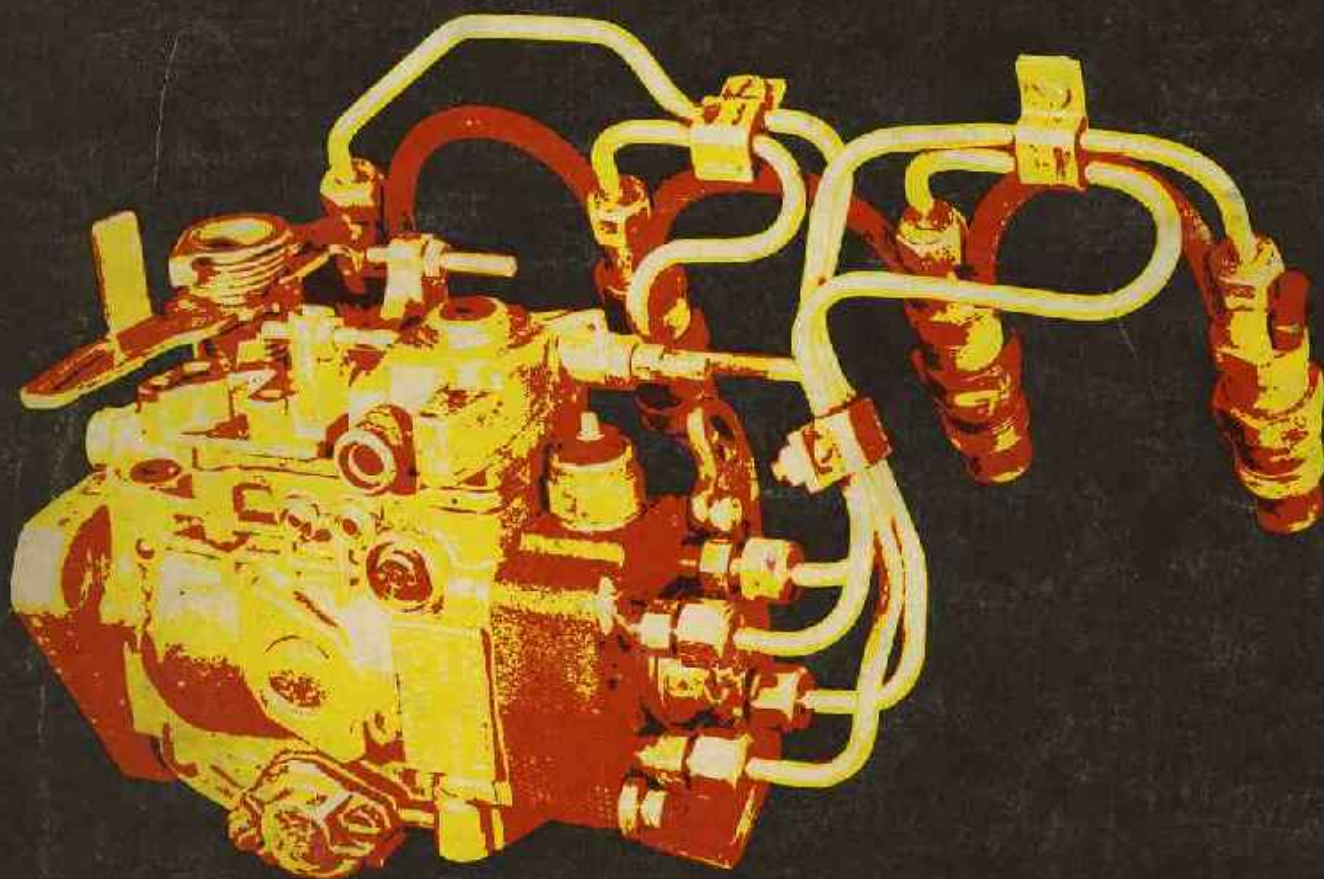


FOUR CYLINDER **DIESEL** 1977-83



ProTraining

Introduction

The Diesel ProTraining book is divided into 5 sections.

Diesel Theory — This section explains how the diesel engine works and how each part of the injection system operates. Also included is information on diesel fuel and oil.

Following Diesel Theory there are 3 sections which contain step by step diagnosis procedures and quality check procedures for 3 classifications of symptoms.

Cold Running and/or Hard Starting Problems

Idle Problems

Warm Running Problems

At the end of the book there is a section for special repairs. The special repairs section contains information for solving several "special" types of problems as well as some general repair hints for diesel cars.

How to use this book — The following 2 pages explain how to use the Diesel ProTraining Book.

How to use this book

Step 1 — The first step is to identify the symptom group — is the customer's complaint related to a Cold Running and/or Hard Starting Problem, or Idle Problem or a Warm Running Problem. After identifying the symptom group choose the symptom which best describes the customer's complaint.

Cold Running/Starting Problems

Symptom:

Engine will not start — Cranking speed is OK

Diagnosis Procedure

• Check for correct starting procedure

If the correct starting procedure is not used, the car may not start. By following the correct starting procedure, you will be able to verify whether or not the car has a starting problem.

• Check the fuel supply system

Once it has been verified that a problem exists, the first step is to check the fuel supply. If there is an air leak in the suction line between the injection pump and the fuel tank, fuel may be siphoned out of the fuel line back to the tank. A clogged fuel filter or blocked fuel line will also prevent fuel from being delivered to the injection pump.

• Remove the fuel tank strainer

In areas where the temperature drops below 20°F (-7°C), the fuel tank strainer should be removed to prevent wax crystals from blocking the fuel supply. This is only necessary on the Rabbit, Jetta, Pick-up, and Dasher. Other 4-cylinder diesels do not have a fuel tank strainer.

• Check the fuel supply to the injectors

After you have checked to make sure that fuel is being delivered to the injection pump, the next step is to see if fuel is being delivered to the injectors. This is done by loosening one of the union nuts on an injector line while cranking the engine.

• Check the glow plug system

During cold starts, the compression heat is dissipated by the cold engine. If the glow plugs are not operating properly, not enough heat will be produced during cranking to start the engine. The test procedure is in two parts; the first step is to check the relay and wiring. The second step is to check the glow plugs.

• Verify fuel quality

Poor fuel quality can cause a cold running problem or a no start condition. The fuel must be properly winterized and any additives that are used, must be used according to the manufacturer's instructions.

Suggested Repair Time — 65 New Units

Note: SRT for removing fuel tank sensing unit is not included in the diagnosis time. See SRT manual for additional labor operation and repair time.

Symptom Group 1

Cold Running and/or Hard Starting Problems

Symptoms:

Engine does not start - cranking speed is too low	page 74
Engine does not start - cranking speed is OK	page 33
Engine starts, runs, then stops	page 46
Engine starts, then idles very roughly	page 46
Engine smokes excessively and/or misses when cold	page 46
Engine starts hard - cranking time is excessive	page 46

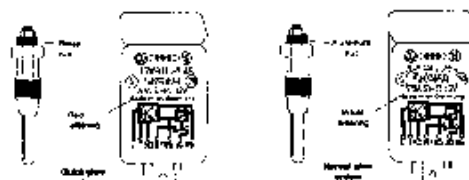
Step 2 — After choosing a specific symptom turn to the page which outlines the diagnosis procedure. This page shows each step of the procedure, explains the importance of each step and shows the suggested repair time for the diagnosis procedure.

Step 3 — Following the outline of the diagnosis procedure, each step of the procedure is shown in sequence. Each step should be performed in the sequence shown in the book.

Cold Running/Starting Problems
Engine will not start — Cranking speed is OK (cont'd.)

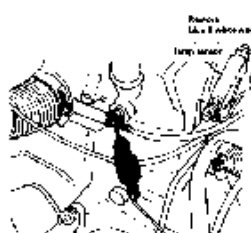
Check glow plug system

Two types of glow plug systems are used on VW and Audi diesels, the normal glow system and the quick glow system. Testing procedures are the same for both but parts from one type of system must not be used in the other type.



Testing procedure

Check the glow plug fuseable wire on the firewall in the engine compartment. Replace the fuse if it is burnt. If the fuse burns repeatedly, there is a short in the system which must be repaired before further testing.



Disconnect the blue and white wire from the temperature sensor on the cylinder head. This will allow the glow plug relay to stay energized for the maximum glow time. Connect a test light between #4 glow plug and ground.

Turn the ignition key to the glow position.

If the test light lights and stays on for:

Quick glow system = 15 seconds (min.)

Normal glow system = 90 seconds (min.)

Turn to page 38 and test the glow plugs.

If the test light does not light, first test the glow plug circuit, then the glow plugs.

If the test light lights, but the minimum glow time is not reached, replace the relay and retest.

36

Verify fuel quality

Poor fuel quality can cause a cold running problem or a no start condition. The causes could be:

Fuel not winterized — At temperatures below 20°F wax crystals begin to form in the fuel. This will plug the fuel lines, cutting off the fuel supply to the engine.

Improper mixing — If too much gasoline or other flow improvers are mixed with the fuel, the cetane rating of the fuel will be lowered below the point at which it will burn properly in the engine.

Quality check

Suggested Repair Time — 10 time units

- Connect engine tester VW 1367.
- Pull out the cold start timing advance knob.
- Turn the ignition on, the glow plug light will come on.
- After the glow plug light goes out, depress the clutch with the gear shift lever in neutral and crank the engine.

The cranking speed should be at least 150 RPM.
 The engine should start within 10 seconds.

- Check to see that the engine:

- idles smoothly
- accelerates evenly
- does not smoke excessively

Note: It is normal that the engine noise is louder and that some whitish-blue smoke may be emitted from the exhaust during the warm up period in cold weather.

If test passed

Return car to customer.

If test failed

Perform diagnosis procedure II, page 48.

Step 4 — After completing the diagnosis procedure and performing any necessary repairs the final step is to perform the Quality Check.

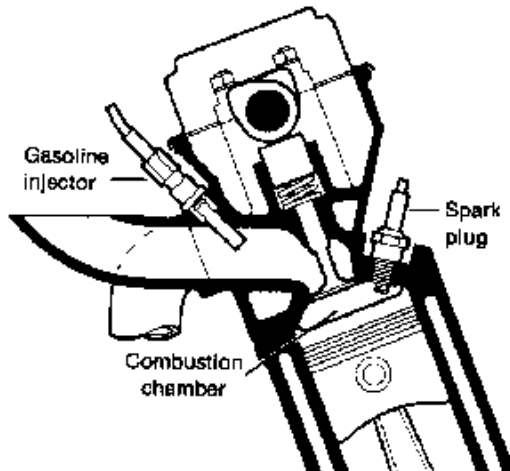
For some symptoms it may be necessary to perform a second diagnosis if the car does not pass the Quality Check. Just follow the book through the Quality Check sequence to determine if a second diagnosis is necessary.

Diesel History

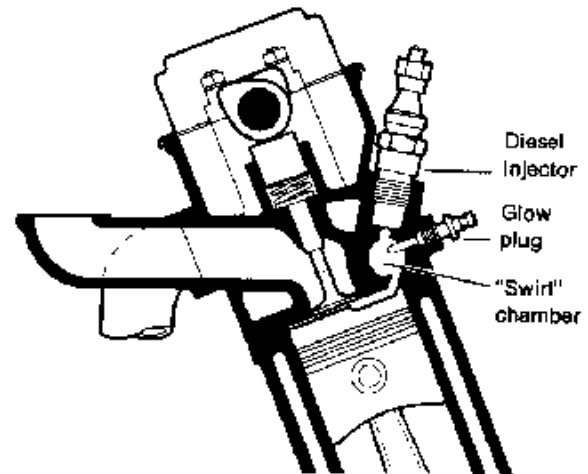
- 1794 — Robert Street builds piston engine which runs on turpentine fumes.
- 1801 — Phillipe Lebou builds spark-ignition engine which runs on coal gas and air.
- 1868 — Beau de Rochas writes detailed pamphlet on theory of gasoline piston engine.
- 1876 — Dr. N.A. Otto develops and runs first successful gasoline engine.
- 1885 — Priestman runs first successful "heavy oil" engine.
- 1885-1889 — Ackroyd-Stuart develops compression-ignition engine with "modern" injection.
- 1890 — James Hargraves makes first "inward-opening" injector.
- 1892 — Rudolph Diesel "blows-up" engine attempting to run it on coal dust and compressed air.
- 1893 — Rudolph Diesel successfully runs "air-blast" engine on heavy oil.
- 1895 — Diesel obtains U.S. patents for compression-ignition engine.
- 1900 — Diesel engines in wide practical use in Europe
- 1909 — Prosper L'Orange designs first pre-combustion chamber for diesel engines.
- 1912 — Diesel patents expire: U.S. diesel industry begins.
- 1913 — Vickers Co. develops first multi-plunger injection pump.
- 1914 — Francois Feyens develops first "distributor" injection pump.
- 1916-1920 — U.S. diesel industry "comes into its own" with pipeline pumping stations.
- 1922 — Peugeot tries first diesel engine in a passenger car.
- 1923 — Marine use of diesels begins.
- 1924 — First diesel-powered ocean liner.
- 1925 — First diesel-powered bus.
- 1927 — Robert Bosch Co. begins making injection pumps.
- 1929 — First diesel-powered truck.
- 1934 — First diesel-powered railroad locomotive.
- 1936 — Mercedes-Benz develops first production diesel passenger car.
- 1977 — Volkswagen produces first light-weight, high-speed diesel car for U.S.
- 1979 — Audi introduces an economical 5 cylinder diesel.

Gasoline engines — Diesel engines: Differences and Similarities

Gasoline Engine



Diesel Engine



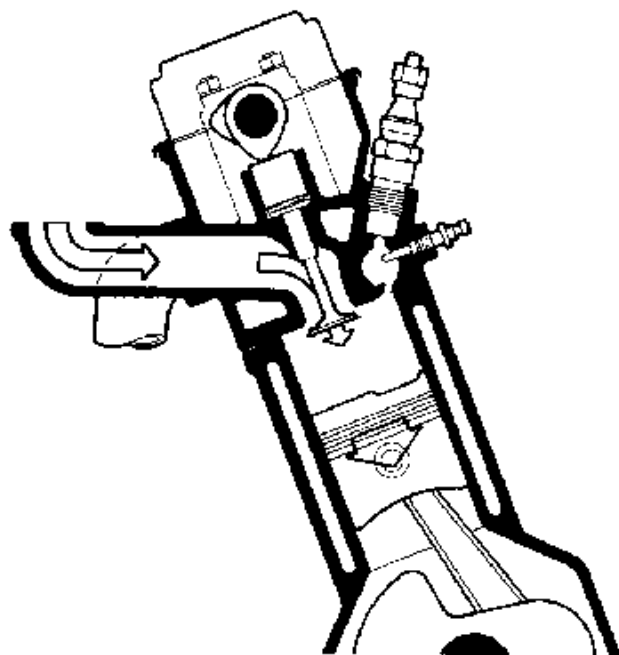
Internal combustion engine	Internal combustion engine
Four stroke cycle	Four stroke cycle
In-line cylinder arrangement	In-line cylinder arrangement
Compression ratio approx. 8.0:1	Compression ratio approx. 23.0:1
Thermal efficiency about 25%	Thermal efficiency about 36%

*The thermal (heat) efficiency of an engine
is the amount of fuel energy capable of
being converted into usable power*

Point of ignition is timed by spark	Point of ignition is timed by fuel injection
Spark ignition (air and gasoline ignited by spark)	Compression-ignition (Fuel is ignited by hot air)
Ignition distributor distributes spark	Fuel injection pump distributes fuel

Diesel Engine Fundamentals

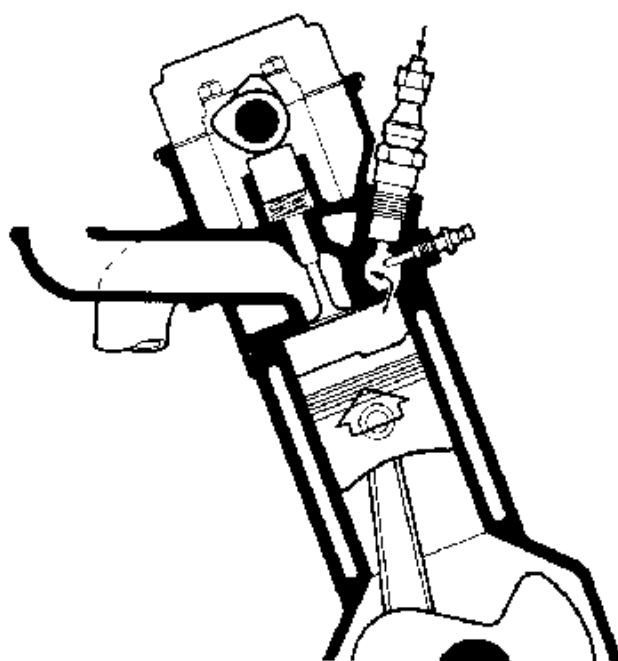
A diesel engine is similar to a gasoline engine in that it gets its power from the expansion of burning gases. The diesel depends on the heat caused by compression of the air to ignite the fuel instead of an electric spark as used in gasoline engines.



Air Intake

On the intake stroke the intake valve opens and the piston begins its movement downward in the cylinder.

Air without fuel is taken into the cylinder.



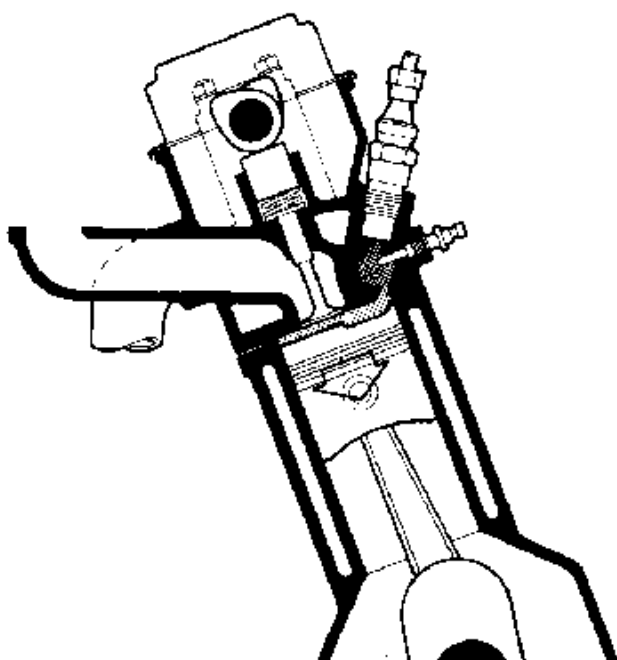
Air Compression

On the compression stroke the intake valve closes and the piston begins its movement upward in the cylinder.

The "air only" charge present in the cylinder is compressed until it becomes very hot (superheated to about 1000° F).

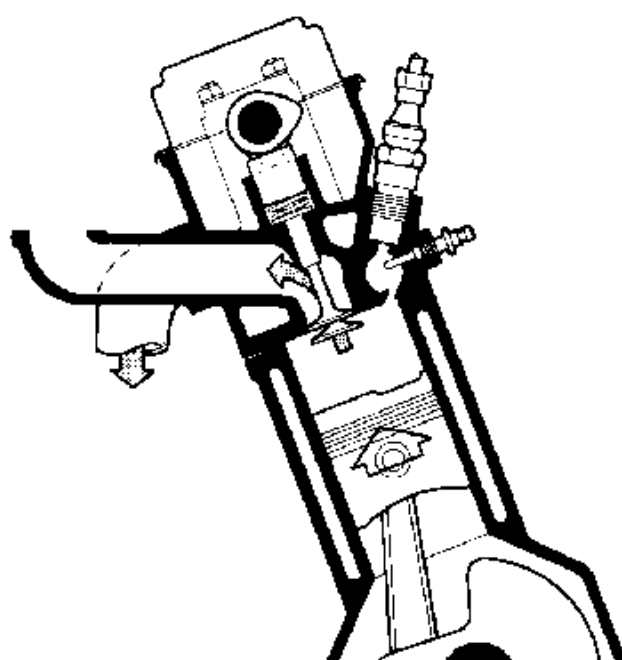
Fuel is injected into the swirl chamber near the end of the compression stroke and is ignited by the hot air.

When the diesel fuel injected is timed to mix with the superheated compressed air, diesel ignition can be compared to spark ignition on a gasoline engine: combustion occurs at the precise instant of injection, just as it does when the spark plug fires on a gasoline engine.



Power

On the power stroke - the fuel rapidly burning from the swirl chamber to the cylinder causes high pressure to be exerted on the piston thrusting it downward in the cylinder and providing power for the engine.

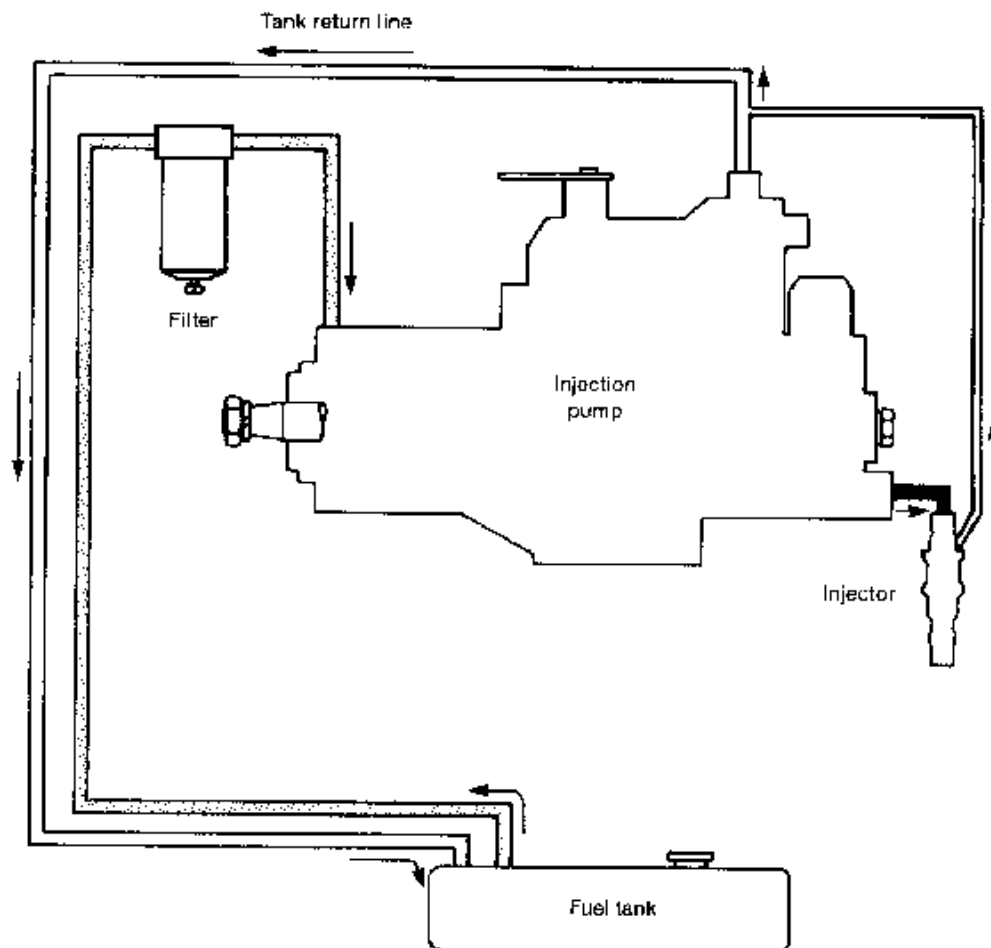


Exhaust

On the exhaust stroke the exhaust valve opens and the piston begins its movement upward in the cylinder.

The gases from the fuel burned during the power stroke are pushed out the exhaust port.

Diesel Fuel Supply System



Diesel fuel is drawn from the fuel tank through the filter by the injection pump. The injection pump pressurizes, meters, distributes and times the fuel to the injectors. Excess fuel from the pump and injectors returns to the tank via a tank return line. Diesel fuel cools and lubricates the injection pump and injectors. Diesel fuel circulation also aids in warming the fuel in the tank and lines thus helping to prevent waxing in cold weather.

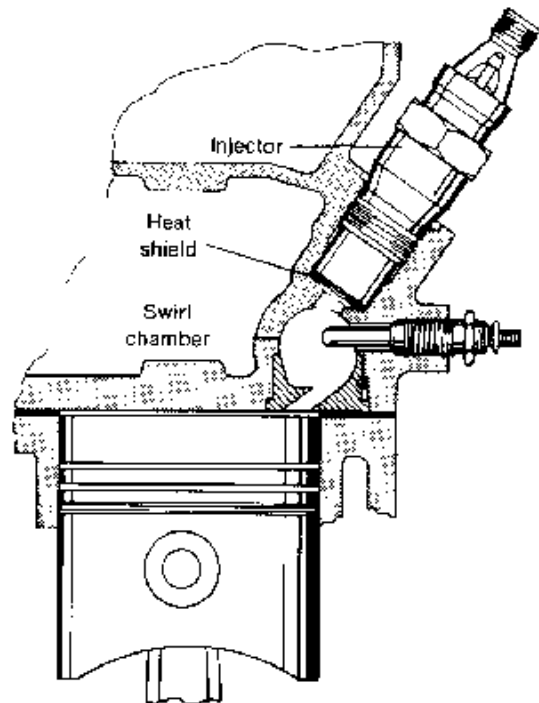
Swirl Chamber/Injectors

A swirl chamber is located in the cylinder head. Diesel injectors spray fuel directly into the swirl chamber near the end of the compression stroke. It is in the swirl chamber that air and fuel begin to burn.

A small passage leading from the swirl chamber connects it to the cylinder. The burning air and fuel expand down through this passage and the rest of combustion occurs in the narrow scalloped section of the piston.

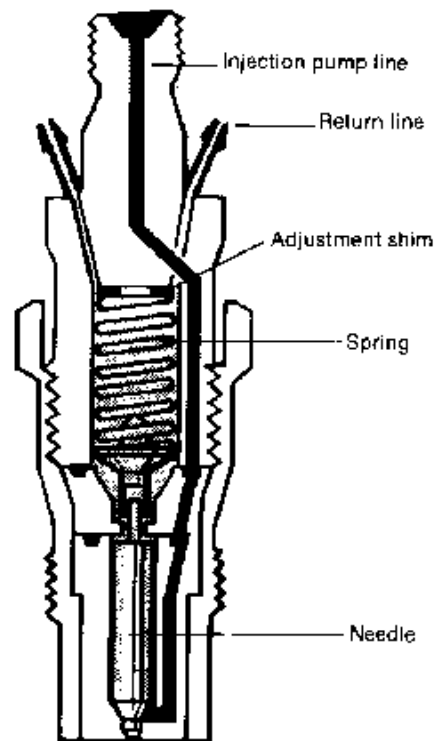
The injectors are protected from the heat of combustion by a heat shield. The heat shield acts as an insulating and sealing washer.

Compression stroke



Fuel pressure from the injection pump forces the needle up against spring pressure so that the injector sprays a cone shaped mist of diesel fuel at the precise time for ignition.

A small amount of fuel bleeds around the injector needle to lubricate and cool the injector - this fuel returns to the tank via a separate fuel line.

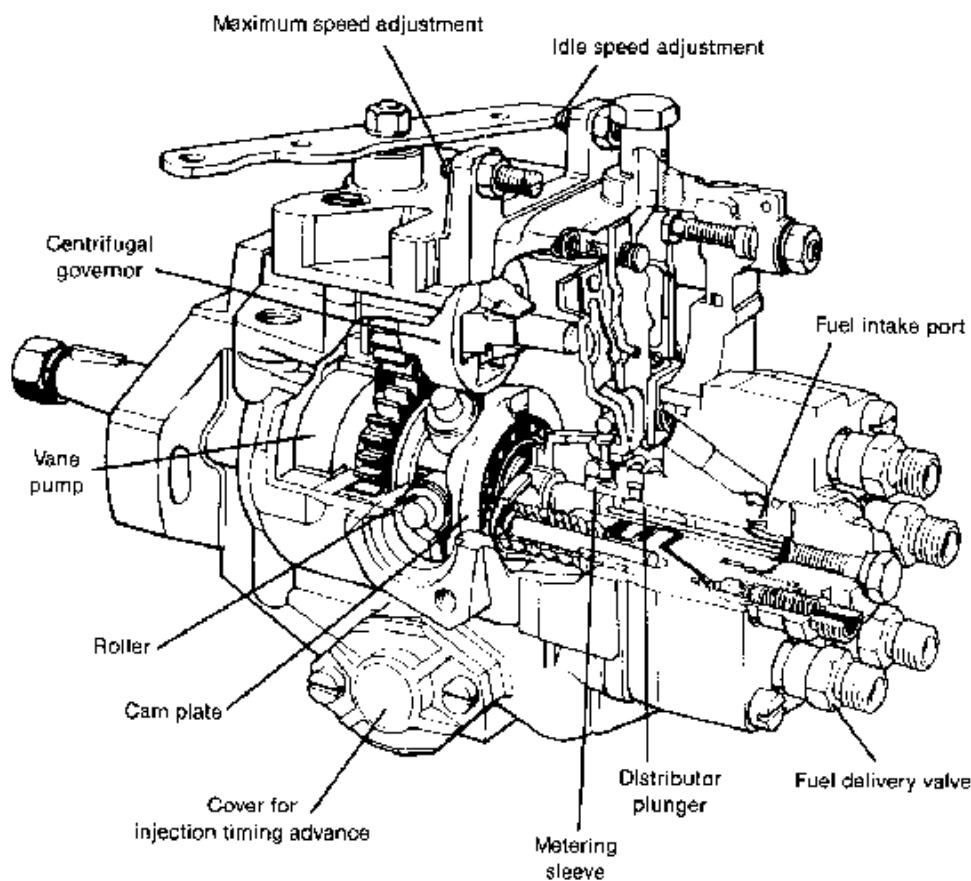


Injection Pump — Overview

The injection pump used on the four cylinder diesel is a single-plunger mechanical pump and performs the following functions:

- It pressurizes the fuel
- It meters the fuel according to engine load and speed
- It times the fuel delivery at the precise time
- It distributes fuel to the injectors in the correct firing sequence

The injection pump is driven by the camshaft spur belt at one-half crankshaft speed. The injection pump is maintenance free and is lubricated by the diesel fuel passing through it; clean fuel is essential to pump reliability.



The following repairs and adjustments to the injection pump are possible:

- Replacing fuel shut-off solenoid
- Replacing fuel delivery valve bodies
- Replacing fuel delivery valve gaskets
- Adjusting idle and maximum speed
- Adjusting injection pump timing

All other causes of injection pump malfunction necessitates pump replacement.

Injection Pump Vane Pump

The rotary vane pump located inside the injection pump draws fuel through the fuel filter from the fuel tank.

The vane pump rotor is driven off of the injection pump driveshaft which in turn is driven by the engine-camshaft spur belt.

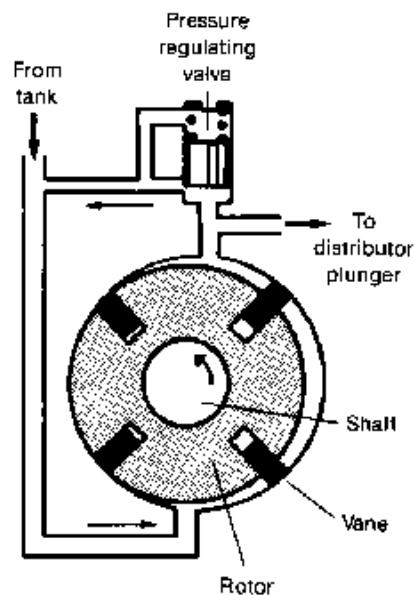
Centrifugal force holds the vanes against the walls of the pressure chamber as the rotor spins. This squeezes the fuel trapped between the vanes and forces it toward the distributor plunger.

The vane pump supplies a constant quantity per revolution and fuel pressure in the pressure chamber is regulated by the pressure regulating valve at between 3-7 bar depending upon engine speed.

The vane pump does the following:

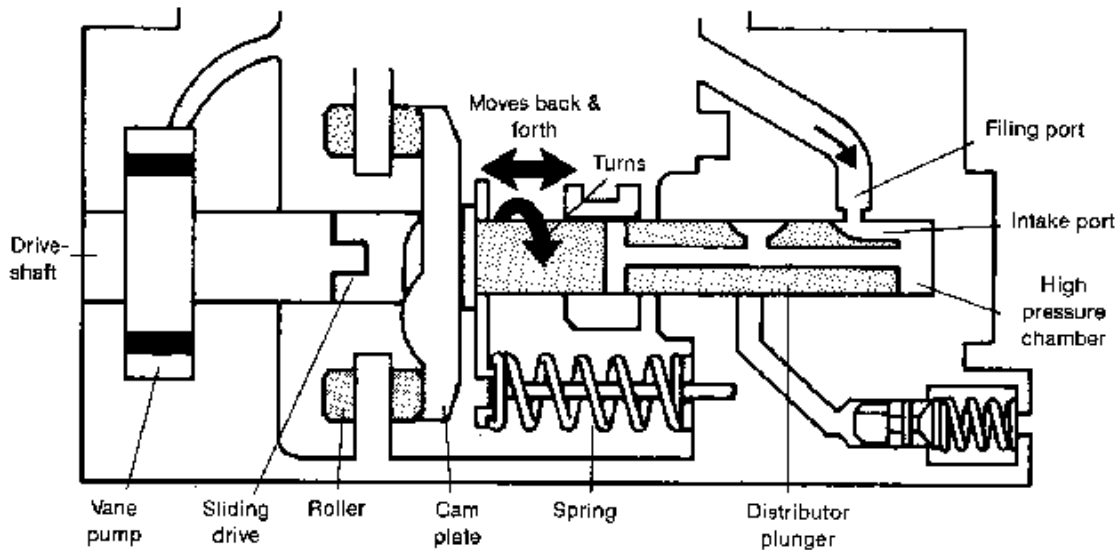
1. Transfers fuel from the fuel tank to the injection pump
2. Pressurizes the fuel
3. Lubricates moving parts in the injection pump
4. Supplies fuel to the distributor plunger for the injectors
5. Operates the injection timing advance mechanism

The vane pump and vane pump pressures cannot be serviced or checked in the workshop.



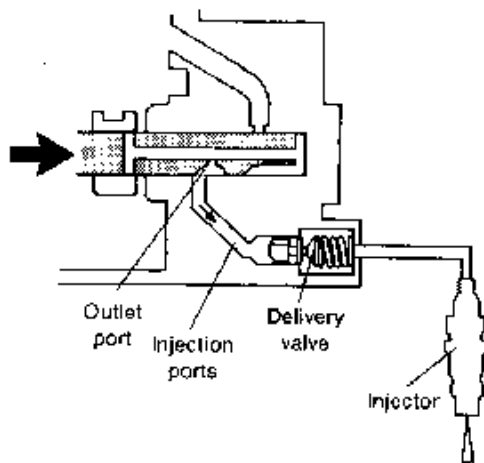
Injection Pump Distribution and Injection

The injection pump driveshaft turns the vane pump, cam plate and distributor plunger as a unit.



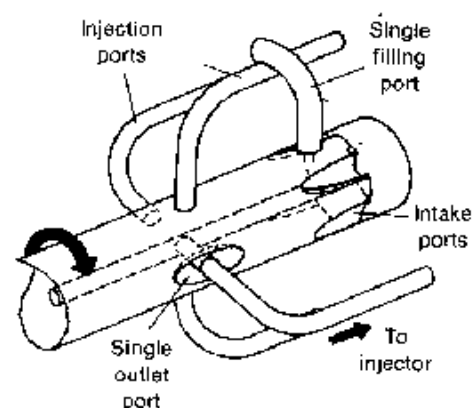
Springs hold the cam plate and distributor plunger against four rollers allowing the plunger to move back and forth as well as turn.

Whenever an intake port on the plunger is in line with the filling port in the pump body, fuel from the vane pump fills the high pressure chamber. The cam plate pushes the plunger to "squeeze" the fuel in the high pressure chamber to about 1800 PSI.



As the plunger continues to turn, the outlet port lines up with the injection ports in the pump body.

The delivery valve opens under pressure and high pressure fuel is supplied to the injector.

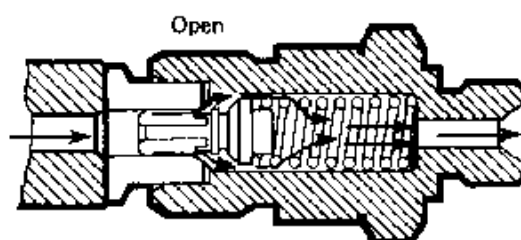


The ports in the pump are arranged so that the injectors receive fuel in the correct cylinder firing sequence.

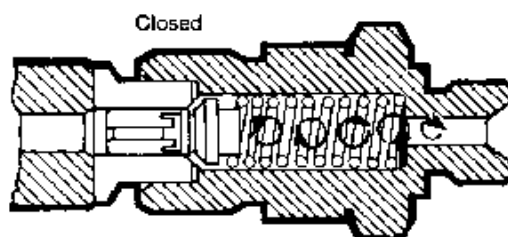
Fuel Delivery Valves

The fuel delivery valves on the injection pump help ensure that the injector will close quickly at the end of each injection. The injectors must close quickly in order to prevent fuel "dribble" which can cause pre-ignition and high exhaust emissions.

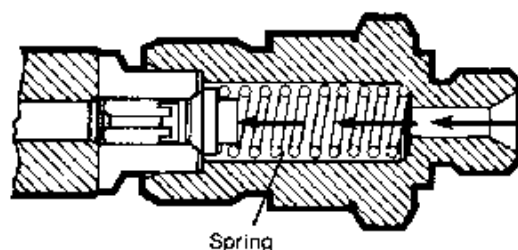
At the start of injection the delivery valve opens and pressurized fuel flows to the injector.



At the end of injection the delivery valve closes. Fuel is now trapped in the injection line.



In addition, the force of the spring pushes the valve further into its seat and the trapped fuel now expands. The sudden drop in pressure, caused by the expanding fuel, allows the injector to snap shut. This eliminates fuel "dribble".



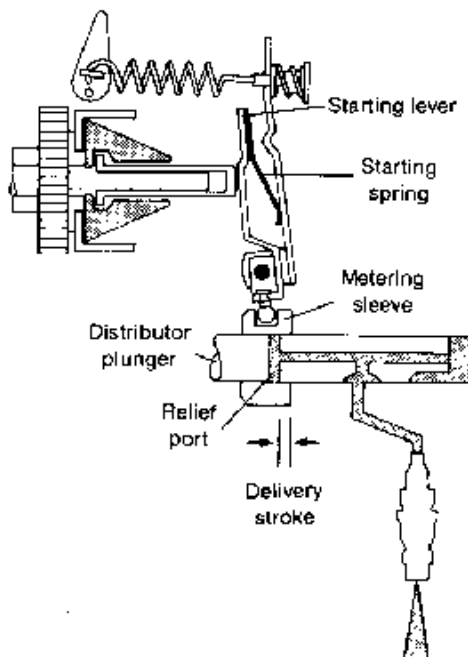
Injection Pump Metering

The amount of fuel injected is determined by the injection cut-off point. The injection cut-off point varies according to the engine speed and engine load.

The injection cut-off point is controlled by the metering sleeve on the distributor plunger.

The metering sleeve covers and uncovers a relief port in the plunger - uncovering the relief port stops injection.

The 4 diagrams on the next two pages shows the application of fuel metering over the entire speed range covering: starting, idle, part load, and full load.

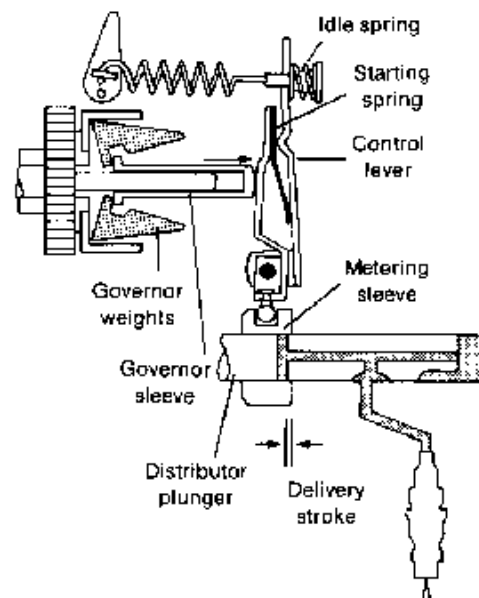


Starting

When the engine is not running, the starting spring presses the starting lever to the left so that the metering sleeve moves to the right.

The distributor plunger must move further to expose the relief port.

Injection lasts longer so that more fuel is supplied during starting.

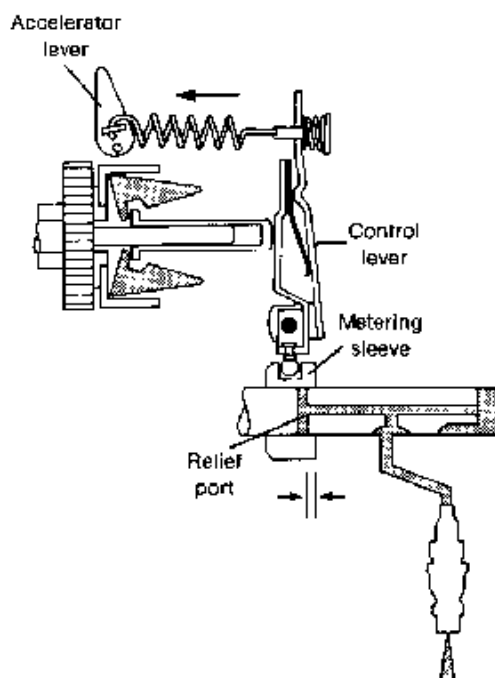


Idle

At idle speed the weights in the centrifugal governor are partially expanded so that the governor sleeve moves to the right. The starting lever pushes against the control lever so that the metering sleeve moves to the left.

The distributor plunger now moves less to expose the relief port.

Injection lasts a shorter time so that less fuel is supplied at idle.

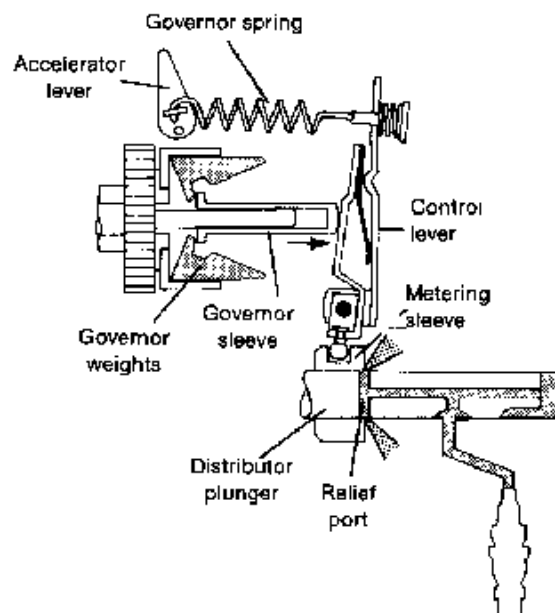


Acceleration

During acceleration, the control lever is pulled to the left by the accelerator lever.

The metering sleeve is moved to the right so that more fuel is injected before the relief port is uncovered.

Engine speed increases until the movement of the governor "neutralizes" the effect of the pedal linkage.



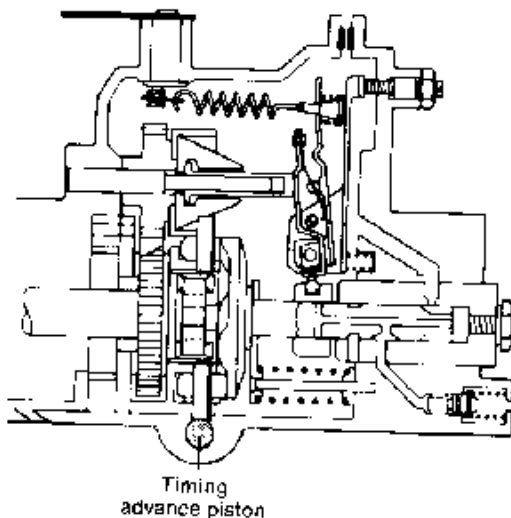
Maximum speed

With the accelerator lever at "full load", engine speed increases to maximum RPM (about 5400).

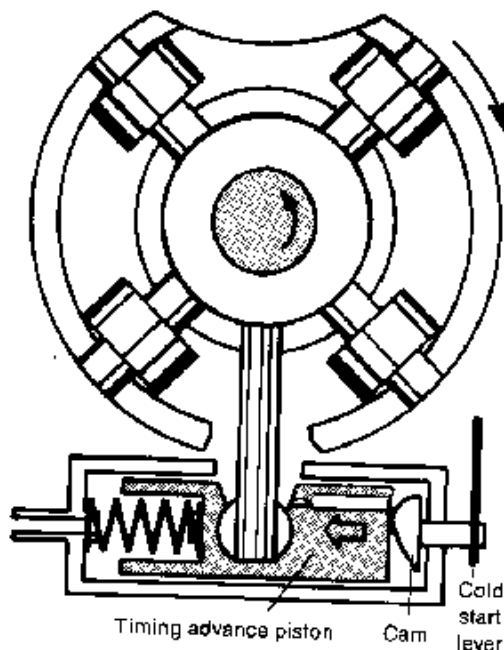
The governor weights are now stretching the governor spring and the control lever moves to the right.

The metering sleeve moves to the left and uncovers the relief port at the beginning of the distributor plunger stroke. Therefore there is LESS fuel injected and top speed is limited.

Injection Pump Injection Timing Advance Cold Starting — Cold Running

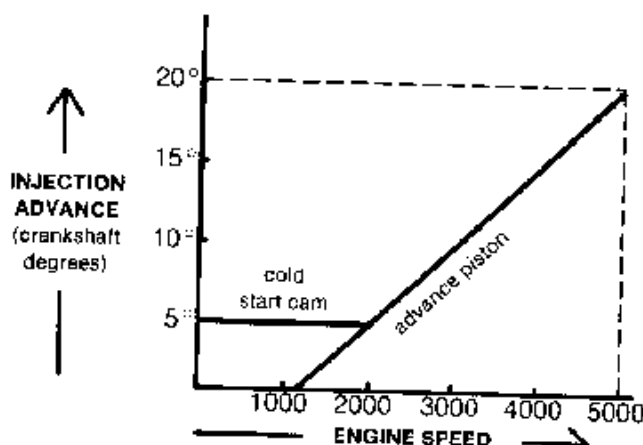


The injection pump timing advance piston is located in the bottom of the injection pump body.



Cold starting and running is improved by advancing the injection timing at idle and at low speed.

The cold start lever turns a cam which in turn pushes the timing advance piston to the left. This advances injection timing about 5° . Advancing the timing allows more time for the fuel to burn, thereby improving starting and running when cold.

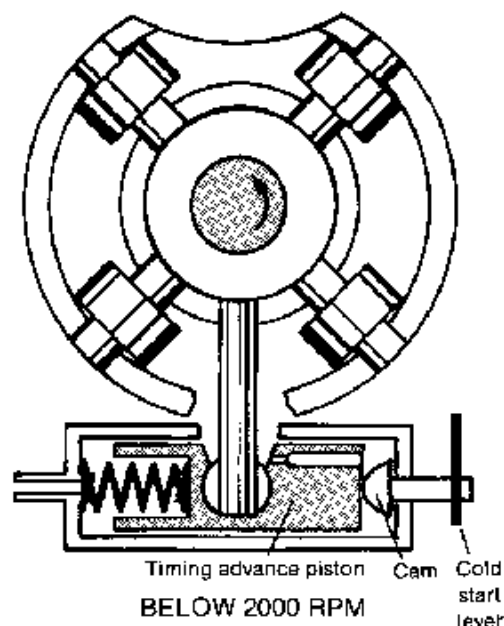


The cold starting/cold running injection timing advance does not affect the entire range of injection timing — since above 2000 RPM the timing advance piston does not contact the cam.

Injection Pump Injection Timing Advance Below 2000 RPM and at Maximum Speed

Below 2000 RPM with the cold start advance lever pulled up, the timing advance piston contacts the cam.

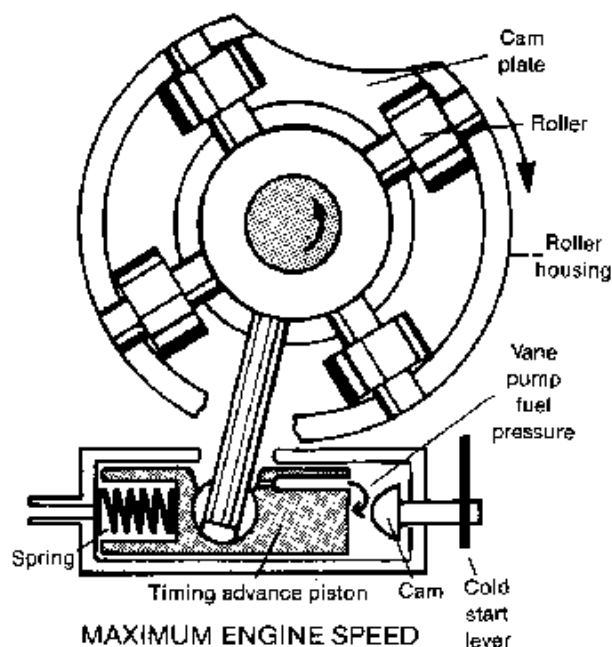
Injection timing begins sooner (timing is advanced) to compensate for cold starting and cold running.



Above 2000 RPM (cold start advance lever pulled up), the timing advance piston does not contact the cam.

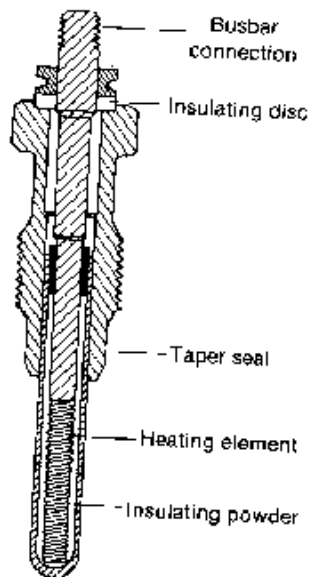
As engine speed increases, vane pump fuel pressure increases and pushes the timing advance piston to the left against the spring so that the roller housing shifts.

This means that the distributor plunger begins injection sooner (timing is advanced) to compensate for higher engine speeds.



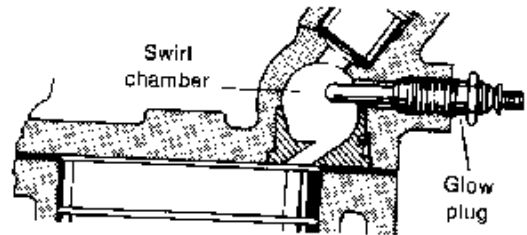
Glow Plugs

Glow plugs are installed in the diesel engine as a preheating provision to aid in cold starting. Two types of glow plug systems are used: 1) quick glow system and 2) normal glow system.

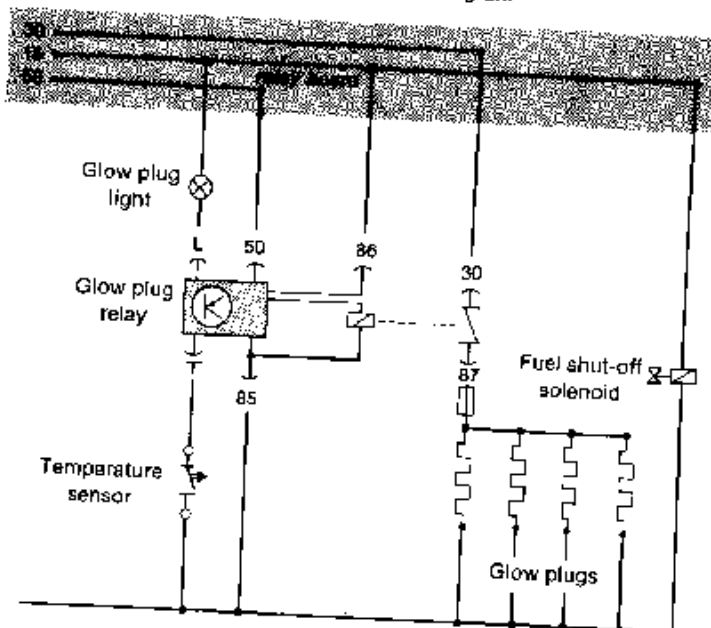


When the glow plug is supplied with voltage the heating element reaches temperatures over 1000° C.

The time actually required for preheating depends on cylinder head temperature.



Current Flow Diagram



Voltage is supplied to the glow plugs from the battery via the glow plug relay.

With the ignition switch "on" voltage flows to energize the glow plug relay.

The temperature sensor, connected to a time circuit in the relay, determines whether or not the relay gets activated. It also determines pre-heat time.

The colder the engine the longer the pre-heat time.

The glow plug relay performs the following functions:

1. Pre-glow — pre-heating time with the ignition key on (t 15) — (time depends upon temperature sensor)
2. After-glow — pre-heating time with the ignition key on (t 15) after the glow plug light goes out (after glow lasts a few seconds).
3. Cranking glow — pre-heating time with the ignition key in the cranking mode (t 50). (cranking glow time ends when the key is returned to the "on" position)

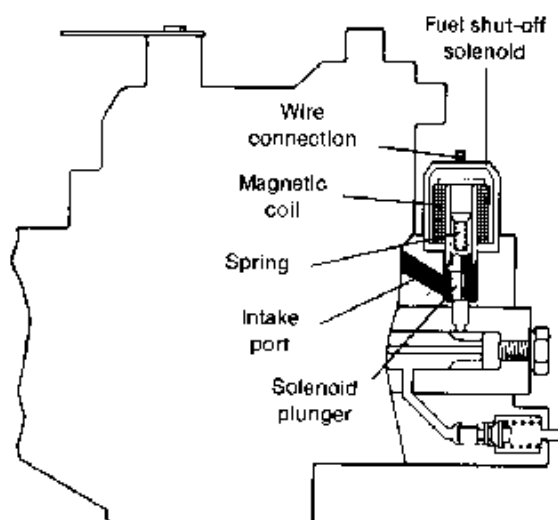
Fuel Shut-Off Solenoid

Diesel engines are switched off by a fuel shut-off solenoid on the injection pump.

Current is supplied to the fuel shut-off solenoid whenever the ignition switch is "on." The magnetic coil pulls the solenoid plunger up against the spring, opening the filling port.

When the ignition switch is turned off, the solenoid plunger closes the filling port, cutting off the supply of fuel for injection from the vane pump.

The engine will not run if the fuel shut-off solenoid sticks closed or does not receive current; if it sticks open, the engine will continue to run after the ignition is turned off.



Fuel Filter

Diesel fuel systems operate reliably as long as the fuel is free from dirt and water.

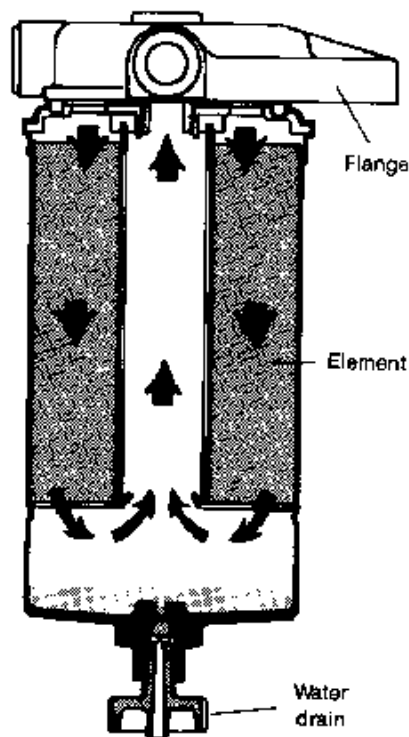
Moving parts inside the injection pump and injectors can be damaged by a small amount of dirt or corrosion.

The diesel fuel filter is designed to stop any dirt or water before it reaches the pump.

The replaceable element is similar to an oil filter — it threads onto a removable flange in the engine compartment.

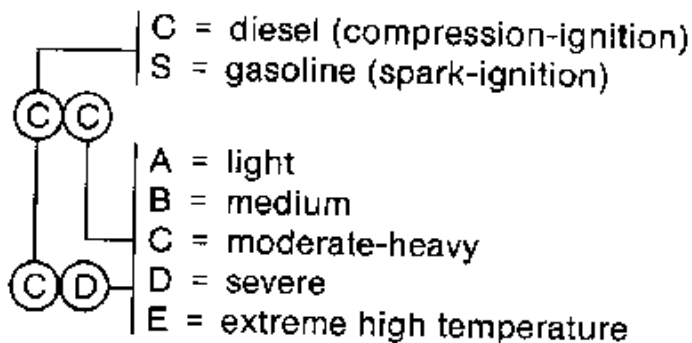
The filter element should be replaced or drained at normal maintenance intervals to ensure reliable operation of the pump and injectors. To prevent freezing and blocking of the filter in cold weather, a water drain is located in the bottom of the element.

The filtering mesh of the original equipment designed to allow sufficient fuel flow while maintaining maximum filtering capacity. It is important that only approved filters are installed during maintenance services or repairs.

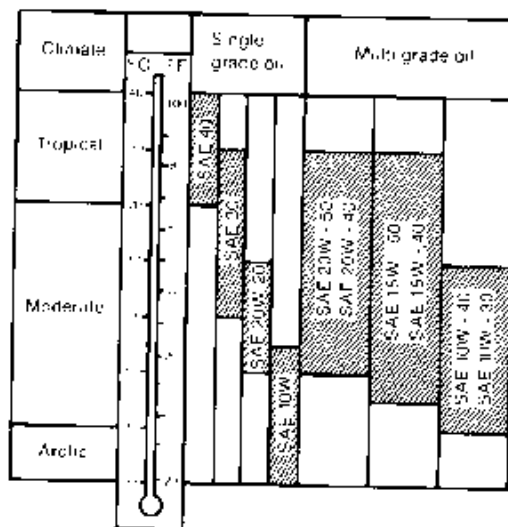


Engine Oil

A diesel engine does not use the same lubricating oil as a gasoline engine since the chemistry of acid formation and other corrosive build-up in the oil is different: a diesel is more likely to form deposits at high temperatures rather than at low temperatures like a gasoline engine. Diesel fuel also has a higher sulphur content, making sulphuric acid build-up in the oil more likely. Diesel engine oils are compounded to neutralize the harmful effects of these tendencies.



In 1971, the American Petroleum Institute, the Society of Automotive Engineers, and the American Society for Testing Materials jointly approved a new and simplified system for classifying engine oils. The naturally aspirated diesel engine should use oil labeled with a CC or CD rating. Due to higher thermal loads on turbo-diesel engines, only oil labeled with a "CD" rating should be used.



Engine oil gets thicker as it gets colder, making it harder to crank the engine when starting. Change over to the proper engine oil viscosity when cold weather sets in. Refer to the chart at right for proper selection.

For diesel engine use API grade "CC" or "CD"

For turbo-diesel use API grade "CD"

Diesel Fuel

Diesel fuel is obtained from distilled crude oil. The distilling process is a highly complicated one involving precision control of temperatures and pressures. Because of the variability of the refining process, as well as the variability in crude oil sources, the diesel fuel that we find in our customer's fuel tanks will also vary depending on where the fuel was bought.

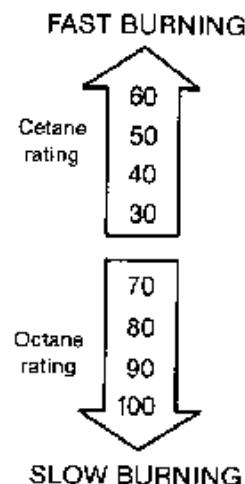
At low outside temperatures we begin to be concerned with 1) Cloud Point (the temperature at which wax forms in diesel fuel) and 2, Pour Point (the temperature at which fuel stops flowing). As the temperature drops wax can sometimes form in the fuel tank, fuel lines, and/or fuel filter. If it does, the fuel supply lines will become plugged and result in running and no start problems.

Another property of diesel fuel essential to diesel engine performance is Cetane Number, a measure of its ignition quality which influences both ease of starting and combustion roughness. A cetane number rating is obtained by comparing the given fuel with cetane (a colorless liquid hydrocarbon that has excellent ignition qualities). Cetane is assigned a rating number of 100 since it burns very fast.

The Diesel should use diesel fuel with at least a 45 cetane rating.

Diesel fuel's cetane number is opposite to gasoline's octane number:

The higher diesel fuel's cetane number, the better its ignition quality.



Overcoming Cold Weather Problems With Diesel Fuel

The following guidelines will help you solve cold weather problems with Diesel Fuel: Temperatures below 20°F (-7°C) are critical to wax formation and result in problems with clogging in the fuel tank, fuel strainer, fuel filter and/or fuel lines.

If outside temperature is above 20°F (-7°C):

- Use Diesel Fuel no. 2.

If outside temperature is below 20°F (-7°C):

- Diesel Fuel no. 1, if available, should be used.
- If Diesel Fuel no. 1 is not available ask the fuel station if his Diesel Fuel no. 2 is winterized.
- A fuel flow improver can be added to Diesel Fuel.

The effectiveness of a flow improver varies depending upon the fuel. Fuel flow improvers should be used according to the manufacturer's instructions.

- If winterized Diesel Fuel no. 2 is not available, Diesel Fuel no. 2 should be mixed with up to 50% kerosene. A 50/50 mixture will reduce engine power slightly.
 - at 20°F use 75% no. 2 to 25% kerosene
 - at below 14°F use 50% no. 2 to 50% kerosene

Only if neither Diesel Fuel no. 1, nor kerosene are available, up to 30% leaded or unleaded regular gasoline can be mixed with Diesel Fuel no. 2.

- Do not use premium gasoline.
- Mixing Diesel Fuel no. 2 with kerosene or gasoline must be done before wax starts to separate.
- Always add the prescribed amount of kerosene or gasoline to the fuel tank first, then fill up with Diesel Fuel.
- Do not use starting assist fluids; they will cause engine damage.
- Do not use fuel line antifreeze intended for gasoline engines.

Safety

- Any amount of gasoline added to Diesel Fuel renders the mixture as flammable as pure gasoline.
- Handle all fuels in a well ventated area. Do not smoke or have anything flammable near the fuel.

Symptom Group 1

Cold Running and/or Hard Starting Problems

Symptoms:

Engine does not start - cranking speed is too low	page 24.
Engine does not start - cranking speed is OK	page 33.
Engine starts, runs, then stops	page 40.
Engine starts, then idles very roughly	page 40.
Engine smokes excessively and/or misses when cold	page 40.
Engine starts hard, cranking time is excessive	page 40.

Cold Running/Starting Problems

Symptoms:

Engine will not start — Cranking speed is too low

Diagnosis procedure

- **Check for correct starting procedure**

If the correct starting procedure is not used in cold weather, the cranking speed may be too low. This step is used to verify that a problem actually exists. If cranking speed is too low, all steps in this procedure must be completed.

- **Check the charging system**

A problem in the charging system can result in an undercharged battery, which will result in the cranking speed being too low. It is important to check all components in the charging system. First check the battery, then the alternator. If the battery has been replaced, make sure that the correct battery has been installed. Some VW diesels require batteries with different capacities.

- **Check the starter connections**

Loose or corroded connections from the battery to the engine or starter will result in cranking speed that is too low even with a fully charged battery. By performing a quick voltage drop test you can detect any resistance in the starter circuit caused by bad connections or cables.

- **Check the engine oil viscosity**

Engine oil which is too thick for existing temperature conditions will cause excessive engine drag when starting a cold engine. This is more critical as fall turns to winter because the engine may still have "summer" oil in it. A quick check of the lubrication sticker can usually verify if this condition exists.

- **Check the starter**

Worn bearings, shorted windings or other internal problems can cause the starter to turn too slowly, resulting in low cranking speed. If the battery is fully charged and there is no excessive drag in the engine, the starter can be checked by performing a cranking voltage test.

Suggested Repair Time — 60 time units

- **Install an engine or battery heater (optional)**

In some northern climates where extremely cold temperatures are experienced, it may be necessary to install an engine or battery heater, to insure that cranking speed will be sufficient to start a cold engine. This should only be done after the previous items have been checked and found to be in order.

Check for correct starting procedure

It is important that the correct starting procedure is followed when starting a cold engine.

Pull out the cold start timing advance knob.

Turn the ignition on, the glow plug light should come on.

After the glow plug light goes out, place the transmission in neutral and depress the clutch pedal.

Depress and hold the accelerator pedal depressed if the temperature is below freezing.

Engage the starter.

Do not operate the starter for more than 10 seconds.

If the engine does not start, wait about 30 seconds and pre-glow again.

The cold start knob can be pushed in after the engine has run about 2 minutes.

On a warm engine the glow plug light will not come on.

Do not pull out the cold start timing advance knob.

The engine can be started immediately.

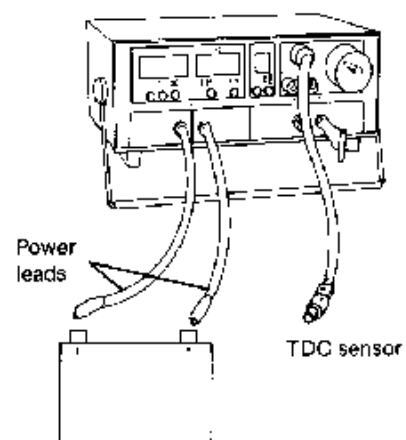
If necessary connect engine tester VW 1367 and check the cranking speed.

Cold cranking speed must be at least 150 rpm.

If the cranking speed is above 150 rpm but the engine will not start, see page 33.

If the cranking speed is below 150 rpm see page 26.

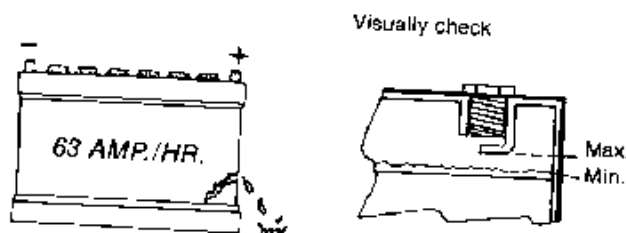
Note: if for any reason an auxiliary power unit is used to "jump" start the car, system voltage must not exceed 16 volts.



Cold Running/Starting Problems

Engine will not start — Cranking speed is too low (cont'd.)

Check battery charge



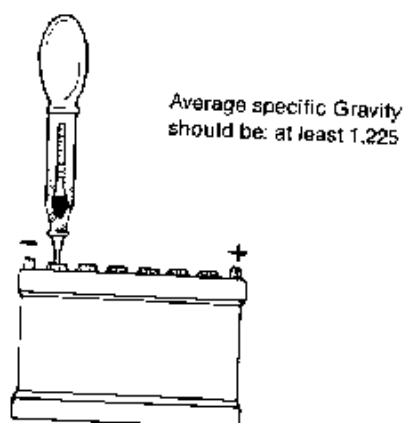
Visually check the battery to make sure:

The battery is clean

The terminals are tight

Each cell is filled with electrolyte

If water is added, the battery must be fast charged for several minutes to mix the water with the electrolyte, otherwise the hydrometer readings will be incorrect.



Non-maintenance free batteries

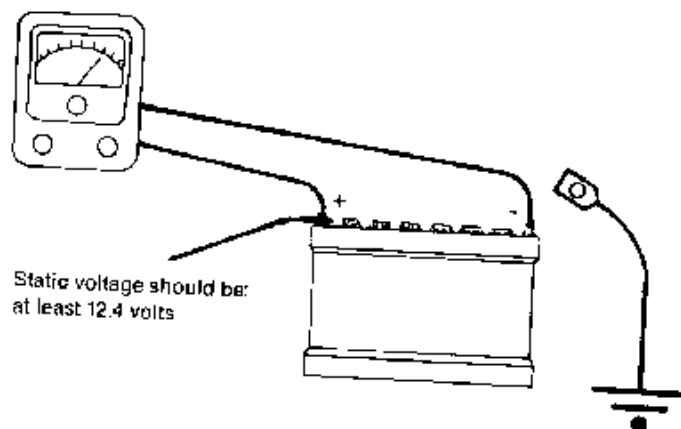
Measure the specific gravity in each cell, correcting for temperature if necessary.

For every 10°F above 80°F, add .004

For every 10°F below 80°F, subtract .004

If specific gravity varies more than .050 between cells, replace the battery

If the specific gravity is above 1.225 the battery can be load tested.



Maintenance free batteries

Measure the static voltage of the battery.

Turn the headlights on for 1 minute to remove any surface charge from the battery.

Disconnect the battery ground strap and measure the static voltage.

If the static voltage is at least 12.4 volts the battery can be load tested.

Load test battery

The battery must be at least 75% charged before performing a load test. If the average specific gravity is below 1.225 or the static voltage is below 12.4 volts, recharge the battery at 15 amps maximum for either 4 hours or until;

The average specific gravity is above 1.225 or

The static voltage is above 12.4 volts

Hook up load tester according to manufacturer's instructions.

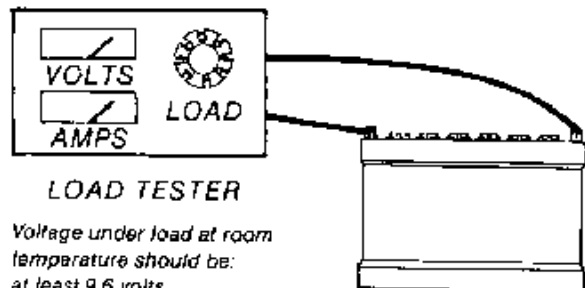
Adjust the load to either 3x the amp/hour rating or $\frac{1}{2}$ the 0°F cold cranking capacity.

After 15 seconds:

If the battery voltage is at least 9.6 volts the battery is o.k.

If the battery voltage is below 9.6 volts replace the battery.

3 times amp/hour or
 $\frac{1}{2}$ cold crank capacity



Check for correct battery installation

If a battery has been or needs to be replaced, the correct size battery must be used. There are two standards for identifying battery size and performance capability.

Original equipment batteries are classified in the DIN (German) standard.

Replacement batteries are classified in the SAE (American) standard.

The two different standards result in two values for cold cranking capacity

	DIN	SAE
1.5 liter	300 amps	500 amps
1.6 liter	380 amps	620 amps

Original equipment label (DIN)

Example:



After market replacement label (SAE)

Example:



Cold Cranking Capacity at 0°F

Cold Running/Starting Problems

Engine Will Not Start — Cranking Speed Is Too Low (cont'd.)

Check alternator

Visually check the alternator to make sure that:

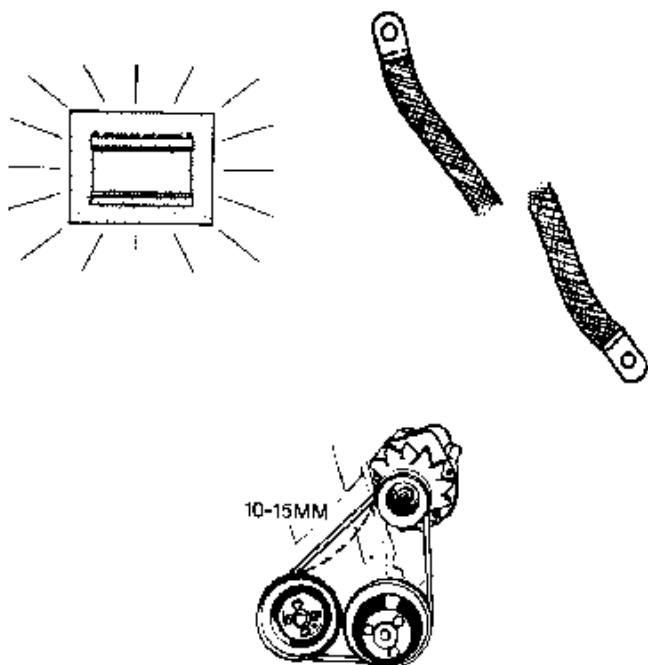
The drive belt is not damaged and is adjusted properly.

The ground strap (if applicable) is secure.

The charging indicator light works when the ignition is turned on.

It is normal for the charging indicator light to stay on after the engine is started. However the light should go out and not come back on once the engine speed is increased. It is also normal for the light to glow dimly at low engine speeds when there is no load on the electrical system and the battery is fully charged.

Both of these characteristics are a result of the circuitry in the voltage regulator and do not represent a fault in the system.



Test alternator output

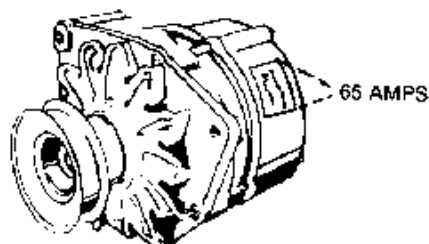
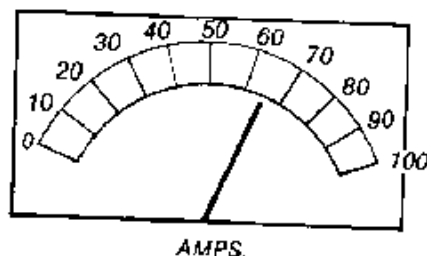
Connect the alternator output tester according to the manufacturer's instructions.

Start the engine and run it at approximately 3000 rpm (make sure that all electrical consumers are switched off).

Slowly turn the load adjuster knob until the maximum ammeter reading is obtained. (Do not allow the system voltage to drop below 12 volts.).

The maximum ammeter reading should be the rated alternator output minus 7 amps (Diesel only).

If the ammeter reading is too low, replace the voltage regulator and retest. If the output is still too low, replace the alternator.



Maximum Ammeter Reading should be at least the alternator rated output minus 7 Amps.

Test voltage regulator

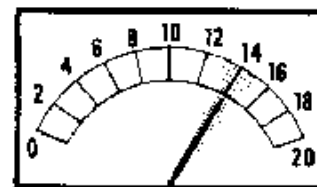
Connect a voltmeter to the battery.

Turn off all electrical consumers.

Start the engine and run it at approximately 3000 rpm for 2 minutes to stabilize the system.

The voltmeter should read between 13.5 and 14.5 volts. The reading must be steady.

If voltage is out of specification, replace the regulator and retest.



VOLTS

13.5 - 14.5 VOLTS

Check starter connections

If the battery passes a load test but the cranking speed is still below 150 rpm there may be a problem with the starter or the starter connections.

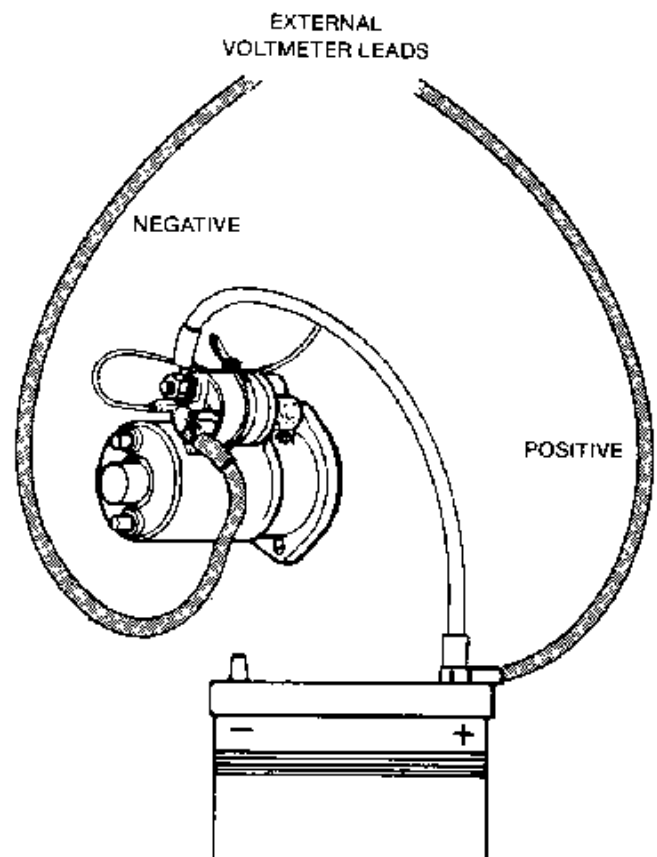
Disconnect wire from the fuel shut-off solenoid and insulate the wire.

Connect a voltmeter between the center of the battery (+) terminal and the starter (+) terminal (field winding) as shown. Make sure the connections are clean and secure.

Crank the engine and observe the voltmeter reading while cranking.

Switch voltmeter to low scale while cranking to prevent damaging meter.

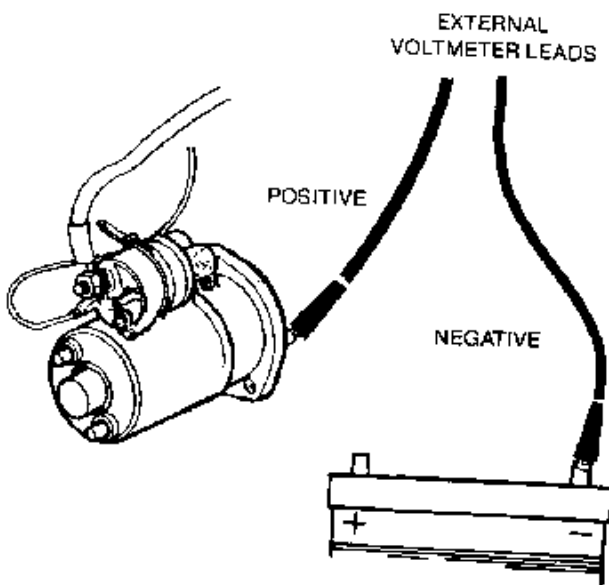
If voltmeter reads more than 0.5 volts, there is excessive resistance in the starter cable, its connections, or the connections in the starter solenoid.



Cold Running/Starting Problems

Engine will not start — Cranking speed is too low (cont'd.)

Check starter connections (cont'd)



Connect the voltmeter between the center of the battery (-) terminal and the transmission or starter housing as shown. (Scratch through paint if necessary to ensure a good connection).

Switch voltmeter to low scale.

Crank the engine and observe the voltmeter reading while cranking.

If the voltmeter reads more than 0.5 volts, there is excessive resistance in the ground cable or its connections between the battery and the transmission. Locate the problem and repair.

Check Engine oil

Climate	°C	°F	Single grade oil	Multi grade oil
Tropical	40	104	SAE 40	
	30	86	SAE 30	
	20	68	SAE 20W	SAE 20W - 30 SAE 20W - 40
Moderate	10	50	SAE 15W	SAE 15W - 30 SAE 15W - 40
	0	32	SAE 10W	SAE 10W - 30 SAE 10W - 40
Arctic	-10	14	SAE 5W	
	-20	-4		

If the battery passed a load test and the starter connections are o.k., the problem could be:

Engine oil that is too thick for temperature conditions

Excessive engine drag

A problem in the starter itself

First check to see what grade engine oil is in the engine. If there is any doubt or the engine oil had not been changed since the previous season, change the engine oil. Refer to the chart for the proper grade. The viscosity of the oil to be used should be selected for the lowest anticipated temperature at which engine will be started.

For diesel engine use API grade "CC"
For turbo-diesel use API grade "CD"

Check starter

If the battery passed a load test and you have checked for excessive drag in the engine, test the cranking voltage.

Connect a voltmeter to the battery.

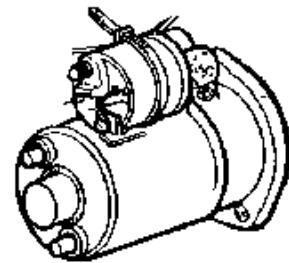
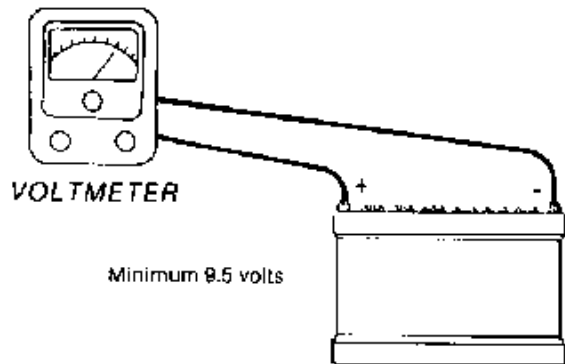
Crank the engine.

If the voltmeter reads less than 9.5 volts while the engine is cranking, there is a problem in the starter.

Reconnect the fuel shut-off solenoid.

Before replacing the starter, check the bushing in the transmission housing. If the bushing is worn or dry, extra drag will be put on the starter.

If the starter pinion shaft is bent or broken and the starter was not loose, check the flywheel and replace if it is out of round.

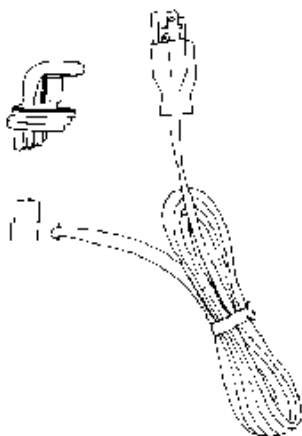


Install engine and/or battery heater

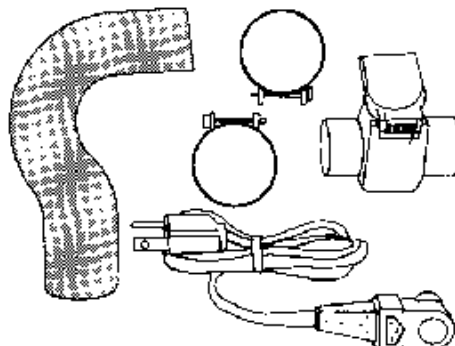
In northern regions where extreme cold temperatures are experienced it may be necessary to install an engine heater to insure that the car starts. This should only be done after all steps in this diagnosis procedure have been completed and any problems found are corrected.

Several units are available through the VW/Audi parts department. After following installation instructions, the unit can be plugged into house current.

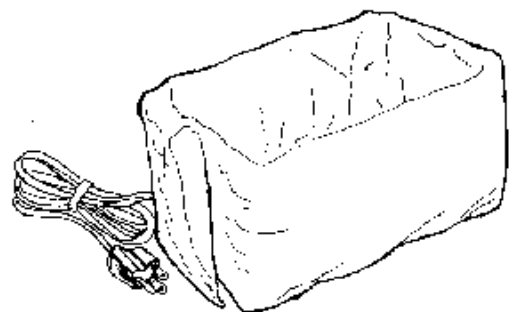
Engine block heater



Engine pre-heater



Battery heater



Cold Running/Starting Problems

Engine will not start — Cranking speed is too low

Quality check

Suggested Repair Time — 10 time units

- **Connect engine tester VW 1367.**
- **Pull out the cold start timing advance knob.**
- **Turn the ignition on, the glow plug light will come on.**
- **After the glow plug light goes out, depress the clutch with the gear shift lever in neutral and crank the engine.**

The cranking speed should be at least 150 RPM

The engine should start within 10 seconds.

- **Check to see that the engine:**
 - Idles smoothly
 - Accelerates evenly
 - Does not smoke excessively

Note: It is normal that the engine noise is louder and that some whitish-blue smoke may be emitted from the exhaust during the warm-up period in cold weather.

If test passed

Return car to customer

If the cranking speed is now OK, but the car will not start, see page 33.

Cold Running/Starting Problems

Symptom:

Engine will not start — Cranking speed is OK

Diagnosis Procedure

- **Check for correct starting procedure**

If the correct starting procedure is not used the car may not start.

By following the correct starting procedure, you will be able to verify whether or not the car has a starting problem.

- **Check the fuel supply system**

Once it has been verified that a problem exists, the first step is to check the fuel supply. If there is an air leak in the suction lines between the injection pump and the fuel tank, fuel may be siphoned out of the fuel line back to the tank. A plugged fuel filter or blocked fuel line will also prevent fuel from being delivered to the injection pump.

- **Remove the fuel tank strainer**

In areas where the temperature drops below 20°F (-7°C) the fuel tank strainer should be removed to prevent wax crystals from blocking the fuel supply. This is only necessary on the Rabbit, Jetta, Pick-up, and Dasher. Other 4 cylinder diesels do not have a fuel tank strainer.

- **Check the fuel supply to the injectors**

After you have checked to make sure that fuel is being delivered to the injection pump, the next step is to see if fuel is being delivered to the injectors. This is done by loosening one of the union nuts on an injector line while cranking the engine.

- **Check the glow plug system**

During cold starts, the compression heat is dissipated by the cold engine. If the glow plugs are not operating properly, not enough heat will be produced during cranking to start the engine. The test procedure is in two parts, the first step is to check the relay and wiring. The second step is to check the glow plugs.

- **Verify fuel quality**

Poor fuel quality can cause a cold running problem or a no start condition. The fuel must be properly winterized and any additives that are used must be used according to the manufacturers instructions.

Suggested Repair Time — 65 time units

Note: SRT for removing fuel tank sending unit is not included in the diagnosis time. See SRT manual for additional labor operation and repair time.

Cold Running/Starting Problems

Engine will not start — Cranking speed is OK

Check for correct starting procedure

It is important that the correct starting procedure is followed when starting a cold engine.

Pull out the cold start timing advance knob.

Turn the ignition on, the glow plug light should come on.

After the glow plug light goes out, place the transmission in neutral and depress the clutch pedal.

Depress and hold the accelerator pedal depressed if the temperature is below freezing.

Engage the starter.

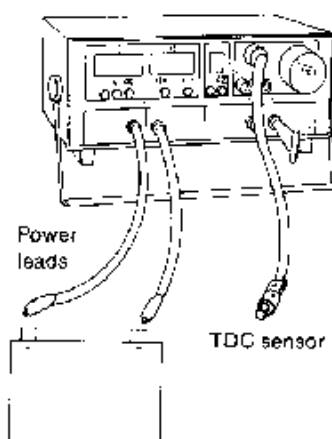
Do not operate the starter for more than 10 seconds.

If the engine does not start, wait about 30 seconds and pre-glow again.

The cold start knob can be pushed in after the engine has run about 2 minutes.

On a warm engine the glow plug light will not come on.

Do not pull out the cold start timing advance knob. the engine can be started immediately.



If necessary, connect engine tester VW 1367 and check the cranking speed.

Cold cranking speed must be at least 150 rpm.

If the cranking speed is above 150 rpm but the engine will not start, see page 35.

If the cranking speed is below 150 rpm see page 24.

Note: If for any reason an auxiliary power unit is used to "jump" start the car, system voltage must not exceed 16 volts.

Check fuel supply

Check the clear fuel line between the filter and the injection pump.

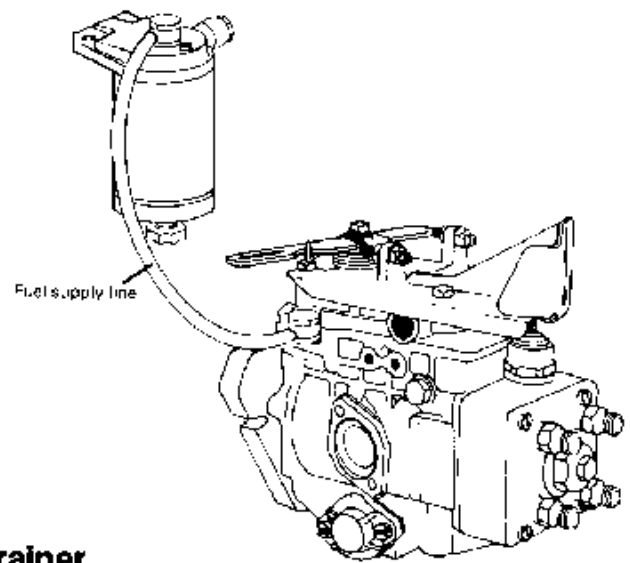
If the fuel in the line is of a whitish color, wax crystals are forming in the fuel, see winter operation page 22.

If there is no fuel in the line,

Check for fuel in the tank.

Check for air leaks at the fuel filter assembly or fuel supply lines.

Remove the fuel filter and check to see if it is plugged.



Remove fuel tank strainer (Rabbit, Jetta, Dasher, and Pick-up only)

In areas where the temperature drops below 20°F, the fuel tank strainer should be removed.

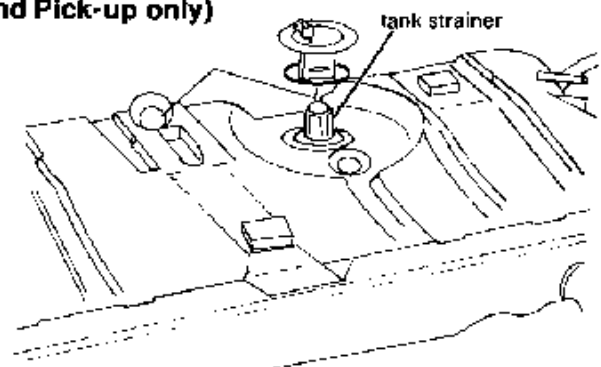
Remove the fuel gauge sending unit.

Remove the fuel tank strainer.

Replace the O ring for the sending unit and lubricate it with graphite powder.

Install the fuel gauge sending unit (note the installation position).

If wax crystals are visible in the fuel tank see winter operation, page 22.



Rabbit, Jetta and
Pickup

Dasher



Check fuel supply to injectors

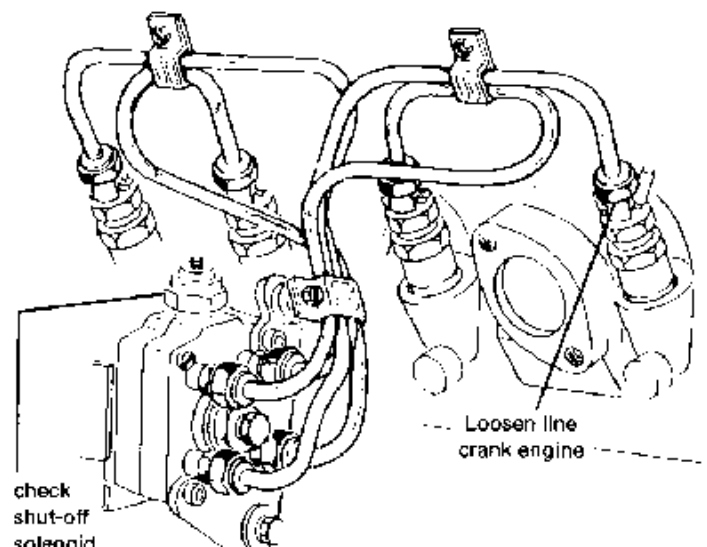
After it has been established that fuel is being delivered to the injection pump, loosen an injector line at one of the injectors.

Crank the engine to see if fuel is being delivered to the injectors.

Goggles should be worn and a fire extinguisher should be kept close by.

If no fuel is supplied to the injectors check the power supply to the fuel shut-off solenoid.

If the power supply is o.k., replace the shut-off solenoid.

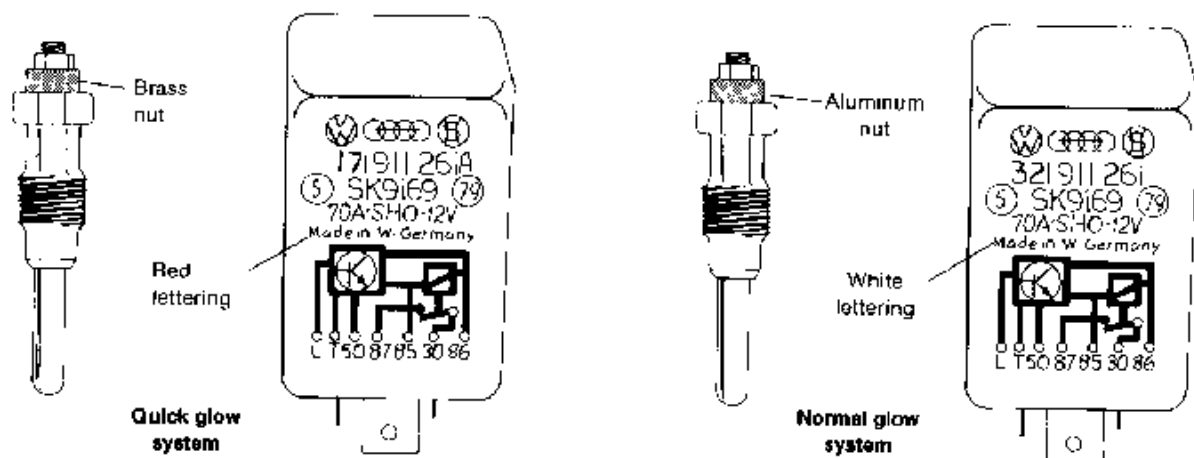


Cold Running/Starting Problems

Engine will not start — Cranking speed is OK (cont'd.)

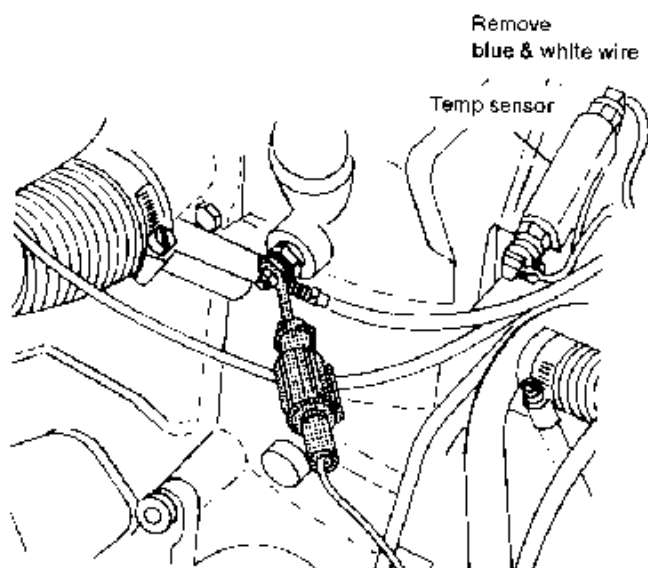
Check glow plug system

Two types of glow plug systems are used on VW and Audi diesels, the normal glow system and the quick glow system. Testing procedures are the same for both but parts from one type of system must not be used in the other type.



Testing procedure

Check the glow plug fuseable strip on the firewall in the engine compartment. Replace the fuse if it is burnt. If the fuse burns repeatedly, there is a short in the system which must be repaired before further testing.



Disconnect the blue and white wire from the temperature sensor on the cylinder head. This will allow the glow plug relay to stay energized for the maximum glow time.

Connect a test light between #4 glow plug and ground.

Turn the ignition key to the glow position

If the test light lights and stays on for:

Quick glow system = 15 seconds (min.)

Normal glow system = 90 seconds (min.)

Turn to page 38 and test the glow plugs.

If the test light does not light, first test the glow plug circuit, then the glow plugs.

If the test light lights, but the minimum glow time is not reached, replace the relay and retest.

Check glow plug circuit

If the test light does not light:

Reconnect the blue and white wire to the engine temperature sensor.

Remove the glow plug relay.

Connect a voltmeter between the following terminals at the relay plug on the fuse panel

Terminals	Condition	Voltmeter reading
30 + 87	Key off	Battery voltage
85 + 86	Key on	Battery voltage
50 + ground	Engine cranking	Cranking voltage

If any of the test results are incorrect refer to the applicable wiring diagram and repair the problem (wiring or connections).

Connect a jumper wire between terminal L and ground.

Turn the ignition switch to the glow position.

Glow plug indicator light should come on.

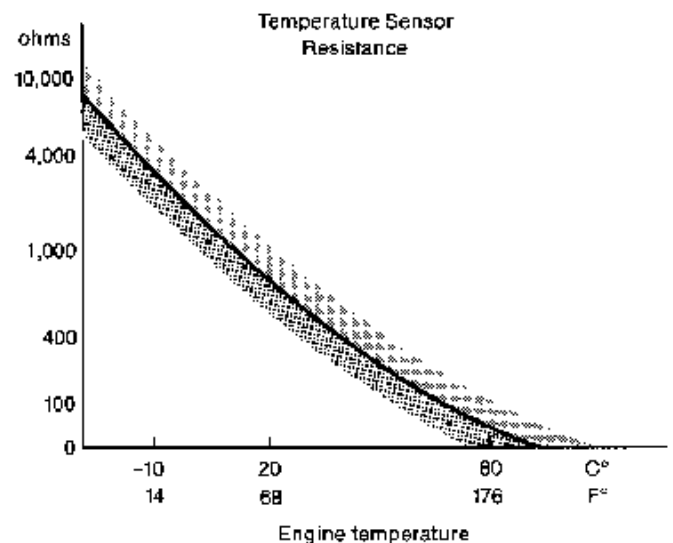
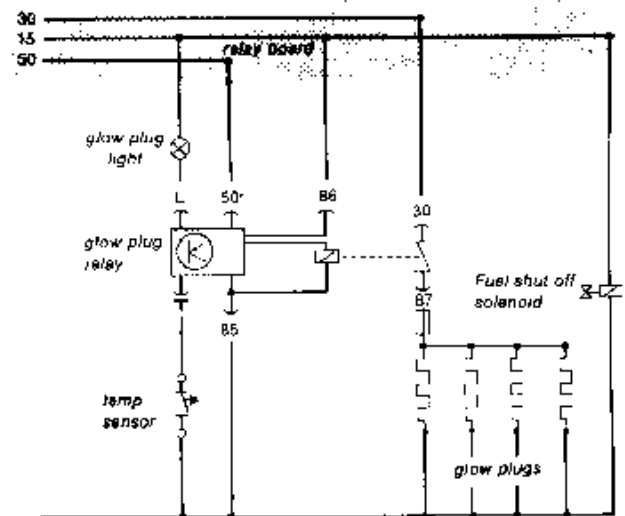
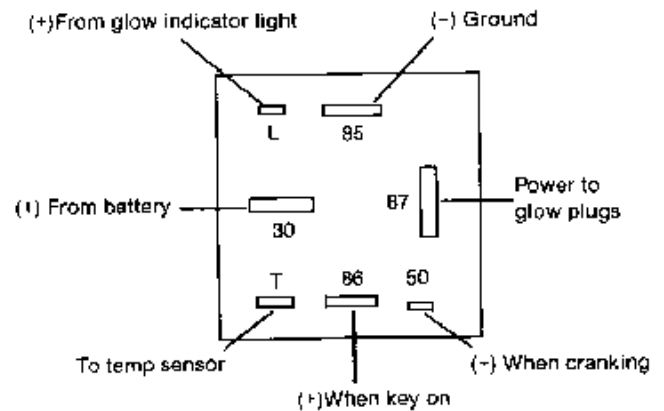
Connect an ohmmeter between terminal T and ground to check the temperature sensor.

-10° C (14° F)	3,500 - 5,500 Ω
+20° C (68° F)	800 - 1,400 Ω
+80° C (176° F)	130 - 170 Ω

If the resistance is out of this range check the sensor wiring and connections. If they are o.k., replace the sensor.

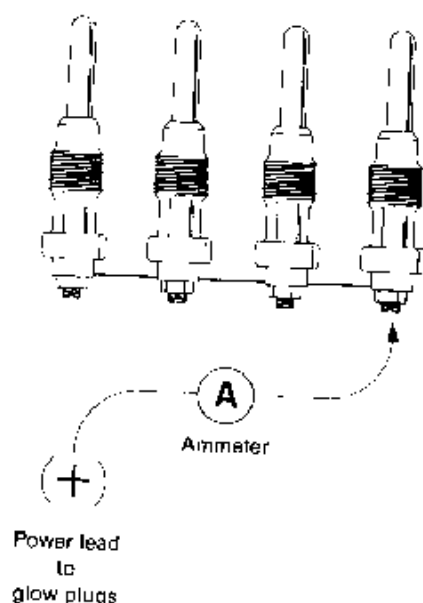
If a problem is found and repaired, recheck maximum glow time.

If all test results are o.k. but the glow plugs still do not receive power, replace the glow plug relay.



Cold Running/Starting Problems **Engine will not start — Cranking speed is OK**

Check glow plugs



Connect an ammeter to the power lead for the glow plugs.

Turn the ignition key to the glow position.

Initial current draw may be as high as 140 amps but will stabilize to a steady value after a short period of time.

Quick glow system (brass nut)

Each glow plug draws approximately 12 amps

48 amps
 36 amps
 24 amps
 12 amps
 0 amps

Glow plugs o.k.
 One glow plug bad
 Two glow plugs bad
 Three glow plugs bad
 Four glow plugs bad

Normal glow plug system (silver nut)

Each glow plug draws approximately 9 amps

36 amps
 27 amps
 18 amps
 9 amps
 0 amps

Glow plugs o.k.
 One glow plug bad
 Two glow plugs bad
 Three glow plugs bad
 Four glow plugs bad

To locate bad glow plugs disconnect the bus bar from the glow plugs.

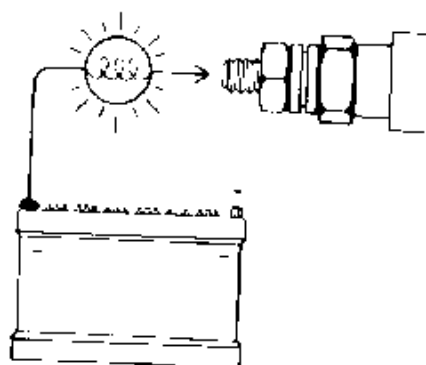
Connect a test light between the battery positive terminal and each glow plug.

If the test light lights, the glow plug is o.k.

If the test light does not light the glow plug is bad and must be replaced.

Note:

If the glow plug tip is worn away, check the spray pattern of the injector and replace the injector if necessary.



Verify fuel quality

Poor fuel quality can cause a cold running problem or a no start condition. The causes could be:

- Fuel not winterized — At temperatures below 20°F, wax crystals begin to form in the fuel. This will plug the fuel lines, cutting off the fuel supply to the engine.
- Improper mixing — If too much gasoline or other flow improvers are mixed with the fuel, the cetane rating of the fuel will be lowered below the point at which it will burn properly in the engine.

Quality check

Suggested Repair Time — 10 time units

- **Connect engine tester VW 1367.**
- **Pull out the cold start timing advance knob.**
- **Turn the ignition on, the glow plug light will come on.**
- **After the glow plug light goes out, depress the clutch with the gear shift lever in neutral and crank the engine.**

The cranking speed should be at least 150 RPM

The engine should start within 10 seconds.

- **Check to see that the engine:**
 - Idles smoothly
 - Accelerates evenly
 - Does not smoke excessively

Note: It is normal that the engine noise is louder and that some whitish-blue smoke may be emitted from the exhaust during the warm-up period in cold weather.

If test passed

Return car to customer

If test failed

Perform diagnosis procedure II, page 48 .

Cold Running/Starting Problems

Symptoms:

Engine starts, runs, then stops

Engine starts, but idles roughly when cold

Engine smokes excessively and/or misses when cold

Engine is hard to start, cranking time is too long

Diagnosis Procedure

- **Check for correct starting procedure**

A cold diesel engine will not start and run properly if the correct starting procedure is not followed. It is important that the glow plugs are allowed to complete their glow cycle and that the cold start timing advance is used. Both of these items help to overcome the loss of compression heat in a cold engine.

- **Check the fuel supply system**

Loose connections or cracked hoses between the fuel tank and the injection pump will allow air to enter the fuel system. The air then becomes trapped in the fuel system and can cause the engine to run roughly, stall, or smoke excessively.

- **Check the fuel line union bolts**

The union bolt on the return fuel line from the injection pump has a restriction to help maintain adequate fuel pressure in the injection pump. If this bolt is placed in the inlet side or the incorrect bolt is used, the injection pump will not develop enough pressure, and the car will not run properly.

- **Remove the fuel tank strainer**

In areas where the temperature drops below 20°F (-7°C), the fuel tank strainer should be removed to prevent wax crystals from blocking the fuel supply. This is only necessary on the Rabbit, Jetta, Pick-up, and Dasher. Other 4 cylinder diesels do not use a fuel tank strainer.

- **Check the glow plug system**

During cold starts, the compression heat is dissipated by the cold engine. If the glow plugs are not operating properly, the engine may start, but run roughly and/or smoke. This could be caused by temperatures being too low in the swirl chambers where the glow plugs are located.

- **Verify Fuel Quality**

Poor fuel quality can cause a cold running problem or starting problem. The fuel must be properly winterized and any additives that are used must be used according to the manufacturer's instructions.

Suggested Repair Time — 50 time units

Note: SRT for removing fuel tank sending unit is not included in the diagnosis time. See SRT manual for additional labor operation and repair time.

Check for correct starting procedure

It is important that the correct starting procedure is followed when starting a cold engine.

- Pull out the cold start timing advance knob.

- Turn the ignition on, the glow plug light should come on.

- After the glow plug light goes out, place the transmission in neutral and depress the clutch pedal.

- Depress and hold the accelerator pedal depressed if the temperature is below freezing.

- Engage the starter.

- Do not operate the starter for more than 10 seconds.

- If the engine does not start, wait about 30 seconds and pre-glow again.

- The cold start knob can be pushed in after the engine has run about 2 minutes.

On a warm engine the glow plug light will not come on.

- Do not pull out the cold start timing advance knob, the engine can be started immediately.

Note: It is important to verify that the customer is following this starting procedure.

Cold Running/Starting Problems

(idles rough, smokes, stalls, hard to start — cont'd.)

Check fuel supply

Start the engine and run it at about 2000 RPM.

Check the clear fuel supply line.

A steady stream of bubbles indicates either an air leak in the fuel supply system or water in the fuel filter. (A few bubbles may appear, this is normal)

Check for air leaks caused by:

- Loose fuel filter

- Loose connections on fuel filter assembly

- Loose union bolt on fuel pump

- Loose connections on fuel supply lines

- Loose bleeder screw on filter housing

If no air leaks are found and if bubbles still appear, the bubbles could be water in the fuel.

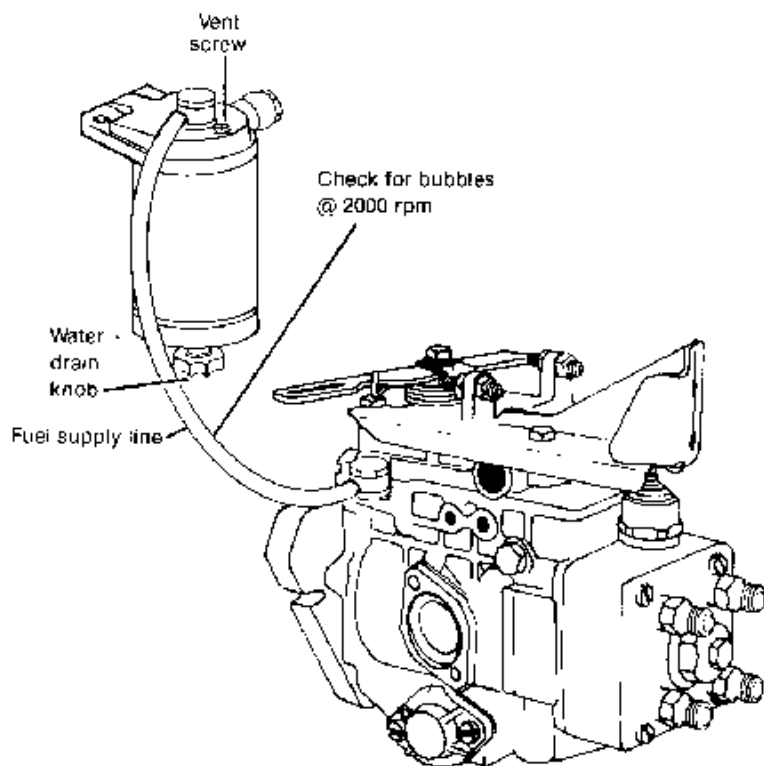
Drain the water trap in the fuel filter.

- Open the vent screw on the filter flange.

- Loosen the drain plug on the filter.

- Drain the fuel into a container until the drained fuel is pure.

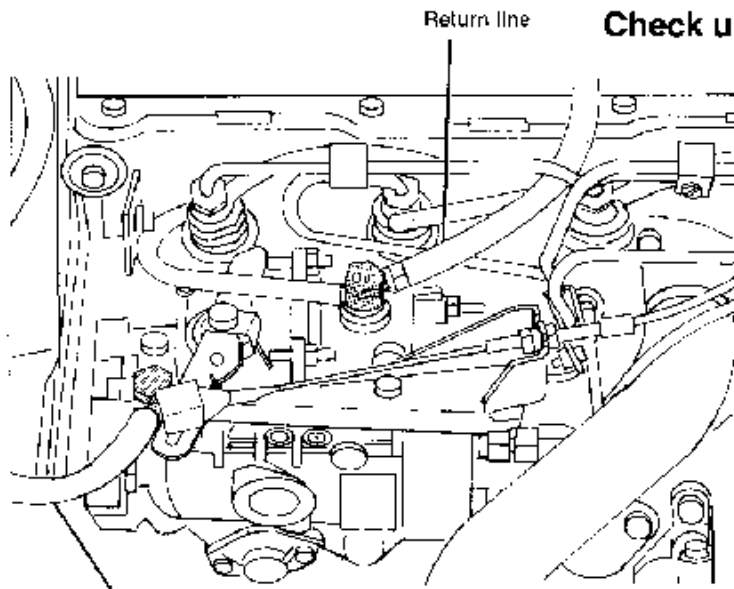
- Tighten the drain plug and the vent screw.



Check union bolts

Check the union bolts on the injection pump to make sure the correct bolts are installed on the fuel supply and return lines.

The bolt on the fuel return line should be marked *out*, and have a very small opening which is visible when the bolt is removed. The restrictor helps maintain fuel pressure inside the injection pump.



Remove fuel tank strainer (Rabbit, Jetta, Dasher and Pick-up only)

In areas where the temperature drops below 20°F, the fuel tank strainer should be removed.

This will help prevent the strainer from becoming plugged with wax crystals and restricting fuel supply to the injection pump.

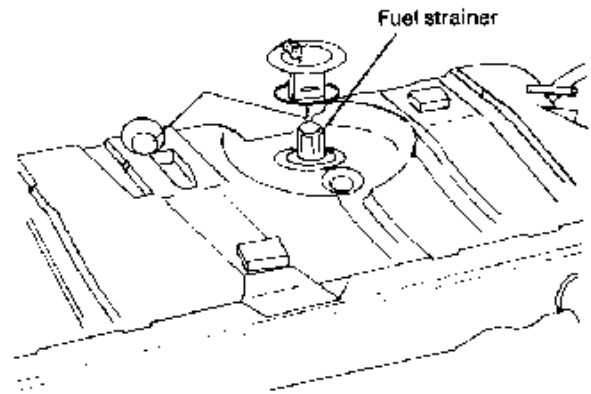
Remove the fuel gauge sending unit.

Remove the fuel tank strainer.

Replace the O ring for the sending unit and lubricate it with graphite powder.

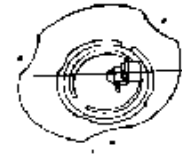
Install the fuel gauge sending unit (note the installation position.)

If wax crystals are visible in the fuel tank, see winter operation, page 22.



Rabbit, Jetta &
Pick-up

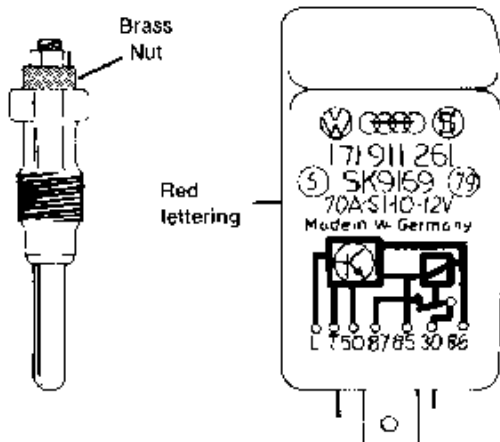
Dasher



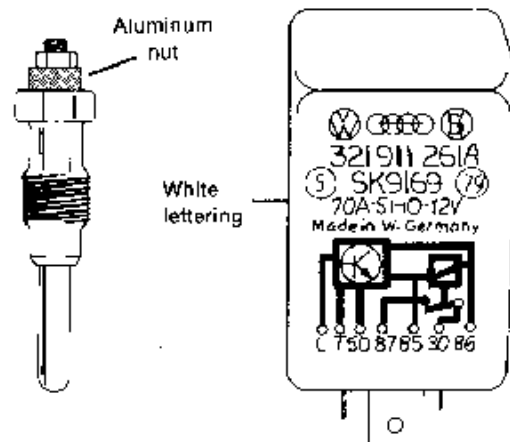
Front
of
car →

Check glow plug system

Two types of glow plug systems are used on VW and Audi diesels, the normal glow system and the quick glow system. Testing procedures are the same for both but parts from one type of system must not be used in the other type.



Quick glow
system



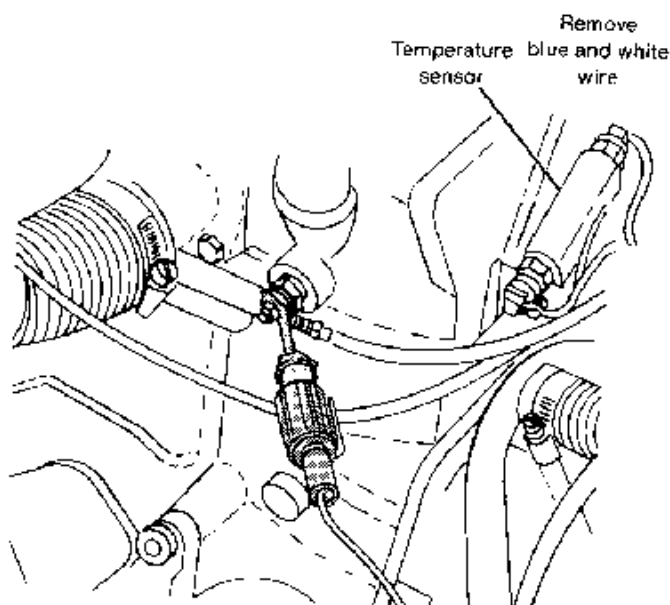
Normal glow
system

Cold Running/Starting Problems

(Idles rough, smokes, stalls, hard to start — cont'd.)

Glow system testing procedure

Check the glow plug fuseable strip on the firewall in the engine compartment. Replace the fuse if it is burnt. If the fuse burns repeatedly, there is a short in the system which must be repaired before further testing.



Disconnect the blue and white wire from the temperature sensor on the cylinder head. This will allow the glow plug relay to stay energized for the maximum glow time. Connect a test light between #4 glow plug and ground.

Turn the ignition key to the glow position.

If the test light lights and stays on for:

Quick glow system = 15 seconds (min.)

Normal glow system = 90 seconds (min.)

Turn to page 46 and test the glow plugs.

If the test light does not light, test first the glow plug circuit, then the glow plugs.

If the test light lights, but the minimum glow time is not reached, replace the relay, and retest.

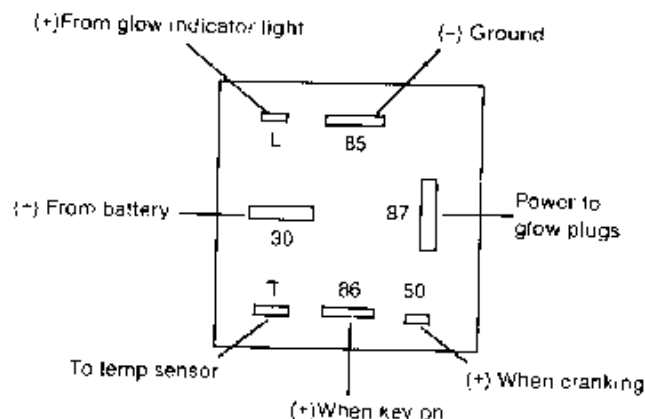
Check glow plug circuit

If the test light does not light:

Reconnect the blue and white wire to the engine temperature sensor.

Remove the glow plug relay.

Connect a voltmeter between the following terminals at the relay plug on the fuse panel



Terminals	Condition	Voltmeter reading
30 + 87	Key off	Battery voltage
85 + 86	Key on	Battery voltage
50 + ground	Engine cranking	Cranking voltage

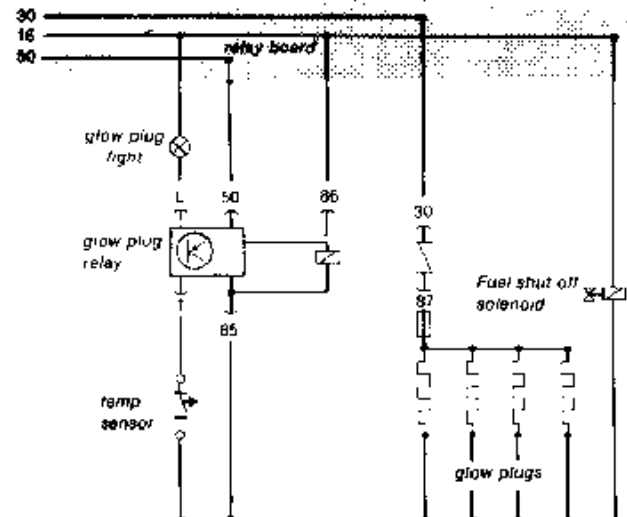
If any of the test results are incorrect refer to the applicable wiring diagram and repair the problem (Wiring or connections).

Check glow plug circuit (cont'd)

Connect a jumper wire between terminal L and ground.

Turn the ignition switch to the glow position.

The glow plug indicator light should come on.



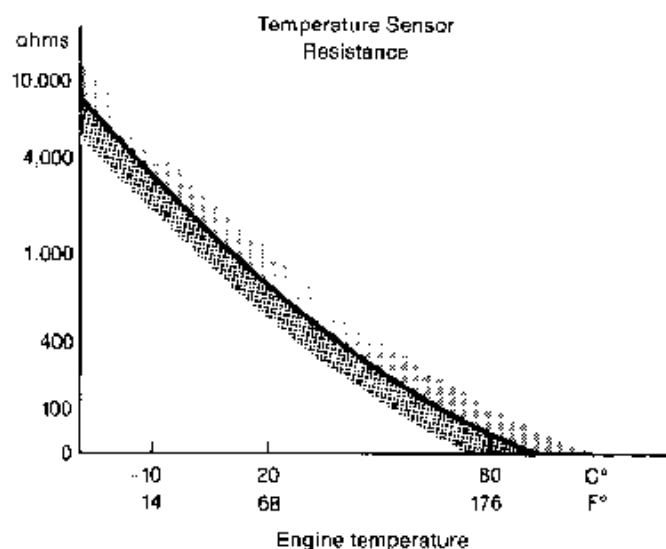
Connect an ohmmeter between terminal T and ground to check the temperature sensor.

-10°C (14°F)	3,500 - 5,500 Ω
+20°C (68°F)	800 - 1,400 Ω
+80°C (176°F)	130 - 170 Ω

If the resistance is out of this range, check the sensor wiring and connections. If they are OK replace the sensor.

If a problem is found and repaired, recheck maximum glow time.

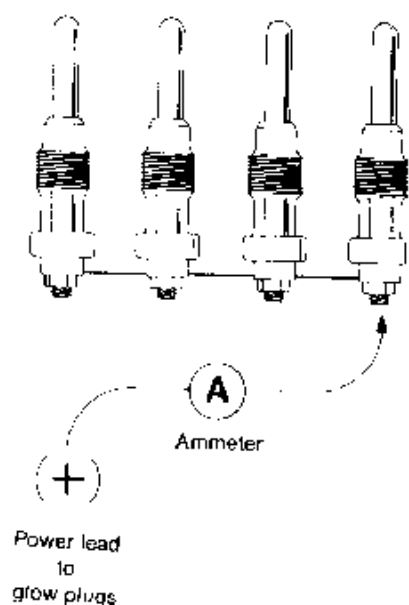
If all test results are OK but the glow plugs still do not receive power, replace the glow plug relay.



Cold Running/Starting Problems

(idles rough, smokes, stalls, hard to start — cont'd.)

Check glow plugs



Connect an ammeter to the power lead for the glow plugs.

Turn the ignition key to the glow position.

Initial current draw may be as high as 140 amps but will stabilize to a steady value after a short period of time.

Quick glow system (brass nut)

Each glow plug draws approximately 12 amps

48 amps	Glow plugs o.k.
36 amps	One glow plug bad
24 amps	Two glow plugs bad
12 amps	Three glow plugs bad
0 amps	Four glow plugs bad

Normal glow plug system (silver nut)

Each glow plug draws approximately 9 amps

36 amps	Glow plugs o.k.
27 amps	One glow plug bad
18 amps	Two glow plugs bad
9 amps	Three glow plugs bad
0 amps	Four glow plugs bad

To locate bad glow plugs, disconnect the bus bar from the glow plugs.

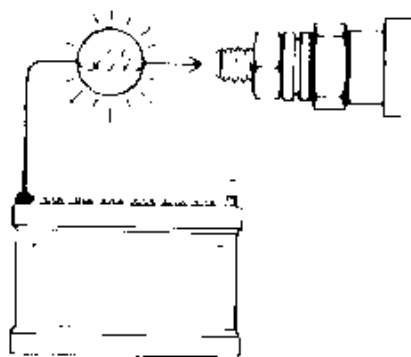
Connect a test light between the battery positive terminal and each glow plug.

If the test light lights, the glow plug is OK.

If the test light does not light, the glow plug is bad and must be replaced.

Note:

If the glow plug tip is worn away, check the spray pattern of the injector and replace the injector if necessary.



Verify fuel quality

Poor fuel quality can cause a cold running problem or a no start condition. The causes could be:

- Fuel not winterized - At temperatures below 20°F, wax crystals begin to form in the fuel. This will plug the fuel lines, and/or filters, cutting off the fuel supply to the engine.
- Improper mixing - If too much gasoline or other flow improvers are mixed with the fuel, the cetane rating of the fuel will be lowered below the point at which it will burn properly in the engine.

Quality check

Suggested Repair Time — 30 time units

- **Start engine, allow to warm up and observe idle quality**
 - engine should idle smoothly
 - engine should not misfire or knock
- **With correct tire pressure, drive car on a level road**
- **Accelerate to a constant speed of 35 MPH**
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the acceleration quality**
 - engine should accelerate evenly
 - engine should not misfire or knock
- **Maintain steady speed and observe performance quality**
 - engine should maintain even performance at all speeds and show no symptoms of misfire or knock

If test passed:

Return car to customer.

If test failed:

Perform Diagnosis Procedure II, page 48.

Diagnosis II — Cold Running/Starting Problems

240

Step 1 Check for Crankshaft bolt modification on 1.5L engines

Step 2 Check air filter

Step 3 Check valve clearance

Step 4 Check compression

Step 5 Check injectors

Step 6 Perform injection system tests*

- Check/adjust valve timing
- Check/adjust cold start advance
- Check/adjust injection pump timing
- Check/adjust idle and maximum speed

**Warm running problems are affected by valve timing, spur belt tension, cold start advance, injection pump timing, idle RPM and maximum RPM. Therefore all of these items should be checked to assure that all factors that could affect vehicle performance are adjusted properly.*

Suggested Repair Time — 240 time units

Check for crankshaft bolt modification - 1.5L diesel engine

Visually check —

That the old style front crankshaft bolt and washer have been replaced with the new style bolt and washer.

new style bolt has shoulder

new style washer has collar

If not:

Remove old style bolt and washer.

Visually check the crankshaft sprocket, key way and key for signs of wear or damage.

If not damaged:

Replace old style bolt and washer with new style bolt and washer.

Torque new style bolt to
150Nm (108 ft. lbs.)

If damaged:

Remove crankshaft sprocket.

If sprocket, key or key way are damaged,
replace parts as necessary.

Cars with dealer-installed A/C

When installing the new style crankshaft
bolt on cars with dealer-installed A/C —

Remove old spacer (with shoulder)
and

Replace with new spacer ZVW 455 218(flat).

Old style

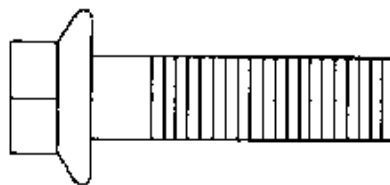


Bolt

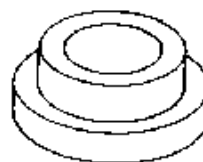


Flat washer

New style

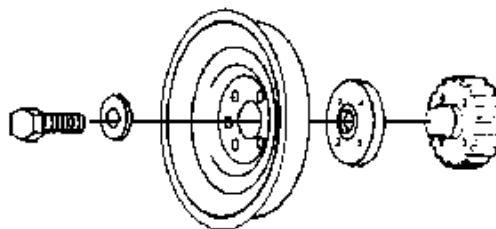


Bolt
(N901 120 01)

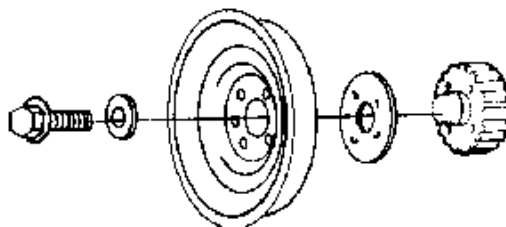


Collared washer
(068 105 289)

Old spacer w/shoulder



New spacer — flat
(ZVW 455 218)



Diagnosis II — Cold Running/Starting Problems

Check for crankshaft bolt modification 1.5L diesel engine (Continued)

1980 Rabbit diesel with factory air conditioning

When checking for the new style crankshaft bolt and washer

or

when installing the new style crankshaft bolt and washer on 1.5L diesels with factory air-conditioning:

Loosen alternator belt.

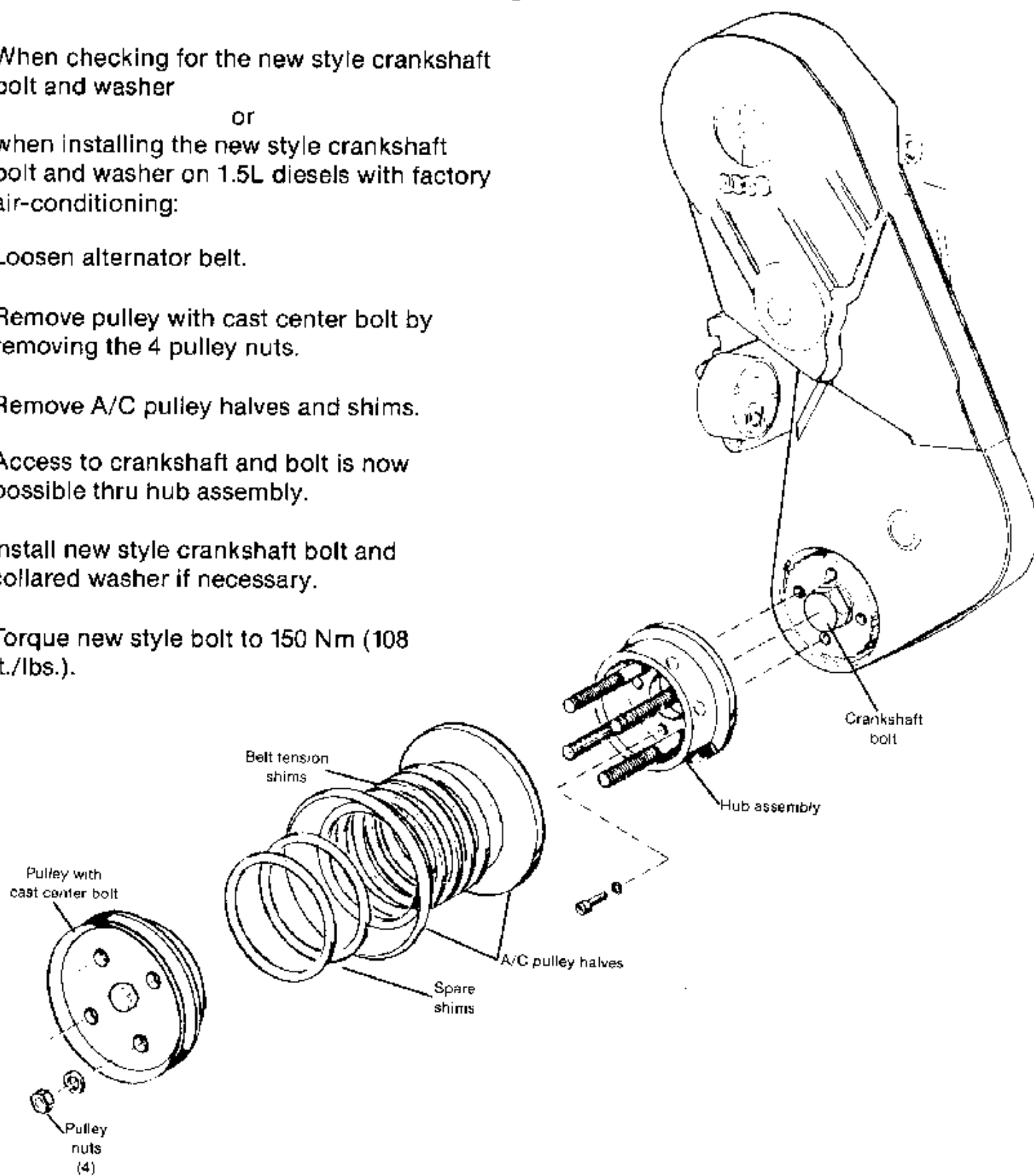
Remove pulley with cast center bolt by removing the 4 pulley nuts.

Remove A/C pulley halves and shims.

Access to crankshaft and bolt is now possible thru hub assembly.

Install new style crankshaft bolt and collared washer if necessary.

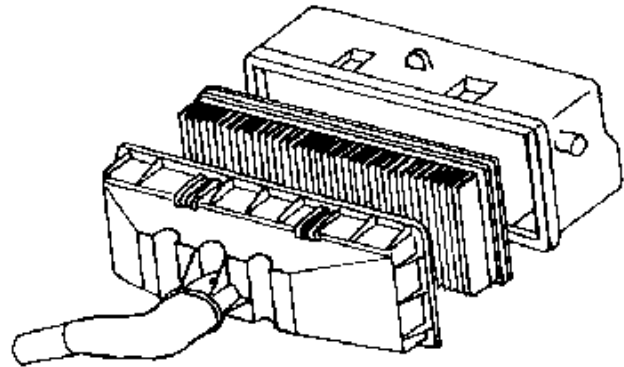
Torque new style bolt to 150 Nm (108 ft./lbs.).



Check air filter

Visually check air filter

Replace if dirty and check to see that Breather Hose Kit was installed (1977-1979 cars, 1980 cars to engine # CK 513 210) . . . page 130.

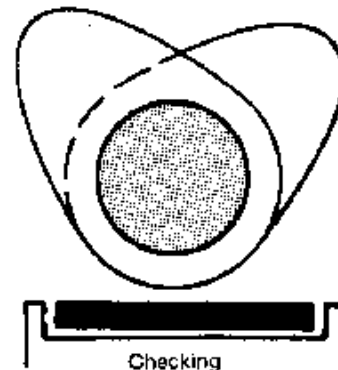


Check valve clearance

Remove valve cover.

Turn crankshaft bolt clockwise until the cam lobes of the cylinder to be checked point upward.

Insert feeler gauge between cam lobe and valve shim.



Warm engine specifications (coolant temp. above 35° C (95° F)

Intake — 0.20 — 0.30mm (0.008 — 0.012in.)

Exhaust — 0.40 — 0.50mm (0.016 — 0.020in.)

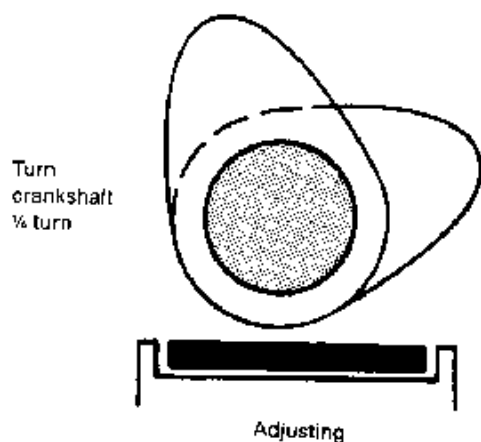
Cold engine (coolant temp. below 35° C (95° F)

Intake — 0.15 — 0.25mm (0.006 — 0.010in.)

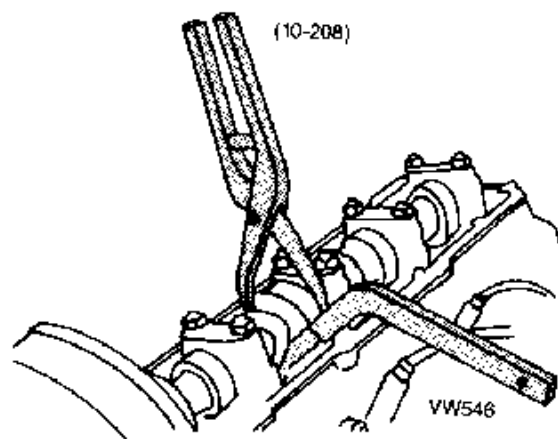
Exhaust — 0.35 — 0.45mm (0.014 — 0.018in.)

Diagnosis II — Cold Running/Starting Problems

Adjust valve clearance



If valve clearance is incorrect —
Turn crankshaft clockwise about 1/4 turn.
When adjusting valves, camshaft must be slightly offset so that valves do not contact piston when cam followers are depressed.



Depress cam followers with VW546.
Remove shim to be exchanged with 10-208.
Install proper shim.
Too small clearance — use thinner shim
Too large clearance — use thicker shim
Recheck valve clearance.

Check compression

Remove wire from fuel shut-off solenoid and insulate the wire.

Clean connections on injector lines.

Remove injector lines (be sure that delivery valves are not loosened when loosening injector lines on injection pump.).

Remove injectors using US2775 deep well socket and store in clean area.

Remove all heat shields except #1 cylinder.

Caution: loose heat shields can be blown out during compression check.

Install adaptor on #1 cylinder.

Install VW 110 gauge onto adaptor.

Operate starter until gauge reads highest reading.

**28-34 bar (400 - 500 psi)
maximum cylinder variation
5 bar (71 psi)**

Release pressure

Repeat process on remaining cylinders.

Low readings on adjacent cylinders
gasket leakage between cylinders.

Low readings on one cylinder
valve leakage.

Low readings on all cylinders
worn piston rings or jumped valve timing.

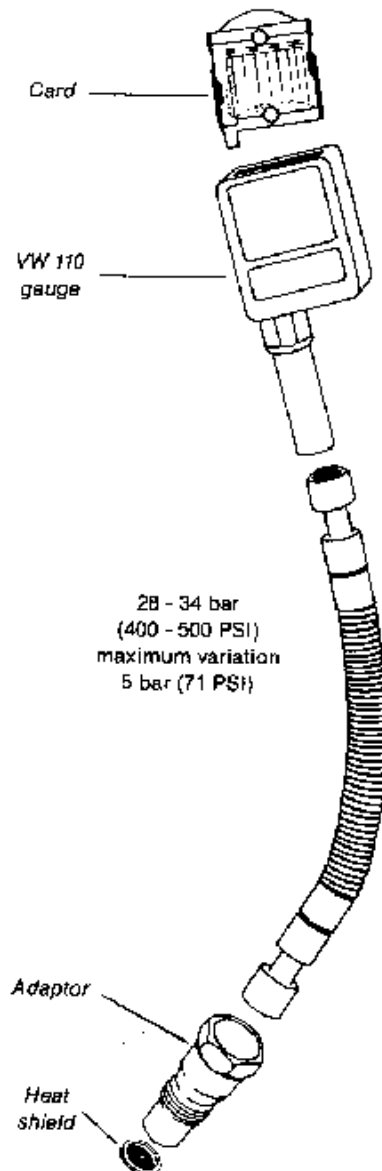
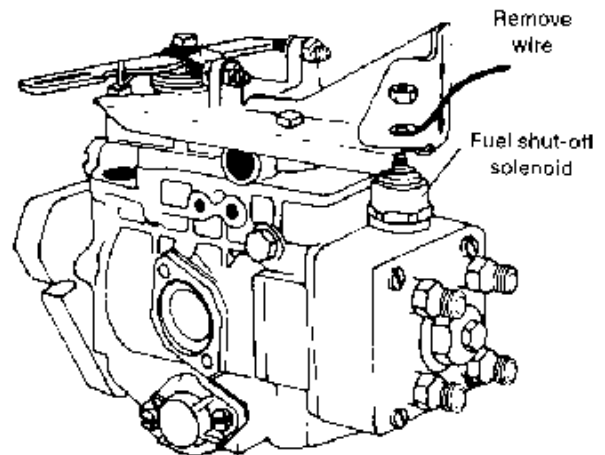
A low reading can be rechecked by adding 1 tablespoon of engine oil through the injector hole:

If the compression readings increase slightly this indicates valve leakage.

If the compression readings increase significantly this indicates worn piston rings.

If compression does not increase, check valve timing.

Always install new heat shields before reinstalling injectors.

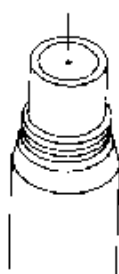


Diagnosis II — Cold Running/Starting Problems

Test injectors

There are four tests for injectors. Perform the tests in the following sequence:

Remove carbon deposits



1. Opening pressure
2. Leakage
3. Chatter
4. Spray pattern

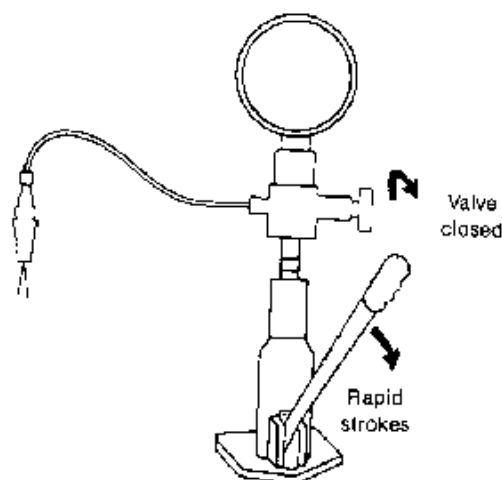
Bleed tester

Remove carbon deposits from the injector tip with a small brass brush.

Mount the injector in the tester.

Turn the tester valve clockwise to close the gauge.

Operate the tester lever with rapid strokes to prime the tester and to bleed the injector.



Opening pressure

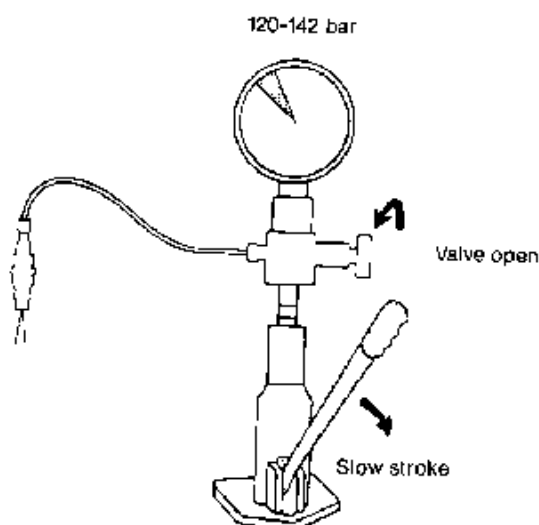
Turn the tester valve knob counterclockwise to open the gauge.

Slowly depress the tester lever until the injector just begins to spray.

Read the opening pressure.

Should be 120 to 142 bar.

Replace the injector if it is out of specifications.



Leakage

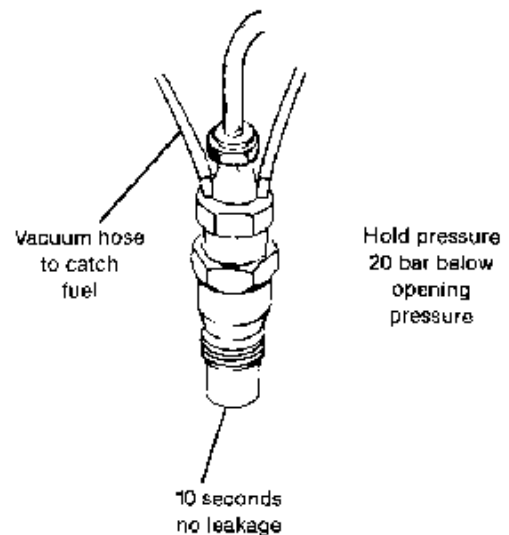
Install two pieces of vacuum hose on the injector return fittings to keep fuel from running down the side of the injector.

Dry the injector with compressed air or a lint free cloth.

Slowly depress the tester lever until the gauge reading is 20 bar below the measured opening pressure.

Hold the pressure for 10 seconds

The injector should not drip.
(A drop may form on the end of the injector - this is normal).



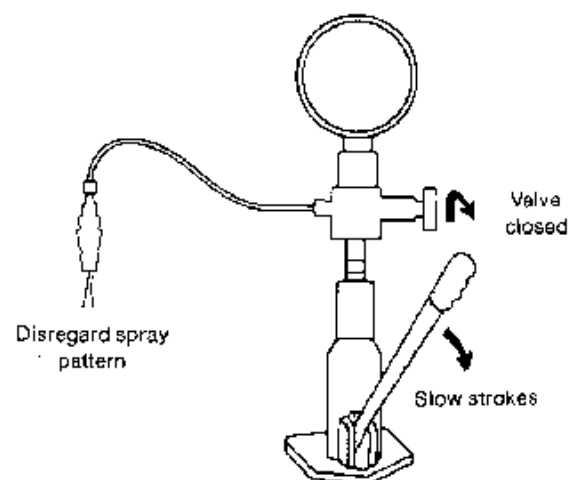
Chatter

Turn the tester valve knob clockwise to close the gauge.

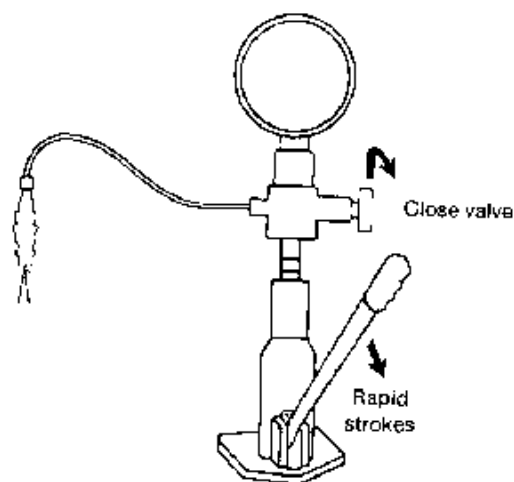
Operate the tester lever with slow strokes.
(1 to 2 strokes per second)

The injector should make a chattering or creaking sound if the injector is in good condition.

Disregard the spray pattern when checking chatter. Spray pattern can only be checked at fast pumping speeds.



Diagnosis II — Cold Running/Starting Problems



Spray pattern

Turn the tester valve knob clockwise to close the gauge.

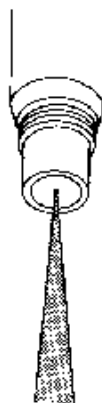
Operate the tester lever with rapid strokes (4 to 6 strokes per second).

The spray pattern should be finely atomized and cone shaped.

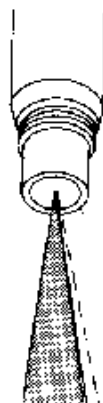
Replace injectors which have a bad spray pattern.

The tester lever must be operated rapidly. At slow pumping speeds it is normal for the spray to stream or dribble out of the injector.

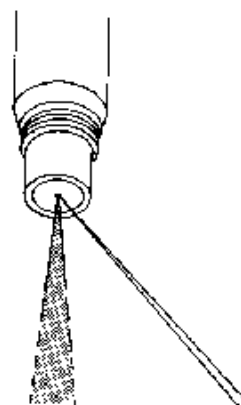
Good injector



Bad injector



Bad injector



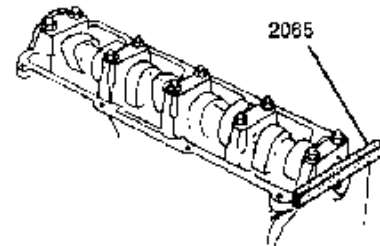
Safety

- Do not put your hands near the injector when testing injectors. The high pressure diesel fuel spray can penetrate your skin and cause blood poisoning.
- Always wear safety goggles when testing injectors.
- The injector sprays a finely atomized combustible mist when testing. Avoid sparks and high heat sources when testing injectors.
- Do not use gasoline as a "test fuel".

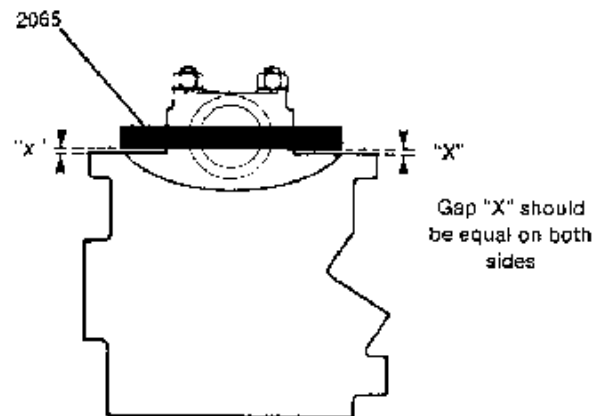
Injection system tests

Check valve timing

Turn crankshaft to align slot in rear of camshaft with valve cover sealing surface.

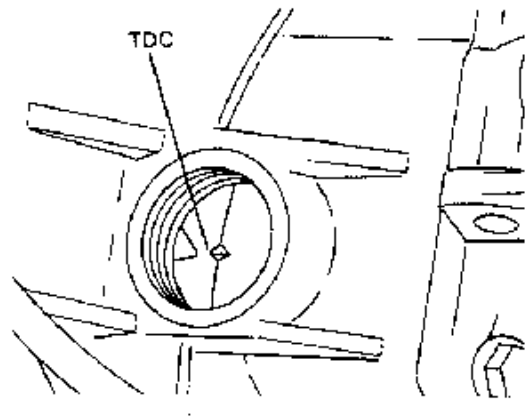


Install camshaft and setting bar #2065 and center camshaft by inserting feeler gauges between each end of 2065.
Gap "X" should be equal on both sides.



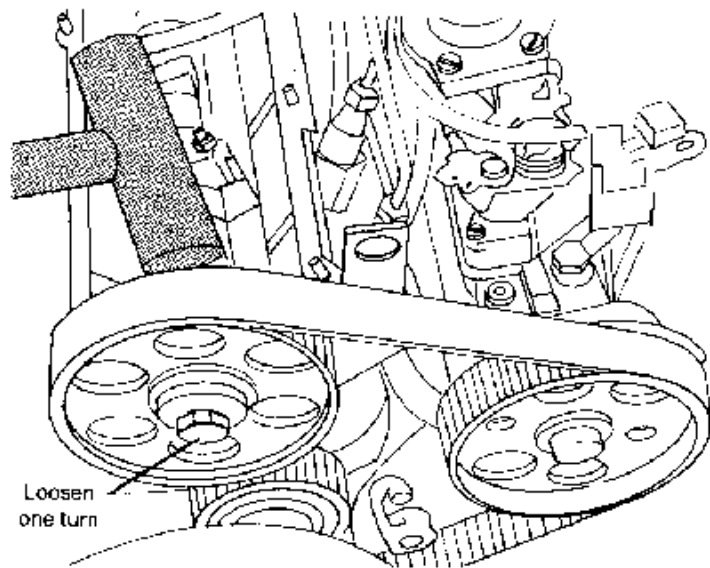
With camshaft aligned, check that flywheel is exactly on TDC.

If not — adjust valve timing.



Diagnosis II — Cold Running/Starting Problems

Adjust valve timing



If valve timing is out of adjustment:

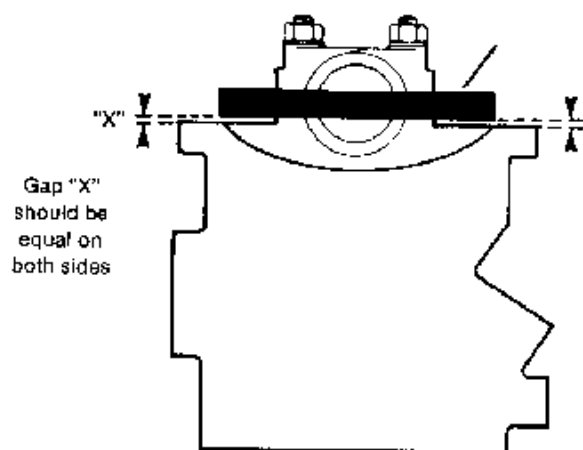
Remove spur belt cover.

Install locking tool 2065 to hold camshaft.

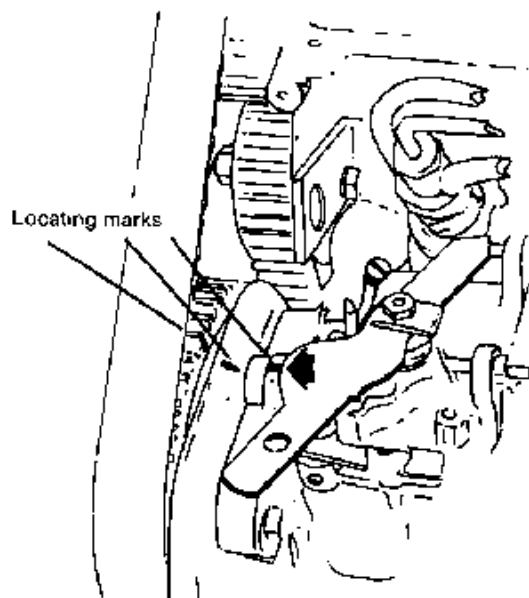
Loosen camshaft sprocket bolt one turn.

Tap backside of camshaft sprocket with rubber hammer to loosen.

The camshaft sprocket is fitted to the camshaft with a "locking taper" and does not use a locating key.



Align camshaft with 2065 and feeler gauges at "X".



Check that locating marks on sprocket, bracket and pump body are aligned.

Set flywheel to TDC.

Note: if drive belt is removed, lock injection pump sprocket with locking pin 2064.

Adjust valve timing (continued)

Install belt tension gauge VW 210 on spur belt between cam sprocket and pump sprocket.

Set VW 210 to 12 to 13mm.

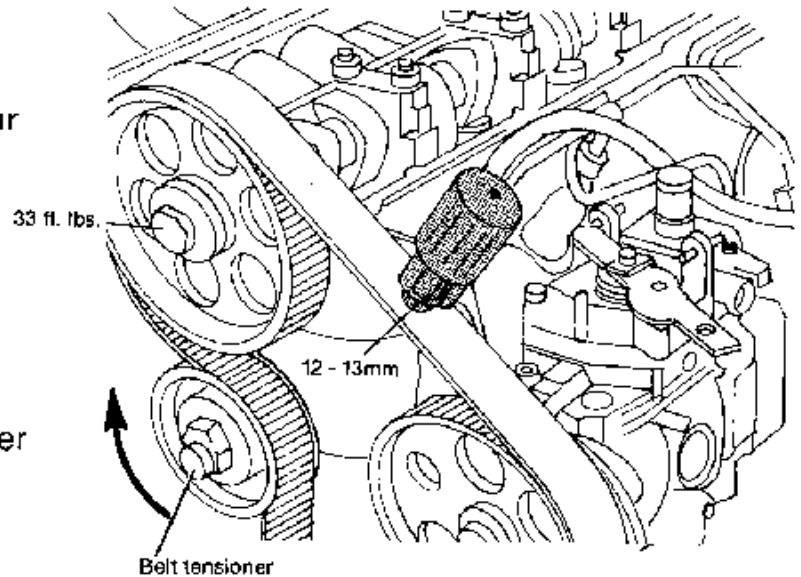
Turn belt tensioner clockwise until reference mark on tool (12 to 13mm) is aligned with edge of barrel.

Tool US4493 required on 1981 and later cars to turn belt tensioner.

Tighten tensioner nut to 33 ft.lbs.

Tighten cam sprocket bolt to 33 ft.lbs.

Make sure flywheel remains on TDC.



Remove 2065 and 2064.

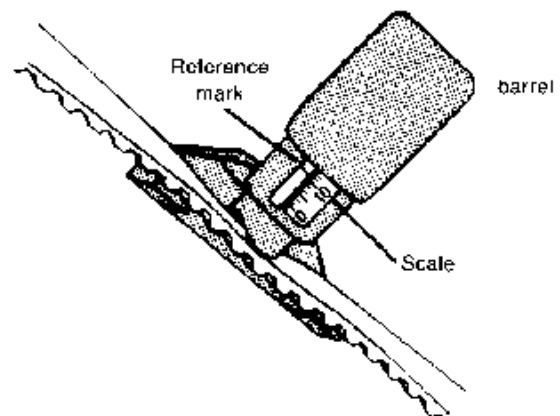
Turn crankshaft clockwise 2 turns.

Strike belt with a rubber hammer between cam sprocket and injection pump sprocket.

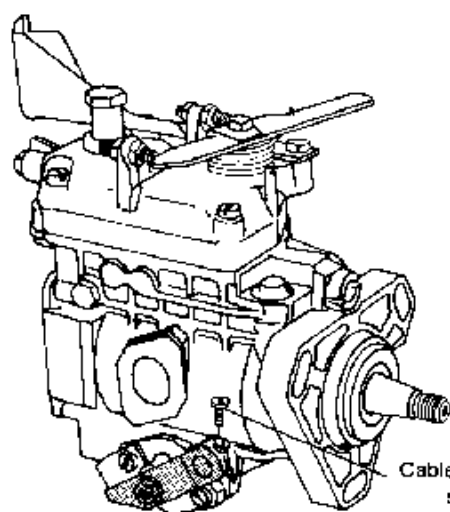
Recheck valve timing with #2065 —flywheel at TDC.

Recheck belt tension with VW 210.

Re-install spur belt cover/valve cover.



Diagnosis procedure II — Cold Running/Starting Problems



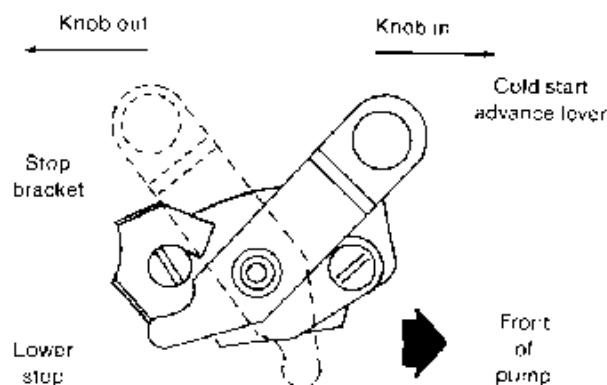
Adjust Cold Start Advance

Push in cold start knob on dash.

Loosen cable adjusting screw at cold start advance lever.

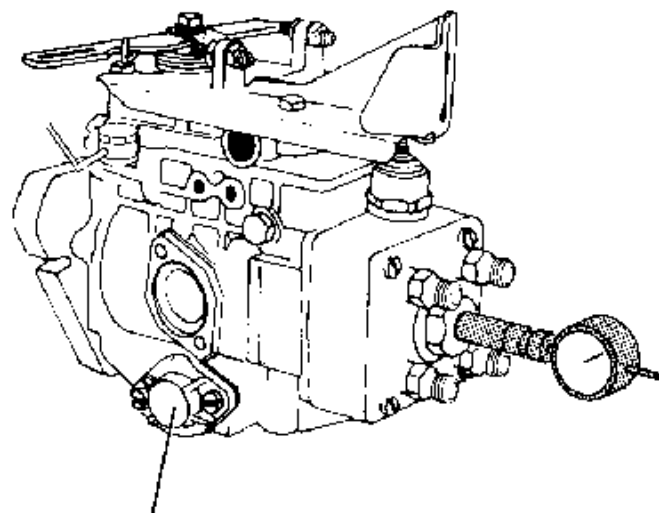
Push cold start lever down to lower stop on stop bracket.

Tighten cable adjusting screw.



Recheck that cold start advance lever touches both the lower stop and the upper stop on the stop bracket whenever the cold start cable is operated from inside the car.

Injection Timing



With cold start knob on dash pushed in.

Remove bolt from end of pump (always replace washer).

Turn engine clockwise until flywheel is at TDC.

Install adapter 2066 and dial gauge at end of pump.

Preload dial gauge (about 3mm).

Turn engine counter clockwise until dial gauge needle just stops moving.

Zero gauge.

Turn engine clockwise to TDC.

Injection Timing (cont'd.)

Gauge should read:

1.5 L engine

0.88 ± 0.05 mm (1977-80)

1.15 ± 0.05 mm (1980 cars with yellow
paint dot on advance cover)

1.6 L Turbo Diesel

1.00 ± 0.05 (1982 - 83)

1.6 L engine

0.88 ± 0.05 (1981 - 82)(and 1983 Pick-up)

0.95 ± 0.05 (1983 Rabbit, Jetta, and 4000)

0.90 ± 0.05 (1983 Vanagon)

If necessary adjust and recheck.

Adjust Idle speed

Connect VW 1367 or equivalent —
With engine warm, check idle speed.

820 ± 50 RPM (1977 - 82 and 83 Vanagon)

880 ± 50 RPM (1983 Rabbit/Jetta)

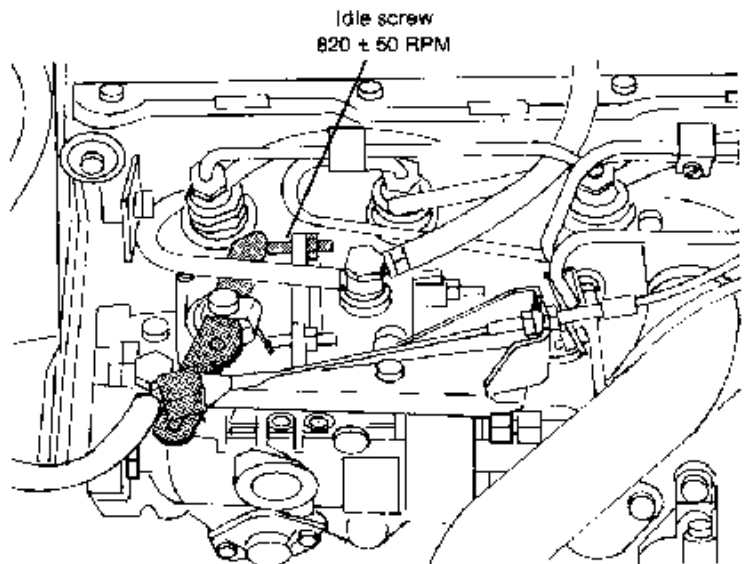
950 ± 50 RPM (82/83 Quantum, 4000)

Loosen locknut and turn adjusting screw.

Clockwise increases RPM

Counterclockwise decreases RPM

Tighten locknut.



Adjust maximum speed

Accelerate engine briefly to "maximum
speed stop."

1.6 L (5300 - 5400 RPM)

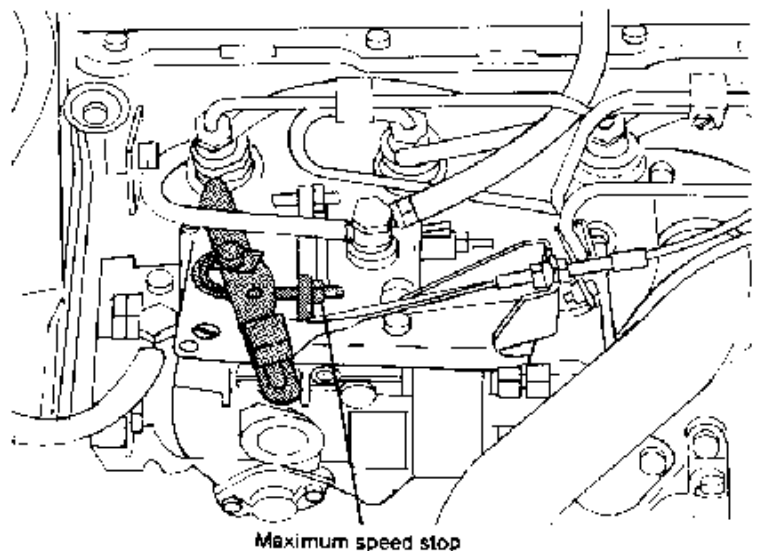
1.5 L (5500 - 5600 RPM)

Vanagon (4750 - 4850 RPM)

Adjust by loosening lockut and turning
maximum speed screw.

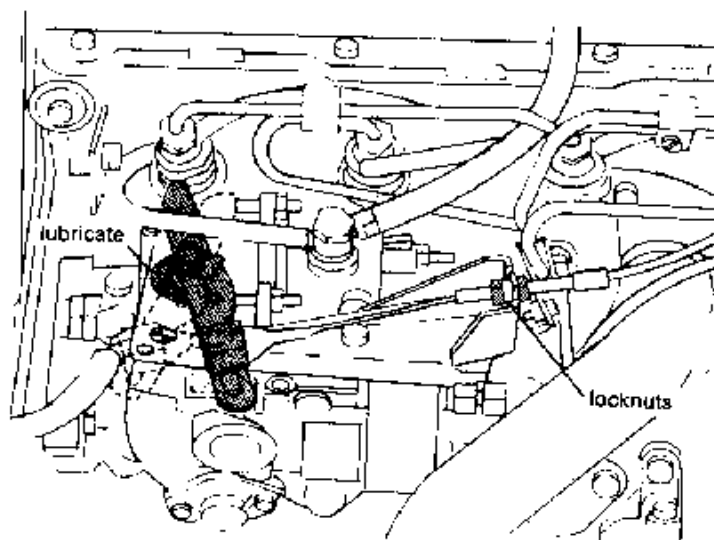
Clockwise decreases maximum RPM

Counter clockwise increases
maximum RPM



Diagnosis II — Cold Running/Starting Problems

Check accelerator cable adjustment



Lubricate throttle lever spring with spray lubricant (WD 40 or equivalent).

Check to ensure that the throttle lever rests against the idle adjustment stop.

Check to ensure that the throttle lever moves freely and does not stick.

Depress the accelerator pedal fully and check to ensure that the throttle lever contacts the maximum speed adjustment stop.

If the accelerator cable is out of adjustment.

Cars with manual transmission —

Loosen cable locknuts —

Depress accelerator pedal fully —

Adjust cable so that throttle lever contacts maximum speed screw and is not strained.

Cars with automatic transmission

If throttle linkage is out of adjustment,

See page 134.

Quality check

Suggested Repair Time — 50 time units

Except 1981 - 82 Rabbit/Jetta

- **Start engine, allow to warm up and observe idle quality.**
 - the idle speed is correct
 - engine should idle smoothly
 - the idle speed should not vary more than 50 RPM
- **With correct tire pressure, drive car on a level road.**
 - Accelerate to a constant speed of 35 MPH.
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the acceleration quality from 35 MPH to 55 MPH.**
 - engine should accelerate evenly
 - engine should not lack power or smoke
- **Maintain steady speed and observe performance quality.**
 - engine should maintain adequate performance at all speeds and show no symptoms of loss of power or smoke.

1981 - 82 Rabbit/Jetta

- **Start engine, allow to warm up and observe idle quality.**
 - the idle speed is correct
 - engine should idle smoothly
 - the idle speed should not vary more than 50 RPM
- **With correct tire pressure, drive car on a level road.**
 - Accelerate to a constant speed of 35 MPH.
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the time it takes to reach 55 MPH.**
 - should be 16.1 seconds maximum (4-speed transmission)
 - should be 18.6 seconds maximum (5-speed transmission)

If test passed

Return car to customer

If test failed — if diagnosis I and II have been completed

Replace injection pump — except 1981 - 82 Rabbit/Jetta see Special Repairs page 123.

Symptom Group 2

Idle Problems

Symptoms:

- Idle speed is erratic, speed varies up and down page 68.
- Idle speed is too high or too low..... page 68.
- Idle speed cannot be adjusted to specification page 68.
- Warm engine has rough idle but performs OK above idle..... page 71.

Idle Problems

Symptoms:

Idle speed is erratic, speed varies up and down

Idle speed is too high or too low

Idle speed cannot be adjusted to specification

Diagnosis Procedure

- **Adjust Idle speed**

Idle speed should be checked and adjusted to within specifications. If the idle speed is too high, the centrifugal advance in the pump may begin to work. This could result in symptoms of high or erratic idle.

- **Check adjustment of accelerator cable and lubricate injection pump lever**

Unless the accelerator cable is adjusted properly, the injection pump lever may not touch the idle stop. It is also important to lubricate the injection pump lever to assure that it moves freely on its pivot.

Suggested Repair Time — 40 time units

Adjust idle speed

Connect VW 1367 or equivalent.

Check idle speed, with engine warm

820 ± 50 RPM (1977 - 82 and 83 Vanagon)

880 ± 50 RPM (1983 Rabbit/Jetta)

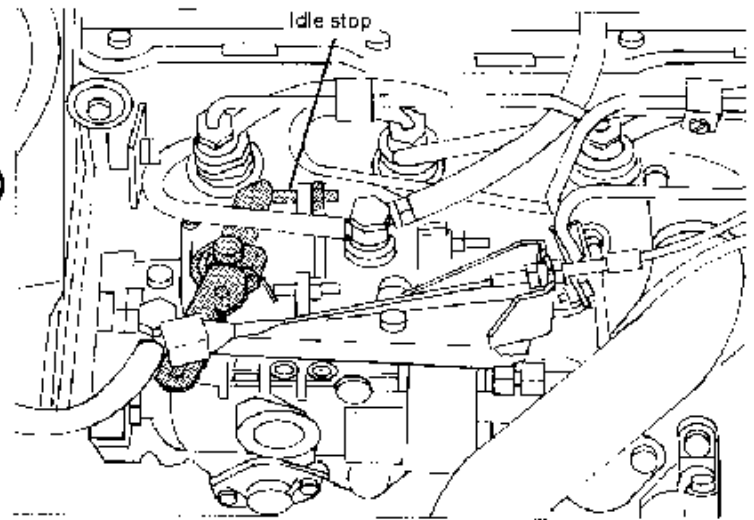
950 ± 50 RPM (82/83 Quantum, 4000)

Loosen locknut and turn adjusting screw.

clockwise increases RPM

counterclockwise decreases RPM

Tighten locknut.



Check accelerator cable adjustment Lubricate accelerator lever

Lubricate accelerator lever return spring with spray lubricant (WD 40 or equivalent).

Check to ensure that the accelerator lever rests against the idle adjustment stop.

Check to ensure that the accelerator lever moves freely and does not stick.

Depress the accelerator pedal fully and check to ensure that the accelerator lever contacts the maximum speed adjustment stop.

If the accelerator cable is out of adjustment,

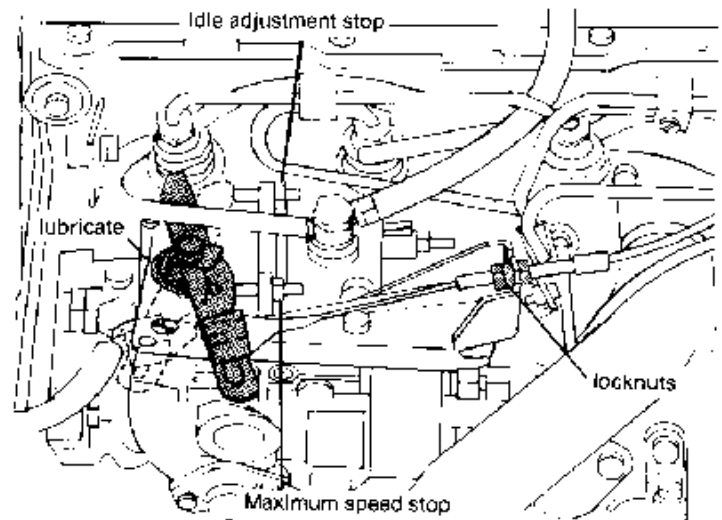
Cars with manual transmission —

If the throttle linkage is out of adjustment,

Loosen cable locknuts —

Depress accelerator pedal fully —

Adjust cable so that throttle lever contacts maximum speed screw and is not strained.



Cars with automatic transmission

If throttle linkage is out of adjustment,

See page 134.

Quality check

Suggested Repair Time — 5 time units

- **With fully warmed engine, raise engine speed to 3000 RPM for about 5 seconds.**
- **Release the injection pump lever and let the engine return to idle.**
- **Measure idle speed with VW 1367 and check that:**
 - The idle speed is correct
 - The idle speed does not vary more than 50 RPM
 - The idle is not rough

If test passed

Return car to customer

If test failed

Perform diagnosis procedure II, page 81.

Idle problems

Symptom:

Warm engine has rough idle but performs OK above idle.

Rough idle can cause vibration. If a customer describes a "vibration" symptom, first assess whether or not the vibration is due to a rough idle. If the idle is not rough, skip this section and go directly to Special Repairs — page 124.

Diagnosis Procedure

- **Adjust idle speed**

Idle speed should be checked and adjusted to within specifications. If the idle speed is too low, a rough idle as well as a vibration may result.

- **Check for air leaks**

Loose connections or cracked hoses between the fuel tank and injection pump may result in air in the fuel system. Air trapped in injectors or fuel lines may result in a rough idle.

- **Check for fuel leaks**

Fuel leaks at fuel lines and fuel delivery valves reduce fuel pressure affecting fuel delivery — a rough idle can result.

- **Check injection pump mounting brackets**

Loose pump mounting brackets can cause pump misalignment and injection timing change resulting in idle problems.

- **Perform idle speed drop test**

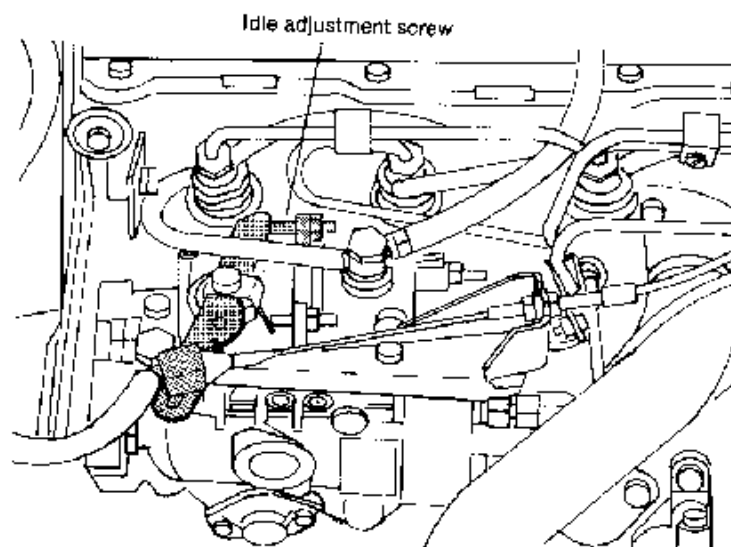
If fuel is not supplied equally by all injectors, a rough idle may result. The idle speed drop test will verify equal fuel delivery by injectors.

Suggested Repair Time — 50 time units

Note: If a problem is found in the idle speed drop test, see SRT manual for additional labor operations for checking injectors, valve adjustment, and compression.

Idle Problems — Rough Idle (cont'd.)

Adjust idle speed



Connect VW 1367 or equivalent.

Check idle speed, with engine warm.

820 ± 50 RPM (1977 - 82 and 83 Vanagon)

880 ± 50 RPM (1983 Rabbit/Jetta)

950 ± 50 RPM (82/83 Quantum, 4000)

Loosen locknut and turn adjusting screw.

clockwise increases RPM.

counterclockwise decreases RPM.

Tighten locknut.

Check for air leaks

Start the engine and run it at about 2000 RPM.

Check the clear fuel supply line.

A steady stream of bubbles indicates either an air leak in the fuel supply system or water in the fuel filter. (A few bubbles may appear, this is normal)

Check for air leaks caused by :

Loose fuel filter

Loose connections on fuel filter assembly

Loose union bolt on fuel pump

Loose connections at fuel supply lines

Loose bleeder screw on filter housing

If no air leaks are found and if bubbles still appear, check for water in the fuel.

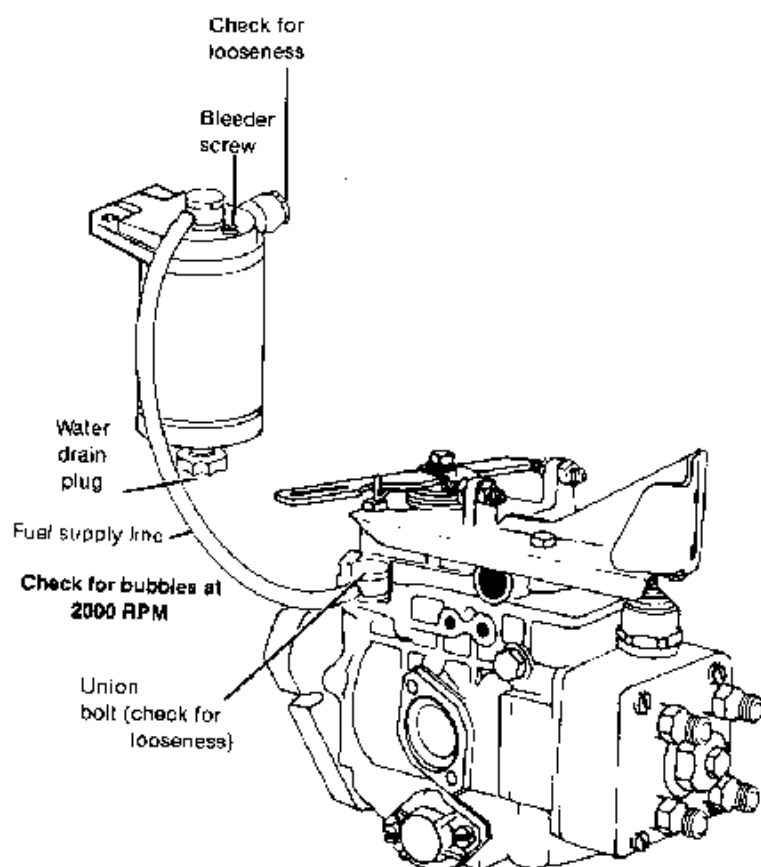
Drain the water trap in the fuel filter

Open the bleeder screw on the filter flange.

Loosen the drain plug on the filter.

Drain the fuel into a container until the drained fuel is pure.

Tighten the drain plug and the bleeder screw.



Check for fuel leaks

With engine running, check all connections for fuel leaks:

Check fuel lines at injectors and delivery valves.

If leaking —

Retorque fuel lines to 25Nm (18 ft. lbs.) (use 17mm split socket).

If still leaking —

Replace lines and torque to specifications.

Check fuel delivery valves at injection pump.

If leaking —

Remove fuel lines and fuel delivery valves.

Replace sealing washer with bronze washer #068 130 787.

Torque delivery valve to 55 Nm (40 ft.lbs.).

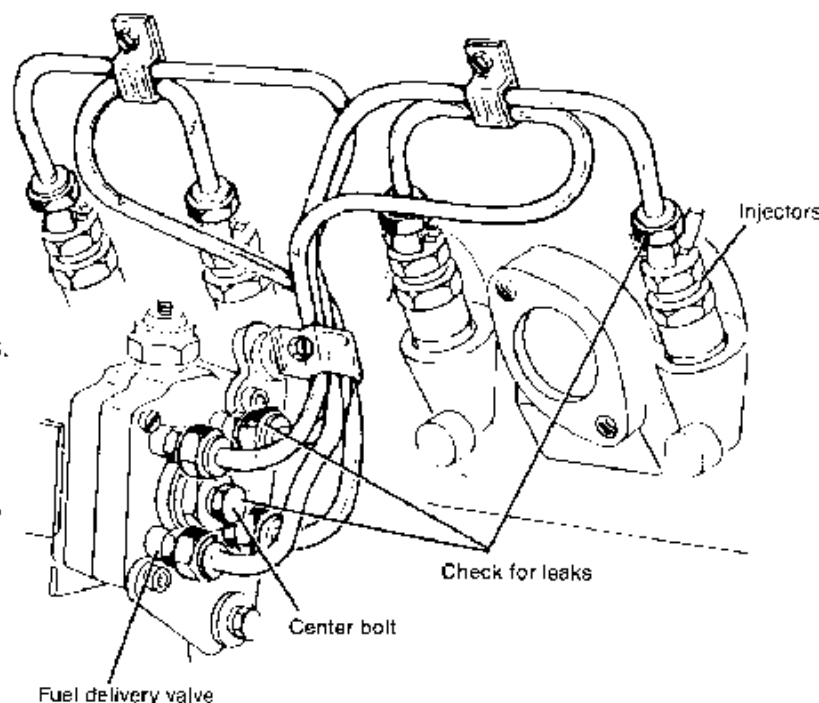
Reinstall and torque fuel lines.

Start engine and check for leaks.

Check center bolt at end of injection pump.

If leaking —

Remove bolt and replace sealing washer.



Note: Wipe off all spilled fuel with rubbing alcohol. Diesel fuel left on hoses will cause the hoses to deteriorate.

Check pump mounting brackets

Check tightness of:

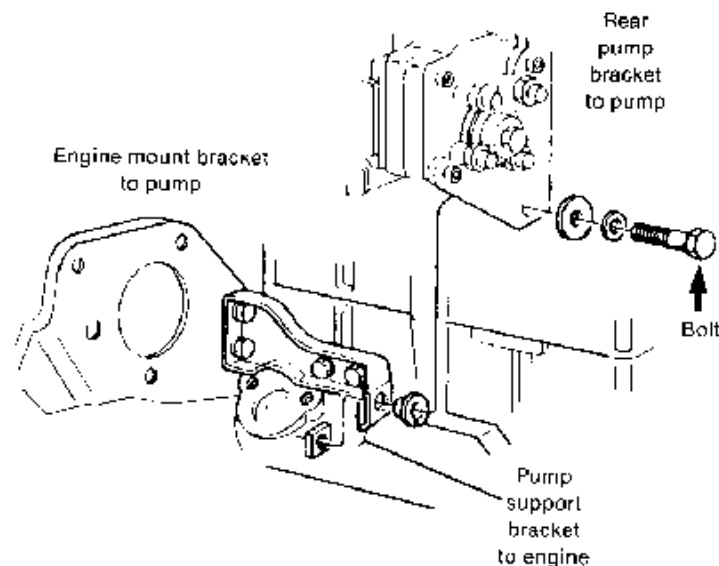
Engine mount bracket to pump

Pump support bracket to engine

Bolt fastening rear pump bracket to pump support bracket

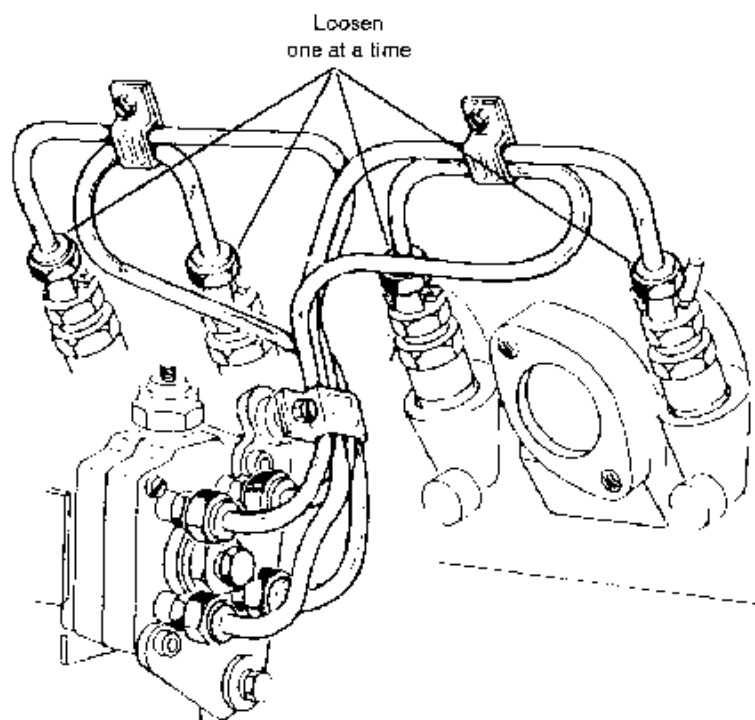
With a mirror, visually check for clearance between rear pump bracket and pump support bracket.

Install a flat washer between brackets to take up any clearance.



Idle Problems — Rough Idle (cont'd.)

Perform idle speed drop test



Connect VW 1367 to measure engine RPM

With car running:

Loosen injector lines at injectors one at a time.

Observe amount of change or no change in idle speed to determine "weak" or "dead" cylinder(s).

Idle speed should drop approximately the same on all cylinders as injector lines are loosened.

If the problem cannot be isolated to a particular cylinder see Diagnosis II page 81.

If a "weak" or "dead" cylinder is found —

1. Check that injector line on affected cylinder is not crimped or restricted.
2. Check injectors
page 75.
3. Check valve clearance
page 78.
4. Check compression
page 79.

Safety

- Wear safety goggles when performing idle speed drop test.
- After performing idle speed drop test, be sure to wipe off all spilled fuel with rubbing alcohol. Diesel fuel spilled on hoses will cause the hoses to deteriorate.
- Keep a fire extinguisher accessible.

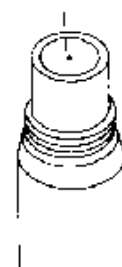
Test injectors

If a "weak" or "dead" cylinder is found, the injector for that cylinder should be checked.

There are four tests for injectors. Perform the tests in the following sequence:

1. Opening pressure
2. Leakage
3. Chatter
4. Spray pattern

Remove carbon deposits



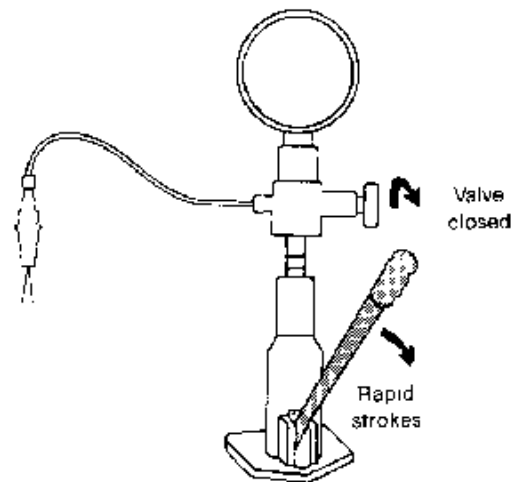
Bleed Tester

Remove carbon deposits from the injector tip with a small brass brush.

Mount the injector in the tester.

Turn the tester valve clockwise to close the gauge.

Operate the tester lever with rapid strokes to prime the tester and to bleed the injector.



Opening Pressure

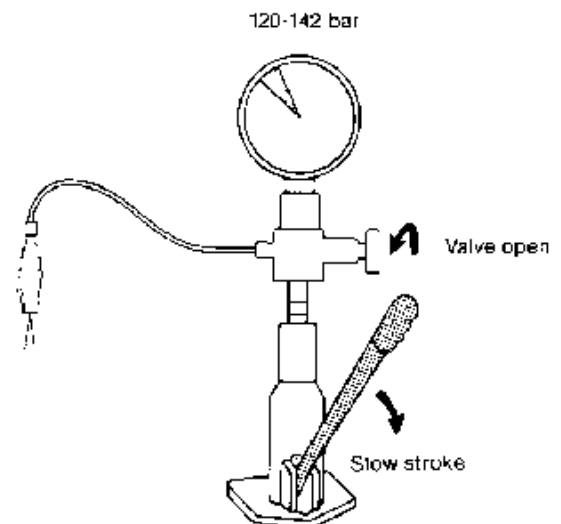
Turn the tester valve knob counterclockwise to open the gauge.

Slowly depress the tester lever until the injector just begins to spray.

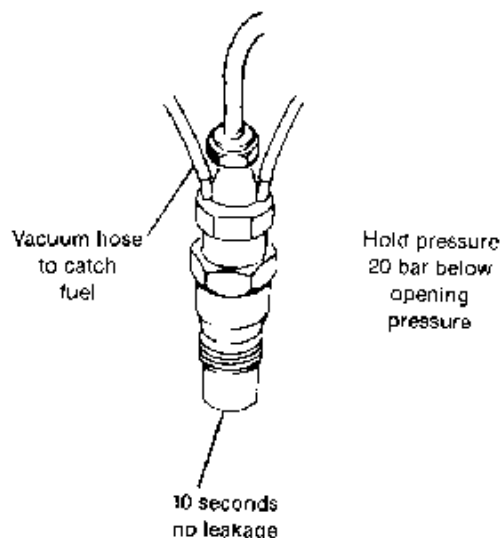
Read the opening pressure,

should be 120 to 142 bar

Replace the injector if it is out of specifications.



Idle Problems — Rough Idle (cont'd.)



Leakage

Install two pieces of vacuum hose on the injector return fittings to keep fuel from running down the side of the injector.

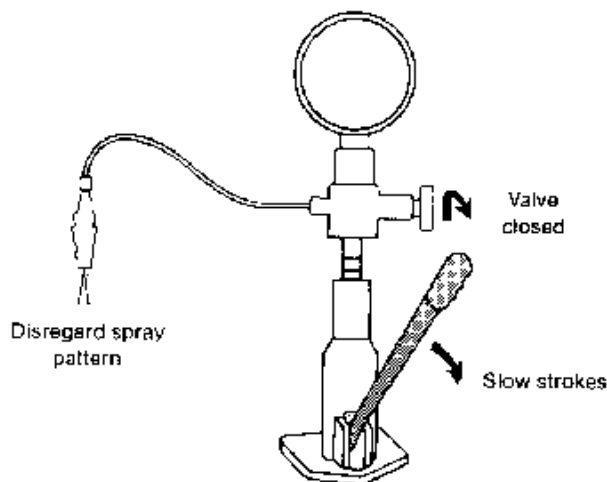
Dry the injector with compressed air or a lint free cloth.

Slowly depress the tester lever until the gauge reading is 20 bar below the measured opening pressure.

Hold the pressure for 10 seconds

the injector should not drip.

(a drop may form on the end of the injector — this is normal.)



Chatter

Turn the tester valve knob clockwise to close the gauge.

Operate the tester lever with slow strokes. (1 to 2 strokes per second)

The injector should make a chattering or creaking sound if the injector is in good condition.

Disregard the spray pattern when checking chatter. Spray pattern can only be checked at fast pumping speeds.

Spray Pattern

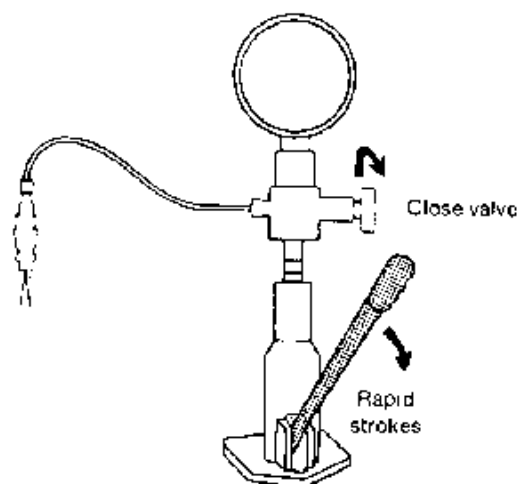
Turn the tester valve knob clockwise to close the gauge.

Operate the tester lever with rapid strokes (4 to 6 strokes per second).

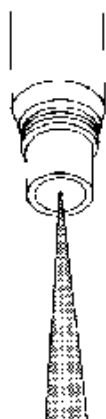
the spray pattern should be finely atomized and cone shaped.

Replace injectors which have a bad spray pattern.

The tester lever must be operated rapidly. At slow pumping speeds it is normal for the spray to stream or dribble out of the injector.



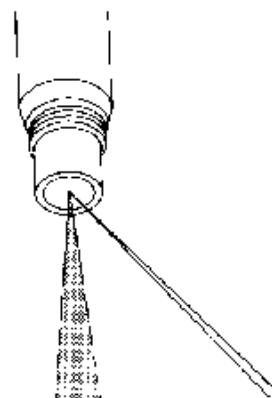
Good injector



Bad injector



Bad injector

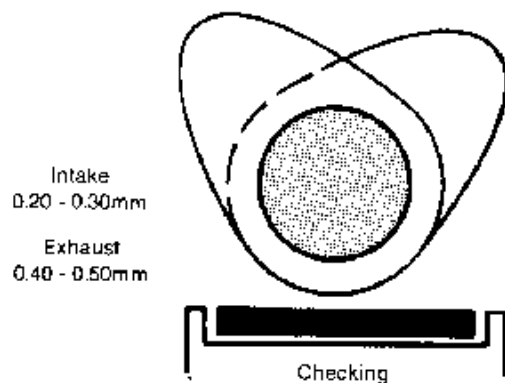


Safety

- Do not put your hands near the injector when testing injectors. The high pressure diesel fuel spray can penetrate your skin and cause blood poisoning.
- Always wear safety goggles when testing injectors.
- The injector sprays a finely atomized combustible mist when testing. Avoid sparks and high heat sources when testing injectors.
- Do not use gasoline as a "test fluid."

Idle Problems — Rough Idle (cont'd.)

Check valve clearance



Remove valve cover.

Turn crankshaft clockwise until the cam lobes of the cylinder to be checked point upward.

Insert feeler gauge between cam lobe and valve shim.

Warm engine specifications (coolant temp. above 35°C (95°F))

Intake — 0.20 - 0.30mm (.008 - .012in.)

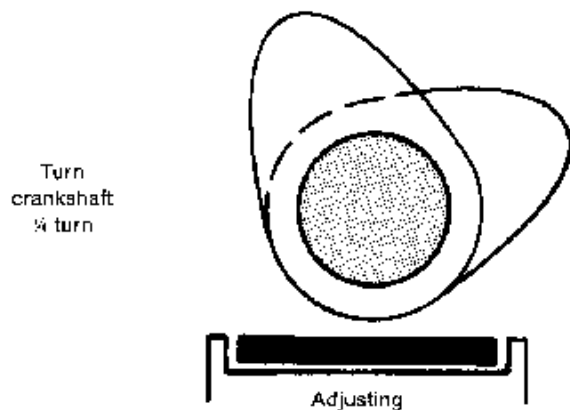
Exhaust — 0.40 - 0.50mm (.016 - .020in.)

Cold engine (coolant temp. below 35°C (95°F)).

Intake — 0.15 - 0.25mm (0.006 - 0.010in.)

Exhaust — 0.35 - 0.45mm (0.014 - 0.018in.)

Adjust Valve Clearance



If valve clearance is incorrect —

Turn crankshaft clockwise about ¼ turn.

When adjusting valves on the diesel, the camshaft must be slightly offset so that valves do not contact pistons when the cam follower is depressed.

Depress cam followers with VW 546.

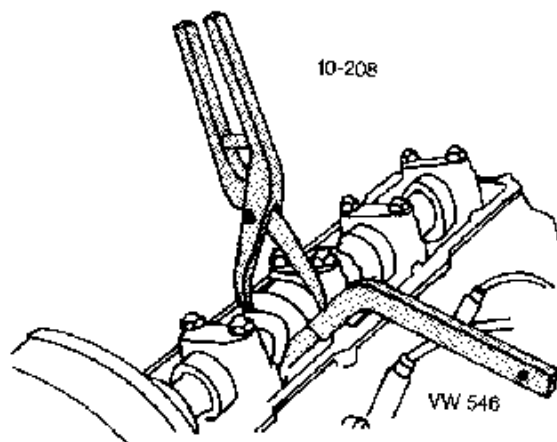
Remove shim to be exchanged with 10-208.

Install proper shim.

too small clearance - use thinner shim

too large clearance - use thicker shim

Recheck valve clearance.



Check compression

Remove wire from fuel shut-off solenoid and insulate the wire.

Clean connections on injector lines.

Remove injector lines (be sure that delivery valves are not loosened when loosening injector lines on injection pump.).

Remove injectors using US2775 deep well socket and store in a clean area.

Remove all heat shields except #1 cylinder.

Caution: loose heat shields can be blown out during compression check.

Install adaptor on #1 cylinder.

Install VW 110 gauge onto adaptor.

Operate starter until gauge reads highest reading.

**28-34 bar (400 - 500 psi)
maximum cylinder variation
5 bar (71 psi)**

Release pressure

Repeat process on remaining cylinders.

Low readings on adjacent cylinders
gasket leakage between cylinders.

Low readings on one cylinder
valve leakage.

Low readings on all cylinders
worn piston rings or jumped valve timing.

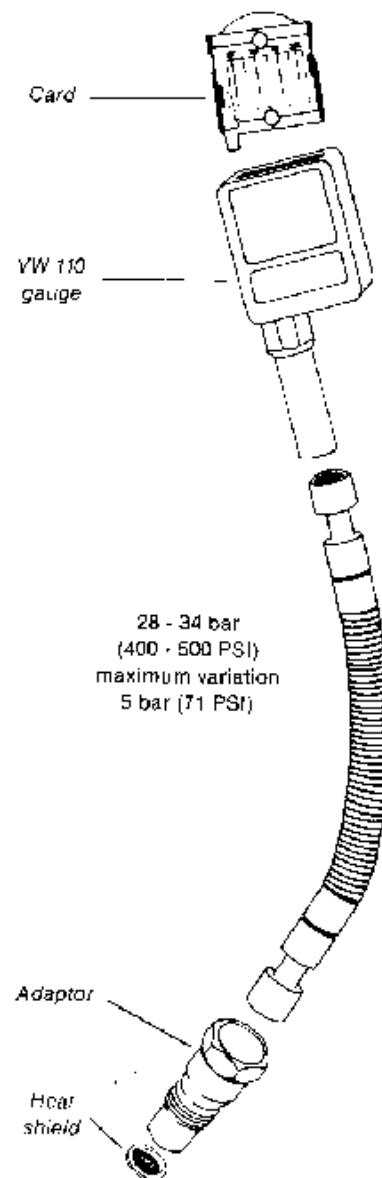
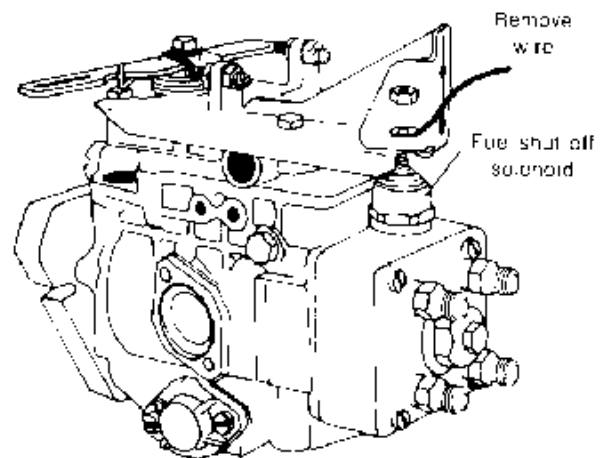
A low reading can be rechecked by adding 1 tablespoon of engine oil through the injector hole:

If the compression readings increase slightly this indicates valve leakage.

If the compression readings increase significantly this indicates worn piston rings.

If compression does not increase, check valve timing.

Always install new heat shields before reinstalling injectors.



**28 - 34 bar
(400 - 500 PSI)
maximum variation
5 bar (71 PSI)**

Idle Problems

Quality Check

Suggested Repair Time — 5 time units

- **With fully warm engine, raise engine speed to 3000 RPM for about 5 seconds.**
- **Release the throttle and let the engine return to idle.**
- **Measure idle speed with VW 1367 and check that:**
 - The idle speed is correct
 - The idle speed does not vary more than 50 RPM
 - The idle is not rough

If test passed

Return car to customer

If test failed

Perform diagnosis procedure II, page 81.

Diagnosis II — Idle problems

Perform injection system tests*

Includes:

Check/adjust valve timing

Check/adjust cold start

Check/adjust injection pump timing

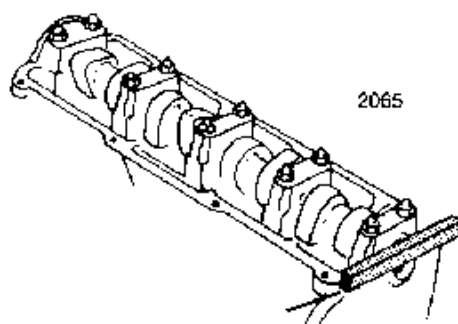
Check/adjust idle and maximum speed

Suggested Repair Time — 150 time units

*Engine idle is affected by valve timing, spur belt tension, cold start advance, injection pump timing, accelerator cable adjustment, idle speed and maximum speed. Therefore all of these items should be checked to assure that all factors that can cause idle problems are adjusted properly.

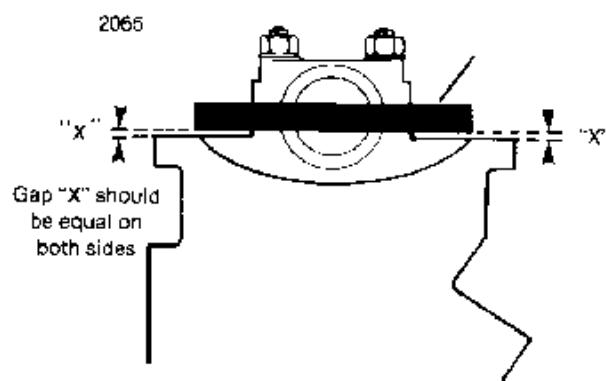
Diagnosis II — Idle problems

Check valve timing



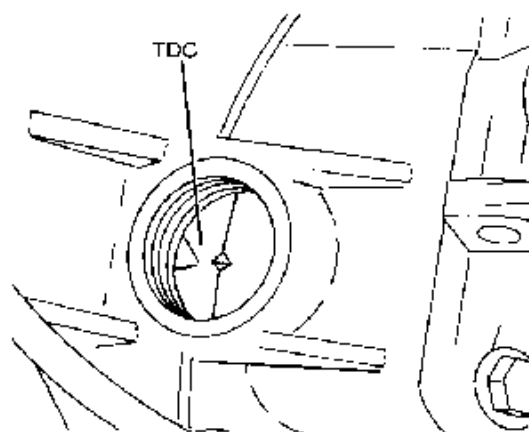
Remove valve cover.

Turn crankshaft clockwise to align slot in rear of camshaft with valve cover sealing surface.



Install camshaft setting bar #2065 and center camshaft by inserting feeler gauges between each end of #2065.

Gap "x" should be equal on both sides.



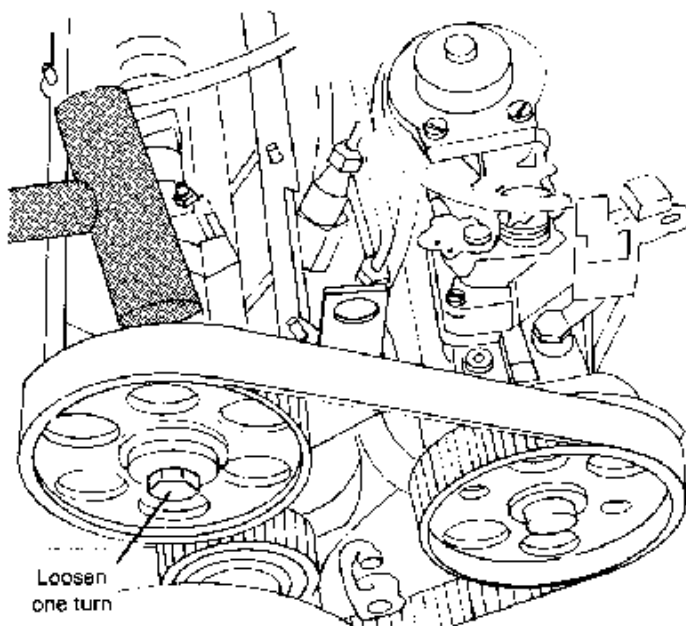
With camshaft aligned:

Check that the flywheel is exactly on TDC.
If not - adjust valve timing.

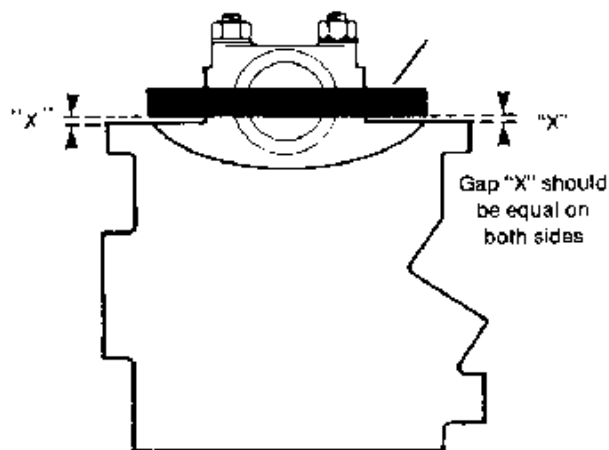
Adjust valve timing

If valve timing is out of adjustment,
Remove spur belt cover.
Install locking tool 2065 to hold camshaft.
Loosen camshaft sprocket bolt one turn.
Tap backside of camshaft sprocket with
rubber hammer to loosen.

The camshaft sprocket is fitted to the
camshaft with a "locking taper" and
does not use a locating key.



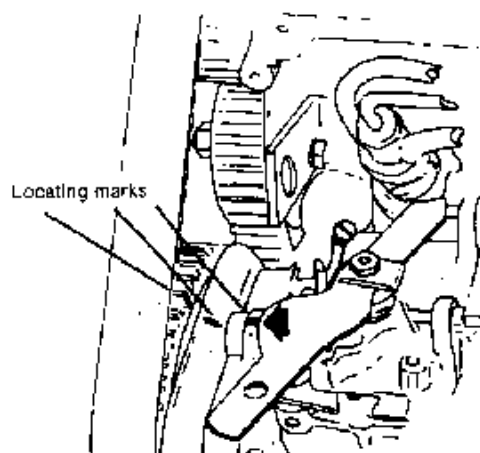
Align camshaft with bar # 2065 and feeler
gauges at "X".



Check that locating marks on sprocket,
bracket and pump body are aligned.

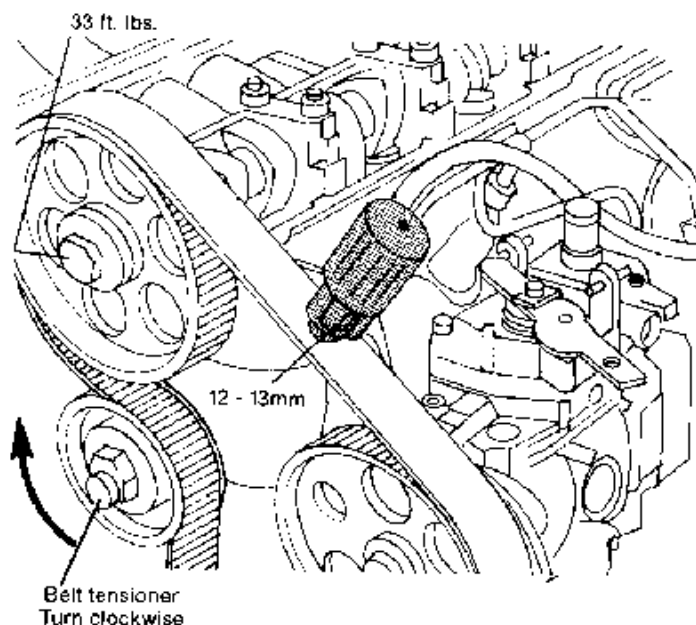
Set flywheel to TDC

Note: if drive belt is removed, lock injection
pump sprocket with locking pin 2064.



Diagnosis II — Idle problems

Adjust valve timing (continued)



Install belt tension gauge VW 210 on spur belt between cam sprocket and pump sprocket.

Set VW 210 to 12 to 13mm.

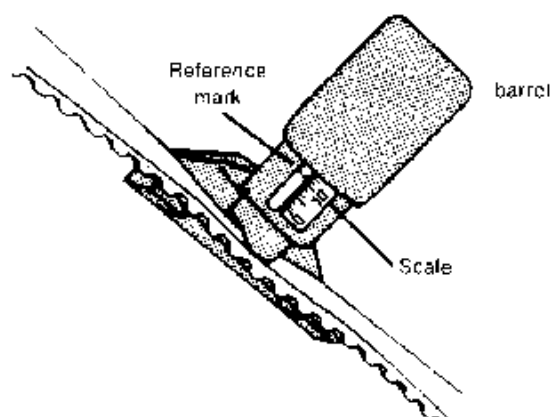
Turn belt tensioner clockwise until reference mark on tool (12 to 13mm) is aligned with edge of barrel.

Tool US 4493 required on 1981 and later cars, to turn belt tensioner.

Tighten tensioner nut to 33 ft.lbs.

Tighten cam sprocket bolt to 33 ft.lbs.

Make sure flywheel remains on TDC.



Remove 2065 and 2064.

Turn crankshaft clockwise 2 turns.

Strike belt with a rubber hammer between cam sprocket and injection pump sprocket.

Recheck valve timing with #2065 — flywheel at TDC.

Recheck belt tension with VW 210.

Re-install spur belt cover/valve cover.

Adjust Cold Start Advance

Push in cold start knob on dash.

Loosen cable adjusting screw at cold start advance lever.

Push cold start lever down to lower stop on stop bracket.

Tighten cable adjusting screw.

Recheck that cold start advance lever touches both the lower stop and the upper stop on the stop bracket whenever the cold start cable is operated from inside the car.

Injection Timing

With cold start knob on dash pushed in,

Remove bolt from end of pump (always replace washer).

Turn engine clockwise until flywheel is at TDC.

Install adapter 2066 and dial gauge at end of pump.

Preload dial gauge (about 3mm).

Turn engine counter clockwise until dial gauge needle just stops moving.

Zero gauge.

Turn engine clockwise to TDC.

Gauge should read:

1.5 L engine

$0.88 \pm 0.05\text{mm}$ (1977-80)

$1.15 \pm 0.05\text{mm}$ (1980 cars with yellow paint dot on advance cover)

1.6 L engine

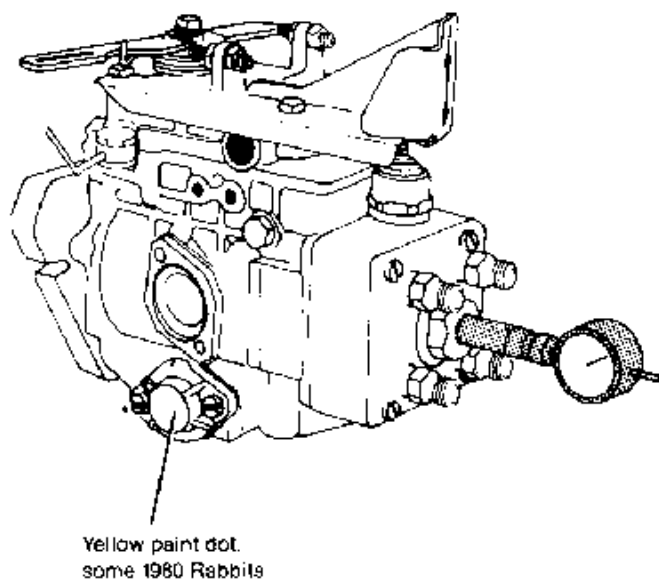
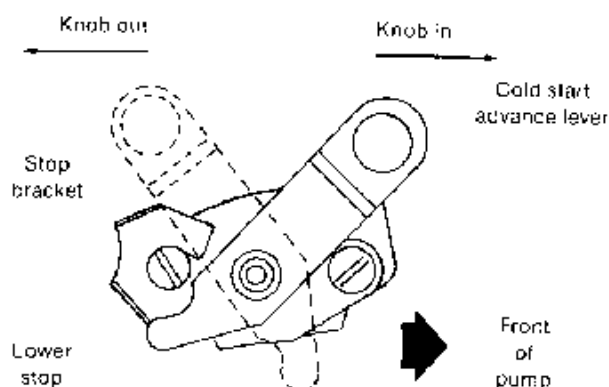
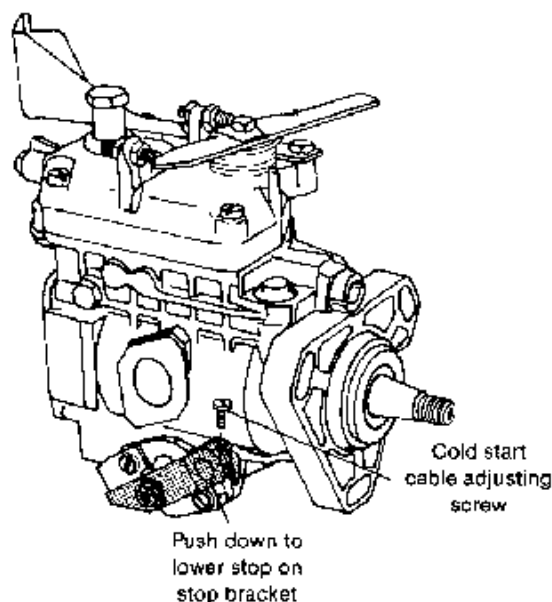
0.88 ± 0.05 (1981 - 1982)(and 83 Pick-up)

0.95 ± 0.05 (1983 Rabbit, Jetta, 4000)

0.90 ± 0.05 (83 Vanagon)

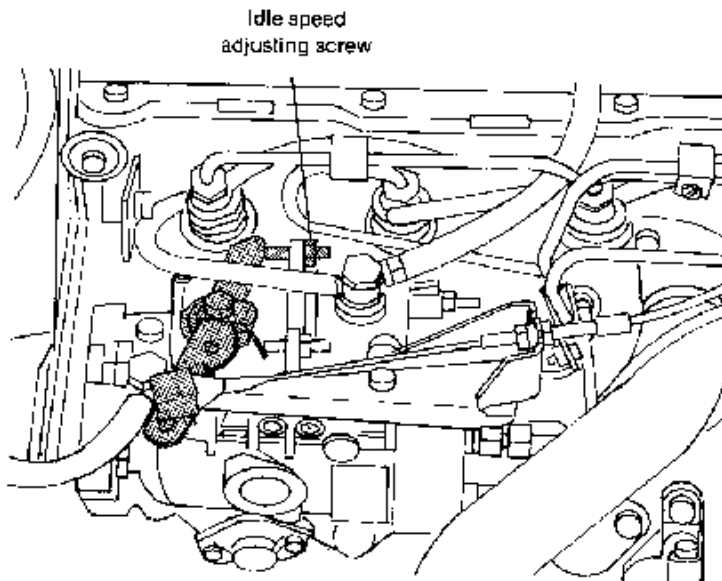
1.6 L Turbo Diesel

1.00 ± 0.05 (1982 - 83)



Diagnosis II — Idle Problems

Adjust Idle Speed



Connect VW 1367 or equivalent. With engine warm check idle speed

820 ± 50 RPM (1977 - 82 and 83 Vanagon)

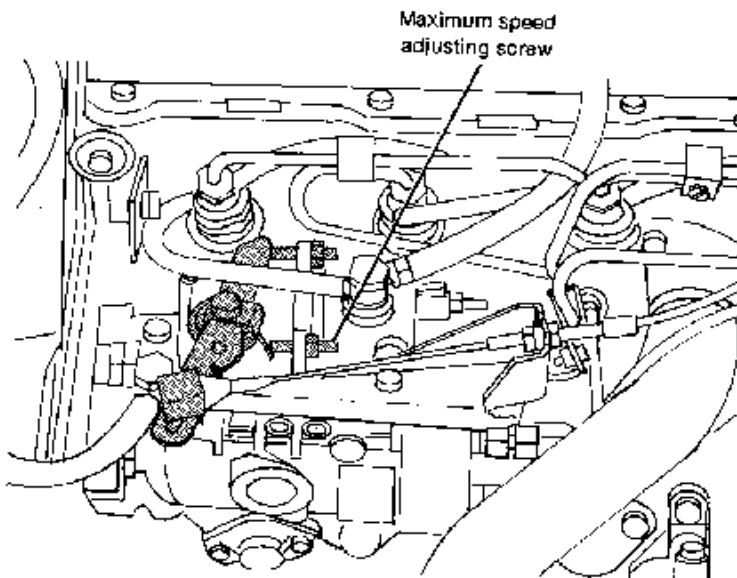
880 ± 50 RPM (1983 Rabbit/Jetta)

950 ± 50 RPM (82/83 Quantum, 4000)

Loosen lock nut and turn adjusting screw.
clockwise increases rpm
counter clockwise decreases rpm

Tighten lock nut.

Adjust Maximum Speed



Accelerate engine briefly to maximum speed stop.

1.6 L (5300 - 5400 RPM)

1.5 L (5500-5600 RPM)

Vanagon (4750 - 4850 RPM)

Adjust by loosening locknut and turning maximum speed screw.

clockwise decreases maximum RPM
counterclockwise increases maximum RPM

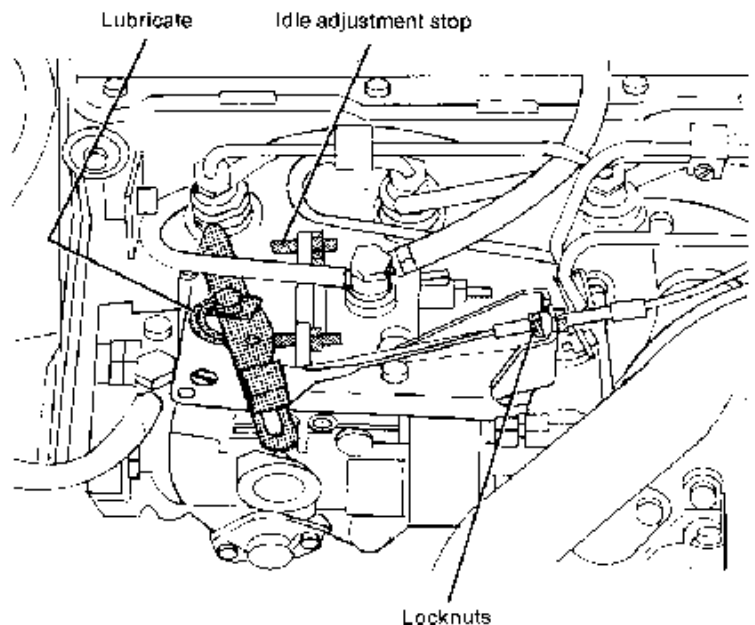
Check accelerator cable adjustment

Lubricate accelerator lever return spring with spray lubricant (WD 40 or equivalent).

Check to ensure that the accelerator lever rests against the idle adjustment stop.

Check to ensure that the accelerator lever moves freely and does not stick.

Depress the accelerator pedal fully and check to ensure that the accelerator lever contacts the maximum speed adjustment stop.



If the accelerator cable is out of adjustment,

Cars with manual transmission —

If the throttle linkage is out of adjustment,

Loosen cable locknuts —

Depress accelerator pedal fully —

Adjust cable so that throttle lever contacts maximum speed screw and is not strained.

Cars with automatic transmission

If throttle linkage is out of adjustment,

See page 134.

Idle Problems

Quality check

Suggested Repair Time — 50 time units

Except 1981 - 82 Rabbit/Jetta

- **Start engine, allow to warm up and observe idle quality.**
 - the idle speed is correct
 - engine should idle smoothly
 - the idle speed should not vary more than 50 RPM
- **With correct tire pressure, drive car on a level road.**
Accelerate to a constant speed of 35 MPH.
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the acceleration quality from 35 MPH to 55 MPH.**
 - engine should accelerate evenly
 - engine should not lack power or smoke
- **Maintain steady speed and observe performance quality.**
 - engine should maintain adequate performance at all speeds and show no symptoms of loss of power or smoke.

1981 - 82 Rabbit/Jetta

- **Start engine, allow to warm up and observe idle quality.**
 - the idle speed is correct
 - engine should idle smoothly
 - the idle speed should not vary more than 50 RPM
- **With correct tire pressure, drive car on a level road.**
Accelerate to a constant speed of 35 MPH.
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the time it takes to reach 55 MPH.**
 - should be 16.1 seconds maximum (4-speed transmission)
 - should be 18.6 seconds maximum (5-speed transmission)

If test passed

Return car to customer

If test failed — If diagnosis I and II have been completed

Replace injection pump.

Symptom Group 3

Warm Running Problems

Symptoms:

- Warm engine misfires or makes knocking noises page 92.
Warm engine surges page 102.
Warm engine lacks power and/or smokes excessively page 106.

Warm Running Problems

Symptom:

Warm Engine Misfires or Makes Knocking Noises

(Symptoms may not occur at all engine speeds)

Diagnosis Procedure

- **Check fuel quality**

Poor fuel quality, low cetane rating, additives, improper mixing with kerosene or gasoline can cause a less combustible mixture and possible misfire.

- **Check fuel supply system for air leaks**

Loose connections or cracked hoses between the fuel tank and injection pump may result in air in the fuel system. Air trapped in injectors or lines can cause a misfire or knocking noise.

- **Check fuel delivery system for fuel leaks**

Fuel leaks at fuel lines and fuel delivery valves reduce fuel pressure and therefore affect fuel delivery to the cylinders.

- **Check injection pump mounting brackets**

Loose pump mounting brackets can cause pump misalignment and injection timing change resulting in a misfire or knocking noise.

- **Idle speed drop test**

Whether or not fuel is being supplied to injectors can be verified so that a misfire or knocking noise can be isolated to the affected cylinder.

Suggested Repair Time — 50 time units

Note: If a problem is found in the idle speed drop test, see SRT manual for additional labor operations for checking injectors, valve adjustment, and compression.

Check fuel quality

Poor fuel quality can cause a lack of performance and engine smoking. In addition, if too much gasoline or other additives are mixed with the fuel, the cetane rating of the fuel will be lowered below the point at which it will burn properly in the engine.

Check for air leaks

Start the engine and run it at about 2000 RPM.

Check the clear fuel supply line.

A steady stream of bubbles indicates either an air leak in the fuel supply system or water in the fuel filter. (A few bubbles may appear, this is normal)

Check for air leaks caused by :

- Loose fuel filter
- Loose connections on fuel filter assembly
- Loose union bolt on fuel pump
- Loose connections at fuel supply lines
- Loose bleeder screw on filter housing

If no air leaks are found and if bubbles still appear, check for water in the fuel.

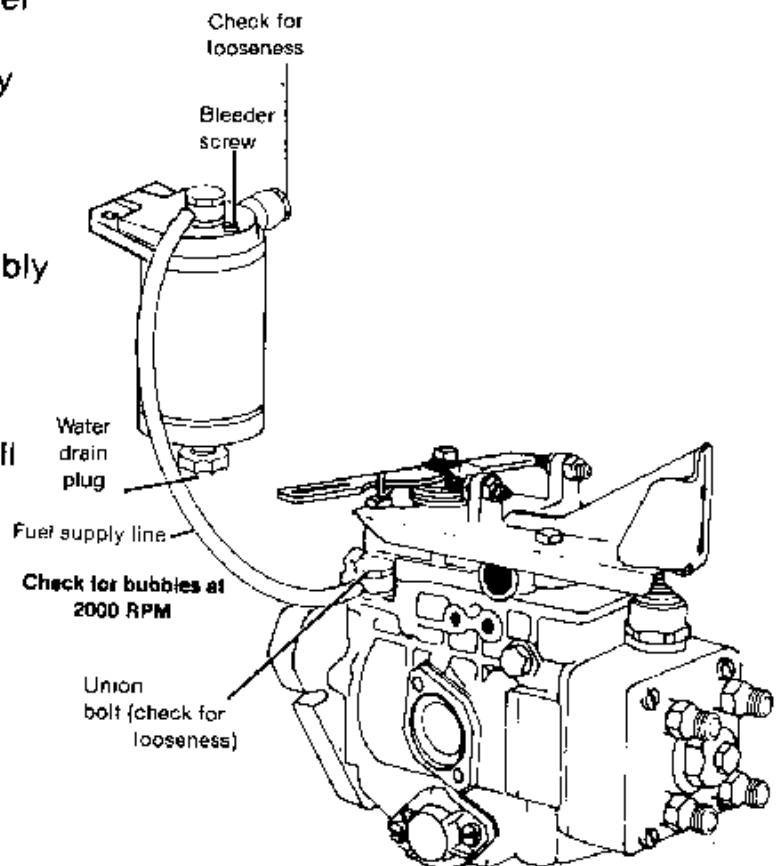
Drain the water trap in the fuel filter

Open the bleeder screw on the filter flange.

Loosen the drain plug on the filter.

Drain the fuel into a container until the drained fuel is pure.

Tighten the drain plug and the bleeder screw.



Warm Running Problems

Warm Engine Misfires or Knocks (cont'd.)

Check for Fuel Leaks

With engine running, check all connections for fuel leaks:

Check fuel lines at injectors and delivery valves.

If leaking - retorque fuel lines to 25 Nm (18 ft./lbs.)
(use 17mm split socket)

If still leaking - replace lines and torque to specifications.

Check fuel delivery valves at injection pump.

If leaking - remove fuel lines and fuel delivery valve.

Replace sealing washer with bronze washer #068 130 787.

Torque delivery valve to 55 Nm (40 ft./lbs.)

Reinstall fuel lines.

Start engine and check for leaks.

Check center bolt at end of injection pump.

If leaking - replace washer.

Note: Wipe off all spilled fuel with rubbing alcohol. Diesel fuel left on hoses will cause the hoses to deteriorate.

Check pump mounting brackets

Check tightness of:

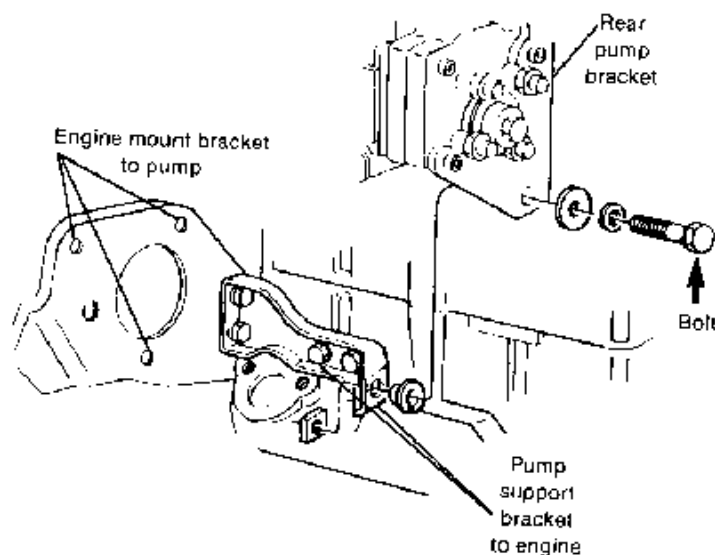
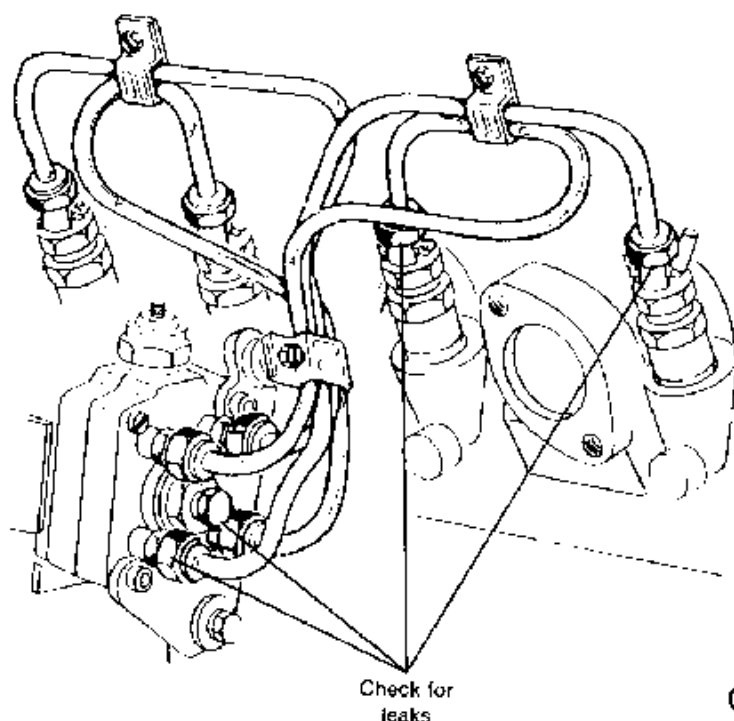
Engine mount bracket to pump.

Pump support bracket to engine.

Bolt fastening rear pump bracket to rear support bracket.

With a mirror, visually check for clearance between rear pump bracket and pump support bracket.

Add a flat washer between brackets to take up any clearance.



Perform Idle speed drop test

Connect VW 1367 to measure engine RPM

With car running:

Loosen injector lines at injectors one at a time.

Observe amount of change or no change in idle speed to determine "weak" or dead cylinder(s).

Idle speed should drop approximately the same on all cylinders as injector lines are loosened.

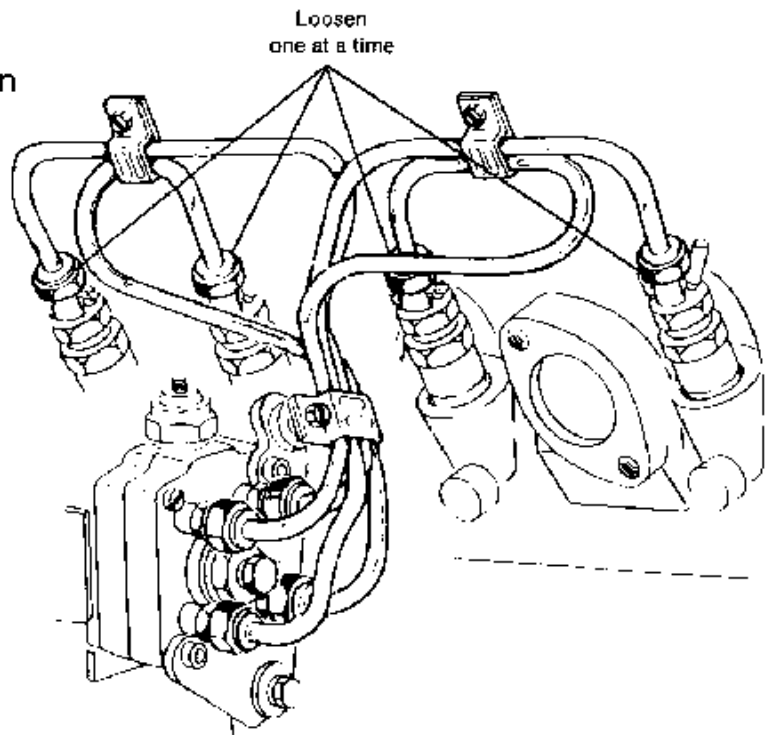
If problem cannot be isolated to one particular cylinder, turn to page and perform Diagnosis II.

If a "weak" or "dead" cylinder is found -

1. Check that injector line on affected cylinder is not crimped or restricted.
2. Check injectors
page 96.
3. Check valve clearance
page 99.
4. Check compression
page 100.

Safety

- Wear safety goggles when performing the idle speed drop test.
- After performing idle speed drop test, be sure to wipe all spilled fuel with rubbing alcohol. Diesel fuel spilled on hoses will cause the hoses to deteriorate.
- Keep a fire extinguisher accessible.



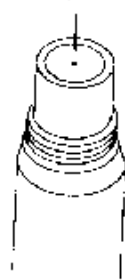
Warm Running Problems

Warm Engine Misfires or Knocks (cont'd.)

Test injector(s)

If a "weak" or "dead" cylinder is found the injector for that cylinder should be checked. Diesel injectors can be checked for the following items with a "pop" tester in this order.

Remove carbon deposits



1. Opening pressure
2. Leakage
3. Chatter
4. Spray pattern

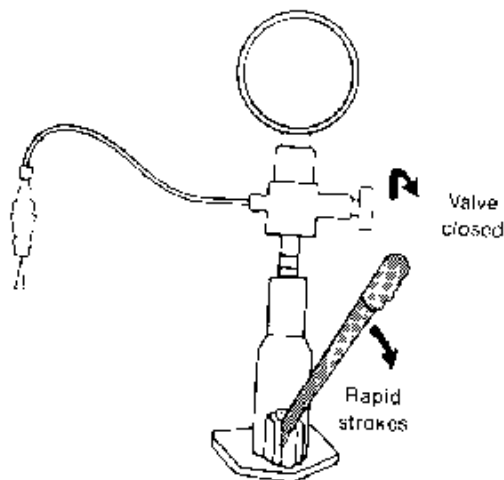
Bleed tester

Remove carbon deposits from the injector tip with a small brass brush.

Mount the injector in the tester.

Turn the tester valve clockwise to close the gauge.

Operate the tester lever with rapid strokes to prime the tester and to bleed the injector.



Opening pressure

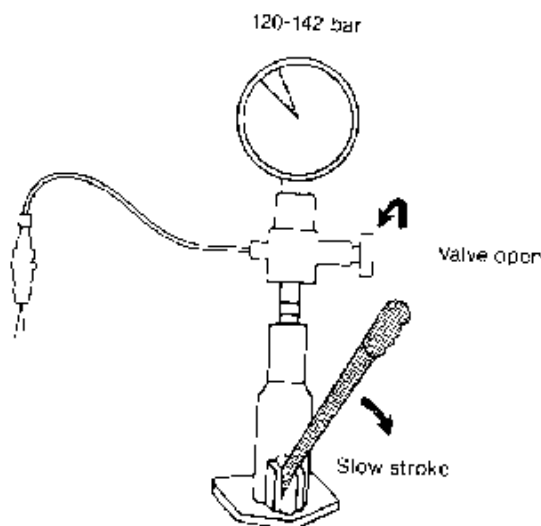
Turn the tester valve knob counterclockwise to open the gauge.

Slowly depress the tester lever until the injector just begins to spray.

Read the opening pressure

Should be 120 to 142 bar

Replace the injector if it is out of specifications.



Leakage

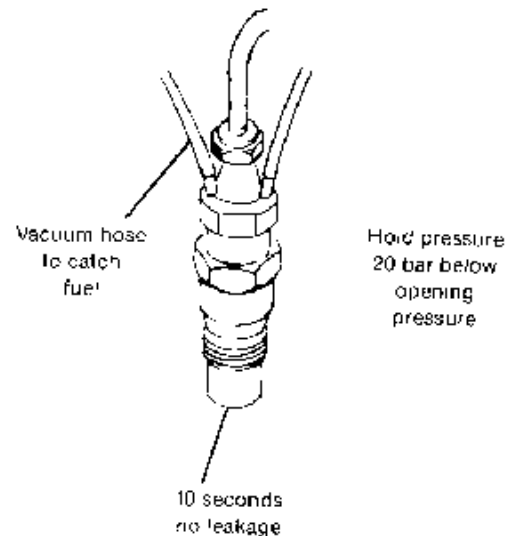
Install two pieces of vacuum hose on the injector return fittings to keep fuel from running down the side of the injector.

Dry the injector with compressed air or a lint free cloth.

Slowly depress the tester lever until the gauge reading is 20 bar below the measured opening pressure.

Hold the pressure for 10 seconds.

The injector should not drip.
(A drop may form on the end of the injector - this is normal).



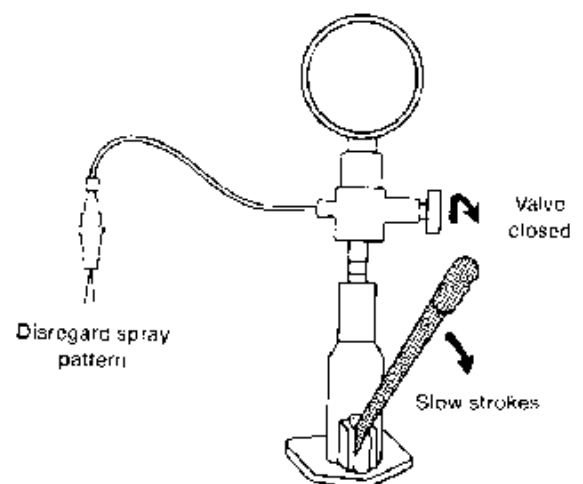
Chatter

Turn the tester valve knob clockwise to close the gauge.

Operate the tester lever with slow strokes.
(1 to 2 strokes per second)

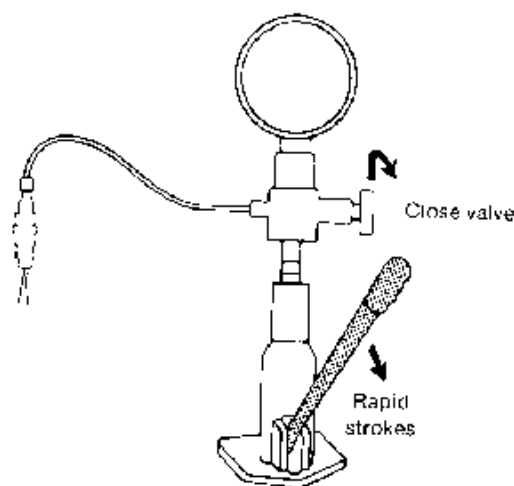
The injector should make a chattering or creaking sound if the injector is in good condition.

Disregard the spray pattern when checking chatter. Spray pattern can only be checked at fast pumping speeds.



Warm Running Problems

Warm Engine Misfires or Knocks (cont'd.)



Spray pattern

Turn the tester valve knob clockwise to close the gauge.

Operate the tester lever with rapid strokes (4 to 6 strokes per second)

The spray pattern should be finely atomized and cone shaped

Replace injectors which have a bad spray pattern.

The tester lever must be operated rapidly. At slow pumping speeds it is normal for the spray to stream or dribble out of the injector.

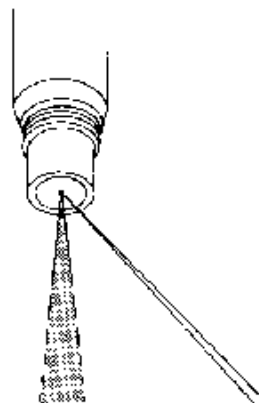
Good injector



Bad injector



Bad injector



Safety

- Do not put your hands near the injector when testing injectors. The high pressure diesel fuel spray can penetrate your skin and cause blood poisoning.
- Always wear safety goggles when testing injectors.
- The injector sprays a finely atomized combustible mist when testing. Avoid sparks and high heat sources when testing injectors.
- Do not use gasoline as a "test fuel".

Check valve clearance

Remove valve cover.

Turn crankshaft bolt clockwise until the cam lobes of the cylinder to be checked point upward.

Insert feeler gauge between cam lobe and valve shim.

Warm engine specifications (coolant temp. above 35°C (95°F)

Intake — 0.20 - 0.30mm (.008 - .012in.)

Exhaust — 0.40 - 0.50mm (.016 - .020in.)

Cold engine (coolant temp. below 35°C (95°F).

Intake — 0.15 - 0.25mm (0.006 - 0.010in.)

Exhaust — 0.35 - 0.45mm (0.014 - 0.018in.)

If valve clearance is incorrect —

Turn crankshaft clockwise about ¼ turn.

When adjusting valves on the diesel, the camshaft must be slightly offset so that valves do not contact pistons when the cam followers are depressed.

Depress cam followers with VW 546.

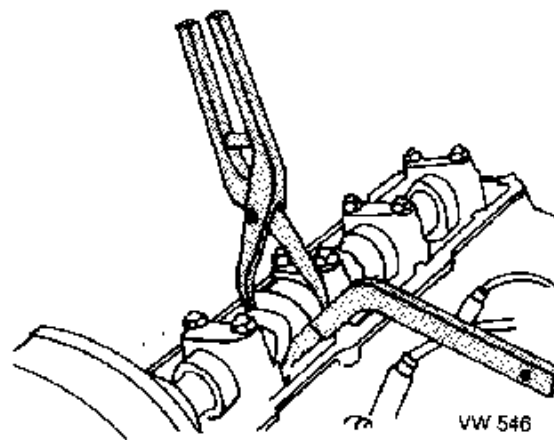
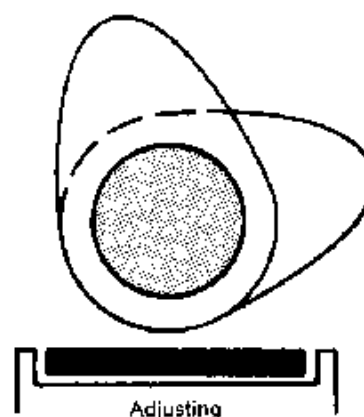
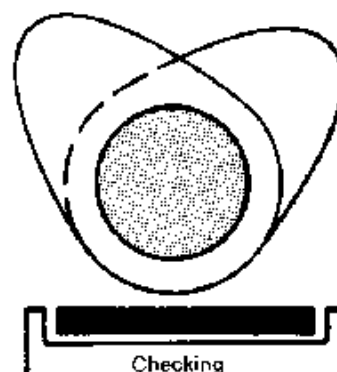
Remove shim to be exchanged with 10-208.

Install proper shim.

too small clearance - use thinner shim

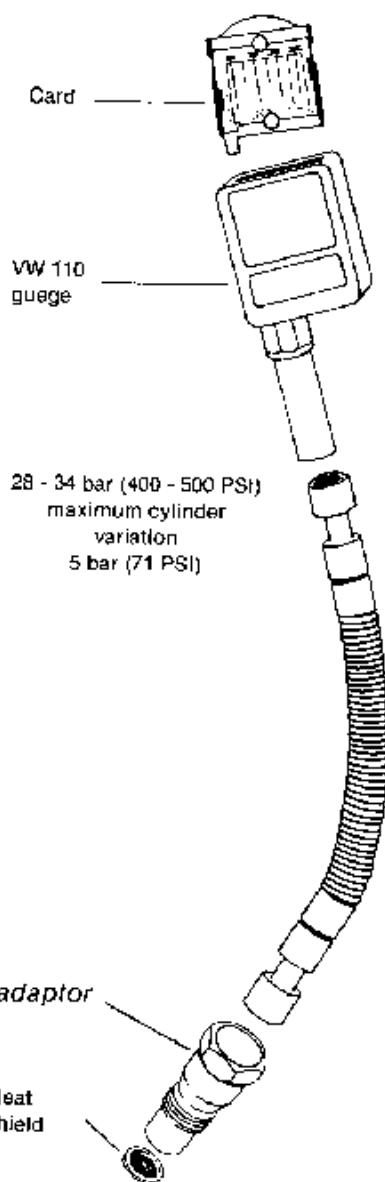
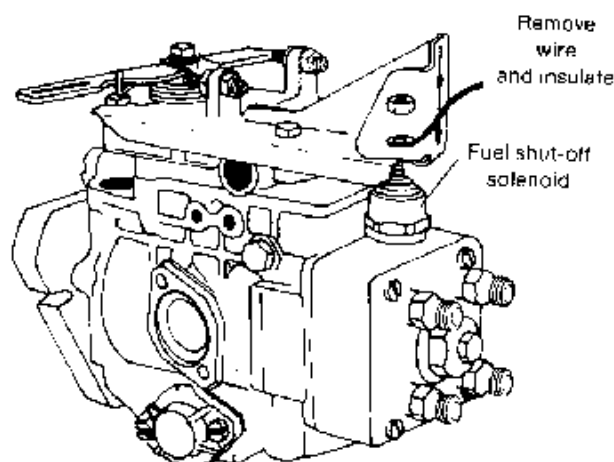
too large clearance - use thicker shim

Recheck valve clearance.



Warm Running Problems

Warm engine misfires or knocks (cont'd.)



Check Compression

Remove wire from fuel shut-off solenoid and insulate the wire.

Clean connections on injector lines.

Remove injector lines (be sure that delivery valves are not loosened when loosening injector lines on injection pump.).

Remove injectors using US2775 deep well socket and store in a clean area.

Remove all heat shields except #1 cylinder.

Caution: loose heat shields can be blown out during compression check.

Install adaptor on #1 cylinder.

Install VW 110 gauge onto adapter.

Operate starter until gauge reads highest reading.

**28-34 bar (400 - 500 psi)
maximum cylinder variation
5 bar (71 psi)**

Release pressure

Repeat process on remaining cylinders.

Low readings on adjacent cylinders
gasket leakage between cylinders.

Low readings on one cylinder
valve leakage.

Low readings on all cylinders
worn piston rings or jumped valve timing.

A low reading can be rechecked by adding 1 tablespoon of engine oil through the injector hole:

If the compression readings increase slightly this indicates valve leakage.

If the compression readings increase significantly this indicates worn piston rings.

If compression does not increase, check valve timing.

Always install new heat shields before reinstalling injectors.

Quality check

Suggested Repair Time — 30 time units

- **Start engine, allow to warm up and observe idle quality**
 - engine should idle smoothly
 - engine should not misfire or knock
 - **With correct tire pressure, drive car on a level road**
 - **Accelerate to a constant speed of 35 MPH**
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
 - **Accelerate again to full throttle and note the acceleration quality.**
 - engine should accelerate evenly
 - engine should not misfire or knock
 - **Maintain steady speed and observe performance quality**
 - engine should maintain even performance at all speeds and show no symptoms of misfire or knock
- If test passed**
Return car to customer
- If test failed**
Perform diagnosis II, page 107.

Warm Running Problems

Symptom:

Warm engine surges (speed of car changes or varies while driving)

Diagnosis Procedure

- **Check fuel quality**

Poor fuel quality can cause a less combustible mixture and a possible engine surge.

- **Check for air leaks**

Loose connections or cracked hoses between the fuel tank and injection pump may result in air in the fuel system. Air trapped in injectors or lines can cause an engine to surge at driving speeds.

- **Check for fuel leaks**

Fuel leaks at fuel lines and fuel delivery valves reduce fuel pressure and effect delivery to the injectors.

- **Check injection pump mounting brackets**

Loose pump mounting brackets can cause pump misalignment and injection timing change, resulting in an engine surge at driving speeds.

Suggested Repair Time — 30 time units

Check fuel quality

Poor fuel quality can cause a lack of performance and engine smoking. In addition, if too much gasoline or other additives are mixed with the fuel, the cetane rating of the fuel will be lowered below the point at which it will burn properly in the engine.

Check for air leaks

Start the engine and run it at about 2000 RPM.

Check the clear fuel supply line.

A steady stream of bubbles indicates either an air leak in the fuel supply system or water in the fuel filter. (A few bubbles may appear, this is normal)

Check for air leaks caused by:

- Loose fuel filter
- Loose connections on fuel filter assembly
- Loose union bolt on fuel pump
- Loose connections at fuel supply lines
- Loose bleeder screw on fuel filter

If no air leaks are found and if bubbles still appear, check for water in the fuel.

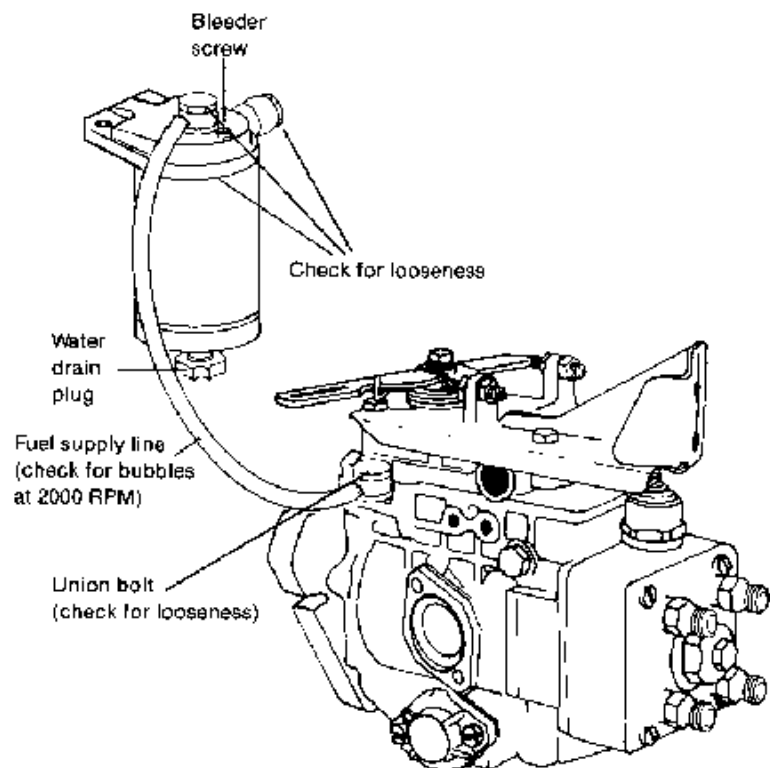
Drain the water trap in the fuel filter.

Open the bleeder screw on the filter flange.

Loosen the drain plug on the filter.

Drain the fuel into a container until the drained fuel is pure.

Tighten the drain plug and the bleeder screw.



Warm Running Problems

Warm Engine Surges (cont'd.)

Check for fuel leaks

With engine running, check all connections for fuel leaks:

Check fuel lines at injectors and delivery valves.

If leaking - retorque fuel lines to 25 Nm (18 ft./lbs.) use 17mm split socket.

If still leaking - replace lines and torque to specifications.

Check fuel delivery valves at injection pump.

If leaking - remove fuel lines and fuel delivery valves

Replace sealing washer with bronze washer #068 130 787

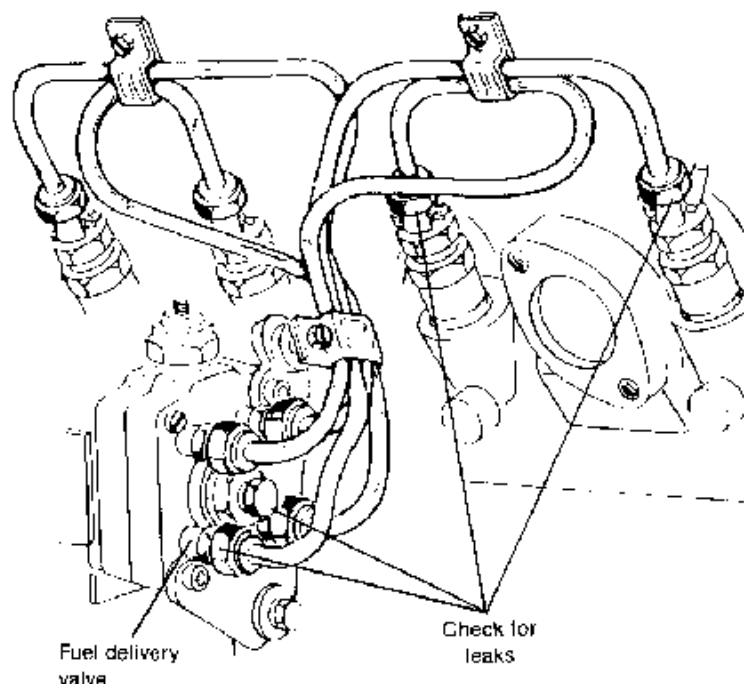
Torque to 55 Nm (40 ft./lbs.)

Reinstall fuel lines.

Start engine and check for leaks.

Check center bolt at end of injection pump.

If leaking - replace washer



Check pump mounting brackets

Check tightness of:

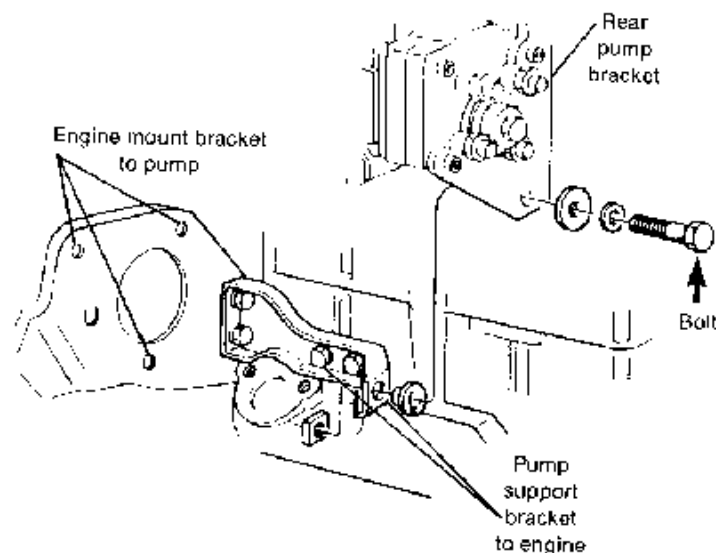
Engine mount bracket to pump.

Pump support bracket to engine.

Bolt fastening rear pump bracket to rear support bracket.

With a mirror visually check for clearance between rear pump bracket and pump support bracket.

Add a flat washer between brackets to take up any clearance.



Quality check

Suggested Repair Time — 30 time units

- **Start engine, allow to warm up and observe idle quality**
engine should idle smoothly
- **With correct tire pressure, drive car on a level road**
Accelerate to a constant speed of 35 MPH
in 3rd gear (4-speed transmission)
in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the acceleration quality.**
engine should accelerate evenly
engine should not surge
- **Maintain steady speed and observe performance quality**
engine should maintain even performance at all speeds and show no symptoms of surging.

If test passed

Return car to customer

If test failed

Perform diagnosis II, page 107.

Warm Running Problems

Symptom:

Warm engine lacks power and/or smokes excessively

Diagnosis Procedure

There is no preliminary diagnosis procedure for cars with this symptom. For the symptom *warm engine lacks power and/or smokes excessively*, go directly to Diagnosis II.

Diagnosis II — Warm Running Problems

Step 1 Check for crankshaft bolt modification on 1.5L engines

Step 2 Check air filter

Step 3 Check valve clearance

Step 4 Check compression

Step 5 Check injectors

Step 6 Perform injection system tests*

- Check/adjust valve timing
- Check/adjust cold start advance
- Check/adjust injection pump timing
- Check/adjust idle and maximum speed

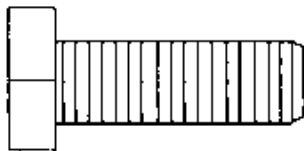
**Warm running problems are affected by valve timing, spur belt tension, cold start advance, injection pump timing, idle RPM and maximum RPM. Therefore all of these items should be checked to assure that all factors that could affect vehicle performance are adjusted properly.*

Suggested Repair Time — 240 time units

Diagnosis II — Warm Running Problems

Check for crankshaft bolt modification - 1.5L diesel engines

Old style

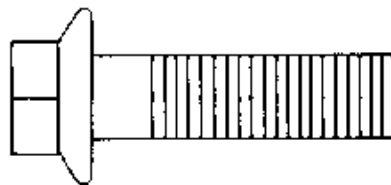


Bolt

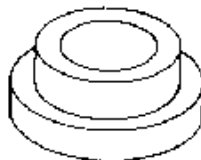


Flat washer

New style



Bolt
(N901 120 01)



Collared washer
(068 105 299)

Visually check —

That the old style front crankshaft bolt and washer have been replaced with the new style bolt and washer.

new style bolt has shoulder
new style washer has collar

If not:

Remove old style bolt and washer.

Visually check the crankshaft sprocket, key way and key for signs of wear or damage.

If not damaged:

Replace old style bolt and washer with new style bolt and washer.

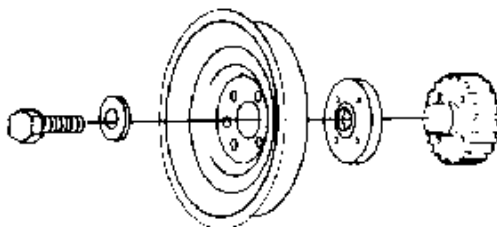
Torque new style bolt to
150Nm (108 ft. lbs.)

If damaged:

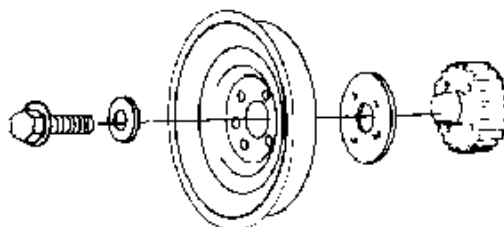
Remove crankshaft sprocket.

If sprocket, key or key way are damaged,
replace parts as necessary.

Old spacer w/shoulder



New spacer — flat
(ZVW 455 218)



Cars with dealer-installed A/C

When installing the new style crankshaft bolt on cars with dealer-installed A/C —

Remove old spacer (with shoulder)
and

Replace with new spacer ZVW 455 218(flat).

**Check for crankshaft bolt modification 1.5L diesel engine
(Continued)**

1980 Rabbit diesel with factory air conditioning 1980 models

When checking for the new style crankshaft
bolt and washer

or

When installing the new style crankshaft
bolt and washer on 1.5L diesels with factory
air-conditioning:

Loosen alternator belt.

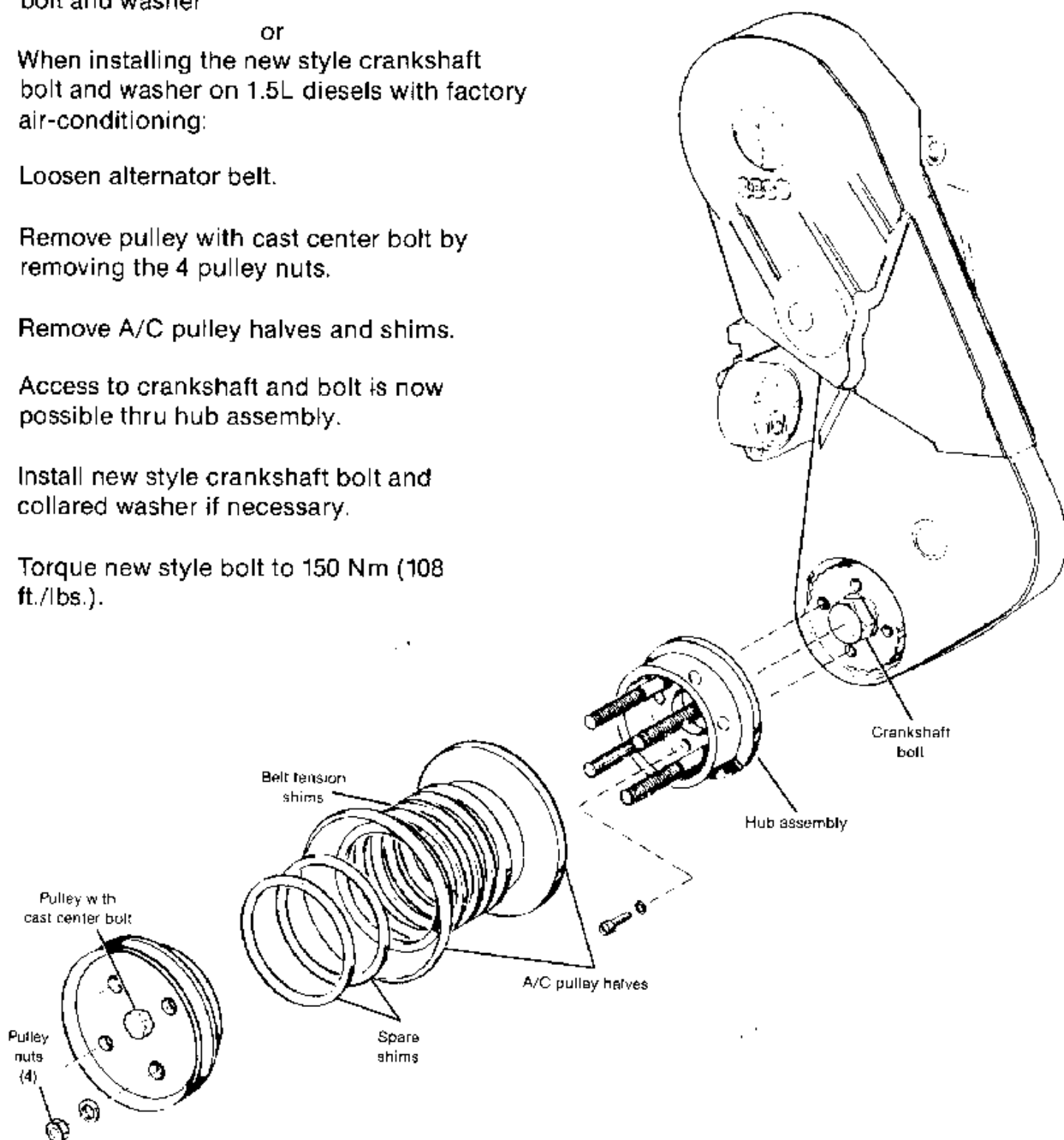
Remove pulley with cast center bolt by
removing the 4 pulley nuts.

Remove A/C pulley halves and shims.

Access to crankshaft and bolt is now
possible thru hub assembly.

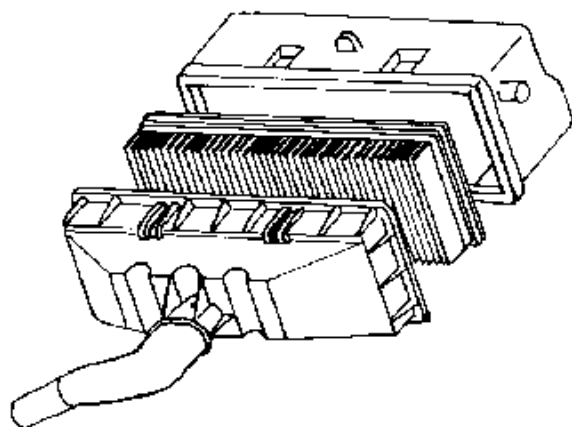
Install new style crankshaft bolt and
collared washer if necessary.

Torque new style bolt to 150 Nm (108
ft./lbs.).



Diagnosis II — Warm Running Problems

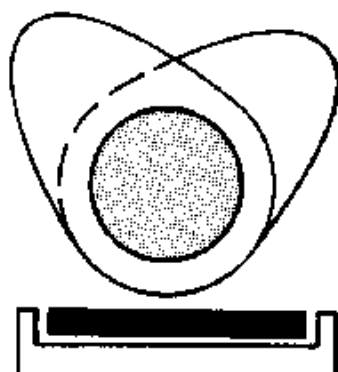
Check air filter



Visually check air filter

Replace if dirty and check to see that Breather Hose Kit was installed (1977-1979 cars, 1980 cars to engine # CK 513 210) . . . page 130.

Check valve clearance



Checking

Remove valve cover.

Turn crankshaft bolt clockwise until the cam lobes of the cylinder to be checked point upward.

Insert feeler gauge between cam lobe and valve shim.

Warm engine specifications (coolant temp. above 35° C / (95° F).

Intake — 0.20 — 0.30mm (0.008 — 0.012in.)

Exhaust — 0.40 — 0.50mm (0.016 — 0.020in.)

Cold engine (coolant temp. below 35° C (95° F)

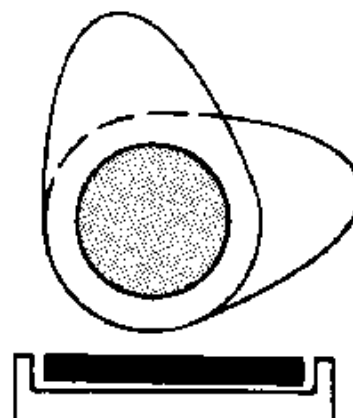
Intake — 0.15 — 0.25mm (0.006 — 0.010in.)

Exhaust — 0.35 — 0.45mm (0.014 — 0.018in.)

Adjust valve clearance

If valve clearance is incorrect —
Turn crankshaft clockwise about $\frac{1}{4}$ turn.

When adjusting valves, camshaft must be slightly offset so that valves do not contact piston when cam followers are depressed.



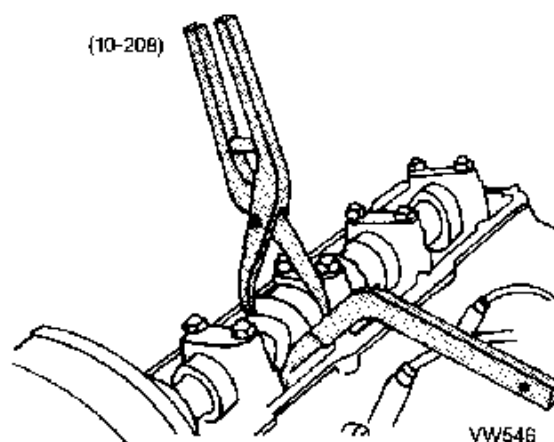
Adjusting

Depress cam followers with VW546.
Remove shim to be exchanged with 10-208.
Install proper shim.

Too small clearance — use thinner shim

Too large clearance — use thicker shim

Recheck valve clearance.



Diagnosis II — Warm Running Problems

Check compression

Remove wire from fuel shut-off solenoid and insulate the wire.

Clean connections on injector lines.

Remove injector lines (be sure that delivery valves are not loosened when loosening injector lines on injection pump.).

Remove injectors using US2775 deep well socket and store in clean area.

Remove all heat shields except #1 cylinder.

Caution: loose heat shields can be blown out during compression check.

Install adapter on #1 cylinder.

Install VW 110 gauge onto adapter.

Operate starter until gauge reads highest reading.

**28-34 bar (400 - 500 psi)
maximum cylinder variation
5 bar (71 psi)**

Release pressure

Repeat process on remaining cylinders.

Low readings on adjacent cylinders
gasket leakage between cylinders.

Low readings on one cylinder
valve leakage.

Low readings on all cylinders
worn piston rings or jumped valve timing.

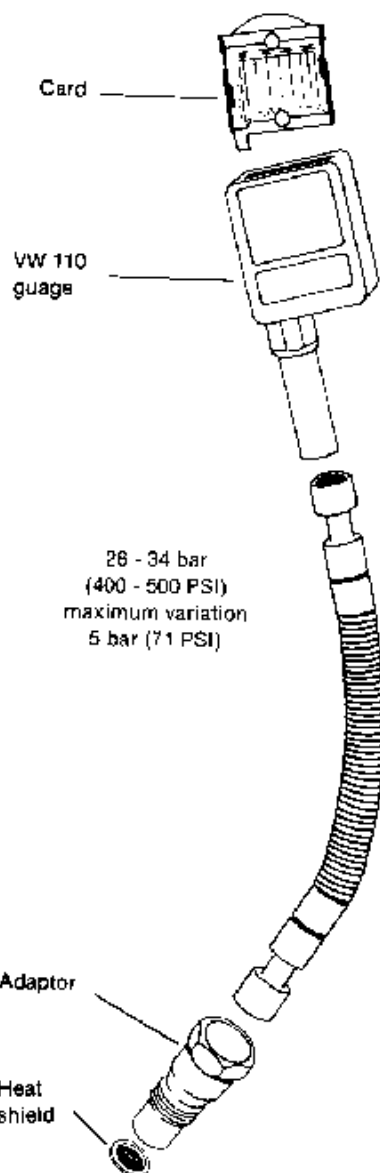
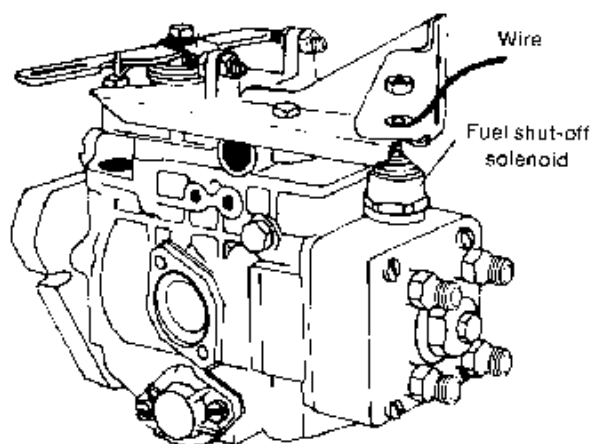
A low reading can be rechecked by adding 1 tablespoon of engine oil through the injector hole:

If the compression readings increase slightly this indicates valve leakage.

If the compression readings increase significantly this indicates worn piston rings.

If compression does not increase, check valve timing.

Always install new heat shields before reinstalling injectors.



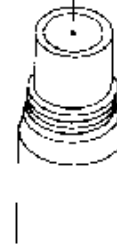
28 - 34 bar
(400 - 500 PSI)
maximum variation
5 bar (71 PSI)

Test injectors

If a "weak" or "dead" cylinder is found, the injector for that cylinder should be checked. There are four tests for injectors. Perform the tests in the following sequence:

1. Opening pressure
2. Leakage
3. Chatter
4. Spray pattern

Remove carbon deposits



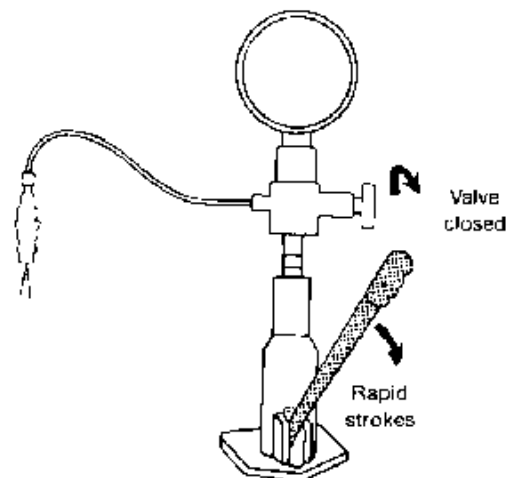
Bleed Tester

Remove carbon deposits from the injector tip with a small brass brush.

Mount the injector in the tester.

Turn the tester valve clockwise to close the gauge.

Operate the tester lever with rapid strokes to prime the tester and to bleed the injector.



Opening Pressure

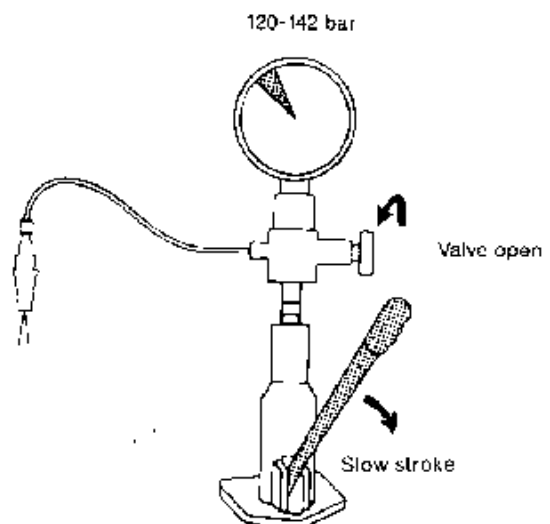
Turn the tester valve knob counterclockwise to open the gauge.

Slowly depress the tester lever until the injector just begins to spray.

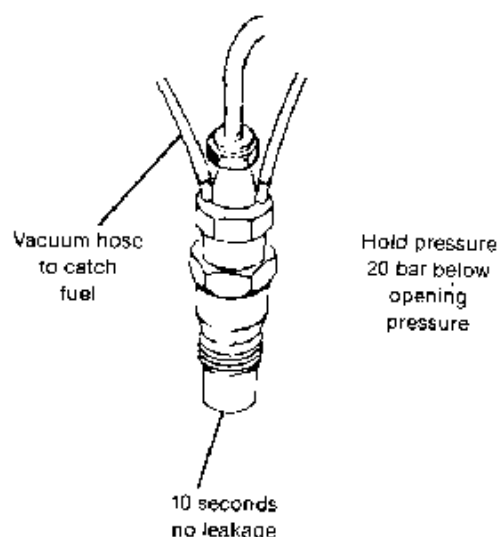
Read the opening pressure,

should be 120 to 142 bar

Replace the injector if it is out of specifications.



Diagnosis II — Warm Running Problems



Leakage

Install two pieces of vacuum hose on the injector return fittings to keep fuel from running down the side of the injector.

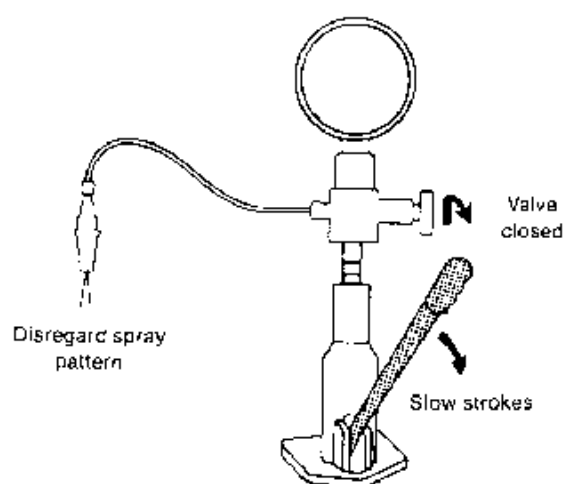
Dry the injector with compressed air or a lint free cloth.

Slowly depress the tester lever until the gauge reading is 20 bar below the measured opening pressure.

Hold the pressure for 10 seconds

the injector should not drip.

(a drop may form on the end of the injector — this is normal.)



Chatter

Turn the tester valve knob clockwise to close the gauge.

Operate the tester lever with slow strokes. (1 to 2 strokes per second)

The injector should make a chattering or creaking sound if the injector is in good condition.

Disregard the spray pattern when checking chatter. Spray pattern can only be checked at fast pumping speeds.

Spray Pattern

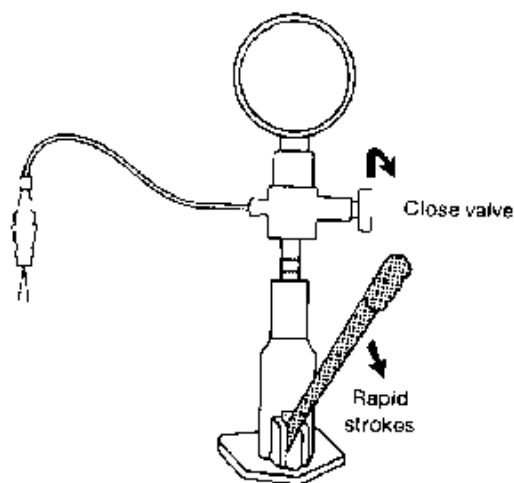
Turn the tester valve knob clockwise
To close the gauge

Operate the tester lever with rapid strokes
(4 to 6 strokes per second).

the spray pattern should be finely
atomized and cone shaped.

Replace injectors which have a bad spray
pattern.

The tester lever must be operated rapidly.
At slow pumping speeds it is normal for the
spray to stream or dribble out of the
injector.



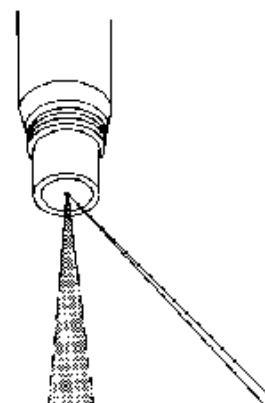
Good
injector



Bad
injector



Bad
injector

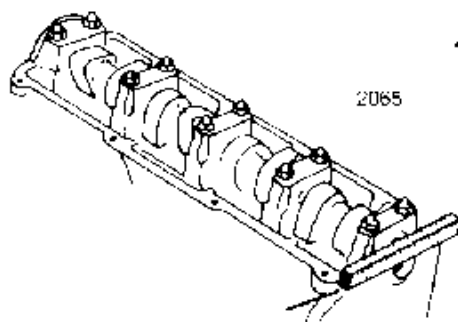


Safety

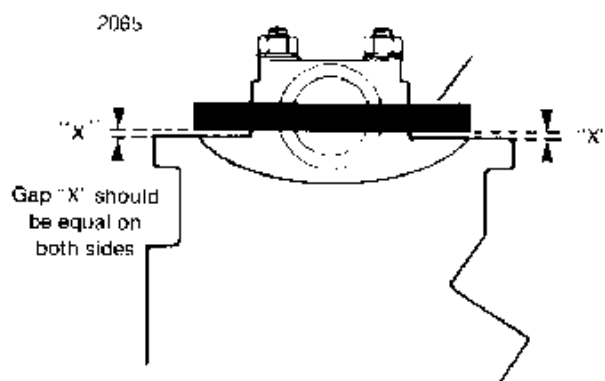
- Do not put your hands near the injector when testing injectors. The high pressure diesel fuel spray can penetrate your skin and cause blood poisoning.
- Always wear safety goggles when testing injectors.
- The injector sprays a finely atomized combustible mist when testing. Avoid sparks and high heat sources when testing injectors.
- Do not use gasoline as a "test fluid."

Diagnosis II — Warm Running Problems

Check valve timing

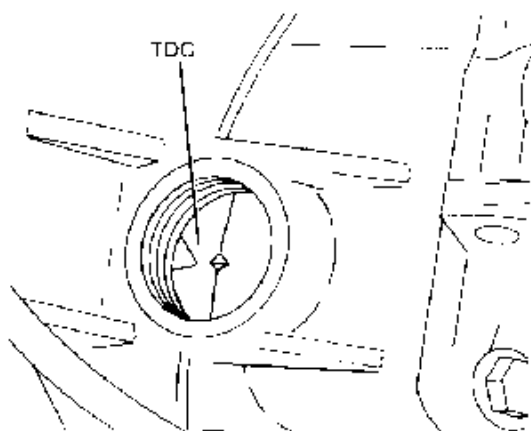


Turn crankshaft clockwise to align slot in rear of camshaft with valve cover sealing surface.



Install camshaft setting bar #2065 and center camshaft by inserting feeler gauges between each end of #2065.

Gap "x" should be equal on both sides.



With camshaft aligned:

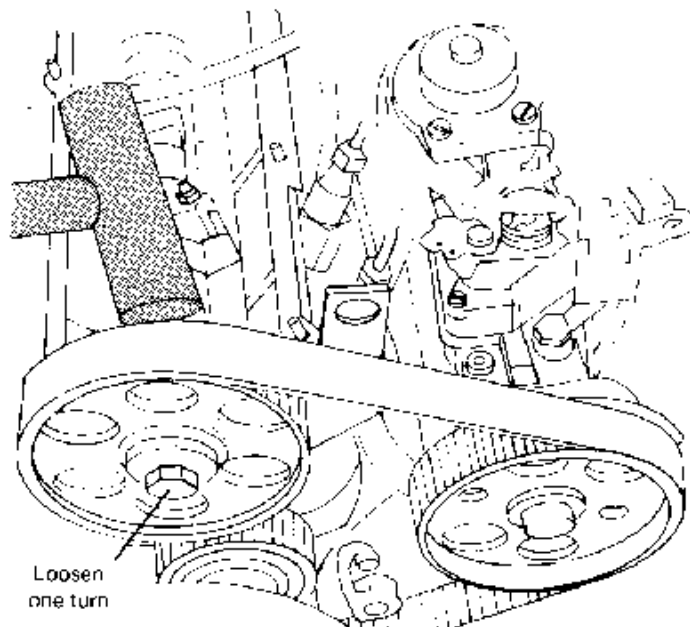
Check that the flywheel is exactly on TDC.

If not - adjust valve timing.

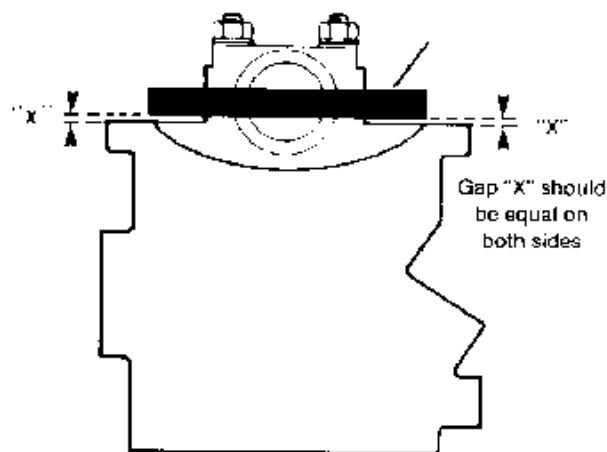
Adjust valve timing

If valve timing is out of adjustment,
Remove spur belt cover.
Install locking tool 2065 to hold camshaft.
Loosen camshaft sprocket bolt one turn.
Tap backside of camshaft sprocket with
rubber hammer to loosen.

The camshaft sprocket is fitted to the
camshaft with a "locking taper" and
does not use a locating key.



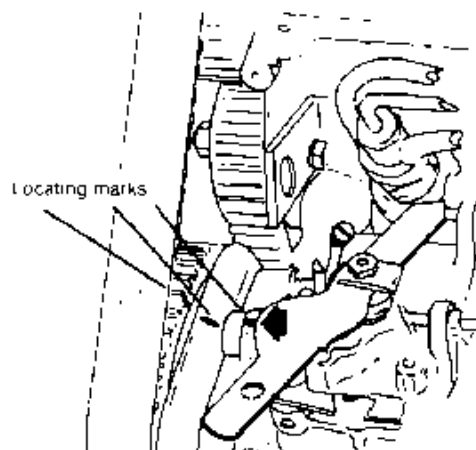
Align camshaft with bar # 2065 and feeler
gauges at "x".



Check that locating marks on sprocket,
bracket and pump body are aligned.

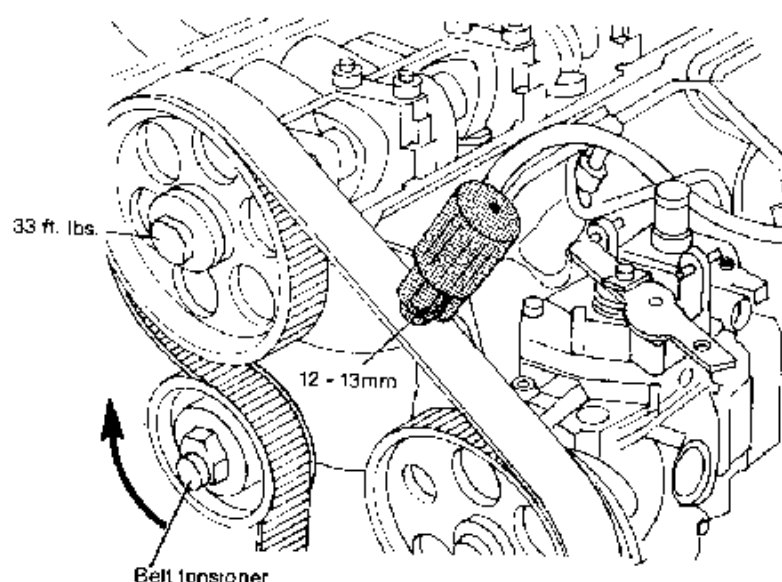
Set flywheel to TDC

Note: if drive belt is removed, lock injection
pump sprocket with locking pin 2064.



Diagnosis II — Warm Running Problems

Adjust valve timing (continued)



Install belt tension gauge VW 210 on spur belt between cam sprocket and pump sprocket.

Set VW 210 to 12 to 13mm.

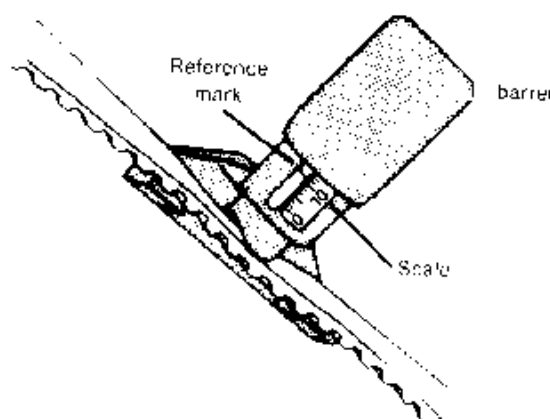
Turn belt tensioner clockwise until reference mark on tool (12 to 13mm) is aligned with edge of barrel.

Tool US 4493 required on 1981 and later cars, to turn belt tensioner.

Tighten tensioner nut to 33 ft.lbs.

Tighten cam sprocket bolt to 33 ft.lbs.

Make sure flywheel remains on TDC.



Remove 2065 and 2064.

Turn crankshaft clockwise 2 turns.

Strike belt with a rubber hammer between cam sprocket and injection pump sprocket.

Recheck valve timing with #2065 — flywheel at TDC.

Recheck belt tension with VW 210.

Re-install spur belt cover/valve cover.

Adjust Cold Start Advance

Push in cold start knob on dash.

Loosen cable adjusting screw at cold start advance lever.

Push cold start lever down to lower stop on stop bracket.

Tighten cable adjusting screw.

Recheck that cold start advance lever touches both the lower stop and the upper stop on the stop bracket whenever the cold start cable is operated from inside the car.

Injection Timing

With cold start knob on dash pushed in,

Remove bolt from end of pump (always replace washer).

Turn engine clockwise until flywheel is at TDC.

Install adapter 2066 and dial gauge at end of pump.

Preload dial gauge (about 3mm).

Turn engine counter clockwise until dial gauge needle just stops moving.

Zero gauge.

Turn engine clockwise to TDC.

Gauge should read:

1.5 L engine

$0.88 \pm 0.05\text{mm}$ (1977-80)

$1.15 \pm 0.05\text{mm}$ (1980 cars with yellow paint dot on advance cover)

1.6 L engine

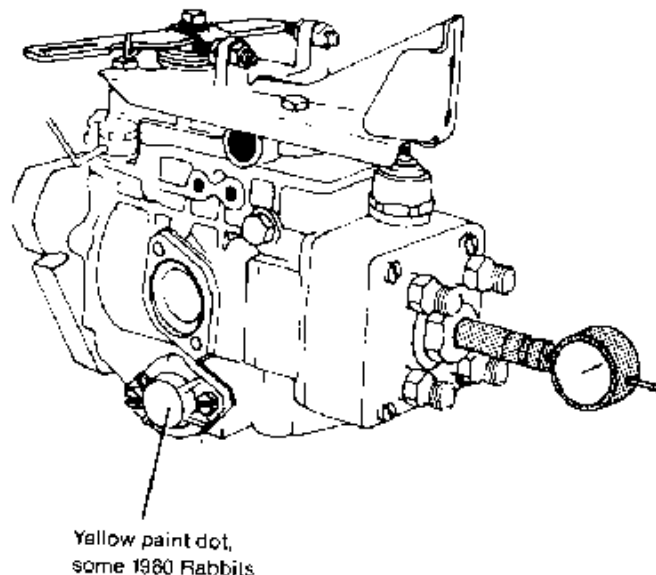
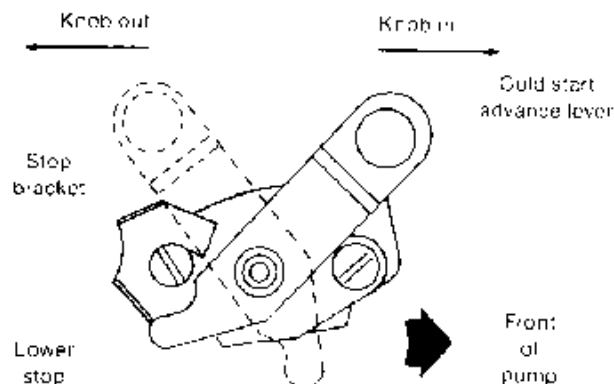
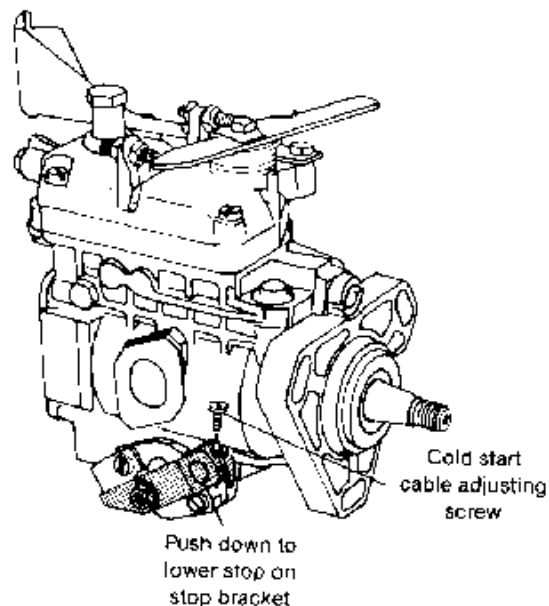
0.88 ± 0.05 (1981 - 1982) (and 83 Pick-up)

0.95 ± 0.05 (1983 Rabbit, Jetta, 4000)

0.90 ± 0.05 (83 Vanagon)

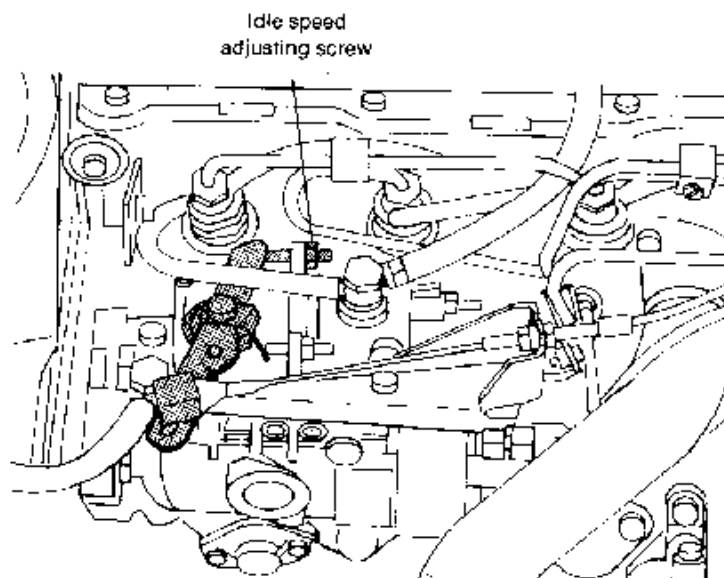
1.6 L Turbo Diesel

1.00 ± 0.05 (1982 - 83)



Diagnosis II — Warm Running Problems

Adjust Idle Speed



Connect VW 1367 or equivalent. With engine warm check idle speed.

820 ± 50 RPM (1977 - 82 and 83 Vanagon)

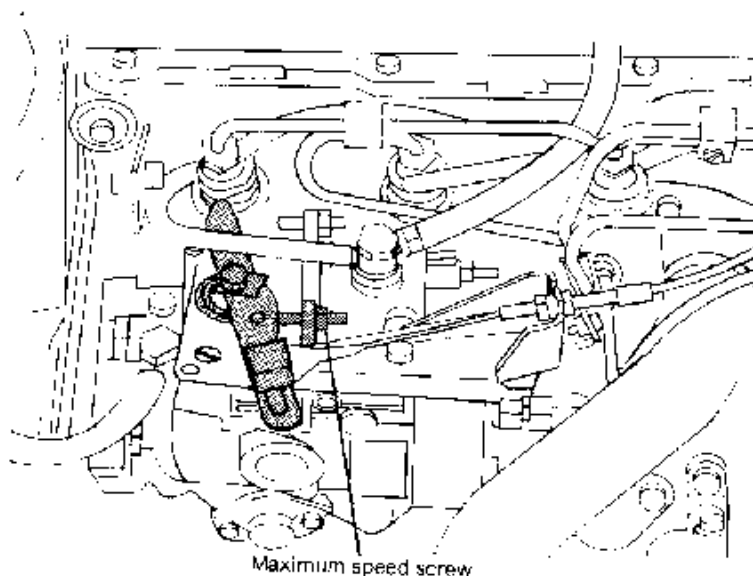
880 ± 50 RPM (1983 Rabbit/Jetta)

950 ± 50 RPM (82/83 Quantum, 4000)

Loosen lock nut and turn adjusting screw.
clockwise increases rpm
counter clockwise decreases rpm

Tighten lock nut.

Adjust Maximum Speed



Accelerate engine briefly to maximum speed stop.

1.6 L (5300 - 5400 RPM)

1.5 L (5500-5600 RPM)

Vanagon (4750 - 4850 RPM)

Adjust by loosening locknut and turning maximum speed screw.

clockwise decreases maximum RPM

counterclockwise increases maximum RPM

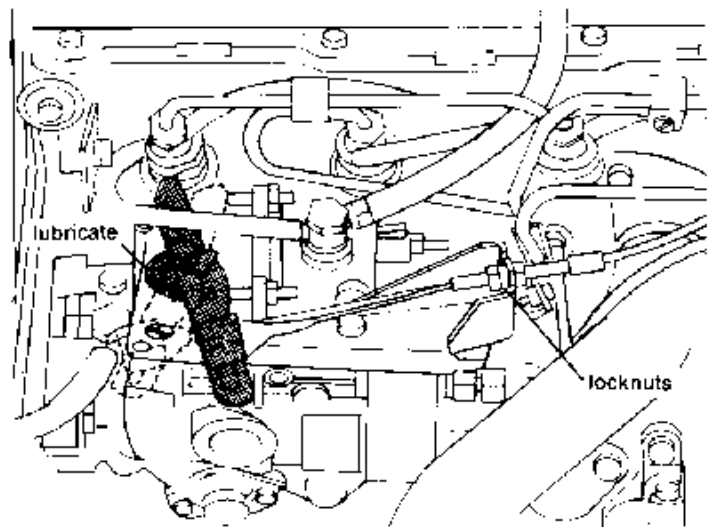
Check accelerator cable adjustment

Lubricate accelerator lever return spring with spray lubricant (WD 40 or equivalent).

Check to ensure that the accelerator lever rests against the idle adjustment stop.

Check to ensure that the accelerator lever moves freely and does not stick.

Depress the accelerator pedal fully and check to ensure that the accelerator lever contacts the maximum speed adjustment stop.



If the accelerator cable is out of adjustment,

Cars with manual transmission —

If the throttle linkage is out of adjustment,

Loosen cable locknuts —

Depress accelerator pedal fully —

Adjust cable so that throttle lever contacts maximum speed screw and is not strained.

Cars with automatic transmission

If throttle linkage is out of adjustment,

See page 134.

Warm Running Problems

Quality check

Suggested Repair Time — 50 time units

Except 1981 - 82 Rabbit/Jetta

- **Start engine, allow to warm up and observe idle quality.**
 - the idle speed is correct
 - engine should idle smoothly
 - the idle speed should not vary more than 50 RPM
- **With correct tire pressure, drive car on a level road.**
Accelerate to a constant speed of 35 MPH.
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the acceleration quality from 35 MPH to 55 MPH.**
 - engine should accelerate evenly
 - engine should not lack power or smoke
- **Maintain steady speed and observe performance quality.**
 - engine should maintain adequate performance at all speeds and show no symptoms of loss of power or smoke

1981 - 82 Rabbit/Jetta

- **Start engine, allow to warm up and observe idle quality.**
 - the idle speed is correct
 - engine should idle smoothly
 - the idle speed should not vary more than 50 RPM
- **With correct tire pressure, drive car on a level road.**
Accelerate to a constant speed of 35 MPH.
 - in 3rd gear (4-speed transmission)
 - in 4th gear (5-speed transmission)
- **Accelerate again to full throttle and note the time it takes to reach 55 MPH.**
 - should be 16.1 seconds maximum (4-speed transmission)
 - should be 18.6 seconds maximum (5-speed transmission)

If test passed

Return car to customer

If test failed — if diagnosis I and II have been completed

Replace injection pump — except 1981 - 82 Rabbit/Jetta see Special Repairs page 123.

Modified Injection Timing Adjustment 1981, 82 Rabbit, Pick-up and Jetta

Because of variations in fuel quality (cetane rating) and production tolerances, the injection timing on some 1981-82 Rabbit, Pick-up and Jetta's may have to be changed to $0.98 \pm 0.05\text{mm}$ if the engine

- Lacks power and/or smokes excessively
- Engine misfires
- Engine surges

The injection timing can only be changed after both diagnosis procedure I and diagnosis procedure II have been completed.

Injection timing adjustment

The cold start knob on the dash must be pushed in and the advance lever must touch the lower stop on the stop bracket.

Remove the bolt from the end of the pump.

Turn the engine clockwise until it is at TDC.

Install adapter 2066 with dial indicator and pre-load the indicator to about 3mm.

Turn the engine counter clockwise until the dial indicator needle just stops moving.

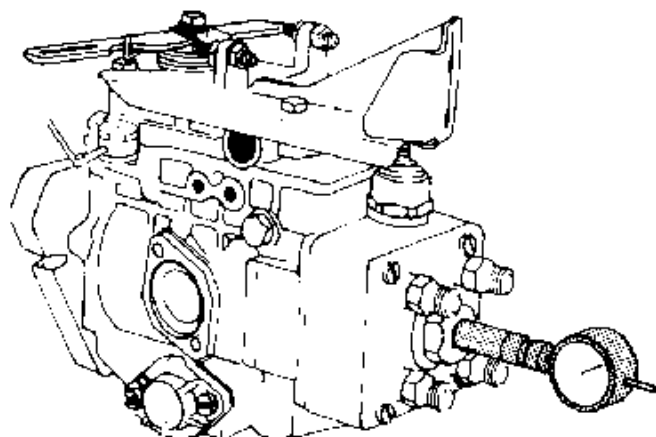
Zero the dial indicator

Turn the engine clockwise until it is at TDC

Loosen injection pump mounting bolts and adjust pump timing to $0.98 \pm 0.05\text{mm}$.

Retighten bolts and recheck injection pump timing.

Perform quality check, page 122.



Vibration Problems

To correct problems of excessive vibration at idle speed, perform the following 4 steps:

Check for installation of vibration damper (1981 - 82 only)

Check to see if the vibration damper is installed in the front bumper.

The damper helps soften secondary vibrations from the engine.

If the car already has a damper installed, check to make sure that the insulator is installed with the damper. If the insulator is not used, the damper will not be as effective.

Check and adjust motor mounts

One of the purposes of the motor mounts is to insulate engine noise and vibration from the body assembly. If the motor mounts are collapsed or if they are misaligned, excessive engine vibration will be transferred to the body.

The first step is to inspect the mounts to make sure they are not collapsed. Pay close attention to the right side engine mount on cars with dealer installed air-conditioning. The next step is to adjust the engine mounts so they are aligned and free of tension.

Adjust the steering column

If the steering column assembly is not installed with the proper amount of tension, it will vibrate at idle. This will result in excessive vibration in the steering wheel and dashboard.

To correct the problem, loosen the clamping bolt for the steering lock assembly and pull upward on the steering wheel to tension the steering column, then retighten the bolt.

Adjust the idle speed

The engine idle speed should be adjusted within the specified range, at the point where the least vibration occurs.

Check for vibration damper (1981 - 82 only)

Check to see that:

The vibration damper is installed in the front bumper with the insulating strip.

If not, install vibration damper.

Remove the front license plate bracket with the plastic inserts.

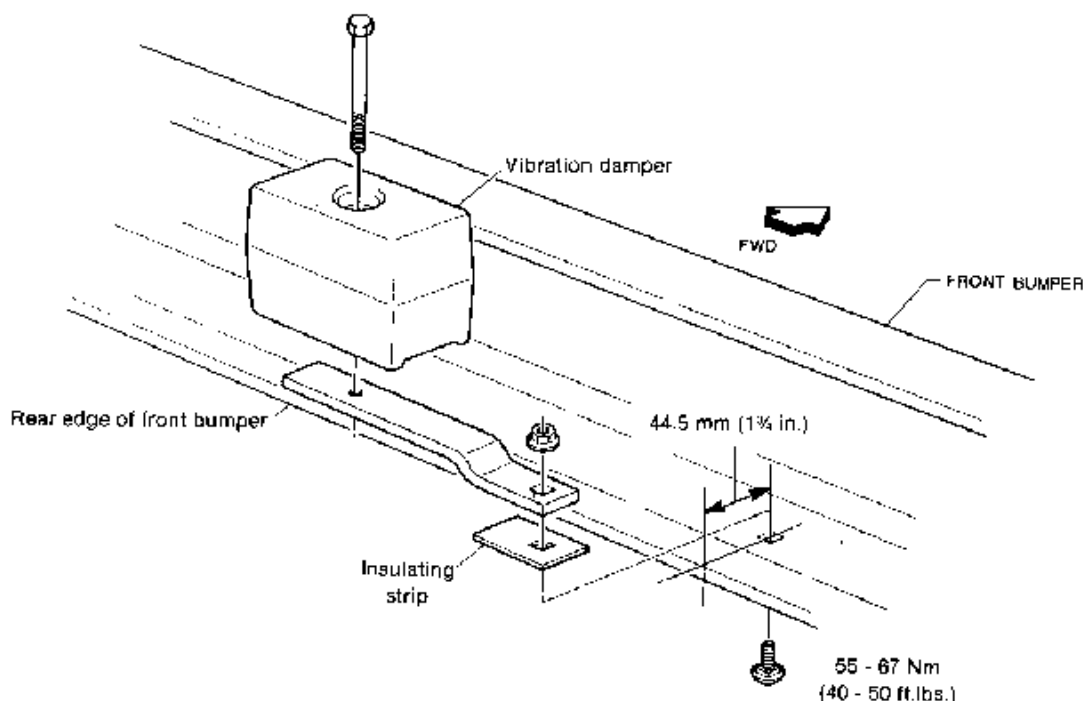
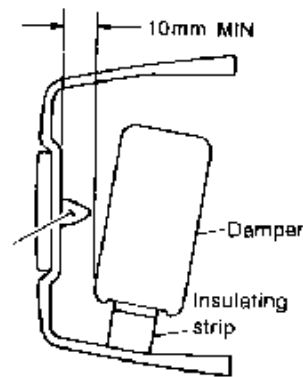
Mark and drill a 10.5 mm hole midway between the license plate bracket holes and 44.5 mm from the back edge of the bumper.

Install the vibration damper with the insulating strip on the inside of the bumper.

The damper weight should be towards the left side of the car.

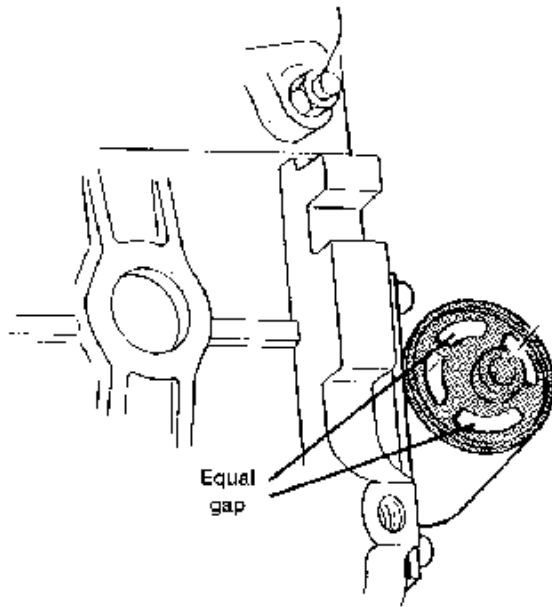
Torque the bolt to 55-67 Nm
(40-50 ft. lbs.)

Reinstall the license plate bracket.



Vibration Problems

Check engine mounts

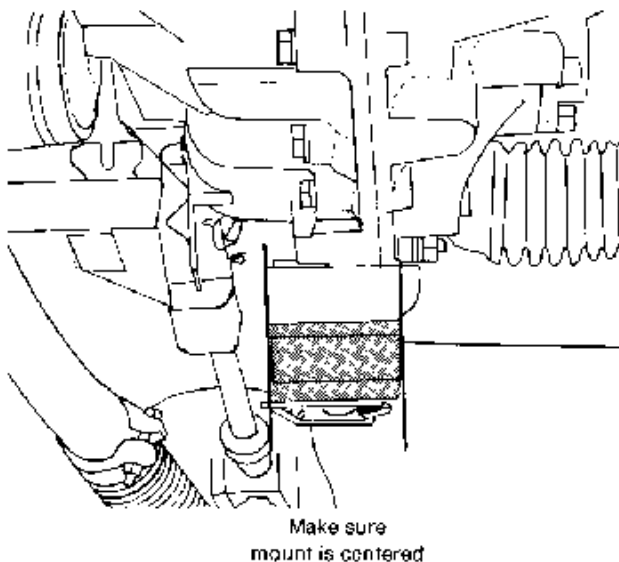


Visually inspect the gaps in the right and left engine mounts to see if the mounts are collapsed.

On cars with dealer installed air conditioning:

If the right side engine mount is collapsed, replace it with the type of mount used on cars with factory installed air-conditioning (refer to parts micro-fiche).

Adjust engine mounts



Loosen the attachment bolts for the left and right engine mounts.

Loosen the body brackets for the front and rear engine mounts.

Move the engine/transmission assembly from side to side so that the rear engine mount is straight.

Start the engine and let it idle.

Move the engine/transmission assembly frontwards and backwards until;

The least amount of engine vibration is felt in the front bumper.

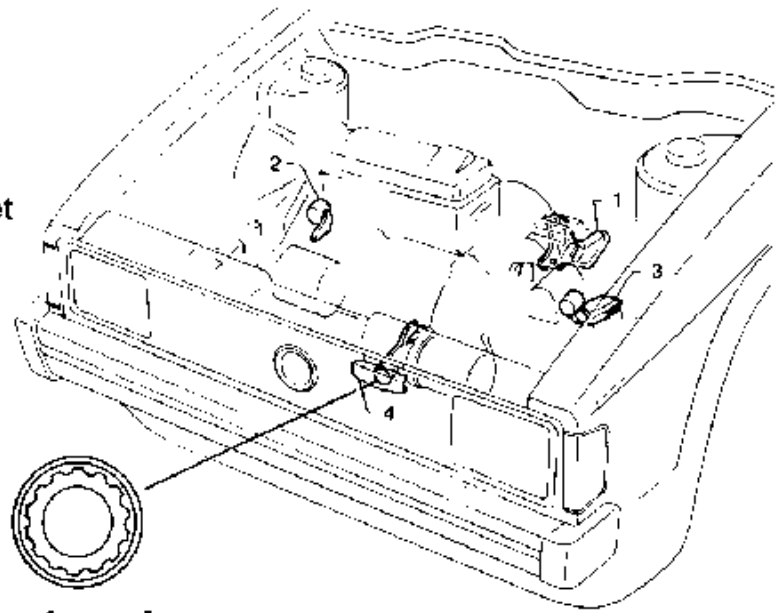
Hold the engine/transmission assembly at this point while a second mechanic tightens the engine mounts (see next page).

Tighten engine mounts

Tighten the mounts in the following order

- 1 - Rear
- 2 - Right
- 3 - Left

Push up slightly on the front mount bracket to center the mount in the bracket and tighten.

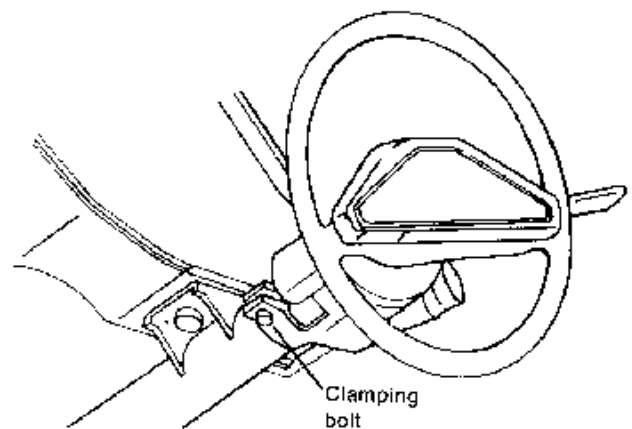


Adjust steering column

Loosen the clamping bolt for steering lock assembly.

Pull up (towards the rear of the car) on the steering wheel with moderate pressure.

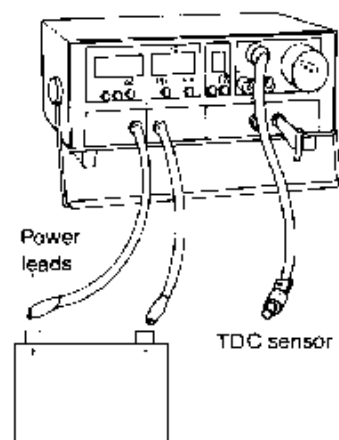
Tighten the clamping bolt to 10 Nm (7 ft. lbs.) while pulling up on the steering wheel.



Adjust idle speed

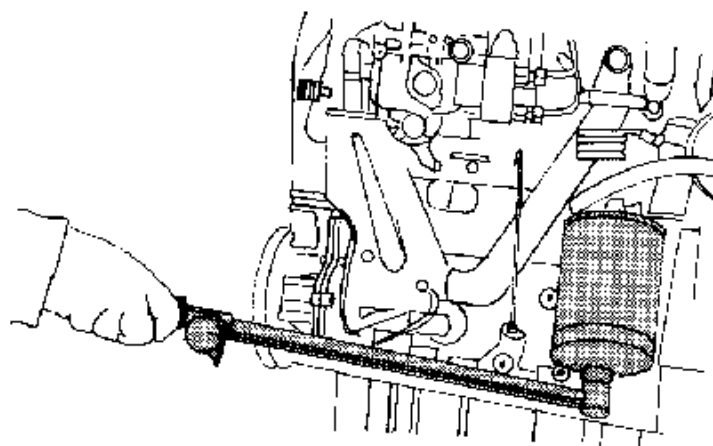
Connect VW 1367

With the engine fully warm, adjust the idle speed within the specified range at the point where the least vibration occurs.



Oil Filter

Oil filter installation



To prevent oil leaks after installing a new oil filter, the following procedure must be used.

Apply a film of oil to the filter gasket (do not use grease)

Screw on the filter and tighten it $\frac{3}{4}$ of a turn after the gasket contacts the flange.

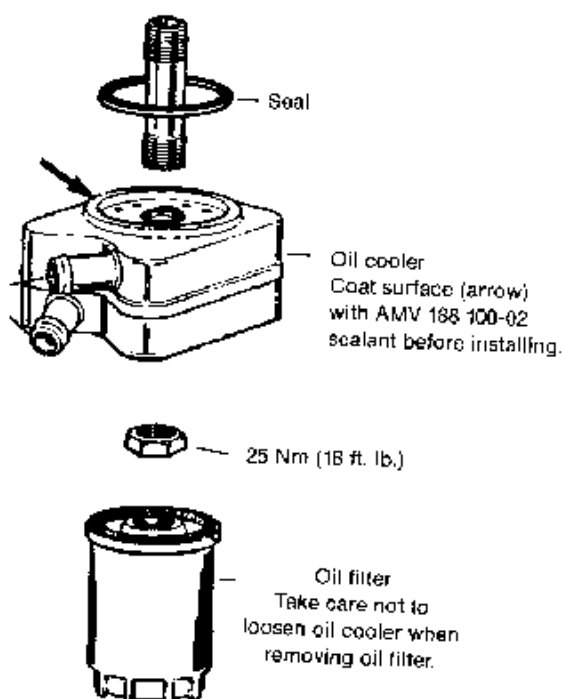
Start the engine and run for 3-5 minutes at various speeds.

Stop engine and check the tightness of the filter with special tool US 4496 (or equivalent) and a torque wrench.

The filter must be torqued to 25 Nm (18 ft.lbs.)

Start the engine and check for leaks

Engine with oil cooler



Care must be taken to insure that the oil cooler is not loosened when removing the oil filter.

If necessary, check the tightness of the nut which fastens the oil cooler to the oil filter flange.

The procedure for installing the oil filter is the same as cars without an oil cooler.

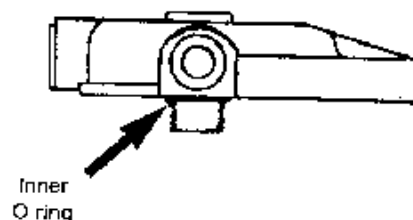
Fuel Filter

The diesel fuel system uses a special fuel filter combined with a water separator. This filter is designed to allow sufficient fuel flow while maintaining maximum filtering capability. After market fuel filters do not always meet these requirements. If the wrong fuel filter is used, the result may be impaired performance or damage to the fuel system (injection pump or injectors). It is important that only approved fuel filters are installed during maintenance or repairs.

Fuel filter replacement

When replacing the fuel filter, the inner O ring on the filter flange mounting stud is not required. If the O ring is broken or lost, operation of the filter will not be affected.

Some fuel filters have a plastic sleeve to help protect the filter from becoming punctured in the event of an accident. When the fuel filter is replaced, the sleeve must be removed from the old filter and installed on the new filter.



Draining fuel filter

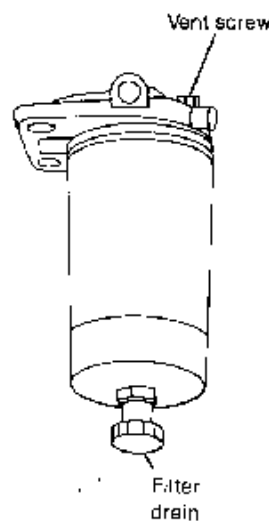
The fuel filter should be drained at 7,500 mile intervals and changed at 15,000 mile intervals. To drain the fuel filter:

- Loosen the vent screw

- Remove the two filter flange mounting nuts, and lift the filter assembly up.

- Loosen the drain screw.

- Drain the fuel into a container until the drained fuel is pure.



Oil in air cleaner

1.5 liter diesel, Rabbit and Pick-up.

To prevent oil from entering the air cleaner on 1.5 liter diesel engines, a modified breather hose assembly should be installed.

First check to see if the modification has already been installed, if not:

Remove hoses from the engine block flange.

Remove the engine block flange and install the new flange supplied in the kit.

On cars without a vacuum pump, plug the unused connection on the flange with the cap supplied in the kit.

Install the new crankcase breather hose as shown in the illustration.

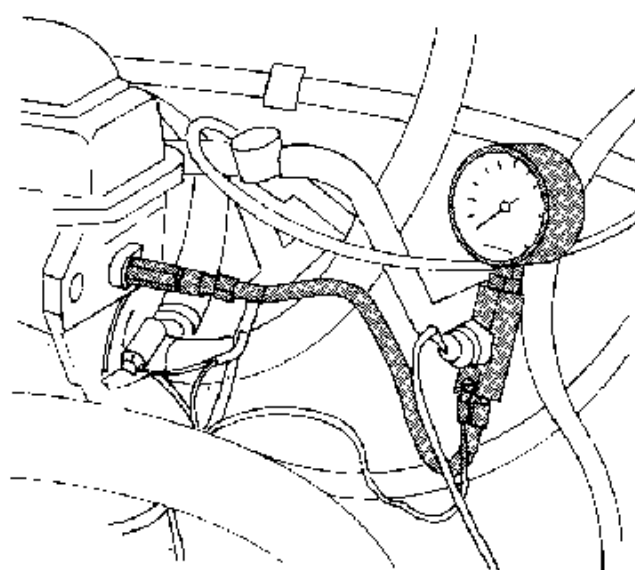
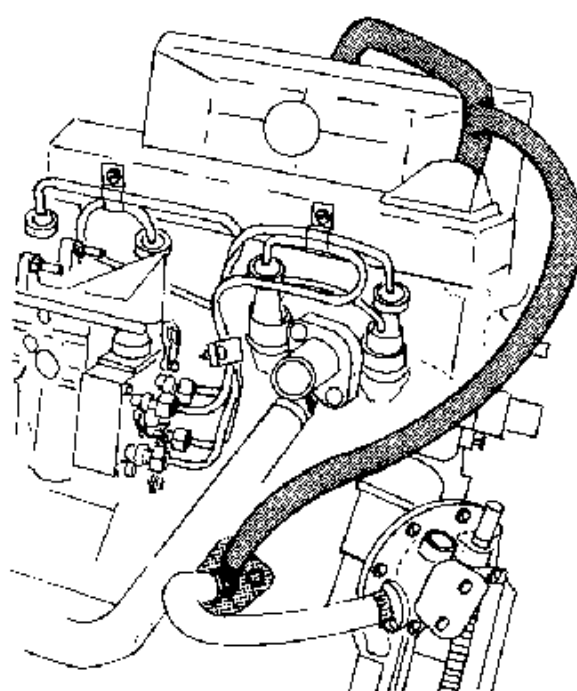
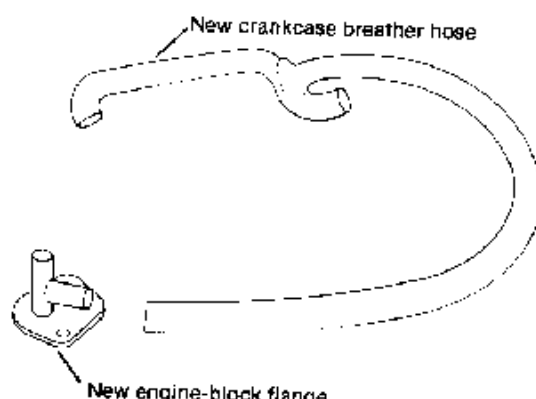
If the modification has been previously installed and excessive oil is found in the air cleaner, check the oil pressure. If the pressure relief valve in the oil pump is sticking, excessive oil pressure will result and too much oil may be supplied to the cylinder head. This could cause oil deposits in the air cleaner.

Remove the oil pressure switch on back of the cylinder head.

Connect an oil pressure gauge to the engine.

Start the engine and measure the oil pressure. (The engine must be fully warmed)

Maximum oil pressure = 7 bar (102 psi) at 5000 RPM.



A/C Compressor Cut-out Switch

An A/C compressor clutch cut-out switch can be installed on diesels with air conditioning. This will ensure that maximum engine power is available during full throttle by eliminating the drag of the air conditioning compressor. A kit, part #ZVW- 449-963, is available through the parts department.

To install the cut-out switch:

Remove the middle bolt of the accelerator bracket.

Install the switch assembly on the top of the accelerator bracket and tighten the bolt.

Some cars will have a bracket for the upshift light switch.

To install the cut-out switch on these cars, grind a slot in the switch bracket as shown.

Route the switch harness towards the A/C compressor and secure it with wire tie wraps.

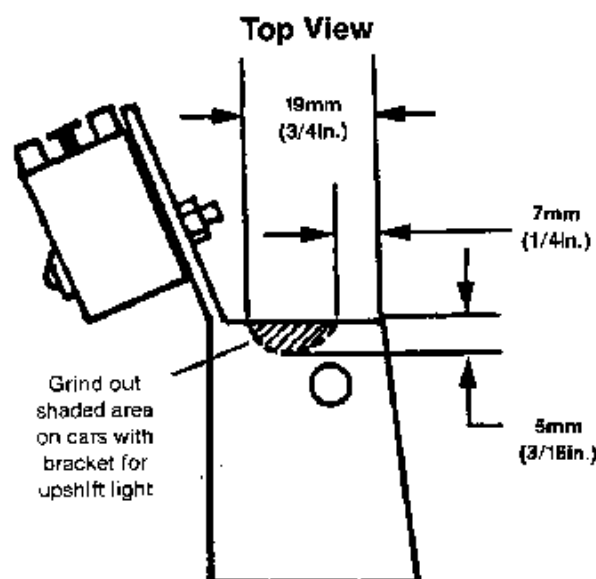
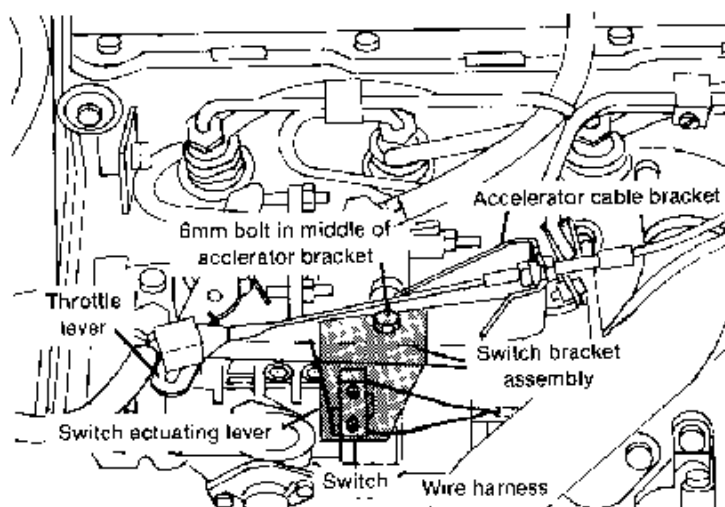
Disconnect the A/C compressor clutch wire connection and connect the cut-out switch wiring harness between the two connectors.

To adjust the cut-out switch:

Move the throttle to the full throttle position.

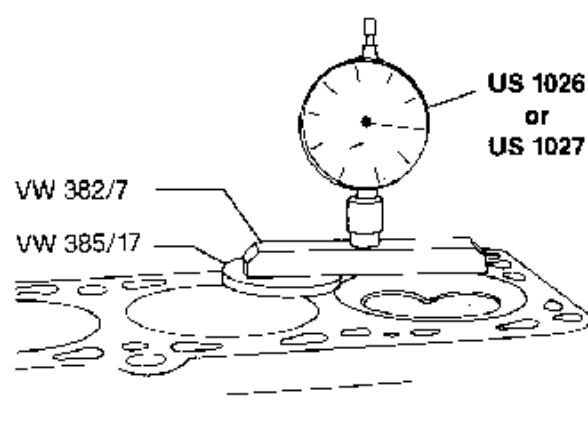
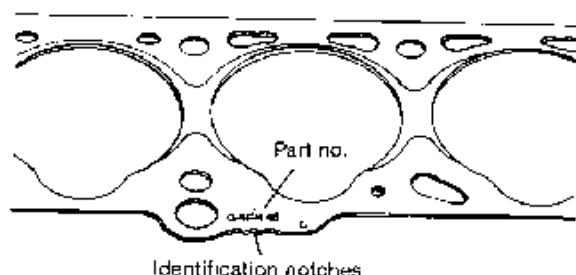
The switch should operate about 1.6mm before the full throttle position is reached.

If necessary, adjust by bending the cut-out switch bracket.



Cylinder Head and Gasket

Note: Diesel cylinder heads **cannot** be resurfaced.



Cylinder head gasket: Identification/Installation

Gasket identified by part no. and number of notches (arrows).

Marking **oben** on gasket **must** face cylinder head.

Cylinder head gasket selection

Always select gasket thickness according to piston height above top of cylinder block.

Measuring piston height

Measure piston height with US1026 (1027), VW 382/7 and VW 385/17.

Piston must be at TDC. Determine piston TDC by reading highest point on dial indicator before measuring piston height.

After measuring piston height, select gasket from following table.

Piston Projection mm (in.)	Thickness of Gasket mm (in.)	Identification Notches in Gasket	
		1977 - 1980 (1.5 L)	1981 and on (1.6 L)
0.43 - 0.62 (0.017 - 0.025)	1.3 (0.051)	2	—
0.63 - 0.82 (0.025 - 0.032)	1.4 (0.055)	3	1
0.83 - 0.92 (0.033 - 0.036)	1.5 (0.059)	4	2
0.93 - 1.02 (0.037 - 0.040)	1.6 (0.063)	5	3

Piston height must be measured when installing new pistons or short block. Then select gasket according to measurement.

Cylinder Head and Gasket (cont'd.)

Loosening/lightening sequence

Tighten in numerical order (1, 2, 3, etc.).

Loosen in reverse order (10, 9, 8, etc.).

When installing head, first install bolts 8 and 10 to center head.

Note: Do not remove a cylinder head from a hot engine.

Tightening Procedure — 6 point bolts

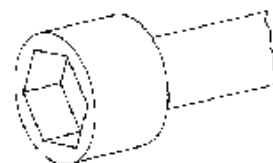
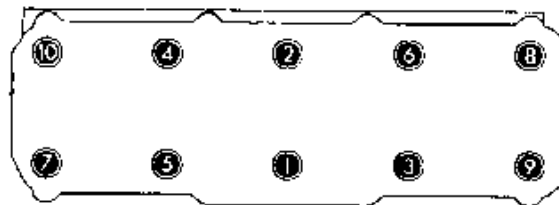
Torque in three steps: Step 1 50 Nm (35 ft.lbs.)
Step 2 70 Nm (50 ft.lbs.)
Step 3 90 Nm (65 ft.lbs.)

After step 3, warm up engine until radiator fan cycles or until oil temperature reaches 50° C (122° F).

Torque head bolts again, without backing off to 90 Nm (65 ft.lbs.).

Engine may be cold or warm.

Bolts may be reused.



Used from
1977 to most 1981 diesels

Tightening Procedure — 12 point bolts

Torque in three steps: Step 1 40 Nm (29 ft.lbs.)
Step 2 60 Nm (43 ft.lbs.)
Step 3 75 Nm (54 ft.lbs.)

After step 3, tighten bolts ½ turn (180°) (two ¼ turns are OK), further without backing off.

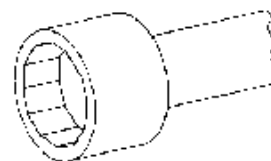
Warm up engine until radiator fan cycles or until oil temperature reaches 50° C (122° F).

Tighten bolts an additional ¼ turn (90°).

Retorque at 1000-mile service an additional ¼ turn (90°) without backing off.

Engine may be cold or warm.

The 12 point bolts **must** be replaced if they are removed.

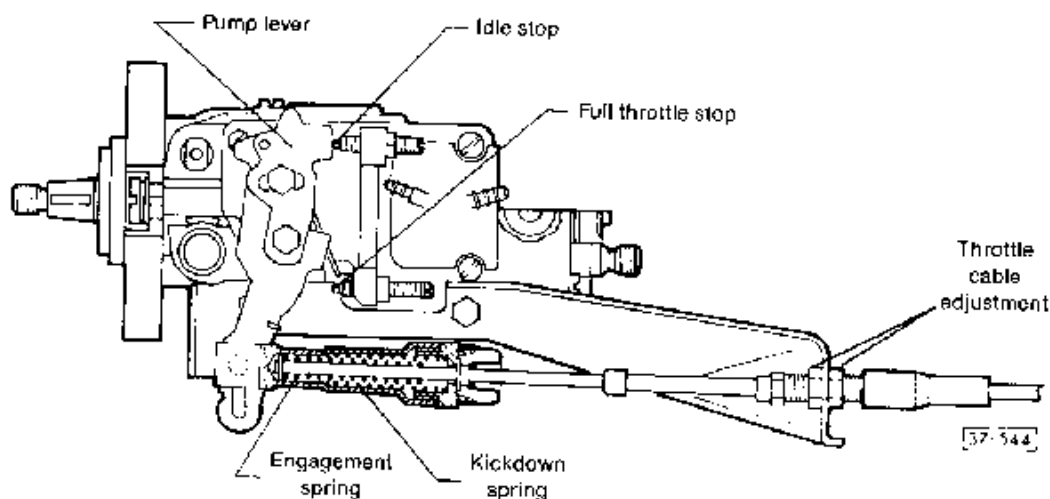


11mm 12 pt.
used starting with some 1981 diesels

E-mode automatic transmission

Throttle Cable Check and Adjustment Procedure

Whenever idle speed or maximum engine speed is adjusted, the throttle cable adjustment must be checked. If this is not done, the "E" mode function of the transmission may not operate or rough engagement of the forward clutch may be experienced. This could result in damage to the transmission.



Checking procedure

Remove the throttle cable from the injection pump throttle lever. Check to insure that the throttle lever rests against the idle speed adjustment stop.

With the transmission operating lever against the closed throttle stop in the transmission, the ball pin socket in the throttle cable must line up with the ball pin on the throttle lever without any tension.

Do not pull on the throttle cable spring assembly while performing this check. This will compress the engagement spring and cause an incorrect adjustment.

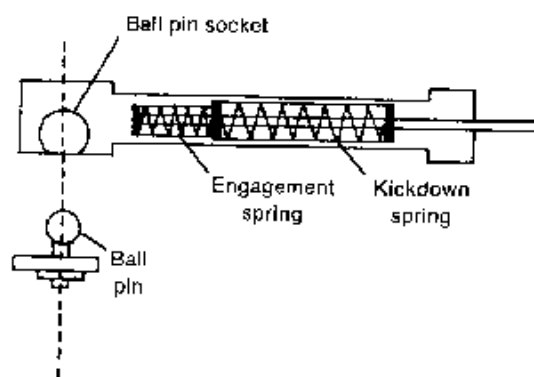
The transmission operation lever must remain against the closed throttle stop while performing this check.

Depress accelerator pedal to full throttle position.

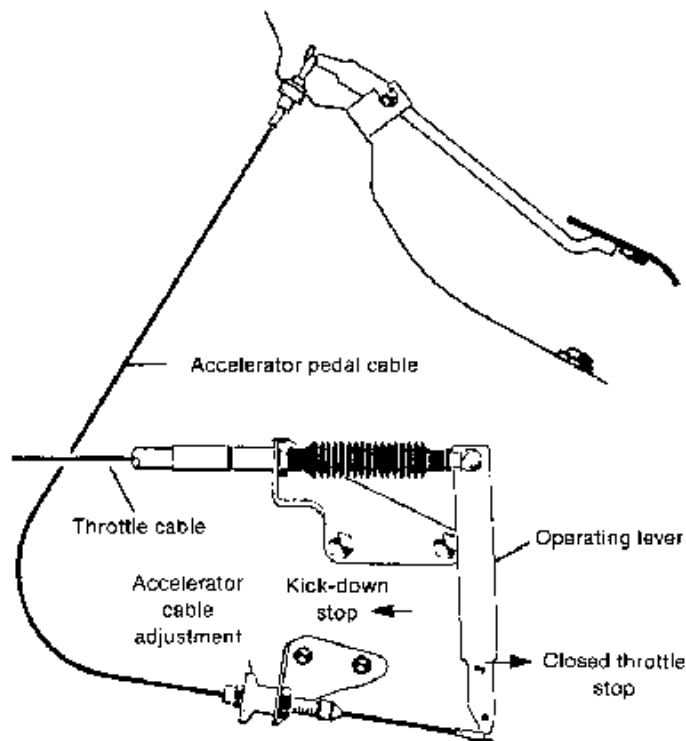
The throttle lever must rest against the full throttle stop on the injection pump.

The transmission operating lever must be against the kickdown stop in the transmission.

Throttle cable spring assembly



Adjustment Procedure



Disconnect the accelerator pedal at the transmission.

Disconnect the throttle cable at the injection pump.

Adjust the ball pin on the injection pump lever so that the total travel from idle to full throttle is 32 ± 1 mm.

Adjust the throttle cable so that the ball pin socket in the throttle cable spring assembly lines up with the ball pin on the throttle lever

The transmission operating lever must be against the closed throttle stop.

The engagement spring in the throttle cable spring assembly must not be compressed.

Reconnect the accelerator pedal cable to the transmission operating lever.

Have someone press the accelerator pedal all the way to the floor (kickdown position)

The transmission operating lever must be against the kickdown stop.

The pump lever must be against the full load stop and the engagement spring must be compressed.

If not, adjust the accelerator cable at the transmission.

