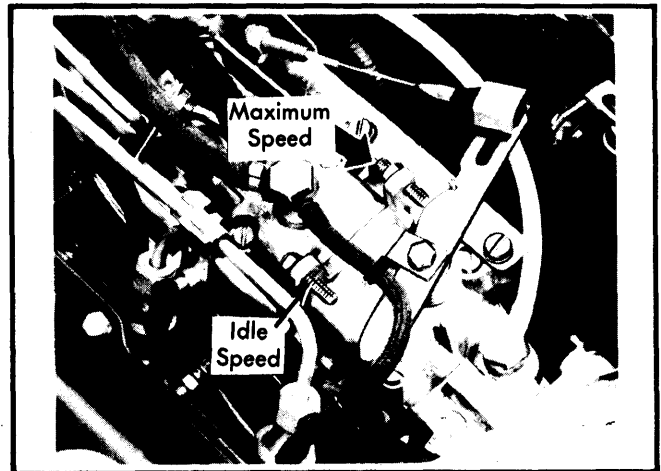


Fig. 19. Adjusting Idle and Maximum Speeds (Volkswagen Vehicles)

MAXIMUM SPEED

Adjust idle speed to proper setting and then open throttle fully. Maximum speed for Audi should be 5330-5450 RPM; for Volkswagen, 5500-5600 RPM. To adjust, loosen lock nut and turn screw out to raise maximum speed and in to lower it. See Figs 18 and 19. Tighten lock nut when adjustment is completed. Seal lock nut and screw with paint.

INJECTION NOZZLES

1) To disassemble nozzles, place upper part in vise and loosen lower part. To prevent parts from falling out, then reverse position with lower part in vise. Carefully disassemble, keeping all individual parts together. See Fig. 20. Do not interchange parts from one nozzle to another.

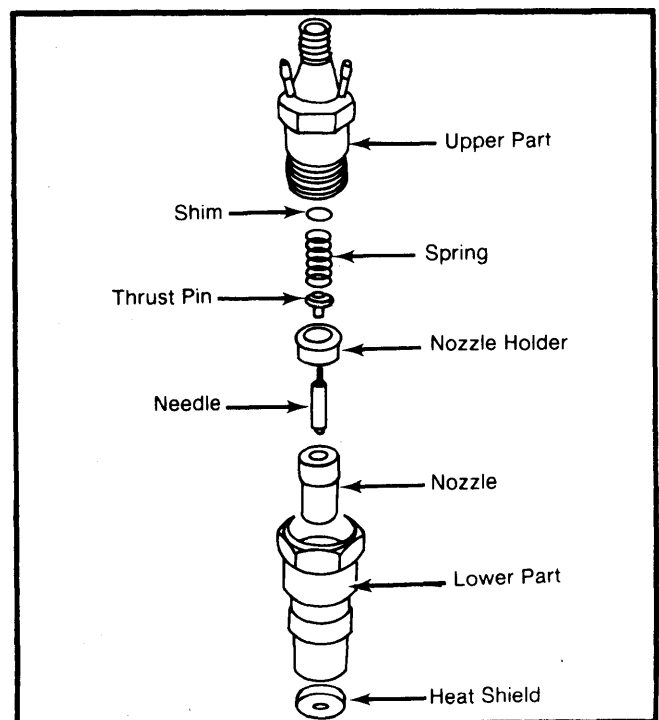


Fig. 20. Exploded View of Injection Nozzle

BOSCH DIESEL FUEL INJECTION – AUDI & VOLKSWAGEN (Cont.)

2) To reassemble, reverse procedure. Tighten upper and lower parts to 51 ft. lbs. (7.0 mkg).

TESTING

INJECTION NOZZLES

CAUTION – Do not expose hands to injector spray during testing, as working pressure will cause fuel oil to penetrate the skin.

Nozzles should be tested for spray formation, noise, opening pressure and leakage.

Spray Formation Test – Isolate special testing gauge (US 1111). See Fig. 21. Use short rapid strokes of testing pump lever (4-6 strokes per second). Spray should be even and stop cleanly. Nozzles should not drip.

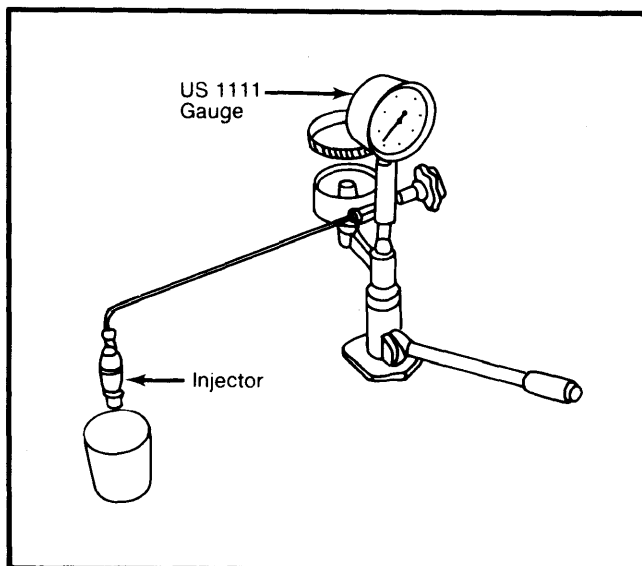


Fig. 21 Injection Nozzle Assembled to Test Gauge

Noise Test – Isolate gauge (US 1111). Use long, slow strokes of testing pump lever (1-2 strokes per second). If nozzle is working properly, it will "ping" as fuel emerges.

Opening Pressure Test – With gauge (US 1111) working, move pump lever down slowly. Note pressure at which injection nozzle releases fuel. Adjust, if necessary, by changing shims until working pressure reaches 1706-1850 psi (120-130 kg/cm²). Thicker shims increase pressure, thinner shims decrease pressure.

NOTE – A shim thickness of .0019" (0.05 mm) increases pressure by 71 psi (5.0 kg/cm²). Shims are available in thicknesses of .039-.070" (1.00-1.95 mm) in .0019" (0.05 mm) increments.

Leakage Test – With gauge working, press pump lever down slowly and hold pressure at about 1564 psi (110 kg/cm²) for 15 seconds. No fuel should leak from nozzle tip.

GLOW PLUGS

1) To check glow plug condition, remove glow plug wire and bus bar connector. Connect test lamp between glow plugs (one at a time) and battery positive terminal. See Fig. 22. Test lamp will light if plugs are good. If not, replace glow plugs.

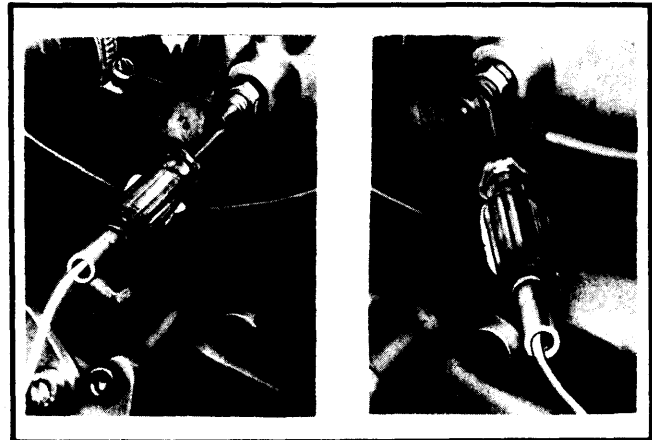


Fig. 22 Checking Glow Plug Condition (Left) and Current Supply to Glow Plugs (Right)

2) To check current supply to glow plug, reinstall wires and bus bar connector. Connect test lamp between glow plug to No. 4 cylinder and ground. See Fig. 22. Turn ignition switch to glow plug position and lamp should light. If not, check wiring or check for a defective glow plug fuse (80 amp.) located to the left of steering column behind instrument panel.

3) If fuse is OK, check terminal 30 of glow plug relay for voltage. If voltage is not present, check terminal connections or defective relay. If voltage is present at terminal 30, relay is not working.

4) Connect test lamp to terminal 86 and turn ignition key to glow plug position. If test lamp lights, repair connection from relay terminal 86 to ground or replace relay. If test lamp does not light, check connection between relay terminal 86 and board terminal 86 or replace board.

TIGHTENING SPECIFICATIONS

Application	Ft. Lbs. (mkg)
Injection Pump Mounting Bolts	18 (2.5)
Fuel Injection Line Unions	18 (2.5)
Fuel Injection Pump Gear Nut	33 (4.5)
Camshaft Gear Bolt	33 (4.5)
Injection Nozzle-to-Socket	51 (7.0)
Nozzle (Upper-to-Lower Part)	51 (7.0)
Injection Pump Drive Gear	72 (100)