Mechanical Gasoline Injection System with Metered Air Volume

service

Training Booklet

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Mechanical Gasoline Injection System with Metered Air Volume

Note Concerning Training Manual

This training manual replaces the enclosure entitled "Mechanical Gasoline Injection System with Metered Air Volume" in the introductory brochure "Model 450 SEL 6.9".

Distributed transparencies can continue to be used. Only the enclosed transparencies replace the corresponding old ones.

Printing Errors

07.3/2/12 overleaf, section 7.2:

Replace	with
Pressure gauge:	Pressure gauge 100 589 13 21 00
Voltmeter and ohmmeter 100 589 13 21 00	Voltmeter and ohmmeter

07.3/2/18, front page, section 13, 1st line:

Replace: Test value	with: Test

Contents:

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1. General

Abbreviation of the injection system: KA (CIS)

K = Continuous
A = Without drive

The new gasoline injection system is operating mechanically and and need not be driven by the engine (A = without drive).

In contrast to the intermittent injection known to this date in this system fuel is injected continuously in front of the intake valves independent of the firing order (K = continuous).

Fuel is metered as a function of the volume of air drawn in by the engine which is measured in an air flow sensor.

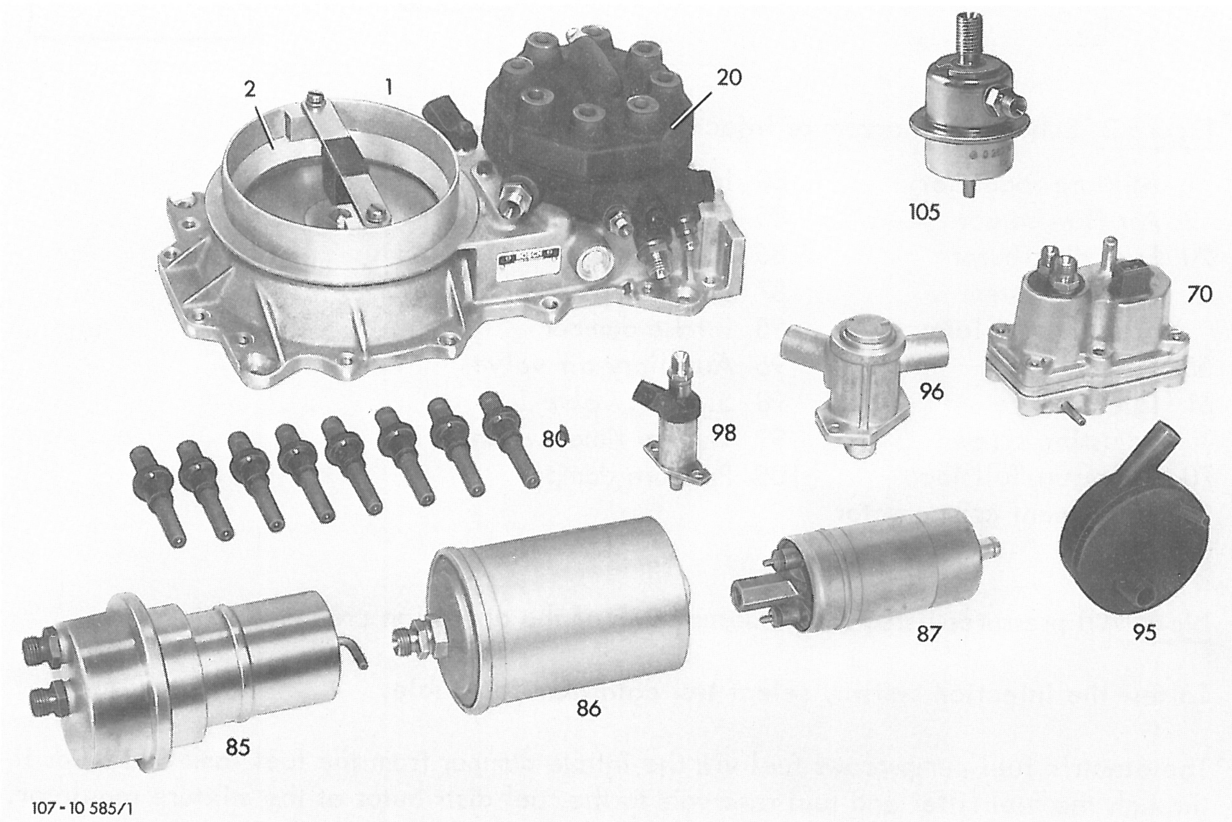


Figure 1 Components of injection system

- 1 Mixture regulator
- 2 Air flow sensor
- 20 Fuel distributor
- 70 Warm-up/full load enrichment compensator
- 80 Injection valves
- 85 Fuel reservoir
- 86 Fuel filter
- 87 Fuel pump
- 95 Intake damper
- 96 Auxiliary air valve
- 98 Starting valve
- 105 Pressure damper

2. Mode of Operation

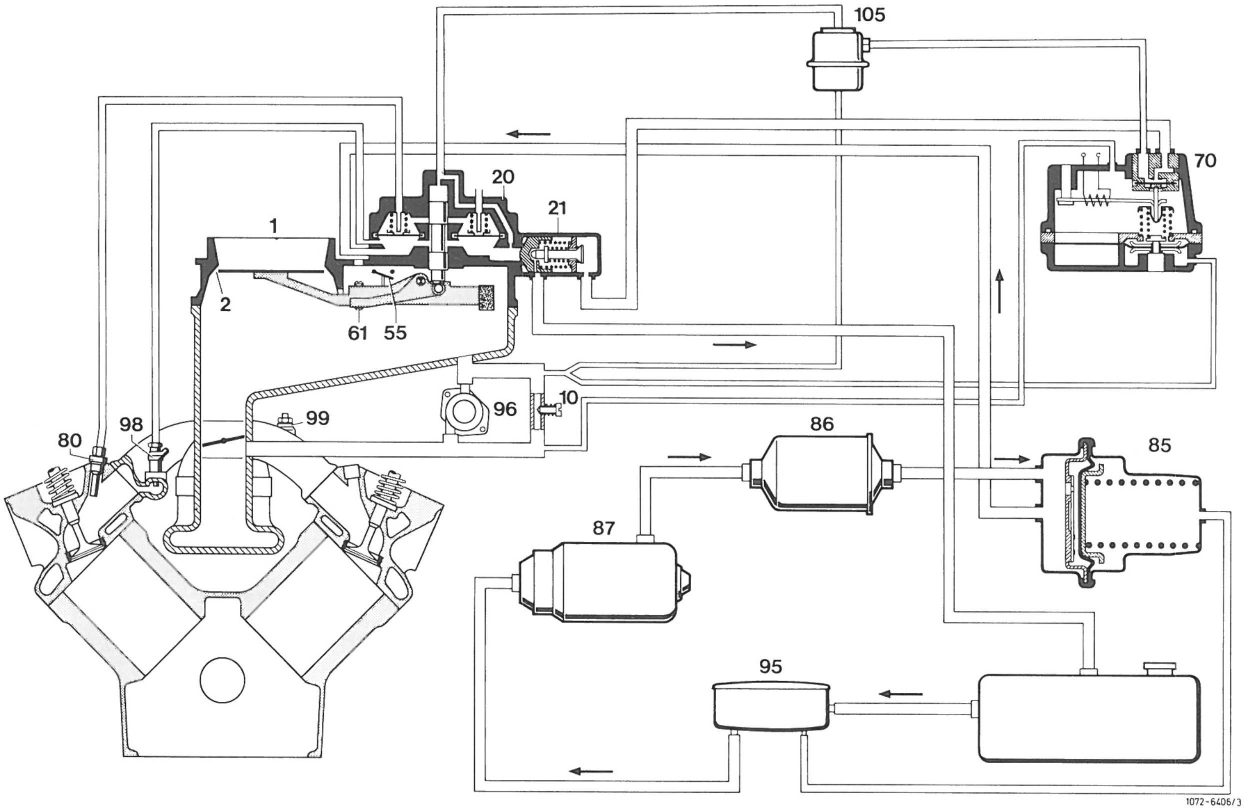


Figure 2 Schematic diagram of injection system

1	Mixture regulator	80	Injection valve
2	Air flow sensor	85	Fuel reservoir
20	Fuel distributor	86	Fuel filter
21	Primary system pressure regulator	87	Fuel pump
55	Safety switch	95	Intake damper
61	Idle mixture adjusting screw	96	Auxiliary air valve
70	Warm-up/full load enrichment compensator	98	Starting valve
		99	Thermo time switch
		105	Pressure damper

Note: All pressures listed in the description of the operation are mean values.

To test the injection system, select test data from test table.

The electric fuel pump draws fuel via the intake damper from the fuel tank and feeds it through the fuel filter and fuel reservoir to the fuel distributor at the mixture regulator.

A pressure regulator in the fuel distributor constantly retains the primary system pressure at approx. 5.5 bar. Depressurized excess fuel flows back to the fuel tank.

The fuel pump is energized only if the starter is actuated and while the engine is running.

The mixture regulator comprises the air flow sensor and the fuel distributor. In the air flow sensor a baffle plate measures the air volume drawn in by the engine.

In doing this the baffle plate travels in a venturi and remains in a given position which corresponds to the intake air volume (principle of float element).
This movement of the baffle plate is transmitted to the control plunger in the fuel distributor via a lever.

Control pressure acting on control plunger counteracts this movement. The control plunger moves in a slotted sleeve which is located centrally in the fuel distributor.
The slotted sleeve bears as many vertical metering slots as there are cylinders in the engine.

The quantity of fuel is adapted to the air volume by changing the cross section of the metering slots.
Each metering slot is assigned a pressure differential valve which keeps constant the pressure drop at the metering slot independent of the cross section.

Fuel flows from the pressure differential valves to the injection valves via the injection lines. The injection valves open at an approx. pressure of 3.8 bar and inject fuel continuously in front of the intake valves of the engine cylinders.
When the intake valves open, fuel is drawn in the engine cylinders together with the air.

Figure 2

2.1. Additional Components

A warm-up/full load enrichment compensator regulates the control pressure acting upon the control plunger and enriches the combustion mixture under warm-up and full-load conditions.

A thermostat responding to the coolant temperature controls an additional air valve which provides for a larger volume of combustion mixture during the warm-up period.

A starting valve serves as cold-starting aid.

Figure 2

3. Design and Function

3.1. Mixture Regulator

The mixture regulator features an assembly composed of air flow sensor and fuel distributor.

Figure 3

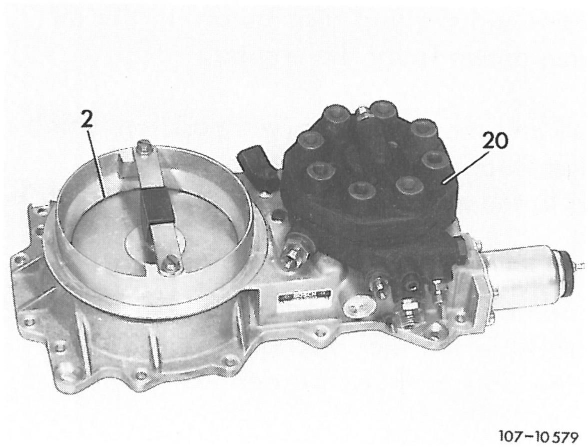


Figure 3

2 Air flow sensor
20 Fuel distributor

3.1.1. Air flow sensor

The air flow sensor comprises a venturi and the baffle plate attached to a lever.

The lever swivels about a fulcrum. The baffle plate's dead weight is balanced by a counterweight.

The entire engine intake air volume is measured in the air flow sensor which is located in front of the throttle valve.

The air flow is measured by the application of the principle of a suspended body which states that a suspended body moves linearly with the air flow rate in a cone.

Figure 4

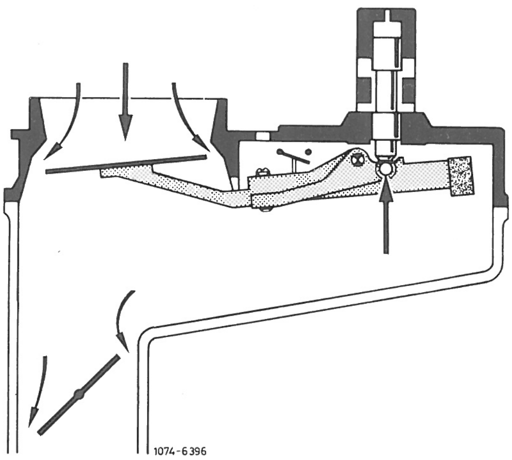


Figure 4

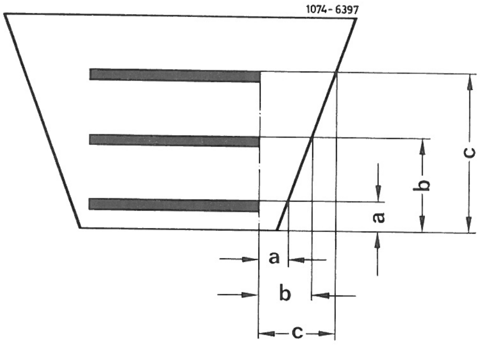


Figure 5

The suspended body depicted in figure 5 clears annular area (a) at a stroke of (a) etc.

Consequently the stroke of the suspended body increases with the flow rate.

In the air flow sensor of the mixture regulator the baffle plate represents the suspended body and the venturi is the cone.

Figure 5

The volume of air drawn in by the engine alters the position of the baffle plate. The stroke of the baffle plate is transmitted in a specified ratio to the control plunger which controls the fuel flow at the metering slots.

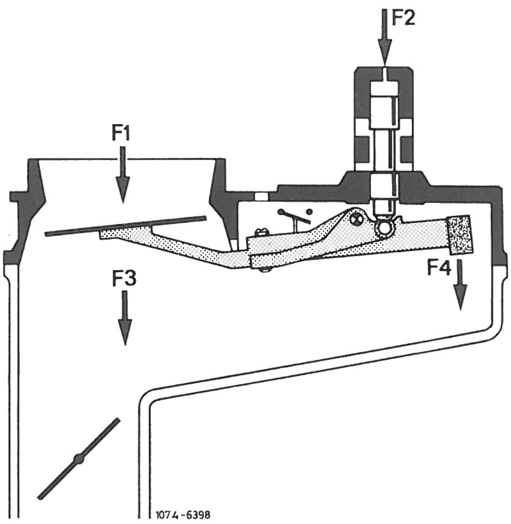


Figure 6

The following forces will therefore become effective at the air flow sensor:

The intake air acts upon the baffle plate as force (F1).

It is counteracted by the hydraulic force (F2) of the control pressure which acts upon the control plunger via a throttle bore.

The dead weight of baffle plate and lever creates force (F3) and is counterbalanced by counterweight (F4).

The baffle plate moves until force (F1) of the air and hydraulic force (F2) are in equilibrium.

As a consequence thereof baffle plate deflection and thus the position of the control plunger with reference to the air flow rate can be effected by the control pressure.

Figure 6

Any engine has a specific performance map, i.e. in specified load and speed ranges the combustion mixture must be enriched, in others it must be leaned down.

Precision adaptation to the engine characteristic is obtained by means of the shape of the venturi. The venturi therefore differs in shape from a straight cone.

Note: Subsequent modifications must therefore neither be carried out on the venturi nor on the baffle plate.

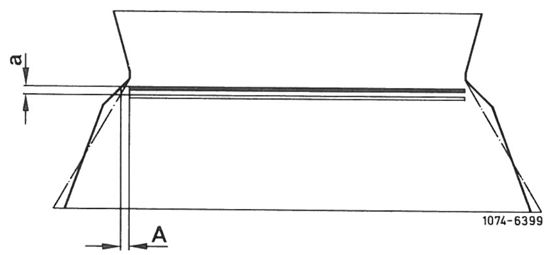


Figure 7

Venturi > cone

Example: If the corrected section in the venturi is wider than the cone the baffle plate stroke in the corrected venturi will be shorter with identical air flow rate.

The fuel/air mixture is leaned down.

Figure 7

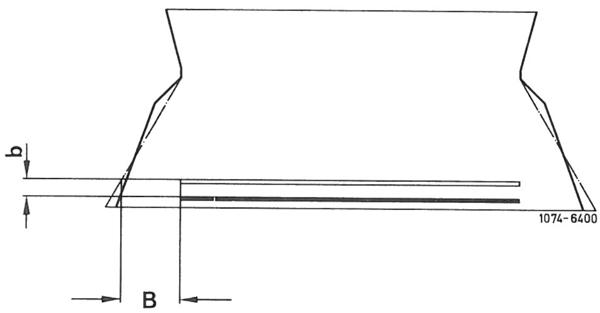


Figure 8

Venturi < cone

If the corrected section in the venturi is narrower than the cone the baffle plate stroke will be longer with identical air flow rate.

The fuel/air mixture is enriched.

Figure 8

In the switched off engine the baffle plate is at the narrowest point of the venturi. The resting position is determined by a resilient stop.

The venturi also flares in the opposite direction to provide for the release of pressure should the engine backfire. The baffle plate will then overcome the resilient stop.

3.1.2. Fuel Distributor

The slotted sleeve with the control plunger is the major component of the fuel distributor.

The slotted sleeve is a hollow cylinder in which approx. 0.1 to 0.2 mm wide and 5 mm long precision slots are machined, i.e. the metering slots.

One metering slot is provided for each engine cylinder via which the fuel is metered.

The control plunger travels in the slotted sleeve and changes the metering slot cross section and thus the flow rate with its control edge.

One pressure differential valve is assigned to each metering slot which keeps the pressure loss (differential pressure) at the slot constant independent of the metering slot opening.

This ensures that the metered quantity of fuel is exclusively subject to the cross section cleared.

Figure 9 and 10

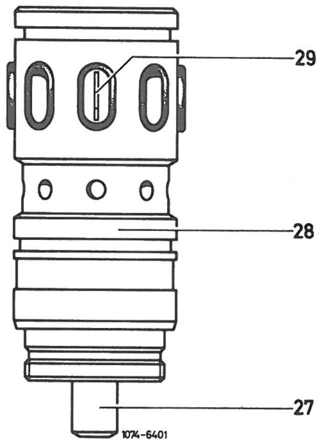


Figure 9

27 Control plunger
28 Slotted sleeve
29 Metering slot

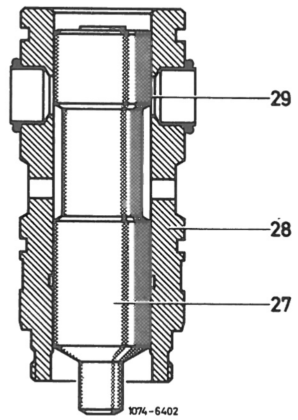


Figure 10

27 Control plunger
28 Slotted sleeve
29 Metering slot

3.1.2.1. Function of Pressure Differential Valves.

The pressure differential valves are split up in lower and upper chambers by a steel diaphragm. The lower chambers are linked up via an annular duct.

The pressure in the lower chambers corresponds to the primary system pressure of approx. 5.5 bar.

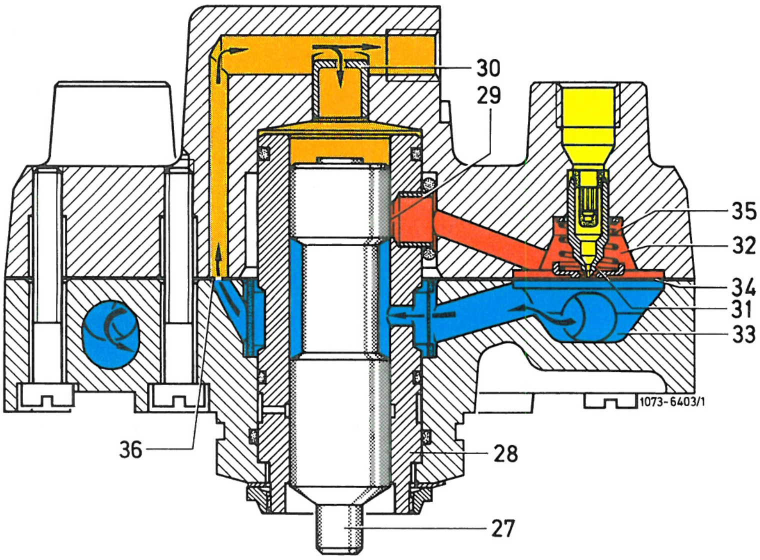


Figure 11

27 Control plunger
28 Slotted sleeve
29 Metering slot
30 Damping throttle
31 Pressure differential valve
32 Upper chamber
33 Lower chamber
34 Diaphragm
35 Compression spring
36 Throttle bore

3.1.2.1. Function of Pressure Differential Valve (continued)

In the upper chambers the pressure is less by the pressure differential of 0.1 bar.

This pressure differential is produced by the coil spring installed in the upper chamber.

Under this condition there is equilibrium at the diaphragm between the upper and the lower chamber.

Figure 11

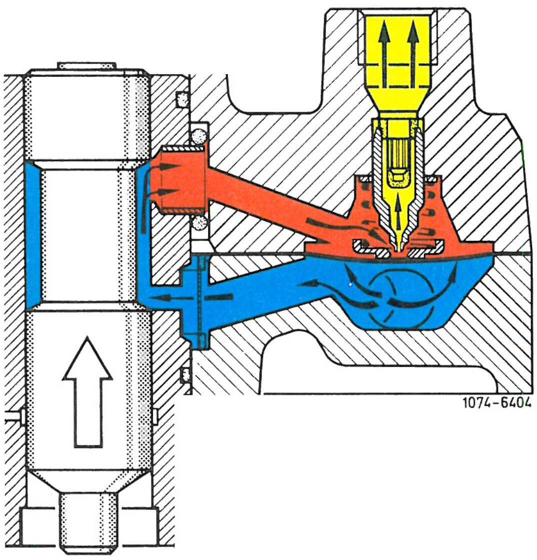


Figure 12

Primary system pressure
Reduced primary system pressure
Control pressure
Injection pressure

If the flow rate is increased at the metering slot, the pressure in the upper chamber rises momentarily by which action the pressure differential becomes less than 0.1 bar.

Since spring action supports the pressure on the diaphragm upper side the steel diaphragm arches more downward and thus clears a larger flow cross section to the injection valve. The fuel pressure on the diaphragm upper side is thus reduced again.

Now equilibrium is regained between diaphragm upper and lower side and the diaphragm remains in the wide open position.

Figure 12

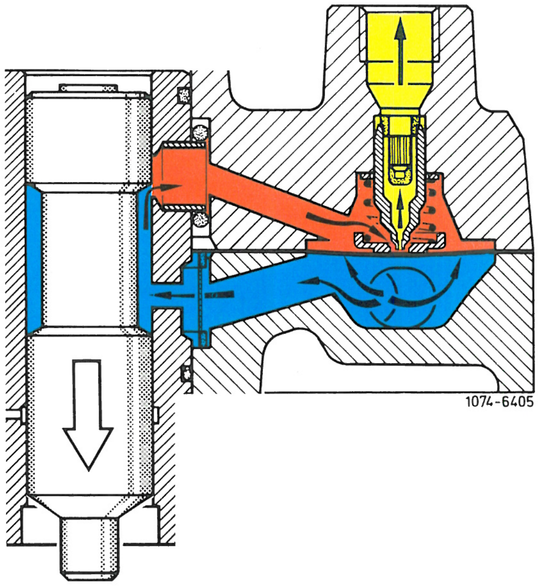


Figure 13

Vice versa the pressure on the diaphragm upper side lowers (pressure differential enlarges) when the metering throttle is closed.

The flowing cross section continues to be reduced until equilibrium is regained.

These cycles are repeated with each new position of the control plunger, i.e. whenever the position of the baffle plate has changed.

Figure 13

4. Fuel System

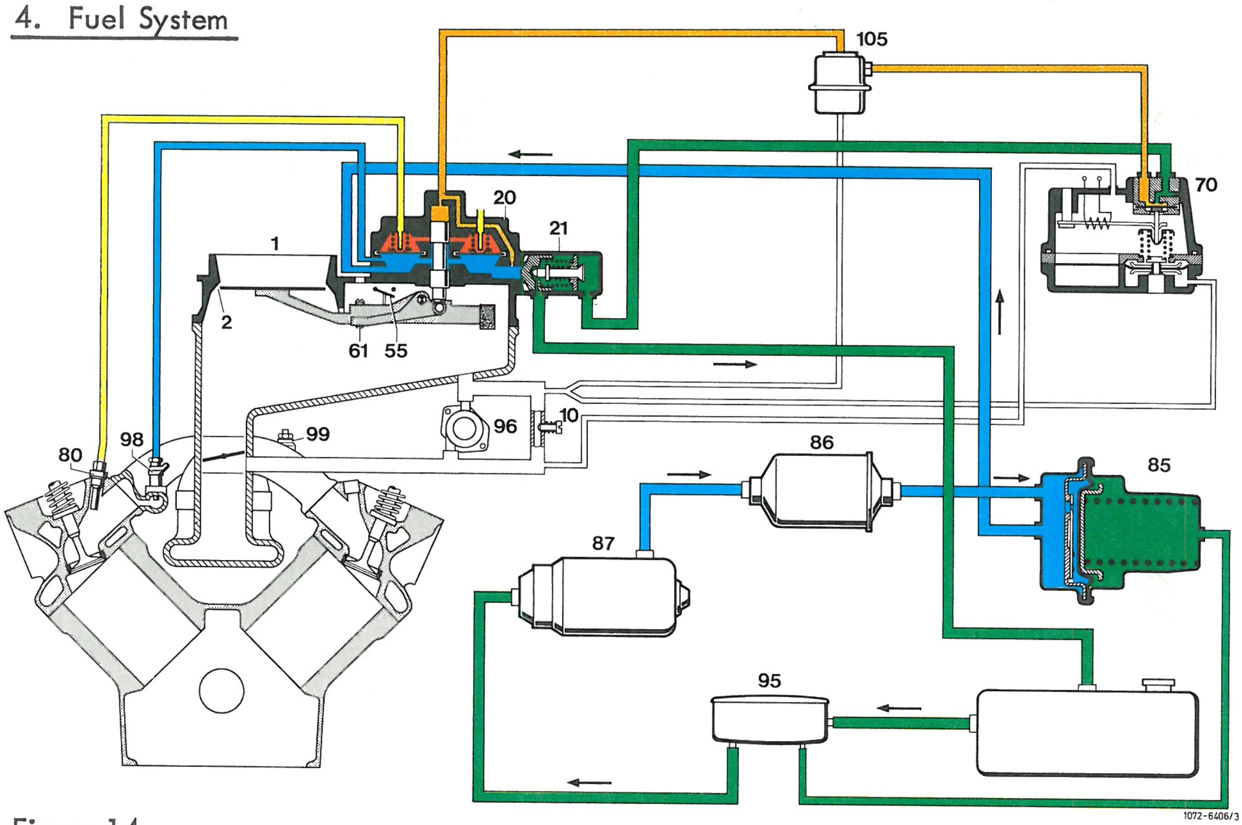
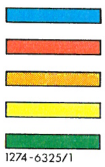


Figure 14



Primary system pressure
Reduced primary system pressure
Control pressure
Injection pressure
Depressurized

The fuel system splits up in the following pressure circuits:

4.1. Primary System Pressure Circuit

The primary system pressure circuit reaches from the fuel pump to the starting valve via fuel filter, fuel reservoir and fuel distributor (pressure differential valve - diaphragm lower side).

The primary system governor installed in the fuel distributor retains the pressure constantly at approx. 5.5 bar.

Depressurized excess fuel returns from the governor to the fuel tank through the return line.

A primary system pressure reduced by 0.1 bar prevails at the diaphragm upper side of the pressure differential valve.

The pressure prevailing in the fuel lines from the fuel distributor to the injection valves corresponds to the injection valve opening pressure of approx. 3.5 bar.

4.2. Control Pressure Circuit

The control pressure circuit is branched off the primary circuit pressure circuit via a throttle bore in the steel diaphragm of the fuel distributor.

A pressure varying from approx. 0.5 - 3.6 bar prevails in the control pressure circuit and is controlled in the warm-up/full load enrichment compensator as a function of temperature and load.

Depressurized excess fuel flows back from the warm-up/full load enrichment compensator to the fuel tank via the primary system governor.

The control pressure acts on the upper side of the control plunger counteracting the force exerted by the air at the baffle plate.

In this system:

high control pressure = less fuel (lean mixture)

low control pressure = more fuel (enriched mixture)

Control pressures:

Warm-up phase with coolant temperatures -20°C to +80°C = pressure of approx. 0.5 - 3.6 bar.

At operating temperature = approx. pressure of 3.6 bar.

At full load (operating temperature) = approx. pressure of 3.0 bar.

A damping throttle is located between the space above the control plunger and the control pressure line.

The throttle dampens the movement of the baffle plate if the air flow is pulsating.

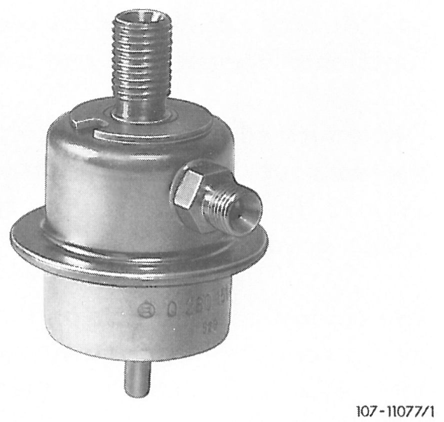


Figure 15

Pressure damper

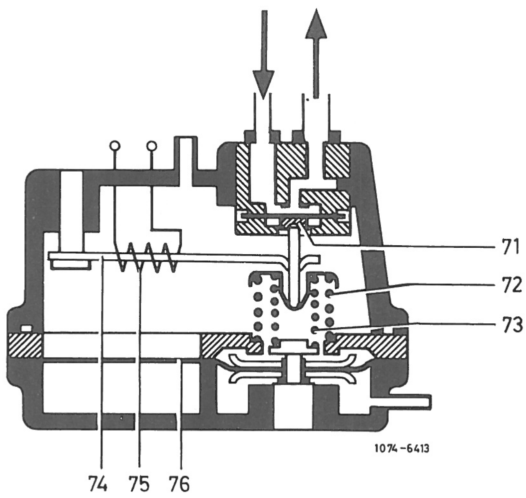


Figure 16

71 Diaphragm valve
72 Outer valve spring
73 Inner valve spring
74 Bimetallic strip
75 Heater coil
76 Vacuum diaphragm

During acceleration peak pressures are produced in the control pressure line due to the rapid evacuation of the space above the control plunger.

In order that these peak pressures cannot damage the diaphragm in the warm-up/full load enrichment compensator a pressure damper is installed in the control pressure line.

For safety reasons the spring chamber of the pressure damper is connected to the air channelling housing via a leak line. Thus no fuel can leak out in case of a defective diaphragm.

Figure 15

4.3. Warm-up/Full Load Enrichment Compensator

The warm-up/full load enrichment compensator regulates the control pressure which acts upon the control plunger and enriches the combustible mixture in the warm-up period and under full load conditions.

Two fuel lines are connected to the warm-up/full load enrichment compensator, namely the control pressure line and the return line.

Control pressure acts upon the upper side of the diaphragm valve which throttles the return line cross section.

Two valve springs act upon the lower side of the diaphragm.

A bimetallic strip provided with a heater coil is installed for the enrichment of the mixture during the warm-up period. The cold bimetallic strip counteracts the valve springs. Thus the diaphragm valve is opened and the control pressure is lowered.

By and by the heating reduces the bimetallic spring action until the control pressure reaches its normal level.

For full-load enrichment the warm-up/full load enrichment compensator is split in two chambers by a vacuum diaphragm.

The intake manifold vacuum becomes effective in the upper chamber.

The lower chamber is connected to the atmosphere via a connection below the baffle plate.

Vacuum prevails in the upper chamber under idle and partial load conditions and the vacuum diaphragm contacts the upper stop. In this position the spring action corresponds to the normal level of the control pressure.

Under full load the vacuum in the upper chamber is neutralized and the vacuum diaphragm moves downward. The force of the inner valve spring is reduced. Consequently the control pressure is lowered and the mixture is thus enriched.

Figure 16

4.4. Components of Fuel System

4.4.1. Intake Damper

To avoid noises in the intake line an intake damper is installed between the fuel tank and the fuel pump.

Figure 17

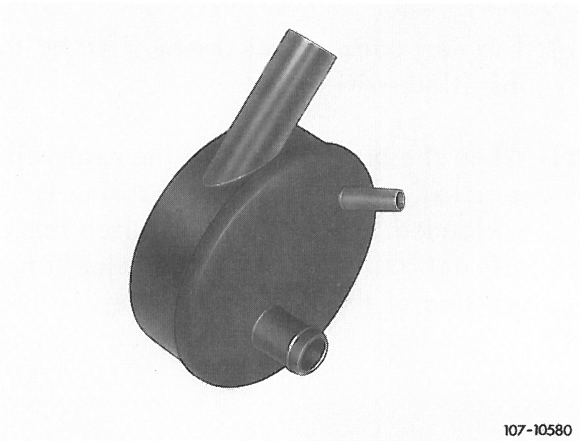


Figure 17

4.4.2. Fuel Pump

The roller type pump has a delivery of approx. 130 liter h at 12 V. The feed pressure corresponds to the primary system pressure. The pressure release valve opens at a pressure of 8.0 bar.

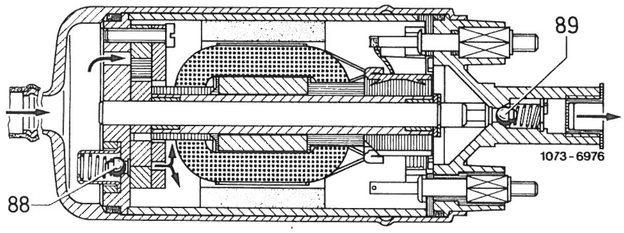


Figure 18

88 Pressure release valve
89 Check valve

There is a check valve in the pressure side connection which retains residual pressure in the lines when the engine is shut off.

The fuel pump is energized via a safety circuit and will operate only if

a) the starter is actuated,

b) the engine is running.

Figure 18

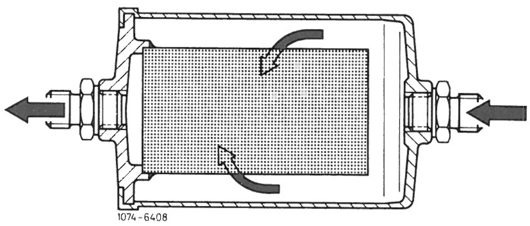


Figure 19

4.4.3. Fuel Filter

The fuel filter is a fine-mesh filter with paper element. The direction of fuel flow is marked with an arrow.

Figure 19

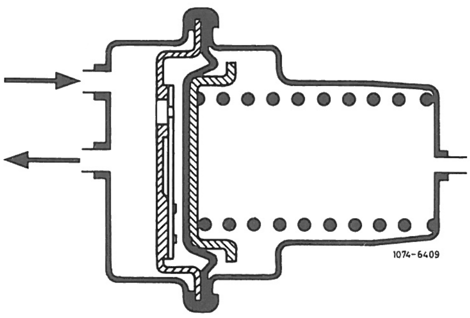


Figure 20

4.4.4. Fuel Reservoir

The fuel reservoir performs the following functions:

a) The fuel pump noises are muffled by the installed swirl bowl.

b) When the pump is started the reservoir is filled and the diaphragm spring is preloaded. The pressure required for this action is lower than the ejection pressure of the injection valves.

The primary system pressure build-up is delayed due to the filling of the reservoir, the control pressure can become effective on the upper side of the control plunger and push the plunger downward.

Thus the metering slots are sealed and uncontrolled ejection of the injection valves is avoided.

c) After the engine has been shut off the fuel reservoir will keep the fuel system pressurized for an extended period.

This prevents the formation of vapor bubbles and ensures good hot starting properties.

For safety reasons the spring chamber of the fuel reservoir is connected with the intake damper by means of a leak line.

Thus no fuel can leak out if the diaphragm is defective.

Figure 20

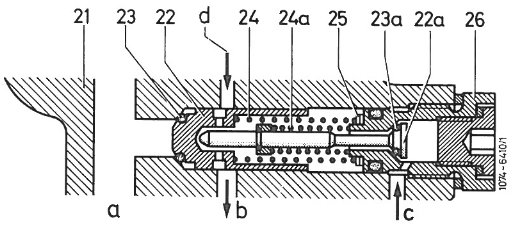


Figure 21

21 Primary system pressure governor
22 Governor plunger
22a Return valve
23 Rubber ring
23a Rubber ring
24 Compression spring
24a Compression spring
25 Washers
26 Screw plug
a Primary system pressure line
b Return line to fuel tank
c Return line from warm-up/ full load enrichment compensator
d Return line from control plunger Leak fuel

4.4.5. Primary System Pressure Governor

The primary system pressure governor is designed as piston type governor and installed in the fuel distributor.

The primary system pressure governor has the following functions:

a) To level the primary system pressure to approx. 5.5 bar.

b) To quickly drop the primary system pressure below the injection valve opening pressure in order that the injection valves seal safely when the engine is shut off. The corresponding pressure drop will be brought about by the surface areas at the governor plunger.

c) To seal off the primary system pressure circuit towards the return line in order to ensure that fuel is retained in the system over an extended period and good hot starting properties are achieved. For this purpose the governor plunger is provided with a seal ring.

d) To seal off the return line from the control pressure circuit. A return line valve installed behind the governor plunger which is also equipped with a seal ring and is actuated by the governor plunger serves this purpose.

Figure 21

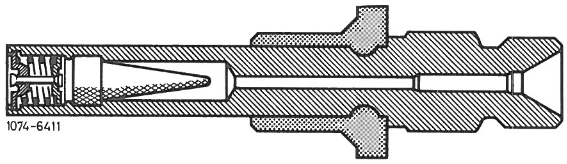


Figure 22

4.4.6. Injection Valves

One injection valve is assigned to each cylinder.

The injection valves have an opening pressure of approx. 3.8 bar and atomize even the smallest quantities of fuel extremely efficiently with the aid of the installed vacuum relief valve.

The fuel is injected continuously in front of the intake valves.

Figure 22

5. Additional Components

5.1. Safety Circuit

5.1.1. Fuel Pump

For safety reasons the fuel pump operates only if the starter is actuated or while the engine is running.

The pump is controlled via the pump relay and the safety switch (ground switch) on the mixture regulator.

When the baffle plate is closed the safety switch grounds pump relay terminal 5. Thus the relay allows the fuel pump to be triggered only via terminal 50 (starter voltage).

The ground switch opens as soon as the baffle plate lifts off.

The pump relay changes over and the fuel pump is now energized via terminal 15/54.

Figure 23

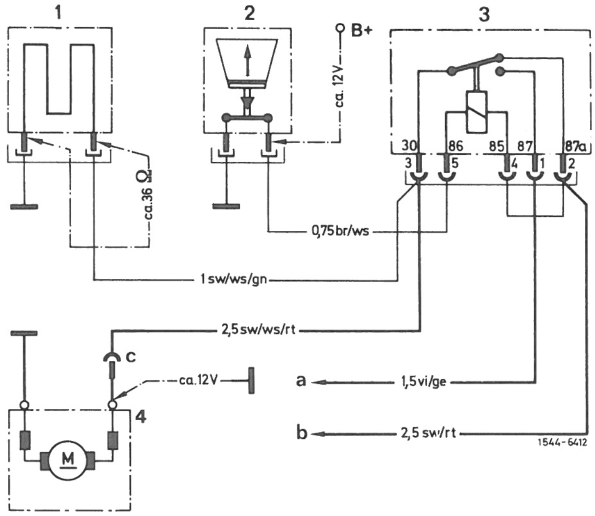


Figure 23

1 Heater coil - warm-up/full-load enrichment compensator
2 Safety switch - baffle plate
3 Relay, fuel pump
4 Fuel pump
a Terminal 50 (starting)
b Terminal 15/54 (ignition)
c Plug connection
Tail light cables

5.1.2. Warm-up/Full Load Enrichment Compensator

To avoid undesired heating of the heater coil in the warm-up/full load enrichment compensator when the ignition is switched on, the heater coil in the warm-up/full load enrichment compensator is also triggered via the fuel pump safety circuit.

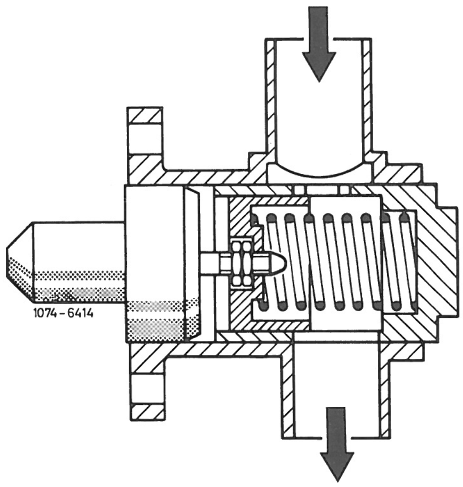


Figure 24

5.2. Additional Air Valve

In the warm-up phase the engine requires an increased volume of combustible mixture to overcome greater frictional resistance and to run smoothly.

The additional air valve is controlled by a thermostatic element and supplies additional air to the engine as a function of the coolant temperature.

Since the volume of the additional air is measured by the baffle plate, the control plunger meters the corresponding quantity of fuel.

The additional air valve is completely opened at temperatures of less than -20°C and completely closed at temperatures of more than +65°C.

Figure 24

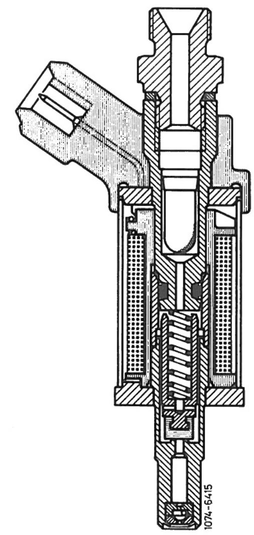


Figure 25

5.3. Starting Valve

Primary system pressure is imposed upon the electromagnetic starting valve. It is controlled via terminal 50 and by a thermo time switch. The thermo time switch is closed at coolant temperatures of less than +15°C. The closing time of the thermo time switch and thus the opening time of the starting valve rises with lowering temperature and reaches 12 seconds at -20°C.

Figure 25

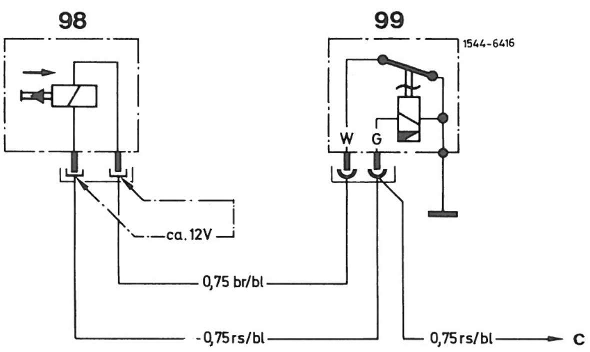


Figure 26

98 Starting valve
99 Thermo time switch
c To terminal 50

5.4. Hot Starting Solenoid

Only engine 100.985 (450 SEL 6.9) had been equipped with a hot starting solenoid on the mixture regulator which had been controlled via a 40°C-temperature switch and a hot starting relay.

Since November 1975 this hot starting device has no longer been installed.

No spare parts are available for it.

The function need not be tested.

5.5. Idle RPM Stabilization - Engine 116

Engine 116 is equipped with an RPM stabilization device. At coolant temperatures of over approx. 40°C and an intake manifold vacuum of more than approx. 350 mm HG additional air is channelled to the intake manifold by by-passing the throttle valve and the air volume sensor.

Thus overenrichment of the fuel/air mixture is avoided and smooth engine idle operation is ensured when the throttle valve should close quickly.

5.5.1. Mode of Operation

At a coolant temperature of more than approx. 40°C thermo valve (2) has opened the passage. Vacuum reaches by-pass air valve (4) via delay valve (3). The by-pass air valve opens at a vacuum of more than approx. 350 mm HG so the engine can take in air via filter (5). Such a vacuum level can be achieved only when accelerating from the idle and easing off the pedal momentarily or in the overrun or under partial load.

Figure 27

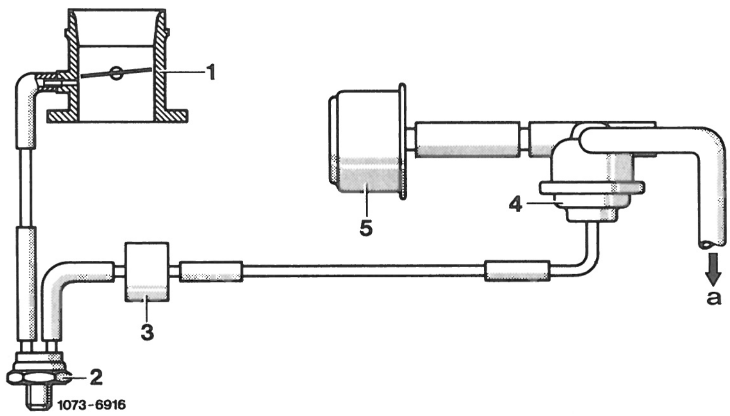


Figure 27

1 Throttle valve housing
2 Thermo valve 40°C
3 Delay valve
4 By-pass air valve
5 Filter

a to intake manifold

5.5.1. Mode of Operation (continued)

The delay valve continues to keep the by-pass air valve open for approximately 4 seconds after the intake manifold vacuum has dropped below approx. 350 mm HG.

5.6. Idle Speed Adjustment

There is an adjustment screw at the idle air distributor for the idle speed adjustment.

Since the idle air is measured via the air volume sensor the quantity of fuel is metered correspondingly.

Figure 28

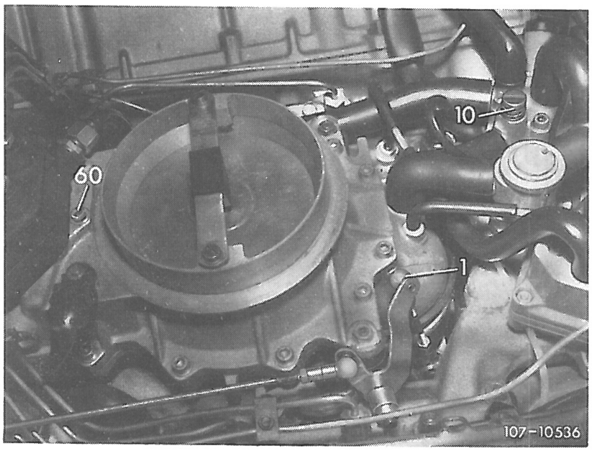


Figure 28

10 Idle air screw

Should the specified exhaust emission level not be achieved with this adjustment, adjust emission level by means of the adjusting screw on the mixture regulator.

The adjusting screw acts on the two-part arm of the baffle plate.
The adjusting screw alters the position of the control plunger in relation to the baffle plate.

Figure 28a

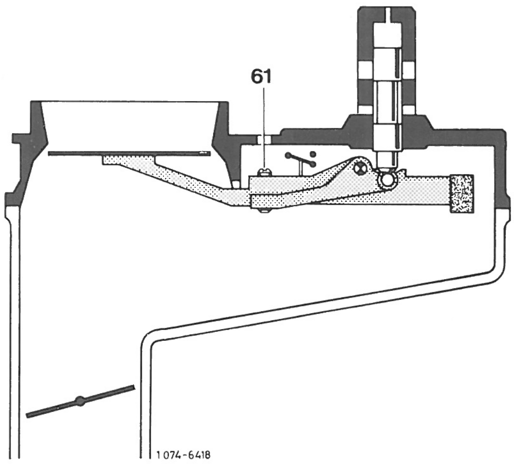


Figure 28a

61 Idle mixture adjusting screw

6. Testing and Adjusting Idle Speed and Exhaust Emission Data

Note: Adjusting data and test jobs apply exclusively to series production engines.

Engines equipped with emission control systems will be dealt with in a special brochure.

6.1. Adjusting Data

Engine	Idle speed 1/minute	Idle Emission Level % CO
100.985	580 - 620	1.0 - 2.0
110.984	750 - 850	1.0 - 2.0
116.984/985 117.985/986	700 - 750	1.0 - 2.0

6.2. Required Tools and Equipment:

Allen wrench with tommy handle for 3 mm hex. socket

Oil temperature gauge 116 589 27 21 00 (not on 100.985 because of dry sump)

Tachometer

CO tester

Note: On vehicles equipped with air conditioner, switch off air conditioner prior to the adjustment of the idle speed because of the idle RPM stabilization.

Prior to idle speed adjustments, test and adjust ignition timing of engine.

6.3. Testing and Adjusting

6.3.1. Run engine to operating temperature (oil temperature of 60-80°C).

6.3.2. On vehicles with cruise control (Tempomat), check whether the flexible control cable contacts the control arm free of tension.
Adjust flexible control cable with the adjusting nut, if required.

6.3.3. Check whether the throttle valve contacts the idle stop.
If necessary, adjust joining rod (2) until roller (3) rests in gate lever (4) free of tension.

Figure 29 and 30.

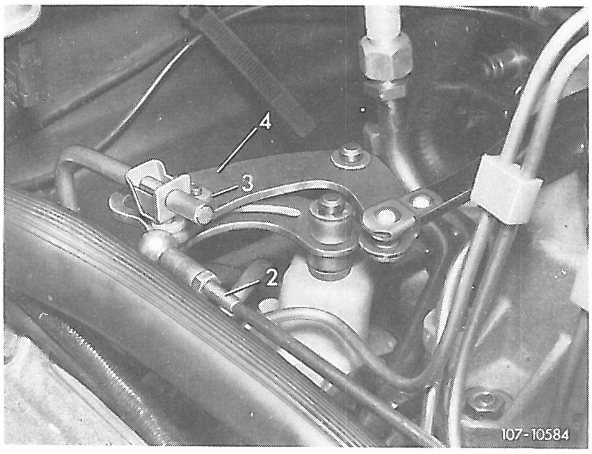


Figure 29

2 Joining rod
3 Roller
4 Gate lever

6.3.4. Adjust specified speed with idle air screw.

6.3.5. Test idle exhaust emission level.

6.3.6. Adjust idle exhaust emission level at idle mixture adjusting screw:

Turning left = leaner
Turning right = more enriched

Figure 31

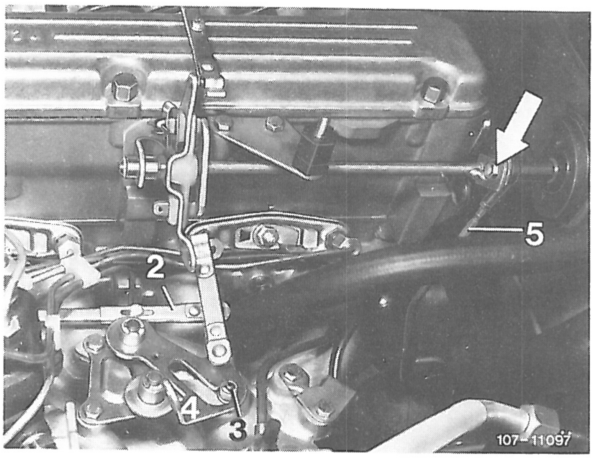


Figure 30

After turning the idle mixture adjusting screw (hex. socket screw), seal bore for screw plug. Briefly accelerate and test idle exhaust emission level. Adjust, if necessary.

Note: During the adjustment, leave engine running so the warm-up/full-load enrichment compensator remains heated.

Figure 31

6.3.7. Attach air cleaner. Once more test idle speed and idle exhaust emission level and readjust, if required.

6.3.8. Move selector lever to driving position (automatic transmission), switch on air conditioner, turn power steering to full lock. The engine must then continue to idle smoothly. If necessary, readjust speed.

7. Testing Fuel Pressures

Note: The below listed test jobs should only be carried out in case of complaints. Check ignition timing, spark plugs and idle speed adjustment prior to working on the injection system.

7.1. Test Data

Primary system pressure (with engine running)		5.2-5.8 bar
Primary system pressure, engine warm (with engine running)	Warm-up/full load enrichment compensator warm-up cycle completed	3.4-3.8 bar
	Full-load enrichment (vacuum hose pulled off)	2.8-3.2 bar (2.5-2.9 bar on engine 116)
Control pressure, engine cold, (with engine running)	Warm-up/full load enrichment compensator cold (ambient temperature)	minimum pressure 0.5 bar

7.2. Required tools and equipment:

Pressure gauge:

Voltmeter and ohmmeter
100 589 13 21 00

7.3. Test jobs

7.3.1. Visual inspection

7.3.1.1. Check all fuel connections for external leaks.

7.3.1.2. Check for leaks the air intake system between mixture regulator and engine. For this purpose, spray sealing points (using iso octane gasoline or gasoline for cleaning purposes)

Note: Any leak in the air intake system causes leaning of the mixture and thus irregular engine operation.

7.3.1.3. Check ease of movement of baffle plate lever in air volume sensor and control plunger in fuel distributor.

7.4. Connect pressure gauge.

The pressure gauge can be connected between the control pressure line and fuel distributor or between control pressure line and warm-up/full load enrichment compensator.

Note: The pressure gauge remains connected at the same point for all pressure tests.

Figure 32

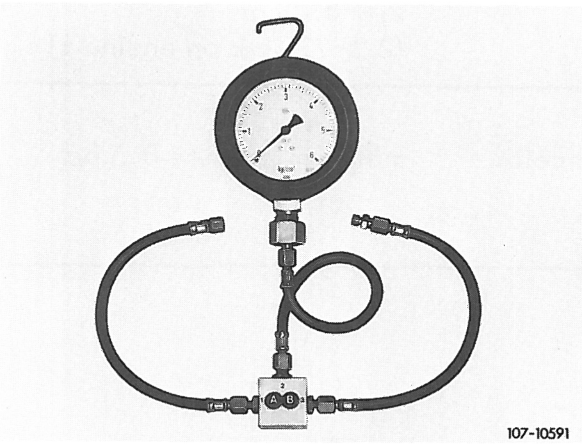


Figure 32

7.5. Testing primary system pressure

7.5.1. Idle engine

7.5.2. Close valve screw on pressure gauge for the line leading to the warm-up/full load enrichment compensator.

7.5.3. Read off primary system pressure.

Nominal pressure: 5.2 - 5.8 bar

Note: If the nominal pressure cannot be reached:

- o Check capacity of fuel pump (refer to page 07.3/2/15)
- o Repair primary system pressure governor.

7.6. Checking control pressure with engine warm.

7.6.1. Open both the valve screws of pressure gauge.

7.6.2. Idle engine.

7.6.3. Read off control pressure as soon as the warm-up/full load enrichment compensator has completed the warm-up cycle, i.e. when the control pressure no longer rises.

7.6.4. Check full-load enrichment. For this purpose, pull vacuum hose (arrow) off the warm-up/full load enrichment compensator. The control pressure must then drop to the full load level.

Figure 33

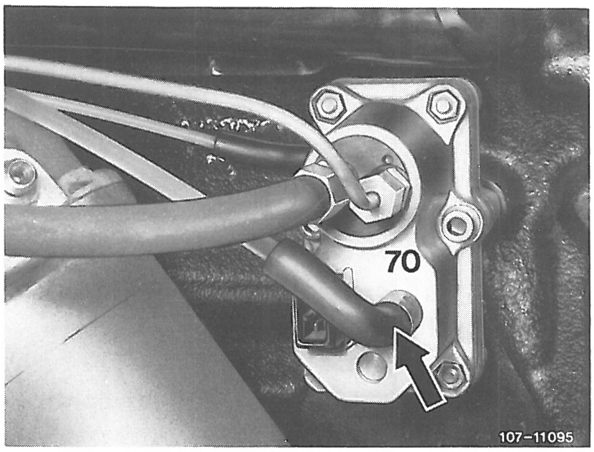


Figure 33

Note: If the data for idle, partial load and full load tests are too low,

- o measure voltage on cable plug of warm-up/full load enrichment compensator: Minimum voltage is 11.5 V
- o check heater coil of the warm-up/full load enrichment compensator for continuity. Coil resistance: approx. 36 Ω

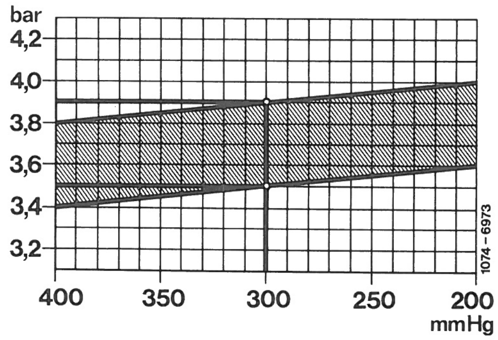


Figure 34

7.6. Checking control pressure with the engine warm (continued)

o check pressure damper in the control pressure line for leaks by pulling off the leak line.

If the control pressure data for idle and partial load operation (with vacuum) deviate from the nominal values, the full load control pressure value, however, corresponds to the nominal value (without vacuum), then test intake manifold vacuum and compare measured data with pressure diagram.

Figure 34

Should additional tests fail to bring about prove, renew warm-up/full load enrichment compensator.

7.7. Checking control pressure with engine cold.

Engine and warm-up/full load enrichment compensator cooled down to ambient temperature.

7.7.1. Open both the valve screws on the pressure gauge.

7.7.2. Pull cable plug from warm-up/full load enrichment compensator.

7.7.3. Idle engine and read off control pressure immediately.

The nominal pressure is subject to the ambient temperature.
Corresponding data can be taken from the control pressure diagram.

Example: Ambient temperature 20°C = 1.1 - 1.5 bar control pressure (control pressure on engine 116 is 1.2 - 1.6 bar).

Figure 34a

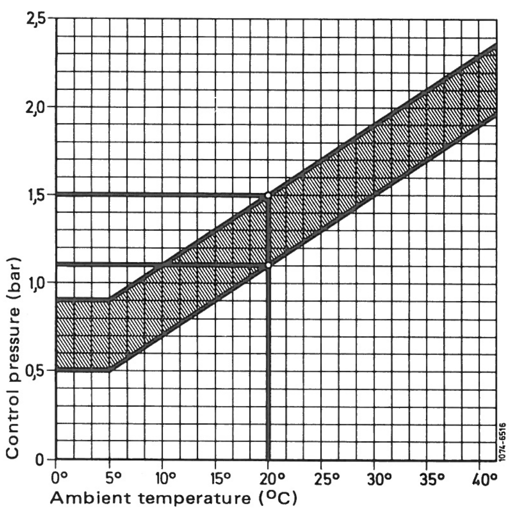


Figure 34a

8. Checking Starting Valve for Leaks and Correct Function

Note: This test is required only in case of starting difficulties at low ambient temperatures or when pressure is lost in the primary system pressure circuit after the engine has been shut off.

Pull cable plugs from safety switch on mixture regulator and from starting valve.

Remove starting valve and place in a reservoir with the fuel line connected.

8.1. Test function

8.1.1. Switch on ignition

8.1.2. Connect starting valve with separate cable to B+ (battery positive terminal) and ground.
The starting valve must then eject a cone shaped jet.

8.2. Leak-test

8.2.1. Remove separate cable connection on starting valve. Dry nozzle of starting valve.
From then on no more drops must form.

8.2.2. Switch off ignition again.

8.2.3. Install starting valve with new gasket.

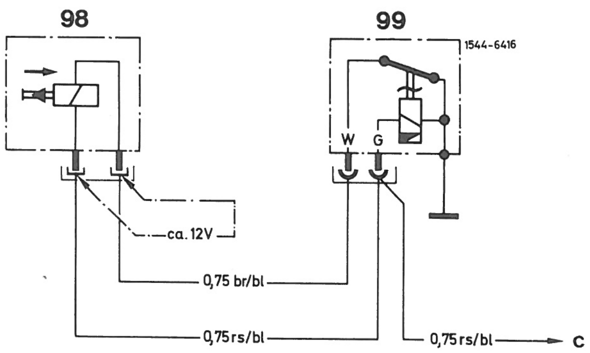


Figure 35

98 Starting valve
99 Thermo time switch
c to terminal 50

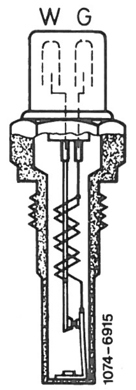


Figure 36

Thermo time switch

9. Testing Thermo Time Switch

The starting valve is activated only at coolant temperatures of less than +15°C by the closed thermo time switch.

The actuation interval rises with lowering temperature and reaches approx. 12 seconds at -20°C.

9.1. Test with coolant temperature below +15°C.

9.1.1. Connect voltmeter to starting valve connection.

9.1.2. Actuate starter. The voltmeter must then indicate 10 V for a specific time, depending upon the coolant temperature.

The switching time increases with lowering temperature by approx. 1.5 seconds per 5°C.

For example + 15°C = 0 seconds
+ 10°C = 1.5 seconds

It is recommended for this test also to check the thermo time switch with an ohmmeter.

Test value less than +15°C:

Connection G ground = approx. 48 Ω
Connection W ground = approx. 0 Ω
(contacts in switch closed)

9.2. Testing with coolant temperature above +15°C.

At coolant temperatures of more than +15°C the thermo time switch can only be tested with an ohmmeter.

9.2. Testing with coolant temperature above +15°C (continued)

Test values above +15°C:

Connection G ground = approx. 62 Ω
Connection W ground = approx. 270 Ω
(with contacts in switch opened)

Figure 35

10. Testing Fuel Pump Delivery

Note: Carry out test only if primary system pressure is reached too slowly or not at all or if lack of fuel under full load is assumed.

10.1. Unscrew fuel return hose (arrow) from fuel distributor.

10.2. Screw locally manufactured fuel line onto fuel distributor and place line end in graduated vessel.

10.3. Pull cable plug from safety switch on mixture regulator. Switch on ignition for 30 seconds.

10.4. Should the quantity delivered be less than 1 liter/30 seconds, check the following items:

10.4.1. Voltage on fuel pump, minimum nominal value 11.5 V

10.4.2. Fuel lines for narrow cross sections (pinched lines).

10.4.3. Detach leak fuel line between fuel reservoir and intake damper. Check delivery once more. If the specified delivery is achieved, renew fuel reservoir.

10.4.4. Renew fuel filter.

10.5. If delivery continues to be insufficient, renew fuel pump.

10.6. Reinsert cable plugs into safety switch and connect fuel return hose.

11. Testing the Fuel Pump Safety Circuit

11.1. Testing of safety switch (2) - ignition switched on.

11.1.1. Detach air cleaner.

11.1.2. Switch on ignition and push down baffle plate momentarily. When the baffle plate is actuated, fuel must be injected audibly (fuel pump in good order).

Note: When the baffle plate is actuated several times or over longer intervals there arises the danger of the engine being flooded.

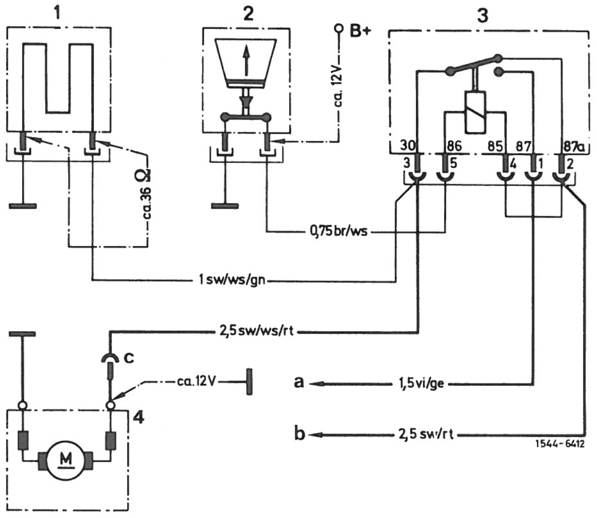


Figure 37

Safety circuit of the fuel pump

1 Heater coil of the warm-up/full load enrichment compensator
2 Safety switch of baffle plate
3 Fuel pump relay
4 Fuel pump
a Terminal 50 (starting)
b Terminal 15/54 (ignition)
c Plug connection of tail light cables

11.1.3. Pull spark plug cable No. 4 from ignition distributor and ground to prevent the engine from starting.

11.1.4. Connect voltmeter to positive terminal of fuel pump (4).

11.1.5. Actuate starter. The voltmeter must indicate 12 V over the entire starting period.

Note: If the fuel pump operates only when the baffle plate is actuated or during the starting process, replace fuel pump relay (3) (code number 21 on cable harness).

If the pump starts operating when the ignition is switched on, check safety switch.

Figure 37

11.2. Testing of safety switch (2) - ignition switched off

11.2.1. Detach air cleaner.

11.2.2. Pull plug from safety switch.

11.2.3. Connect voltmeter to battery positive terminal and to one of the blade-type contacts respectively.

Note: If the baffle plate is not pushed down, the voltmeter must indicate 12 V at both the blade-type contacts.

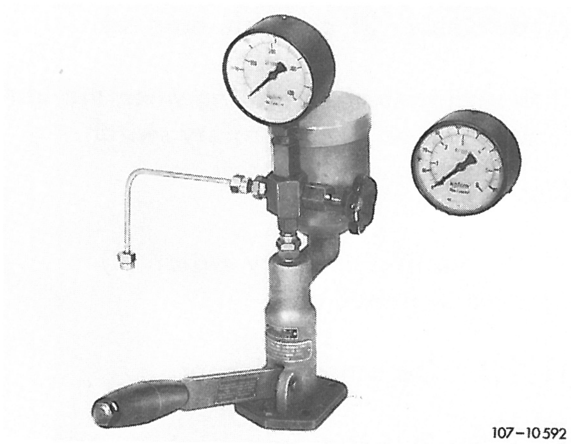
Should the voltmeter indicate 12 V on one of the blade-type contacts of the safety switch only, the mixture regulator must be removed and the contact area of the safety switch cleaned.

12. Testing Injection Valves

Note: Testing of the injection valves becomes necessary if the spark plug appearance suggests unequal combustion.

Should unequal fuel metering by the fuel distributor be diagnosed, in any case remove and test the respective injection valves before replacing the fuel distributor.

12.1. Tester



107-10592

Figure 38

Note: For the test, use the previously applied nozzle tester Bosch EFEP 60 H together with the pressure gauge dial having a gauge pressure range of 0 - 6 bar.

The nozzle tester checks the opening pressure, the jet of fuel ejected and the injection valves for leaks.

Prior to testing the injection valves the tester reservoir must be filled and the equipment bled. Exclusively kerosene should be used for the test.

12.2. Removal of Injection Valves.

12.2.1. Unscrew injection lines form injection valves and fuel distributor.

Counterhold injection valves when unscrewing the injection lines.

Should the injection valves be installed with insulating bushes, counterhold insulating bushes when removing the injection valves.

12.3. Testing Injection Valves.

Notes: Renew injection valves not within the tolerance range. The individual injection valves of one set can be replaced.

12.3.1. Connect removed injection valves to tester. Bleed pressure line by actuating lever several times with the shutoff cock opened and union nut slackened. Then tighten union nut.

12.3.2. With the shutoff cock opened, slowly actuate hand lever (pressure build-up up to a maximum gauge pressure of 1.5 bar).

Thus an injection valve which is temporarily leaking due to dirt particles can be diagnosed (string-shaped jet emitted at the injection valve).

12.3.3. Testing Opening Pressure.

Close shutoff cock.
Flush injection valve by actuating the hand lever quickly several times.

Open shutoff cock and test opening pressure by moving the hand lever slowly.

12.3.4. Leak Test.

Close shutoff cock.
Flush injection valve by actuating the hand lever quickly several times. Open shutoff cock and slowly rise pressure up to 0.5 bar below the previously determined opening pressure and retain.

No drop must form at the injection valve within 15 seconds.

12.3. Testing Injection Valves (continued)

12.3.5. Evaluating the Emitted Jet of Fuel.

The pressure gauge dial must as a rule be shut off for this test.

When the lever is moved quickly (approx. 2 to 3 downstrokes per second) the jet must be well atomized.

12.4. Installation of Injection Valves.

12.4.1. Install injection valves in reverse sequence.

Note: If the insulating bushes have been removed, install them with new O-rings.

12.4.2. Connect injection lines, observing tightening torques (reference value).

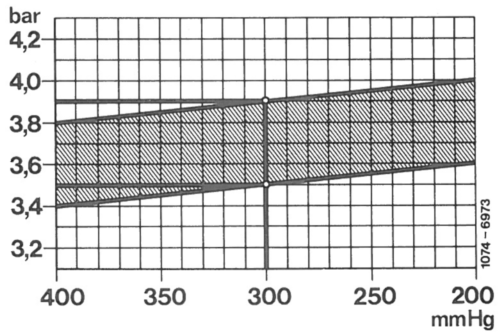
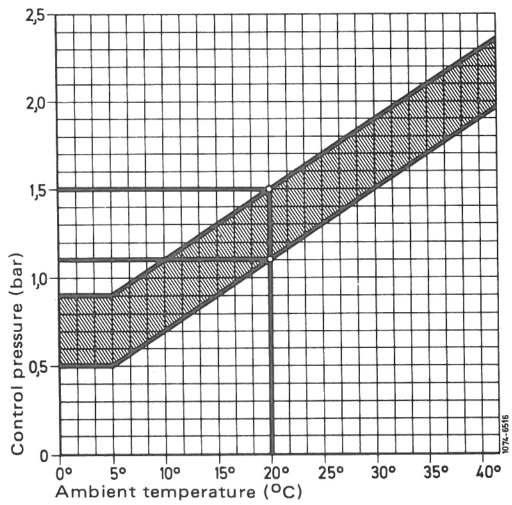
Note: When tightening the injection lines, counterhold injection valves and the hex. nipples on the fuel distributor.

12.4.3. Run engine and check all fuel line connections for leaks.

Tightening Torques	Nm	(kpm)
Injection lines to fuel distributor (reference value)	10 - 12	(1.0 - 1.2)
Injection lines to injection valves (reference value)	20 - 25	(2.0 - 2.5)

Mechanical Gasoline Injection System
with Metered Air Volume

13. Test Table for KA Injection System (CIS) (Standard Version)

Test value		Test data, engine 100	110	117	116
1. Primary system pressure in bar	Engine cold or warm, operating	5.5 ± 0.3			
Control pressure in bar, engine warm Warm-up/full load enrichment compensator has completed warm-up cycle, engine operating	Idle and partial load data (with vacuum)	3.6 ± 0.2			
	Note: In case of deviation from nominal value, take test value from diagram acc. to intake manifold vacuum				
	Full-load value (without vacuum)	3.0 ± 0.2			2.7 ± 0.2
Control pressure in bar, engine cold Cable connector removed from warm-up/full load enrichment compensator Engine or warm-up/full load enrichment compensator cold, i.e. at ambient temperature	Start engine and read off actual value Select test value from diagram acc. to ambient temperature Example: At 20°C = 1.1 - 1.5 bar Note: Control pressure diagram data for engine 116 are higher by 0.1 bar				
2. Fuel pump delivery	measured in return line, min. voltage 11.5 V	1 liter/30 secs min.			
Idle speed 1/min.	Operating temperature	580 - 620	750 - 850	700 - 750	
Idle exhaust emission value % CO	Operating temperature	1 - 2			
Opening pressure of injection valves in bar	Injection valves removed (Bosch No. 0 437 502 010)	new 3.5 - 4.1, used 3.0 min.			