FUEL INJECTION SYSTEM - BOSCH CIS
Article Text
1983 Volkswagen Rabbit
For http://volkswagen.msk.ru

Thursday, March 15, 2001 11:29PM

ARTICLE BEGINNING

1983 Bosch Fuel Injection
BOSCH CIS (LAMBDA) FUEL INJECTION

Volkswagen Jetta, Rabbit, Scirocco, Pickup, Quantum

DESCRIPTION

The Bosch Continuous Injection System (CIS) is a hydraulic-type fuel injection system which uses an air flow sensor, that is mechanically connected to a hydraulic valve, to control injection quantity.

The Lambda system is a feedback control capable of measuring air/fuel ratios and constantly correcting them. The combination of the two systems makes it possible to obtain both economy and performance, while minimizing exhaust emissions. See Fig. 1.

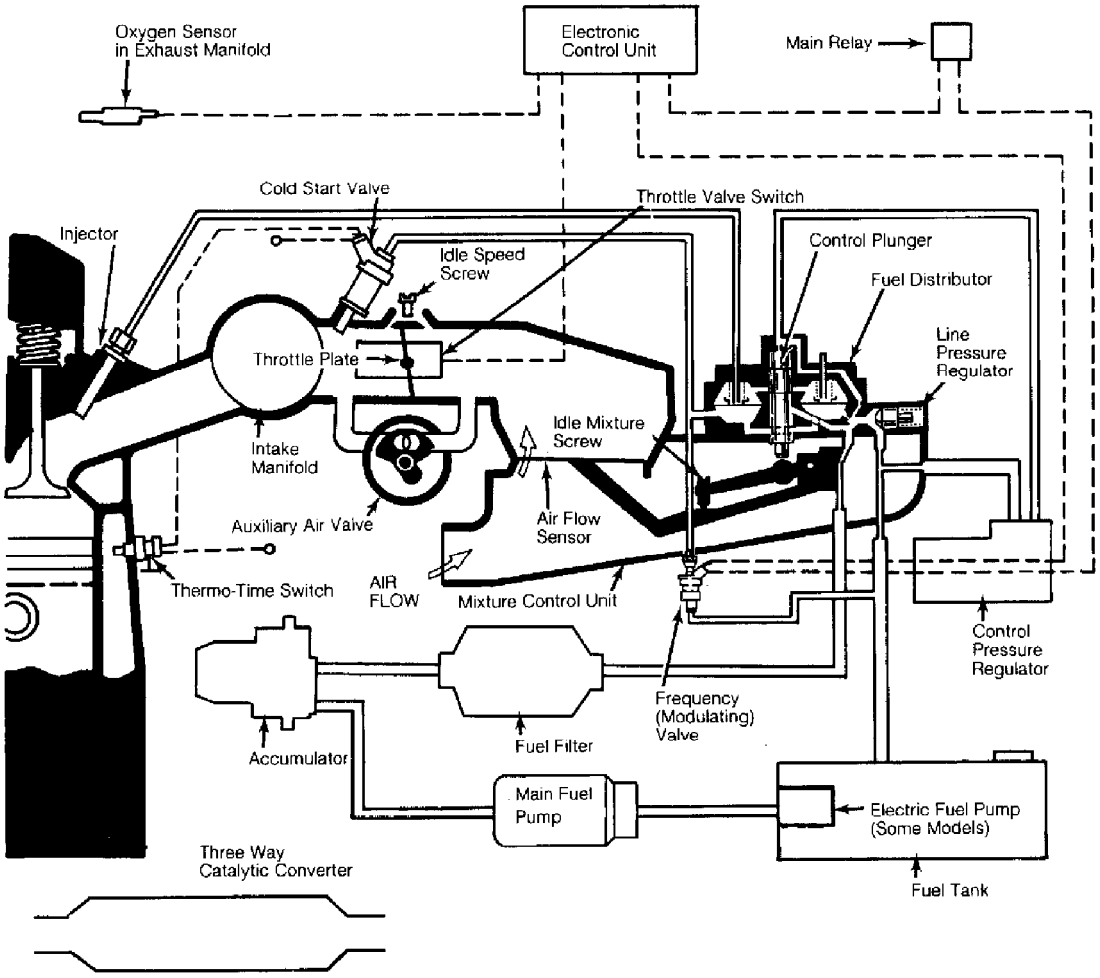


Fig. 1: Bosch CIS Lambda Fuel Injection System Diagram
This illustration is typical of all models. Specific details among models may vary.

The system consists of the mixture control unit (air-flow sensor and fuel distributor), control pressure regulator, auxiliary air valve, cold start valve, thermo-time switch, injector nozzles, fuel pump, filter, oxygen sensor, electronic control unit, frequency valve, and catalytic converter.

Some models use additional components, such as a thermo-vacuum valve, hot start pulse relay, or a constant idle speed control system.

OPERATION

MIXTURE CONTROL UNIT

The air-flow sensor contains a plate, mounted on a hinged lever, which moves in a cone-shaped venturi. All engine air is drawn past this sensor. The plate moves as air is drawn into the engine, moving the hinged lever up or down.

Movement of the sensor plate raises or lowers a fuel control plunger in the fuel distributor, which meters the amount of fuel injected into each cylinder. The movement of the plate is controlled by air flow, cone shape of venturi, a balance weight, and fuel pressure.

NOTE: Air flows UP through the sensor on most inline engines, and DOWN through the sensor on V6, V8 and turbocharged engines. The direction of air flow does not affect system operation. It is changed for convenience of routing air flow.

Fuel distribution can be equal only if the pressure to each injector is equal. Pressure regulating valves in the fuel distributor equalize system pressure. These valves are adjusted during assembly of fuel distributor and cannot be adjusted in service.

CONTROL PRESSURE REGULATOR

The control pressure regulator (or warm-up regulator) controls fuel pressure to the top of the plunger in the fuel distributor. See Fig. 2.

During cold start operation, reduced pressure allows the plate to open farther with same air flow. This supplies more fuel to the cylinders to improve engine warm up, until normal operating temperature is reached. As the engine reaches operating temperature (or a pre-determined time elapses), the control pressure regulator increases control pressure, leaning the air/fuel mixture.

A bi-metallic strip in the control pressure regulator is heated by an electric coil. As it heats up, it gradually increases the control pressure. Poor electrical connections will cause warm-up function of the regulator to cease operation. Some regulators have an altitude-sensitive function that compensates for changes in barometric pressure.

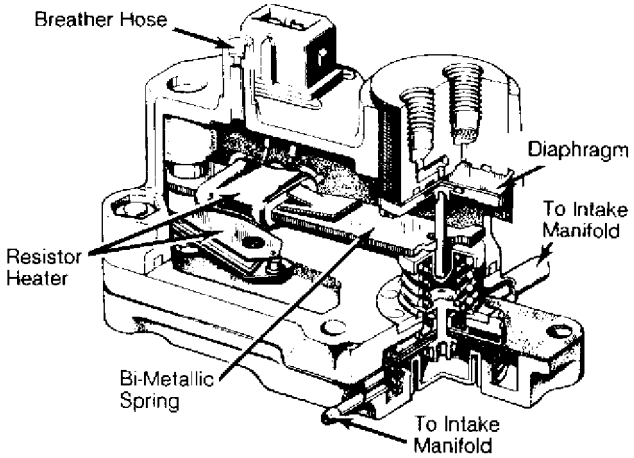


Fig. 2: Control Pressure Regulator
Illustration depicts a pressure-compensated model. Other models are similar.

AUXILIARY AIR VALVE

The auxiliary air valve, or regulator, provides additional air to the engine to increase idle speed when the engine is cold. It allows air to by-pass the throttle valves which are closed at idle.

A heating coil in the valve is connected to the fuel pump circuit. As the coil warms up, it gradually closes the air passage. The valve is calibrated to maintain a smooth idle without a large engine speed change as the engine is warming up.

COLD START VALVE

The cold start valve is mounted on the intake manifold and sprays fuel during starting. It enrichens the mixture so the engine will start easily. The valve is powered through the starter circuit and grounded through the thermo-time switch so it operates for only a short time while the engine is being cranked.

THERMO-TIME SWITCH & HOT START RELAY

The thermo-time switch controls opening time of cold start valve. It is affected by engine temperature and starter current. Depending on coolant temperature (or engine temperature on air-cooled engines), the switch will take from 3-10 seconds to open. Injection through the cold start valve will then stop.

Some models use a hot start pulse relay to improve hot starting. While the starter is being operated, the relay allows the cold start valve to spray small amounts of fuel at regular intervals, until the engine is started.

INJECTOR NOZZLES

The injectors in the CIS system open at a pre-set pressure. Fuel is always present in the lines between the fuel distributor and

the injectors to ensure good starting. As pressure in the fuel distributor increases (when the engine is started), the valves open and spray constantly. The amount of fuel injected will be determined by control pressure and the position of the control plunger. See Fig. 3.

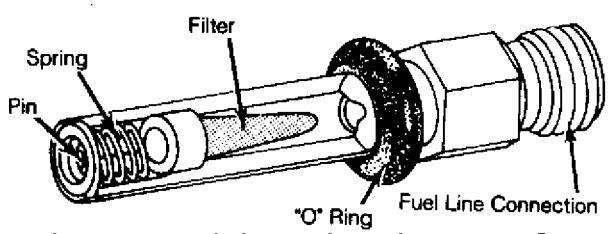


Fig. 3: Bosch CIS Lambda Injection Nozzle
Pin in injector vibrates to atomize fuel.

FUEL PUMP

An electric fuel pump is used to provide fuel pressure of about 60-80 psi (4.1-5.5 kg/cmý)). To aid in starting, a check valve in the pump works in conjunction with the accumulator and the piston seal in fuel distributor, to maintain pressure in the system when the engine is not running.

The fuel pump is controlled by a relay to prevent it from continuing to operate if the engine stalls. It can be wired in several ways, the most common being through a switch on the air flow sensor or through a coil energized by the ignition system. When testing the system, the safety relay must be by-passed.

OXYGEN SENSOR

The oxygen sensor is located in the exhaust manifold and measures the amount of unburned oxygen in the exhaust gas. If oxygen is low (rich mixture) a high voltage will be generated by the sensor. If oxygen is high (lean mixture) low voltage will be generated. The voltage signal from the oxygen sensor is sent to an electronic control unit which controls fuel mixture.

ELECTRONIC CONTROL UNIT & FREQUENCY VALVE

The electronic control unit is designed to continually correct air/fuel mixture, based on signals from the oxygen sensor. It sends a series of pulses to a frequency valve. The frequency valve is located in a fuel line that connects the upper and lower halves of the fuel distributor.

When the frequency valve is closed, fuel pressure to the injectors is determined by a spring in each pressure regulating valve. When the frequency valve is open, fuel pressure decreases in the lower half of the fuel distributor, the tension on the spring is relieved, and more fuel is directed to the cylinders.

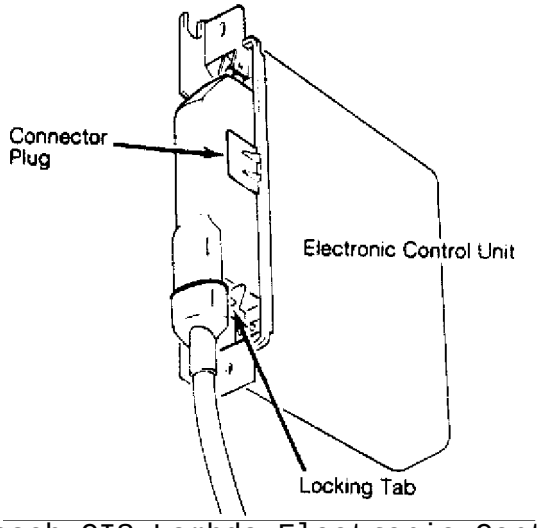


Fig. 4: Bosch CIS Lambda Electronic Control Unit

The electronic control unit opens and closes the frequency valve many times a second to ensure a smooth regulation of fuel pressure and mixture. When the engine is cold, the ratio of valve open to valve closed is about 50%.

After the engine warms up, the voltage produced by the oxygen sensor determines the amount of time the frequency valve must be open or closed. This ratio can be read with a special tester or with a dwell meter (on most models). A dwell reading of 45ø indicates a ratio of 50% open, 50% closed.

CATALYTIC CONVERTER

CIS Lambda systems can control air/fuel ratios within .02%. This close regulation allows the use of a 3-way catalyst that can decrease NOx, HC, and CO emissions. The converter can be damaged by improper adjustment of the system or by the use of leaded fuels.

TESTING

NOTE: Testing procedures described below will apply to all models using the CIS Lambda system unless otherwise noted. Not all models will use all components.

PREPARATION FOR TESTING

1) All CIS systems are very sensitive to air leaks. Check condition of rubber boots, hoses, and gaskets. Other areas of leakage are injectors, cold start valve, and PCV system (filler cap and dipstick).

2) Install a pressure gauge to perform fuel pressure tests. On all models, pressure gauge is installed between the control pressure regulator and the center fitting on fuel distributor. See Fig. 5.

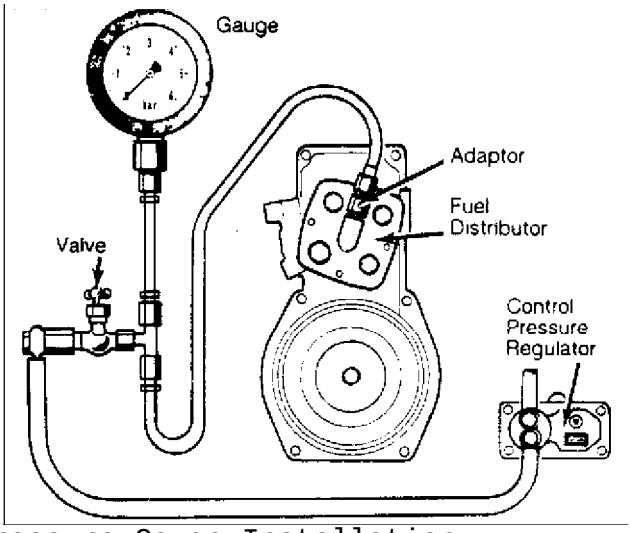


Fig. 5: Pressure Gauge Installation
After installation, bleed pressure gauge by opening and closing valve several times.

3) To operate fuel pump with engine not running, disconnect fuel pump relay from relay panel. Insert a jumper wire into sockets that correspond to terminals 30 and 87 on relay. See Fig. 6.

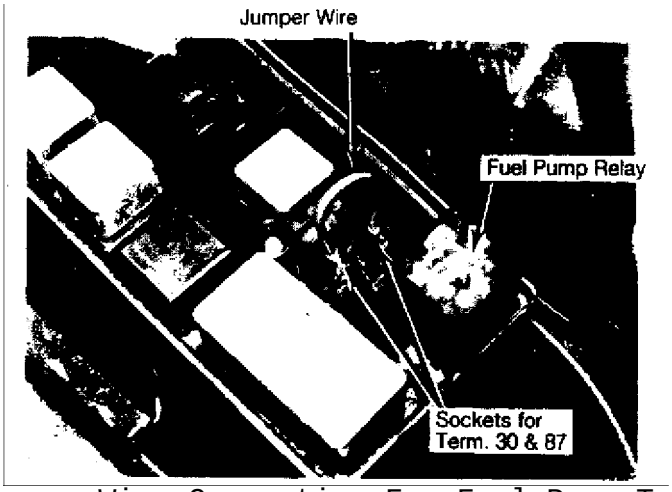


Fig. 6: Jumper Wire Connection For Fuel Pump Testing
Saab is shown; other models are similar.

4) To operate fuel pump turn ignition on. Place pressure gauge as low as possible in engine compartment, then open and close valve 5 times to bleed gauge. Place valve in open position and hang in convenient location. Turn pump off.

AIR/FUEL MIXTURE CONTROL OR AIR-FLOW SENSOR

1) Remove rubber bellows to expose air-flow sensor plate. Disconnect electrical connectors on auxiliary air valve and control pressure regulator, then operate fuel pump for ten seconds to build

up control pressure.

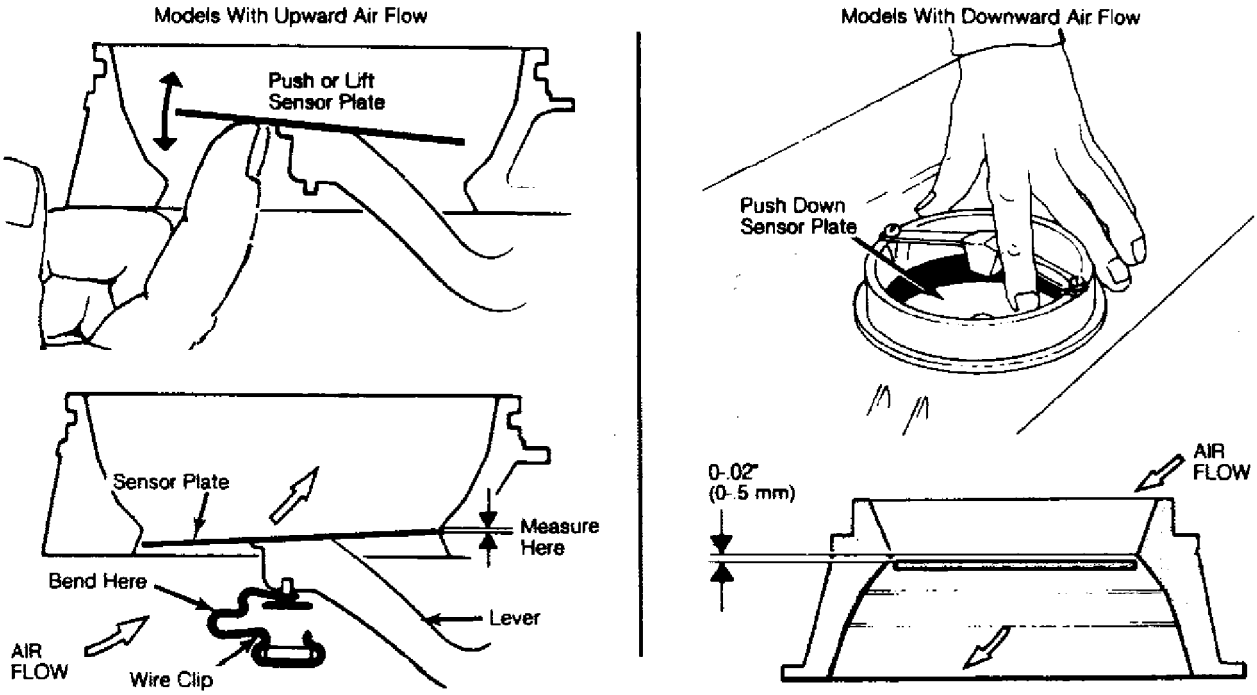


Fig. 7: Checking Air Flow Sensor Operation and Alignment

2) Using extreme care not to damage sensor plate, lift sensor plate slowly with magnet or pliers. Constant resistance due to control plunger pressure should be felt throughout range of lift. Release plate slowly, lever and control piston should follow. See Fig. 7.

3) Lift plate, then return it rapidly to lower position. The piston moves more slowly and should be heard hitting the lever. If not, control piston is sticking.

4) Remove 3 screws from fuel distributor and lift off of air flow sensor housing. Be careful not to drop control plunger. See Fig. 8.

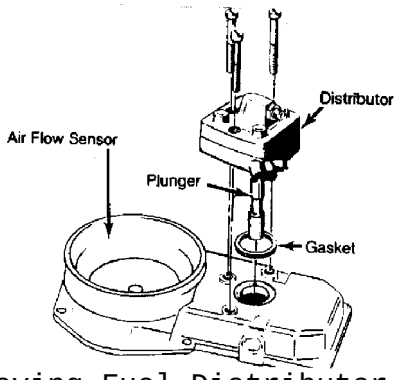


Fig. 8: Removing Fuel Distributor Control Plunger
Use care not to drop control plunger when removing fuel distributor.

5) Clean plunger in solvent. Remove any deposits with finger nail; DO NOT use tools. Slide plunger in and out while turning it. If any sticking or binding is felt, replace fuel distributor.

6) Reinstall fuel distributor. Check air flow sensor plate alignment. Plate should be even with bottom rim or 0.02" (0.5 mm) lower. If not, bend spring clip to correct, or reposition stop pin (tap lightly with punch). See Fig. 7.

7) Plate should be centered in housing. If not, loosen center screw and align plate with 0.004" (.1 mm) feeler gauge at four points around rim. Apply Loctite to screw and install and tighten.

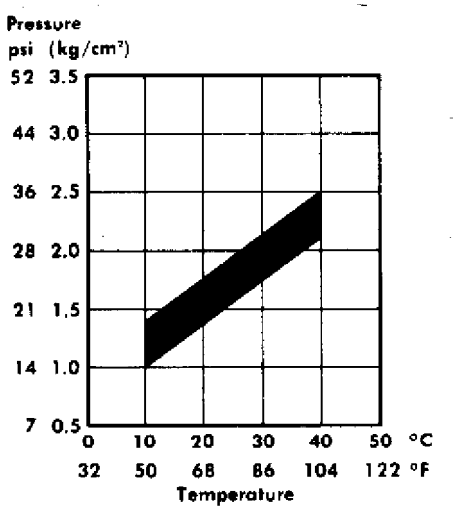
COLD ENGINE CONTROL PRESSURE TEST

1) Testing must be done on cold engine. Unplug connectors at auxiliary air valve and control pressure regulator. Place valve on pressure gauge in open position and operate fuel pump.

2) Check pressure quickly. Reading should fall in shaded area of graph. Be sure to check air temperature and read correct area of graph. See Fig. 9.

3) If control pressure is not correct, retest with new control pressure regulator. No servicing is possible.

NOTE: Some models have a control pressure regulator with atmospheric pressure compensation. Pressures may vary slightly on these models.



VW
Fig. 9: Cold Engine Control Pressure Test Graphs

WARM ENGINE CONTROL PRESSURE TEST

1) Connect plug to control pressure regulator. Leave auxiliary air valve and air flow sensor (if equipped) plugs disconnected. Place valve for pressure gauge in open position and operate fuel pump.

2) After about 5 minutes, pressure should rise to indicated

level. See Fuel Injection Pressure Testing table. On models with vacuum hose connected to control pressure regulator, leave hose connected to read pressure.

3) Start engine and allow to idle. Pressure should remain the same or rise slightly. On models with control pressure regulator vacuum line, remove and plug hose. Pressure should drop.

4) If pressure does not reach level specified, disconnect plug at control pressure regulator. Check for voltage across terminals with test lamp or voltmeter. At least 11.5 volts should be present. If not, check wiring. If voltage is present and pressure not correct, replace control pressure regulator.

FUEL INJECTION PRESSURE TESTING TABLE

Application	Specifications psi (kg/cmý)
Volkswagen	
Line Pressure	68-78 (4.7-5.34
Warm Control Pressure (1)	49-55 (3.4-3.9)
Rest Pressure	36 (2.4)
Nozzle Opening Pressure	51-59 (3.6-4.1)

SYSTEM (LINE) CONTROL PRESSURE TEST

1) Close valve on pressure gauge. With engine off, operate fuel pump. Pressure should rise to level specified. See Fuel Injection Pressure Testing table.

2) If pressure is too low, check fuel pump output. Disconnect fuel return line from fuel distributor and run a hose from fuel distributor to container.

3) Operate fuel pump and measure output after 30 seconds. See Fuel Pump Output Specifications table. If not as specified, check fuel lines, filter, fuel accumulator, and fuel pump.

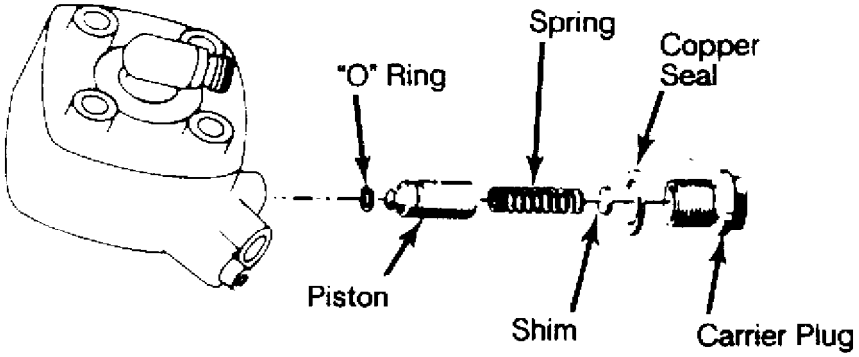
FUEL PUMP OUTPUT SPECIFICATIONS

Application	30 Sec. Flow Rate Oz. (cc)
Volkswagen	
Quantum	23 (700)
Other Models	32 (1000)

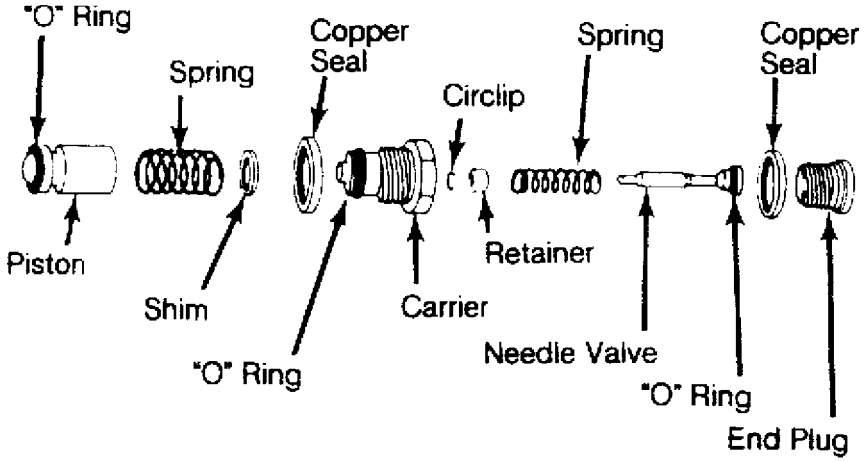
4) If pressure is too high, check for kinked or blocked fuel return line. If lines are clear, system pressure regulator must be adjusted. Turn pump off, loosen return line fitting, and relieve pressure.

5) Loosen line pressure regulator nut. Remove shims, spring(s) and plunger. Raise system pressure by adding shims; lower

pressure by removing shims. Be sure "O" rings are in good condition. If piston is scored or damaged, fuel distributor must be replaced. See Fig. 10.



FIRST DESIGN



SECOND DESIGN

Fig. 10: Pressure Regulator in Fuel Distributor
Replace fuel distributor if piston is scored or damaged.

REST PRESSURE & LEAK TEST

1) After correct warm engine control pressure has been obtained, stop fuel pump and note pressure drop. Pressure gauge valve should be in open position. Minimum pressure after 20 minutes must be as specified. See Fuel Injection Pressure Testing table.

2) If pressure drops too rapidly, run pump again and close valve. Stop pump and observe pressure. If values are now correct, control pressure regulator is faulty and must be replaced.

3) If pressure still drops, check all connections, fuel pump check valve, cold start valve, and fuel injectors.

COLD START VALVE, THERMO-TIME SWITCH & HOT START PULSE RELAY

1) If engine coolant is below 85øF (30øC), disconnect plug

on cold start valve and connect test lamp across terminals. Remove coil high tension wire to prevent starting. Operate starter.

2) On models without hot start pulse relay, test lamp will light for several seconds, then go out. On models with relay, lamp will continue to flash off and on.

3) If lamp does not light, test thermo-time switch for continuity below opening temperature. If good, check wiring to starter terminal.

4) Remove cold start valve from manifold but leave fuel line connected. Place valve in a container. See Fig. 11. Connect a jumper wire from one terminal to ground, and from other terminal of cold start valve to a switch. The other side of switch should be connected to a source of battery voltage.

CAUTION: Do not connect wire directly to battery. Extreme fire danger is probable due to atomized fuel. Sparks may result if wire is touched to battery.

5) Operate fuel pump. Turn switch to "ON" position. Cold start injector should spray. Turn switch "OFF", but leave fuel pump running. Injector should not spray. Wipe off nozzle and check for leakage. With pump running, no drops should form within one minute.

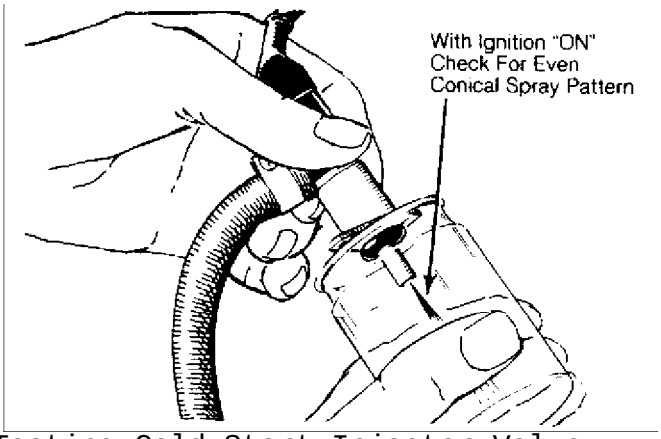


Fig. 11: Testing Cold Start Injector Valve

After turning switch "OFF" (discontinuing electrical supply to valve), injector should cease spraying fuel.

6) Replace cold start valve if faulty. Install original valve if good, making sure that "O" ring is properly positioned.

FUEL INJECTORS

Volkswagen

1) Remove injectors but leave hoses connected. Place injectors in individual measuring containers. With sensor plate in idle position, connect jumper wire in place of fuel pump relay.

2) Disconnect fuel pump when measuring container with highest level of fuel reaches specified capacity. See VW & Audi Fuel Injector Specificationstable.

3) Compare amounts of fuel in measuring containers. Fuel should not vary by more than specified amount. Repeat test with sensor plate in full throttle position.

VW FUEL INJECTOR SPECIFICATIONS

Application	Fuel Capacity Oz. (cc)
Idle	.58-.78 (17-23)
Full Throttle	2.43-2.98 (72-88)

AUXILIARY AIR VALVE

1) Disconnect hoses from auxiliary air valve. Use a mirror and small flashlight to inspect valve. See Fig. 13. At room temperature, valve should be slightly open. If equipped, disconnect wires from air flow sensor. With ignition switch "ON" valve should cover opening within 5 minutes.

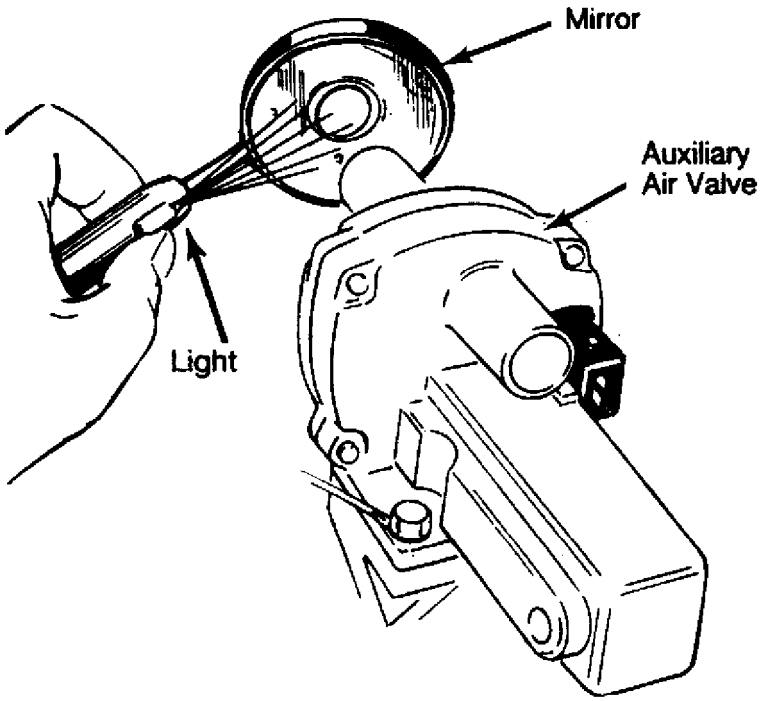


Fig. 12: Checking Auxiliary Air Valve Operation
With ignition switch "ON", valve should cover opening within 5 minutes.

2) If valve does not operate properly, check for power at connector with engine running. Connect a test lamp across connector terminals. If lamp does not light, check fuse and wiring.

3) If lamp lights, check resistance of auxiliary air valve. If no resistance is measured, valve is defective. Ensure electrical connections are tight and terminals are clean, prior to measuring

resistance.

LAMBDA CONTROL SYSTEM CHECKS

PREPARATION FOR CHECKS

NOTE: The frequency valve is operated by pulsating voltage from the electronic control unit. By measuring this signal, certain functions of the system can be tested. A special tester (Bosch KDJE 7453) is recommended, but a high-quality dwell meter may be used instead.

1) Connect dwell meter to testing connector. Connector is located on behind throttle valve housing (Black/White wire) on Volkswagen.
2) Set meter on 4-cyl. scale. Connect positive lead of voltmeter to battery and negative lead to pin 3 of diagnostic plug.
3) Start engine and run until warm. Disconnect oxygen sensor and observe meter needle (should not fluctuate). Place a piece of tape on meter face to indicate 50% position.

OPERATION CHECK

1) Remove fuel pump relay and connect jumper wire across sockets corresponding to terminals 30 and 87. If equipped, remove plug at air flow sensor. Turn ignition "ON".
2) Frequency valve should operate, making a buzzing noise. Dwell meter should indicate 45-65ø. Disconnect wire from oxygen sensor and touch wire end to ground. Readings on dwell meter should rise. Ground one end of a 1.5 volt flashlight battery, and touch positive end to sensor wire. Readings should drop to less than 15ø.
3) On models with throttle enrichment switch, operate throttle. Readings should be higher at idle or wide open throttle. See Fig. 13.
4) If engine is cold, enrichment switches will be closed. Disconnect lead at temperature sender. Readings should drop slightly. If engine is hot, connect temperature sender lead to ground. Reading should rise.
5) If starter enrichment relay is used, disconnect high tension lead at coil and crank engine. Readings should rise above normal level. If vacuum switches are used, apply vacuum to switch and note readings. Level should be higher with switch closed, and lower with switch open.
6) Connect oxygen sensor and start engine. With cold engine, dwell reading should be stable. When engine warms up, meter needle should fluctuate 10-20ø. It may be necessary to run engine faster than idle to heat oxygen sensor and cause needle fluctuation.

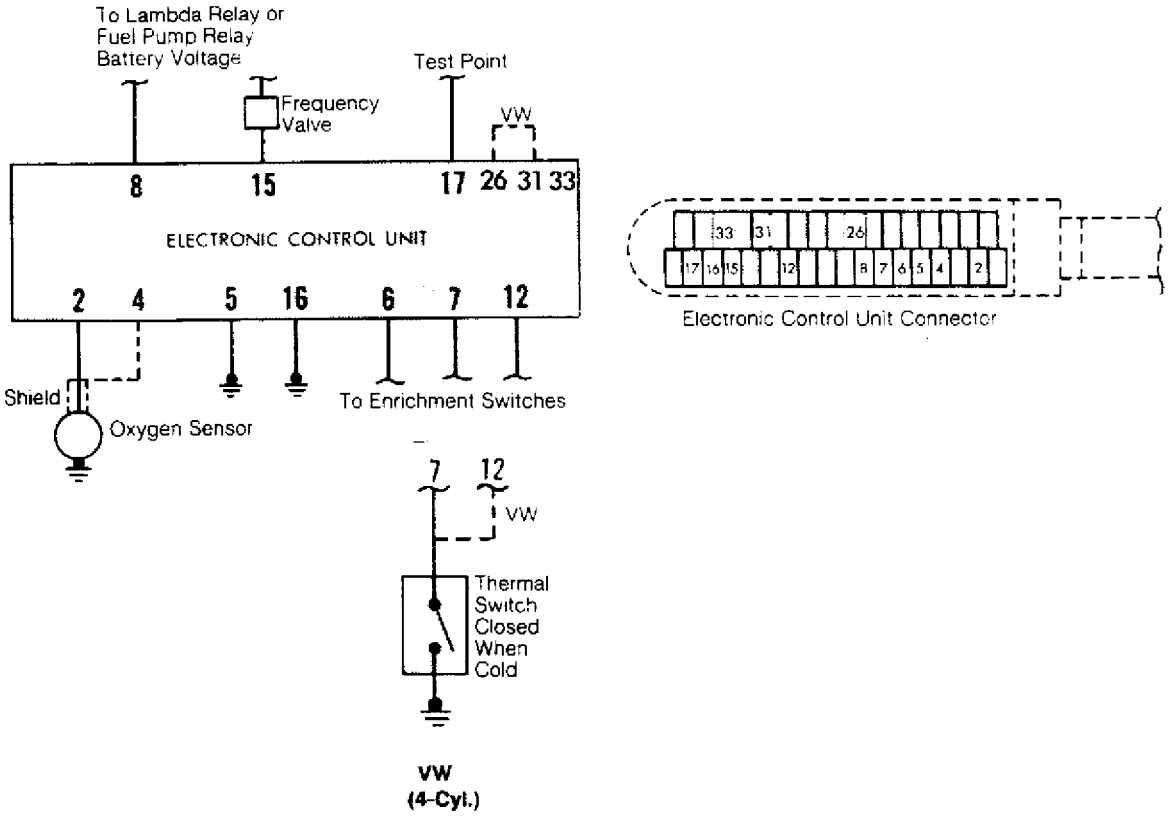


Fig. 13: Bosch CIS Lambda Electronic Control Unit Wiring Diagram

7) Connect a CO meter to exhaust test point. With oxygen sensor disconnected, reading should be stable on dwell meter. Note CO% reading. With sensor lead grounded, reading should rise and CO% increase. With lead connected to flashlight battery, reading and CO% should decrease.

8) If dwell reading does not rise with sensor grounded, check sensor wiring (see "Electrical Testing"). If wiring is good, replace control unit. If dwell rises, but CO% does not, check frequency valve and wiring see Electrical Testing. Replace if necessary.

9) If dwell does not decrease with battery connected to sensor lead, check sensor wiring and replace control unit if wires are good. If dwell decreases but CO% does not, check frequency valve wiring and replace valve if wiring is good.

10) Adjust CO% to rich level (3%) with oxygen sensor still disconnected. Reconnect sensor. Reading should drop at least 1%. If not, replace oxygen sensor.

ELECTRICAL TESTING

NOTE: Electronic control unit is located near glove box on Volkswagen.

1) Locate electronic control unit and press locking tabs back to disconnect connector. All connectors are wired with pin

numbers in the same location. Obtain a high-quality volt-ohmmeter for testing.

2) Refer to wiring diagram for pin locations. With ignition "ON" and fuel pump jumper wire in place, check for battery voltage at terminals 8 and 15. Connect ground lead of voltmeter to terminals 5 and 16 while checking for battery voltage to ensure these wires make a good ground connection.

3) If battery voltage is not available at terminal 8, check Lambda and fuel pump relays. If no voltage at 15, check frequency valve connector. One wire should have battery voltage; the other wire should have continuity to terminal 15. Frequency valve should have 2-3 ohms resistance. Repair or replace as necessary.

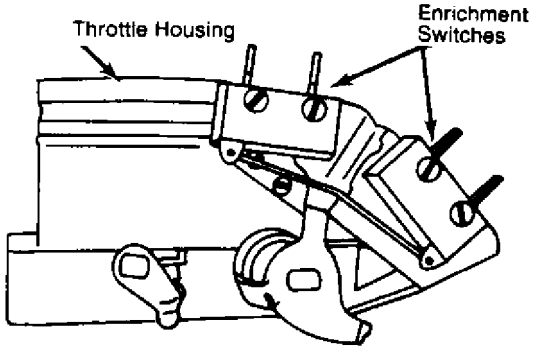


Fig. 14: Throttle Enrichment Switches

4) Disconnect oxygen sensor and check for continuity between sensor lead and terminal 2 (4 on Mercedes-Benz). No continuity should exist between ground and lead wire.

5) All models use enrichment switches. See Fig. 14. All switches provide continuity to ground when switch is closed. Actuate throttle to test throttle switches.

6) Thermal switches can be checked by removing switch and heating in water. Repair wiring or replace switches as necessary.

7) After testing is completed, connect electronic control unit, oxygen sensor, and all switches. Remove fuel pump relay jumper wire and testing equipment.

REMOVAL & INSTALLATION

MIXTURE CONTROL UNIT

CAUTION: On all models, disconnect battery and relieve fuel pressure before removing component parts.

1) On most models, top of mixture control unit must be removed to extract mixture screw plug or steel ball which blocks access opening. Tap plug or ball out with a pin punch.

2) Clean around all fuel line connections. Remove fuel lines and wipe up any spilled fuel. Disconnect electrical wiring and remove rubber boot to manifold. Remove Allen screws and lift off mixture control unit.

3) To install, reverse removal procedure. Replace gaskets and seals and check for leaks after installation.

FUEL DISTRIBUTOR

1) Remove mixture control unit. Remove 3 screws from top of fuel distributor. Lift off carefully, ensuring that plunger does not fall out of distributor.
2) Only pressure regulator shims may be replaced. If plunger or piston is scored, replace fuel distributor. Be sure "O" ring is in place and in good condition when replacing unit.

CONTROL PRESSURE REGULATOR

Disconnect electrical plug and vacuum lines (if equipped). Remove fuel lines and wipe up any spilled fuel. Remove bolts and regulator. To install, reverse removal procedure.

AUXILIARY AIR VALVE

Remove and plug hoses. Disconnect electrical plug. Remove mounting bolts and air valve. Reverse removal procedure to install.

COLD START VALVE

Remove electrical connector and fuel line. Loosen mounting bolts and remove cold start valve. Check "O" ring and replace if necessary. Install valve.

FUEL INJECTORS

1) Clean area around valves. Hold valve secure and remove fuel line fitting. Do not allow valve to turn.
2) Remove retaining plate if present, and pull valves out carefully. Do not remove insulator sleeve, if possible.
3) To install, reverse removal procedure. Replace "O" rings and lubricate with a drop of oil. Place injectors in sleeve and press until seated. Tighten fuel lines and check for leaks.

THERMAL SWITCH

Drain coolant below level of switch. Be careful not to damage connectors on switch while removing. Coat threads of sensor with sealant and reinstall.

FREQUENCY VALVE

1) Disconnect electrical connector. Hold small nut at hose and loosen larger valve nut. Do not spill gasoline on rubber mounting insulator as it will cause the rubber to swell.
2) Remove return lines at fuel distributor and/or control pressure regulator. To install, reverse removal procedure, using new

gaskets. Check for leaks after installation.

ELECTRONIC CONTROL UNIT

Volkswagen
Disconnect plug from control unit beneath glove box. Remove mounting bolts and control unit. To install, reverse removal procedure.

NOTE: Removal and installation procedures were not available for other models.

OXYGEN SENSOR

1) Disconnect wiring from sensor. On Porsche 911SC, remove left rear wheel and protector plate. Remove shield from sensor if equipped. Remove sensor.
2) Coat threads of new sensor with anti-seize compound. Take care not to get compound into slots on end of sensor. Install sensor and tighten to 25-30 ft. lbs. (35-41 N.m). Refit shield and connect sensor wire.

END OF ARTICLE