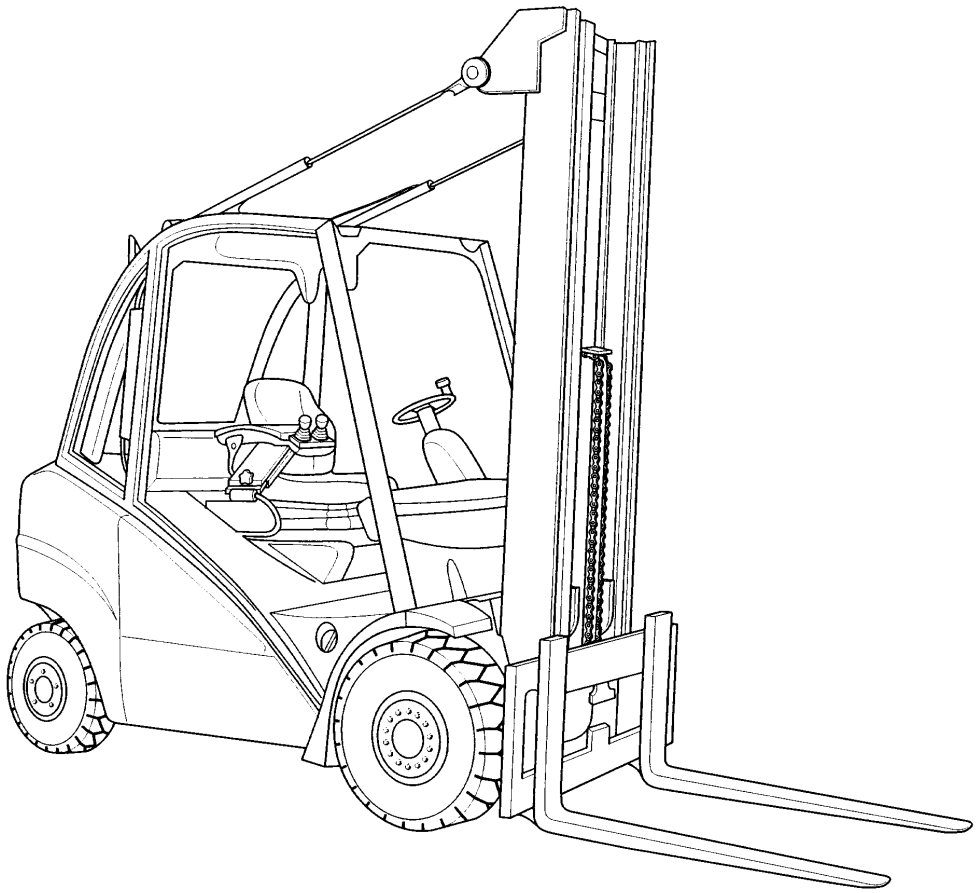
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Service Training

Linde IC Engined Truck

H30D H30T H35D H35T

Series 393



Edition 01/2005

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Edition 01/2005

- Editorial changes as well as corrections and additions in the module "Standardised measured value blocks"
- VW terms for components removed and replaced by Linde terms.
- Changes in Chapter 1: Standardised measured value blocks - measured value block 01 amended.
- Mixer basic setting revised.
- Changes in Chapter 2: Sealing of oil motor HMF 550 R corrected. Tighten groove nut at 1300±50 Nm. Groove nut key 000 941 8010 changed to 000 941 7000.
- Setting of charge pressure valve changed to $p = 18.0^{+0.5}$ bar.
- Setting of discharging valve changed to p = 13 bar.
- **Attention**: Hydraulic circuit diagram still outdated!
- Changes in Chapter 7: Pressure settings on the control valve for standard, duplex and triplex lifting scaffolds changed.
- Layout plans of piping systems corrected
- Changes in Chapter 8: Charts of screw-in depths for mechanical adjustment of tilt cylinders changed
- Changes in Chapter 9: Circuit diagrams corrected and amended.

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The Company

Everything began in the year 1904. Carl von Linde and Hugo Güldner founded the "Güldner Motorenwerke", the precursor of our company. No-one could imagine how dynamically this business would expand in the decades to follow. Today Linde Material Handling has over seven factories in Germany, France and Great Britain and a production site in China. More than 600 patents - many of them milestones in material handling engineering - attest to unrivalled innovative power, the basis for the success today and tomorrow.

Today, the Linde plant II in 63701 Aschaffenburg is one of the largest and most modern production facilities in the world. New assembly structures with only one direction of flow, trolleys without drivers, new supply systems, vacuum filling of the working hydraulics: The points were set correctly from the start to achieve maximum productivity and quality. The distances are short, as one might expect. In the entire assembly process, a Linde fork truck only travels approx. 2000 metres. It is therefore one of the fastest even before it sees the light of day.

People are always at the centre of our work, no matter what we plan, no matter what we do. On the one side are our employees, who receive a lot of room for development. On the other side are our customers. They measure us on the basis of productivity and quality, but also on the basis of service and flexibility. We provide this worldwide in cooperation with our marketing and service organisations. With vehicles which, in the final analysis, are nothing else than the technical answer to their needs. Closeness to the customer is more than a word in this respect. It is lived reality.

Linde is one of the world's leaders in the sectors of material handling technology and hydraulics. The primary aim of our efforts is to offer our clients a convincing value for their money.Our decades of experience in material flow and the synergetic benefits of a large company allow us to tap new potential again and again. The most recent example is the Linde 39X with hydrostatic direct drive. A fork truck which links the fascination of technology and economy as no other forklift does.

We want to achieve a lot. We will give everything to achieve it. To be in a strong position in tomorrow's market you need more than yesterday's success. You need to be willing to work on yourself permanently. In research and development. In operations. And last, but not least, in service. In this respect, we have created the best conditions with our main plants in Aschaffenburg and the plants in Kahl, Weilbach and Ballenstedt.

Bruno Kulick
Management

Structure of the training document

This training document is based on the related seminar in the training centre and supplements it. The training document alone and without the accompanying training is not suited for self-study.

In order to allow you find the answer to problems at hand in the training document in case of a necessary repair, we want to give you some information on how and where you can find the desired information.

The training document is divided into numbered main sections. These main sections are again divided into subsections which in turn are also divided into more detailed subsections of the related section. The numbers and headings of the main sections and the subsections comply with internal guidelines and are retained for reasons of standardizations and continuity.

Overview of the main sections and (summarised) their content:

Section	Content
00	Product information Diagnosis
01	Motor Internal combustion engine Electric motor
02	Gearbox Hydrostatic drive axle Mechanical drive axle Drives
03	Body Chassis Operator's compartment
04	Running gear Steering system Mechanical guidance Inductive guidance Wheels and tyres Brake system

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Section	Content
05	Controls Controls - general Display elements
06	Electrical / electronic installation Electrical / electronic installation - general Electronic controls
07	Hydraulic system Working hydraulics Hydraulic controls Valves
08	Load lifting system Load lifting system - general Mast Cylinders Fork carriage Attachments
09	Options and accessories Options and accessories - general

The training document has a modular structure, it does **not** successively describe the structure of the truck.This means that individual "modules" are strung together as independent units. This is another reason why training in a our training centre is indispensable.

We point out that a list of all the special tools and test equipment used for this vehicle, including part number, use and illustration, can be retrieved in the diagnostic software "Truck Expert" according to type.

With the introduction of the new form of the training documents in the year 2004, we have made a new index. This index should also make it easier to find the desired information fast. In this connection we would like to ask you to inform us under the e-mail address "service.training@linde-mh.de" if you miss an entry in the index or if you discover a technical or formal error. We are also not free of errors and mistakes and we are thankful for any support.

Thank you very much in advance for your assistance and cooperation.

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Explanation of the levels of danger notices

This document contains danger notices depicted using international pictograms in the following levels and using the syntax "Description of Danger" with the possible consequences, as long as they do not already ensue from the type of danger, and "Avoiding Danger" with explanations on how to avoid danger.

DANGER

There is direct danger to life or the danger of severe, life-threatening injuries and/or significant property damage. Description of cause of danger.

Description on how to avoid the existing danger.

WARNING

There is risk of severe injuries or large-scale property damage. Description of the risk of injury or the significant property damage.

Description on how to avoid the risk of injury or significant property damage.

CAUTION

Non-compliance may result in damage to or destruction of the material.

Description of how to avoid possible damage or destruction.

NOTE

Special attention should be paid to technical interconnections which might not be apparent even to a specialist.

ENVIRONMENT NOTE

Follow the notices indicated here since non-compliance may lead to environmental damage.

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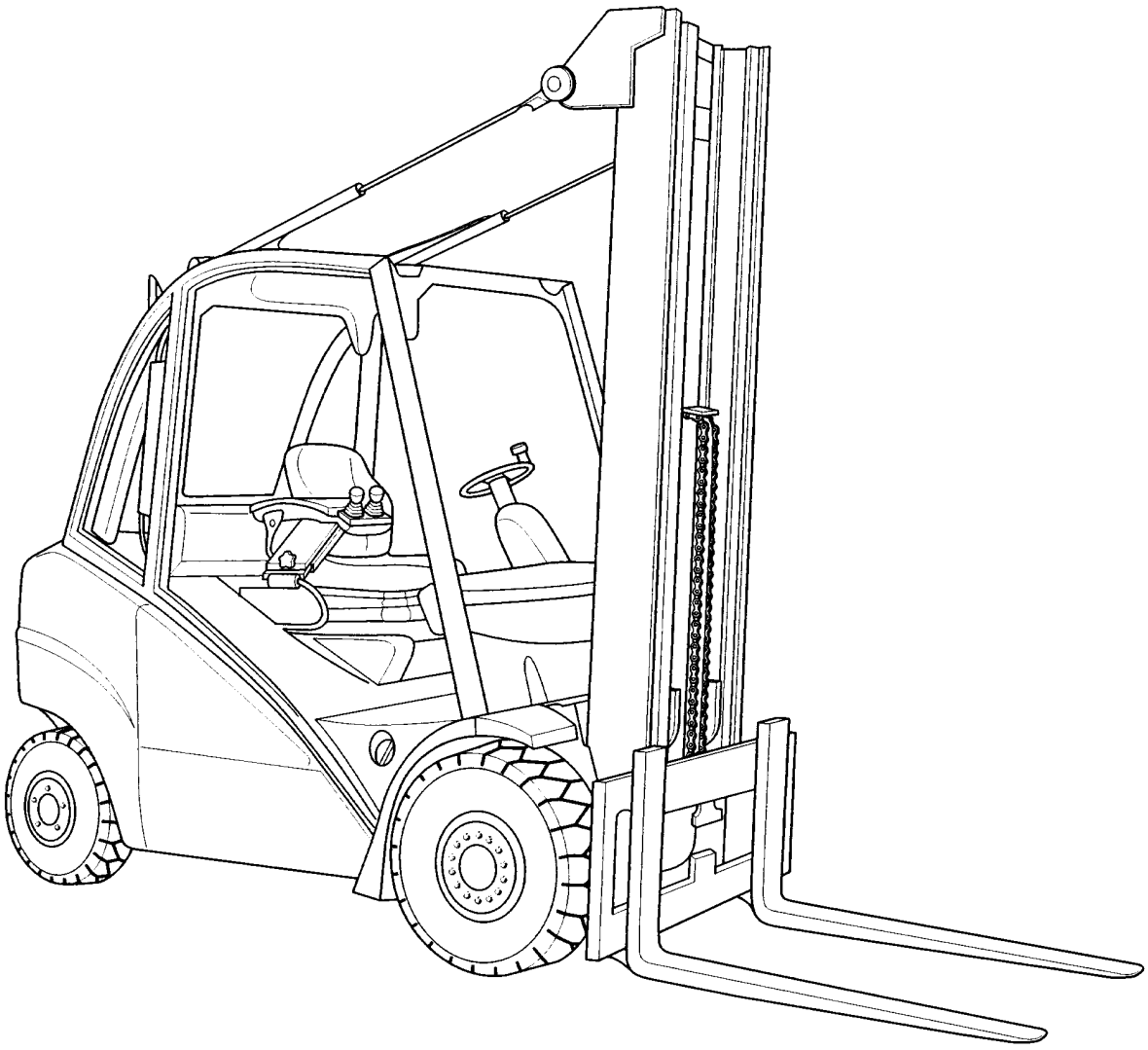
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The truck



The H 30 and H 35 trucks represent the next generation of IC-engined Linde fork trucks.The truck is perfectly tailored to the driver. Its operating comfort ensures little fatigue when working, protects the driver's health, thus allowing high productivity. Its superior economy comes from its low fuel consumption, low service costs and high re-sale value at the end of its period of use.The low driving noise and pollutant emissions, which are well below the specified limits, make the truck environment-friendly and protect the driver and environment.

Other highlights are:

- Excellent operator's workplace for greatest possible performance of driver and truck.
- Unique shock-absorption system reduces roadway and load impacts before they are transmitted to the truck and driver.
- Maintenance-free hydrostatic direct drive with a high degree of efficiency from Linde.
- Modern, economical engines with low emissions.
- Overhead tilt cylinder for higher residual load capacities and more precise load handling.
- Linde dual pedal for faster and safe working.

Design of operator's compartment

The operator's workplace is designed according to the latest findings in ergonomics. It has a low access, which can be viewed from above. The large cabin space with a generous footwell and a interior design corresponding to automotive standards imparts a pleasant spatial feeling. The Linde Load Control provides precise and relaxed operation of all mast functions consisting of two control levers, which are integrated in

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an individually adjustable armrest. The Linde dual-pedal control stands for fatigue-free driving with increased productivity. The feet always relaxed on the pedals and allow fast reversing without shifting with short pedal strokes.Due to the rubber-mounted drive axle, road bumps reach the driver only to a small extent, thus reducing body stress. The extremely low noise level is easy on the driver and environment. The steel overhead guard safeguards against falling loads. The anti-glare indicators, gauges and switches are installed in the canopy console of the truck are easily accessible. They allow a narrow steering wheel cover and a good view forward. Along with the frame construction, these features allow excellent all-round visibility.

Chassis

The overhead guard and frame form a unit: the Linde ProtectorFrame. This design provides greatest possible stability and safety. The wide-opening bonnet and service covers make all components easily accessible and therefore easy to service. The otherwise closed chassis prevents dust and foreign particles from penetrating the assemblies and reduces noises.

Engine

The diesel and LPG engines installed are equipped with sophisticated engine technology. The benefits are: high torque, fuel economy, low exhaust emissions (NO_x, CO, HC), minimal soot emissions (diesel) and low noise levels.

Drive

The Linde hydrostatic drive stands for know-how and quality developed and produced by Linde. As a fully automatic drive, it allows sensitive, smooth driving and fluent reversing without delay. The drive has proven itself to be rugged under a great variety of duties and extreme conditions. The Linde hydrostatic drive does not need a clutch, differential and drum brakes.

Electronics / electrical system

The control electronics for the traction and lift hydraulics, the Linde Truck Control (LTC), has numerous advantages: sensitive, smooth driving and reversing and the automatic control of the engine speed depending on the particular demand of the hydraulic system. This means the engine is always running at the lowest possible speed. This minimises fuel consumption, noise and exhaust gas emissions, making life easier for the driver and the environment. Beyond this, the service engineer can also adjust the truck performance to the particular application. A self-test of the truck facilitates the processing of servicing. All safety-related truck components such as microprocessors exist twice and monitor each other. This provides the greatest possible functional reliability. The control unit is protected from spray water and dust in the sealed enclosure. All the electronic/electric components are also protectively mounted in the centre, but also easily accessible behind the operator's seat. Each strand of the cable connectors are sealed and are therefore safeguarded against foreign particles and moisture.

Steering

The on-demand hydrostatic steering is sensitive and nearly without any play. In conjunction with the ergonomic, small steering wheel, it permits easy and precise steering. The tilt angle of the steering wheel is adjustable.

Mast

The top-mounted tilt cylinders allow the use of slim mast channels and they provide safety through good visibility of load and environment. The top-mounted tilt cylinders also allow a full load capacity up to high lift heights with a high residual capacity. The rubber mounting of the bearings reduces impacts and vibrations and increases the comfort of the driver. The free-view masts are available as standard, duplex or triplex types. If attachments are used in conjunction with duplex and triplex masts, the hose reel mounted inside permits good visibility through the mast and protects the hoses from wear and tear. Maintenance-free mast and tilt cylinder bearings reduce the costs of ownership. Thanks to the electronic limitation of the tilt angle, the mast slides gently and silently to the end positions.

Brake

The truck can be braked safely in three ways:

- Gentle, hydrostatic braking (as soon as the accelerator is released) for wear-free deceleration in everyday operation.
- Emergency braking by depressing the brake pedal (hydrostatic braking as well as added

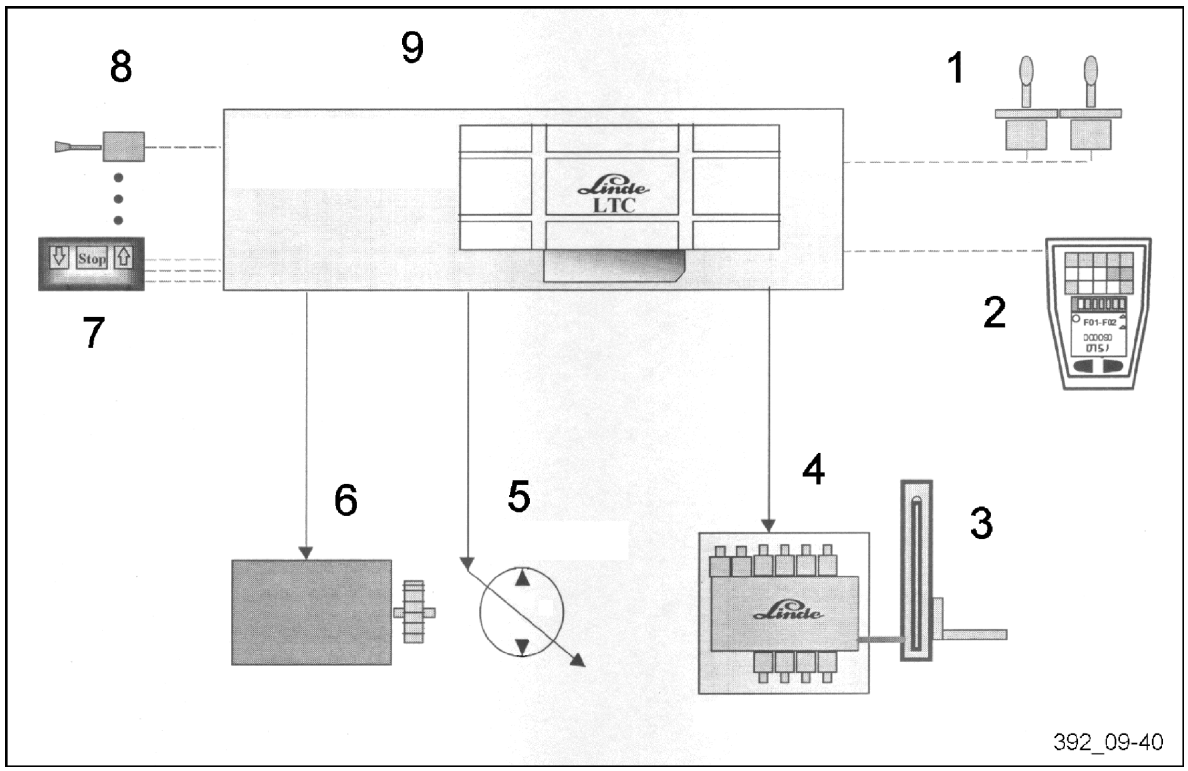
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deceleration by maintenance-free multiple disc brake).

- Automatic application of the parking brake when the engine of the vehicle is shut off.

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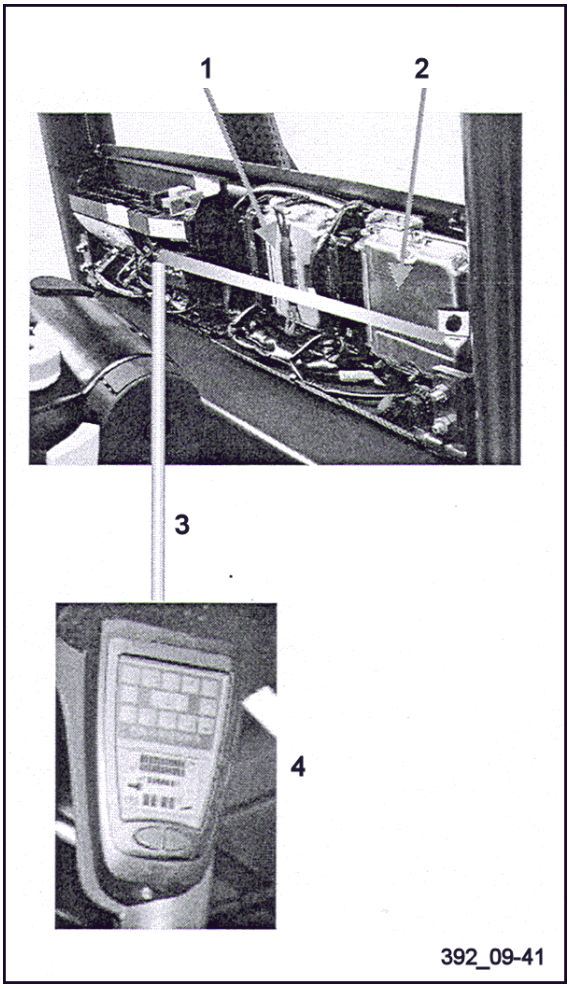
LTC - basic structure



1	Joysticks	6	Internal combustion engine
2	Display	7	Pedal group
3	Mast	8	Directional control switch
4	Directional control valve block	9	Integrated traction/lift control
5	Traction pump		

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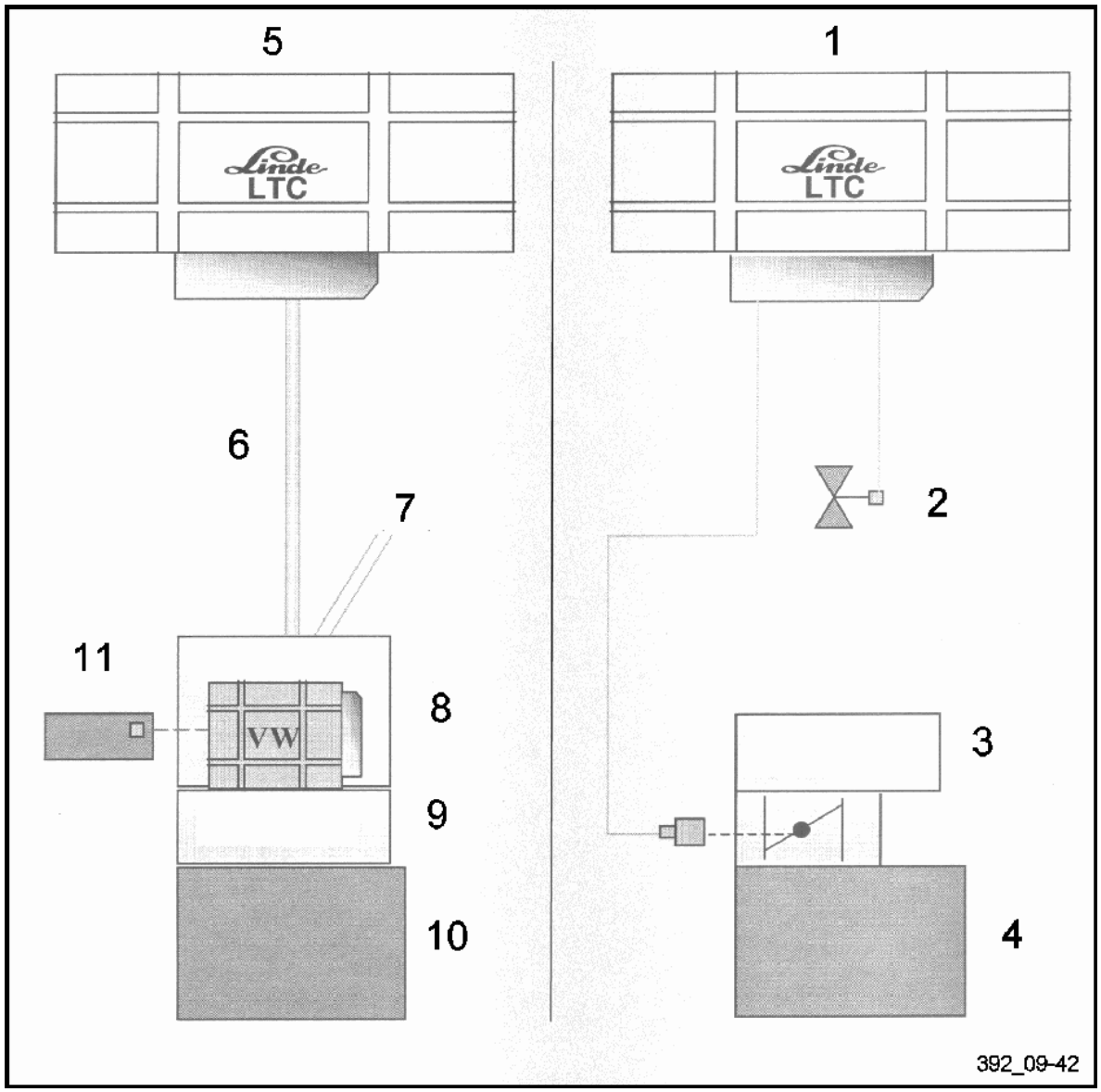
System communication - overview and position of modules ▷



1 VW module
2 LTC module
3 CAN bus (communication)
4 Display

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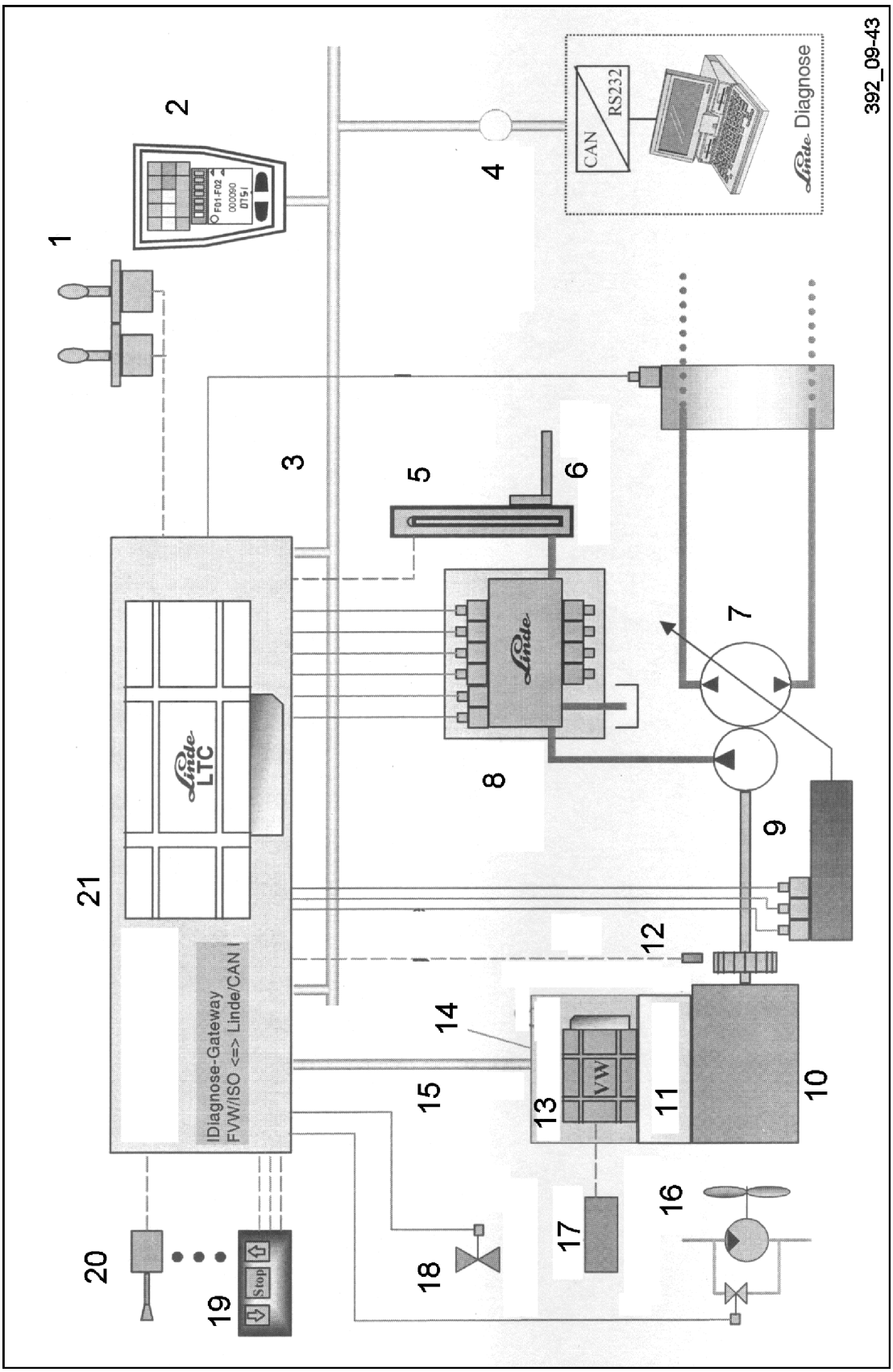
LTC modules - difference between diesel and LPG trucks



1	LP gas, no engine diagnosis	7	VW diagnosis (ISO)
2	LPG shut-off valve	8	engine control
3	Ignition control unit	9	Injection system
4	Internal combustion engine	10	Internal combustion engine
5	Diesel, with engine diagnosis	11	Immobilizer
6	CAN bus		

Engine electronics - overview

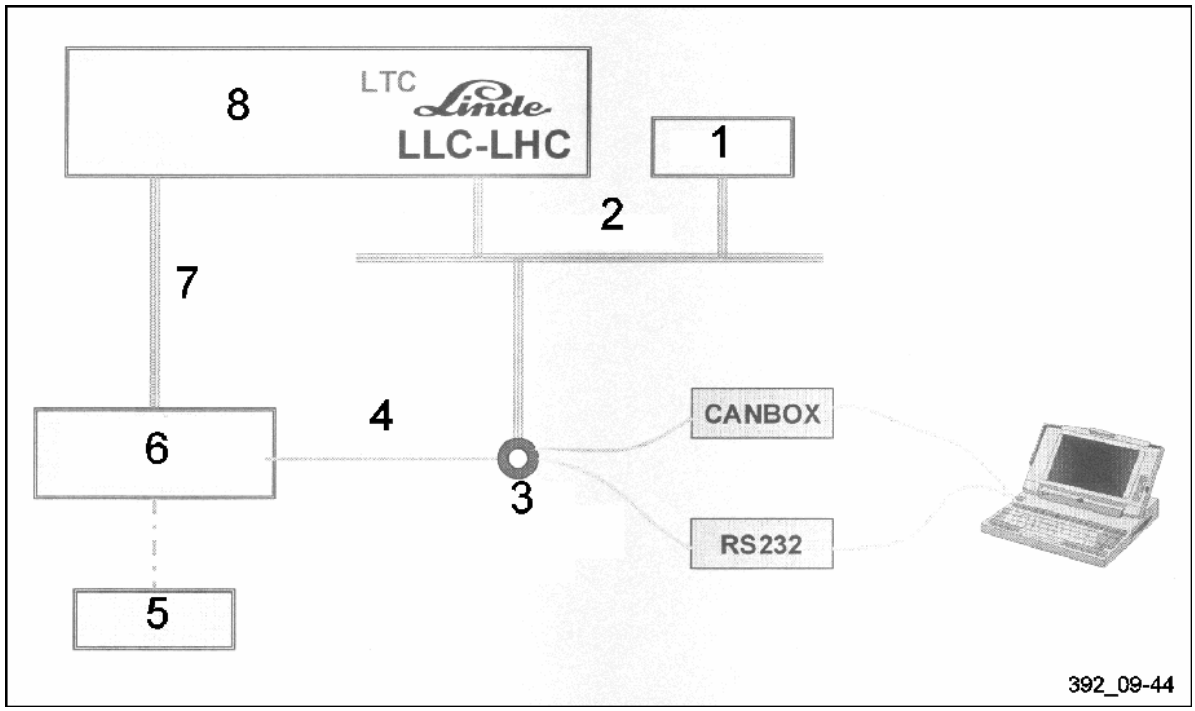
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1	Joysticks
2	Display
3	CAN bus I
4	CAN diagnostic connector
5	Tilt angle sensor mast
6	Mast
7	Traction pump
8	Directional control valve block
9	Pump control
10	Internal combustion engine
11	Injection system
12	Engine speed sensor
13	Engine control unit
14	VW diagnosis
15	CAN bus II
16	Fan
17	Immobilizer
18	Fuel shut-off valve
19	Pedal group
20	Directional control switch
21	Integrated traction/lift control LTC module

LTC - system overview



1	Display
2	CAN bus I
3	CAN diagnostic connector
4	VW diagnosis (ISO)
5	Immobilizer
6	VW engine control unit
7	CAN bus II
8	Integrated traction/lift control LTC module

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Composite instrument - fault codes

The error codes are shown in the text field (1) (2x11 characters) and in case an "optional soot filter" is fitted, its residual capacity.

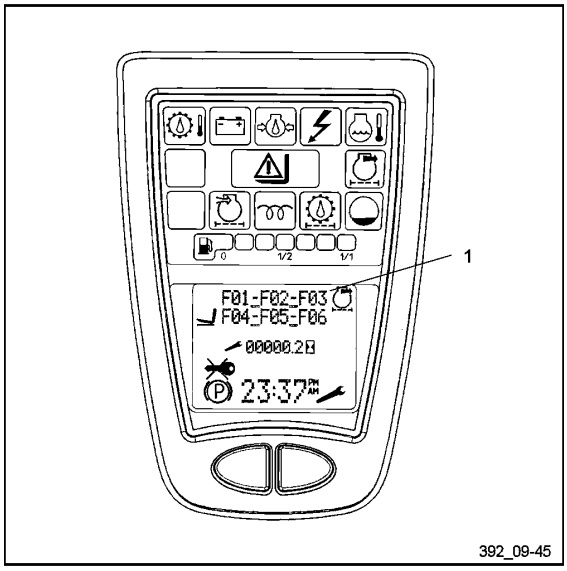
The sequence in which the error codes are shown depends on the one hand on the code letter (T before L before D... error) and on the other hand from the sequence in which the error numbers are transmitted on the CAN. If more faults have occurred than can be shown, the list must be scrolled with the button.

In the event of characters "<" in the text field scroll with the left button to the left and in the event of characters ">" in the text field scroll with the right button to the right.

Priority of error code display: T before L before D before F before R before X before Y before Z

T	Traction
L	Lift
D	Display
F	Soot filter
R	Recorder (data logger)
X, Y, Z	CSM 1 to 3

An engine fault message is indicated by a flashing of the preheating indicator.



1 Text field

NOTE

Error codes and possible remedial action are outputted and evaluated via the diagnostic program "Pathfinder".

LTC traction control codes, release 1.0.0

Conditions	
1	Error accelerator potentiometer zero position or 5 V potentiometer supply fault after ignition ON
2	Accelerator potentiometer in zero position
3	Brake pedal not yet actuated after ignition ON
4	Seat not occupied
5	Speed restriction active
6	Directional control switch in zero position (single-pedal model)
8	Brake pedal depressed half way
9	Brake pedal depressed fully
10	Intervention by working hydraulics requested
11	Control unit in programming mode

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13	Safety relay: Voltage under 8 V
14	Terminal 15: Voltage under 8 V
16	Intervention by data logger requested
17	Intervention by soot filter requested
18	Door not closed (only in trucks with door switch)
19	Teaching of accelerator potentiometer not yet performed
Warnings	
104	Signals of seat switch and accelerator potentiometer not plausible for more than 2 seconds
124	Seat switch signals overlapping for more than 5 s
130	Coolant temperature sending unit: Signal outside of valid range
134	Hydraulic oil sensor: Signal outside of valid range
150	Throttle plate solenoid: Current too low (LPG trucks only)
157	Fan bypass valve: Current too high
158	Fan bypass valve: Current too low
159	Throttle plate solenoid: Current too high (LPG trucks only)
160	Throttle plate solenoid never activated (LPG trucks only)
167	Power stage of fan bypass valve always activated
168	Power stage of fan bypass valve never activated
169	Throttle plate solenoid always activated (LPG trucks only)
175	Fault in throttle plate solenoid circuit (LPG trucks only)
179	Fault in the fan bypass valve circuit
180	No data from safety processor
Problem	
220	Invalid truck type
221	Production test not OK
222	EEPROM error
225	Directional control switch: Direction signal overlaps zero setting signal for more than 10 s
226	The switch-controlled speed limitation function is activated and the corresponding signals of the switch (change-over contact) are not compatible.
231	Accelerator: Signals of reference potentiometer and watchdog potentiometer not plausible
232	Accelerator: Reference potentiometer cable breakage or short
233	Accelerator: Reference potentiometer cable breakage or short
235	Directional control switch: Signals not plausible
236	Directional control switch: All inputs open (eg coded connector missing)
237	Brake: Semi-actuation signals not compatible
238	Brake: Normally closed contact switch 1 and switch 2 not plausible
239	Seat switch: Signals not plausible
240	Power stage of LPG shut-off valve never activated (LPG trucks only)
241	5V supply voltage for sensor too low
243	Safety relay does not close
244	Safety relay does not open

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245	Power stage release: Activation and feedback not plausible
246	Power stage of release valve never activated
247	Release valve: Current too low
248	Speed sensing fault
249	LPG shut-off valve: Current too low (LPG trucks only)
250	Throttle plate solenoid: Current too low (LPG trucks only)
251	Brake valve: Current too high (only for trucks with retarder brake)
252	Brake valve: Current too low (only for trucks with retarder brake)
253	Pump forward: Current too high
254	Pump forward: Current too low
255	Pump reverse: Current too high
256	Pump reverse: Current too low
259	Throttle plate solenoid: Current too high (LPG trucks only)
260	Throttle plate solenoid never activated (LPG trucks only)
261	Power stage of brake valve always activated (trucks with brake valve only)
262	Power stage of brake valve never activated (trucks with brake valve only)
263	Power stage for pump forward always activated
264	Power stage for pump forward never activated
265	Power stage for pump reverse always activated
266	Power stage for pump reverse never activated
269	Throttle plate solenoid always activated (LPG trucks only)
270	Safety processor detects deviating signal from speed sensor
271	Safety processor detects deviating value to 5V supply voltage
272	Safety processor detects deviating signal from truck accelerator potentiometer
273	Safety processor detects deviating signal current pump forward
274	Safety processor detects signals deviating from directional control switch
275	Fault in throttle plate solenoid circuit (LPG trucks only)
276	Fault in brake valve circuit (trucks with retarder brake only)
277	Fault in pump forward circuit
278	Fault in pump reverse circuit
340	Power stage of LPG shut-off valve always activated (LPG trucks only)
345	Release valve: Maximum current exceeded
346	Power stage of release valve always activated
347	Release valve: Current too high
348	Gas shut-off valve: Maximum current exceeded (LPG trucks only)
349	LPG shut-off valve: Current too high (LPG trucks only)
350	Throttle plate solenoid: Current zero with power stage activated (LPG trucks only)
352	Brake valve: Current zero with power stage activated (only for trucks with retarder brake)
354	Pump forward: Current zero with power stage activated
356	Pump reverse: Current zero with power stage activated
370	Safety processor detects deviating feedback signal at PWM power stages for IC engine actuators
371	Safety processor detects deviating feedback signal at PWM power stage for hydrostatic actuators
372	Safety processor detects deviating signal at operator inputs

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373	Safety processor detects deviating signal for pump reverse current
374	Safety processor detects deviating signal pedal coding
380	No data from safety processor
481	Safety processor: truck speed too high
482	Safety processor: truck speed too low
483	Safety processor: pump control in forward direction not plausible in relation to accelerator potentiometer
484	Safety processor: pump control in reverse direction not plausible in relation to accelerator potentiometer
484	Safety processor: Activation of pump reverse not plausible to accelerator potentiometer
488	Safety processor: LPG shut-off valve activated at speed 0 (LPG trucks only)
490	Safety processor: Switch-off test fault

LTC - Lift Control Codes, Version 1.0.0

States	
1	Power On, procedure not completed
2	Joystick neutral
3	Tilting at the stop, end position damping active or programmed position reached
4	Programmed end position exceeded
5	Invalid truck type
7	Door not closed (only on trucks with door switch)
11	Control unit in programming mode
12	Safety processor not active
14	Terminal 15: Voltage under 8 V
15	EEPROM fault
16	Mast positioning active
17	Seat switch not actuated
18	not
19	No teaching of joysticks
20	Switching from 2nd to 3rd auxiliary hydraulics results in implausible signals briefly
Warnings	
141	Incompatibility between signal/reference signal seat switch
146	Seat switch: Seat not occupied for more than 2 seconds
180	No data from safety processor
Faults	
220	Tilt sensor cable breakage
221	Reference potentiometer tilt sensor incompatible
222	Joystick not in neutral position for more than 2 sec after Power On
230	Cable breakage joystick lifting/lowering
231	Cable breakage joystick tilting
232	Cable breakage joystick AUX1
233	Cable breakage joystick AUX1
235	Incompatibility between signal/reference potentiometer lifting/lowering

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236	Incompatibility between signal/reference potentiometer tilting
237	Incompatibility between signal/reference potentiometer AUX1
238	Incompatibility between signal/reference potentiometer Aux2
239	Incompatibility between signal/reference signal seat switch
247	Switching from 2nd to 3rd auxiliary hydraulics constantly results in implausible signals
250	Monitoring PWM (pulse width modulation) lifting/lowering
251	Monitoring PWM tilting
252	Monitoring PWM AUX1
253	Monitoring PWM AUX2
254	Solenoid current lifting/lowering too low
255	Solenoid current tilting too low
256	Solenoid current AUX1 too low
257	Solenoid current AUX2 too low
258	Solenoid current lifting/lowering too high
259	Solenoid current tilting too high
260	Solenoid current AUX1 too high
261	Solenoid current AUX2 too high
262	Voltage at lifting solenoid permanently high
263	Voltage at lowering solenoid permanently high
264	Voltage at forward tilting solenoid permanently high
265	Voltage at backward tilting solenoid permanently high
266	Voltage at solenoid AUX1+ permanently high
267	Voltage at solenoid AUX1- permanently high
268	Voltage at solenoid AUX2+ permanently high
269	Voltage at solenoid AUX2- permanently high
270	Voltage at lifting solenoid permanently low
271	Voltage at lowering solenoid permanently low
272	Voltage at forward tilting solenoid permanently low
273	Voltage at backward tilting solenoid permanently low
274	Voltage at solenoid AUX1+ permanently low
275	Voltage at solenoid AUX1- permanently low
276	Voltage at solenoid AUX 2+ permanently low
277	Voltage at solenoid AUX 2- permanently low
280	Safety relay always Off
281	Safety relay always Off after Power On
282	Safety relay always On
283	Safety relay always On after Power On
284	Lowering release valve current too low although activated
285	Lowering release valve current too high although not activated
286	Lowering release valve current very high
287	Lowering release valve always OFF
288	Lowering release valve always ON
289	Safety valve current low although activated
290	Lowering release valve current too high although not activated
291	Lowering release valve current very high

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292	Safety valve always OFF
293	Safety valve always ON
294	5V power supply too low
295	Production test not OK
350	Safety processor detects deviating lifting/lowering joystick signal
351	Safety processor detects deviating tilting joystick signal
352	Safety processor detects deviating joystick AUX 1 signal
353	Safety processor detects deviating joystick AUX 2 signal
354	Safety processor detects deviating PWM of lifting/lowering joystick
355	Safety processor detects deviating tilting PWM
356	Safety processor detects deviating AUX 1 PWM
357	Safety processor detects deviating AUX 2 PWM
358	No teaching of tilt angle limit stops in safety processor
359	Safety processor detects deviating tilt angle signal
380	No data from safety processor
410	Safety processor: Lifting, PWM high though joystick signal low
411	Safety processor: Lowering, PWM high although joystick signal low
412	Safety processor: Forward tilt, PWM high though joystick signal low
413	Safety processor: Backward tilt, PWM high though joystick signal low
414	Safety processor: AUX1+, PWM high though joystick signal low
415	Safety processor: AUX1-, PWM high though joystick signal low
416	Safety processor: AUX1+, PWM high though joystick signal low
417	Safety processor: AUX2-, PWM high though joystick signal low
418	Safety processor: Safety valve switch-off test unsuccessful
419	Safety processor: Safety relay switch-off test unsuccessful
420	Safety processor: Lowering release valve switch-off test unsuccessful
421	Safety processor: Internal signals PWM lifting/lowering incompatible
422	Safety processor: Internal signals PWM tilting incompatible
423	Safety processor: Internal signals PWM AUX1 incompatible
424	Safety processor: Internal signals PWM AUX2 incompatible
425	Safety processor: Internal PWM signals error
426	Safety processor: Forward tilt driven although mast outside of the front electric stops
427	Safety processor: Backward tilt controlled although mast outside of the behind electric stops

LTC codes of composite instrument

Warnings	
152	General fault of composite instrument
154	Composite instrument CAN interface over 200 ms in the bus-off condition
156	Traction control / heartbeat message missing for over 400 ms
158	Lift control / heartbeat message missing for over 400 ms
160	Soot filter control / heartbeat message missing for over 400 ms
162	Data logger / heartbeat message missing for over 400 ms
164	CSM 2 CAN / heartbeat message missing for over 400 ms

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166	CSM 2 CAN / heartbeat message missing for over 400 ms
168	CSM 3 CAN / heartbeat message missing for over 400 ms
182	Display button pressed for over 120 s
184	Oil pressure control signal shorted to earth and engine speed < 10 rpm.
186	UD alternator < 8.2 V for t > 300 ms and engine speed > 900 rpm or if battery charging warning light signal OFF and engine speed < 10 rpm.
188	Air filter restricted signal shorted to earth and engine speed < 10 rpm
190	Signal of differential pressure of hydraulic system oil micro-filter shorted to earth and engine speed < 10 rpm
192	Selected characteristic does not match the signals of the fuel level sending unit

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Description of transmission

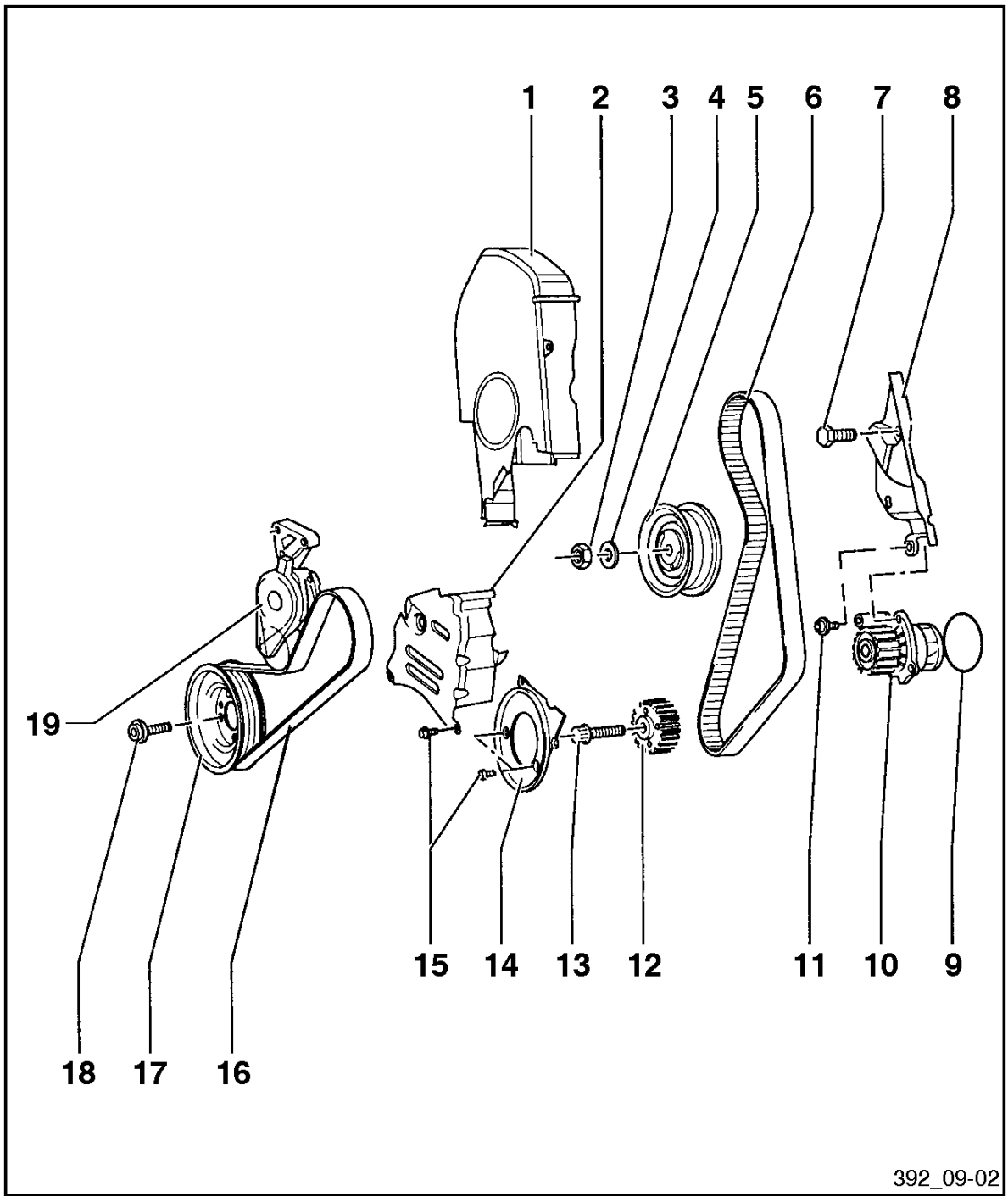
Technical Data VW BEF

Engine type	VW BEF (with Impco LPG system)
Number of cylinders	4
Cubic capacity	1984 cm^3
Power output	39 kW at 2600 rpm
Compression ratio	10,5 : 1
Compression	Desired value 10 - 13 bar
	Wear limit 7.5 bar
Maximum admissible pressure difference	3 bar
Lower idle speed	1000^{+50} rpm^{-1}
Upper idle speed during traction	2700 rpm
Upper idle speed while lifting	2800 rpm
Rated speed	2600 rpm
Speed restriction	3500 rpm
Valve clearance	Hydraulic valve clearance compensation
Ignition	Electronic firing order
Ignition point	12° below TDC at 1000 rpm (throttle potentiometer disconnected) 20° below TDC at 1000 rpm with throttle valve sensor
Firing order	1 - 3 - 4 - 2
Lubrication oil pressure at 1000 rpm and 80°C oil temperature	min. 2 bar
Lubrication oil pressure at 2000 rpm	min. 3 - 4.5 bar
Cylinder 1	opposite power output side
Spark plugs at maintenance interval of 500 operating hours	Beru 14 FGH-7DTURX, VW No. 101000041AC
Spark plugs at maintenance interval of 1000 operating hours	NGK BKUR6ET-10, VW No. 101000033AA
Fan switch-on temperature	Coolant approx. 95°C, hydraulic oil approx. 68°C

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Engine block

Ribbed V-belt - removal and installation



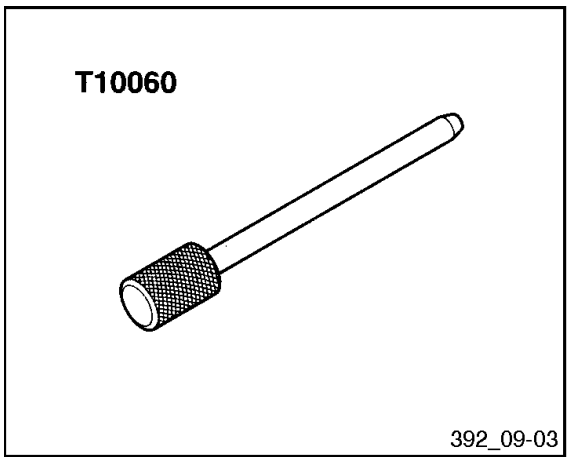
1	Upper toothed belt guard	9	O-ring
2	Lower toothed belt guard	10	Water pump
3	Hexagonal nut, torque 20 Nm	11	Bolt, torque 15 Nm
4	Washer	12	Crankshaft sprocket
5	Idler pulley, semi-automatic	13	Bolt, torque 90 Nm
6	Toothed belt	14	Lower toothed belt guard
7	Bolt, torque 20 Nm	15	Bolt, torque 10 Nm
8	Rear toothed belt guard	16	Ribbed V-belt

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17 Belt pulley
18 Bolt, torque 40 Nm
19 Tensioning element for the ribbed V-belt

Required special tool

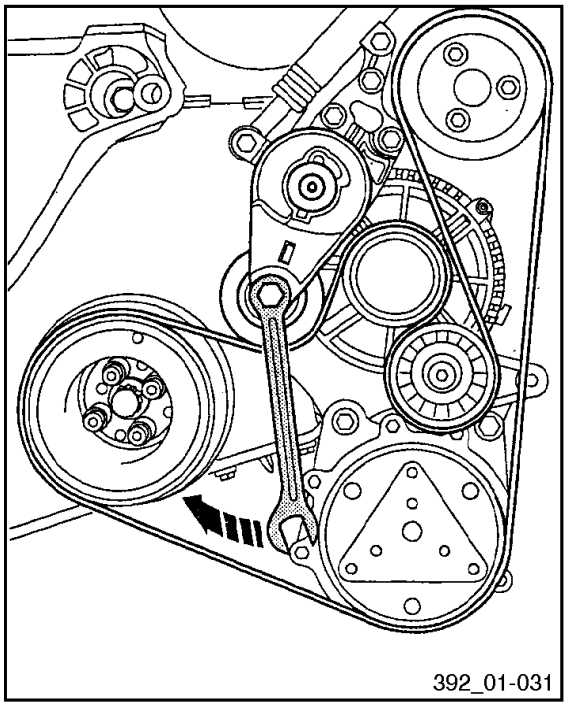
- Locating pin T 10060



Ribbed V-belt - removal

➢ Mark the running direction of the ribbed V-belt.

➢ Swivel the spring-loaded idler pulley with a 16-mm flat ring spanner at the tensioning lever in the direction of the arrow



Ribbed V-belt - installation

Installation is carried out in the reverse order of removal.

NOTE

Before installation of the ribbed V-belt, make sure the running direction of the belt is correct and it is properly positioned in the pulleys.

➢ For trucks **without** air conditioning: Place ribbed V-belt on alternator last.

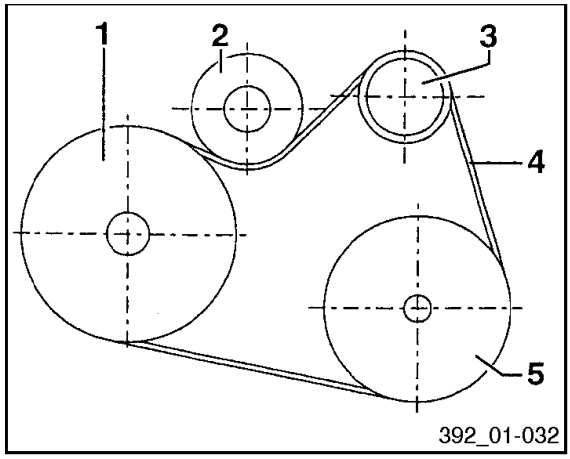
➢ On trucks **with** air conditioning: Place ribbed V-belt on A/C compressor last.

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Ribbed V-belt - A/C compressor drive belt routing

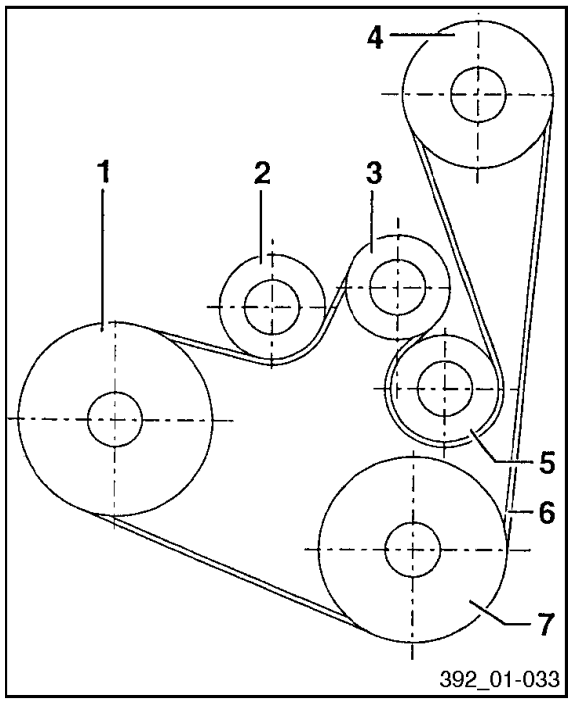
NOTE

The car type is depicted. Linde trucks do not have a vane pump.



1 Pulley vibration damper
2 Spring-loaded idler pulley
3 Alternator pulley
4 Ribbed V-belt
5 Vane pump pulley for power steering

Ribbed V-belt - drive belt routing with A/C compressor



1 Pulley vibration damper
2 Spring-loaded idler pulley
3 Alternator pulley
4 Vane pump pulley for power steering
5 Reflection pulley
6 Ribbed V-belt
7 Belt pulley for A/C compressor

Toothed belt - removal and installation, tensioning

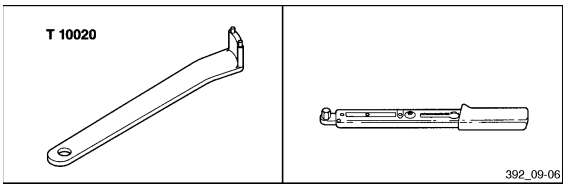
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1 Upper toothed belt guard
2 Lower toothed belt guard
3 Hexagon nut, torque 20 Nm
4 Washer
5 Idler pulley, semi-automatic
6 Toothed belt
7 Bolt, 20 Nm
8 Rear toothed belt guard
9 O-ring
10 Water pump
11 Bolt, 15 Nm
12 Crankshaft sprocket
13 Screw, 90 Nm and turn by a further 1/4 turn
14 Lower toothed belt guard
15 Bolt, 10 Nm
16 Ribbed V-belt
17 Belt pulley
18 Bolt, 40 Nm
19 Tensioning element for ribbed V-belt

Required special tool

▷



- Pin-type face spanner VW T 10020
- Torque spanner (5 - 50 Nm)
- Torque spanner (40 - 200 Nm)

Remove the toothed belt

➢ Remove the ribbed V-belt, belt pulley, upper and lower part of the toothed belt guard.

➢ Loosen the spring-loaded idler pulley

➢ Remove the toothed belt.

Toothed belt - installation

CAUTION

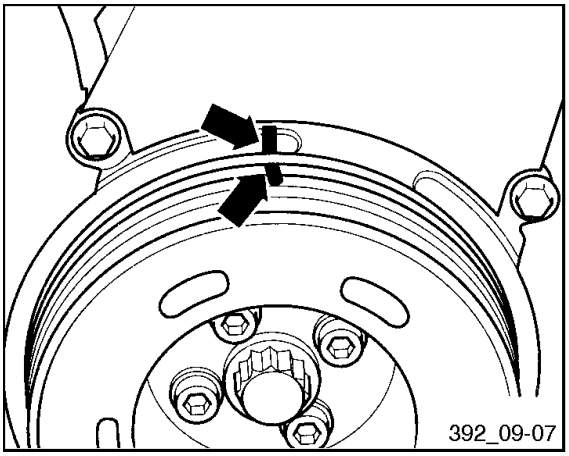
The valves/piston heads can be damaged if the crankshaft is at TDC.

Do not set the crankshaft to TDC.

➢ Install the toothed belt.

▷

Crankshaft mark at TDC of cylinder 1 or overlapping

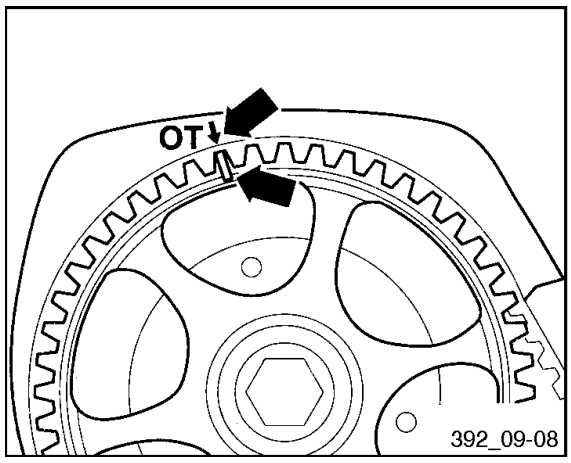


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➢ Set camshaft mark to TDC of cylinder 1

➢ The camshaft sprocket and crankshaft sprocket marks must be aligned.

▷



Tensioning the toothed belt

Prerequisites:

- The engine must be no more than warm to the hand.
- Crankshaft set to TDC of cylinder 1.
- Use the nut spanner T316 to turn the spring-loaded idler pulley at the eccentric bolt 5 times in both directions as far as the stop before the toothed belt is tensioned.

➢ Tension the toothed belt.

➢ To do so, turn the pin-type face spanner WM 316 at the eccentric bolt to the left (direction of arrow) as far as the stop.

➢ Release the toothed belt until the notch(1) and the pointer(2) are opposite one another (use a mirror).

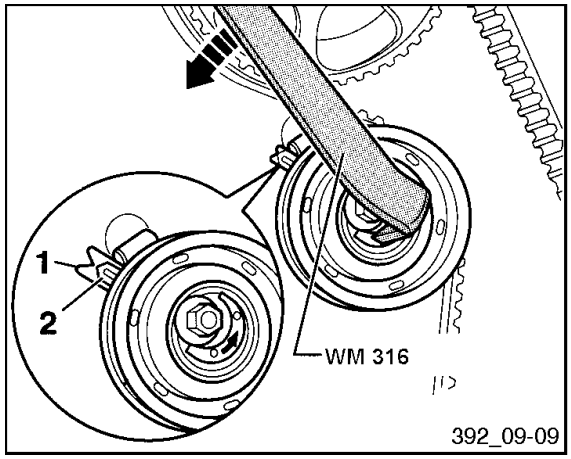
➢ Tighten the fastening nut to 20 Nm.

➢ Turn the crankshaft another two turns in the sense of rotation of the engine until the engine is set to TDC of cylinder 1 again. When doing so, it is important that the last 45° (1/8 turn) are turned without interruption.

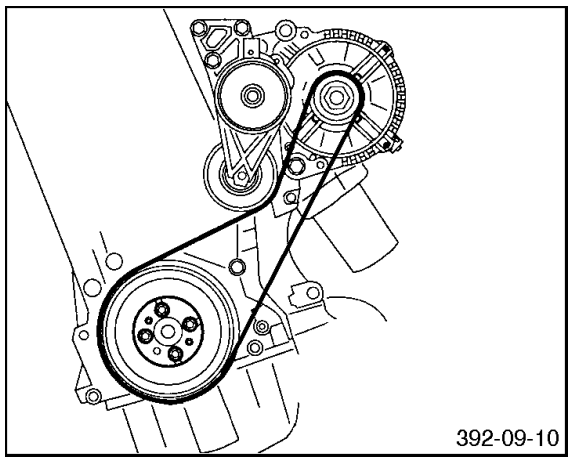
➢ Check the toothed belt tension once more.

➢ Desired position: Pointer and notch are in line.

▷

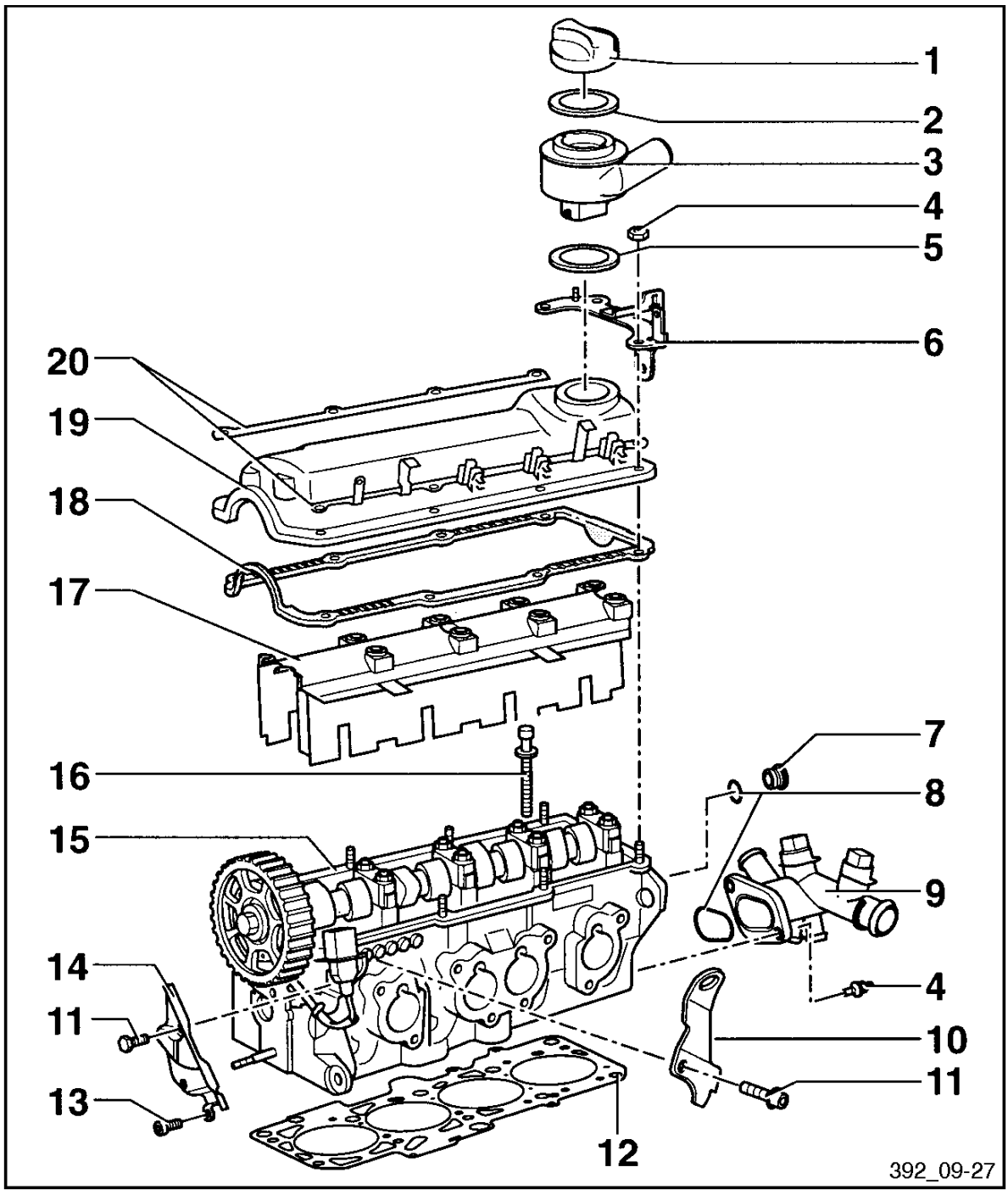


▷



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Cylinder head - removal and installation

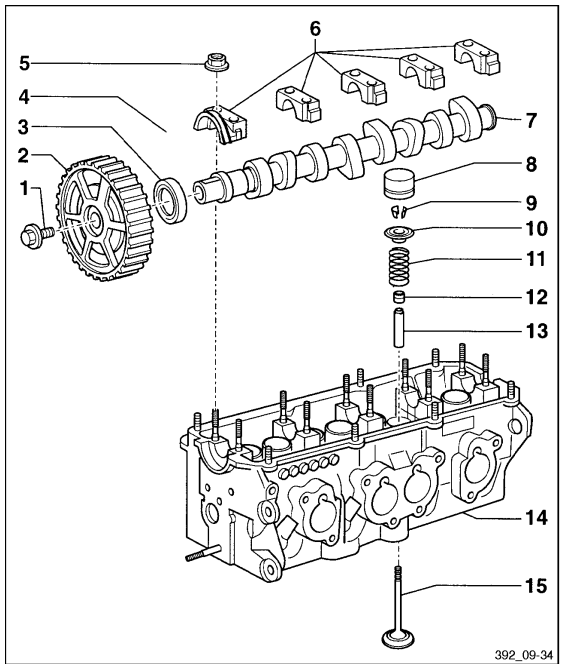


1	Oil filler cap	11	Torque 20 Nm
2	Seal	12	Cylinder head gasket
3	Vent housing	13	Torque 15 Nm
4	Torque 10 Nm	14	Rear toothed belt guard
5	Seal	15	Cylinder head
6	Mounting bracket	16	Cylinder head bolt
7	Screw plug, 15 Nm	17	Oil barrier
8	Sealing ring	18	Gasket for cylinder head cover
9	Manifold	19	Cylinder head cover
10	Lift bracket	20	Packing piece

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NOTE

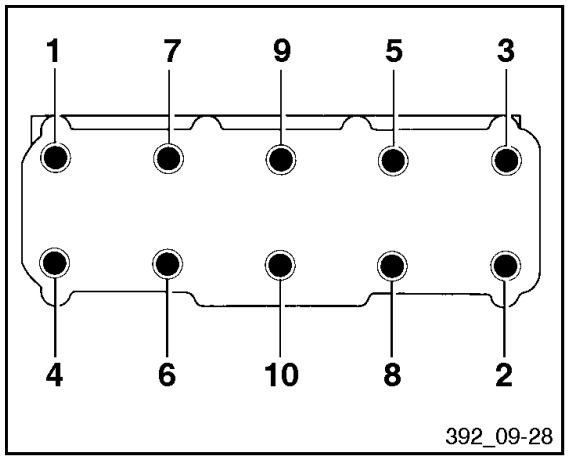
If a replacement cylinder head with camshaft is installed, valve clearances do not need to be adjusted. The contact surface between the bucket tappets and cam faces must be oiled after installation of the head. The plastic caps supplied for the protection of the open valves should not be removed until just before the installation of the cylinder head. If the cylinder head is replaced, the cooling system must be filled with fresh coolant.



1	Torque 100 Nm
2	Camshaft sprocket
3	Sealing ring
4	Woodruff key
5	Torque 5 Nm
6	Bearing cap
7	Camshaft
8	Bucket tappet (do not interchange)
9	Collets
10	Upper valve spring seat
11	Valve spring
12	Valve stem seal
13	Valve guide
14	Cylinder head
15	Valve

Cylinder block - removal

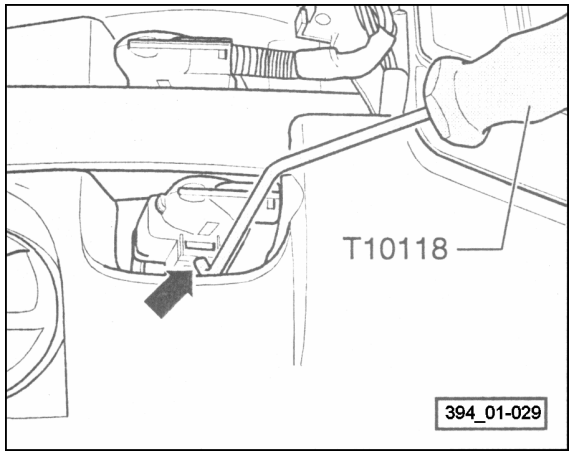
➢ Remove the cylinder head bolts in the given sequence. ▷



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➢ Check the cylinder head for flatness.

Max deviation allowed : 0.1 mm



Cylinder block - installation

- The pocket holes of the cylinder head bolts in the cylinder block must be free of oil or coolant.
- Do not take the new cylinder head gasket out of its packing until it is actually mounted.
- Handle the new gasket with utmost care. Damage will lead to leakage.

➢ Put clean cloths into the cylinders to prevent dirt and abrasive residues from getting between the cylinder face and piston.

➢ Also prevent dirt and abrasive residues from getting into the coolant.

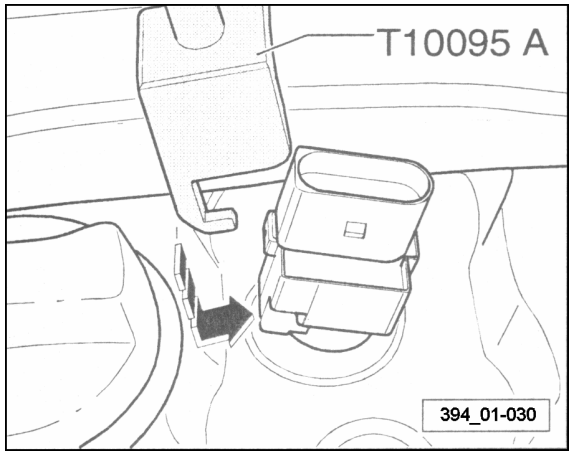
➢ Carefully clean the mating faces of cylinder head and cylinder block. Take care not to cause any long scoring or scratches.

If emery paper is used, the grain should not be under 100.

➢ Carefully remove emery and grinding residues and the cloths.

➢ Set the piston of cylinder 1 to top dead centre and turn the crankshaft back a bit.

➢ For the purpose of centring, screw the guide pins from 3450/2A into the outer front drilled holes for the cylinder head bolts.



NOTE

The tolerance of the centring holes is smaller in the upper area. Before the cylinder head is positioned, you should therefore check whether the guide pins can be removed upwards. If necessary, slightly grind off the knurled surface of the guide pins.

➢ Position the new cylinder head gasket.

➢ Put the cylinder head in place, insert the remaining 8 cylinder head bolts and tighten them by hand.

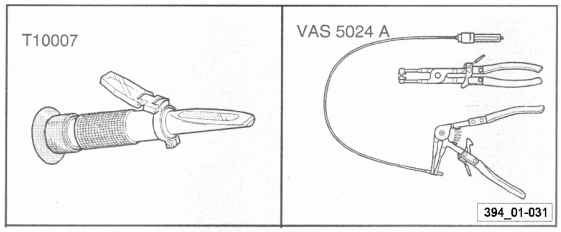
➢ Use removal tool 3450/3 to unscrew the guide pins through the bolt holes. To do so, turn the tool leftward until the pins are free.

➢ Install the remaining two cylinder head bolts and tighten them by hand.

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- Tighten the cylinder head bolts in the sequence shown in the illustration as follows:
- First tighten all bolts to a torque of 40 Nm.
- Subsequently turn all bolts by 1/4 turn (90°) with the help of a normal spanner.
- Finally turn all bolts again by a further 1/4 turn (90°).

▷



The rest of the installation is done in the reverse order of removal.

CAUTION

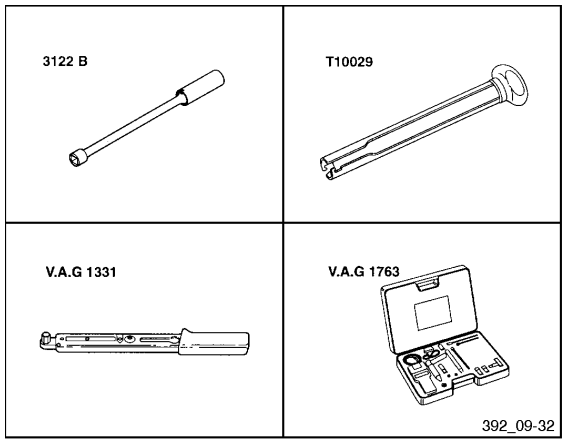
The valves/piston heads can be damaged if the crankshaft is at TDC.

Do not set the crankshaft to TDC.

Compression - check

Required special tools

▷



- Spark plug spanner 3122 B
- Mounting tool T10029
- Torque wrench V.A.G 1331
- Compression tester V.A.G 1763

Test procedure

- Open throttle plate completely.
- Check the compression with the tester.
- Actuate the starter until the tester no longer indicates a rise in pressure.

Compression values:

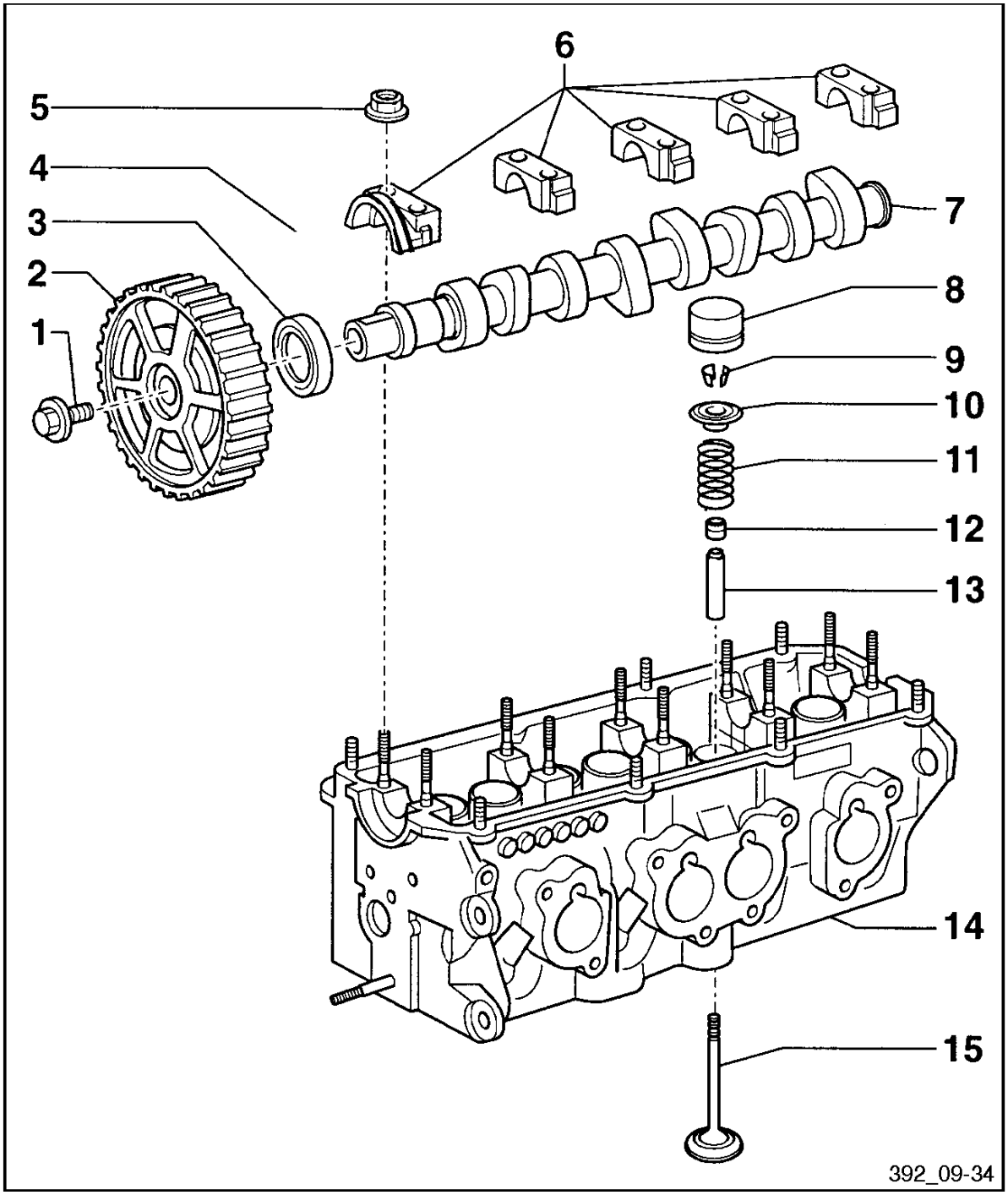
New: 10 - 13 bar

Wear limit: 7.5 bar.

Admissible difference between all cylinders: 3 bar

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Hydraulic bucket tappets - check



1	Bolt, torque 45 Nm	9	Collets
2	Camshaft sprocket	10	Upper valve spring seat
3	Sealing ring	11	Valve spring
4		12	Valve stem seal
5	Hexagonal nut, torque 5 Nm	13	Valve guide
6	Bearing caps	14	Cylinder head
7	Camshaft	15	Valve
8	Bucket tappets		

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Assembly notes

- Item 1: Use holding jig VW 3415 for loosening and tightening.
- Item 6: Coat mating face of bearing cap 1 lightly with sealant AMV 174 004 01.
- Item 8: Do not interchange, with hydraulic valve clearance compensation, lubricate the running surface with oil.

Required special tools

- Feeler gauge
- Wooden or plastic wedge

Test procedure

NOTE

Only replace bucket tappets as a complete assembly. They can not be adjusted or repaired. Irregular valve noises when starting the engine are normal.

- Start the engine and let it run until the engine oil temperature has reached at least 80 °C.
- Increase engine speed to approx. 2500 rpm for 2 minutes.

If the hydraulic bucket tappets are still noisy, locate the defective tappet as follows:

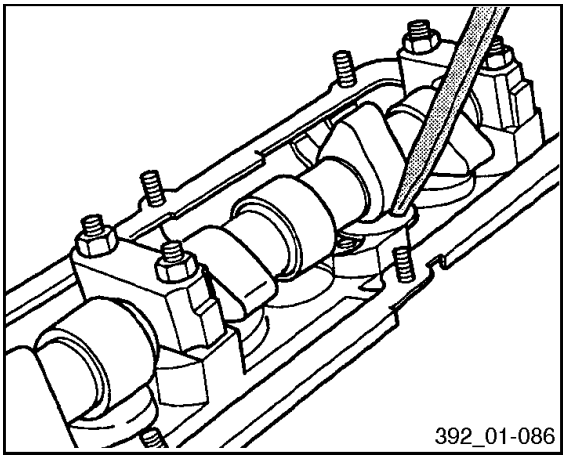
- Remove the cylinder head cover.
- Rotate the crankshaft clockwise until the cam of the bucket tappet to be checked is pointing upwards.
- Determine the clearance between the cam and bucket tappet.

If the clearance exceeds 0.1 mm, replace the bucket tappet.

If the clearance is less than 0.1 mm or no clearance is detected, repeat the test as follows:

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➢ Press the bucket tappet down with a wooden or plastic wedge.



If free travel in excess of 0.1 mm is felt until the valve opens:

➢ replace the tappet.

CAUTION

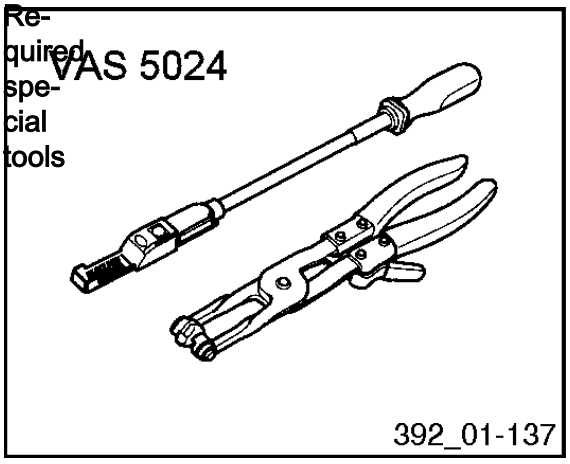
The hydraulic compensation elements must settle, otherwise the valves can strike the pistons and bend.

Do not start the engine for approx. 30 minutes after installing new bucket tappets!

Cooling

Coolant thermostat - removal and installation

- Hose clamp pliers VW VAS 5024



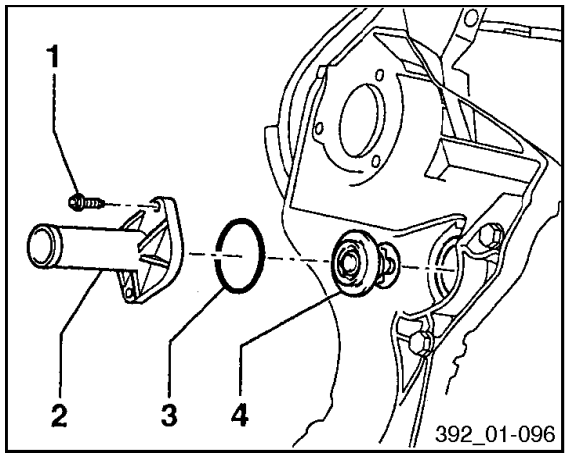
Coolant thermostat - removal

➢ Drain the coolant.

➢ Remove the coolant hose from the union (2).

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➢ Remove the fastening screws (1) of the union (2) and take off the union (2) with the coolant thermostat (4).



➢ Turn the coolant thermostat (4) ¼ turn (90°) to the left and withdraw it from the union (2).

Coolant thermostat - installation

The installation is in the reverse order of removal. Please observe the following instructions:

➢ Coat a new O-ring (3) with coolant.

➢ Insert the coolant thermostat (4) in the union (2) and turn it ¼ turn (90°) to the right.

NOTE

The backets of the coolant thermostat must be nearly vertical.

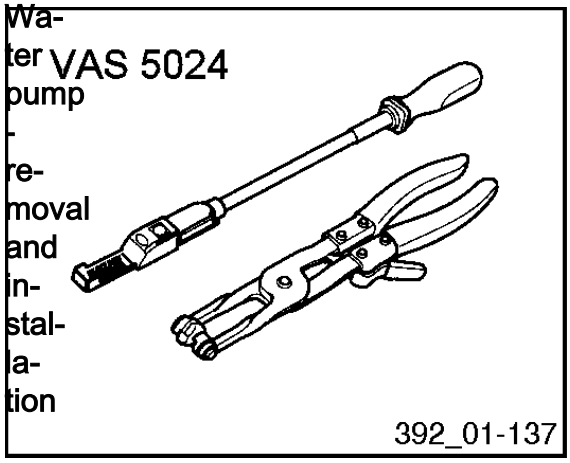
➢ Install the union (2) with the coolant thermostat (4) into the engine block.

➢ Tighten the fastening screws (1).

Torque: 15 Nm

➢ Top up coolant.

- Torque spanner 5 - 50 Nm
- Pliers for spring clamps VW VAS 5024
- Antifreeze tester



Water pump - removal

NOTE

Always renew seals and sealing rings.

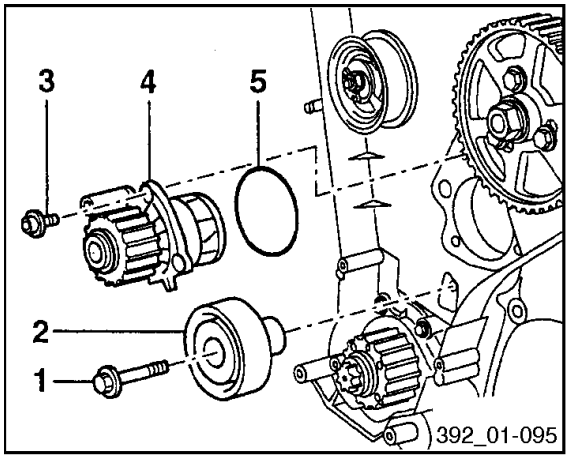
The lower toothed belt guard does not have to be removed.

The toothed belt remains in place on the crankshaft sprocket.

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Before removing the water pump, cover the toothed belt with a cloth to protect it from the coolant.

- Drain the coolant.
- Remove the ribbed V-belt.
- Remove the toothed belt guard.
- Remove the toothed belt from the camshaft sprocket, injection pump sprocket and water pump.
- Screw out the fastening bolt (1) from the reflection pulley (2) and push it down approx. 30 mm.

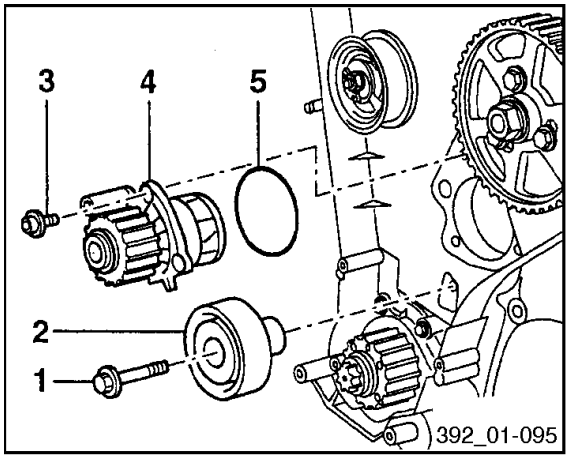


- Remove the water pump fastening bolts (3) and carefully withdraw the water pump (4) from between the engine mount and rear toothed belt guard.

Water pump - installation

The installation is carried out in the reverse order of removal. The following must be observed:

- Coat a new O-ring (5) with coolant.



- Place the water pump (4) in the cylinder block and tighten the fastening bolts (3).

Torque: 15 Nm

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NOTE

The sealing plug on the water pump shows downwards.

➢ Install the reflection pulley (2) and tighten the fastening bolt (1) (replace).

Torque: 40 Nm and ¼ turn (90°).

➢ Install, tension the toothed belt.

➢ Install the ribbed V-belt.

➢ Top up coolant.

Water pump - check wear

Required special tools

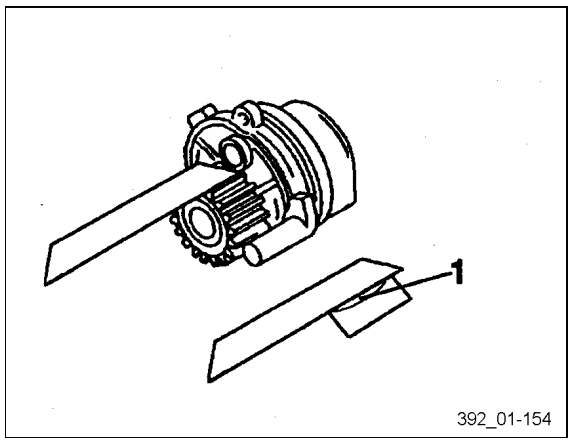
- Straight edge
- Feeler gauge

Water pump - check

➢ Turn drive wheel by hand.

The movement should not be sluggish, nor should there be too much play in the bearing.

➢ Use the straight edge and feeler gauge to determine the wear (1) along the tooth length.



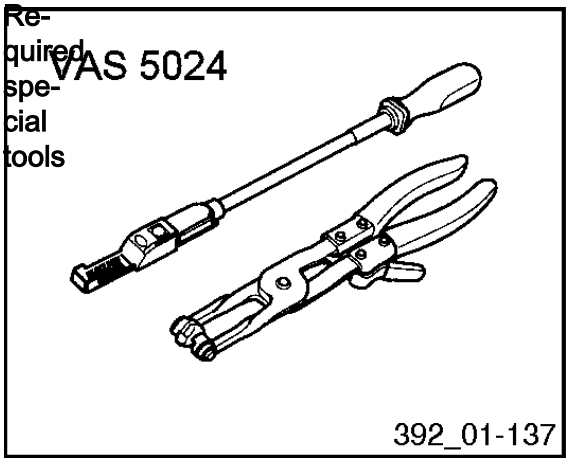
If the wear exceeds 0.30 mm, the water pump must be replaced.

Always replace together with the crankshaft pinion.

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Coolant - draining and filling

- Pliers for spring clamps VW VAS 5024
- Antifreeze tester



Coolant - draining

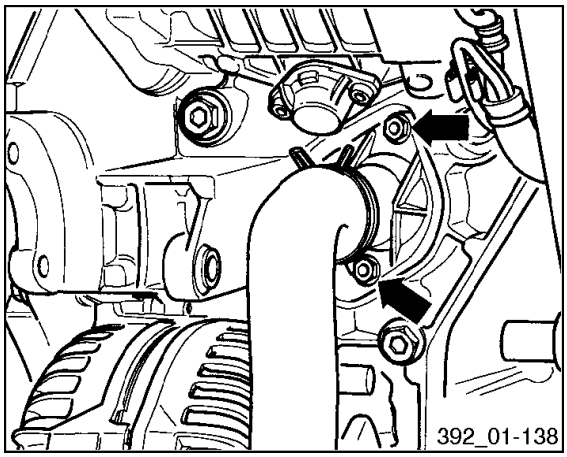
WARNING

When the expansion reservoir is opened, hot steam may escape, causing severe scalding. Cover the cap with a cloth and open it carefully!

➢ Open the sealing cap of the coolant expansion reservoir.

➢ Use the pliers for spring band clamps VW VAS 5024 to pull off the lower coolant hose at the radiator.

➢ To drain the coolant from the engine also remove the connecting piece with the coolant regulator (arrows).



NOTE

Please observe the regulations for discarding coolant!

Coolant - filling

NOTE

- *Only use G 12 acc. to TL VW 774 D as coolant additive. Characteristic feature: red colour.*
- *Never mix G 12 with other coolant additives. If the fluid in the recovery tank is brown, G 12 was mixed with an other coolant. In this case the coolant must be changed.*
- *G 12 and coolant additives with the note "in accordance with TL VW 774 D" prevent damage caused by frost and corrosion, lime deposits and also raise the boiling temperature. For these*

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reasons, the cooling system should always be filled with antifreeze and anti-corrosion agent all the year round.

- *Especially in countries with a tropical climate, the coolant contributes, due its higher boiling point, to operational reliability at high engine loads.*
- *The antifreeze protection must be guaranteed down to approx. -25 °C (in countries with Arctic climate down to approx. -35 °C.*
- *Even during the warm season and in warm countries, never reduce the concentration of the coolant by adding water. The coolant additive portion should be at least 40 %.*
- *If, for climatic reasons, a stronger frost protection is required, the amount of G 12 can be increased, but only up to 60 % (frost protection down to approx. -40 °C), since this would reduce the frost protection again and also the cooling effect.*
- *If the radiator, heat exchanger, cylinder head or cylinder head gasket were replaced, do not reuse the coolant.*

Recommended mixing ratio:

Frost protection to	Percentage of antifreeze	G 12[1]	Water[2]
-25°C	40 %	2.4 L	3.6 L
-35°C	50 %	3.0 L	3.0 L

➢ Close the coolant drain plug.

➢ Fill in coolant up to the maximum mark on the expansion reservoir.

➢ Close the expansion reservoir.

➢ Run the engine until the fan starts operating.

➢ Check the coolant level, adding coolant if necessary.

When the engine is at operating temperature, the coolant level must be at the max mark; when the engine is cold, it must be between the min and max mark.

[1] The coolant quantity may vary depending on the truck equipment.

[2] The coolant quantity may vary depending on the truck equipment.

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Engine electrical system

Alternator

To exchange the three-phase alternator, the freewheel pulley must be removed and installed again.

Freewheel pulley - removal and installation

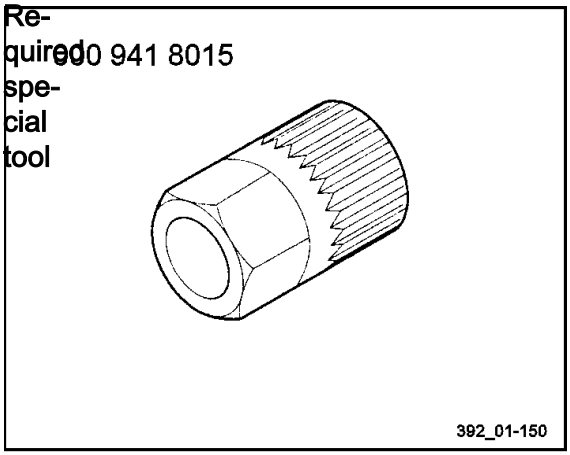
- Polygon head adapter 000 941 8015

Freewheel pulley - removal

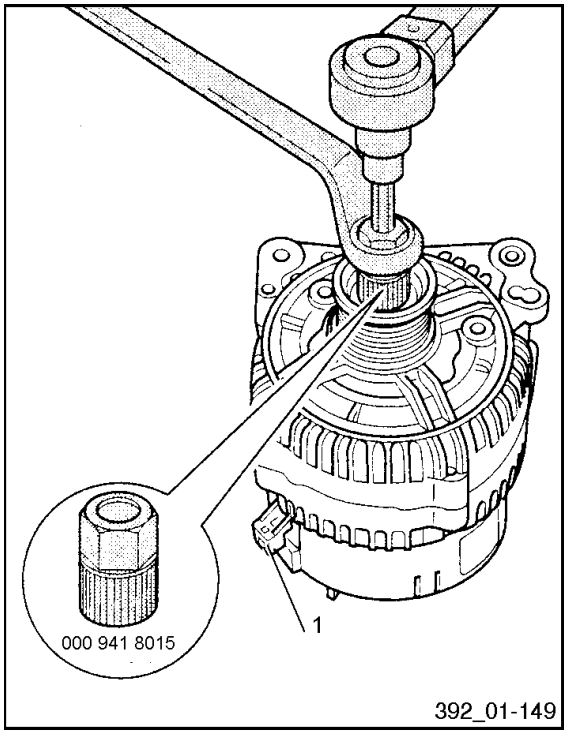
➢ Remove the ribbed V-belt.

➢ Remove the protective cap on the freewheel pulley.

➢ Put the hexagon socket (6 mm) on the drive-shaft of the three-phase alternator.



➢ Support the polygon head adapter 000 941 8015 17 with a ring spanner (17 mm) and release freewheel pulley by turning the driveshaft of the three-phase alternator anticlockwise.



Freewheel pulley - Installing

➢ Insert the polygon head adapter 000 941 8015 in the freewheel pulley.

➢ Screw the freewheel pulley - at first manually - against the stop onto the driveshaft of the three-phase alternator.

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- Support the polygon head adapter 000 941 8015 with a ring spanner (17 mm) and tighten freewheel pulley by turning the three-phase alternator anticlockwise with the torque wrench.

Tightening torque: 80 Nm

- Refit the protective cap on freewheel pulley.
- Install the ribbed V-belt.

Terminal DFM on three-phase alternator

The signal at terminal DFM is only evaluated in connection with the auxiliary heater. The signal for free charging capacity is applied to alternator terminal DFM.

Self-test

Lack of plausibility or interruption are stored as possible error causes.

Terminal DFM - additional signal

Contact 38 at controller 0N1

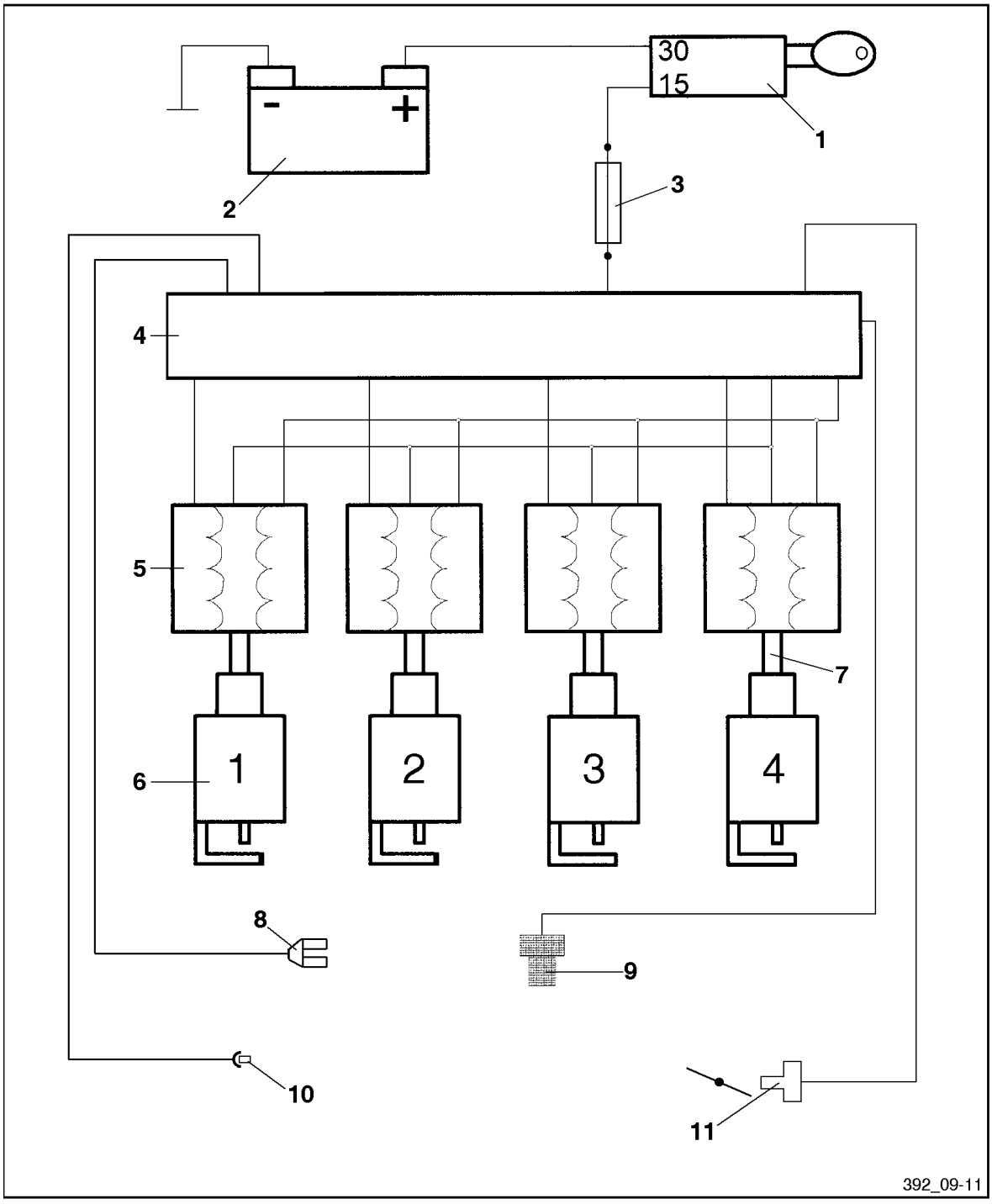
The DFM line connects the electronic control unit 0N1 with the combined processor in which the electronic immobilizer 0N2 (terminal W) is integrated. The immobilizer signal is transmitted over this cable. After each replacement of the control unit the new code must be read into the combined processor.

Self-test

The electronic control unit detects the interruption of this line. The engine can no longer be started in this case.

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Electronic ignition system, overview



1	Ignition switch	7	Ignition cable
2	Battery	8	Phase sensor
3	Fuse	9	Engine speed sensor
4	Ignitionelectronics	10	Connector for modification of ignition map
5	Ignition coils	11	Throttle plate potentiometer
6	Spark plugs		

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Functional description

The engine is equipped with an integrated electronic ignition system without contact breaker points. Due to its design, the ignition system is reliable, non-adjustable and has the following advantages:

- No centrifugal advance.
- Permanent stability of the ignition timing curve.
- High secondary voltage.
- No wear of the controller due to a magnetic pickup without mechanical contact.
- Ignition and ignition advance are controlled by an electronic controller, which is programmed accordingly.

The firing point is changed in accordance with engine speed and throttle plate position (load).

The engine speed sensor provides the ignition control unit with the actual engine rpm. The ignition control unit determines the firing point with the programmed characteristic map for ignition.

The phase sensor provides the ignition control unit with the position of the pistons. In this way the ignition spark is sent to the correct cylinder.

The throttle plate potentiometer modifies the voltage (signal) to the ignition control unit with the position the throttle plate (load state of the engine).

Electronic ignition control unit

The electronic ignition control unit is comparable to a processor. Two are programmed. The firing point is adjusted depending on the speed and throttle plate position. The ignition control unit is waterproof and limits the speed to 3500 rpm.

Input signals at the ignition control unit

0B2 Engine speed sensor

0B10 Phase sensor, position of piston, VW, 5 V with 2,2 k?

0B12 Throttle valve potentiometer 5 k?, adjustment range 0 to 5V

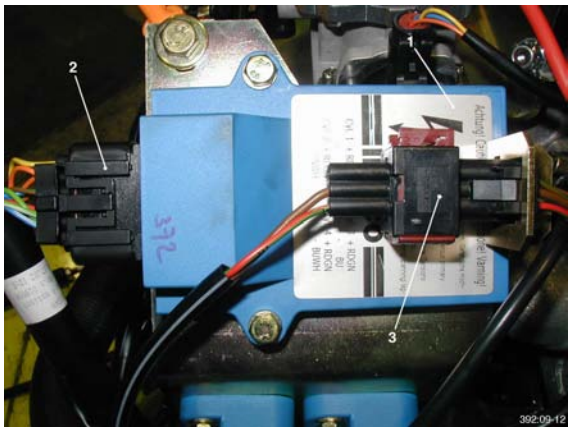
X12 Connector 6 pins, modification of ignition map

Output signals of ignition control unit

0T1 to 0T4 Ignition coil: Low voltage to the four coils

X12 Speed signal

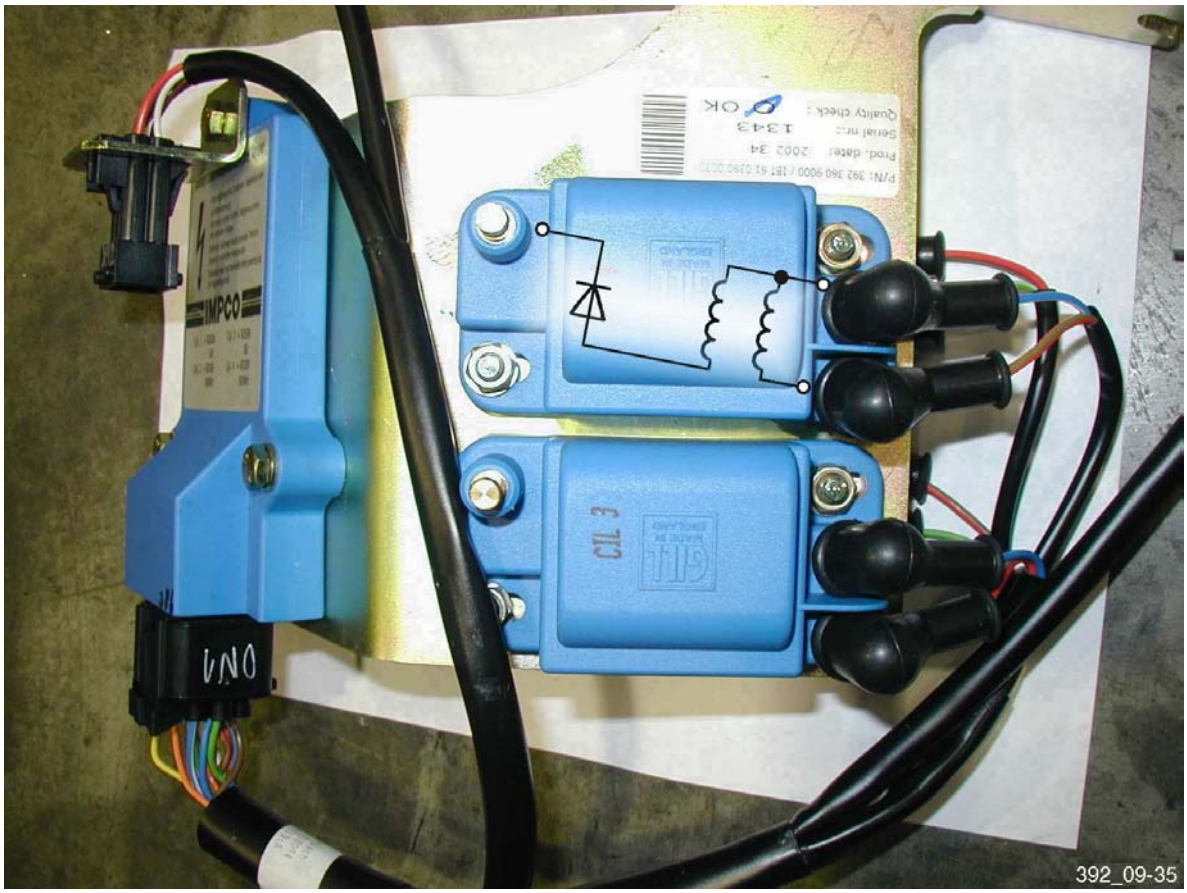
Power supply for throttle valve sensor 5 V



1 Ignition control unit 0N1
2 Connector for signal inputs and outputs AMP 18 pins
3 Connector X12, adjustment of ignition point

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Ignition coil



Design and function of the coil are largely identical with those of the coils in conventional ignition systems. Each cylinder has 1 coil, which can be replaced separately. Primary and secondary coil can be checked by measuring the resistance.

Primary coil resistance: 0.6 ?

Secondary coil resistance: max 35 kV

Ignition coil up to installation date Week 14 - check

CAUTION

During the test, sparks arise at the spark plug. If the spark plug gap is too wide, the ignition coil (diode) can be destroyed.

Be sure the spark plug gap is correct.

- Testing of primary coil (1). Resistance measurement at positive and negative terminals.

Desired resistance: 0.5 - 1.4 ?

Check the diode (secondary coil (2). (diode symbol on multimeter).

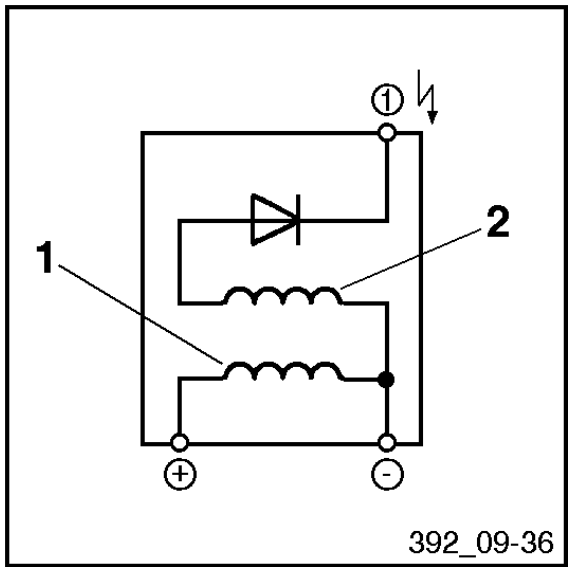
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- Connect the negative line of the meter to the negative terminal of the coil.
- Connect the positive line of the meter to the high-voltage terminal "1" of the coil.

Desired voltage: 1.2 to 2.1 V

Resistance measurement between negative terminal and high-voltage terminal "1" of the coil.

Desired resistance: If the diode is defective, a resistance of approx. 2.2 kW will be indicated.



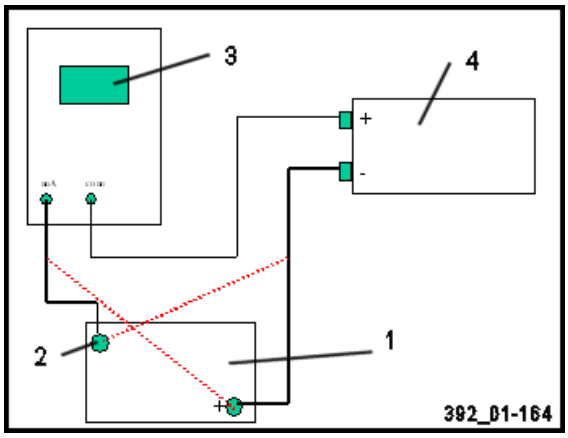
Ignition coil from installation date Week 15 - check

- Set the multimeter to DC voltage reading"DC, mA".
- Connect the red lead from "mA" of the multimeter to the high-voltage terminal (2) of the ignition coil.
- Connect the black lead from battery negative to positive of the ignition coil (1).

Reading with functioning ignition coil I = 1.5 - 2 mA.

- Interchange the test leads at the ignition coil.

The reading with a functioning ignition coil should now be much lower, about 0.2 mA.



1 Ignition coil
2 High-voltage terminal
3 Multimeter
4 Battery 9 V

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Throttle plate potentiometer

Yellow lead: "positive" power supply 5V

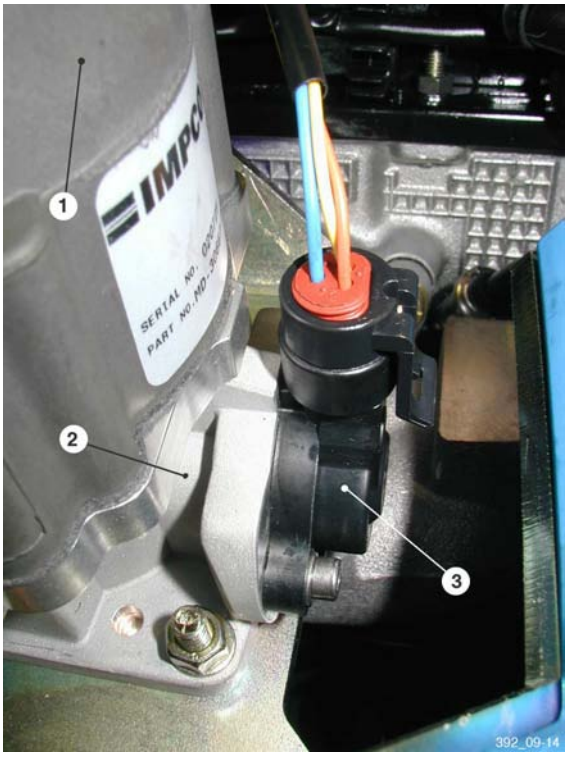
Orange lead: "negative " power supply

Blue lead: Signal output to ignition control unit, 0 to 5V, depending on throttle plate position

The throttle plate potentiometer is connected with the shaft of the throttle plate and is located on the mixer housing (throttle plate body). The voltage going to the ignition control unit changes when the throttle plate rotates.

Output voltage: 0 to 5 V.

In its home position, the throttle plate is set to 750 rpm with the stop screw and has a maximum opening angle of 45°.



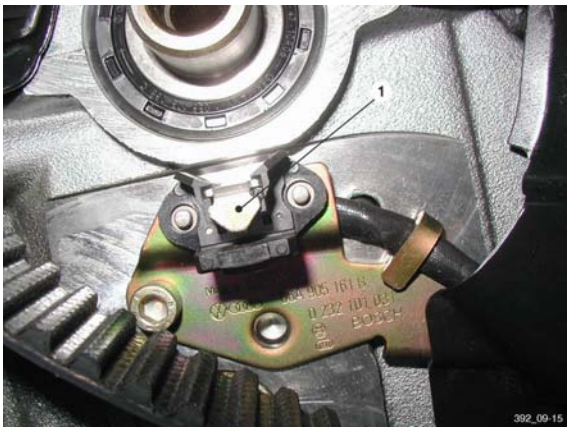
1 Mixer
2 Throttle plate body
3 Throttle plate potentiometer

Phase sensor

The phase sensor is located behind the camshaft sprocket. When the camshaft is turned, the restrictor (2) passes over the sensor (1). . The controller determines the position of the pistons with this signal.

Supply voltage: 5 V

Output voltage to ignition control unit: 0 to 5V





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Engine speed sensor



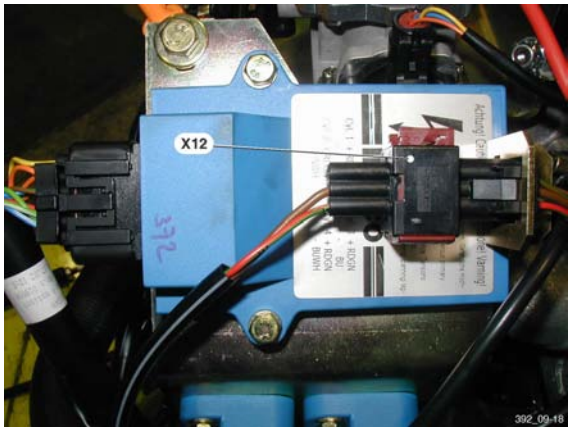
The engine speed sensor in the VW engine is located underneath the ignition system (controller and coils) beside the engine oil filter.The speed sensor transmits the actual engine rpm to the ignition control unit, which "advances the spark.". The speed sensor and phase sensor signals are required to determine the firing point.

Nominal size of the gap between sensor and pulse-generating web: 1.3 mm

The speed sensor can be checked by measuring the resistance. Measurement between terminal 2 and 3:

Desired resistance: 800 - 1000 ?

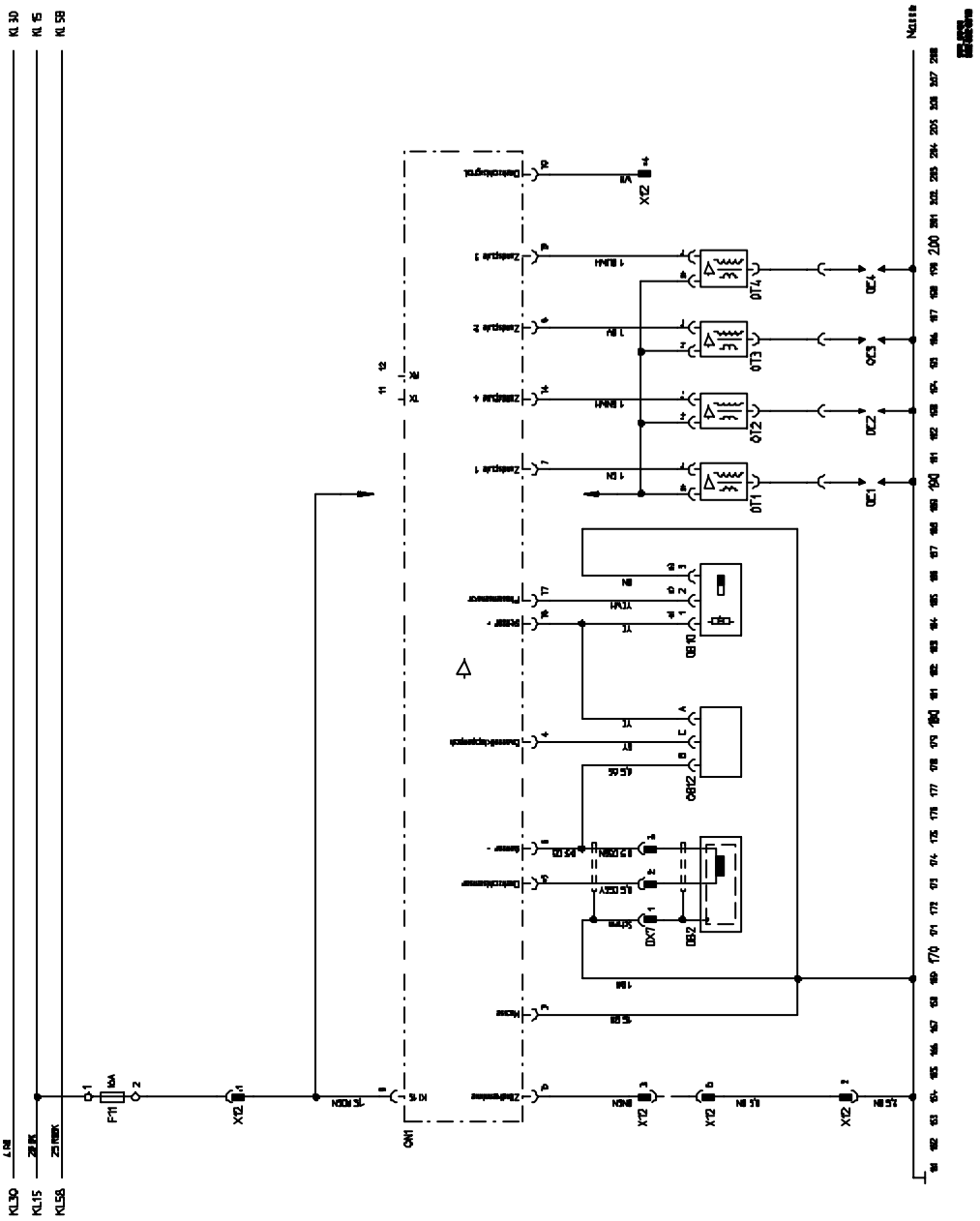
Connector X12



The connector X12 is located at the ignition control unit. By connecting the cable pin 6 and pin 3, a second, modified ignition map is released in the ignition control unit, which changes the firing point over the entire speed range. The spark is retarded "".

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Ignition control unit - wiring diagram



0B2 Engine speed sensor: 171 - 175

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0B10 Phase sensor: 184 - 186
0B12 Throttle plate potentiometer: 178 - 180
0E1 Spark plug, cylinder 1: 190
0E2 Spark plug, cylinder 2: 193
0E3 Spark plug, cylinder 3: 196
0E4 Spark plug, cylinder 4: 199
F11 Fuse 10 A: 164
0N1 Ignition control unit: 163 - 204
0T1 Ignition coil, cylinder 1: 190
0T2 Ignition coil, cylinder 2: 193
0T3 Ignition coil, cylinder 3: 196
0T4 Ignition coil, cylinder 4: 199
X12 Connector 6 pins (engine cable set): 164, 203
0X7 Connector 3 pins: 171 - 175

Cable colours	
BK	black
BU	blue
BN	brown
GN	green
GY	gray
OG	orange
RD	red
VT	violet
WH	white
YE	yellow

LPG installation

Exhaust gases - composition

Exhaust gases - introduction

The fuel combustion in the cylinders of an engine is more or less incomplete. The more incomplete the burning, the greater the amount of pollutants in the exhaust gas. There is no such thing as a complete combustion of fuel, even if there is excess oxygen in the air. To reduce the pollution of the environment, the exhaust gas characteristics of the spark ignition engine must be improved. All measures for reducing pollutant emissions limited by different laws and regulations have the aim of achieving a minimum of pollutant emissions with as much fuel economy as possible, with high performance and good driving characteristics.

In addition to a high percentage of unharmful matter, the exhaust gas of a spark ignition engine contains also contains components considered to be harmful for the environment at least in higher concentrations. The harmful part makes up about one percent of the exhaust gases and it consists of carbon monoxide (CO), nitrogen oxides (NO_x) and hydrocarbons (HC). The greatest problems posed hereby are the opposite concentrations of CO and HC on the one hand and NO_x on the other, dependent on the air-to-fuel ratio.

Exhaust gases - properties

The major components of the exhaust gases are nitrogen, carbon dioxide and water vapour. These are non-poisonous.

Carbon monoxide (CO): Carbon monoxide is a colourless and odourless gas. It has a considerably higher affinity to the hemoglobin (red blood dye) of the blood than does oxygen, and is thus toxic for the body.

Nitrogen oxide (NO, NOx): Nitrogen oxide NO is a colourless gas oxidising to NO_2 in the air. It is known as a severe hemotoxin, as it combines with the hemoglobin in the blood to cause rapid central paralysis. NO_2 is a reddish-brown gas with a sharp, pungent odour. It irritates the lungs and causes damage to the lung tissues. In combination with unsaturated hydrocarbons, nitrogen oxides cause smog formation under the influence of sunlight. NO and NO_2 are designated together as nitrogen oxides (NO_x).

Hydrocarbons (HC): The exhaust gas contains a variety of hydrocarbons:

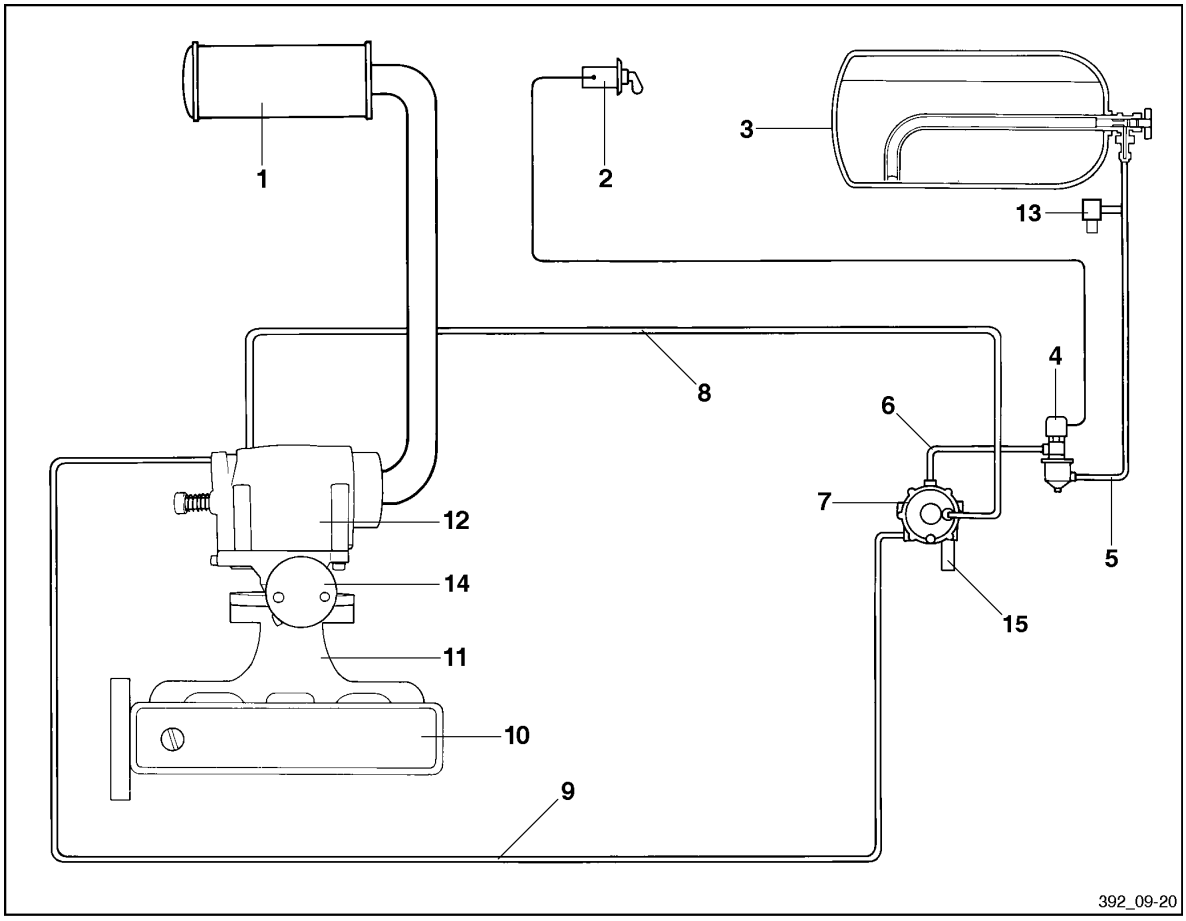
Saturated hydrocarbons (paraffins) are almost odourless, have a narcotic effect and cause a light irritation of mucous membranes.

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Unsaturated hydrocarbons (olefins, acetylenes) have a slightly sweetish smell and in some cases lead to an irritation of mucous membranes. They play a considerable role in the formation of smog, since in the presence of NO and under the influence of sunlight they react further to form oxidants and simultaneously also ozone.

Aromatic hydrocarbons have a characteristic odour. They are nerve toxins with a narcotic effect, have a pungent smell and irritate eyes and nose even at very low concentrations.

LPG system - functions



1	Air filter	9	Gas line vaporiser to mixer
2	Ignition switch	10	Engine
3	LPG cylinder	11	Intake manifold
4	Combined gas cut-off valve	12	Mixer
5	Gas line cylinder to shutoff valve	13	Relief valve
6	Gas line shutoff valve to vaporiser	14	Throttle plate sensor
7	Vaporiser / pressure regulator	15	Relief valve, primary stage 1.7 bar
8	Vacuum line mixer to secondary side of vaporiser		

Method of operation - neutral position

- Ignition switch(2) open.
- Solenoid shutoff valve (4) closed.
- Throttle plate(12) in the mixer closed.

Function - operating position

- Ignition switch ()closed
- Solenoid shut-off valve (4) closed.
- Throttle plate in the mixer (12) open.

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Starting

During the starting process, the solenoid shut-off valve (4) is opened by the LPG control relay. This allows LP gas to flow into the primary side of the vaporiser . . A vacuum in the intake manifold (11) is available at the diaphragm of the secondary valve of the vaporiser (7) via the opened throttle plate of the mixer (12) and the gas line (9). With the diaphragm the vacuum opens a control valve through which the liquid gas now flows in a pressureless gaseous state via gas line (9) to the mixer (12).There the gas is mixed with air and supplied as an ignitable mixture to the individual cylinders via the intake manifold (11).

Operation

During operation the position of the throttle plate is changed by the LTC traction control, dependent on the speed and the load of the engine. The resulting increase or reduction in the vacuum controls the secondary diaphragm in the vaporiservia line (9), therefore changing the gas flow and the mixing ratio in the mixer (12).

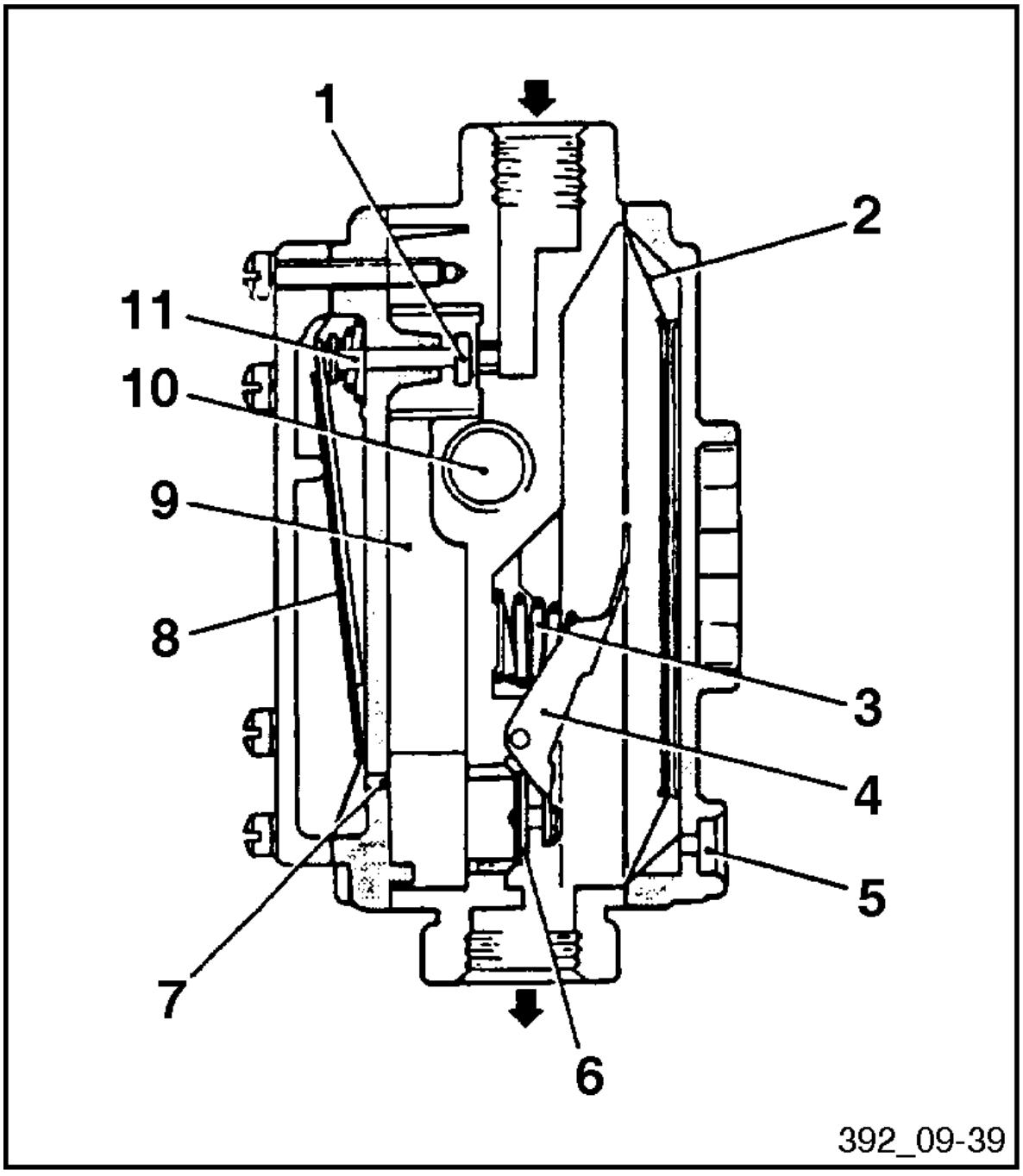
When the vacuum increases due to a restricted air filter, this pressure counteracts the opening pressure of the secondary diaphragm in the vaporiser (7) via line (8). This closes the control valve in the vaporiser (7) slightly so that the gas flow is reduced, thus preventing the mixture from becoming too rich.

Shutoff

When the ignition switch (2) is turned off, the ignition is switched off, the cut-off valve (4) and the throttle plate in the mixer (12) are closed completely. Closing the cut-off valve (4) stops the flow of LP gas to the vaporiser. Due to its low inertia, the engine stops directly without any after-running.

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Vaporiser - functions



1	Primary valve	7	Bore
2	Secondary diaphragm	8	Primary diaphragm
3	Spring	9	Vaporising chamber
4	Lever	10	Heating passage
5	Vacuum hose port	11	Valve pin with spring
6	Secondary valve		

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Vaporiser off position

When the vaporiser is in the off-position (engine shut off), the primary valve (1) is open, the secondary valve (6) is closed by the spring (3). The secondary valve (6) prevents the gas from flowing out when the engine is shut off.

Vaporiser operating position

The primary valve (1) is controlled by the pressure in the vaporising chamber (9), acting on the primary diaphragm (8). This pressure passes through the drilled passage (7) into the chamber upstream from the diaphragm. The valve pin (11) transfers the movement to the primary valve (1) (area valve). The spring below the valve pin (11) establishes the counterpressure. Behind the primary diaphragm (8) there is atmospheric pressure which is produced by the balancing hole.

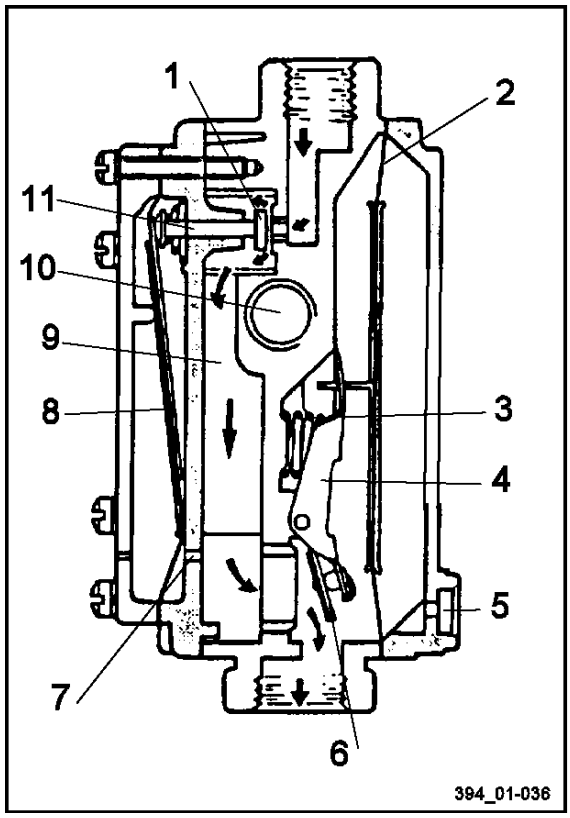
With the engine running (throttle of mixer is open), a vacuum is created in the fuel line to the mixer, which opens the secondary valve (6) allowing the LP gas to flow through the open primary valve (1) into the vaporiser. The secondary diaphragm (2) controls the secondary valve (6).

Due to the reduction of the LP gas pressure (approx. 10 bar in the LPG cylinder), the LP gas expands to atmospheric pressure, causing it to cool. To compensate for the cooling and to accelerate the vaporisation, the vaporiser is heated. The vaporiser is heated by cooling water passing through the heating passage (10) in the vaporiser. Depending on the position of the throttle (dependent on the position of the accelerator pedal), the secondary diaphragm (2) is drawn in more or less, which controls the opening of the secondary valve (6).

Depending on engine speed and the load on the engine, the vacuum behind the secondary diaphragm (2) in the secondary section of the vaporiser either increases or decreases. This changes the gas flow on the secondary valve (6).

If a restricted air filter increases the vacuum, this vacuum counteracts the opening pressure of the secondary diaphragm (2) through port (5). This causes the secondary valve (6) to close a little, reducing the gas flow and preventing the mixture from becoming too rich.

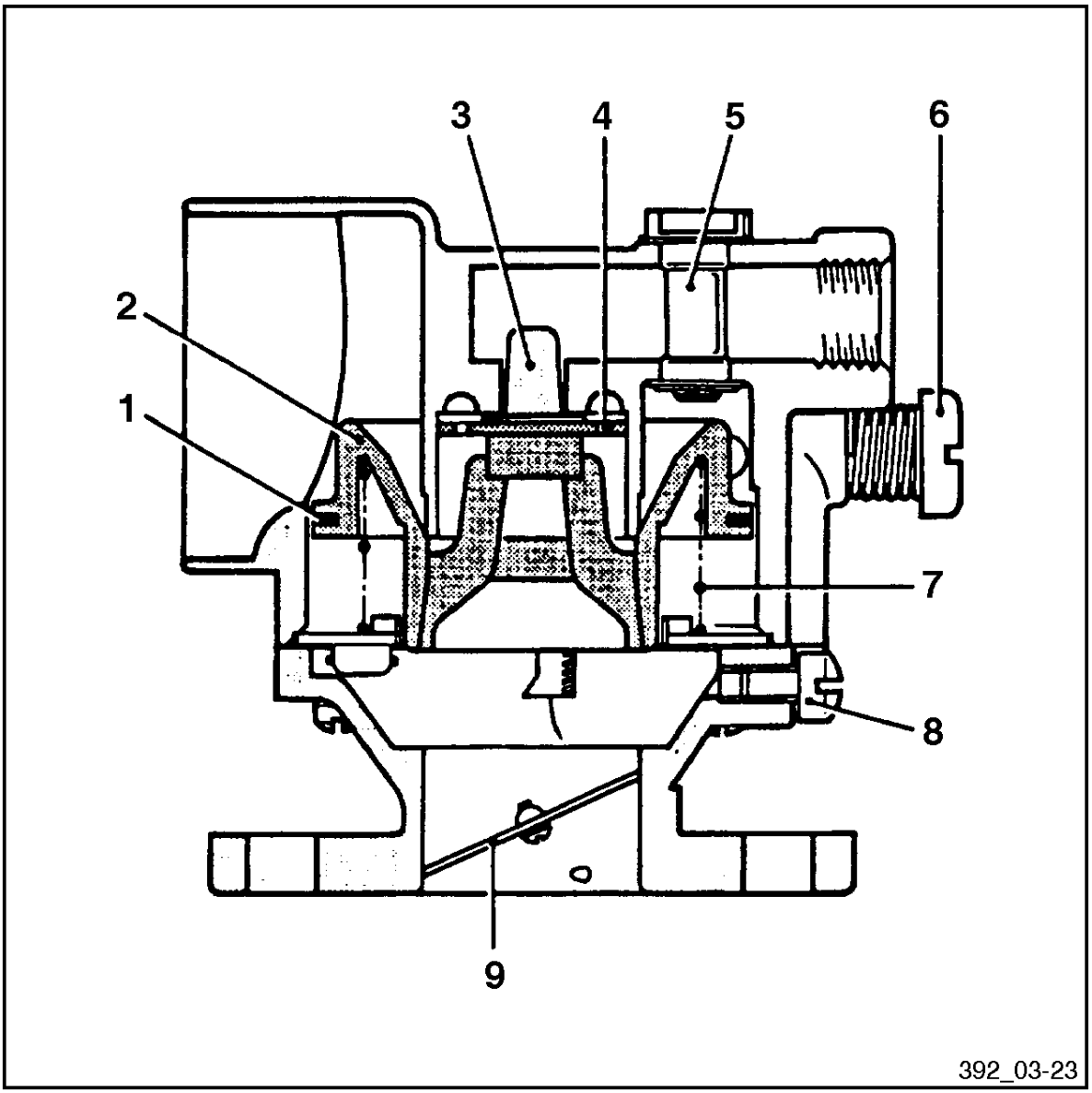
When the engine is shut off, the vacuum at port (5) increases. The secondary valve (6) closes completely. No more gas can flow to the mixer.



1	Primary valve
2	Secondary diaphragm
3	Spring
4	Lever
5	Vacuum hose port
6	Secondary valve
7	Bore
8	Primary diaphragm
9	Vaporising chamber
10	Heating passage
11	Valve pin with spring

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Mixer - functions



1	Sealing ring	6	Air bypass adjustment screw
2	Piston	7	Metering spring
3	Gas metering valve	8	Vacuum port
4	Passages	9	Throttle plate
5	Mixer		

The correct gas-air mixture ratio is important for the proper operation of the engine. A mixer is used for the correct metering of the gas and air.

Its operation is as follows:

When the engine is started (throttle plate (9) open), there is a vacuum in the space below the piston (2), which is created during the intake stroke of the engine piston. The vacuum moves the plunger (7) down against the pressure of the

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metering spring (2).This movement can continue until the plunger is completely open.

The vacuum fluctuates depending on the engine speed and the position of the throttle plate (9). The plunger (2) meters the air flow into the engine.Gas metering valve(3) is connected to the plunger (2) and formed so that for every position of the plunger (2) the correct amount of gas is always metered and mixed with the air flowing in.

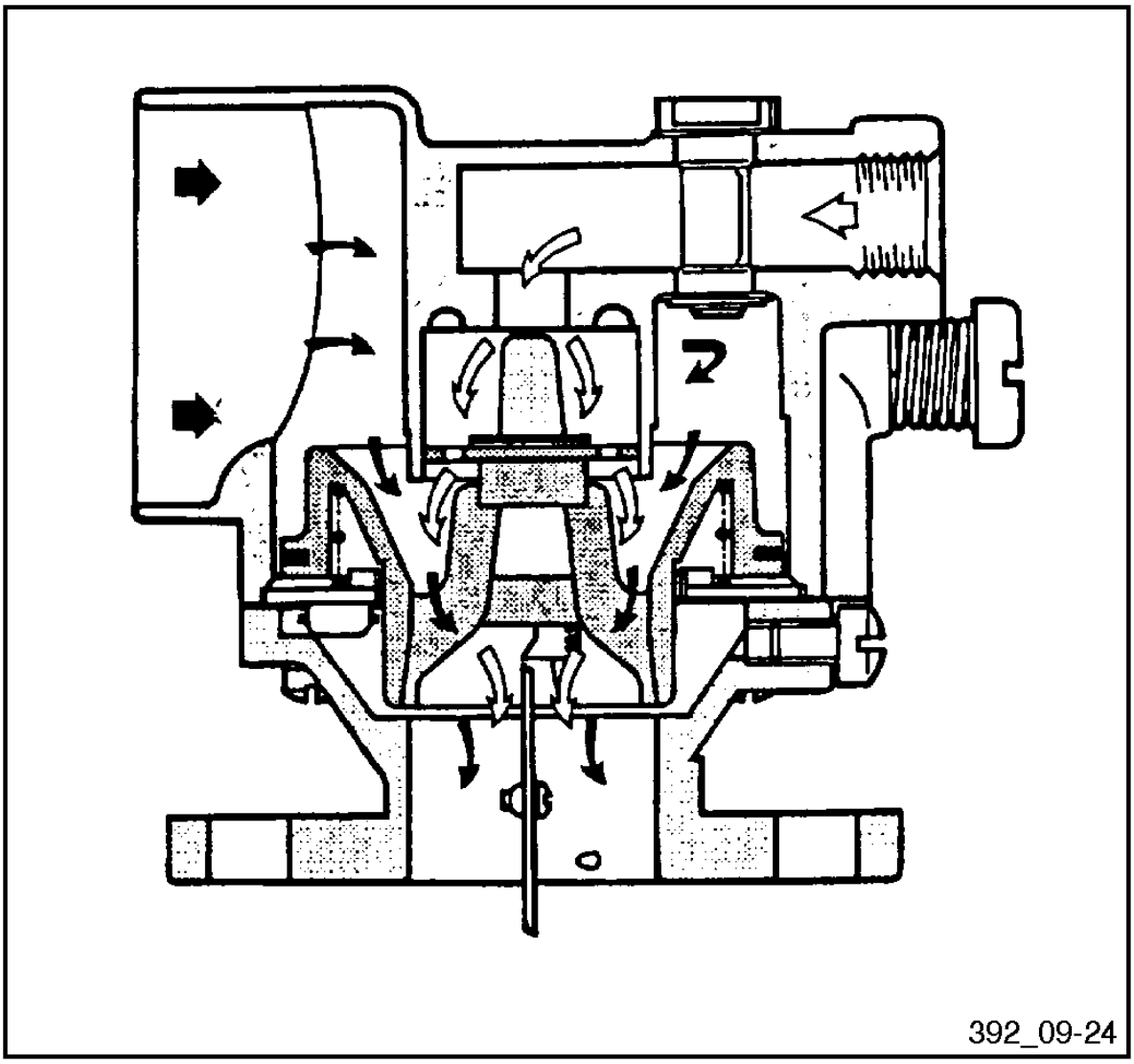
The mixer allows two limited mixture settings. .

Idle adjustment Air bypass

The air and gas passing the closed throttle(9) when the engine is idling is constant. In the idle adjustment a part of the inflowing air is guided around the air intake valve.The idle is adjusted with the air bypass adjustment screw (6), with which the gas-air mixture is made richer or leaner during idle.

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Full load mixture adjustment

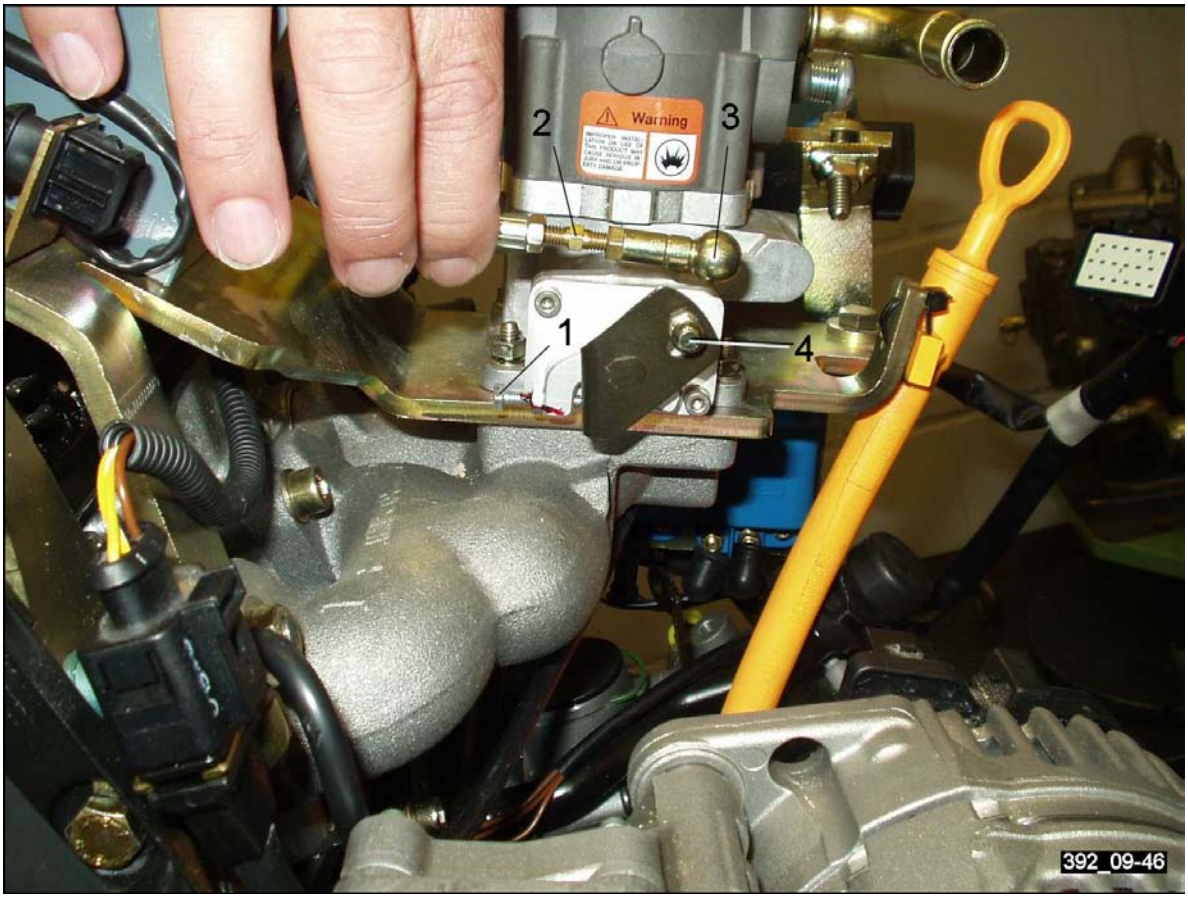


This adjustment controls the mixing ratio when the gas metering valve(3) is open.The adjustment only takes effect when the engine reaches the full load condition. The mixing valve (5) can only be adjusted when the engine is under full load and running at its speed limit (rated speed).

Between idle and full load conditions, the mixture is formed by the form of the gas metering valve. The gas metering valve is formed so that the mixture is lean when the load is low and enriched progressively as the engine load and speed increase.

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Mixer - basic setting



1	Throttle valve stop screw	4	Lever
2	Adjusting pin	5	lower borehole
3	Ball head	6	Mounting plate

Basic setting - throttle valve stop screw

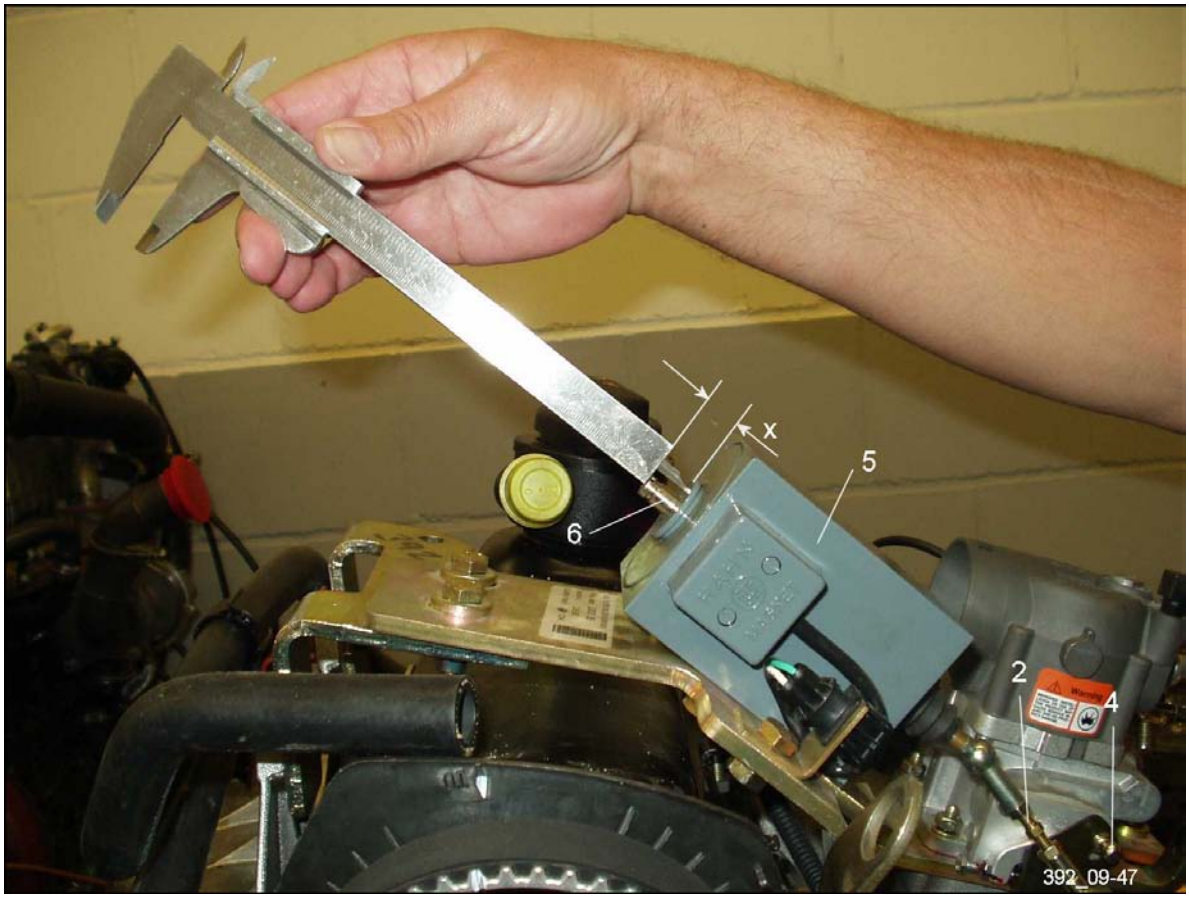
NOTE

The mounting plate (5) has two boreholes. The lever (4) is mounted in the upper borehole in type 392 and in the lower borehole in type 393.

- Detach ball head (3) on the adjusting pin (2) from the lever (4).
- Start engine and set engine speed using the throttle valve stop screw (1) to n = 700 rpm.

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Set positioning magnet pretension



2	Adjusting pin	5	Positioning magnet
4	Lever	6	Magnet shaft

- ➢ Remove bellow on the positioning magnet (5).
- ➢ Hang adjusting pin (2)
- ➢ Calculate dimension **x** on the magnet shaft (6). Example: 10 mm.
- ➢ Mount adjusting pin (2) on lever (4).
- ➢ Adjust adjusting pin (2) until the magnet shaft (6) reaches dimension **x** +1 mm. Example: 10 mm + 1 mm = 11 mm.
- ➢ Secure adjusting pin (2) and mount bellow

CO content setting

Requirements:

- The ignition point of the engine is okay, i.e. 16° ± 2° BTDC at engine idling 1000±10 rpm.

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- Engine and hydraulic oil are at operating temperature.
- Stop screw of throttle valve in home position, 700 ± 100 rpm with positioning magnet disconnected.

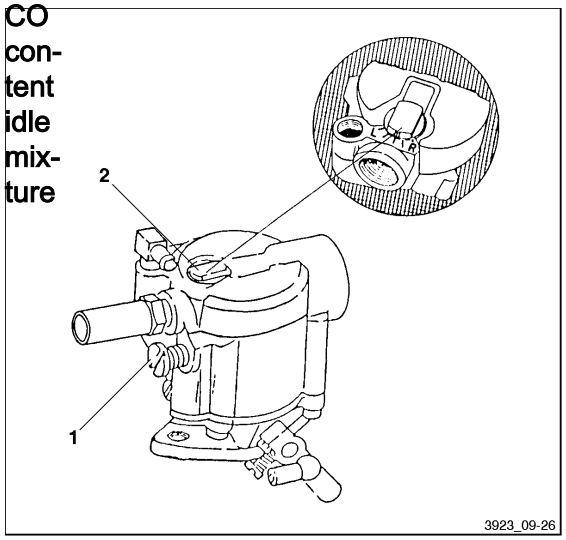
➢ Screw in idle mixture adjustment screw (1) as far as possible.

➢ Connect the CO tester.

➢ Start the engine and measure the CO content with the engine at operating temperature at lower idle speed (1000±10 rpm).

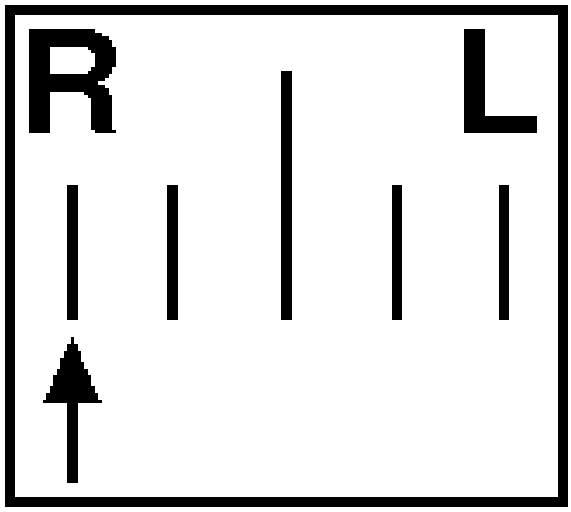
Desired value: CO 0.1% by volume, Lambda 1.05 - 1.20.

If CO > 0.1% by volume, unscrew screw (1) by one turn.



CO content full-load mixture

➢ Set full-load mixture control screw (2) to first scale graduation.

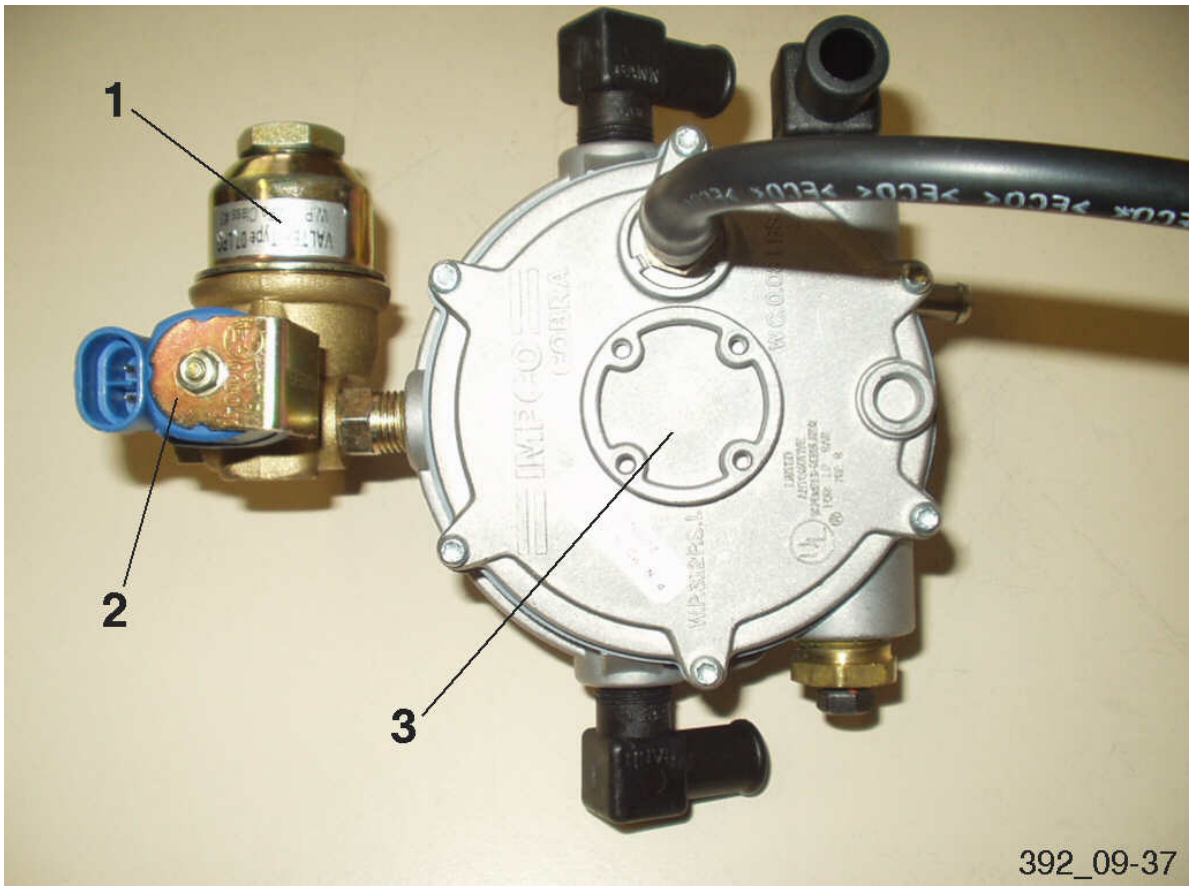


➢ Move mast up to the limit stop. The engine speed must rise to 2750±50 rpm.

CO content 0.1% by volume with CO > 0.1% by volume, turn full-load mixture control screw (2) to L direction until CO content 0.1% by volume

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LPG shut-off valve



1	Shut-off valve	3	Vaporiser cover (no pushbutton)
2	Solenoid valve connection		

The LPG shut-off valve consists of two components:

- Shut-off valve The shut-off valve has a protective diode for the relay.
- Filter

CAUTION

Incorrect polarity when connecting the lines may destroy the diode.

Positive and negative terminals must not be interchanged.

Catalytic converter with Lambda control

Exhaust gases - composition

Exhaust gases - introduction

The fuel combustion in the cylinders of an engine is more or less incomplete. The more incomplete the burning, the greater the amount of pollutants in the exhaust gas. There is no such thing as a complete combustion of fuel, even if there is excess oxygen in the air. To reduce the pollution of

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the environment, the exhaust gas characteristics of the spark ignition engine must be improved. All measures for reducing pollutant emissions limited by different laws and regulations have the aim of achieving a minimum of pollutant emissions with as much fuel economy as possible, with high performance and good driving characteristics.

In addition to a high percentage of unharmful matter, the exhaust gas of a spark ignition engine contains also contains components considered to be harmful for the environment at least in higher concentrations. The harmful part makes up about one percent of the exhaust gases and it consists of carbon monoxide (CO), nitrogen oxides (NO_x) and hydrocarbons (HC). The greatest problems posed hereby are the opposite concentrations of CO and HC on the one hand and NO_x on the other, dependent on the air-to-fuel ratio.

Exhaust gases - properties

The major components of the exhaust gases are nitrogen, carbon dioxide and water vapour. These are non-poisonous.

Carbon monoxide (CO): Carbon monoxide is a colourless and odourless gas. It has a considerably higher affinity to the hemoglobin (red blood dye) of the blood than does oxygen, and is thus toxic for the body.

Nitrogen oxide (NO, NOx): Nitrogen oxide NO is a colourless gas oxidising to NO_2 in the air. It is known as a severe hemotoxin, as it combines with the hemoglobin in the blood to cause rapid central paralysis. NO_2 is a reddish-brown gas with a sharp, pungent odour. It irritates the lungs and causes damage to the lung tissues. In combination with unsaturated hydrocarbons, nitrogen oxides cause smog formation under the influence of sunlight. NO and NO_2 are designated together as nitrogen oxides (NO_x).

Hydrocarbons (HC): The exhaust gas contains a variety of hydrocarbons:

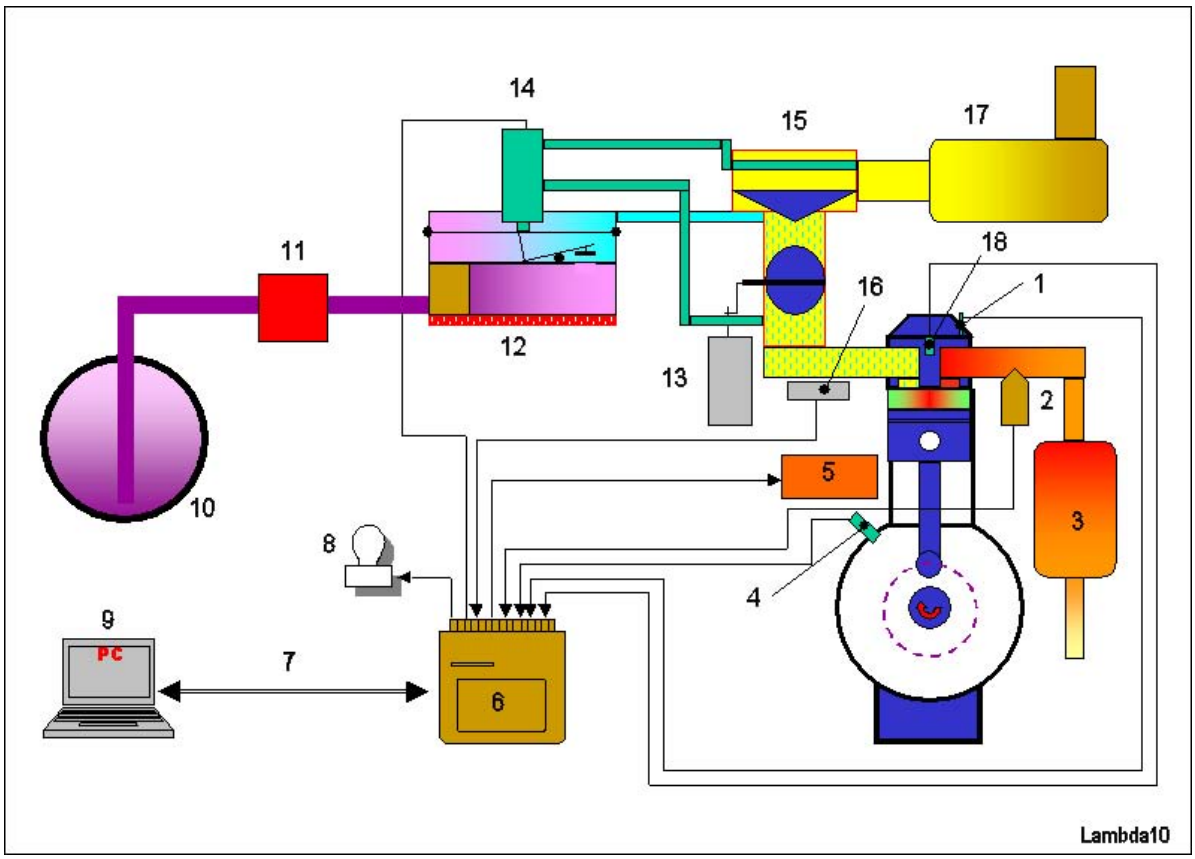
Saturated hydrocarbons (paraffins) are almost odourless, have a narcotic effect and cause a light irritation of mucous membranes.

Unsaturated hydrocarbons (olefins, acetylenes) have a slightly sweetish smell and in some cases lead to an irritation of mucous membranes. They play a considerable role in the formation of smog, since in the presence of NO and under the influence of sunlight they react further to form oxidants and simultaneously also ozone.

Aromatic hydrocarbons have a characteristic odour. They are nerve toxins with a narcotic effect, have a pungent smell and irritate eyes and nose even at very low concentrations.

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Lambda control



1	Coolant temperature sending unit	10	Gas bottle/gas tank
2	Lambda sensor	11	Shut-off valve and filter
3	Three-way catalytic converter	12	Vaporiser
4	Speed sensor	13	Throttle plate actuator
5	Ignition coil	14	Control Valve
6	Control unit	15	Mixer
7	Diagnostic cable 300 365 2504	16	Pressure and temperature sending unit
8	Fault light	17	Air filter
9	Diagnostic software	18	Phase sensor

Lambda control - description

The lambda control in conjunction with the catalytic converter represents the most efficient exhaust gas cleaning process for spark ignition engines available today.

The use of the three-way catalytic converter is especially effective. This catalyst is able to reduce hydrocarbons, carbon monoxide and nitrogen oxide by more than 90 % when the engine is operated in a very limited margin of error (±1 %) to keep the stoichiometric air-fuel ratio to lambda = 1.

The stoichiometric air-fuel ratio is the theoretical mass ratio of 14 kg of air to 1 kg of LP gas required

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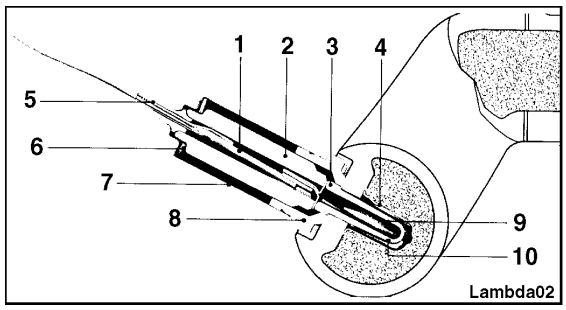
for total combustion. The air ratio (lambda) indicates how much the actual existing air-fuel mixture deviates from the theoretical value.

Lambda = supplied mass air flow : theoretical mass air flow

The lambda control controls the fuel quantity so that the air-fuel mixture allows a nearly total combustion.

Lambda sensor - structure and layout

The lambda sensor in the exhaust pipe uniformly captures the exhaust flow from all cylinders. The sensor ceramic is located in a housing, which protects against mechanical influences and is also used for mounting. The external part of the ceramic monolith is located in the exhaust flow, the internal part is in contact with the ambient air.



1 Contact
2 Protective ceramic tube
3 Sensor ceramic
4 Protective tube on exhaust gas end
5 Electric lead
6 Belleville spring
7 Protective sleeve, on air end
8 Housing (-)
9 Electrode (+)
10 Electrode (-)

Lambda sensor - functional description

The ceramic material used becomes conductive for oxygen ions starting at about 300 °C. If the amount of oxygen on both sides of the sensor is different, an electric voltage is created between the two surfaces. This serves as a measure of the difference in the oxygen concentration on the two sides of the sensor. The residual amount of oxygen in the exhaust gas of an IC engine depends to a large degree on the air-fuel ratio of the mixture supplied to the engine. Even when operating with excess fuel in the mixture, there is still some oxygen in the exhaust gas. This relation makes it is possible to use the oxygen concentration in the exhaust gas as a measure of the air-fuel ratio. The voltage supplied by the lambda sensor as a result of the oxygen content in the exhaust is 800 - 1000 mV with a rich mixture (lambda < 1) and only 100 mV with a lean mixture (lambda > 1). The transition from the rich to the lean range is 450 - 500 mV.

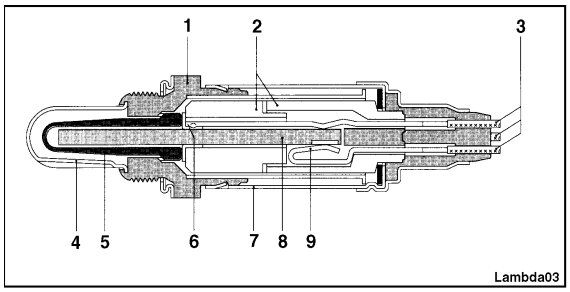
In addition to oxygen concentration in the exhaust, the temperature of the ceramic body also plays a crucial role as it influences the conductivity of the oxygen ions. The characteristic curve of the voltage supplied as a function of the excess air factor is greatly influenced by the temperature. The given values therefore apply for an operating temperature of approx. 600 °C. The response time for a change in voltage after a change in the composition of the mixture also depends very much on the temperature. If these response times are in the range of seconds for a ceramic temperature under 350 °C, the sensor already responds in less than 1 ms at the optimum operating temperature of about 600 °C. That is why

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the Lambda control is shut off after the start of the engine until the minimum operating temperature of about 350 °C is achieved. During this time the engine is operated under open-loop control. Excessive temperatures shorten the operating life. The lambda sensor must therefore be installed so that a temperature of 900 °C to 1000 °C is not exceeded during a longer full load condition. 1200 °C are allowed for short periods.

Lambda sensor - heated

For this sensor type the temperature of the ceramic monolith at a low engine load (ie low exhaust gas temperature) is determined by the electric heater, at a high load by the exhaust gas temperature. The heated lambda sensor allows installation at a greater distance from the engine so that even continuous full load work cycles are unproblematic. The external heater allows rapid heating so that the operating temperature is achieved within 15 - 60 s after the start of the engine, thus enabling the lambda control.



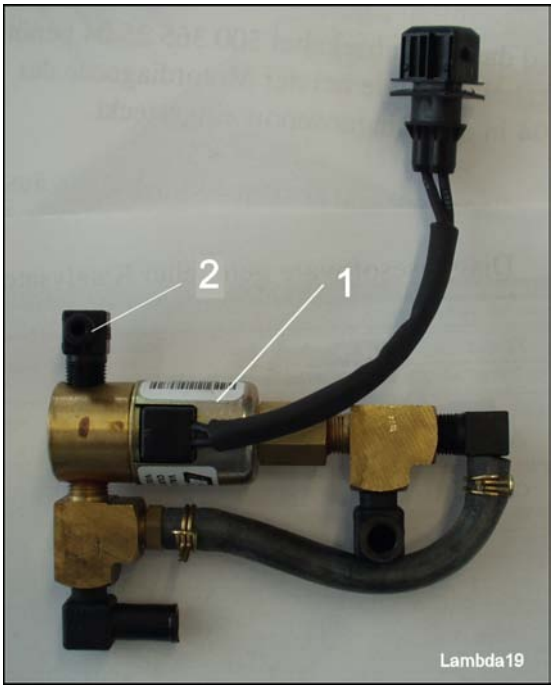
1 Sensor housing
2 Ceramic support pipe
3 Connecting cable
4 Protective pipe with slots
5 Active sensor ceramic
6 Contact
7 Protective sleeve
8 Heating element
9 Heating element terminals

Lambda control - functional description

The lambda sensor sends a voltage signal to the electronic control (200 - 800 mV), which in turn controls the control valve (1) with a PWM (Pulse Width Modulation) signal. The control valve is used to make the mixture either richer or leaner. For this purpose a control threshold of approx. 500 mV is programmed into the control. If the voltage emitted by the lambda sensor is below this value (mixture too lean), more LP gas is added. If the limit is exceeded (mixture too rich), the amount of LP gas is reduced again with the control valve.

The modulation of the amount of LP gas is effected with the control valve, which actuates the secondary diaphragm of the vaporiser according to the PWM (Pulse Width Modulation) signal from the control. If more LP gas (richer mixture) is required, the port (2) is closed. As a result, only the slight vacuum of the intake air acts on the secondary side of the vaporiser. The vaporiser opens the secondary valve completely.

If more LP gas (richer mixture) is required, the port (1) is opened. A large vacuum exists at the secondary diaphragm, which further closes the secondary valve, so that less LP gas flows to the mixer and the mixture becomes leaner.



1 Control Valve
2 Port to vaporiser / pressure regulator (secondary diaphragm)

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The change in the air-fuel ratio, however, may not be made abruptly, otherwise the truck would tend to bucking. That is why is the electronic control contains an integrator, which changes the composition of the mixture slowly with a time function. Some time elapses from the moment the fresh mixture is formed in the LPG mixer until the burned mixture is captured by the lambda sensor (dead time). The dead time is caused by the time the fresh mixture requires to reach the engine, the time required for the work cycles of the engine, the time required for the combusted exhaust gas from the engine to reach the lambda sensor and the response time of the lambda sensor. This dead time makes a constantly exact mixture impossible. The air-fuel ratio rather constantly varies a few tenths of a percent around lambda = 1. In case of a correct adjustment of the integrator, however, the mean value of the air-fuel ratio stays exactly within the converter window, ie in a range in which the catalytic converter achieves the maximum conversion.

Lambda control - functions of the control

The control

- controls the control valve
- assumes not only the lambda 1 control, but also the ignition timing
- recognises the load condition of the engine via a temperature and pressure sending unit. This is important for determining the firing point and for the formation of the mixture
- stores data and evaluates them. This allows changes (wear or damages) to be detected and measures to be taken
- reads the current lambda value and allows it to be indicated on a display

NOTE

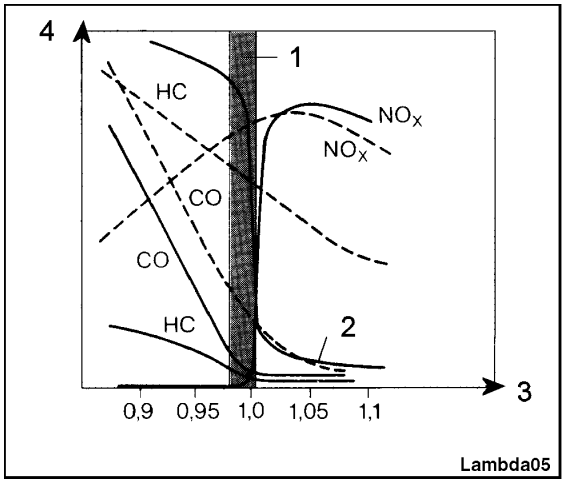
Except for the basic setting, the gas or ignition system does not require any adjustments.

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Lambda sensor - control range

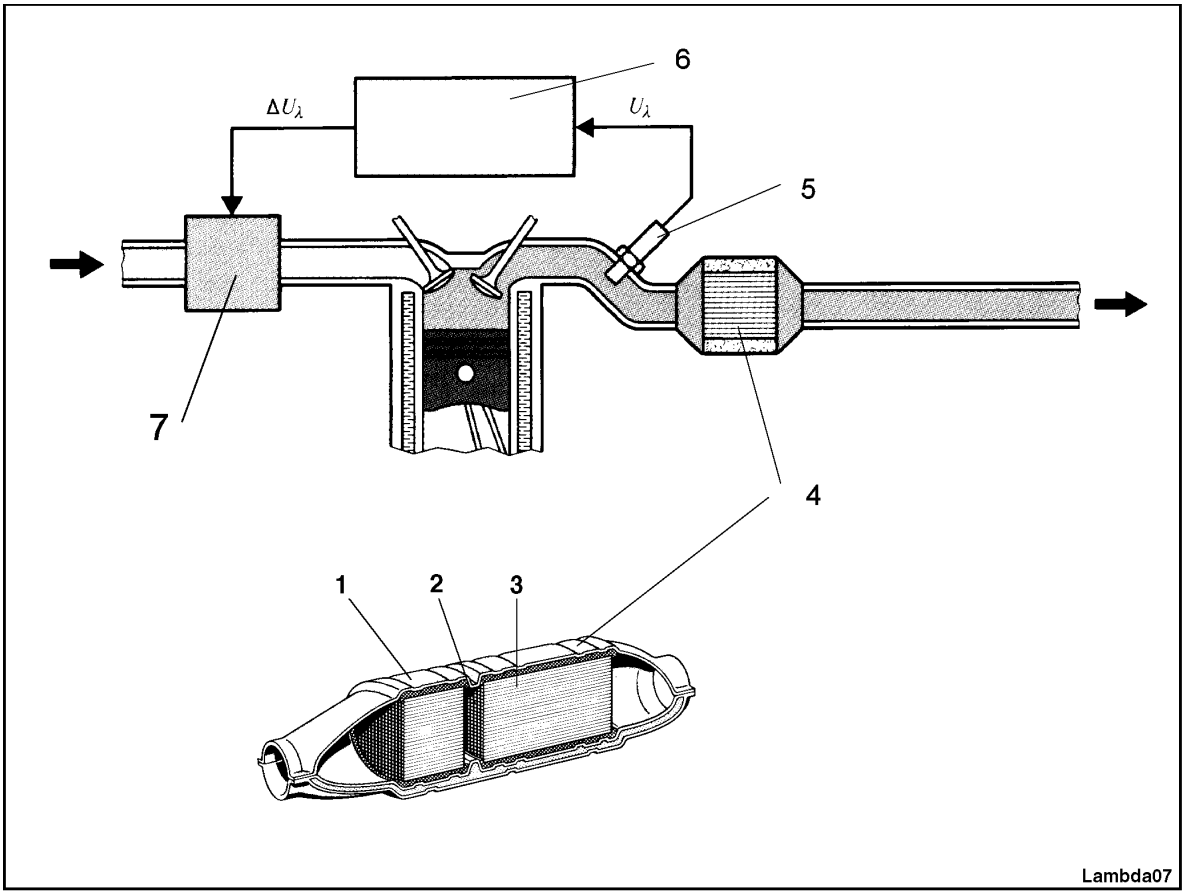
Three-way catalytic converter

The three-way catalytic converter has the characteristic of simultaneously removing all three pollutants (CO, HC, NO) to a high degree. The three-way catalytic converter combined with the lambda control is the most effective pollutant reduction system currently available.



1 Lambda control range
2 Voltage characteristic of the lambda sensor
3 Air ratio lambda
4 Exhaust emission and sensor voltage

Three-way catalytic converter - construction



1 Steel housing
2 Support
3 Active catalytic layer
4 Three-way catalytic converter (NO_x, HC, CO)
5 Lambda sensor
6 Electronic control (computer)
7 Control valve at vaporiser / pressure regulator

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Metal monolithsrequire a substrate coating of aluminium oxide ("wash coat"), which enlarges the effective surface area of the catalytic converter by about the factor 7000.

The effective catalytic layer on it is made of platinum and rhodium in three-way catalytic converters. Platinum speeds up the oxydation of hydrocarbons (HC) and carbon monoxide (CO), rhodium reduces the nitrogen oxides (NO_x).

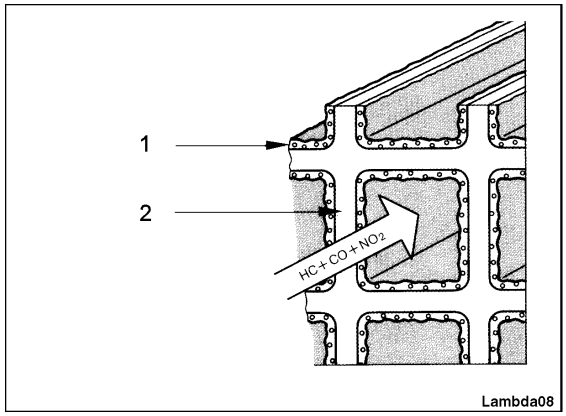
The rare metal content in a catalytic converter is approx. 2 to 3 grams.

Three-way catalytic converter - operating conditions

A notable conversion of the pollutants only begins at an operating temperature of over 250 °C. Ideal operating conditions prevail at temperatures ranging from approx. 400 °C to 800 °C. In the range of 800 °C to 1000 °C, thermal aging is aggravated significantly by the sintering of the noble metals and substrate coating, which leads to a reduction in the active surface area.

The period of operation in this temperature range, therefore, exerts a great influence. Above 1000 °C thermal aging is severely aggravated up to almost total ineffectiveness of the catalytic converter.

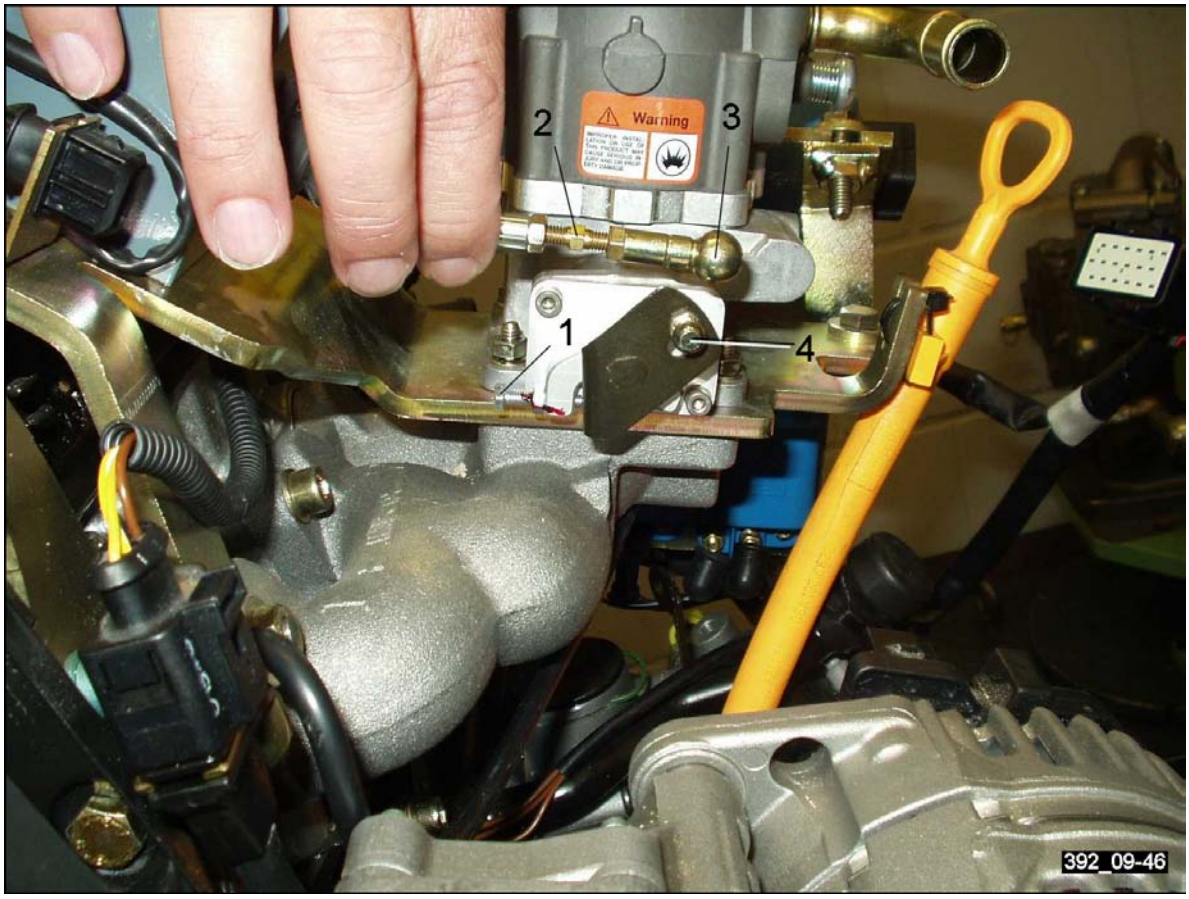
Engine malfunctions, for example misfires, can cause the temperature of the catalytic converter to rise over 1400 °C. Such temperatures lead to the complete destruction of the catalytic converter through melting of the substrate material. Residues from the engine oil (due to a high engine oil consumption) can also lead to a destruction (poisoning) of the catalytic converter.



1 Platinum and rhodium coating
2 Ceramic or metal monoliths (honeycomb)

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Mixer - basic setting



1	Throttle valve stop screw	4	Lever
2	Adjusting pin	5	lower borehole
3	Ball head	6	Mounting plate

Basic setting - throttle valve stop screw

NOTE

The mounting plate (5) has two boreholes. The lever (4) is mounted in the upper borehole in type 392 and in the lower borehole in type 393.

- Detach ball head (3) on the adjusting pin (2) from the lever (4).
- Start engine and set engine speed using the throttle valve stop screw (1) to n = 700 rpm.

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Set positioning magnet pretension



2	Adjusting pin	5	Positioning magnet
4	Lever	6	Magnet shaft

- Remove bellow on the positioning magnet (5).
- Hang adjusting pin (2)
- Calculate dimension **x** on the magnet shaft (6). Example: 10 mm.
- Mount adjusting pin (2) on lever (4).
- Adjust adjusting pin (2) until the magnet shaft (6) reaches dimension **x** +1 mm. Example: 10 mm + 1 mm = 11 mm.
- Secure adjusting pin (2) and mount bellow

CO content setting

Requirements:

- The ignition point of the engine is okay, i.e. 16° ± 2° BTDC at engine idling 1000±10 rpm.

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- Engine and hydraulic oil are at operating temperature.
- Stop screw of throttle valve in home position, 700 ± 100 rpm with positioning magnet disconnected.

➢ Screw in idle mixture adjustment screw (1) as far as possible.

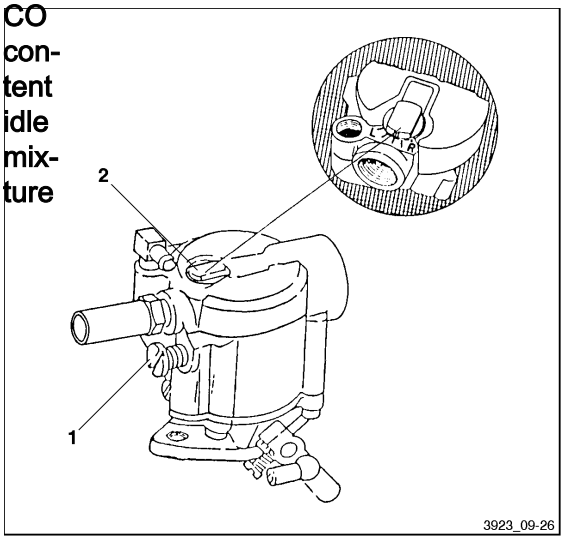
➢ Connect the CO tester.

➢ Start the engine and measure the CO content with the engine at operating temperature at lower idle speed (1000±10 rpm).

Desired value: CO 0.1% by volume, Lambda 1.05 - 1.20.

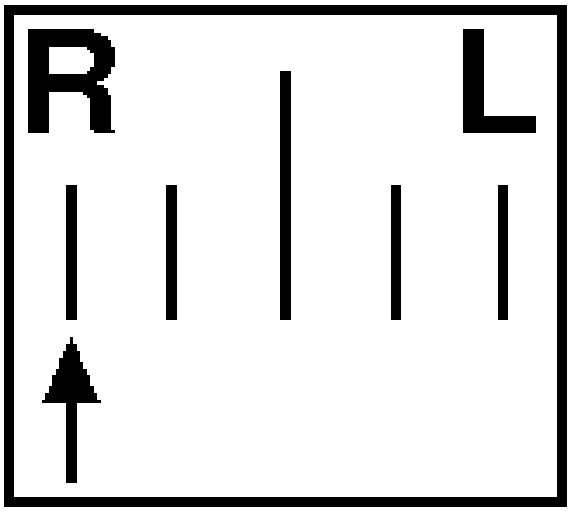
If CO > 0.1% by volume, unscrew screw (1) by one turn.

CO content idle mixture



CO content full-load mixture

➢ Set full-load mixture control screw (2) to first scale graduation.



➢ Move mast up to the limit stop. The engine speed must rise to 2750±50 rpm.

CO content 0.1% by volume with CO > 0.1% by volume, turn full-load mixture control screw (2) to L direction until CO content 0.1% by volume

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Mixer - check and adjustment

Diagnostic software" E-Control"

The diagnostic software is used to display or is required for:

- Lambda control 1
- Temperatures (oil, coolant)
- Suction pressure
- Current faults
- Fault history, which can be cleared any time
- Calibration (adaptation) of new components

A calibration must be carried out if parts are worn or after the installation of new parts.

Required special tools

- Laptop
- Diagnostic software "E-Control"
- Diagnostic cable 300 365 2504

Adjustment - prerequisites

- The engine must be at operating temperature.
- Firing point 16° BTDC at low idle speed n = 1000±10 rpm
- Idle mixture adjustment screw (1) fully closed
- Set the full load mixture adjustment screw to position "R".
- The solenoid pretension must be 0.5 - 1.0 mm. This results in an opening angle of 45° on series 392 and 60° on series 393.

NOTE

The throttle plate stop screw must be screwed out for the adjustment of the solenoid pretension.

Throttle plate stop screw - adjustment

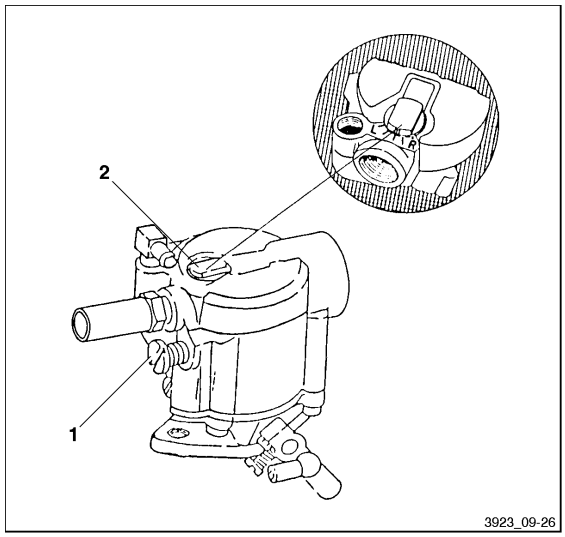
➢ If the ignition is switched off, disconnect the plug from the solenoid.

➢ Start the engine.

➢ Set the rpm to 700±100 rpm with the stop screw.

➢ If the ignition is switched off, disconnect the plug from the solenoid.

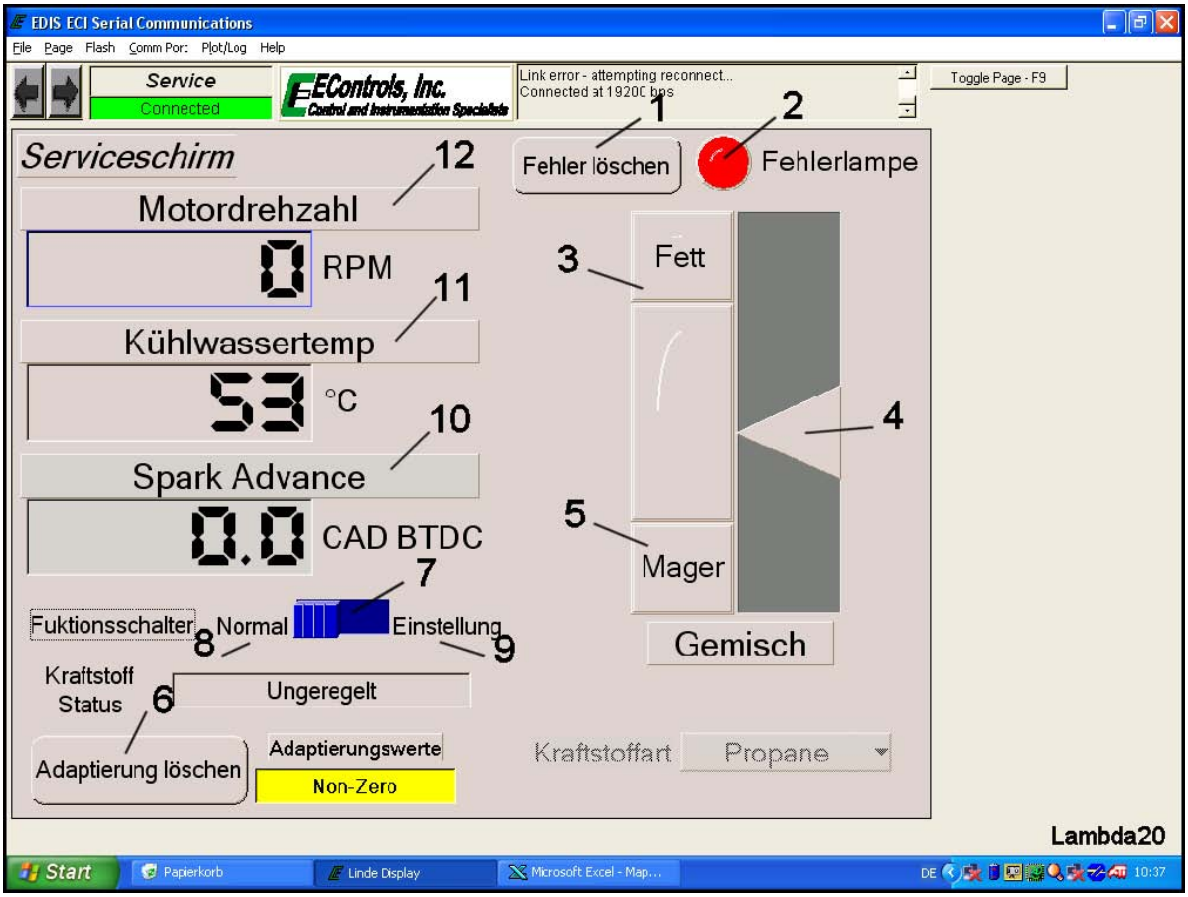
▷



1 Idle mixture adjustment screw
2 Full load mixture adjustment screw

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Calibration of lambda control - "Service window"



1	Button "Clear faults"	7	Function switch
2	Fault light "Fault"	8	Function switch position "normal"
3	Indicator for mixture "rich"	9	Function switch position "adjust"
4	Pointer "Mixture adjustment"	10	Indicator"Firing point"
5	Indicator for mixture "lean"	11	Indicator "Coolant temperature"
6	Button "Clear adaptation"	12	Indicator"Engine rpm"

- ➢ Connect the diagnostic software "E-Control" with diagnostic cable 300 365 2504 to the diagnostic port and start the engine.
- ➢ Open the "Service" window.

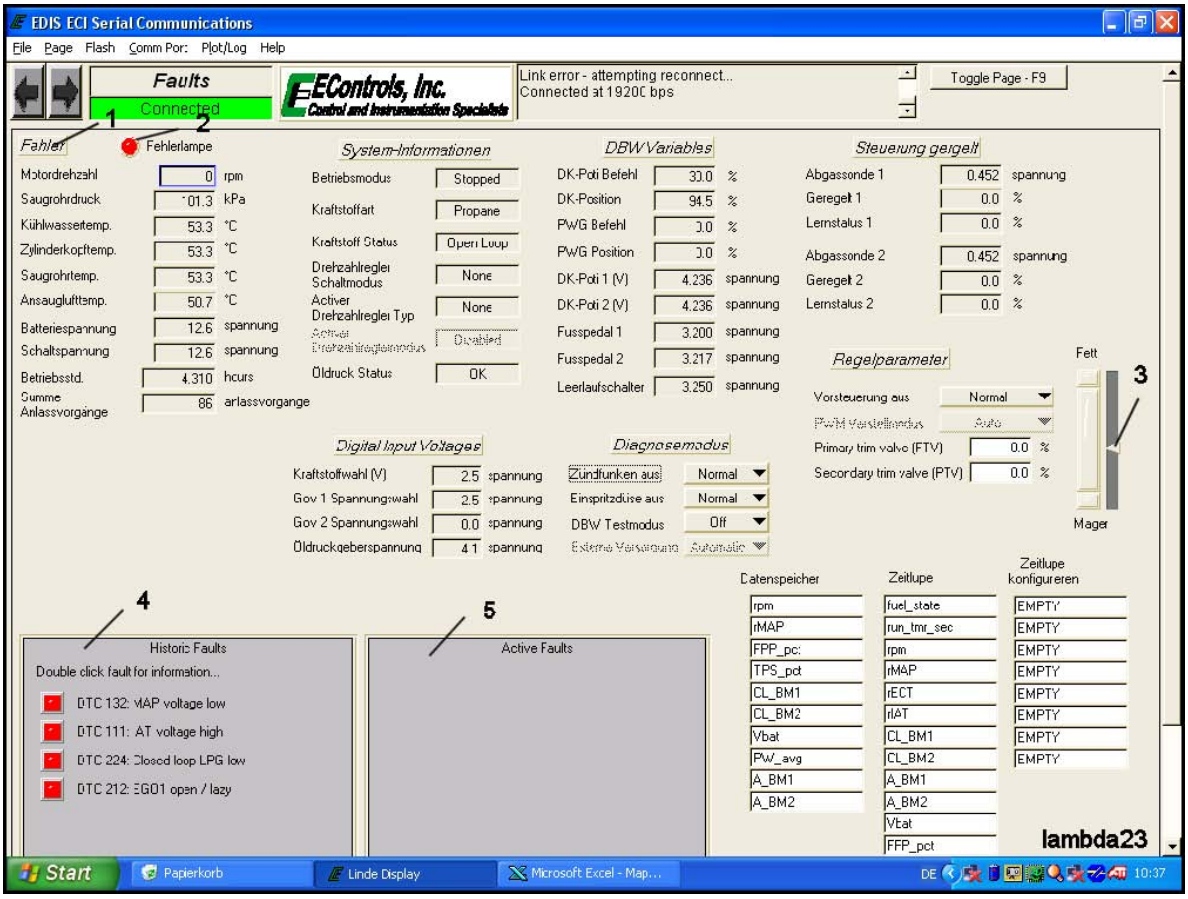
The fault light "Fault" should not come on.

- ➢ Slide the function switch (7) from the "normal "(8) position to the "adjust"(9) position.
- ➢ Operate the button "Clear adaptation"(6).
- ➢ Slide the function switch (7) from the "normal "(8) position to the "adjust"(9) position.

In case of proper operation, the pointer "Mixture adjustment"(4) must go back and forth between the positions "rich"(3) and "lean"(5). This procedure may take a few minutes for a new calibration and after starting the LPG engine.

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Check and adjustment of lambda control - "Faults" window



1 Button "Clear faults"
2 Indicator light"Fault indication"
3 Pointer "Mixture adjustment"
4 Fault history (history folder)
5 Display of active faults

- ➢ Connect the diagnostic software "E-Control" with diagnostic cable 300 365 2504 to the diagnostic port and start the engine.
- ➢ Open the "Faults" window.

The fault light (2) should not come on.

The lambda control is functioning properly if the pointer (3) (on the right of the "Faults"page) oscillates around the green range.

- ➢ If the fault light (2) is illuminated red, read out the fault history on the fault page (4) and correct the fault.
- ➢ Then clear the fault message (click twice on the button (1) and "clear all faults").

Idle mixture - check

- ➢ Run the engine approx. 1 min with a full load so that the catalytic converter can achieve the necessary operating temperature.

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Desired idle speed 1000 rpm

The lambda control is functioning properly if the mixture pointer of the software oscillates around the green range and the CO is < 0.1 percent by volume.

Full load mixture - check

➢ Run the engine approx. 1 min with a full load so that the catalytic converter can achieve the necessary operating temperature.

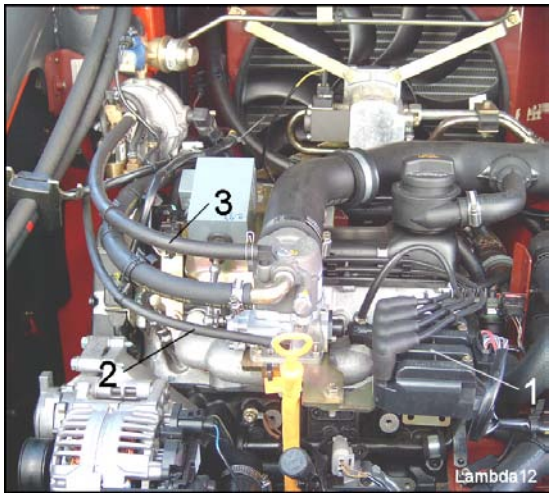
Full load means extending the mast against the pressure relief valve.

The full load mixture is OK if the mixture pointer of the software oscillates around the green range and the CO is < 0.1 percent by volume.

The speed of 2750±50 rpm must be achieved.

➢ After conclusion of the adjustments and checks, secure the adjustment screws and tap with enamel.

Locations - overview

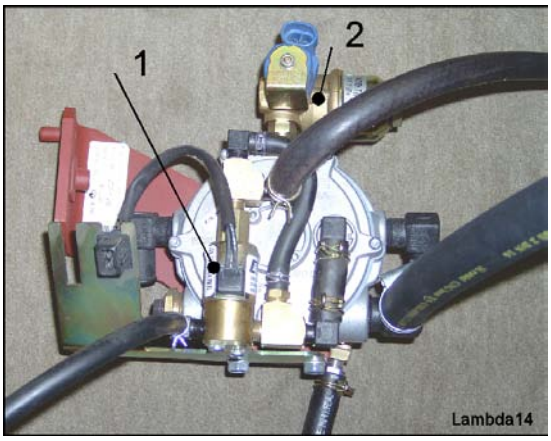


1 Ignition coil module
2 High vacuum
3 Low vacuum

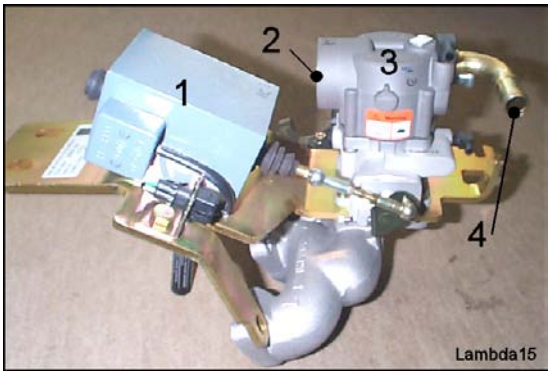


1 Shut-off valve with filter
2 Vaporiser

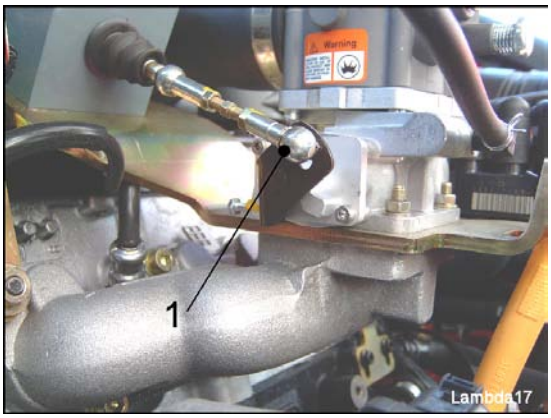
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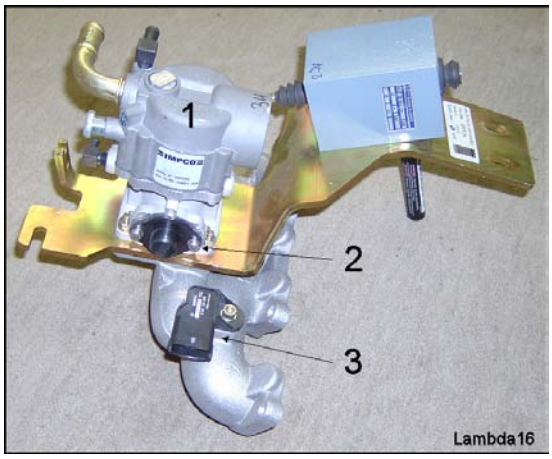
1 Control valve
2 Shut-off valve with filter



1 Throttle plate actuator
2 Air intake
3 Mixer
4 Gas inlet



1 Setting of the throttle plate opening angle (power setting for 392/393)



1 Mixer
2 Cap (throttle plate sensor of the open-loop catalytic converter)
3 Temperature and pressure sending unit



1 Ignition coil module (4 ignition coils in a module)

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Description of transmission

Technical data for BEU

Manufacturer	VW
Type of engine	BEU (SDI industrial engine)
Number of cylinders	4
Cubic capacity	1896 cm^3
Power	43 kW at 2600 rpm
max torque	173 Nm at 1800 rpm
Injection nozzle pressure	220 bar, wear limit 200 bar
Compression ratio	19.5 : 1
compression	25 - 31 bar, wear limit 19 bar
Max admissible pressure difference	5 bar
Lower idle speed	1000 rpm
Upper idle speed	2700 min when driving
	2800 rpm with working hydraulic system
Valve clearance	Self-adjusting
Firing order	1 - 3 - 4 - 2
Position of cylinder 1	Opposite power takeoff side
Thermostat	Thermostat start of opening: 87°C, fully open at 102°C
Fuel	Diesel fuel acc. to DIN EN 590, RME-based biodiesel possible
Number of teeth on flywheel	135
Oil pressure at 2000 rpm and an oil temperature of 80°C	at least 2 bar

Explanation of engine identification: The engine identification letter and the engine number are stamped on the left side of the cylinder block above the fuel pump. There is also a plate on the toothed belt cover.

Structure of engine number: Example: BEU / 002141 (type of engine / consecutive number)

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Particularities of the 1.9-litre BEU type of engine

- Distributor fuel injection pump with a pump pressure of 800 bar. The distributor fuel injection pump is preset.

NOTE

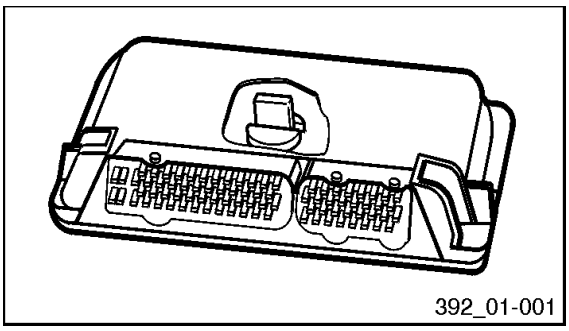
The flange is pressed on to the driveshaft and may not be removed.

- The intake passage is formed as a swirl passage. It imparts the intake air a swirling motion, thus providing for an intensive air swirl in the combustion chamber.
- Specially shaped piston cavity (main combustion chamber).
- Water pump installed in the cylinder block.
- Coolant thermostat installed in cylinder block.
- Plastic-coated injection lines as a protection against corrosion.
- Vulcanised cylinder head cover gasket.
- Oil sump with silicone sealant.
- Change filter for oil as paper cartridge.
- Vacuum pump drive by the camshaft.

Control unit for injection system 0N1

Injection rate and injection timing is controlled electronically due to the high fuel economy and emission requirements. This job is assumed by the Electronic Diesel Control (EDC). It determines the fuel rate and start of injection of the distributor fuel injection pump and controls the preheating time.

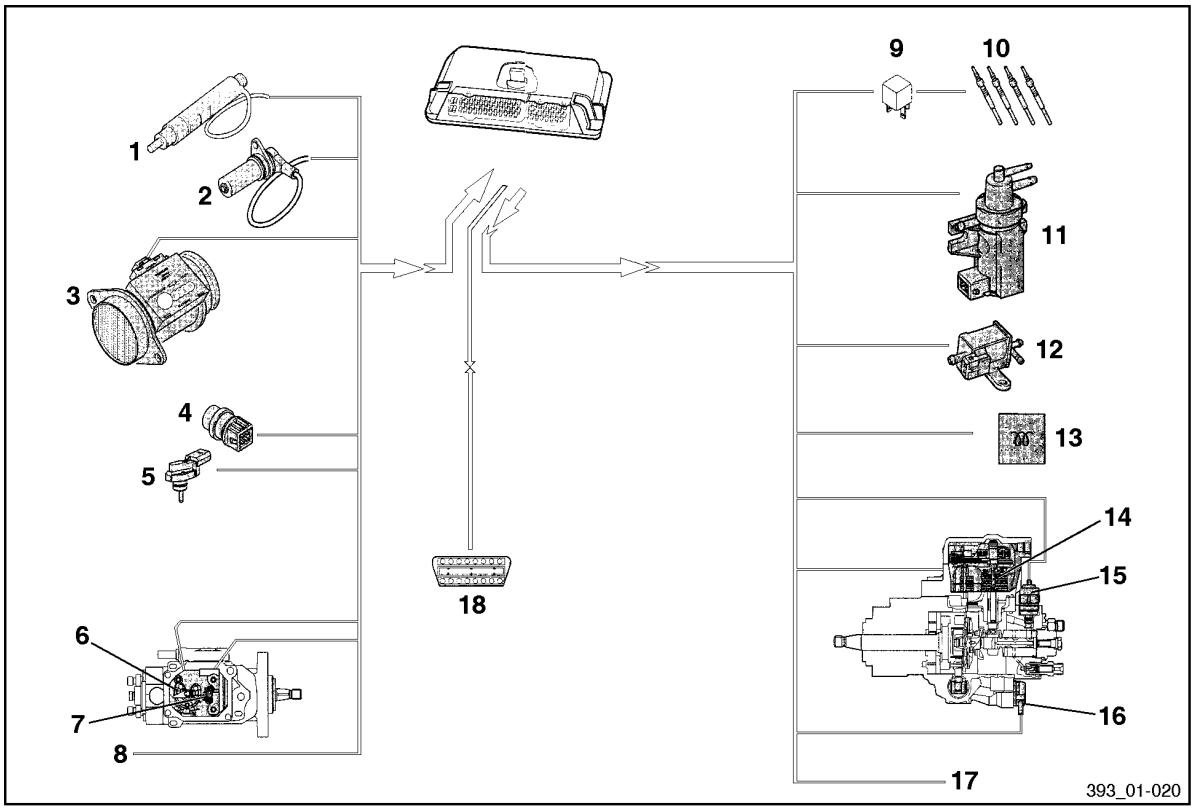
▷



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The electronic engine control unit



Sensor

1	Needle stroke sensor 0B5
2	Engine speed sensor 0B2
3	Mass air flow sensor 0B6
4	Coolant temperature sending unit 0B1
5	Intake pipe temperature sending unit 0B4
6	Control sleeve position sensor 0B3
7	Fuel temperature sending unit 0B3
8	Additional signals; air conditioning, terminal DFM

Actuators

9	Glow plug relay 0K1
10	Glow plugs (engine) 0R1
11	Solenoid valve for exhaust gas recirculation 0Y5
12	Solenoid valve for charge pressure limitation 0Y2
13	Indicator light for preheating time H8
14	Fuel quantity positioner
15	Fuel shut-off valve 0Y1
16	Start of injection valve 0Y2
17	Additional signals for engine speed, fuel consumption, air conditioning

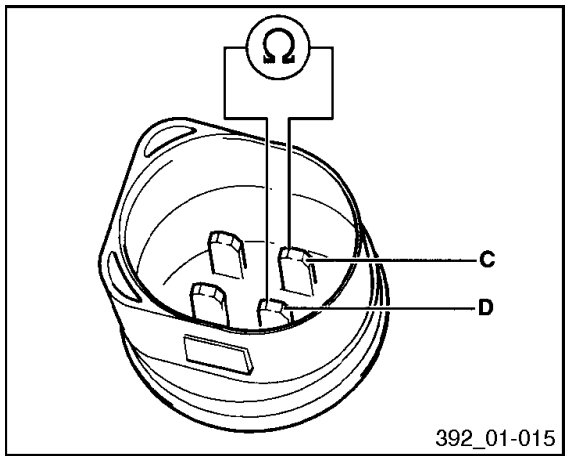
plug

18	Diagnostic plug 6X2

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Sensor

Coolant temperature sending unit 0B1



The coolant temperature sending unit is located in the coolant neck on the cylinder head. The sensor is designed as a resistor with a negative temperature coefficient (NTC). The momentary value of the coolant temperature is transmitted to the electronic control unit by a drop in voltage.

Coolant temperature sending unit - signal evaluation

The signal for the coolant temperature is taken into account for the calculation of the fuel quantity to be injected, the start of injection and the pre-heating time.

Coolant temperature sending unit - substitute function

In case of a problem with this signal, the fuel temperature is used as a substitute signal. The maximum possible time is used for the preheating time.

Coolant temperature sending unit - self-test

The following faults are stored as possible cause:

- short circuit to earth
- interruption/ short circuit

Coolant temperature sending unit - check

Required special tools

- Laptop with software
- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Test procedure

➢ Connect the laptop and start the software.

➢ "Select Inputs and outputs - Group 07". The engine must be idling.

➢ Check the coolant temperature in Display field 4. The temperature value should rise uniformly without interruptions.

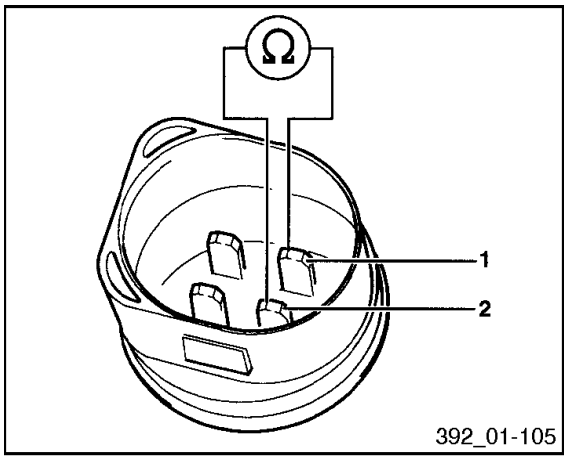
In the event of a fault, the fuel temperature or the value -4.5 °C is indicated instead.

If Display field 4 does not show a realistic read-out or shows the fuel temperature or the value -4.5 °C

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instead, check the coolant temperature sending unit and the line connections to the sensor as follows:

- Terminate the communication between truck and laptop.
- Turn off the ignition.
- Pull the plug from the sensor.
- Measure the resistance between contacts (1) and (2) on the sensor. ▷



- Read the desired resistance on the diagram ▷

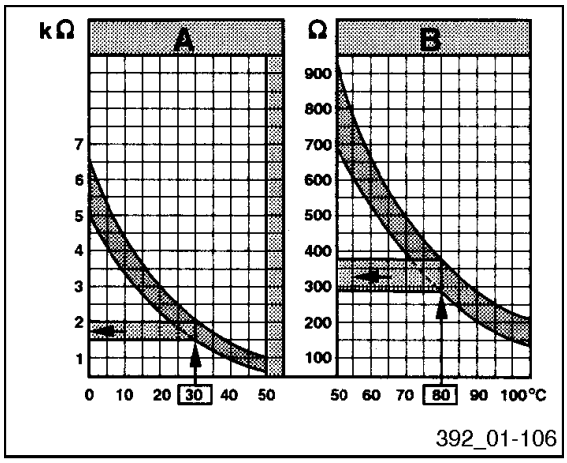


Diagram A shows the resistance values for the temperature range 0 - 50 °C, diagram B the values for the temperature range 50 - 100°C.

Examples of readings

30 °C corresponds to a resistance of 1500 - 2000 Ω

80 °C corresponds to a resistance of 275 - 375 Ω

If the desired resistance is not obtained:

- Replace coolant temperature sending unit 0B1.

If the desired resistance is obtained:

- Connect the test adapter to the cable loom of the engine control unit.
- Using the wiring diagram, check the lines between the test adapter and the 4-pin connector for interruptions.

Max cable resistance 1.5 Ω

- Also check the lines for line-to-line shorts, short circuit to truck earth and to battery positive.

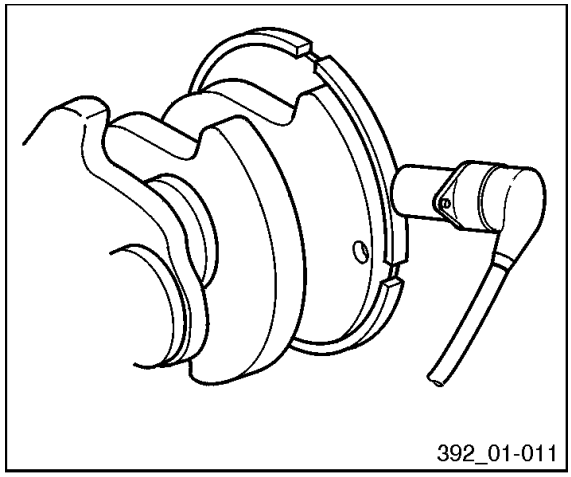
Desired resistance: 8 Ω

If no fault in the lines is detected:

- Replace the control unit of injection system 0N1.

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Engine speed sensor 0B2



The engine speed is one of the most important parameters for calculation of the injection quantity and the start of the injection process. The inductive sensor 0B2 for the engine speed monitors the angular position of the crankshaft. The sensor wheel (a disc with four slots) is mounted on the crankshaft. The correct position is fixed with a dowel pin. The electronic control unit measures the gap between two successive pulses. The momentary value of the position of the crankshaft is calculated by evaluating the four impulses.

Engine speed sensor - signal evaluation

The speed signal is used for the calculation of fuel quantity to be injected and the start of injection. The signal of the engine speed sensor is used for carrying out the functions exhaust gas recirculation, preheating and signal to the preheating time indicator light.

Engine speed sensor - self-test

Two possible fault causes are stored in the electronic control unit:

- Signal not plausible
- No signal

Engine speed sensor check

The engine speed sensor provides the engine rpm and reference marks. When it fails, the engine stops.

Required special tools

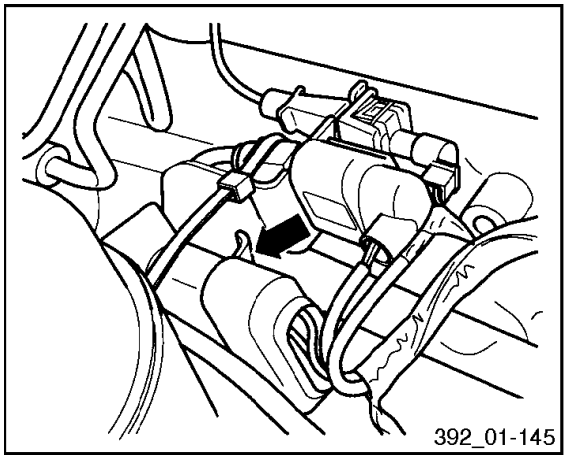
- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Test procedure

➢ Turn off the ignition.

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➢ Disconnect the connector at the engine speed sensor. ▷



➢ Measure the resistance between contacts (1) and (2) of the male connector. ▷

Desired value 1.1 kΩ to 1.6 kΩ

If the specified value is not obtained:

➢ Replace engine speed sensor 0B2

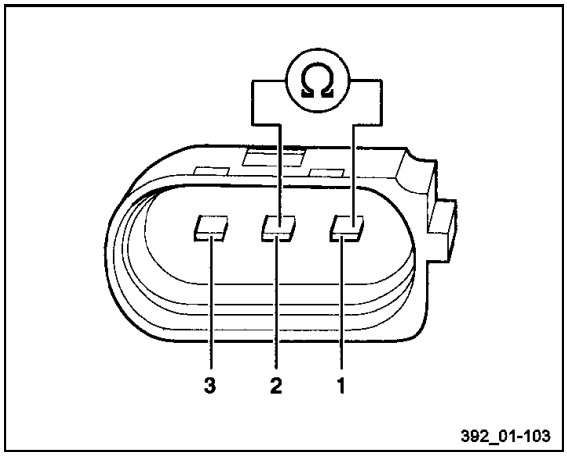
If the desired value is obtained:

➢ Connect the test adapter to the cable loom of the engine control unit

Max cable resistance 1.5 Ω

➢ Using the wiring diagram, check the lines between the test adapter and 3-pin plug for shorts.

Desired value: 8 Ω



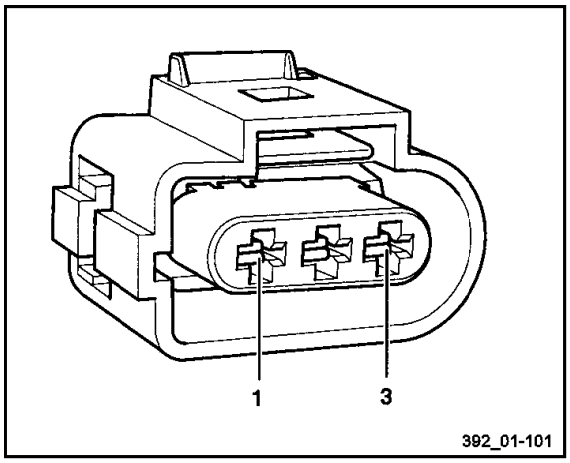
➢ Measure contacts 1, 2 and 3 for interruptions ▷

- Contact 1 and socket 102
- Contact 2 and socket 110
- Contact 3 and socket 86

Max cable resistance 1.5 Ω

If no fault is detected in the lines:

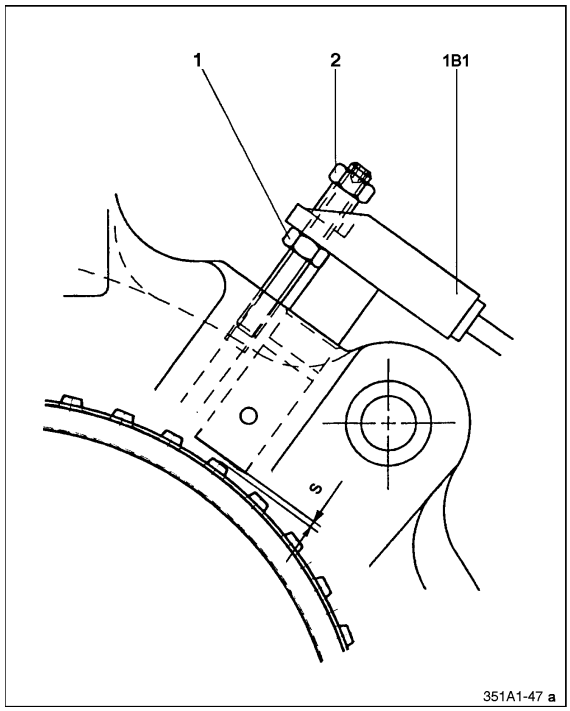
➢ Replace control unit of fuel injection system



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Actual speed sensor 1B1

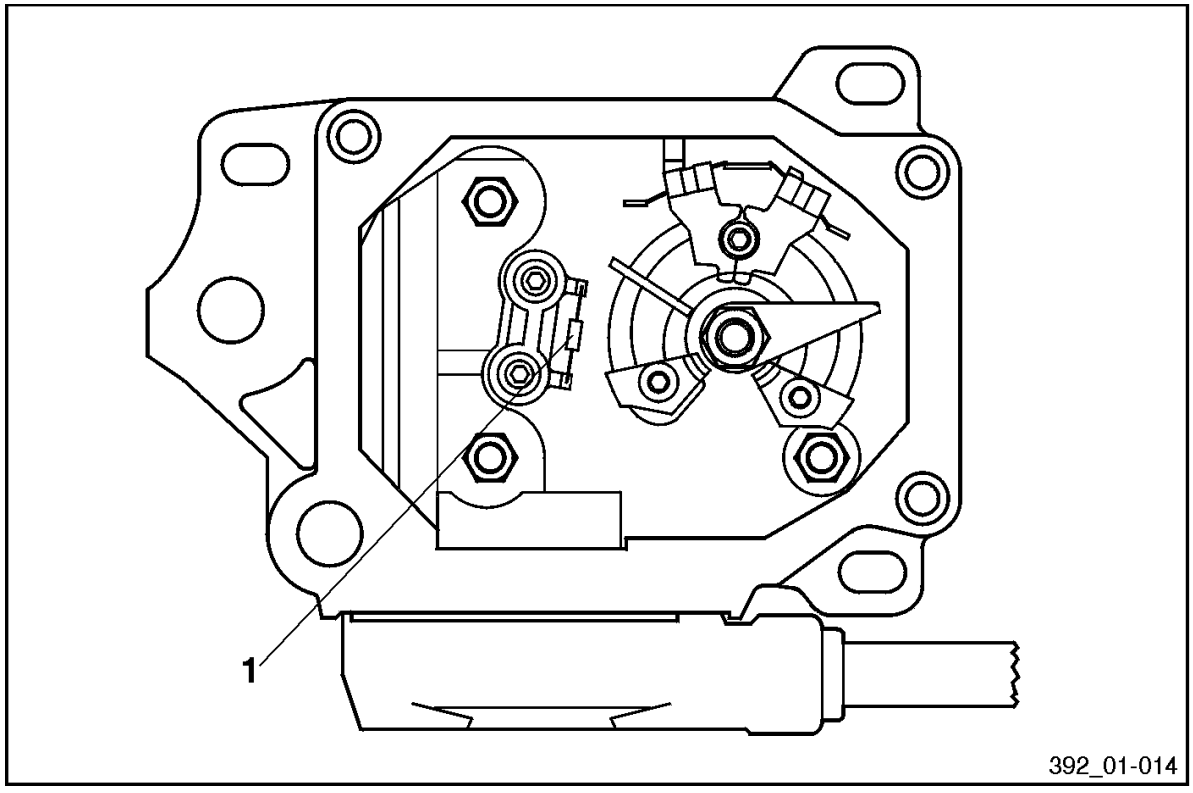
Setting instruction



- Remove actual speed sensor.
- Turn flywheel until one of the teeth lies beneath the borehole.
- Install actual speed sensor. Turn nut (1) downwards until the actual speed sensor rests on the tooth of the flywheel.
- Set the clearance between actual speed sensor and flywheel to s = $0.5^{+0.3}$ mm. Turn the nut (1) by 0.75 to 1 rotation to the left.
- Bring nut (2) back to the installation and tighten with 10 Nm

The functioning of the actual speed sensor can be examined in the "Motor Data" window of the diagnostic programme.

Fuel temperature sending unit 0B3



The fuel temperature sending unit 0B3 (1) measures the temperature of the fuel in the injection pump. The measuring result is transmitted to the electronic control unit as a change in voltage.

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The temperature of the fuel is very important, because the density of the fuel depends directly on its temperature. The fuel is pressed under high pressure through the injection nozzles by a small piston in the injection pump. The temperature of the fuel must be known for the exact determination of the injection rate and the start of injection. The correct values can be calculated with the known connection between temperature and density.

Fuel temperature sending unit - signal evaluation

The fuel quantity to be injected and the start of injection are calculated on the basis of the signal of the fuel temperature sending unit.

Fuel temperature sending unit - substitute function

In case of a sensor failure, the electronic control unit presets a constant value as a basis for calculation.

Fuel temperature sending unit - self-test

The electronic control stores the following fault causes:

- short circuit to earth
- Interruption/ short circuit

Fuel temperature sending unit - check

Required special tools

- Laptop with software
- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Test procedure

➢ Connect the laptop and start the software

➢ Select menu item "Inputs and outputs - Group 07".

The engine must be running at idle speed.

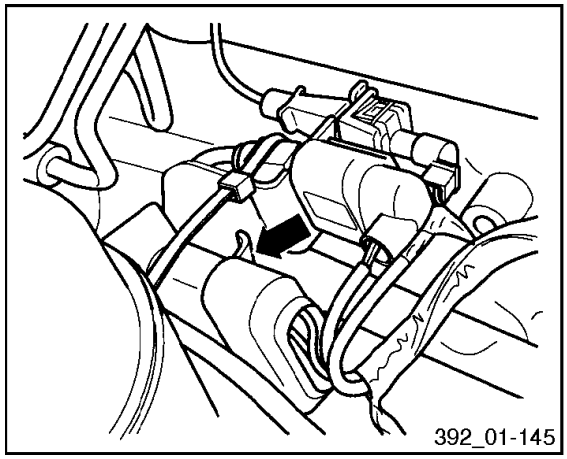
If no realistic reading is shown in the Display field or an operating temperature of -5.4 °C is indicated, check the fuel temperature sending unit and the cable connections to the sensor.

➢ Turn off the ignition.

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➢ Disconnect the 10-pin connector of the fuel temperature sending unit (connector to quantity regulating unit of the injection pump).

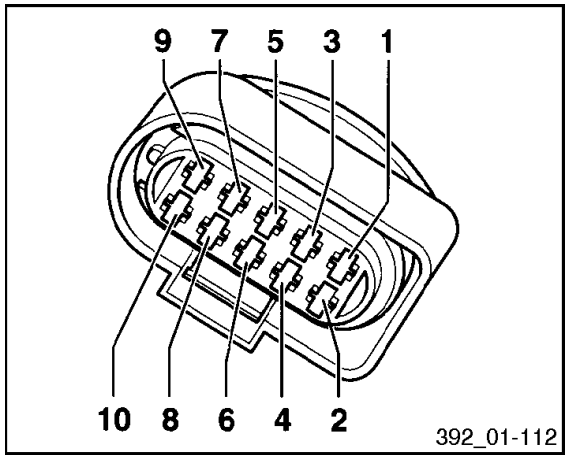
▷



➢ Measure the resistance of the sensor at contacts (4) and (7) of plug.

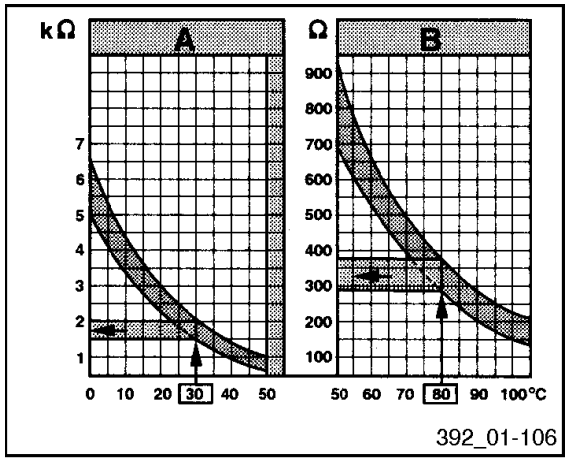
Diagram **A** shows the resistance values for the temperature range 0 - 50°C, diagram **B** , the values for the temperature range 50 - 100°C.

▷



➢ Read in the diagram

▷



30 °C is in diagram **A** and corresponds to a resistance of 1.5 - 2.0 kΩ

80 °C is in diagram **B** and corresponds to a resistance of 275 - 375 Ω

If the specified value is not obtained:

➢ Replace the injection pump

➢ Read out the fault history of the engine control unit.

➢ If necessary, clear the fault history

If the desired value is obtained:

➢ Connect the test adapter 7 917 299 010 to the cable loom of the engine control unit. This does not connect the control unit.

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➢ Using the circuit diagram, check the lines between test adapter and the connector for interruptions

- Contact 7 and socket 111
- Contact 4 and socket 103

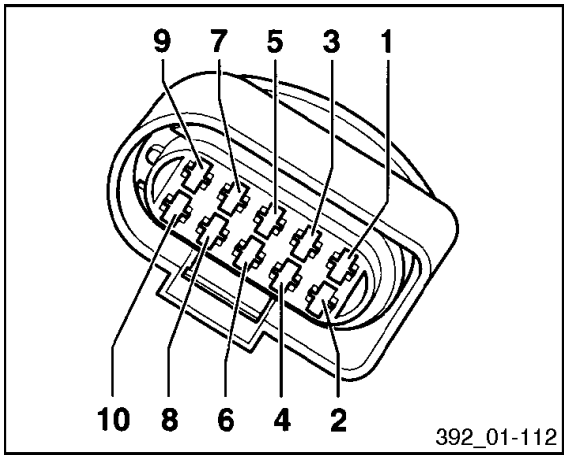
Line resistance: max 1.5 Ω

➢ Also check the lines for line-to-line shorts, short to battery earth/engine earth and to battery positive

Desired value: 8 Ω

If no fault is detected in the lines:

➢ Replace the control unit for direct injection system 0N1.



Intake pipe temperature and intake pipe pressure sending unit 0B4

The sensor is located in the intake pipe. Its signal provides information on the air temperature in the intake manifold.

The signal of sensor 0B4 is used for control purposes.

Intake pipe temperature and intake pipe pressure sending unit - substitute function

In case of a failure of sensor 0B4, the electronic control unit specifies a constant value. In this case the electronic control unit takes a value of approx. 20°C as a basis for calculation.

Intake pipe temperature and intake pipe pressure sending unit - self-test

The control unit stores two possible malfunctions

- short circuit to earth
- Interruption/ short circuit

Required special tools for the test

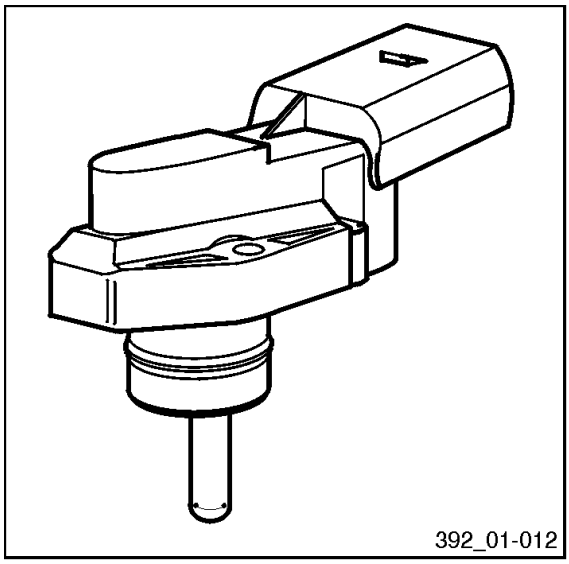
- Laptop with software
- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

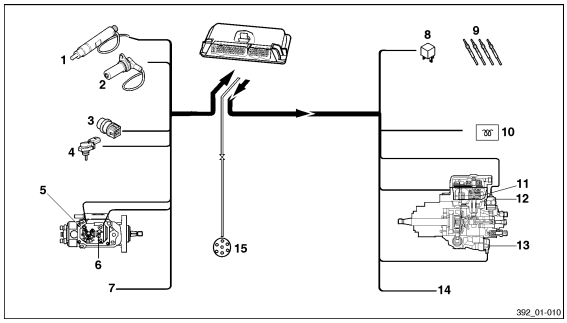
Prerequisites for the test

The engine must run at idle speed.

➢ Connect the Laptop

➢ Start the software





1 Intake pipe temperature and intake pipe pressure sending unit (BEU engine)

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➢ Select menu item "Inputs and outputs - Group 8"

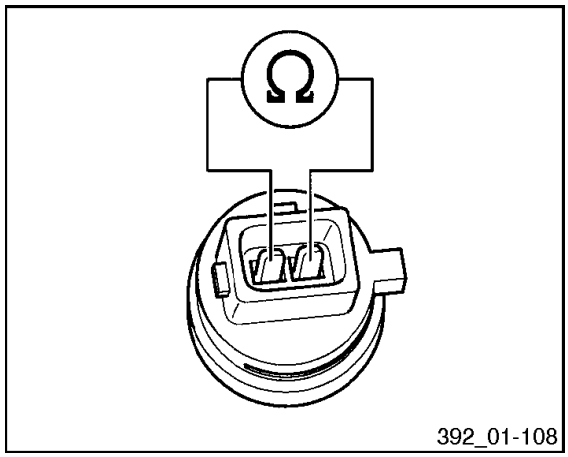
If no realistic reading is shown in the Display field

- or
- a substitute temperature of 136.8°C

is indicated, check the intake pipe temperature sending unit and the cable connections to the sensor

➢ Turn off the ignition

➢ Disconnect the twin plug from intake pipe temperature sending unit 0B4 ▷



➢ Check the resistance between the contacts of the intake pipe temperature sending unit. ▷

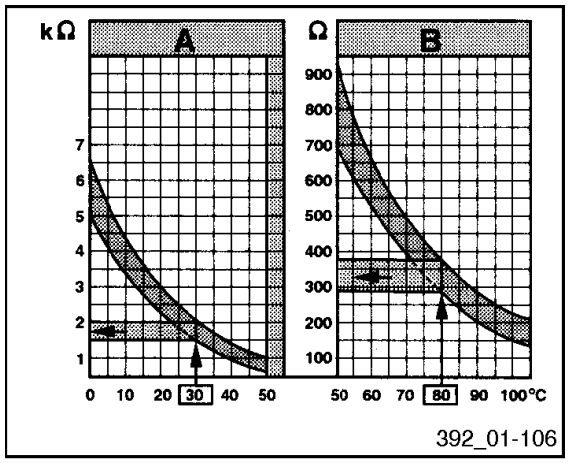


Diagram **A** shows the resistance values for the temperature range 0 - 50°C, diagram **B** , the values for the temperature range 50 - 100°C.

Examples of readings:

30°C is in diagram **A** and corresponds to a resistance of 1.5 k? to 2 k?

80°C is in diagram **B** and corresponds to a resistance of 275 k? to 375 k?

If the desired resistance is not obtained:

➢ Replace intake pipe temperature sending unit 0B4

➢ Read out the fault history of the engine control unit

➢ If necessary, clear the fault history

If the desired resistance is obtained:

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➢ Connect test adapter 7 917 299 010 to the cable loom of the engine control unit. (The engine control unit is not connected in this case).

➢ Check lines between the test adapter and plug for interruptions according to the wiring diagram

- Contact 1 and socket 73
- Contact 2 and socket 54

Cable resistance: maximum 1.5 ?

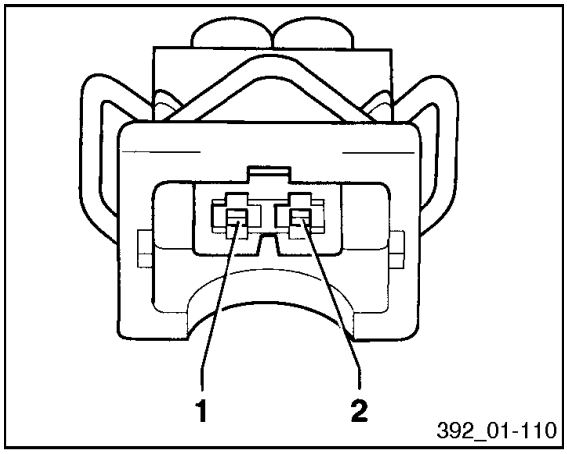
➢ Also check the lines for line-to-line shorts, for shorts to battery negative and to battery positive

Desired resistance: 8 ?

If no fault is detected:

➢ Replace the control unit for direct injection system 0N1

▷



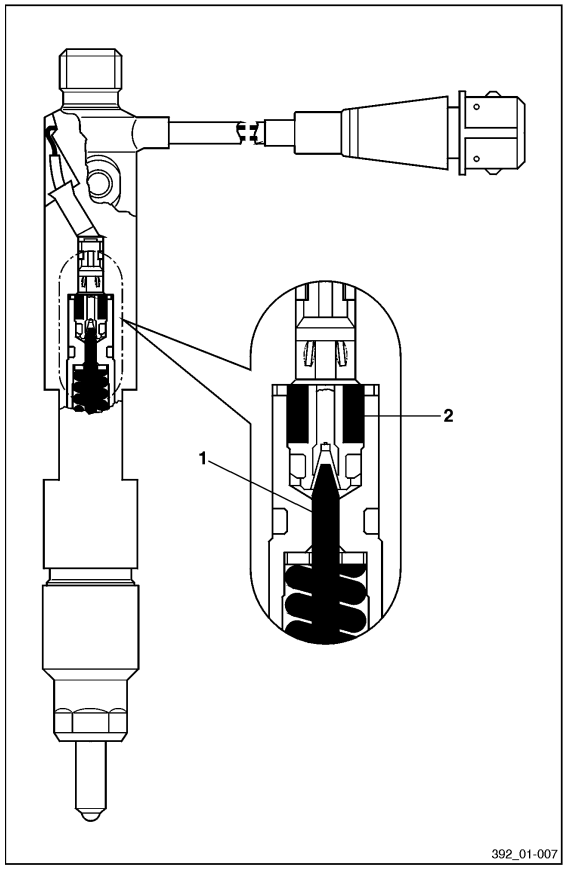
Needle stroke sensor 0B5

For the purpose of recording the start of the injection, the injection nozzle of the 3rd cylinder is equipped with needle stroke sensor 0B5.The sensor monitors the actual time when the injection nozzle opens, and this signal is transmitted to the control unit.The electronic control unit compares the received signal with the characteristic map for the start of injection and evaluates the difference.

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Needle stroke sensor - feature

The needle stroke sensor 0B5 consists of a solenoid (2), which is supplied with a constant current by the control unit. As a result, a magnetic field is created.Inside the solenoid there is a pressure spindle (1) formed as an extension of the nozzle needle. The movement of the pressure spindle leads to a change in the voltage induced in the solenoid.The time of induction of the voltage in the coil is compared with the top dead centre (TDC) signal by the control unit. The actual start of injection is calculated from this difference. Subsequently, the actual value for the start of injection is compared with the desired value, and in case of a deviation, the start of injection is corrected accordingly.



Needle stroke sensor - substitute function

In case of a failure of the needle stroke sensor, an emergency running program is started. With this program, the start of injection is controlled according to a specific characteristic map. The injection quantity is also reduced.

Needle stroke sensor - check

The needle stroke sensor signal is required for determining the start of injection. In case of a failure, the start of injection is controlled according to speed and load; during regular operation, the start of injection is controlled according to speed, load and temperature.

Required special tools

- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Test procedure

➢ Turn off the ignition.

➢ Disconnect the needle stroke sensor connector.

➢ Measure the resistance between the contacts of the male connector.

Desired resistance: 80 - 120 Ω

If the desired resistance is not obtained:

➢ Replace the injection nozzle of cylinder 3 with needle stroke sensor 0B5.

If the desired resistance is obtained:

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➢ Connect the test adapter to the cable loom of the engine control unit. This does not connect the control unit.

➢ Using the wiring diagram, check the lines between test box and the 10-pin connector for interruptions.

- Contact 1 and socket 109
- Contact 2 and socket 101

Line resistance: max 1.5 Ω

➢ Also check the lines for line-to-line shorts, short circuit to truck earth and to battery positive.

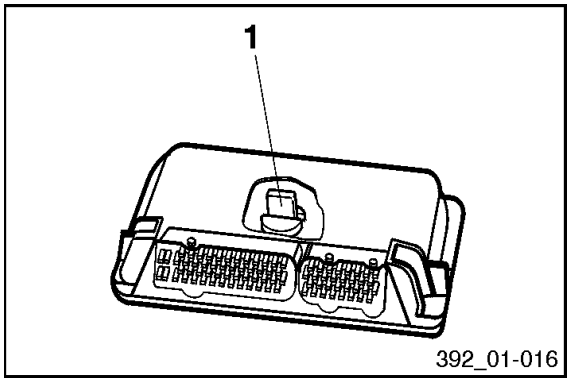
Desired resistance: 8 Ω

If no fault in the lines is detected:

➢ Replace the control unit for direct injection system 0N1.

Height sensor

▷



The height sensor (1) is integrated in the control unit for direct diesel injection 0N1. The measurement is carried out directly in the control unit. The height sensor contains a piezo-ceramic element. If a force is applied to the piezocrystal, it supplies a voltage. This voltage is a measure of the air pressure. The air pressure depends on the geographic height, ie the air pressure sinks with increasing height. The charge pressure and the exhaust gas recirculation are reduced in order to prevent "black smoke"when the air pressure drops.

Height sensor - signal evaluation

The electronic control unit calculates the charge pressure limit value on the basis of the height sensor signal.

Height sensor - substitute function

In case of a failure of the height sensor, the charge pressure is limited by a preset constant value.

Height sensor - self-test

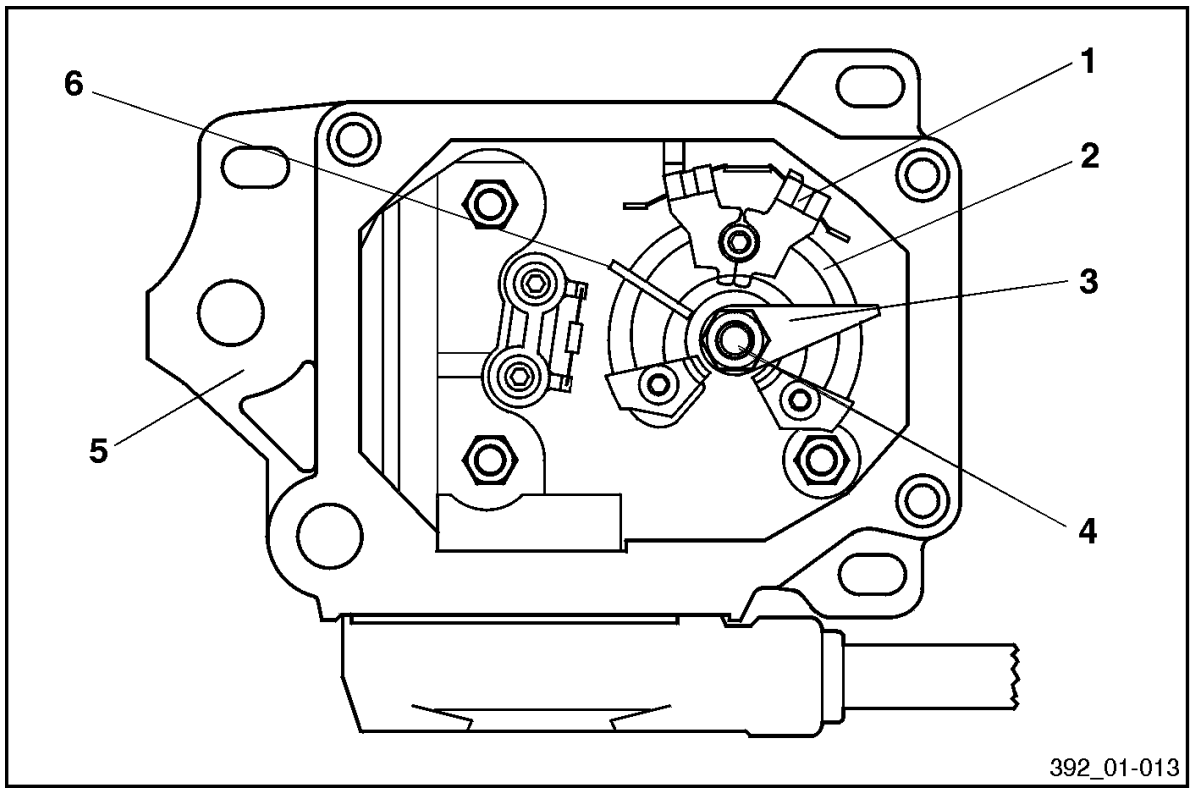
The electronic control unit stores any possible faults.

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NOTE

The height sensor cannot be repaired in case of a malfunction. The electronic control unit must be replaced.

Control sleeve position sensor0B3



1	Coil with alternating voltage	4	Eccentric shaft
2	Iron core	5	Distributor fuel injection pump
3	Moveable iron ring	6	Fixed iron ring

Control sleeve position sensor - description

The sensor for the control sleeve position 0B3 monitors the angle of rotation of the eccentric shaft of the quantity regulating mechanism in the injection pump. This sensor is a non-contact type sensor. Its signals are directly transmitted to the electronic control unit. The sensor consists of two inductive pick-ups, which work in accordance with the differential transformer principle. The use of non-contact pick-ups guarantees its correct operation independent of the surrounding medium so that any water which might be in the fuel does not lead to a falsification of the measuring result. An alternating magnetic field is created by the alternating voltage along an especially shaped iron core. A moveable iron ring

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which can be moved along the iron core is fixed on the eccentric shaft. The alternating magnetic field changes in accordance with the position of the moveable iron ring. As a result, an alternating voltage is induced in the coil. The phase shift of the induced voltage in relation to the desired voltage is recorded as a measure of the position of the fuel quantity regulating mechanism. Temperature influences can be neglected, since both voltages come from the same sensor and are transmitted via the same line system.

Control sleeve position sensor - signal evaluation

The sensor signal corresponds to the momentary position of the quantity regulating mechanism. It is used for the comparison of the "actual position" of the fuel quantity regulating mechanism with the position calculated by the electronic control unit. In case of a difference between the desired and actual position, the quantity regulating mechanism corrects the position of the fuel quantity positioner.

Control sleeve position sensor - substitute function

If the control unit does not receive a signal from the sensor for control sleeve position 0B3, the engine is stopped for safety reasons.

Control sleeve position sensor - test

The fuel quantity positioner is an electromagnetic rotating actuator which is activated by the control unit via a specific on/off ratio. The eccentric shaft of the fuel quantity positioner moves the control sleeve at the high-pressure piston, thereby determining the injection quantity.

The sensor for control sleeve position delivers the control unit the position of the fuel quantity positioner and so determines the volume of the injection quantity.

Required special tools and aids

- Laptop with software
- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Prerequisites for the test

➢ Connect the laptop, start the software.

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➢ Select menu item " Group 01 Inputs and outputs ".

The engine must be running at idle speed.

➢ Check coolant temperature in Display field.

➢ Desired temperature: at least 80°C

➢ Proceed with test only after coolant temperature is reached.

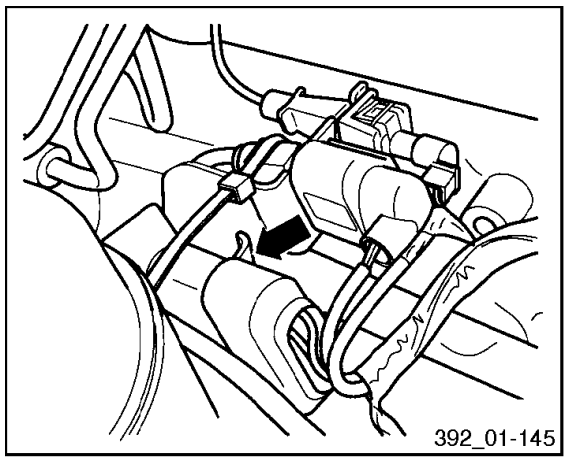
➢ Check the reading in the Display field (pump voltage).

Engine identification letter BEU: Desired voltage: 1.92 - 2.19 V

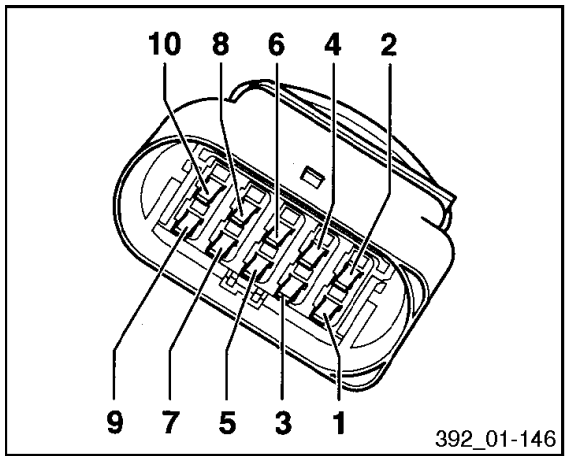
If the desired voltage is not reached, check the sensor for control sleeve position and the fuel quantity positioner.

Test

➢ Disconnect the 10-pin connector of the sensor for the control sleeve position (connector to the quantity regulating unit of the injection pump).



➢ Measure the resistance between contacts 1 and 2 and 2 and 3.



Desired resistance: 4.9 to 7.5 ?.

If the desired resistance is not obtained:

➢ Replace the injection pump

➢ Read out the fault history of the engine control unit.

➢ If necessary, clear the fault history

If the desired resistance is obtained:

➢ Connect test adapter to the cable loom of the engine control unit. (The engine control unit is not connected in this case).

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➢ Using the wiring diagram, check the lines between the test adapter and plug for interruptions. ▷

- Contact 1 and socket 108
- Contact 2 and socket 106
- Contact 3 and socket 99

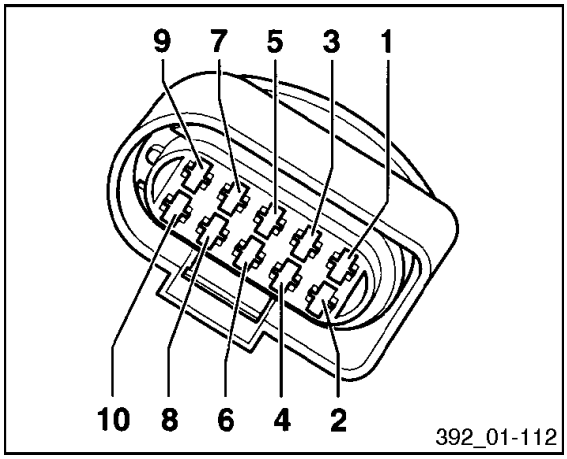
Max cable resistance thereby 1.5 ?

➢ Also check the lines for line-to-line shorts. Also check the lines for short to battery earth, engine earth and to battery positive

The desired resistance is 8 ?

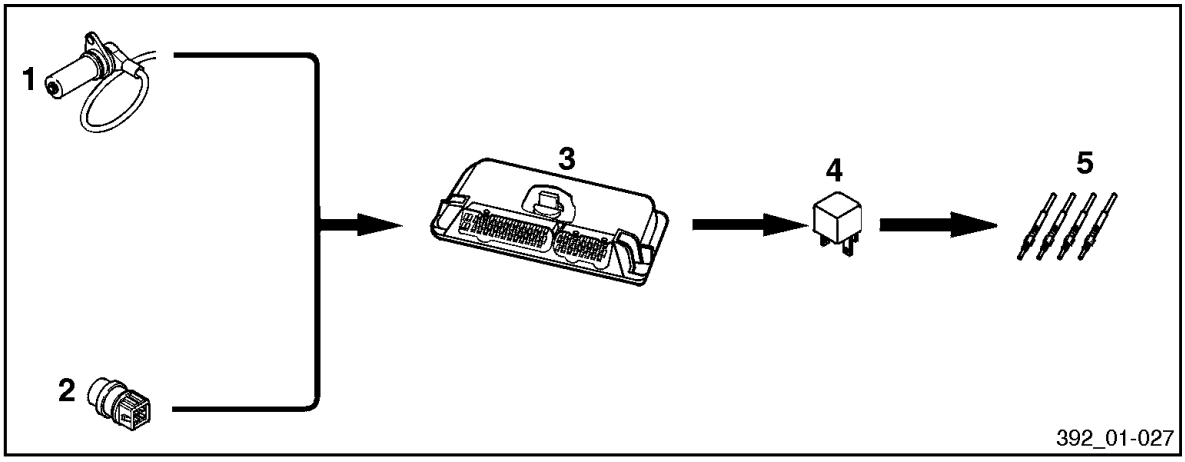
If no fault is detected:

➢ Replace control unit of fuel injection system



Preheating system

Pre-heater system



1 Engine speed sensor
2 Sensor for coolant temperature
3 Control unit for direct diesel injection
4 Glow plug relay
5 Glow plug

High pressure and high temperature are generated in the combustion chamber during the compression phase. This affects the combustion process substantially. Due to the small surface of the combustion chamber, the heat dissipation is low. Pre-heating is only necessary at low temperatures.

Basically, there are three glow phases:

- Pre-heating time
- Glow time
- Post-heating time

Pre-heater system - control

The electronic control unit controls the pre-heater system. Pre-heating is only activated if the coolant temperature is below +10°C. The colder the coolant, the longer the pre-heating time. After pre-heating, the five-second waiting time is activated, during which glowing is active. Post-heating is activated for about 30 s during the starting procedure in case of coolant temperatures below +20 °C. In total, a post-heating time of 90 seconds is possible, depending on the coolant temperature. In case of speeds exceeding 2500 rpm, post-heating is switched off.

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Pre-heater system - test

Required special tools

- Laptop with software
- Multimeter
- Circuit diagram

Prerequisites for testing

- The fuses must be okay.
- The battery voltage must be at least 11.5 V.
- Earth connections okay.
- All electric loads must be switched off.
- No fault may be stored in the fault memory.

Test Procedure

➢ Pull the connectors from the glow plugs.

➢ Connect the multimeter for voltage measurements between a glow plug connector and the battery earth/engine earth.

➢ Carry out actuator diagnosis and energise the glow plug relay

The voltage value should vary between 0 V and around the battery voltage.

Continue and finish the actuator test.

➢ Switch the ignition off.

If the voltage value does not vary as described:

➢ Eliminate the fault in the lines to the glow plug relay (0K1) according to circuit diagram.

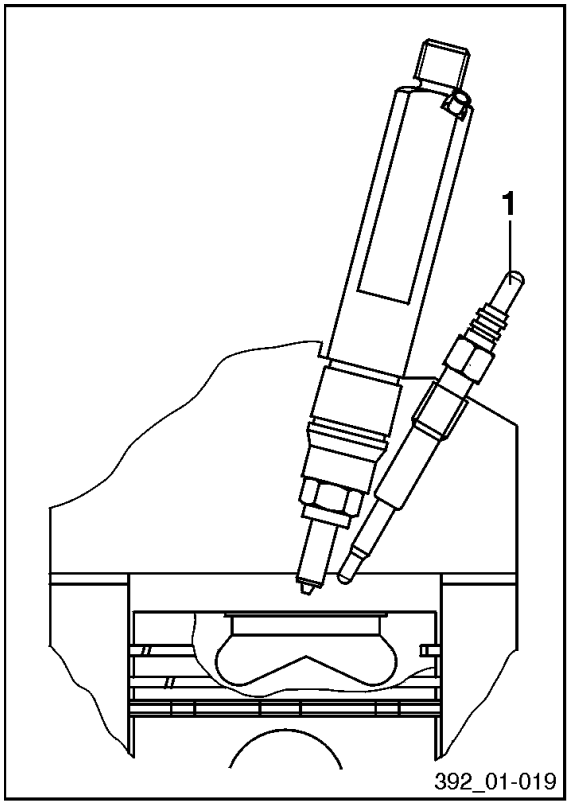
➢ Then poll the fault memory of the engine control unit.

➢ Clear the fault memory if necessary.

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Engine glow plugs 0R1

The glow plugs (1)are arranged in such a way that only their tips project into the combustion chamber. A quick-connect coupling enables rapid testing and replacement of the glow plugs.



Glow plugs - control

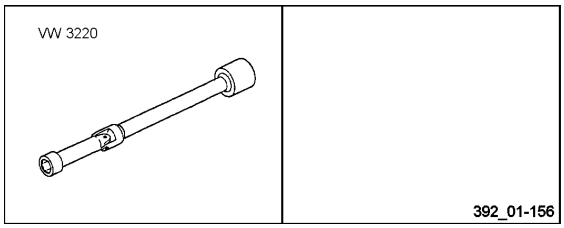
The relay for the glow plugs is switched via the electronic control unit. It determines the preheating time, the glow-time and the post-heating time.

Glow plugs - self-test

Faults in the preheating system are not stored. The glow plugs and the preheating system are tested with the function is used."Actuator test"

Glow plugs - checking

Required special tools



- Diode test lamp
- Flexible head spanner VW 3229

Prerequisites for testing

- Battery voltage at least 11.5 V
- Ignition switched off

Test procedure

➢ Pull the connector from the glow plugs.

➢ Connect the line of the diode test light to battery positive (+) by using the auxiliary terminals of the test aids set.

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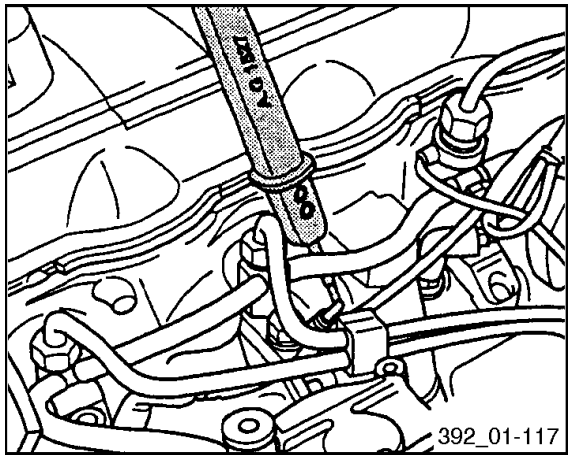
➢ Place the probe of the diode test light successively on each glow plug.

- Diode lights up: glow plug ok.
- Diode does not light up: replace glow plug.

➢ Remove and install the glow plugs with the flexible head spanner VW 3229.

Tightening torque: 15 Nm.

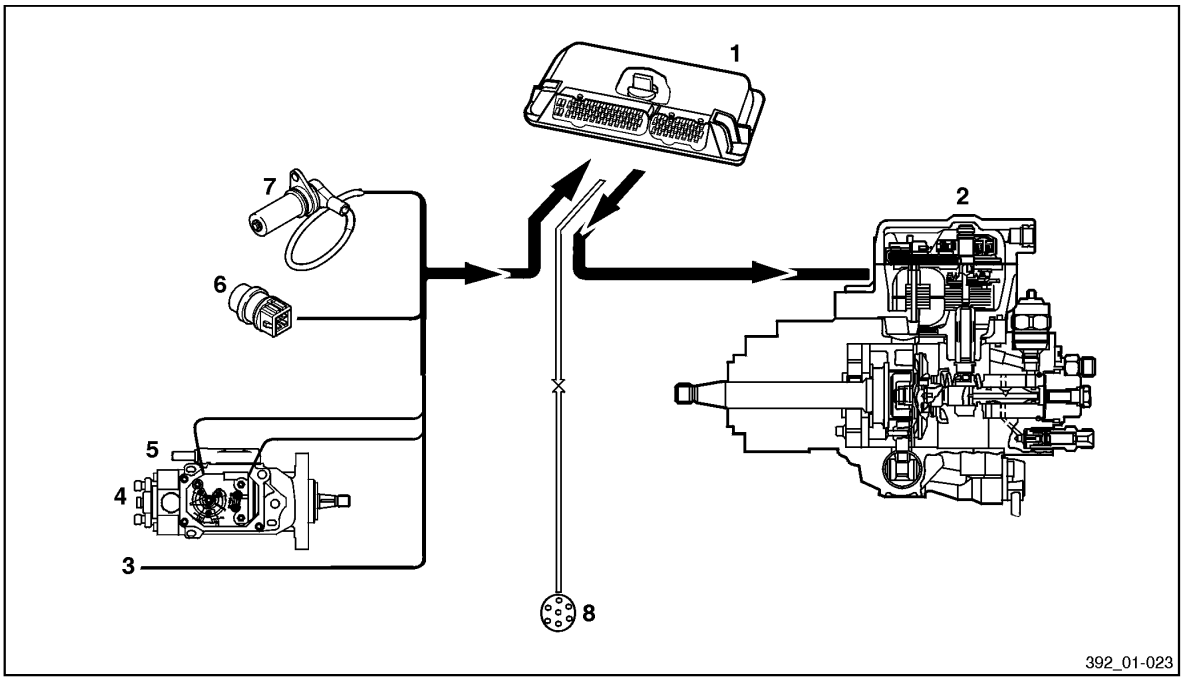
▷



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Fuel supply

Fuel metering



1	Control unit for direct diesel fuel injection	5	Fuel temperature sending unit
2	Fuel quantity positioner	6	Coolant temperature sending unit
3	Additional signal	7	Speed sensor
4	Sensor for control sleeve position	8	Diagnostic plug 6X2

The electronic control unit controls the fuel quantity positioner dependent on the parameters injection rate, speed, torque, driving comfort and starting. Depending on a stored characteristic map value, the fuel quantity to be injected is specified by various parameters transmitted by sensors. Included in the control signal for the fuel quantity positioner are also the following sensor signals:

- LTC interrogation (CAN signal)
- Coolant temperature
- Fuel temperature
- Engine speed
- Control sleeve position

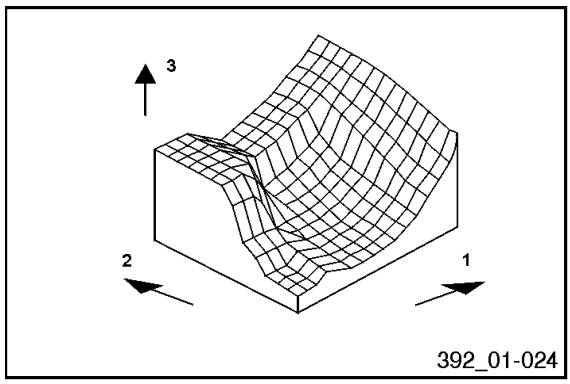
Executed functions

- Characteristic map value for injection quantity
- Control of idle and full load speed
- Overrun fuel cut-off
- Starting quantity control
- Smoke limitation

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Injection quantity characteristic map

The basis for the signal transmitted to the fuel quantity positioner is a value taken from a characteristic map. This characteristic map signal is modified by specific corrective factors in order to modify the amount of fuel to be injected as exactly as possible. The signal for the control sleeve position is used as acknowledgement and corrective value for the execution.



1 Engine speed
2 Fuel mass
3 Start of injection

Governing idle and full load speed

Values for the idle- and full-load speed are specified in the controller unit. The full load speed is changed by the engine temperature, the connection of electric loads and the air conditioning compressor. The governing of the idle speed starts when the engine speed data is taken from its characteristic map, taking the coolant temperature into account. This characteristic map value is compared with actual engine speed. The required injection quantity is calculated from the difference. The maximum speed is always constant. When this speed is reached, the injection quantity is reduced progressively. If the speed drops again, the injection quantity is increased.

Overrun fuel cut-off

The function overrun fuel cut-off cuts off the fuel supply to the injection valves completely. This function is always carried out when the idle speed rises to over 1300 rpm without an increase in speed being demanded.

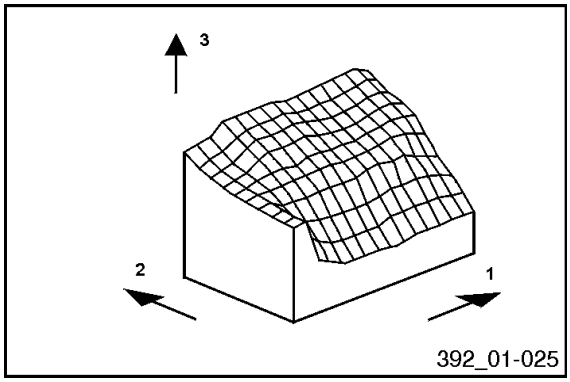
Starting quantity control

The electronic control unit raises the injection quantity when starting. The characteristic map data for the injection quantity are raised in dependence on the coolant temperature.

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Characteristic map for smoke

The quantity to be injected at any given time is determined in accordance with the stored characteristic map for smoke.When the mass air flow is too small, the injection quantity is reduced to such a degree that no black smoke arises.

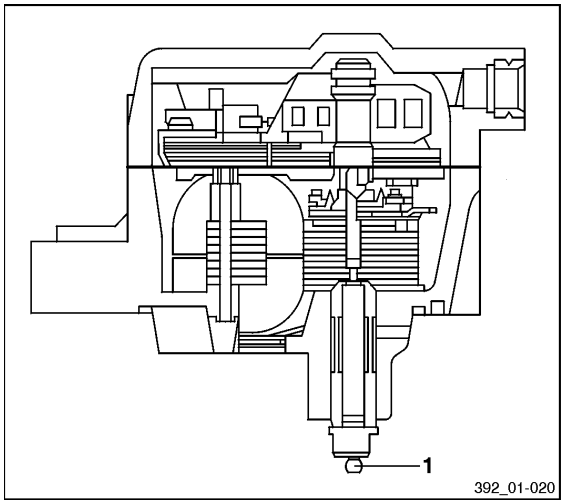


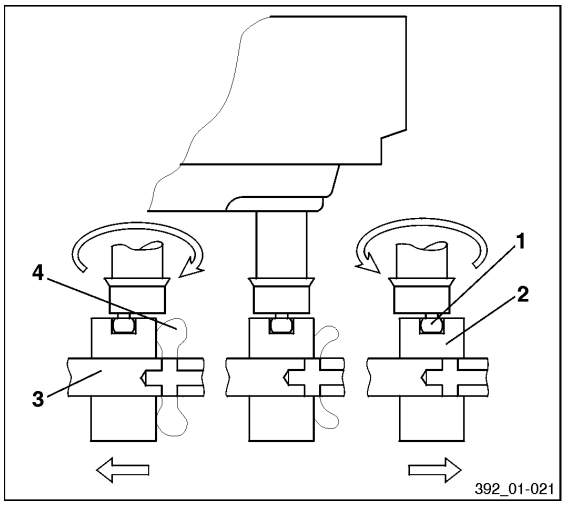
1 Engine speed
2 Mass air flow
3 Fuel mass

Fuel quantity positioner 0B3

The fuel quantity positioner is located in the top section of the injection pump. It translates the signals received from the electronic control unit into a position change of the control sleeve. For this purpose the received electric signals are translated into defined movements of the driveshaft with eccentric ball-and-socket joint (1) by means of the electromotive principle.

The driveshaft may carry out movements up to a rotation angle of 60°. A spring provides for a permanent righting moment of the driveshaft in the direction of its initial position. The eccentric ball-and-socket joint pushes the axially moveable control sleeve on the distributor plunger back and forth. During this process the control edge can be fully opened (cut-off) and fully closed (full load).





1 Eccentric ball-and-socket joint
2 Control sleeve
3 Distributor plunger
4 Leakage quantity

Fuel quantity positioner - control

In the electronic control unit, the CAN signal of the LTC controller and the signal for the engine speed are used as parameters for controlling the injection quantity.

In addition, the following corrective values are taken into account:

- Coolant temperature
- Fuel temperature

On the basis of these parameters, the electronic control unit calculates a manipulated variable, which is transmitted as a voltage to the fuel quantity positioner.

Fuel quantity positioner - substitute function

In case of a failure of the fuel quantity positioner, the engine is stopped. In case of a failure of the

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power supply the return moment of the spring returns the driveshaft to its initial position. This leads to the complete release of the control edge of the distributor plunger and the engine stops.

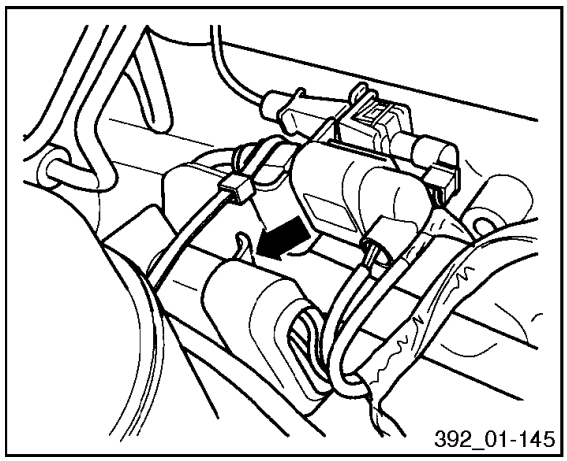
Fuel quantity positioner - self-test

Any problems are detected in the electronic control unit.

Fuel quantity positioner - check

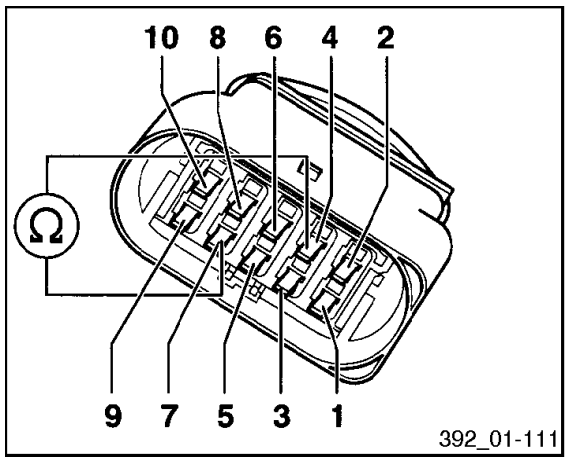
➢ Disconnect the 10-pin connector to the quantity regulating mechanism of the injection pump.

▷



➢ Measure the resistance between contacts 5 and 6 of the fuel quantity positioner.

▷



Desired resistance: 0.5 - 2.5 Ω

If the desired resistance is not obtained:

➢ Replace injection pump

➢ Subsequently read out the fault history of the engine control unit.

➢ If necessary, clear the fault history

If the desired resistance is obtained:

➢ Connect the test adapter to the cable loom of the engine control unit. This does not connect the control unit.

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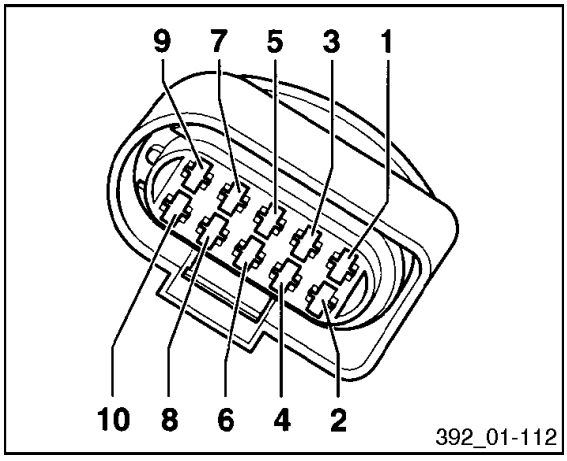
➢ Check the lines between the test adapter and the 10-pin connector for interruptions according to wiring diagram.

- Contact 5 and socket 1
- Contact 5 and socket 2
- Contact 6 and socket 116
- Contact 6 and socket 121

➢ Also check the lines for line-to-line shorts, short to battery earth/engine earth and to battery positive.

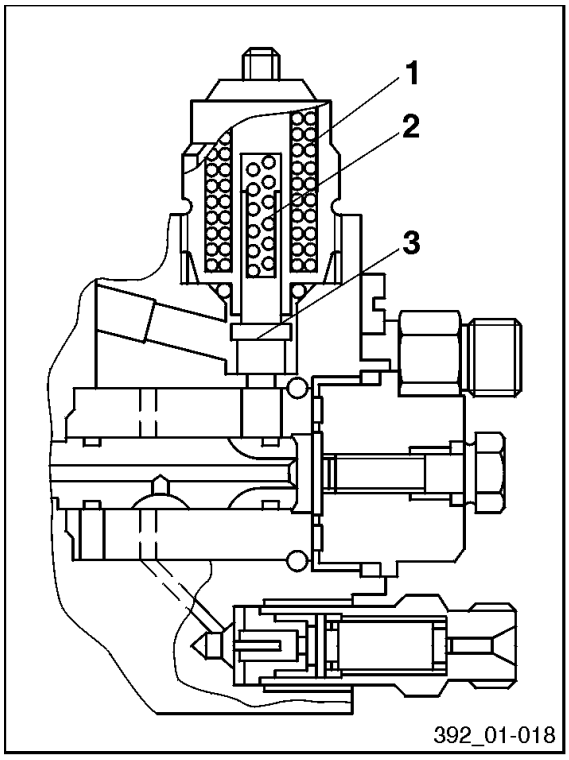
If no fault in the lines is detected:

➢ Replace the control unit for injection system 0N1



Fuel shut-off valve 0Y1

An auto-ignition engine can only be switched off by cutting off the fuel supply. This is achieved with the fuel shut-off valve 0Y1. The valve is located in the top section of the injection pump. When the power is cut off, it cuts off the fuel supply to the distributor injection pump. The fuel shut-off valve is a solenoid valve. The armature (3) also serves as check valve. When the spool (1) is excited, the armature is drawn in, the force of the spring overcome and the flow of fuel released.



Fuel shut-off valve - control

The fuel shut-off valve is operated via a contact of the electronic control unit. When the contact opens, the power supply is interrupted and the engine stops immediately.

Fuel shut-off valve - substitute function

In case of a failure, the vehicle is shut down immediately as the fuel supply is cut off at once.

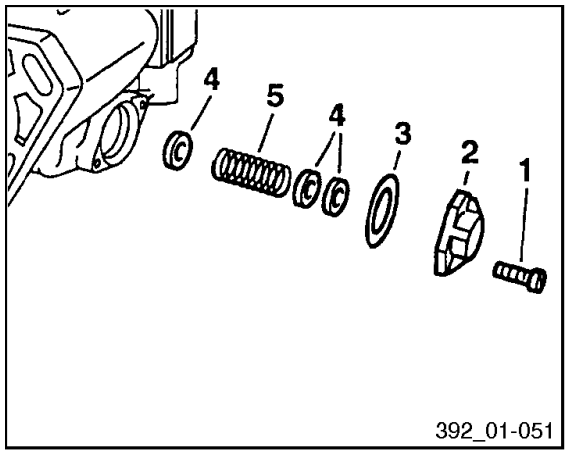
Fuel shut-off valve - self-test

A fault is registered by the electronic control unit. When using the diagnostic software, the correct state of the fuel shut-off valve is checked with the help of the function "Actuator test".

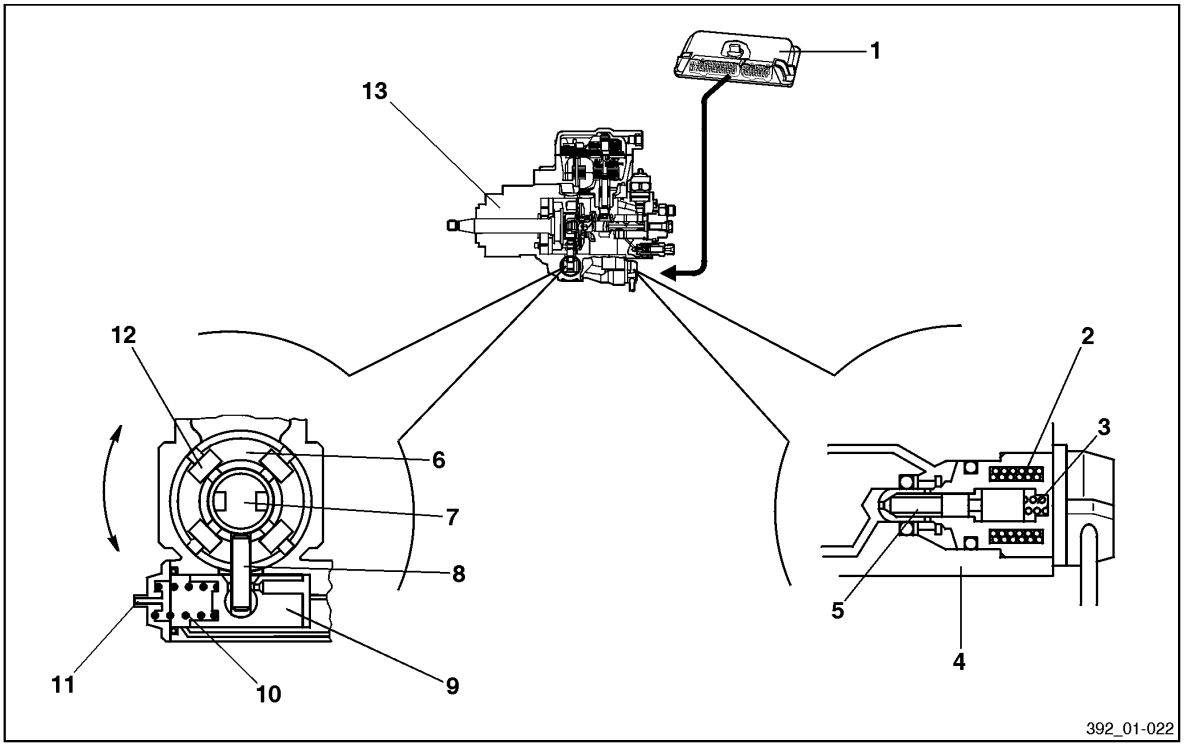
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Injection timing device- replacement of O-ring on cover

- Place a clean cloth underneath the injection pump.
- Remove the cover screws (1) with a commercial offset screwdriver for Torx head screws, for example, Hazet 2115-T30.
- Remove and clean the cover (2).
- Replace the O-ring (3) and install the cover with the existing shims (4).



Start of injectionvalve 0Y2



1	Controller for direct fuel injection 0N1	8	Pin
2	Solenoid	9	Timing device plunger
3	Spring	10	Spring
4	Start of injection valve 0Y2	11	To suction side of vane-cell pump
5	Piston	12	Pressure roller
6	Fuel under pressure in pump interior	13	Injection pump
7	Cam plate		

Valve 0Y2 for the start of the injection process is mounted in the lower part of the injection pump. It

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translates the on/off ratio into a change in the control pressure. This change acts on the part of the timing device plunger which is not preloaded. The valve is a solenoid valve. It consists of a piston, a spring and a coil. In its neutral position, the piston shuts off the fuel return flow through the force of the spring. The return flow opening is opened by the activation of the solenoid of the valve via the electronic control unit. Due to the pressure of the fuel acting on the piston and counteracting the spring power, an equilibrium of forces is created for each fuel pressure. This equilibrium provides a defined position of the timing device plunger and causes a shift in the start of injection. As a result of the position change of the timing device plunger, the pin is displaced.This displacement is transmitted to the radially mounted cam in the injection pump. Due to the connection between pin and cam, the displacement of the pin is translated into a specific angle. Consequently, the cam is turned into the direction "early" or "late" and the start of injection is shifted accordingly.

Valve 0Y2 - control

For the calculation of the value for the signal to the solenoid valve, the signal of the needle stroke sensor is used as actual value parameter. The electronic control unit transmits a pulse sequence of constant frequency and a different phase angle to the solenoid valve.

Valve 0Y2 - self-test

Malfunctions of the start of injection control are stored in the fault history (interruption and short circuit).

Valve 0Y2 - check

Required special tools

- Laptop with software
- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Test procedure

➢ Connect the Laptop, start the software

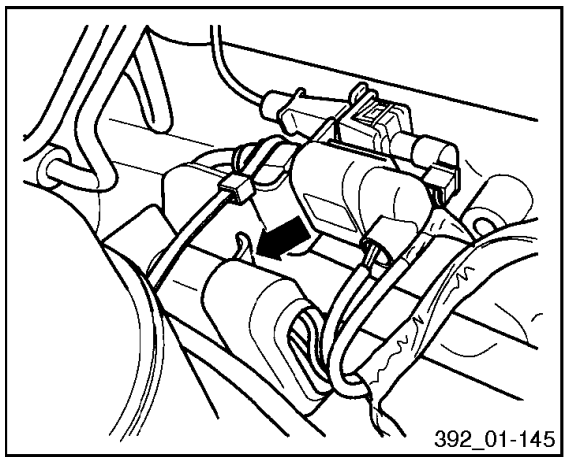
➢ Select the menu item "Guided diagnosis - actuator test". The engine must be running at idle speed.

Activating the valve results in a clearly audible change in the combustion noise (knocking).

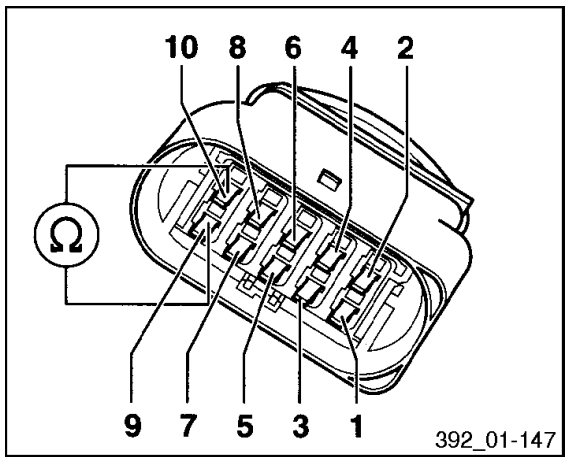
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Check the valve. If no change in the combustion noise can be heard:

➢ Disconnect the 10-pin connector for the start of injection valve (connector to the fuel quantity positioner of the injection pump). ▷



➢ Measure the resistance between contacts 9 and 10 of the start of injection valve. ▷



Desired resistance: 12 - 20 Ω

If the desired resistance is not obtained:

➢ Replace the start of injection valve 0Y1.

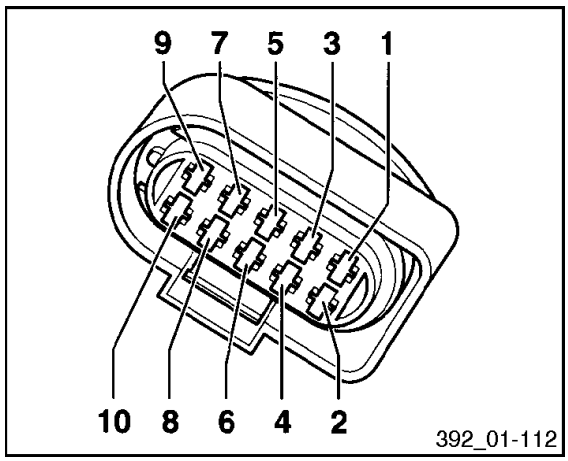
➢ Subsequently read out the fault history of the engine control unit.

➢ If necessary, the clear the fault history

If the desired resistance is obtained:

➢ Connect the test adapter to the cable loom of the engine control unit. This does not connect the control unit.

➢ Using the wiring diagram, check the lines between test box and the 10-pin connector for interruptions. ▷



- Contact 9 and socket 114
- Contact 10 and socket 1
- Contact 10 and socket 2

Max cable resistance 1.5 Ω

➢ Also check the lines for line-to-line shorts, short to battery earth/engine earth and to battery positive.

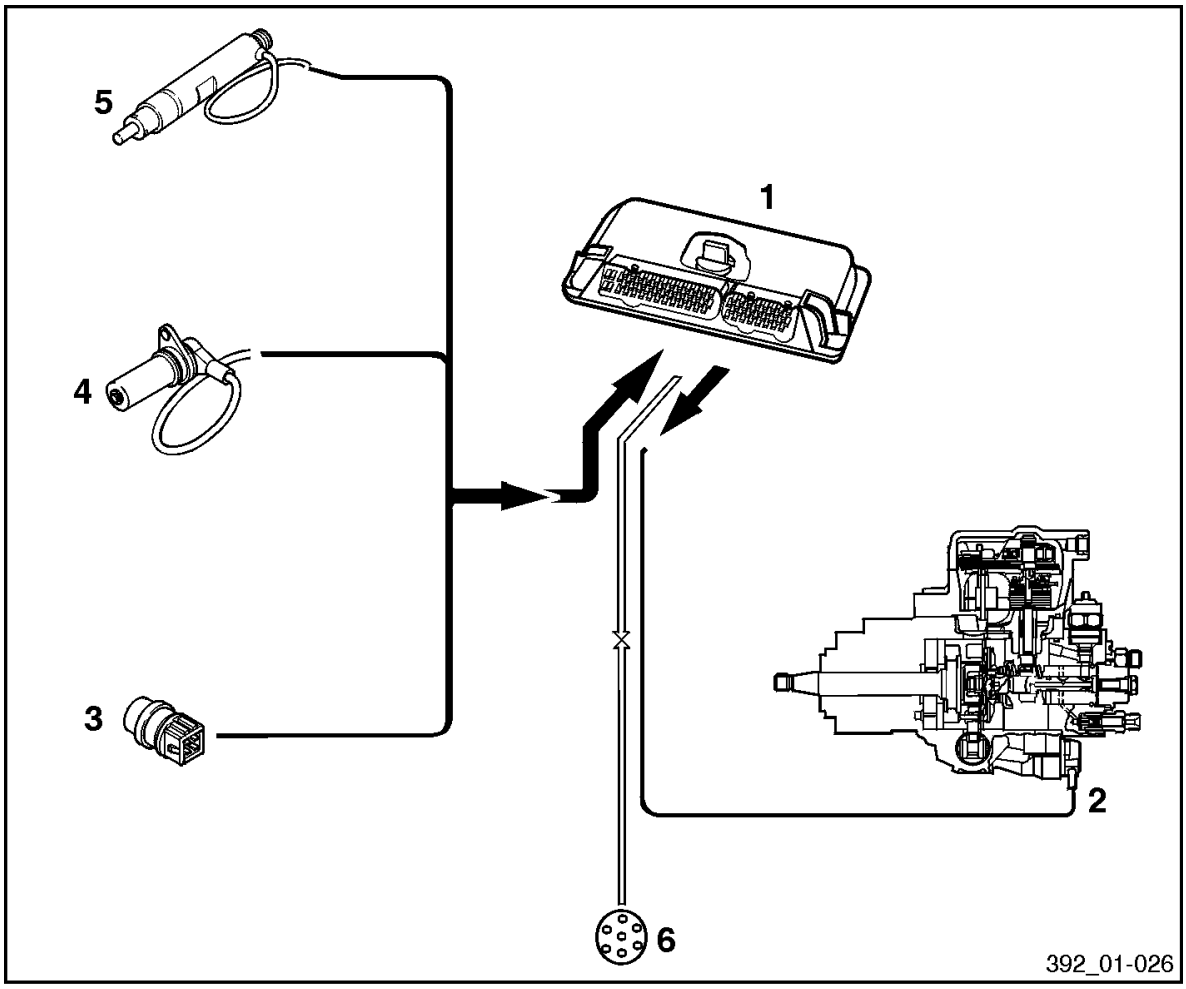
Desired resistance: 8 Ω

If no fault in the lines is detected:

➢ Replace the control unit for the direct diesel injection system 0N1

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Start of injection - governing



1	Controller for direct fuel injection	4	Engine speed sensor
2	Valve for start of injection	5	Needle lift sensor
3	Coolant temperature sending unit	6	Diagnostic plug 6X2

The start of the injection has an influence on various engine characteristics such as starting behaviour, fuel consumption and exhaust gas emission. These correlations are taken into account in programmed characteristic maps for the start of injection.

The purpose of ignition timing is to determine the right moment for the delivery of the fuel to the injection nozzles. The required high accuracy of the start of injection is ensured by the closed-loop control.

Start of injection - executed functions

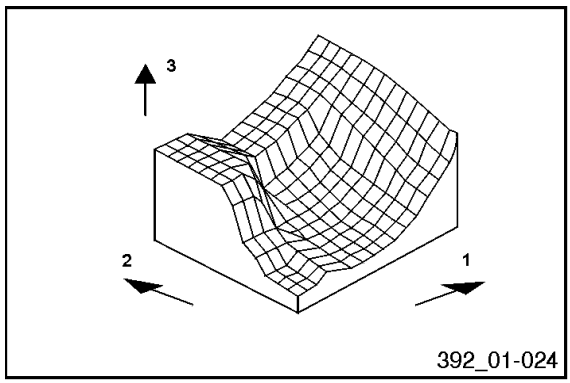
The following functions are governed with the start of injection:

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- Calculation of start of injection on the basis of characteristic map data
- Correction of the start of injection in the warm-up phase
- Governing the start of injection during starting and overrun operation

Start of injection - calculation of characteristic map data

Programmed characteristic maps for the start of injection serve as a basis for the calculation of the start of delivery. The actual start of injection is recorded by the needle stroke sensor directly at the nozzle. This measured value is compared with the map data. The difference causes a change of the control for the solenoid valve at the injection timing device. The control is changed until the system deviation is zero.



1 Engine speed
2 Fuel mass
3 Start of injection

Start of injection - constant value governing during the warm-up phase

During the starting process and in the warm-up phase, the start of injection is governed with constant values. The electronic control unit corrects the start of injection depending on the coolant temperature. When the coolant temperature decreases, the start of injection is "retarded". Conversely, with increasing engine temperature the start of injection is "advanced". This improves the ignition performance of the fuel at low temperatures.

Start of injection - when starting the engine

The time of the start of injection during starting is also governed on the basis of the coolant temperature. The start of injection is advanced to improve starting.

Start of injection - dynamic check and adjustment

The dynamic check and corrections of the start of injection is only possible in the function "basic setting".

As a general rule, the start of injection must be checked and, if necessary, adjusted after the toothed belt has been replaced and after any screws at the injection pump or the sprockets have been unscrewed.

Required special tools

- Torque spanner (5 - 50 Nm)

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- Laptop with software
- Interface cable (diagnostic connector to laptop) 300 365 2503

Test and adjustment prerequisites

- Basic mechanical setting of the engine OK
- Toothed belt tension OK
- Operate the engine at lower idle speed

Test procedure

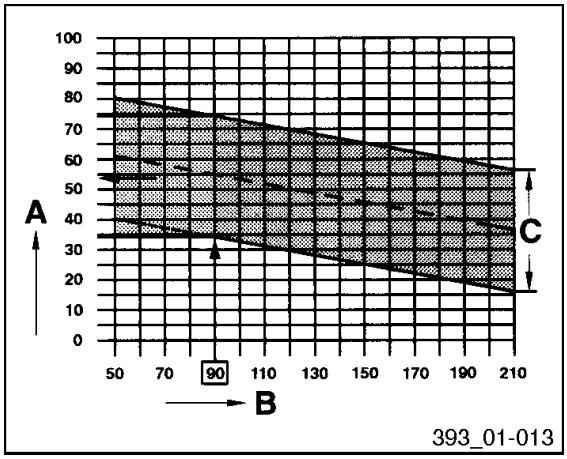
➢ Connect the laptop and diagnostic connector with interface cable.

➢ Start the diagnostic program"Pathfinder".

➢ Select the button "Basic setting" in the "Inputs and outputs" menu.

➢ Follow the prompts given by the software.

➢ Read the example diagram.



The start of injection in the Display field depends on the fuel temperature in the Display field.

A	Display field for start of injection
B	Display field for fuel temperature
C	Desired range for start of injection

Reading example:

The number 90 in Display field (B) corresponds to a numerical value ranging from 34 - 73 in Display field (A).

NOTE

If the start of injection is in the desired range during the check, no adjustment is necessary. After repairs like: Injection pump installation and removal, valve timing adjustment, the start of injection must be set to the mean value of the desired range.

If the start of injection is outside of the desired range, adjust the start of injection as follows:

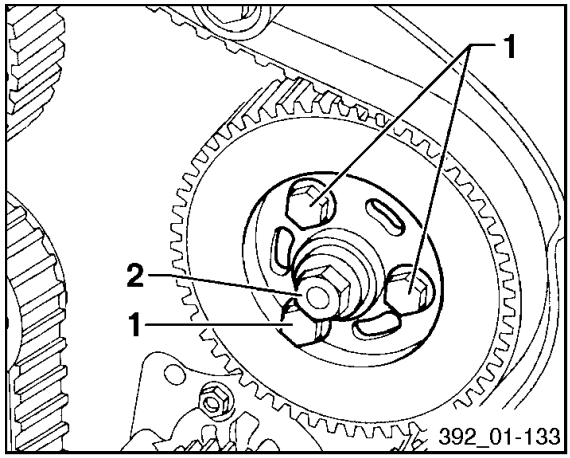
➢ Remove the upper toothed belt guard.

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➢ Loosen the two fastening bolts (1) at the injection pump sprocket.

➢ Install a 22 mm ring spanner on the hub nut (2) to hold the pump shaft.

▷



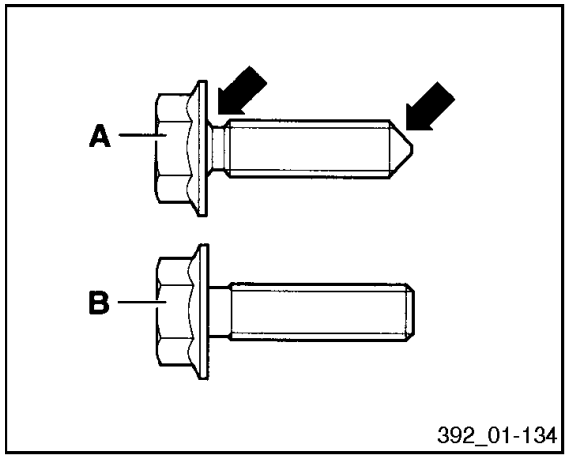
NOTE

Do not loosen the nut (2) for the hub. If so, the basic adjustment of the injection pump will be out of adjustment and it can not be adjusted with workshop tools.

➢ Loosen the third injection pump sprocket fastening bolt and turn the pump shaft slightly:

Anti-clockwise	To retard start of injection
Clockwise	To advance start of injection

▷



Type **A**: Fastening bolts machined on shaft and tip (arrows)

NOTE

*The fastening bolt type **A** may only be used once as they are anti-fatigue screws.*

After the dynamic check of the start of injection, the fastening bolts must be retightened 90° (¼ turn).

➢ Tighten the new injection pump sprocket fastening bolts.

Torque: 20 Nm

Type **B**: Fastening bolts not machined on shaft and tip

NOTE

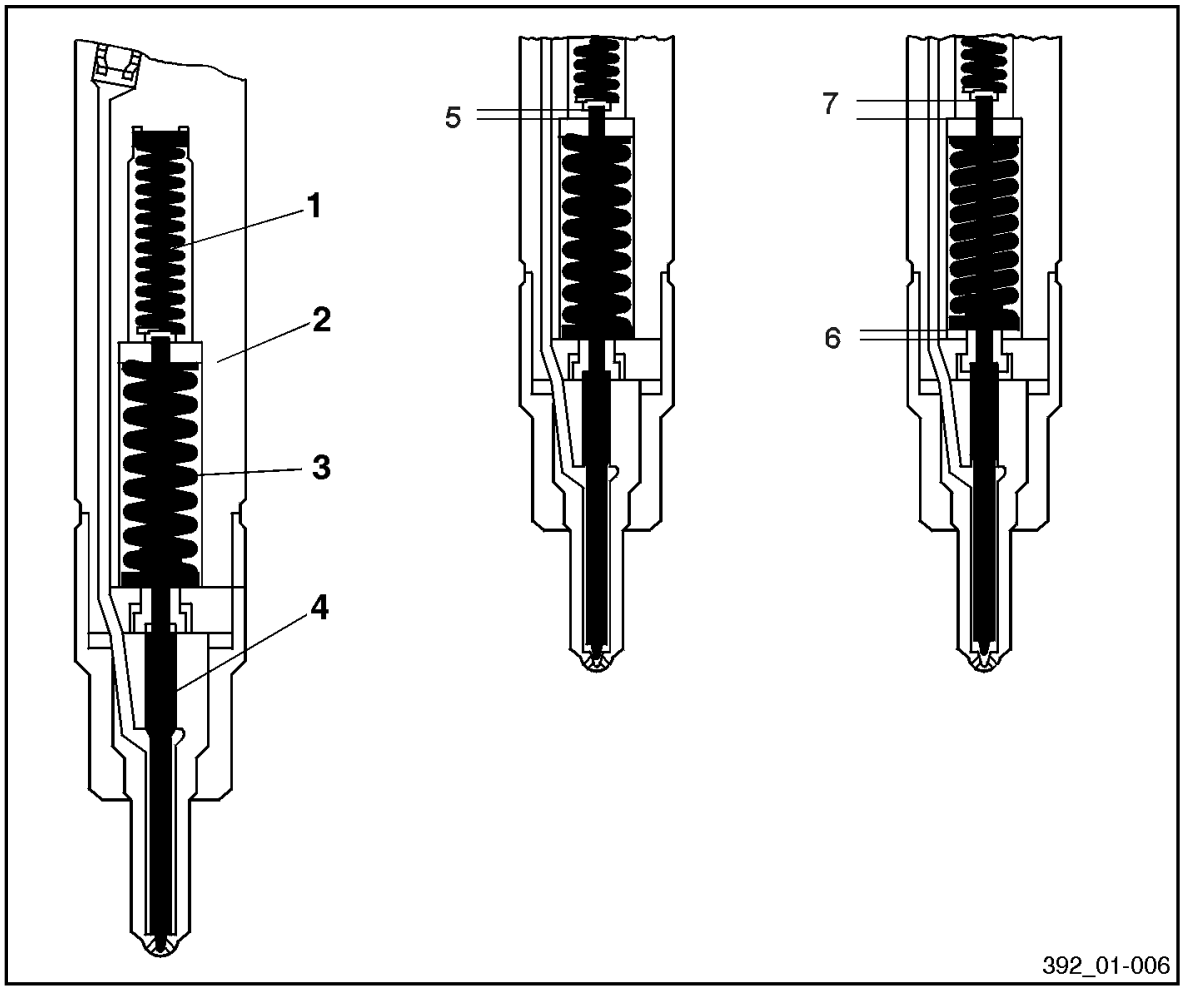
*Do not replace type **B** fastening bolts.*

➢ Tighten the old injection pump sprocket fastening bolts.

Torque: 25 Nm

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Injection nozzles - two-spring nozzle holder



To reduce the combustion noise to a minimum and also reduce the mechanical load, a slow pressure increase in the combustion chamber is necessary.

Moreover, the fuel should not be injected abruptly, but continuously over a longer period of time.

A two-spring nozzle holder was developed for the 1.9-litre engine to make combustion smoother. With this nozzle fuel injection pump proceeds in two steps.

Two-spring nozzle holder - method of operation

Step 1 (prestroke)

The nozzle holder (2) has two springs of different strengths. These are adjusted to each other in such a way that at the beginning of injection the nozzle needle is lifted against the power of spring 1 (1) only. Initially, only a small quantity of fuel is

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injected at a low pressure (p = 190 bar) through the gap which arises as a result of stroke 1 (5).

This leads to a smooth pressure increase of the combustion pressure, thus creating the ignition conditions for the main fuel quantity.

Step 2 (total stroke)

The injection pump continues to deliver fuel. This leads to a pressure rise in the injection nozzle, because the delivered fuel quantity cannot run off through the small gap. Due to this pressure rise, the force of spring 2 (3) is overcome and the nozzle needle (4) is raised by stroke 2 (6)to the total stroke (7).

The main injection of the residual amount is effected at a higher injection pressure (p = 300 bar) through the enlarged gap.

Injection nozzles - check

NOTE

NOTE: In case the injection nozzles are defective, they must be replaced since neither a pressure adjustment nor repair is possible.

Required special tools

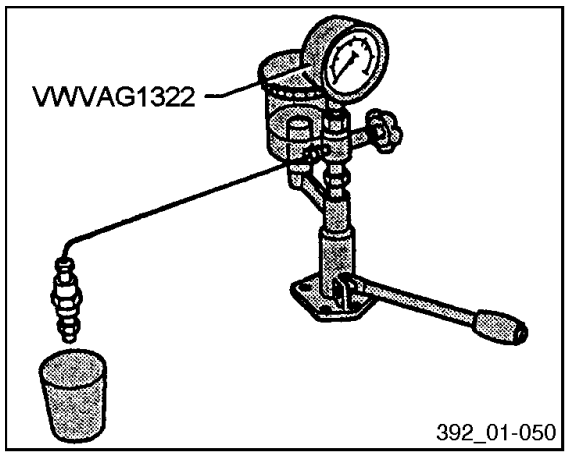
- Injection nozzle tester with pressure line VW VAG 1322

Checking the injection pressure

WARNING

During the test, the fuel comes from the nozzle with high pressure. The fuel jet can penetrate the skin and cause serious injury.

Never expose parts of the body to the fuel jet. Wear protective goggles.



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➢ Connect the injection nozzle to the nozzle tester.

➢ Depress the pump lever slowly. Read the injection pressure at the start of injection.

If the injection pressure deviates from the desired pressure, replace the injection nozzles.

Desired pressures:

New nozzles:	220 bar
Wear limit:	200 bar

Nozzle leakage test

➢ Depress the pump lever slowly and hold a pressure of approx. 150 bar for 10 seconds. No fuel should leak from the nozzle tip.

➢ In case of leakage, replace the injection nozzle.

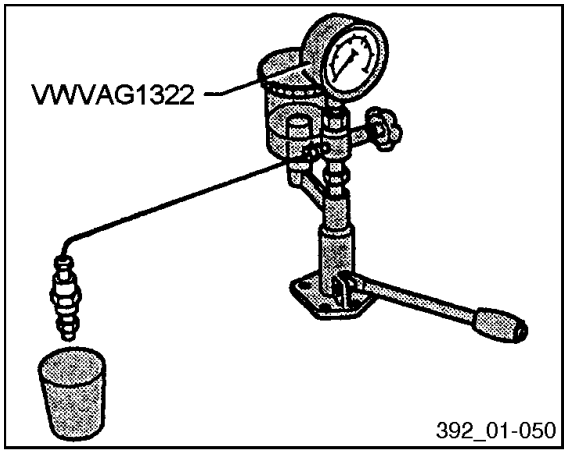
Injection nozzles - removal and installation

Defective nozzlesare found by loosening injection line union nuts in succession while the engine is operated at fast idle speed. The nozzle is defective if the engine speed stays constant after the union nut is loosened.

Defective injection nozzles cause the following malfunctions:

- Backfiring
- Knocking in one or more cylinders
- Engine overheated
- Drop in performance
- Excessive black exhaust smoke
- High fuel consumption
- Increased blue smoke during cold start

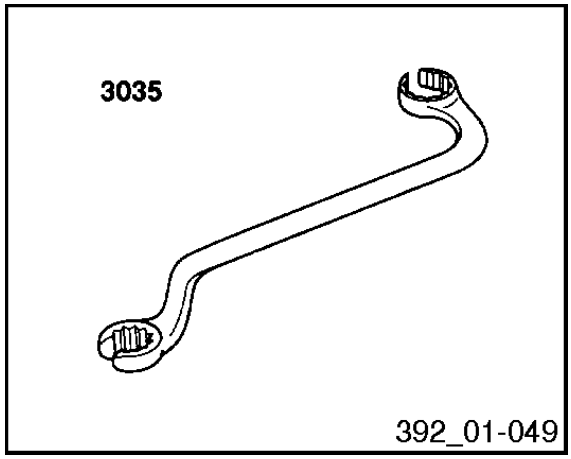
▷



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Required special tools

- torque wrench 5 - 50 Nm
- ring spanner VW 3035



Injection nozzles - removal

➢ Remove the injection lines with the open ring spanner VW 3035.

➢ Loosen the fastening screw, remove the clamp and withdraw the injection nozzle.

Injection nozzles - installation

NOTE

Always replace the protective seals between the cylinder head and injection nozzles.

➢ Install the injection nozzles.

➢ Pay attention to the correct seat of the bearing pedestals in the cylinder head.

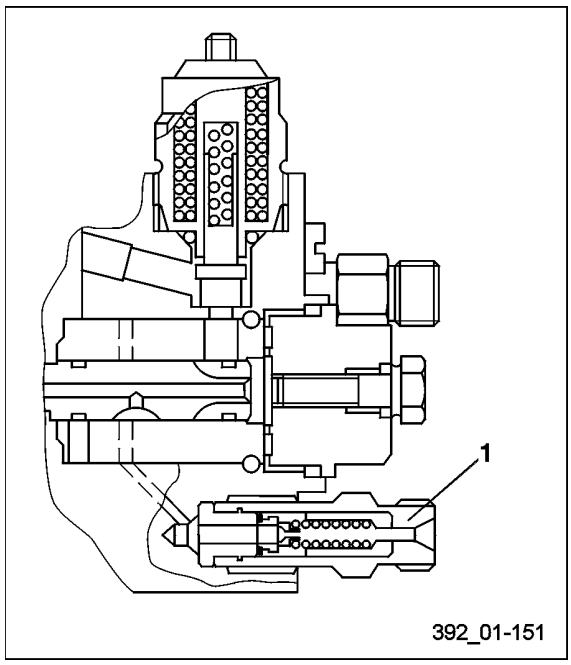
➢ Fit the clamps.

Tightening torques:

Fuel injection lines:	25 Nm
Screw for clamp:	20 Nm

One-way restrictor

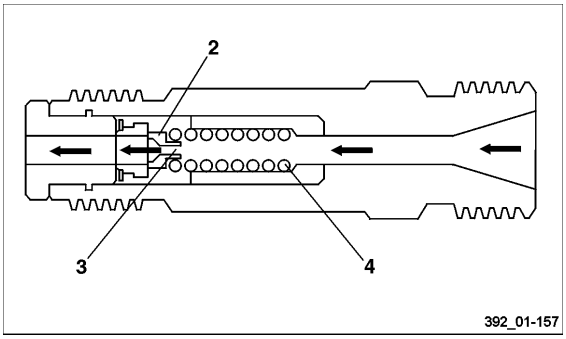
The one-way restrictor (1) is located in the pressure valve of the injection pump. The one-way restrictor avoids dribbling at the injection nozzle and the formation of bubbles in the injection line.



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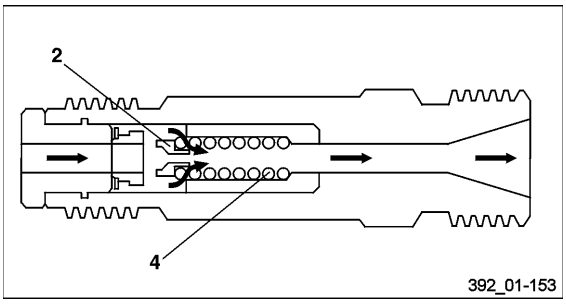
One-way restrictor - return flow function

During the return flow, the valve plate (2) shuts off the main passage by means of the power of the compression spring (4). The fuel flows only through the throttle passage (3). This dampens an existing pressure wave.



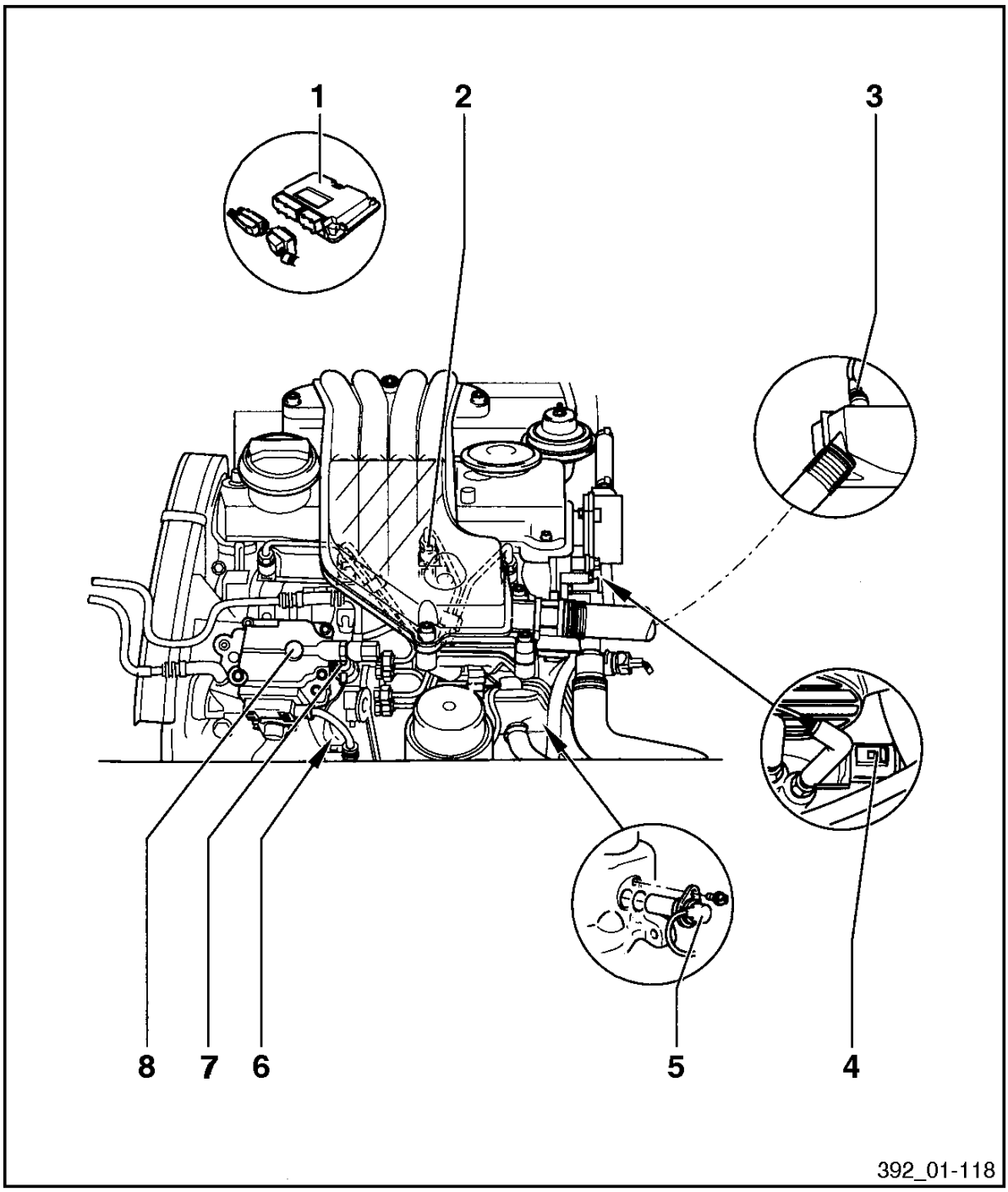
One-way restrictor - fuel supply function

When the fuel is delivered, the valve plate (2) is lifted up by the pressure of the fuel and the restrictor has no effect. The fuel flows through the main passage.



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Injection system - overview



1	Control unit for injection system 0N1
2	Injection nozzle with needle stroke sensor 0B5
3	Intake pipe temperature sending unit 0B4
4	Coolant temperature sending unit 0B1
5	Engine speed sensor 0B2
6	Start of injection valve 0Y2
7	Fuel shut-off valve 0Y1
8	Fuel quantity regulating mechanism of the injection pump with fuel temperature sending unit 0B3

The control unit of the direct injection unit is equipped with a fault history. The fault history must be displayed and an actuator diagnosis

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has to be carried out before any repairs and adjustments and fault finding are carried out.

The control unit can detect and store faults when testing and adjusting. For this reason the fault history must be cleared after the completion of testing and adjusting activities.

WARNING

If the engine is to be operated at cranking speed without starting the engine (eg for the compression check), fuel can be ejected at the injection nozzles, causing severe skin injuries.

Pull the plug off the fuel shut-off valve at the injection pump.

CAUTION

Short can occur when testing the injection and preheating systems.

Connect/disconnect the preheating and injection system cables and also the tester leads only with the ignition switched off.

NOTE

The following five rules for cleanliness should be observed when working on the fuel supply/injection system:

- Before disconnecting any connections, clean the junction points and the surrounding area thoroughly.
- Put dismantled parts on a clean surface and cover them. Use lint-free cloths.
- If the repair is not carried out immediately, cover or seal open components with care.
- Install only clean parts. Do not take spare parts out of the packing before they are actually installed. Do not use parts which were stored without packing (eg in tool boxes).
- If the system is open: Do not work with compressed air if at all possible. Do not move the truck if possible.
- Moreover, make sure that no diesel fuel drops on the coolant hoses. In such a case, the hoses must be cleaned immediately. Affected hoses must be replaced.

Injection system - supply voltage check

Required special tools

- Test adapter 7 917 299 010
- Multimeter
- Wiring diagram

Prerequisites for testing

- Battery voltage is correct

Test procedure

➢ Turn off the ignition.

➢ Connect the test adapter to the control unit cable loom.

➢ Measure the supply voltages.

If the specified value is not obtained:

➢ Check the voltage supply relay, terminal 30.

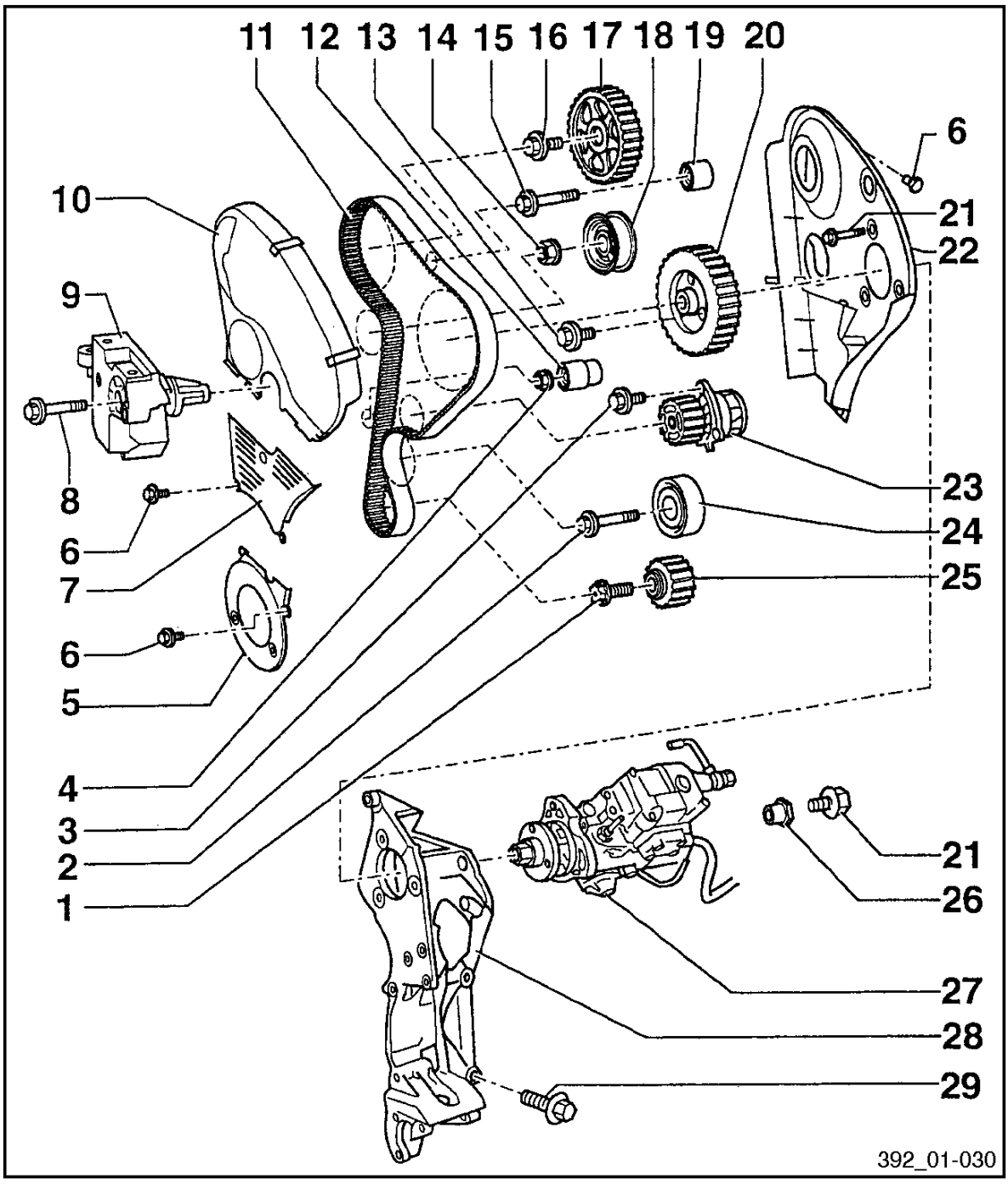
➢ Check the line connections in accordance with the circuit diagram for interruption, short circuit and resistance at the contact points.

If the lines or the relay are not defective:

➢ Replace the control unit for direct injection system 0N1.

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Injection pump - removal and installation, toothed belt replacment



1	Bolt (torque 120 Nm)	12	Reflection pulley
2	Bolt (torque: 40 Nm)	13	Bolt (torque 20 Nm)
3	Bolt (torque 15 Nm)	14	Bolt (torque 20 Nm)
4	Bolt (torque 22 Nm)	15	Bolt (torque 20 Nm)
5	Lower toothed belt guard	16	Bolt (torque 45 Nm)
6	Bolt (torque 10 Nm)	17	Camshaft sprocket
7	Middle toothed belt guard	18	Spring-loaded idler pulley
8	Bolt (torque 45 Nm)	19	Reflection pulley
9	Engine mount	20	Injection pump sprocket, bipartite
10	Upper toothed belt guard	21	Bolt (torque 30 Nm)
11	Toothed belt	22	Rear toothed belt guard

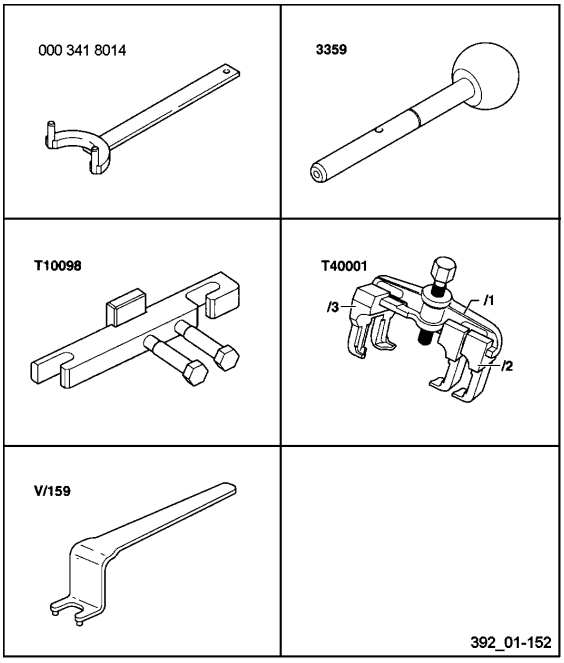
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23 Water pump
24 Reflection pulley
25 Toothed belt sprocket on crankshaft
26 Bush
27 Injection pump
28 Bracket
29 Bolt (torque 45 Nm)

Toothed belt - removal and installation, tightening

Required special tools

- Locating pin VW 3359
- Camshaft setting jig VW T10098
- Nut driver VW V 159
- Torque spanner (5 - 50 Nm)
- Puller VW T40001
- Holding jig 000 941 8014



NOTE

The toothed belt may only be adjusted with the engine cool.

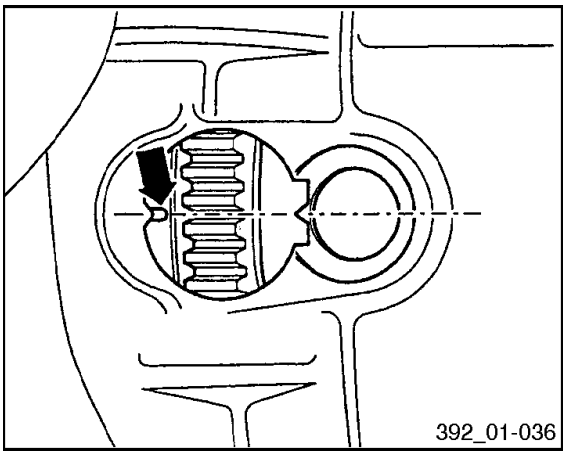
Toothed belt - removal

➢ Remove the upper toothed belt guard.

➢ Remove the vacuum pump.

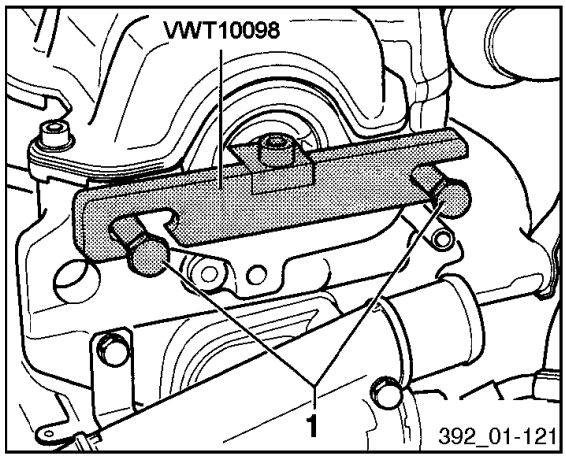
➢ Remove the ribbed V-belt.

➢ Turn the crankshaft until the TDC mark on the flywheel is in line with the mark on the intermediate housing.

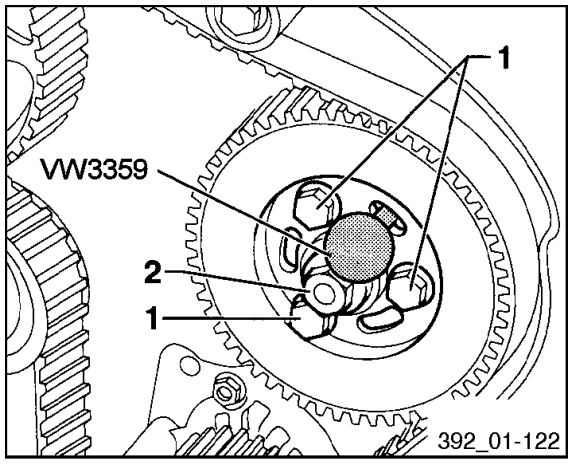


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- Screw the close-tolerance screws (1) into the cylinder head against the stop by hand.
- Lock the camshaft as shown with the camshaft setting jig VW T10098.



- Lock the injection pump sprocket with locating pin VW 3359.
- Loosen the fastening screws (1) of the injection pump sprocket.



NOTE

Do not loosen the nut (2) for the hub. If so, the basic adjustment of the injection pump will be out of adjustment and it can not be adjusted with workshop tools.

- Loosen the idler pulley.
- Remove the vibration damper/pulley.
- Remove the rear and middle toothed belt guard.
- Mark the running direction of the toothed belt.
- Remove the toothed belt.
- Check the water pump for wear (see section "Water pump")

Toothed belt - installation

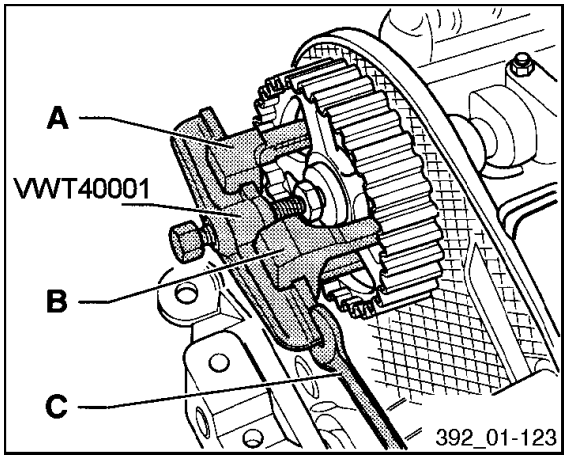
- Check the TDC mark on the flywheel or carrier plate. The mark must be aligned with the reference mark.
- Loosen the camshaft sprocket fastening bolt one turn. Hold the camshaft sprocket fastening bolt with the holding jig 000 941 8014.

NOTE

Never use the camshaft setting jig VW T10098 as holding jig to release and tighten the camshaft sprocket! Use the holding jig 000 941 8014.

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- Position the puller VW T40001 with the single claw (A) and the double claw (B) centrally on the camshaft sprocket and pull it off.
- Use an open-end spanner (C) as holding jig.
- Install the toothed belt on toothed belt sprocket of the crankshaft, reflection pulley, injection pump sprocket, water pump sprocket and spring-loaded idler pulley.
- Align the injection pump sprocket in the middle position in the elongated holes.
- Refit the camshaft sprocket together with the toothed belt and fix with the fastening screw (camshaft sprocket can still be turned).
- Tightening the toothed belt. Turn the nut driver (eg VW V 159) at the cam clockwise until the notch and the boss (arrow) are in line. ▷

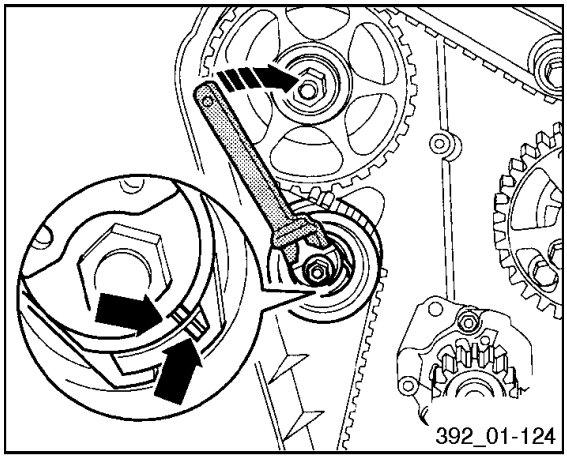


NOTE

If the cam was once turned too far once, the tension of the spring-loaded idler pulley must be fully relieved and retensioned. Do not turn the cam back by the dimension turned too far.

- Tighten the clamping nut on the spring-loaded idler pulley.

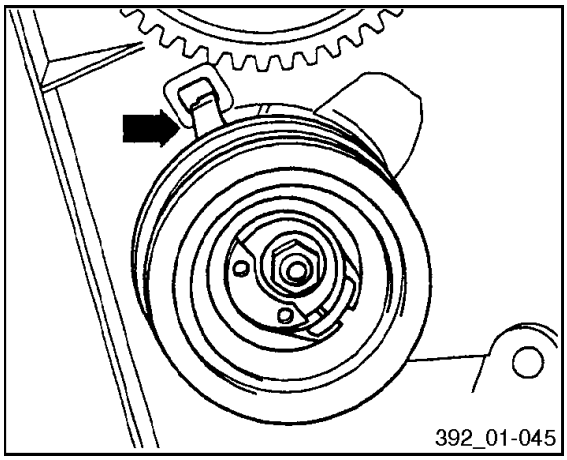
Torque: 20 Nm



- Recheck the TDC mark on the flywheel or carrier plate. ▷

NOTE

Pay attention to the correct seating of the spring-loaded idler pulley in the rear toothed belt guard (arrow).



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➢ Tighten the camshaft sprocket fastening screw.

Torque: 45 Nm

Fastening bolts for injection pump type **A**:

Fastening bolts machined on shaft and tip (arrows)

The fastening bolts may be used once only, since they are anti-fatigue bolts.

➢ Tighten the new injection pump sprocket fastening bolts.

Torque: 25 Nm

NOTE

After the dynamic check of the start of injection, the fastening bolts must be retightened 90° (¼ turn).

Fastening bolts for injection pump type **B**:

Fastening bolts not machined on shaft and tip

NOTE

Do not replace the fastening bolts.

➢ Tighten the old injection pump sprocket fastening bolts.

Torque: 25 Nm

➢ Remove the camshaft setting jig VW T10098 from the camshaft.

➢ Remove the locating pin.

➢ Rotate the crankshaft two turns in the direction of engine rotation and set to TDC for cylinder 1.

➢ Check the following points:

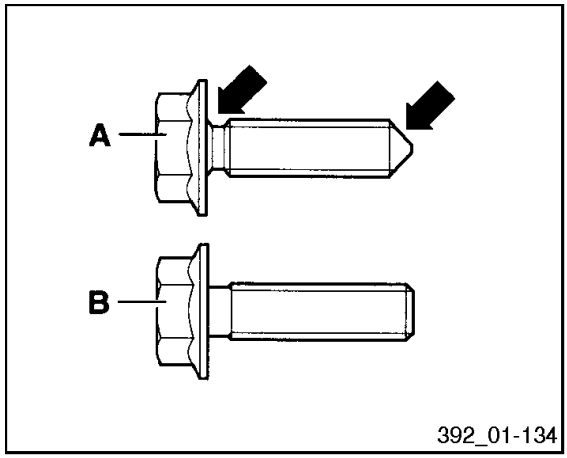
- the TDC mark on the flywheel or the carrier plate
- the camshaft setting jig in the camshaft
- the locating pin in the ijection pump sprocket
- the setting of the spring-loaded idler pulley (notch/boss or notch/arrow)

➢ Start the engine. Let it run for about 10 seconds, then stop the engine.

If the notch and boss or notch and arrow are not in line:

➢ Retighten the spring-loaded idler pulley and the fastening nut to 20 Nm.

▷



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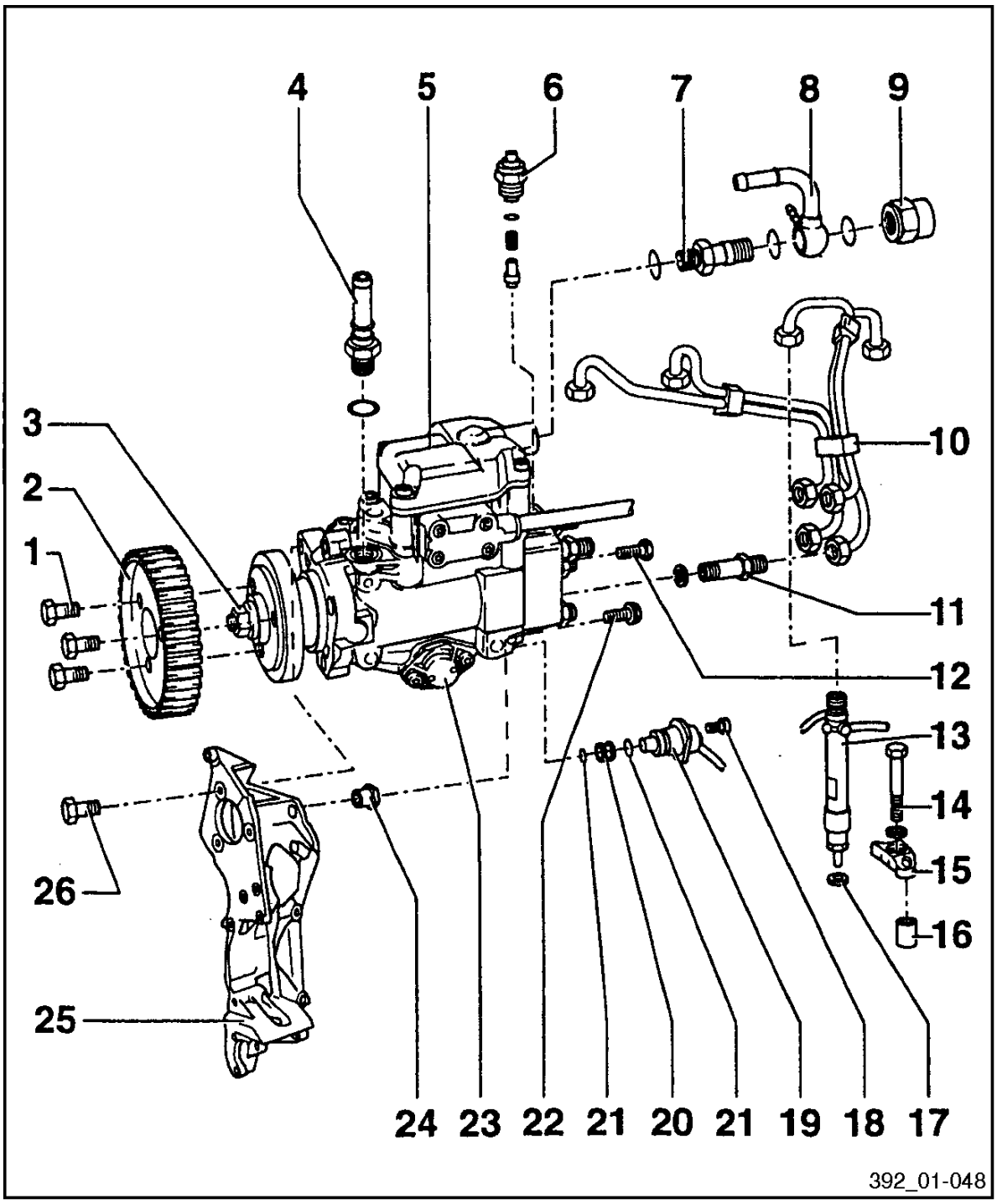
- Rotate the crankshaft two turns in the direction of engine rotation until the crankshaft is at TDC for cylinder 1 again.
- Repeat the check.
- Install the vacuum pump.

Torque: 20 Nm.

- Install the toothed belt guard and vibration damper/pulley.
- Install the ribbed V-belt.
- Check the start of injection dynamically and, if necessary, adjust it.

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Injection pump - removal and installation



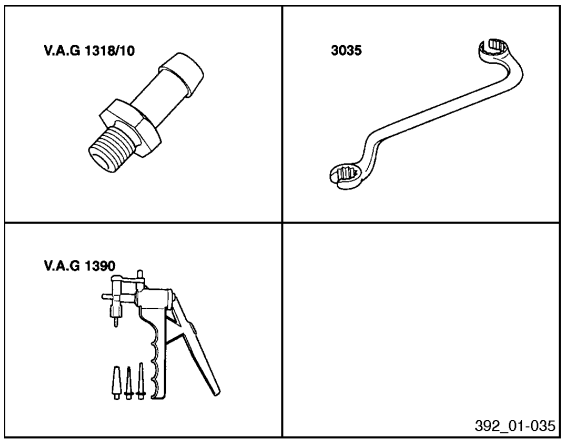
1	Bolt (torque 20 Nm)	11	Fitting with pressure valve (torque 20 Nm)
2	Injection pump sprocket	12	Screw (torque 25 Nm)
3	Fastening nut	13	Injection nozzle for cylinder 3 with needle lift sensor
4	Outlet - supply line		
5	Injection pump	14	Screw (torque 20 Nm)
6	Fuel shut-off valve (torque: 40 Nm)	15	Clamp
7	Inlet - return line	16	Bearing pedestal
8	Return line to control valve/fuel filter	17	Heat shield
9	Screw (torque 25 Nm)	18	Screw (torque 10 Nm)
10	Injection lines	19	Valve for start of injection

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20 Strainer
21 O-ring
22 Screw (torque 25 Nm)
23 Cover for injection timing device
24 Bush with nut
25 Bracket
26 Screw (torque 25 Nm)

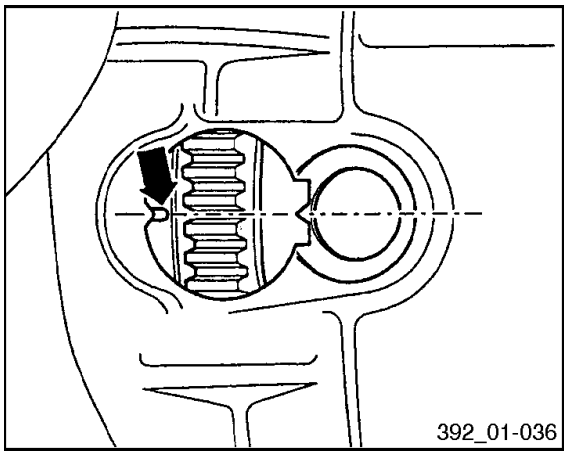
Required special tools

- Adapter VW VAG 131810
- Manual vacuum pump VW VAG 1390
- Ring spanner VW 3035



Injection pump - removal

➢ Set the crankshaft to TDC of cylinder 1 (arrow).



➢ Disconnect all fuel lines at the pump.

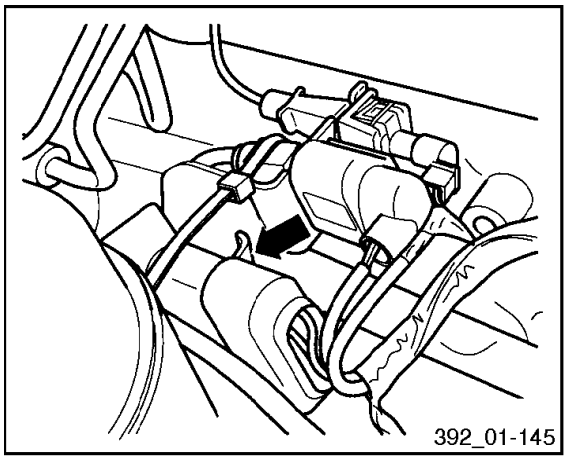
NOTE

To loosen the injection lines, use the open ended ring spanner VW 3035.

➢ Remove the toothed belt.

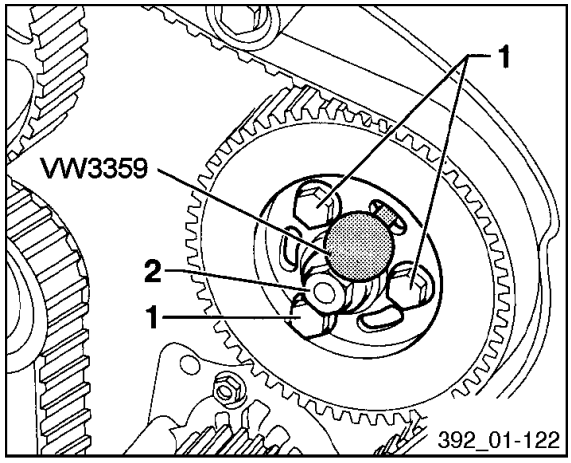
➢ Cover the openings with a clean cloth.

➢ Disconnect the 10-pin connector to the injection pump (arrow) and remove the plug from the holder.



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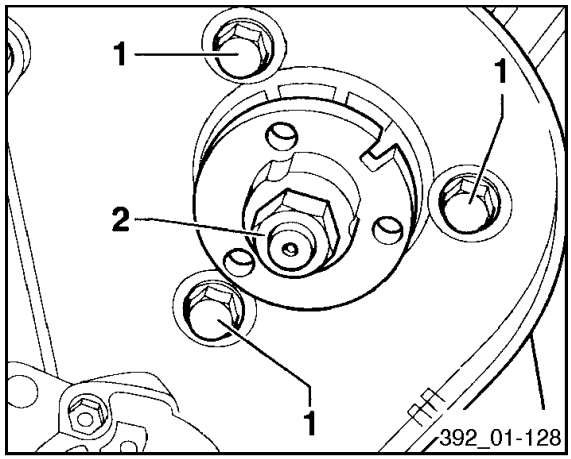
➢ Remove the loosened fastening screws (1) for the injection pump sprocket. ▷



NOTE

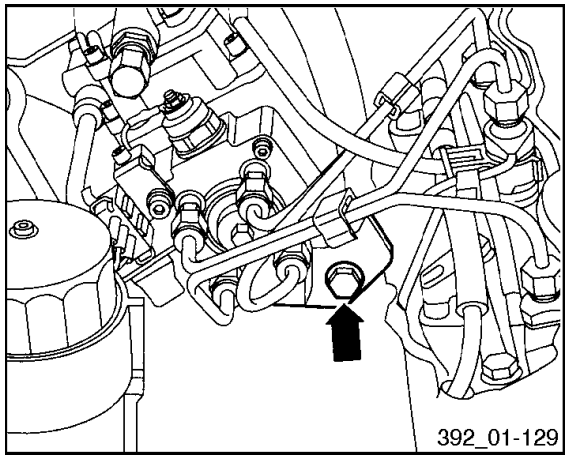
Do not loosen the nut (2) for the hub. If so, the basic adjustment of the injection pump will be out of adjustment and it can not be adjusted with workshop tools.

➢ Remove the fastening screws (1) from the retainer. ▷



➢ Remove the fastening screw from the rear support (arrow). ▷

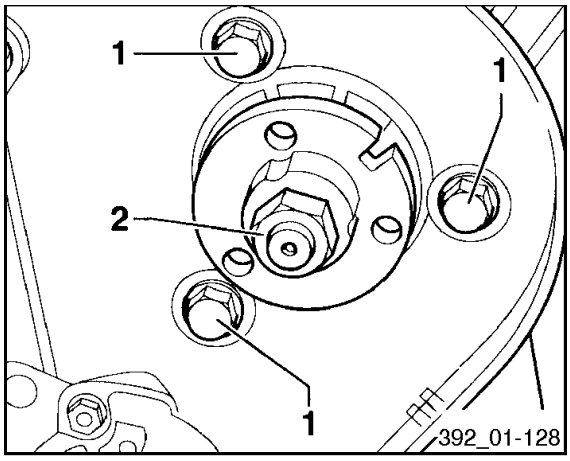
➢ Remove the injection pump.



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Injection pump - installation

➢ Position the injection pump in the compact holder and fasten the screw to the rear support with the fastening nut.



NOTE

*The fastening screws **machined** at the threaded shaft and tip **must** be replaced. Do **not** replace fastening screws **not machined** on the shaft and tip.*

➢ Insert the fastening screws (1) and tighten the screws.

Torque: 25 Nm.

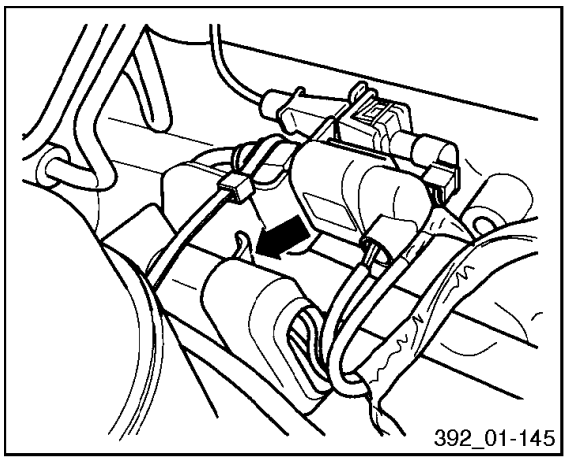
➢ Install, tension the toothed belt.

➢ Install the injection lines.

Torque: 25 Nm

➢ Fasten the supply line to the outlet on the injection pump.

➢ Connect the 10-pin connector to the injection pump (arrow) and the insert the plug in the holder.



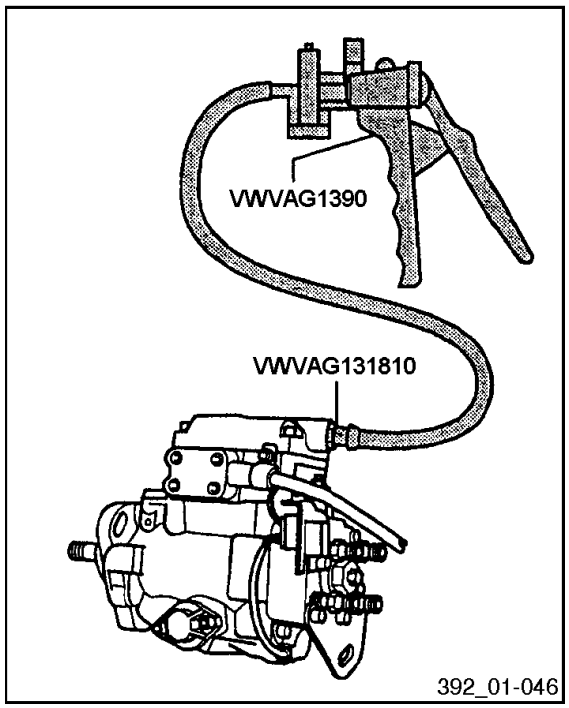
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Injection pump - filling with fuel

- Screw the adapter VW VAG 131810 into the return line port of the injection pump.
- Connect the manual vacuum pump VW VAG 1322 to the adapter with approx. 1 m of transparent plastic hose.
- Operate the manual vacuum pump until fuel emerges from the return line port. Do not draw the fuel into the manual vacuum pump.
- Remove the adapter VW VAG 131810 and install the union with the return line.

Torque: 25 Nm.

- Check the start of injection dynamically and, if necessary, adjust.
- Subsequently read out the fault history of the engine control unit.
- If necessary, clear the fault history



Injection pump - pump and toothed belt adjustment

Toothed belt - overview

Method of operation

The toothed belt drives the

- camshaft
- distributor injection pump
- water pump

The required wrap is brought about by two reflection pulleys, the tension is provided by the semi-automatic spring-loaded idler pulley.

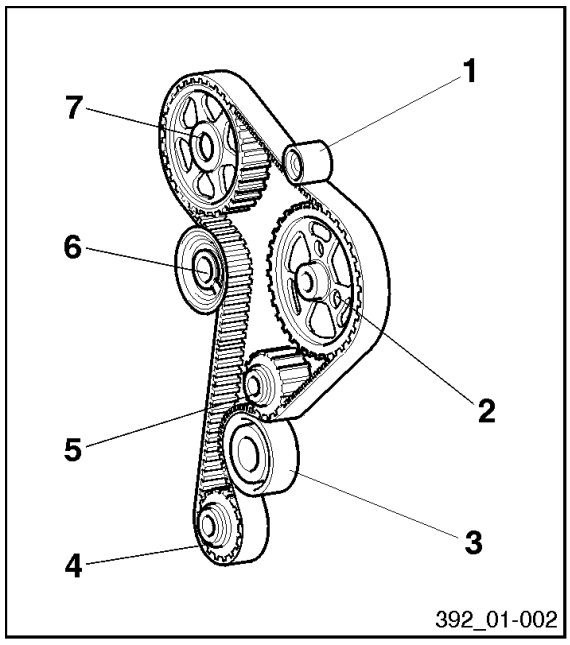
Toothed belt - adjustment

NOTE

There are marks for the adjustment of engine valve timing (position of crankshaft, camshaft and injection pump).

Crankshaft position

The top dead centre mark for cylinder 1 shows up on the flywheel in the inspection hole of the bell housing.

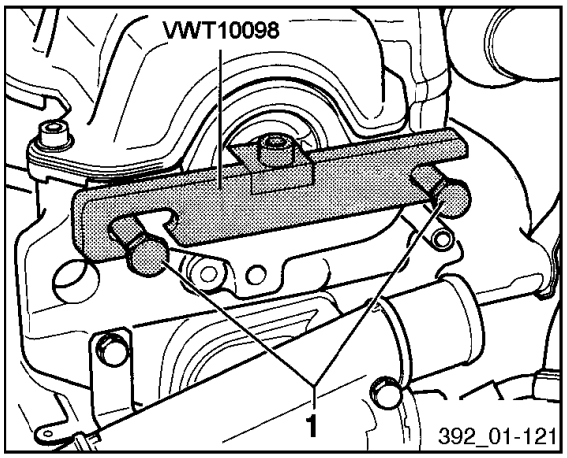


1 Reflection pulley
2 Injection pump sprocket
3 Reflection pulley
4 Sprocket - crankshaft
5 Water pump
6 Semi-automatic tensioner pulley
7 Camshaft sprocket

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Camshaft position

The correct position is fixed with a new adjusting ruler. The exact camshaft position is very important for precise valve timing when installing the toothed belt.



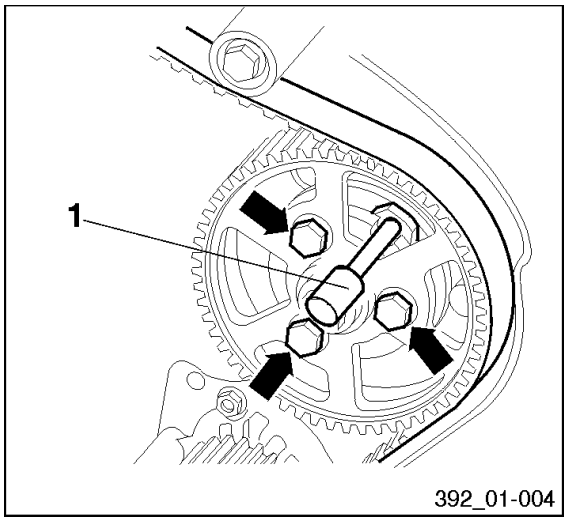
Injection pump sprocket

The injection pump is locked with the locating pin (1). The injection pump sprocket consists of two parts. A fine adjustment can be made by loosening the 3 screws (arrow).

NOTE

Do not loosen the nut for the injection pump hub. This would change the basic setting of the injection pump. It can not be adjusted with workshop tools.

The exact procedure is described in the section "Injection pump - removal and installation, toothed belt replacement".

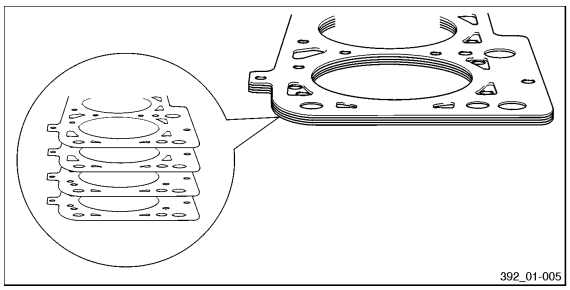


Cylinder head gasket

The cylinder head gasket is made of metal and is thus resistant to higher temperatures and pressures.

NOTE

When installing new parts like pistons, crankshaft, etc. the tolerances must be taken into consideration with the appropriate thickness of the cylinder head gasket.



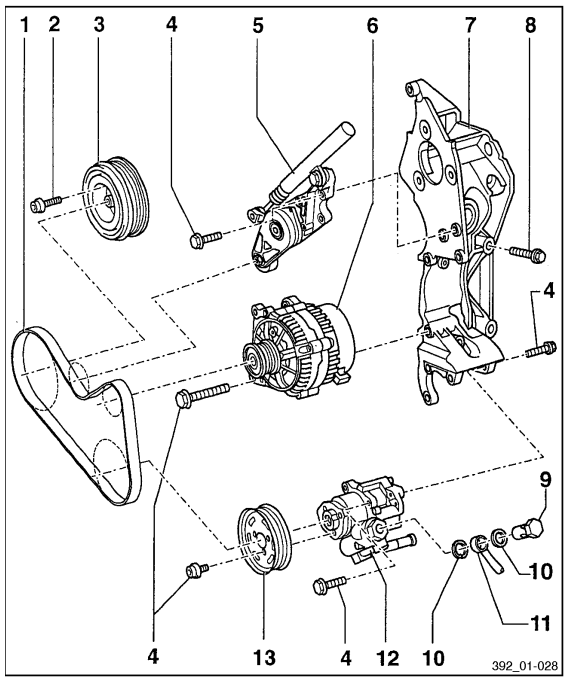
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Engine block

Ribbed V-belt - removal and installation ▷

Ribbed V-belt - removal

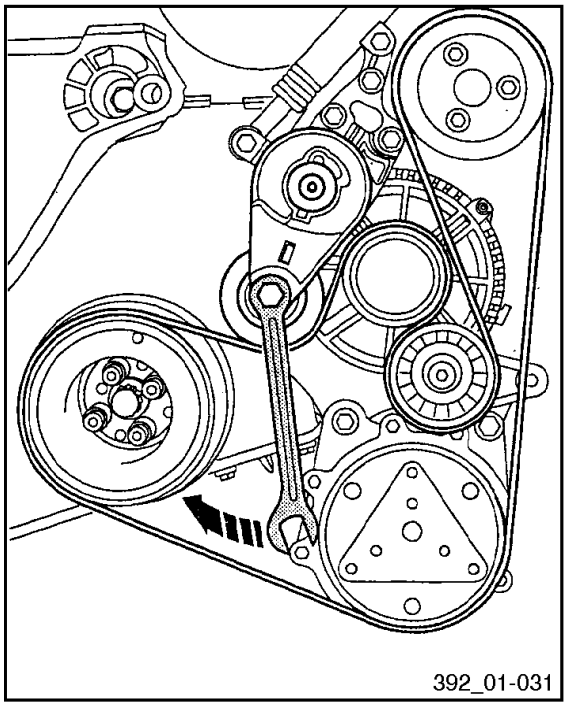
➢ Mark the running direction of the ribbed V-belt.



1	Ribbed V-belt
2	Bolt, torque 10 Nm
3	Pulley of vibration damper
4	Bolt, torque 25 Nm
5	Tensioner
6	Alternator
7	Compact holder for injection pump, three-phase alternator and vane pump
8	Bolt, torque 45 Nm
9	Banjo bolt, torque 30 Nm
10	Sealing ring
11	Pressure line
12	Steering pump

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➢ Swivel the spring-loaded idler pulley with a 16 mm flat ring spanner at the tensioning lever in the direction of the arrow



Ribbed V-belt - installation

Installation is carried out in the reverse order of removal.

NOTE

Before installation of the ribbed V-belt, make sure the running direction of the belt is correct and it is properly positioned in the pulleys.

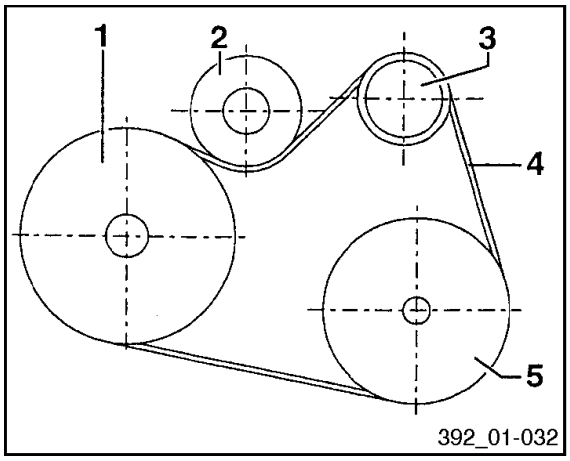
➢ For trucks **without** air conditioning: Place ribbed V-belt on alternator last.

➢ On trucks **with** air conditioning: Place ribbed V-belt on A/C compressor last.

Ribbed V-belt - A/C compressor drive belt routing

NOTE

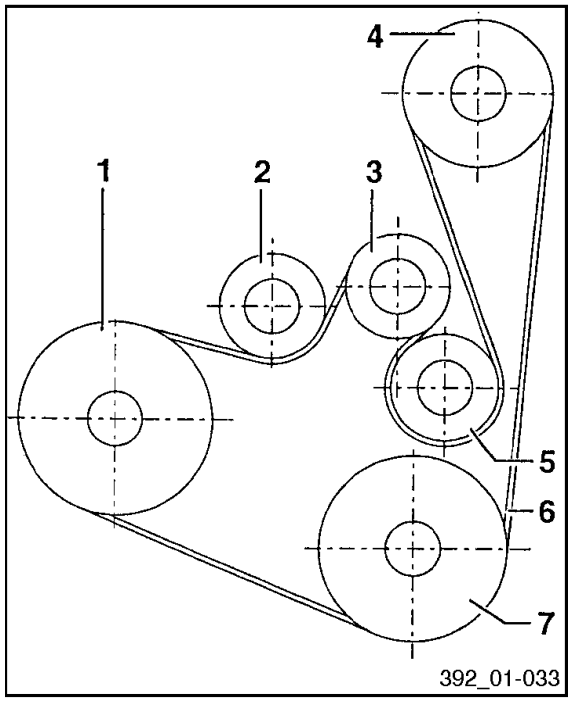
The car type is depicted. Linde trucks do not have a vane pump.



1 Pulley vibration damper
2 Spring-loaded idler pulley
3 Alternator pulley
4 Ribbed V-belt
5 Vane pump pulley for power steering

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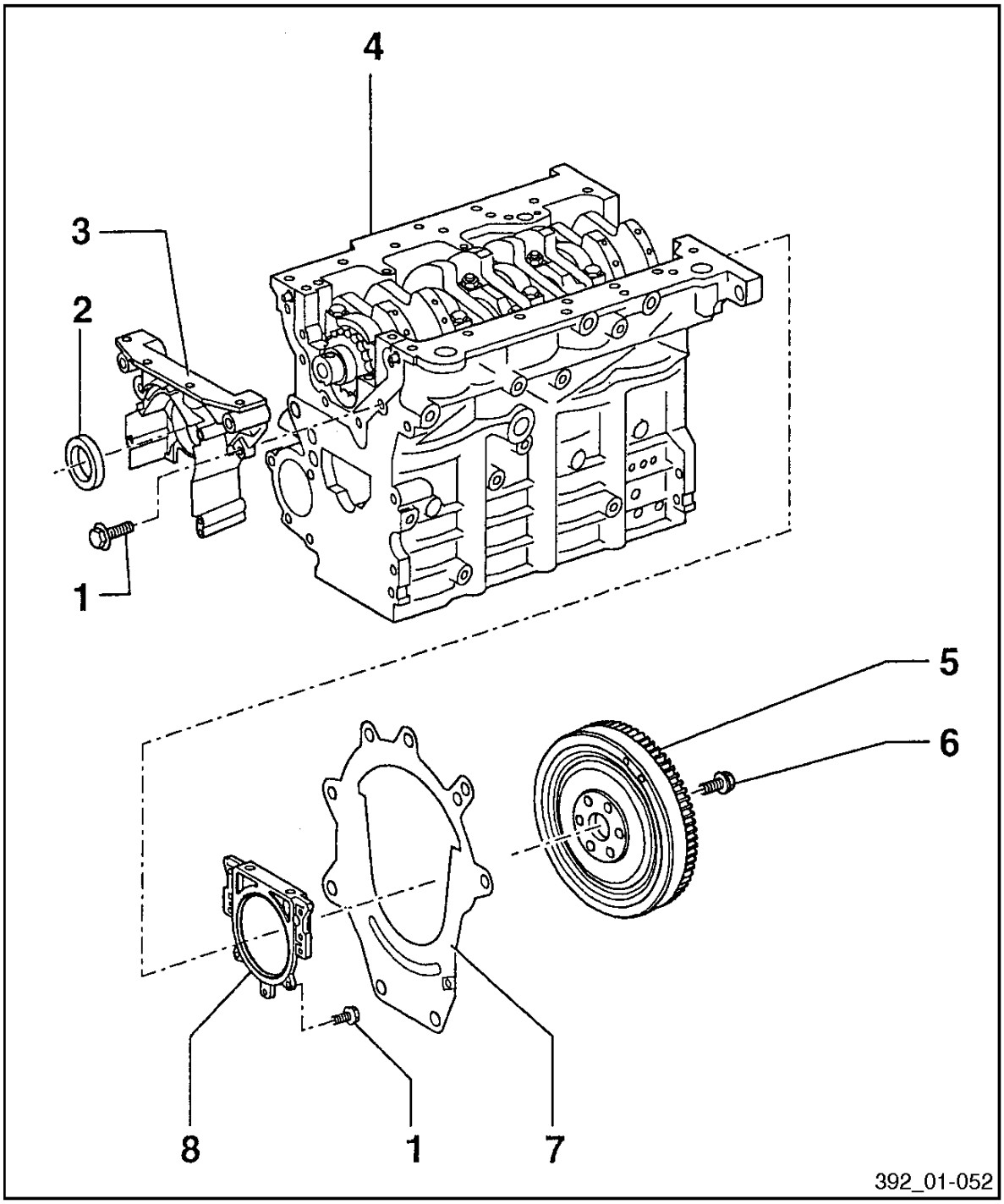
Ribbed V-belt - drive belt routing with A/C compressor ▷



1	Pulley vibration damper
2	Spring-loaded idler pulley
3	Alternator pulley
4	Vane pump pulley for power steering
5	Reflection pulley
6	Ribbed V-belt
7	Belt pulley for A/C compressor

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Crankshaft oil seal on pulley end - removal and installation

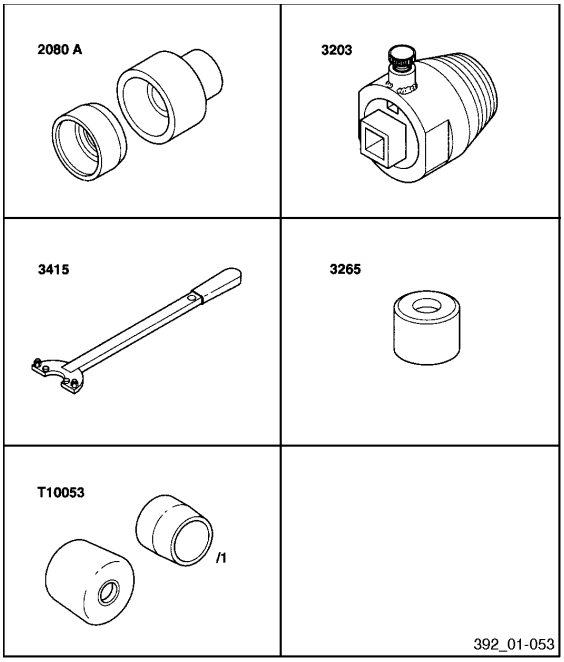


1	Bolt (torque 15 Nm)	5	Flywheel
2	Sealing ring	6	Bolt (torque 60 Nm)
3	Sealing flange	7	Intermediate plate
4	Cylinder block	8	Sealing flange

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Required special tools

- Guide bush VW 2080 A
- Holding jig VW 3415
- Sealing ring extractor VW 3203
- Clamping sleeve VW 3265
- Mounting device for PTFE design VW T10053
- Torque spanner (5 - 50 Nm)
- Torque spanner (40 - 200 Nm)



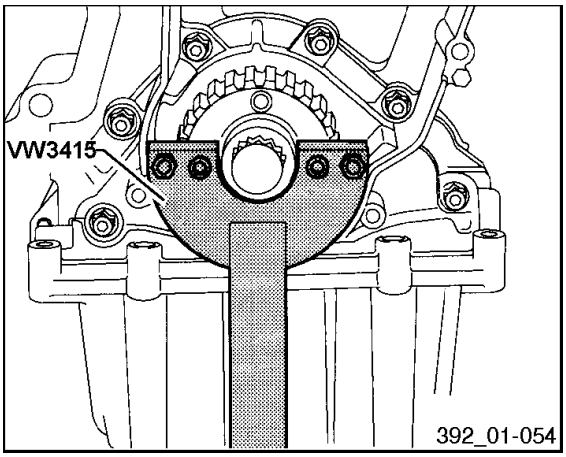
Sealing ring - removal

➢ Remove the ribbed V-belt

➢ Remove the toothed belt

➢ Remove the crankshaft sprocket. To do so, hold the pulley with the holding jig VW 3415.

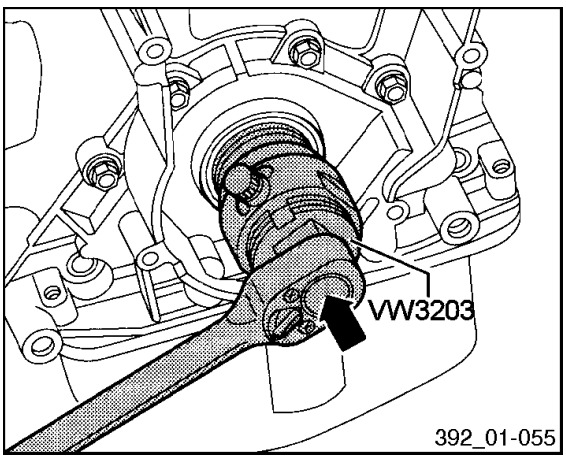
➢ To guide the seal extractor, screw the central screw manually as far as the stop into the crankshaft.



➢ Turn the internal part of the seal extractor VW 3203 by two turns (approx. 3 mm) out of the external part and lock with knurled screw.

➢ Grease the threaded part of the seal extractor with oil, position the extractor and screw it as far as possible into the sealing ring, applying strong pressure.

➢ Loosen the knurled screw and turn the internal part against the crankshaft until the sealing ring is pulled out.

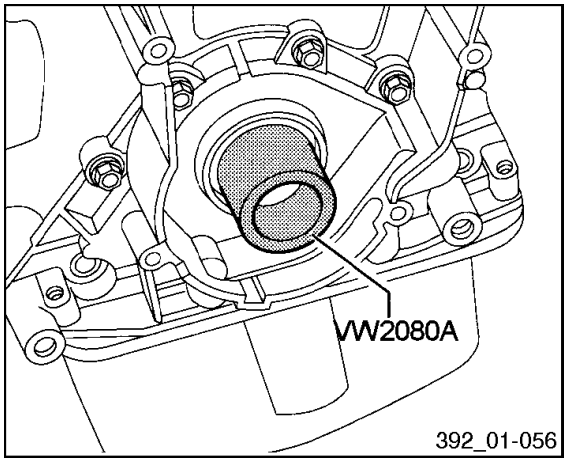


Sealing ring - installation

➢ Grease the sealing lip of the sealing ring slightly with oil.

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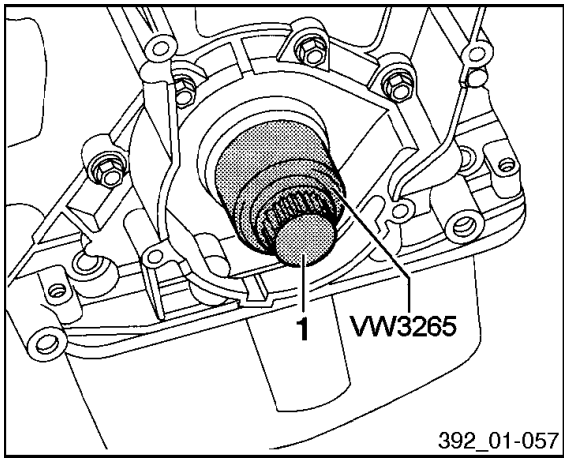
- Put the guide bush of VW 2080 A onto the crankshaft journal.
- Push the sealing ring over the guide bush.



- Use the clamping sleeve VW 3265 to press in the sealing ring with the central screw as far as the stop (1).
- Installing, tensioning the toothed belt

NOTE

Use of PTFE sealing rings (characteristic: without internal hose spring, sealing lip broader). Do not oil or grease the sealing lip of these seals.An early-type radial shaft seal (with internal hose spring) may only be replaced with a PTFE seal, but not vice versa

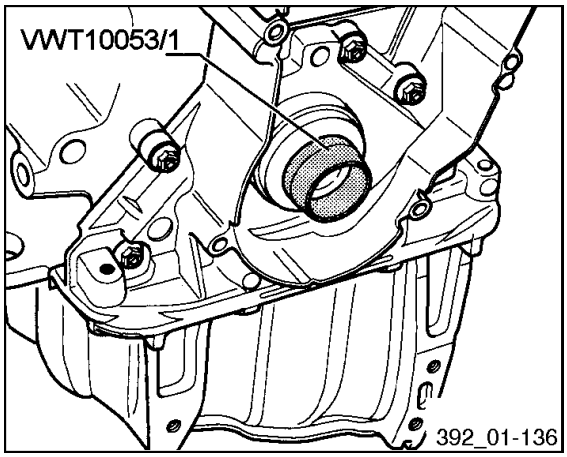


Installing the PTFE sealing ring

NOTE

Do not also oil or grease the sealing lip of the seal.

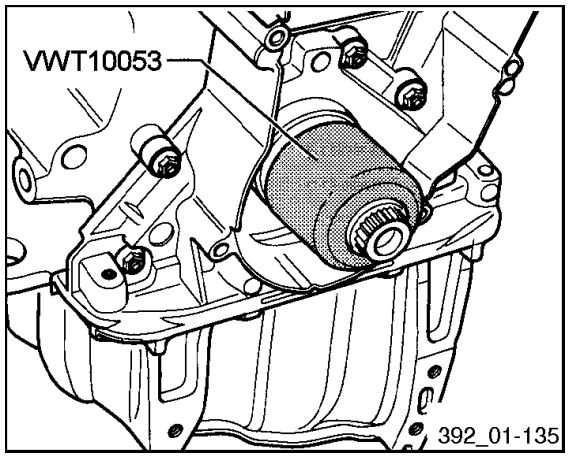
- Remove the oil residues on the crankshaft journal with a clean cloth.
- Put the guide bush VW T10053/1 onto the crankshaft journal.
- Push the sealing ring over the guide bush onto the crankshaft journal.



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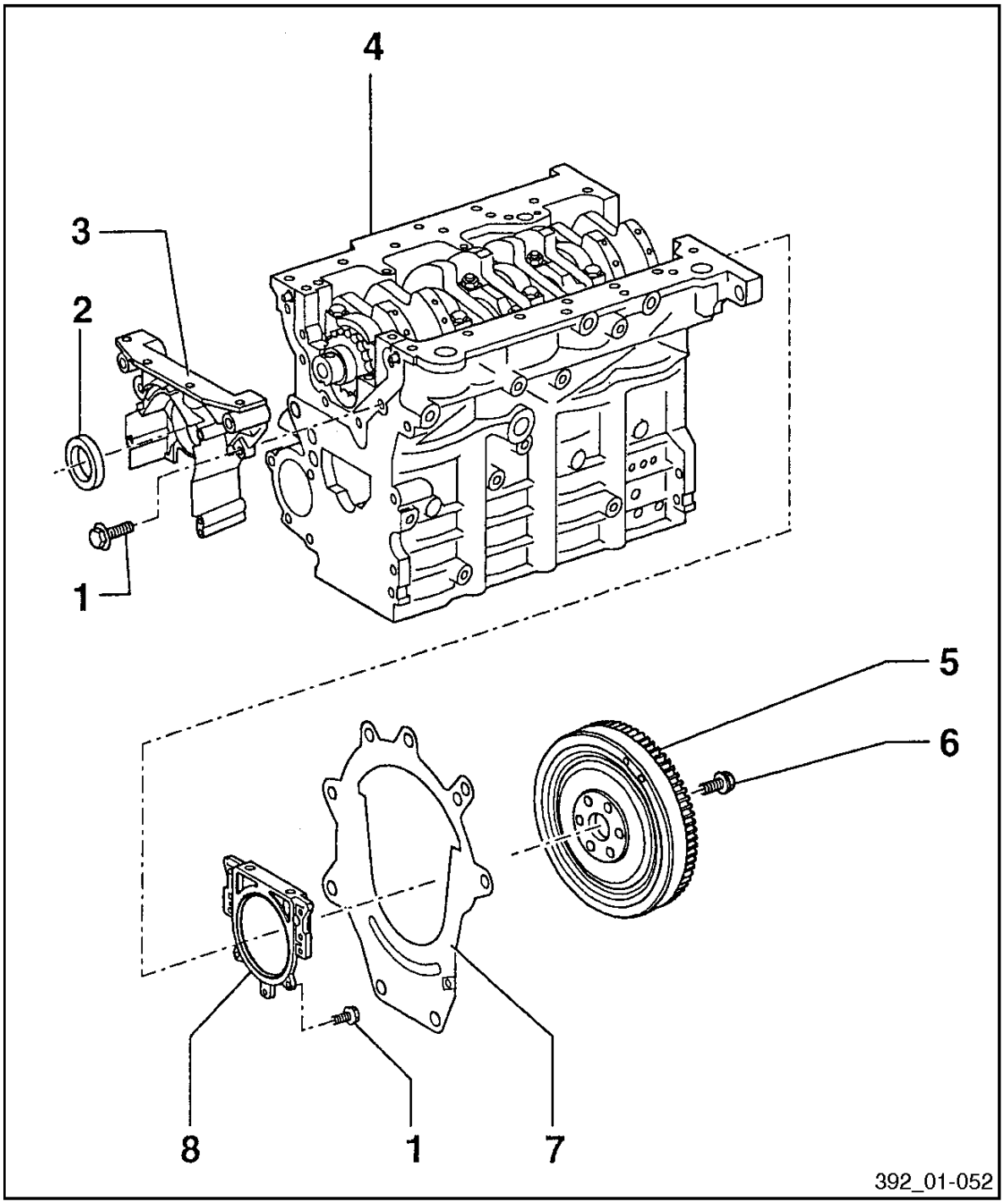
- Press in the sealing ring with the clamping sleeve VW T10053 and screw VW T10053/2 as far as the stop.
- Installing, tensioning the toothed belt
- Install the ribbed V-belt

▷



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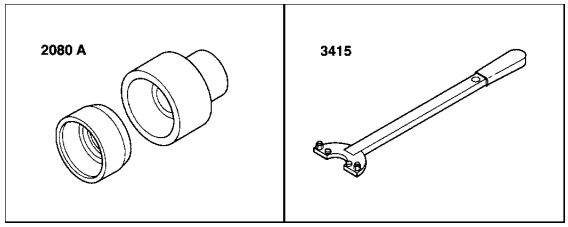
Crankshaft sealing flange - removal and installation



1	Bolt (torque 15 Nm)	5	Flywheel
2	Sealing ring	6	Bolt (torque 60 Nm)
3	Sealing flange	7	Intermediate plate
4	Cylinder block	8	Sealing flange

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Required special tools



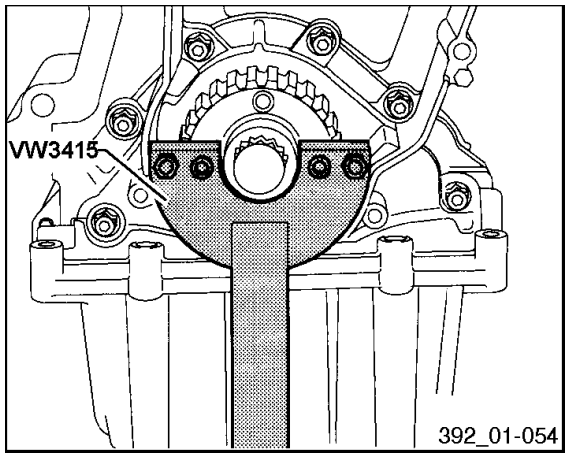
- Guide bush VW 2080 A
- Holding jig VW 3415
- Torque spanner 5 - 50 Nm
- Torque spanner 40 - 200 Nm
- Power drill with plastic brush insert
- Silicone sealant D 176404 A2
- Blunt scraper

Sealing flange - remove

➢ Remove the ribbed V-belt.

➢ Remove the toothed belt.

➢ Remove the crankshaft sprocket. To do so, hold the pulley with the holding jig VW 3415.



NOTE

When screwing on the holding jig, put two washers between the sprocket and jig.

➢ Drain the engine oil.

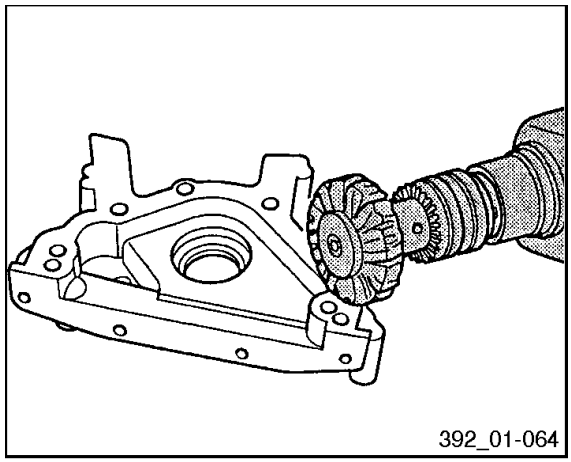
➢ Remove the oil sump.

➢ Unscrew the front sealing flange.

➢ Take the sealing flange off, hitting it lightly, if necessary, with a rubber mallet.

➢ Remove any sealant residues on the cylinder block with a blunt scraper.

➢ Remove any sealant residues on the sealing flange with a rotating plastic brush.



WARNING

The rotating brush loosens particles, which are flung off at high speed. These particles can cause eye injuries.

Wear protective glasses!

➢ Clean the mating faces. They must be free from oil and grease.

Sealing flange - installation

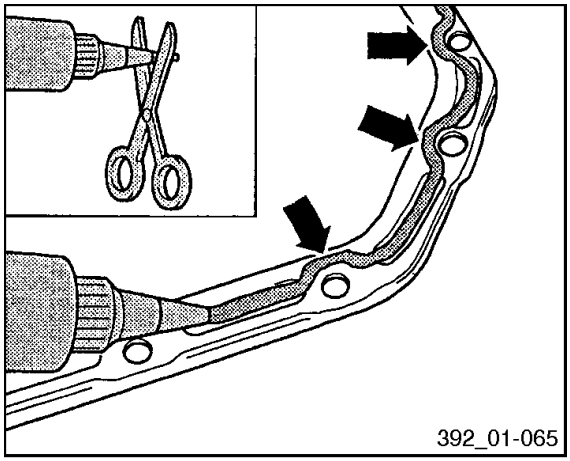
NOTE

Observe the use-by date of the sealant.

Once the silicone sealant has been applied, the sealing flange must be installed within 5 minutes.

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- Cut off the tube nozzle at the front mark (nozzle diameter approx. 3 mm).
- Apply the silicone sealant on the clean mating face of the oil sump as shown in the figure. The sealant bead (arrow) must have a thickness of 2 to 3 mm.

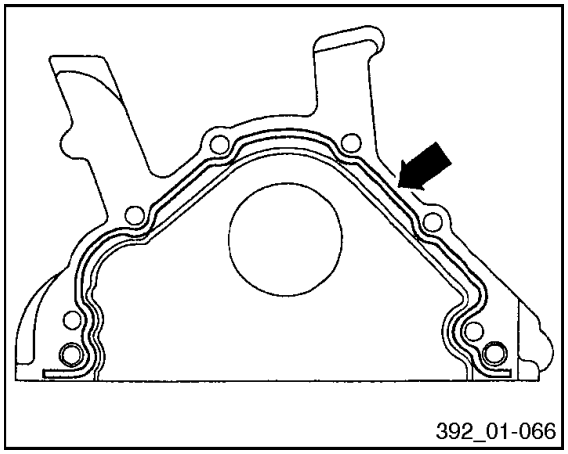


CAUTION

Any excess sealant can drop into the oil sump and clog the screen in the suction line, thus causing damage to the engine.

The sealant bead should not be thicker than 3 mm.

- Apply silicone sealant bead as shown in the figure on the clean sealing surface of the sealing flange.
- Position the sealing flange immediately and slightly tighten all screws.



NOTE

To position the sealing flange with the sealing ring mounted, use the guide bush from WM 298.

- Fasten the sealing flange by tightening opposite screws.

Torque: 15 Nm

- Install the oil sump.

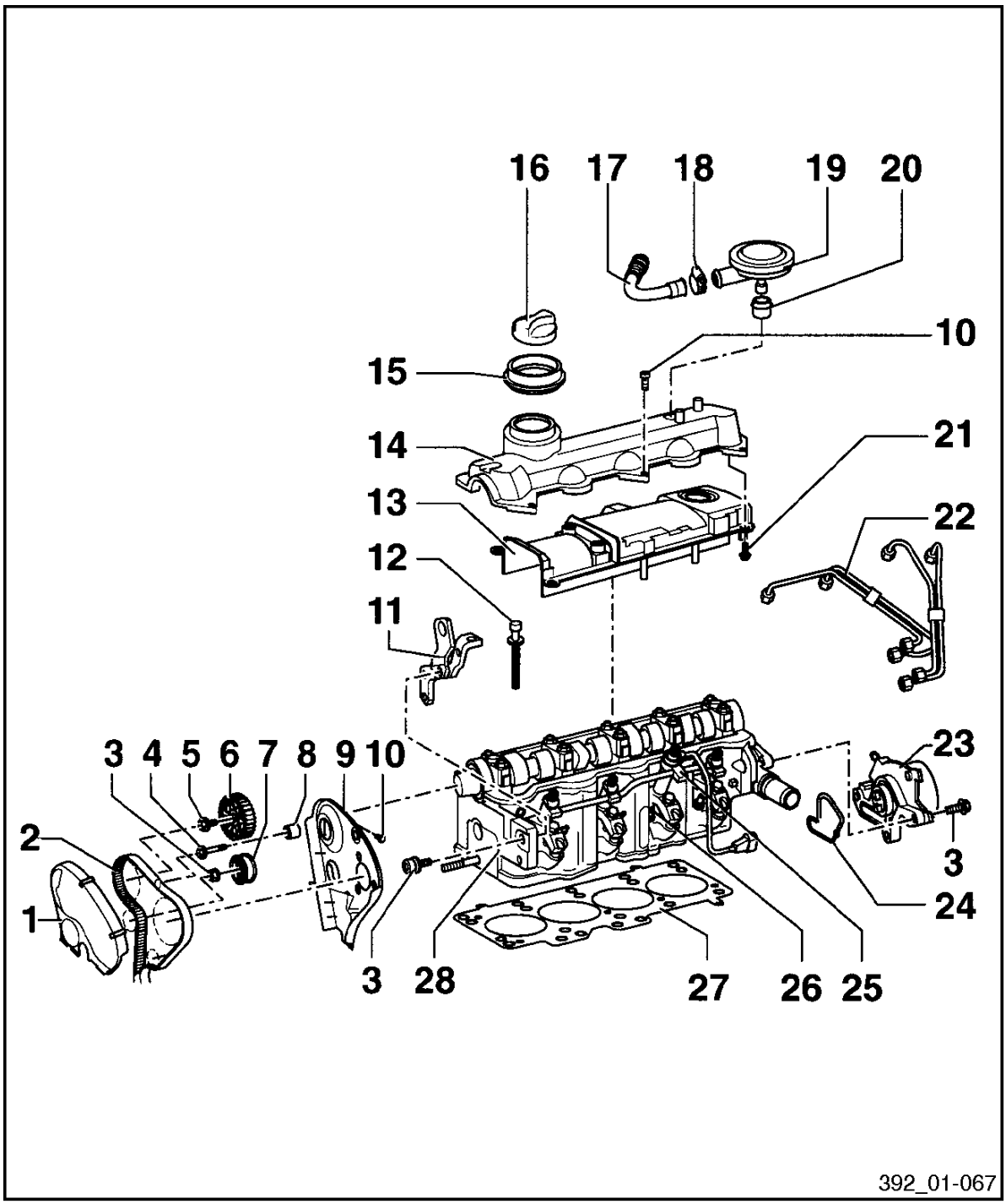
NOTE

After fitting the oil sump, the sealant must dry for about 30 minutes. Do not the fill engine oil before this period is over.

- Install the toothed belt and adjust the engine valve timing.
- Install the ribbed V-belt.

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Cylinder head - check



1	Upper toothed belt guard	11	Lift bracket
2	Toothed belt	12	Cylinder head bolt
3	Bolt (torque 20 Nm)	13	Oil barrier
4	Bolt (torque 20 Nm)	14	Cylinder head cover
5	Bolt (torque 45 Nm)	15	Sealing boot
6	Camshaft sprocket	16	Oil filler cap
7	Spring-loaded idler pulley	17	Ventilation tube
8	Reflection pulley	18	Clamp
9	Rear toothed belt guard	19	Pressure control valve
10	Bolt (torque 10 Nm)	20	Seal

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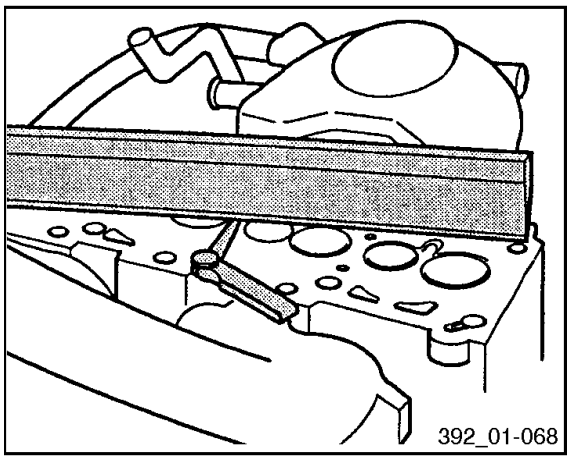
21 Bolt (torque 5 Nm)
22 Injection lines
23 Vacuum pump
24 Seal
25 Injection nozzle
26 Glow plug
27 Cylinder head gasket

Cylinder head - check for flatness

Maximum permissible distortion: 0.1 mm

NOTE

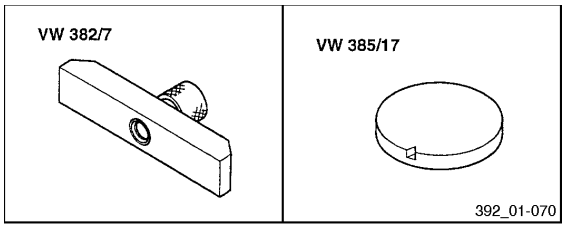
Resurfacing of diesel cylinder heads is not allowed.



Cylinder head - check piston position at TDC

Required special tools

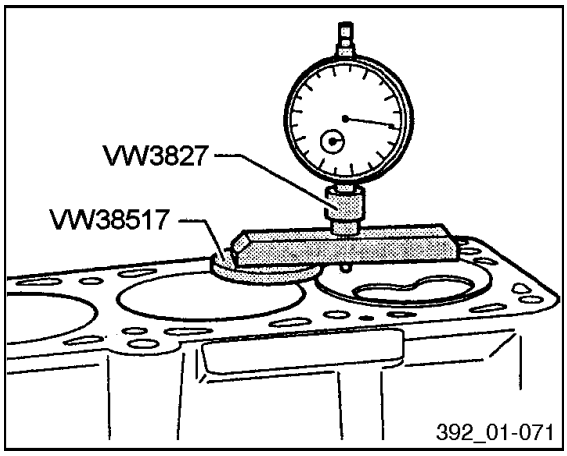
- Dial gauge holder VW 3827
- Measuring plate VW 38517



Test procedure

When installing a new piston or a partial engine, the piston position must be checked at TDC. Depending on the projection of the piston, the appropriate cylinder head gasket must be installed according to the following table:

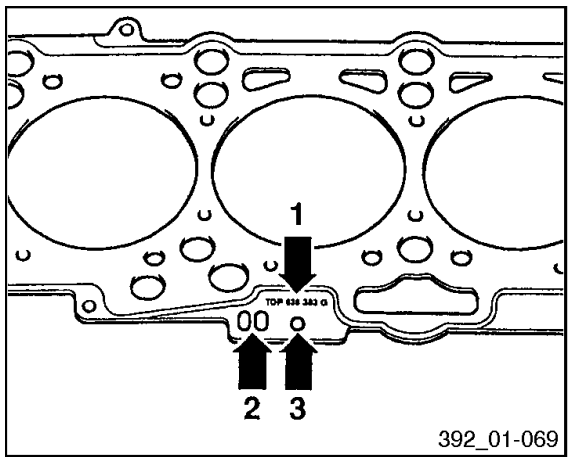
Piston projection	Marking
	Notches/holes/thickness
0.91 mm - 1.00 mm	1 / 1.55 mm
1.01 mm - 1.10 mm	2 / 1.36 mm
1.11 mm - 1.20 mm	3 / 1.71 mm



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Cylinder head - identification

Part No.	Arrow 1
Control code	Arrow 2 (not required)
Holes	Arrow 3



NOTE

If different values are measured when measuring the piston projection , the largest dimension shall apply for the selection of the gasket.

Cylinder head - removal and installation

Cylinder head - removal

Due to the confined conditions, pay special attention to the following when dismantling parts: Route all kind of lines (eg for fuel, hydraulic system oil, coolant and refrigerant, vacuum) and electrical lines so that the original line routing can be restored when reassembling.

Make sure there is sufficient clearance to all moveable or hot components.

All cable binders which were loosened or cut open during removal must be attached at the same place upon installation.

- Disconnect the battery earth lead with the ignition switched off.
- Drain the coolant.
- Pull off all coolant hoses to the cylinder head with the spring clamp pliers VAS 5024.
- Pull off/disconnect all further electric lines from the cylinder head as required and put them to the side.
- Pull off the vacuum and vent lines from the cylinder head.
- Remove the upper part of the intake pipe.
- Remove the top toothed belt guard, the cylinder head cover and the vacuum pump.
- Remove the camshaft sprocket.
- Loosen the cylinder head bolts. Observe the correct sequence.

NOTE

Always replace the cylinder head bolts.

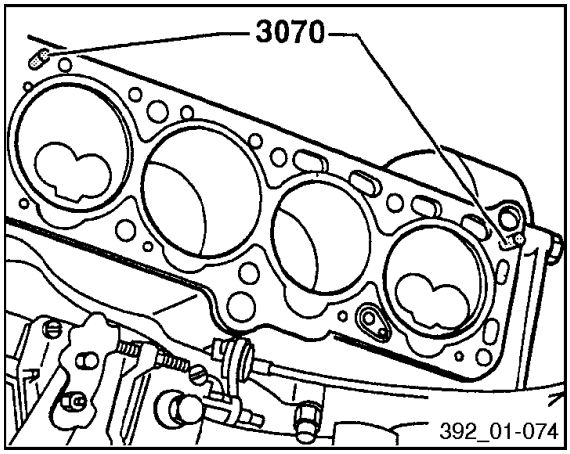
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In case of repair, remove sealant residues carefully from cylinder head and cylinder block. Take care not to cause any long scoring or scratches.

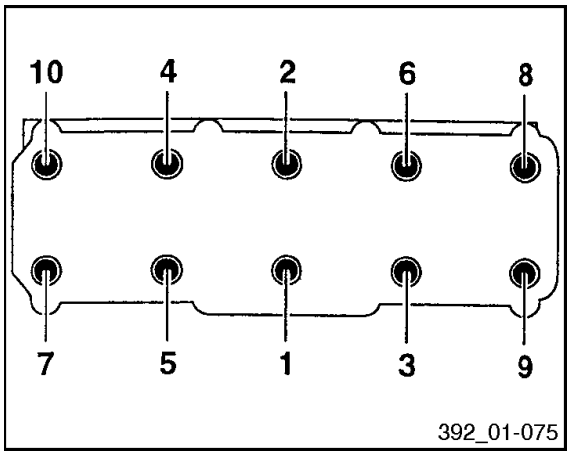
If emery paper is used, the grain should **not be under 100**. Remove abrasive residues with care.

Do not take the new cylinder head gasket out of its packing until it is actually mounted. Handle the new gasket with utmost care. Any damage of the silicone layer and in the bead area will lead to leakage.

- Put the crankshaft to the TDC mark before mounting the cylinder head.
- Turn the crankshaft against the sense of rotation of the engine until all pistons are almost uniformly under TDC.
- Position the cylinder head gasket.
- Put the cylinder head in place, insert the remaining cylinder head bolts and tighten them by hand.



- Tighten the cylinder head bolts in four stages in the order shown in the figure as follows:



1. Initial tightening with torque wrench

Stage 1	40 Nm
Stage 2	60 Nm

2. Continue tightening with a rigid spanner

Stage 3	¼ turn (90°)
Stage 4	¼ turn (90°)

NOTE

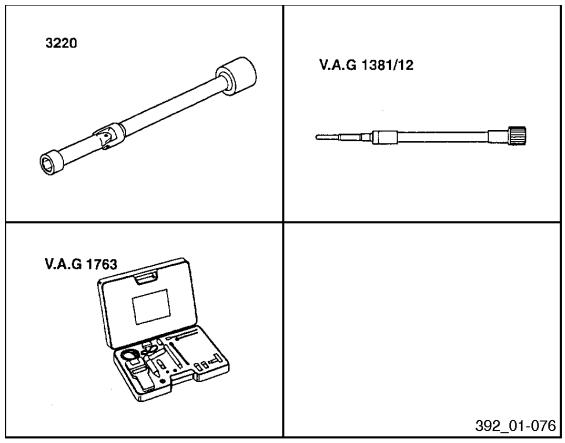
Note: The cylinder head bolts do not need to be tightened after repairs.

- After tightening the cylinder head, turn the camshaft sprocket so that the cams for cylinder 1 face upwards at the same angle. Before installing the toothed belt, set the crankshaft to TDC by rotating the engine in the direction of rotation.

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Cylinder head - compression check

Required special tools



- Flexible head spanner VW 3220
- Torque spanner 5 - 50 Nm
- Adapter VW VAG 138112
- Tester for compression VW VAG 1763

Test prerequisite

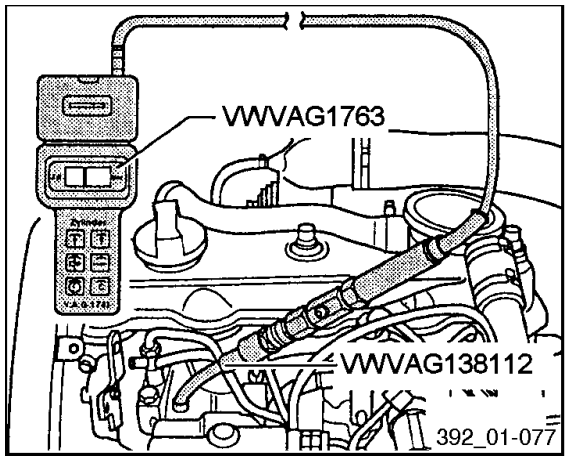
Engine oil temperature at least 30°C

Test procedure

➢ Disconnect the 10-pin connector to the quantity regulating mechanism of the injection pump.

➢ Remove all glow plugs with the flexible head spanner VW 3220.

➢ Screw in the adapter VW VAG 138112 instead of the glow plugs.



➢ Check the compression with tester VW VAG 1763.

NOTE

For tester handling, refer to the tester operating instructions.

➢ Actuate the starter until the tester no longer indicates a rise in pressure.

Compression readings

New	25 - 31 bar
Wear limit	19 bar

Admissible difference between all cylinders: 5 bar

➢ Install the glow plugs with the flexible head spanner VW 3220.

Tightening torque: 15 Nm.

➢ Display the fault history

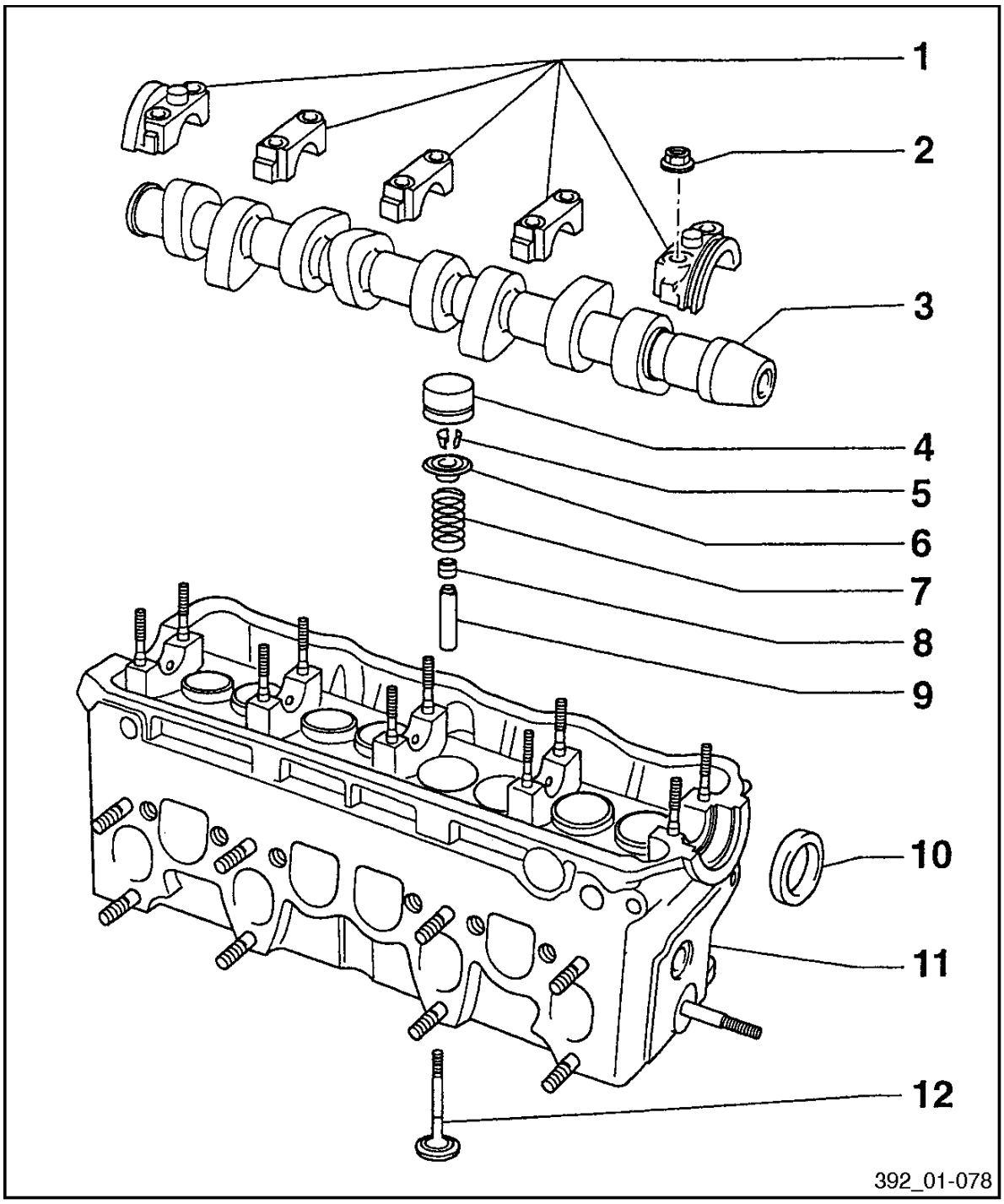
➢ Clear the fault history, if necessary

NOTE

Disconnecting the connectors to the injection pump causes faults to be stored.

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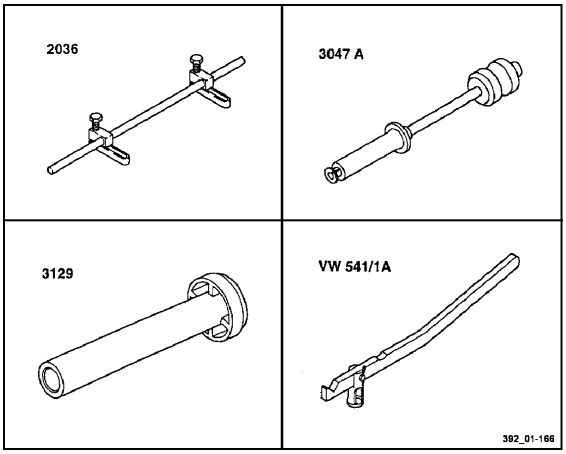
Valve gear



1	Bearing cap	7	Valve spring
2	Screw (tightening torque 20 Nm)	8	Valve stem seal
3	Camshaft	9	Valve guide
4	Tappet	10	Sealing ring
5	Valve keepers	11	Cylinder head
6	Valve spring seat	12	Valve

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Required special tools



- Mounting device VW 2036
- Mounting lever VW 5411 A
- Pulling unit VW 3047
- Valve stem seal installer VW 3129

Dismantle valve stem seal

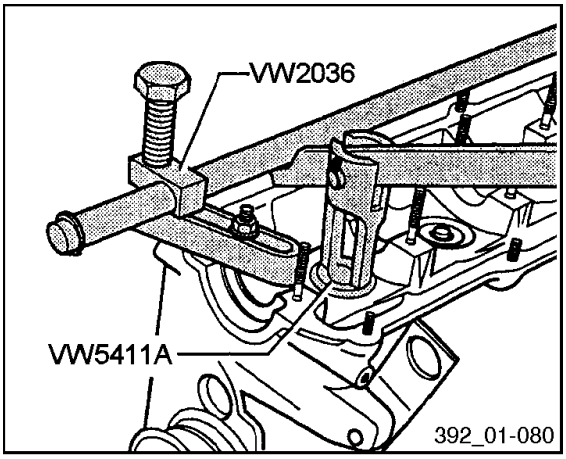
(with cylinder head installed)

➢ Remove camshaft.

➢ Take tappet out and put it down with the running surface pointing downwards. Make sure that the tappets are not mixed up.

➢ Put the piston of the respective cylinder to the top dead centre (TDC).

➢ Use mounting device VW 2036 and adjust the bearing to stud height.

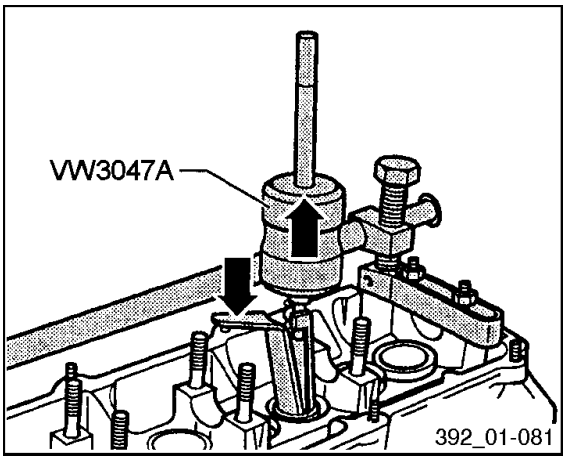


➢ Dismantle valve springs using mounting lever VW 5411 A.

NOTE

During this procedure, the valves are supported on the piston bottom.

➢ Pull off the valve stem seals with the VW 3047.

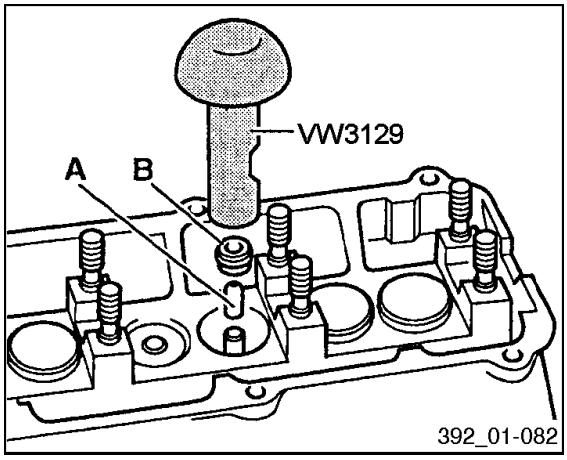


Install valve stem seal

➢ Plug the supplied plastic bushing into the corresponding valve stem. This prevents damage to the new valve stem seal.

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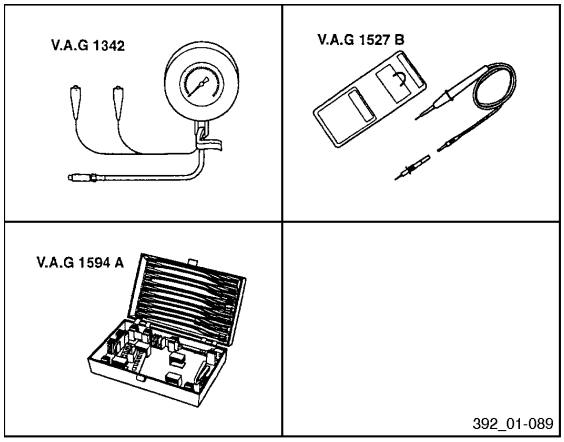
- Insert the new valve stem seal into the valve stem seal installer VW 3129.
- Grease the sealing lip of the valve stem seal with oil and push it carefully onto the valve guide.



Oil pressure and oil pressure switch - check

Required special tools

- Tester for oil pressure VW VAG 1342
- Diode test light VW VAG 1527 B
- Testing aids set VW VAG 1395 A



Test procedure

- Remove the oil pressure switch (F1) and screw into the tester.
- Screw the tester instead of the oil pressure switch into the oil filter holder.
- Connect the brown line of the tester to earth (-).
- Connect the diode test light VW VAG 1527 B with auxiliary lines from VW VAG 1594 A to the positive battery pole (+) and the oil pressure switch.

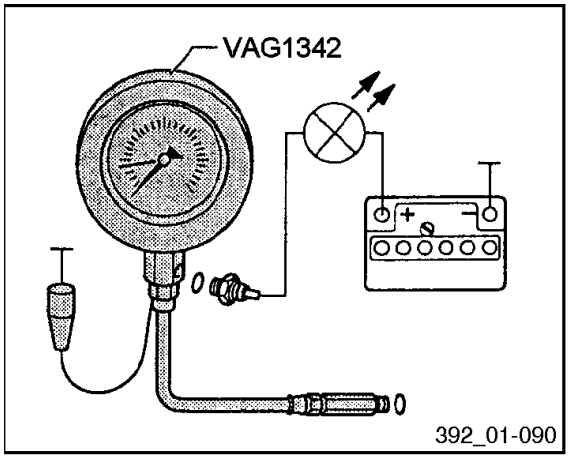
The LED should not light up.

- Start the engine and raise the speed slowly.

At a pressure of 0.55 - 0.85 bar, the LED should light up; if not, replace the oil pressure switch.

- Increase the speed further.

At 2000 rpm and an oil temperature of 80 °C, the oil pressure should be at least 2.0 bar.



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At higher speeds, the oil pressure should not exceed 7.0 bar. If necessary, replace the oil pump cover with pressure control valve.

Oil sump - removal and installation

Required special tools

- Power drill with plastic brush insert
- Silicone sealant D 176404 A2
- Blunt scraper

Oil sump - removal

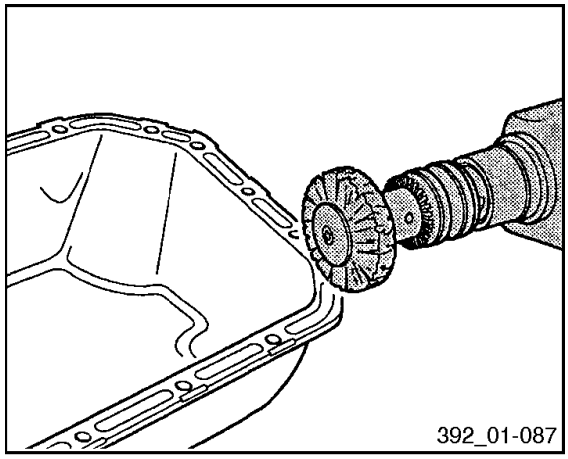
➢ Drain the engine oil.

➢ Remove the oil sump.

If necessary, loosen the oil sump by hitting it lightly with a rubber mallet.

➢ Remove any sealant residues on the cylinder block with a blunt scraper.

➢ Remove any sealant residues on the oil sump with a rotating brush, eg a power drill with plastic brush insert ▷



WARNING

The rotating brush loosens particles, which are flung off at high speed. These particles can cause eye injury

Wear protective goggles!

➢ Clean the mating faces.

They must be free from oil and grease.

Oil sump - installation

NOTE

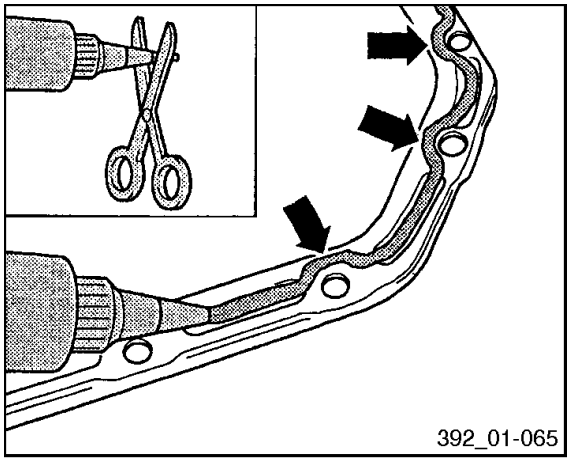
Observe the use-by date of the sealant.

Once the silicone sealant has been applied, the oil sump must be installed within 5 minutes.

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- Cut off the tube nozzle at the front mark (nozzle diameter approx. 3 mm).
- Apply the silicone sealant on the clean mating face of the oil sump as shown in the figure.

The sealant bead should have a thickness of 2 - 3 mm and run around the screw holes on the inside (arrows).



CAUTION

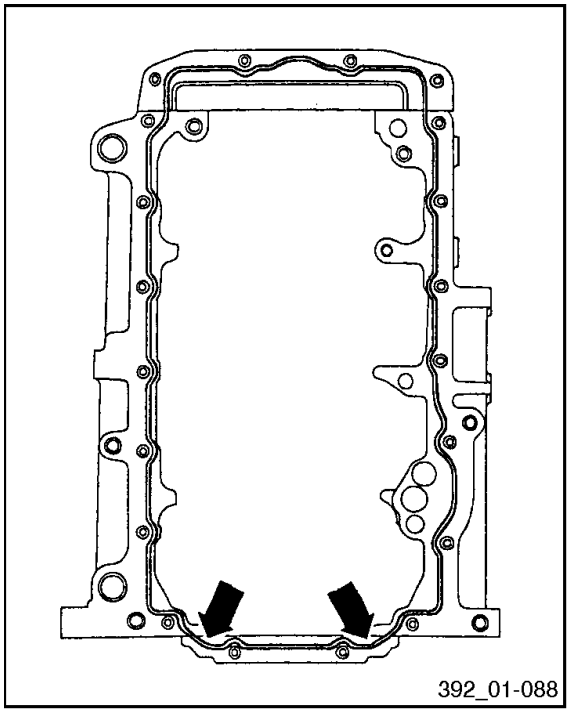
The sealant bead should not be thicker as excess sealant can drop into the oil sump and clog the screen in the suction line.

The sealant bead should not be thicker than 3 mm.

- Apply the silicone sealant on the clean mating face of the oil sump as shown in the figure (the figure shows the position of the sealant bead on the cylinder block).
- Install the oil sump immediately and slightly tighten all screws.

The oil sump must be flush with the cylinder block.

- Tighten the oil pan screws to a torque of 15 Nm.



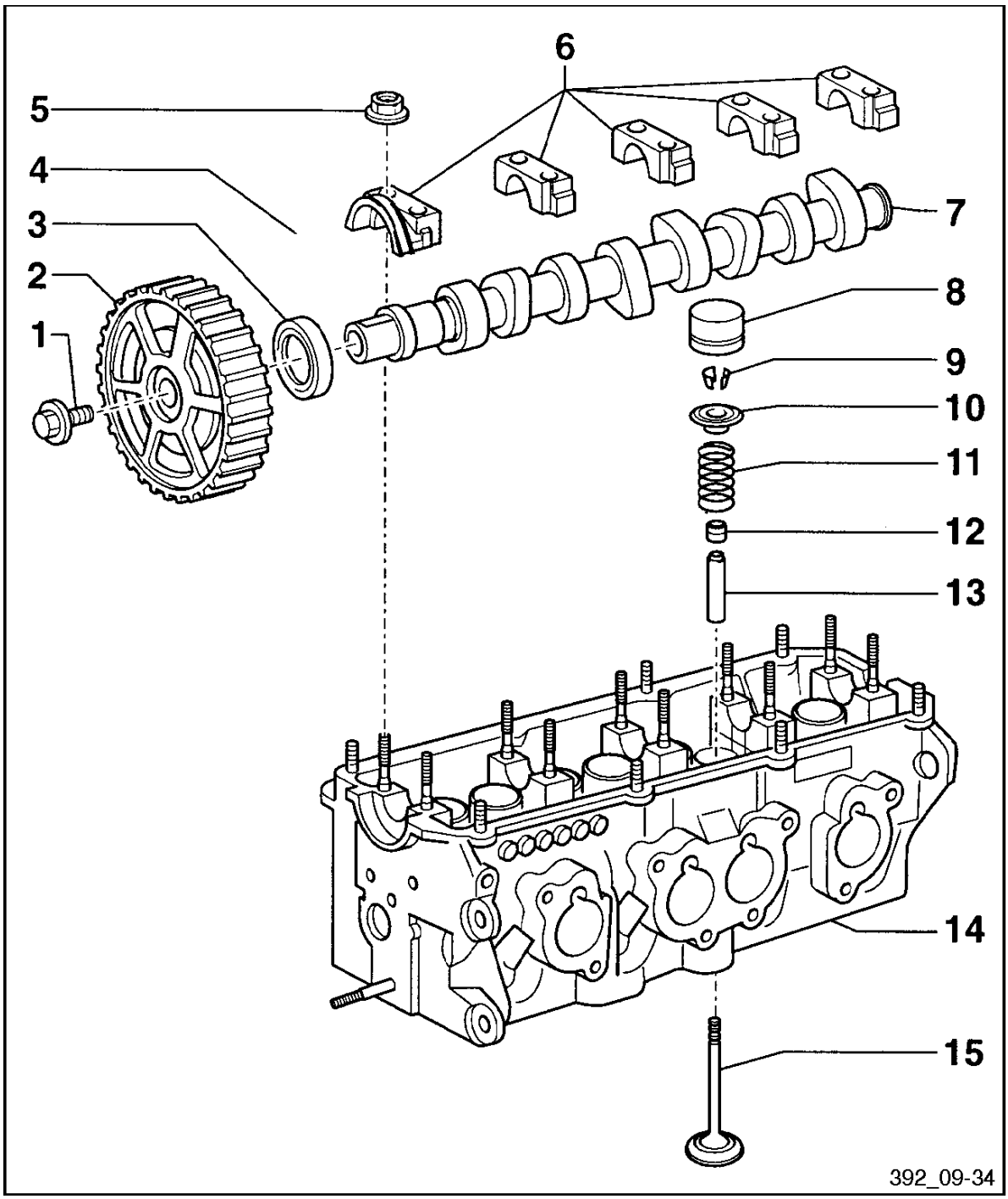
NOTE

After fitting the oil sump, the sealant must dry for about 30 minutes. Do not fill the engine oil before this period is over.

The rest of the installation is done in the reverse order of removal.

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Hydraulic bucket tappets - check



1	Bolt, torque 45 Nm	9	Collets
2	Camshaft sprocket	10	Upper valve spring seat
3	Sealing ring	11	Valve spring
4		12	Valve stem seal
5	Hexagonal nut, torque 5 Nm	13	Valve guide
6	Bearing caps	14	Cylinder head
7	Camshaft	15	Valve
8	Bucket tappets		

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Assembly notes

- Item 1: Use holding jig VW 3415 for loosening and tightening.
- Item 6: Coat mating face of bearing cap 1 lightly with sealant AMV 174 004 01.
- Item 8: Do not interchange, with hydraulic valve clearance compensation, lubricate the running surface with oil.

Required special tools

- Feeler gauge
- Wooden or plastic wedge

Test procedure

NOTE

Only replace bucket tappets as a complete assembly. They can not be adjusted or repaired. Irregular valve noises when starting the engine are normal.

- Start the engine and let it run until the engine oil temperature has reached at least 80 °C.
- Increase engine speed to approx. 2500 rpm for 2 minutes.

If the hydraulic bucket tappets are still noisy, locate the defective tappet as follows:

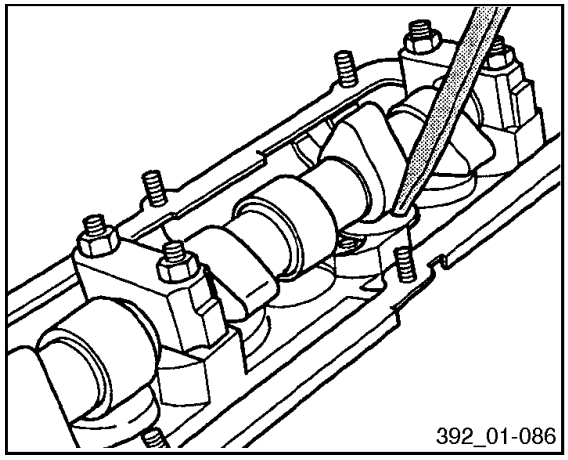
- Remove the cylinder head cover.
- Rotate the crankshaft clockwise until the cam of the bucket tappet to be checked is pointing upwards.
- Determine the clearance between the cam and bucket tappet.

If the clearance exceeds 0.1 mm, replace the bucket tappet.

If the clearance is less than 0.1 mm or no clearance is detected, repeat the test as follows:

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➢ Press the bucket tappet down with a wooden or plastic wedge.



If free travel in excess of 0.1 mm is felt until the valve opens:

➢ replace the tappet.

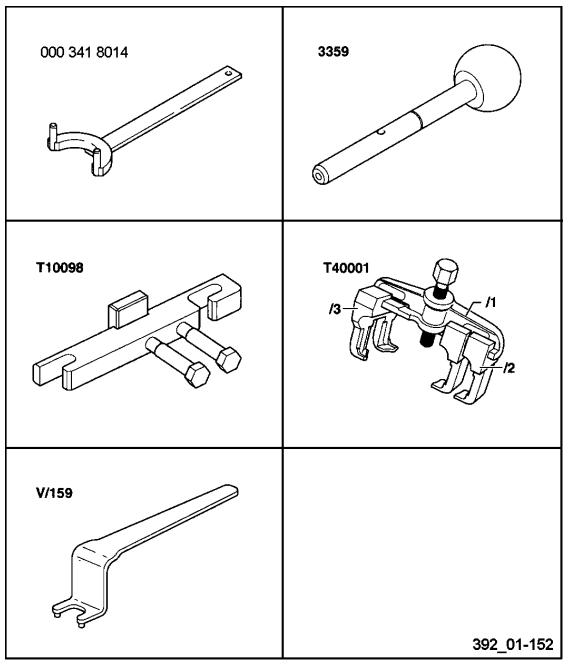
CAUTION

The hydraulic compensation elements must settle, otherwise the valves can strike the pistons and bend.

Do not start the engine for approx. 30 minutes after installing new bucket tappets!

Camshaft - removal and installation

Required special tools



- Locating pin VW 3415
- Holding jig 000 941 8014
- Camshaft setting jig VW T10098
- Puller VW T40001
- Nut driver VW V 159

Camshaft - removal

➢ Relieve the toothed belt tension and take it off the camshaft and injection pump sprockets.

NOTE

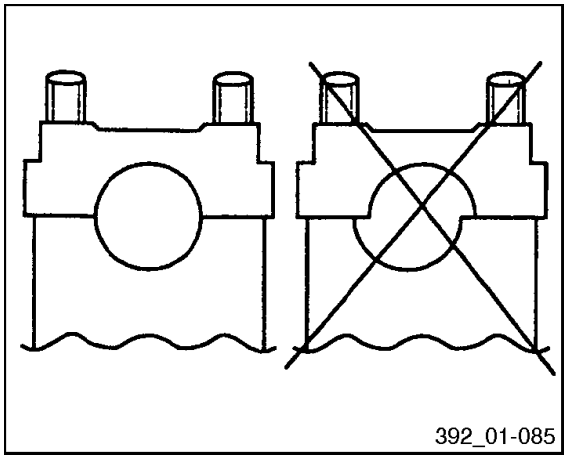
The vibration damper/pulley and the middle and lower toothed belt guard can remain in place.

➢ Remove the camshaft sprocket.

➢ First remove bearing cap 5, 1 and 3. Loosen opposite bearing caps 2 and 4 alternately.

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Camshaft - installation



NOTE

When installing the camshaft, the cams for cylinder 1 must be pointing upwards. When installing the bearing caps, be sure the drilled holes are aligned; before installation, position the bearing caps and determine the fitting position.

- Coat the running surfaces of the camshaft with oil.
- Tighten opposite bearing caps 2 and 4 alternately to a torque of 20 Nm.
- Install bearing caps 5, 1 and 3 and also torque to 20 Nm.
- Fit the bearing caps by tapping lightly on the end of the camshaft.
- Fit the camshaft sprocket.
- Install, tension the toothed belt.

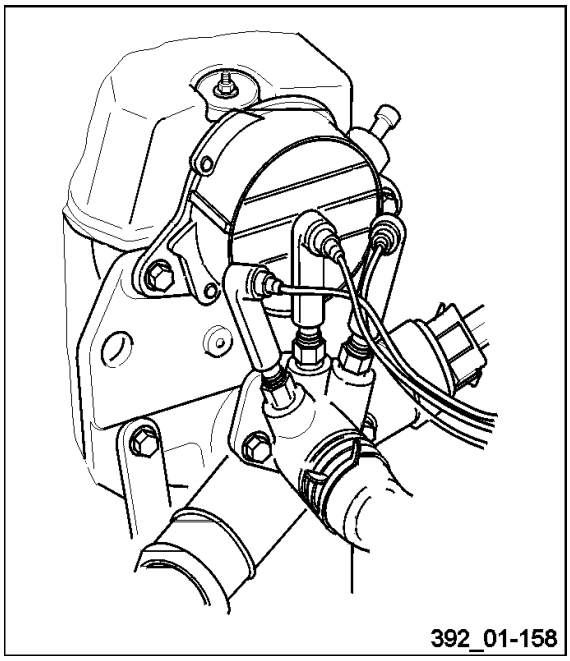
CAUTION

The hydraulic compensation elements must settle, otherwise the valves can strike the pistons and bend.

Do not start the engine for approx. 30 minutes after installing new bucket tappets!

Vacuum pump

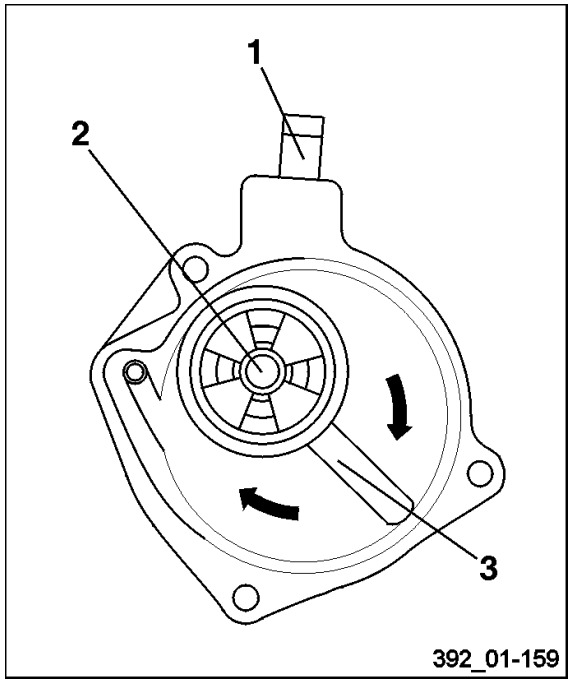
The vacuum pump, which is also required in the diesel engine to create a vacuum, is directly driven by the camshaft. The vacuum pump consists of a rotor and an impeller. The impeller is made of plastic and is moveably mounted.



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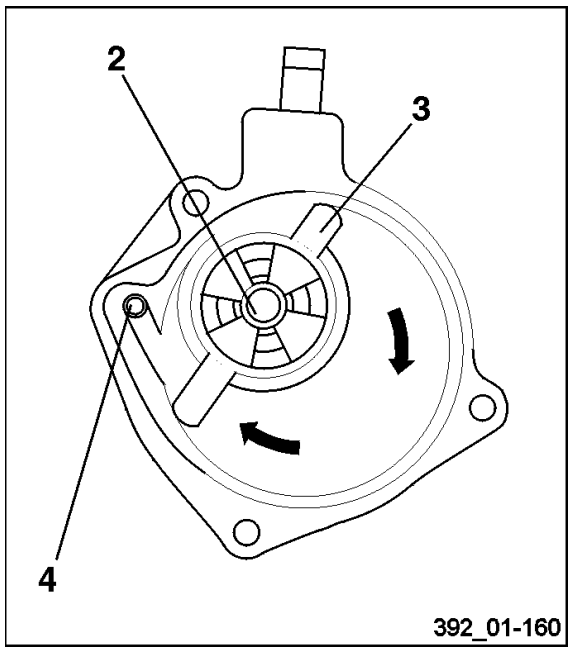
Space expansion function

During a rotation of the rotor (2) the impeller (3) is pressed outwards and the space is expanded. The space fills with air and, as a result, a vacuum is created at the air inlet (1).This vacuum is used by the turbocharger control mechanism and the exhaust gas recirculation (EGR) valve.



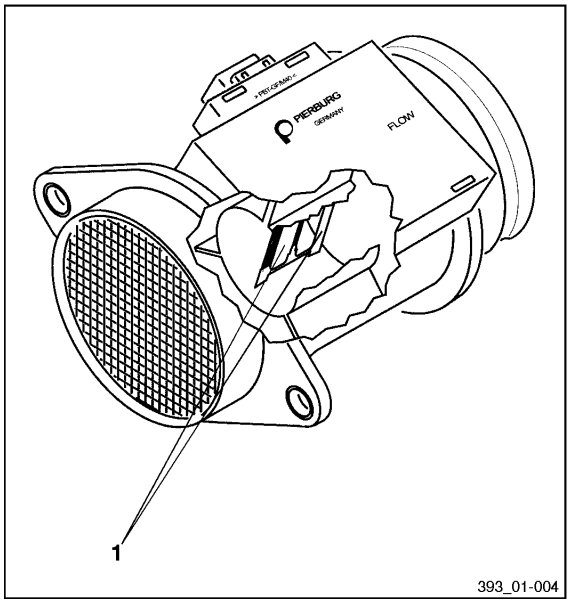
Function: Space narrowing

Due to the continued movement of the rotor and the impeller, the created space becomes smaller again. In this way the intake air is compressed and blown off through the air outlet (4) to the cylinder head. At the same time, a new space is created at the top.



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Mass air flow sensor 0B6



The purpose of the mass air flow sensor is to determine the amount of fresh air supplied to the engine. The mass air flow sensor 0B6 is mounted in the intake pipe directly behind the air filter. It measures the mass air flow with a hot film sensor (1).

The hot film is heated with 12 V. The passing intake air cools the surface of the hot film. This cooling lowers the resistance of the hot film. The electronic control unit evaluates the drop in voltage caused by the change in resistance as the equivalent for the temperature and quantity of air drawn in.

Signal evaluation

The measuring result of the mass air flow sensor is the basis for the control of the percentage of recirculated exhaust gas to be added and the maximum quantity of fuel to be injected.

A smoke map stored in the control unit limits the injection quantity if the mass air flow is too small for smokeless combustion.

Substitute function

In the event of a failure, the charge pressure limit is reduced and constant values are specified for the optimum operation of the engine in various load ranges. The engine power is reduced as a result.

Mass air flow sensor - check

The mass air flow sensor signal is required by the control unit for the calculation of the permissible injection rate and for governing the exhaust gas recirculation. The smaller the signal from the mass air flow sensor, the less fuel may be injected.

Required special tools

- Test adapter 7 917 299 010
- Wiring diagram
- Laptop with software

Prerequisites for testing

- Fuses must be OK.
- The battery voltage must be at least 11.5 V.
- All electric loads must be switched off.

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- Earth connections are OK.
- The fault history must be cleared.

Test procedure

➢ Connect the laptop and start the software.

➢ "Select inputs and outputs", "Data blocks", "Group 10".The engine must be running at idle speed

➢ Check the mass air flow in the Display field.

Desired air flow: 635 - 750 mg/stroke.

If the desired air flow is not obtained:

➢ Check the exhaust gas routing.

If the desired air flow is obtained:

➢ Repeat the test. Increase the engine speed of approx. 1500 rpm under full load to maximum speed.

➢ Check the desired value of the mass air flow sensor (air intake) in the Display field.

Desired value: 700 - 1050 mg/stroke.

➢ End the communication between the vehicle and laptop.

➢ Turn off the ignition.

If the desired air flow is not obtained:

➢ Replace the mass air flow sensor 0B6.

➢ Subsequently read out the fault history of the engine control unit and clear the fault history.

If a constant value of 550 mg/stroke is shown in the Display field:

➢ Disconnect the 5-pin plug from the mass air flow sensor 0B6.

➢ Turn on the ignition.

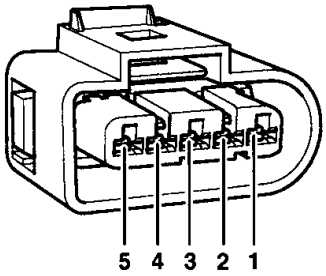
➢ Measure the supply voltage for the mass air flow sensor between the following contacts of the plug:

Contact in plug 0B6	Desired value
2 + earth	approx. battery voltage
2 + 3	approx. battery voltage
4 + earth	approx. 5 Volt
4 +3	approx. 5 Volt

If the desired values are not obtained:

➢ Turn off the ignition.

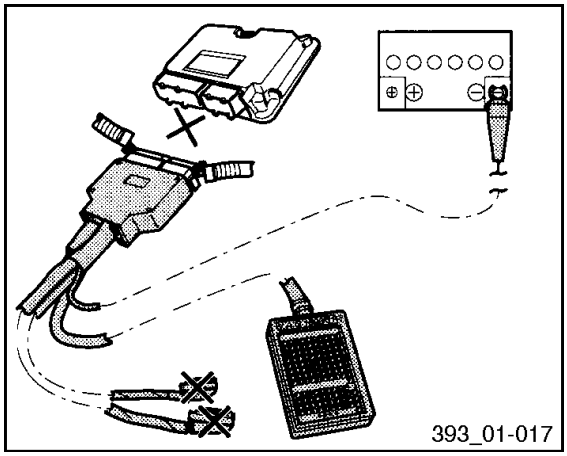
▷



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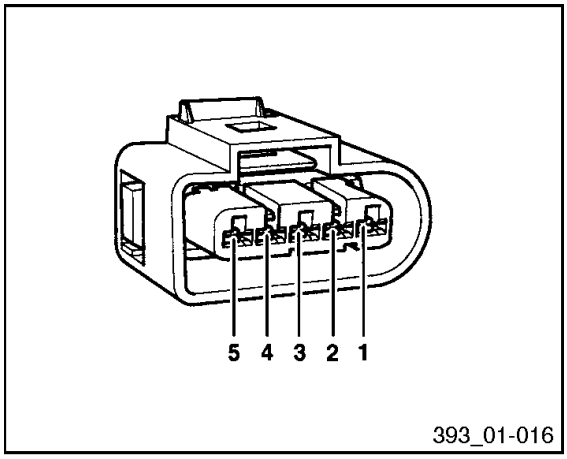
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➢ Connect the test adapter 7 917 299 010 to the control unit cable loom. This does not connect the control unit. ▷



➢ Using the wiring diagram, check the lines between the test box and the plug for interruptions. ▷

- Contact 2 + socket 1
- Contact 2 + socket 2
- Contact 3 + socket 49
- Contact 4 + socket 30
- Contact 5 + socket 68



Cable resistance: maximum 1.5 ?

➢ Also check the lines for line-to-line shorts, short to battery earth/engine earth and to battery positive.

Desired value: 8 ?

If no fault is detected in the lines:

➢ Replace the control unit for the direct diesel injection system 0N1.

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Solenoid valve for charge pressure limitation 0Y4

The solenoid valve limits the actual charge pressure depending on the values supplied by electronic control unit.

The load cell of the mechanical charge pressure control valve is activated.

In the home position the charge air (3) can pass through the valve with suction pipe pressure. In the activated state, a part of the charge air is drawn off to the inlet port (1)

Solenoid valve - control

The electronic control unit sends signals to the solenoid valve corresponding to the charge pressure map. By opening or closing the valve as required, either a higher or lower intake pipe pressure is applied to the charge pressure control valve of the turbocharger.

Solenoid valve - substitute function

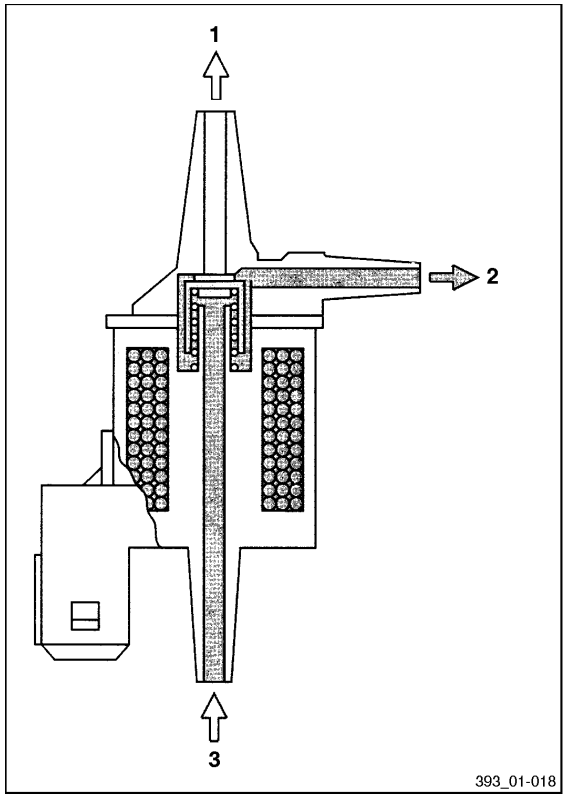
In case of a failure, the excess pressure is limited to 0.75 bar by the mechanical governor.

Solenoid valve - self-test

A malfunction of the solenoid valve for charge pressure limitation 0Y4 is not stored by the electronic control unit. A malfunction of the charge pressure control, however, is stored. The correct operation can be checked in the actuator diagnosis.

Solenoid valve - resistance check

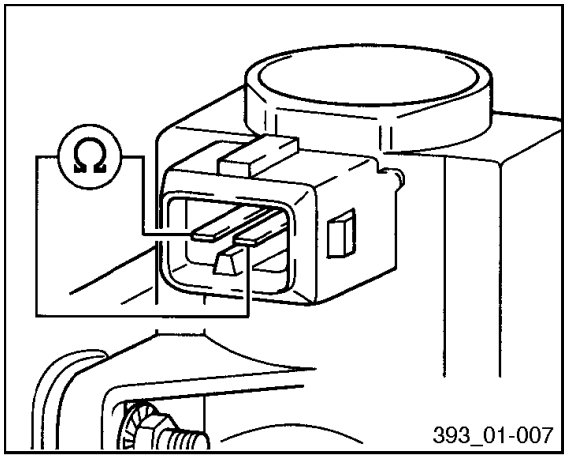
➢ Disconnect the 2-pin plug from the solenoid valve for charge pressure limitation 0Y4.



1 To inlet port
2 To mechanical charge pressure valve
3 Intake pipe pressure

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➢ Connect the multimeter for the resistance test to the contacts of the valve. ▷



Desired resistance: 14.0 - 20.0 Ω

NOTE

At room temperature the resistance is in the lower tolerance range, at operating temperature in the upper tolerance range.

If the desired resistance is **not** obtained:

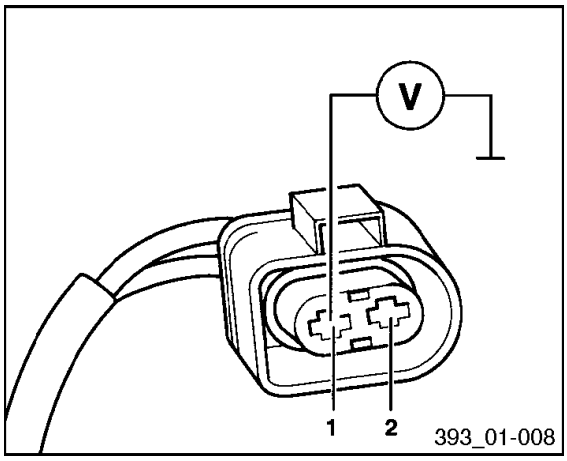
➢ Replace the solenoid valve for boost pressure limitation 0Y4.

➢ Subsequently interrogate the fault history of the engine control unit and, if necessary, clear the fault history.

If the desired resistance is obtained, check the supply voltage.

Solenoid valve - supply voltage check

➢ Connect the multimeter to contact 1 of the plug and to engine earth for the voltage test. ▷



➢ Turn on the ignition.

Desired voltage: at least 11.5 Volt

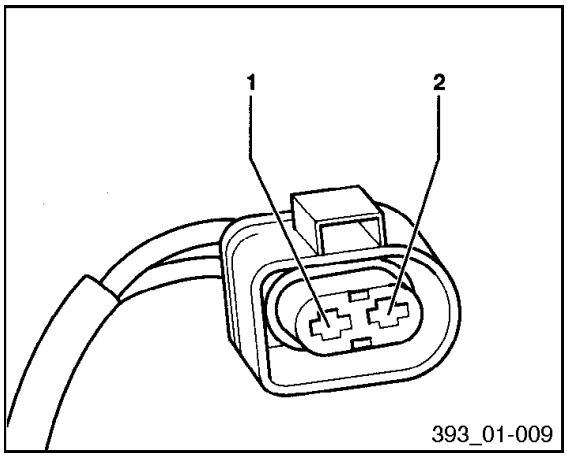
If the minimum voltage is **not** obtained:

➢ Check the voltage supply relay terminal 30 (0K2) using the wiring diagram-

➢ Using the wiring diagram, check line connections for interruptions, shorts and contact resistances at the contact points.

If the minimum voltage is obtained:

➢ Connect the test adapter to the cable loom of the engine control unit. This does not connect the control unit. ▷



➢ Using the wiring diagram, check the lines between the test box and the plug for interruptions.Desired value:

- Contact 1 + socket 1
- Contact 2 + socket 2
- Contact 2 + socket 62

Line resistance: max 1.5 Ω

➢ Also check the lines for line-to-line shorts, short to battery earth/engine earth and to battery positive.

Desired resistance: 8 Ω

If no fault is detected in the lines:

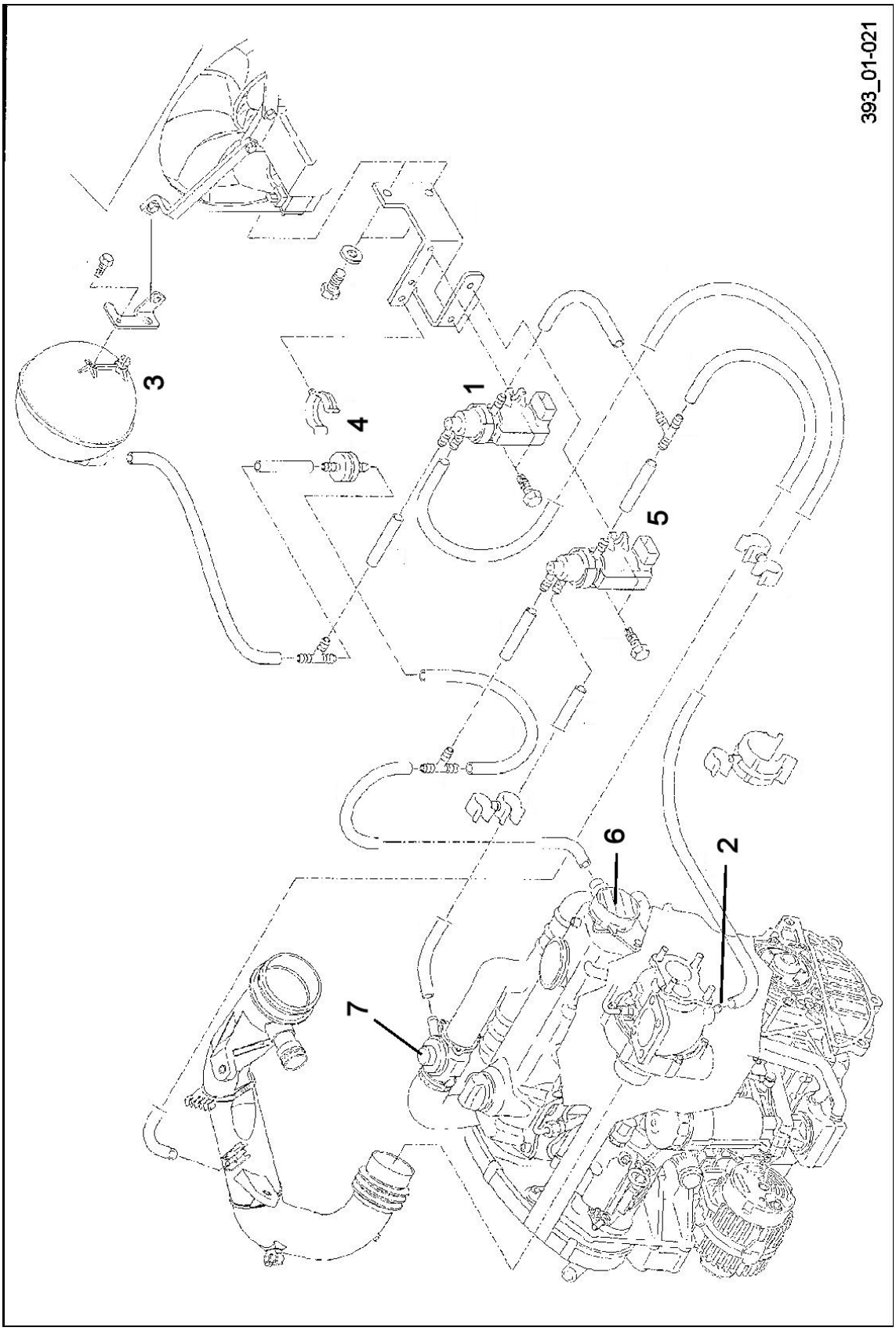
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- Replace the control unit for direct injection system 0N1.

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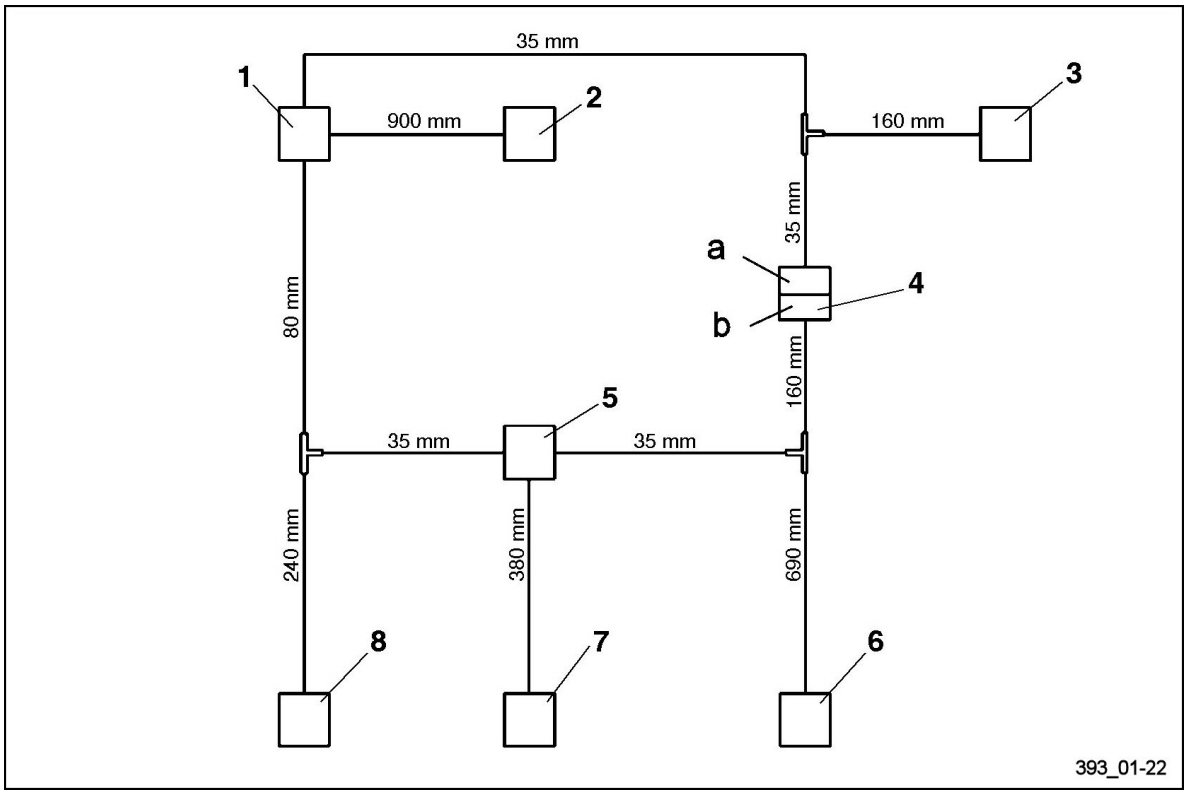
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Charge air system with turbocharger



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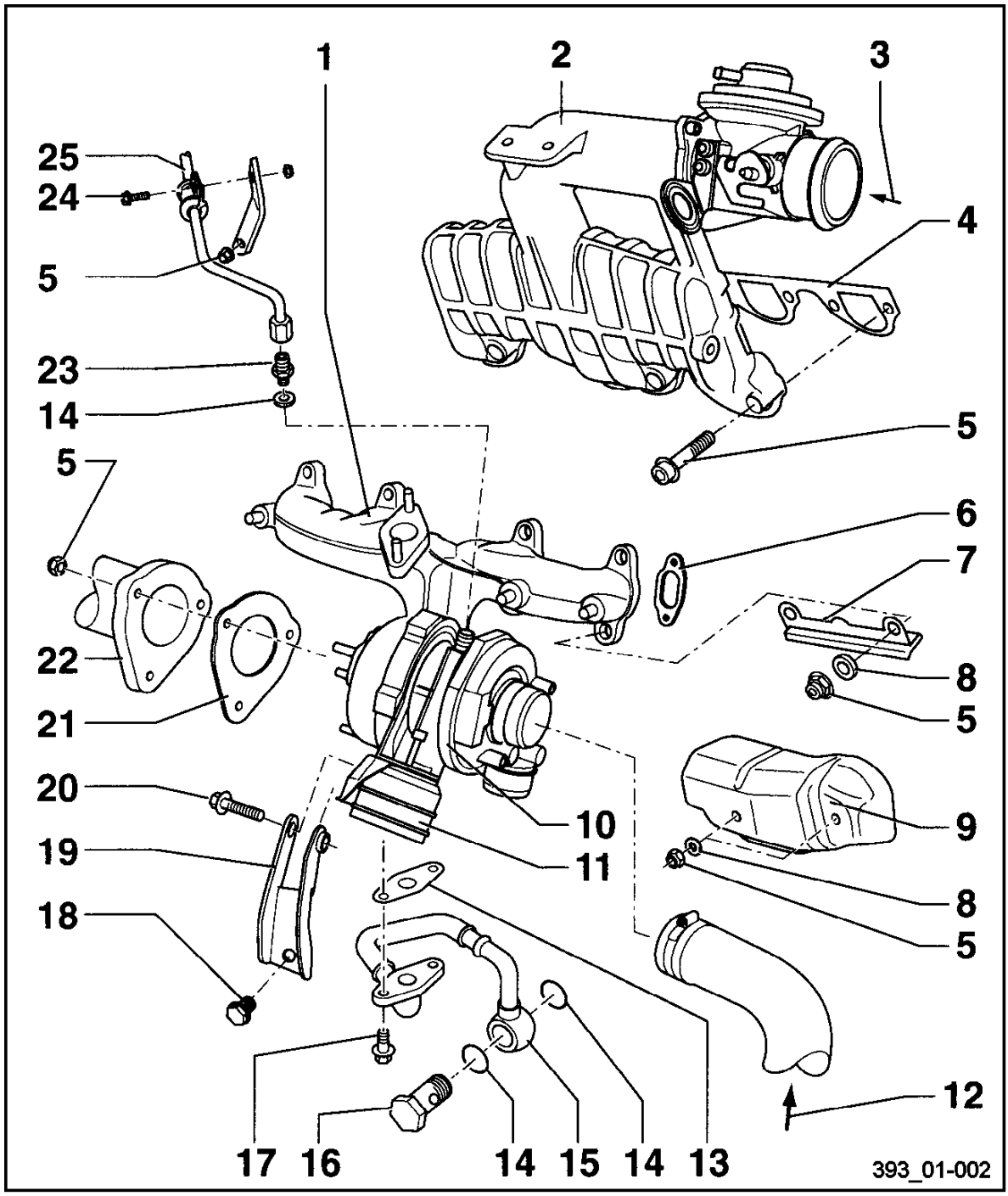
1	Solenoid valve for charge pressure control (0Y4)	5	Solenoid valve for exhaust gas recirculation (0Y5)
2	Load cell for charge pressure control	6	Vacuum pump
3	Accumulator	7	Exhaust gas recirculation valve
4	Check valve		



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1	Solenoid valve for charge pressure control (0Y4)	6	Vacuum pump
2	Load cell for charge pressure control	7	Exhaust gas recirculation valve
3	Accumulator	8	Vent pipe
4	Check valve	a	white
5	Solenoid valve for exhaust gas recirculation (0Y5)	b	black

Assembly notes



1	Exhaust manifold with turbocharger	2	Intake pipe

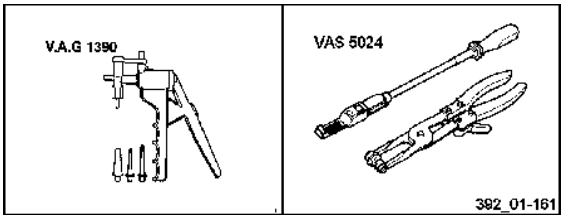
https://truckmanualshub.com/

3	Intake air
4	Gasket
5	Torque: 25 Nm
6	Gasket
7	Holder for heat shield, item 9
8	Washer
9	Heat shield
10	Turbocharger
11	Load cell for charge pressure control
12	From air filter
13	Gasket
14	Gasket
15	Oil return line to cylinder block
16	Banjo bolt, torque 30 Nm
17	Torque: 15 Nm
18	Torque: 40 Nm
19	Bracket
20	Torque: 25 Nm
21	Gasket
22	Exhaust pipe, front
23	Union, torque 30 Nm
24	Torque: 10 Nm
25	Oil supply line, 22 Nm

- Item 4: Coating (bead) to intake pipe.
- Item 6: Observe mounting position.
- Item 10: Replace only together with exhaust manifold.
- Item 11: Part of turbocharger, cannot be replaced.
- Item 23: Apply "G 052 112 A3" to thread and head mating face.
- Item 25: Before installation, fill turbocharger at union of oil feeder line with engine oil.

Boost pressure control - check

Required special tools



- Manual vacuum pump VAG 1390
- Hose clamp pliers VAS 5024
- Multimeter
- Test adapter 7 917 299 010
- Wiring diagram
- Laptop with software

Prerequisites for testing

- Fuses must be OK.
- The battery voltage must be at least 11.5 V.
- All electric loads must be switched off.
- Earth connections are OK.
- No leaks either on inlet side or on exhaust gas side.
- Engine oil temperature at least 80°C.
- No problems in engine/injection system such as start of injection, injection nozzles, compression.
- No fault should be stored in the fault history.Check the fault history

Test procedure

➢ Connect the laptop, start the software and select "Standardised data blocks". The engine must be idling.

➢ "Select Group 11".

➢ Increase the engine speed of approx. 1500 rpm under full load to maximum speed.

➢ Check the desired charge pressure (actual) in the Display field.

Desired pressure: 1650...2000 mbar.

➢ Terminate the communication between the vehicle and laptop.

➢ Turn off the ignition.

If the desired pressure is **not** obtained:

➢ Carry out an actuator diagnosis and activate the solenoid valve for charge pressure limitation.

The solenoid valve must click and the linkage of the load cell for charge pressure control at the turbocharger must move to and fro.The linkage must move to and fro at least 3 to 4 times, as long as a vacuum is present in the vacuum reservoir.

NOTE

The clicking of the valve cannot be heard due to the engine noise and can therefore only be checked by touch.

➢ Continue and finish the actuator test.

➢ Turn off the ignition.

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If the linkage moves and the desired charge pressure (actual) is not obtained:

➢ Turbocharger defective, replace turbocharger.

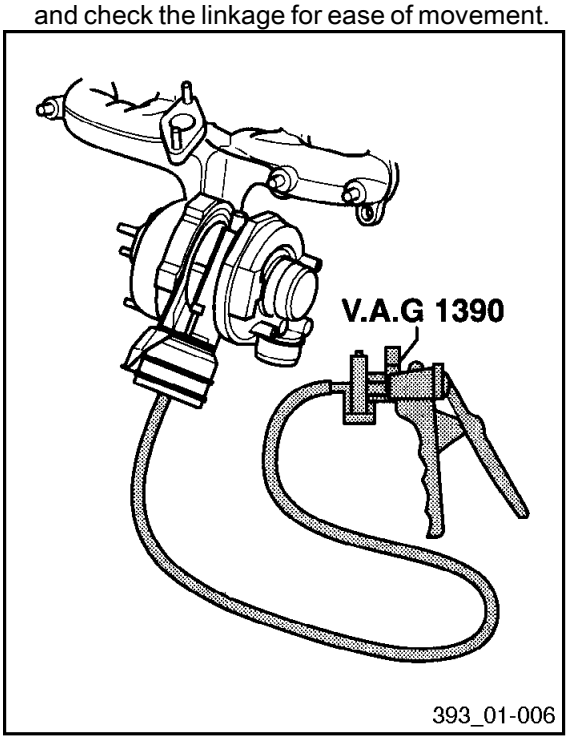
If the linkage does not move because the solenoid valve is not working:

➢ Checking the solenoid valve for charge pressure limitation 0Y4.

➢ Check the vacuum hoses.

If the linkage does not move although the solenoid valve works:

➢ Connect the manual vacuum pump VAG 1390 with the load cell for charge pressure control and check the linkage for ease of movement.



If the linkage cannot move freely:

➢ Turbocharger defective, replace turbocharger.

Turbocharger - replacement

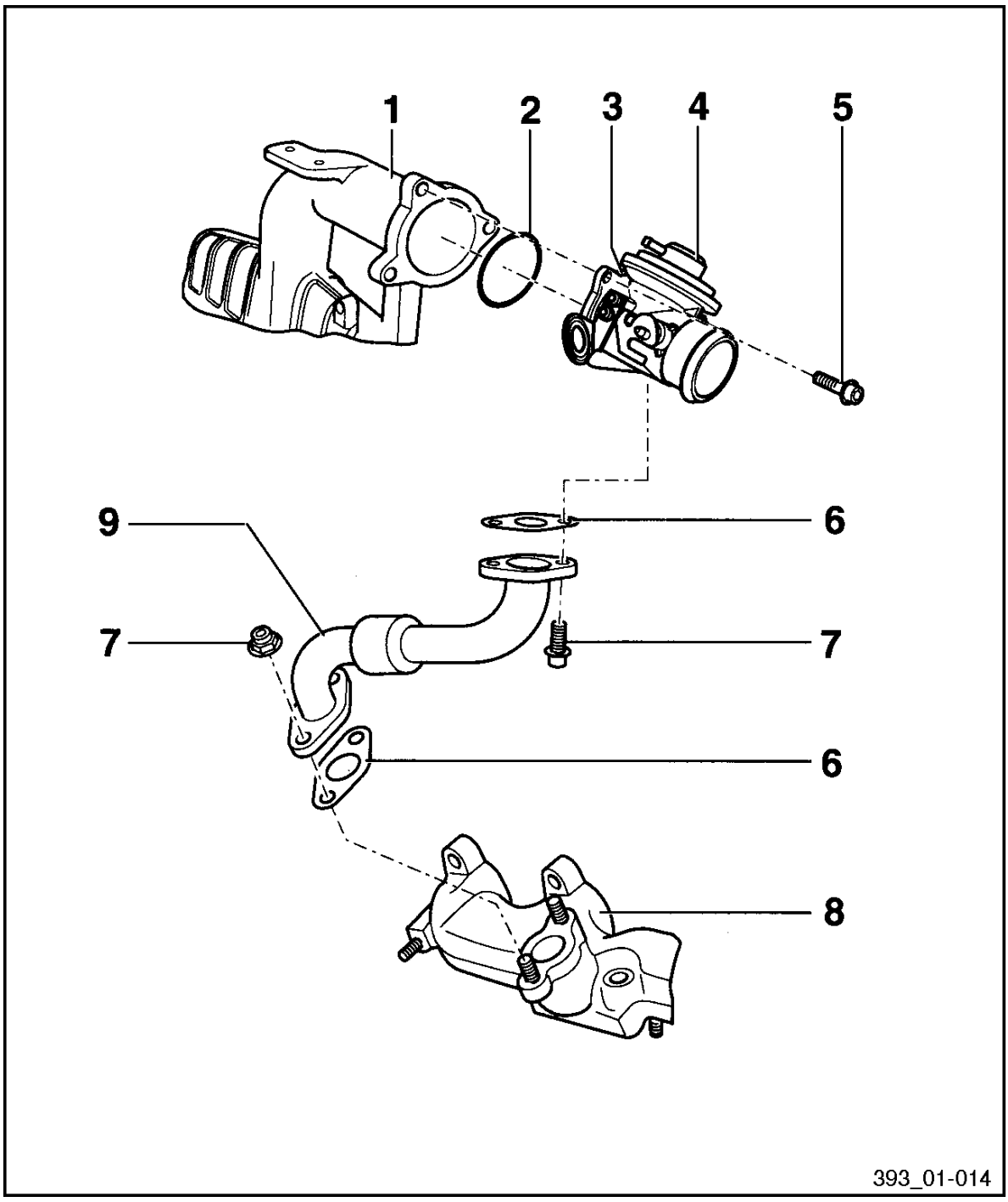
NOTE

Observe safety measures. Observe the rules for cleanliness.

- Hose connections are secured with spring clamps. In case of repair, only spring clamps should be used.
- The charge air system must be tight.
- Replace self-locking nuts.

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Exhaust gas recirculation - removal and installation



1	Intake pipe	6	Seal
2	O-ring	7	Bolt, torque 22 Nm
3	Inlet	8	Exhaust manifold
4	Exhaust gas recirculation valve	9	Connecting pipe
5	Bolt, torque 10 Nm		

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Assembly notes

NOTE

- Observe the safety precautions.Observe the rules for cleanliness

Item 2: always replace.

Item 3: with exhaust gas recirculation valve and intake pipe throttle plateAlways replace completely.

Item 4: Part of inlet can only be replaced completely with inlet.

Item 6: always replace.

Item 7: always replace.

General notes

- The exhaust gas recirculation system is controlled by the injection system control unit 0N1 via solenoid valve 0Y5 to the exhaust gas recirculation valve (4).
- .The mechanical valve for exhaust gas recirculation with cone-shaped plungers allows different through-flow openings with different valve strokes.
- Due to the cycled control of the valve, any desired valve position is possible.

Exhaust gas recirculation - check

Required special tools

- Manual vacuum pump VAG 1390

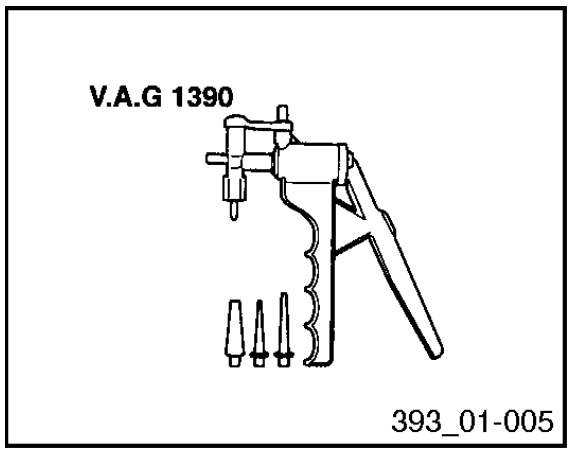
Test procedure

➢ Remove the hose to the charge cooler at the intake pipe inlet.

➢ Remove the vacuum hose at the exhaust gas recirculation valve.

➢ Connect the manual vacuum pump VAG 1390 to the valve.

▷



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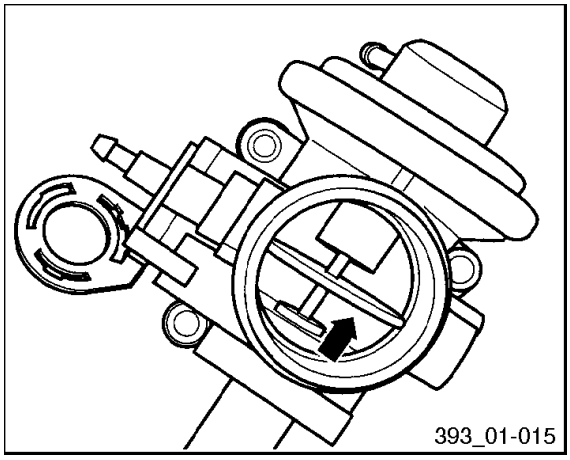
➢ Operate the manual vacuum pump and observe the diaphragm pin.

The diaphragm pin must move in the direction of the arrow.

➢ Pull the manual vacuum pump hose from the exhaust gas recirculation valve.

The diaphragm pin must return to its home position by moving in the opposite direction of the arrow.

▷



Required special tools

- Test adapter 7 917 299 010
- Wiring diagram
- Laptop with software

Prerequisites for testing

- The fuses must be okay.
- The battery voltage must be at least 11.5 V.
- All electric loads must be switched off.
- Earth connections are OK.
- No leaks on the intake and exhaust gas end.
- Engine oil temperature at least 30°C.
- No engine/injection system problems such as start of injection, injection nozzles, compression.
- No fault should be stored in the fault history, check the fault history.

Test procedure

The check of the exhaust gas recirculation is carried out in the function "Actuator test" . This procedure times the valve for exhaust gas recirculation so that the extreme readings for exhaust gas recirculation can be read in data block 03.

➢ Connect the laptop, start the software and the menu item "Actuator test".

The engine must be running at idle speed.

➢ "Select data block 3".

NOTE

If a constant value of 550 mg/stroke is shown in the actual value field, the mass air flow sensor must be checked.

The reading in the window "Actual exhaust gas recirculation" must vary in the following control ranges:

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Message: **Exhaust gas recirculation not active**

- The value in the Display field AGR "Actual" varies at least ±100 mg/stroke.
- The value in the Display field AGR "On/off ratio" varies 0 - 100%.

➢ Turn off the ignition.

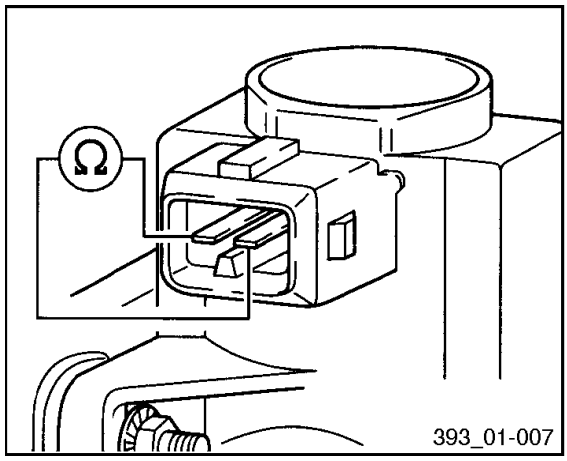
If the desired values are not achieved:

- Check the mechanical exhaust gas recirculation valve.
- Check the valve for exhaust gas recirculation 0Y5.
- Check the vacuum lines.

Check the valve for exhaust gas recirculation 0Y5.

➢ Disconnect the 2-pin plug from the solenoid valve for charge pressure limitation 0Y5.

➢ Connect the multimeter for the resistance test to the contacts of the valve. ▷



Desired resistance: 14.0 - 20.0 ?

NOTE

At room temperature the resistance is in the lower tolerance range, at operating temperature in the upper tolerance range.

If the desired value is not obtained:

➢ Replace the valve for exhaust gas recirculation 0Y5.

➢ Subsequently read out the fault history of the engine control unit and clear it, if necessary.

If the desired value is obtained of the steering resistance achieved is, must the supply voltage check are.

➢ Connect the multimeter to contact 1 of the plug and to engine earth for the voltage test.

➢ Turn on the ignition.

Desired voltage: at least 11.5 V.

If the minimum voltage is not obtained:

➢ Turn off the ignition.

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➢ Check the voltage supply relay terminal 30 (0K2) using the wiring diagram.

➢ Using the wiring diagram, check line connections for interruptions, shorts and contact resistances at the contact points.

If the minimum voltage is obtained

➢ Connect the test adapter to the control unit cable loom. This does not connect the control unit.

➢ Using the wiring diagram, check the lines between the test box and the plug for interruptions.

- Contact 1 + socket 1
- Contact 2 + socket 2
- Contact 2 + socket 61

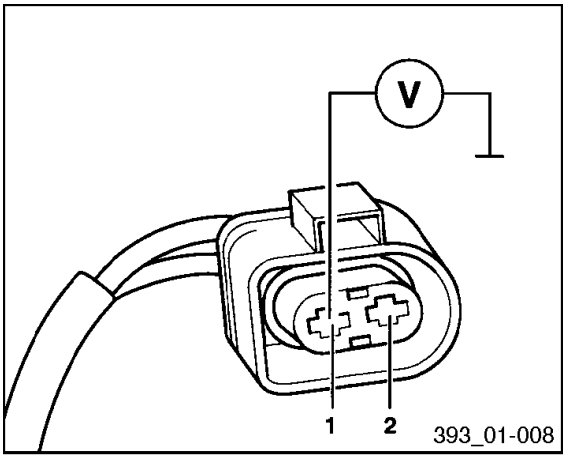
Cable resistance: max 1.5 ?

➢ Also check the lines for line-to-line shorts, short to battery earth/engine earth and to battery positive.

Desired resistance: 8 ?

If no fault is detected in the lines:

➢ Replace the control unit for the direct diesel injection system 0N1.



Cooling

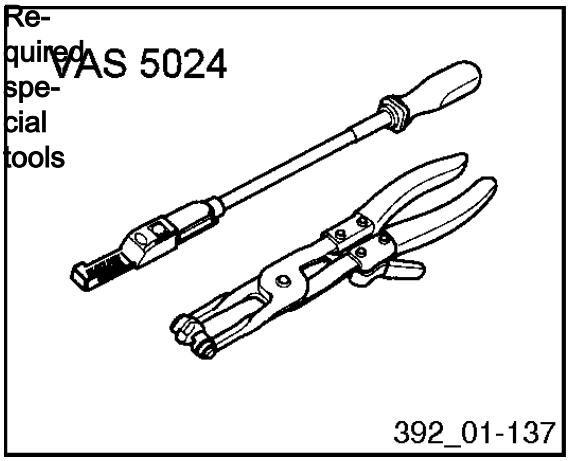
Coolant thermostat - removal and installation

- Hose clamp pliers VW VAS 5024

Coolant thermostat - removal

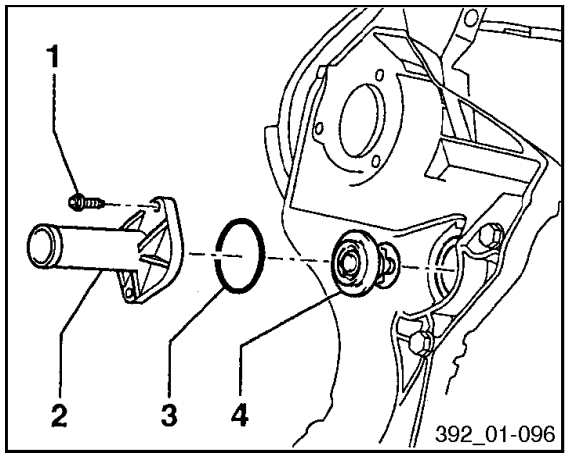
➢ Drain the coolant.

➢ Remove the coolant hose from the union (2).



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➢ Remove the fastening screws (1) of the union (2) and take off the union (2) with the coolant thermostat (4).



➢ Turn the coolant thermostat (4) ¼ turn (90°) to the left and withdraw it from the union (2).

Coolant thermostat - installation

The installation is in the reverse order of removal. Please observe the following instructions:

➢ Coat a new O-ring (3) with coolant.

➢ Insert the coolant thermostat (4) in the union (2) and turn it ¼ turn (90°) to the right.

NOTE

The backets of the coolant thermostat must be nearly vertical.

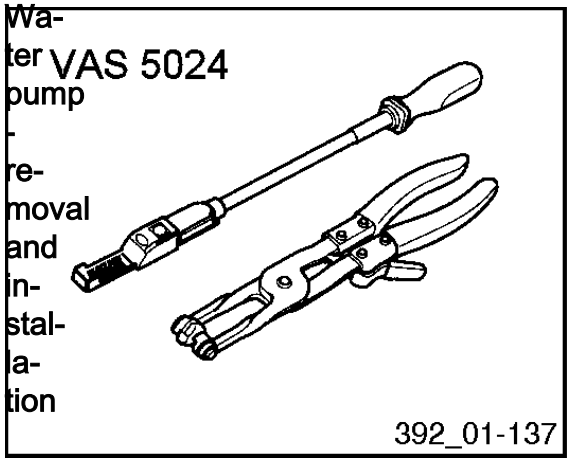
➢ Install the union (2) with the coolant thermostat (4) into the engine block.

➢ Tighten the fastening screws (1).

Torque: 15 Nm

➢ Top up coolant.

- Torque spanner 5 - 50 Nm
- Pliers for spring clamps VW VAS 5024
- Antifreeze tester



Water pump - removal

NOTE

Always renew seals and sealing rings.

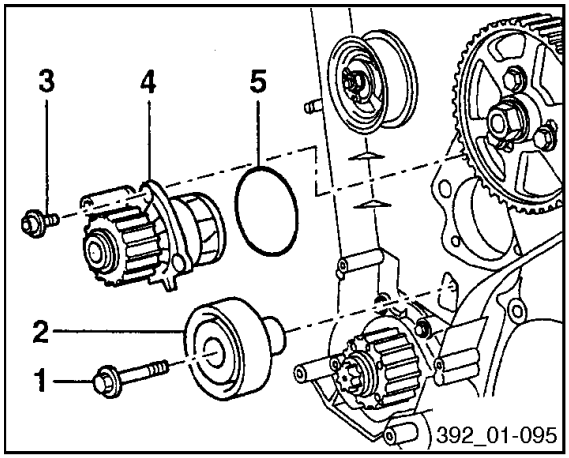
The lower toothed belt guard does not have to be removed.

The toothed belt remains in place on the crankshaft sprocket.

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Before removing the water pump, cover the toothed belt with a cloth to protect it from the coolant.

- Drain the coolant.
- Remove the ribbed V-belt.
- Remove the toothed belt guard.
- Remove the toothed belt from the camshaft sprocket, injection pump sprocket and water pump.
- Screw out the fastening bolt (1) from the reflection pulley (2) and push it down approx. 30 mm.

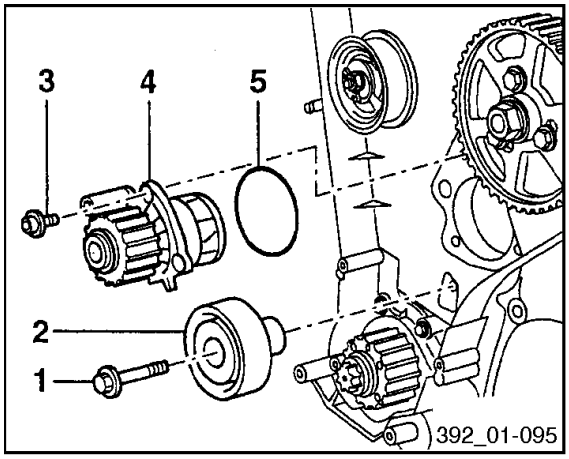


- Remove the water pump fastening bolts (3) and carefully withdraw the water pump (4) from between the engine mount and rear toothed belt guard.

Water pump - installation

The installation is carried out in the reverse order of removal. The following must be observed:

- Coat a new O-ring (5) with coolant.



- Place the water pump (4) in the cylinder block and tighten the fastening bolts (3).

Torque: 15 Nm

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NOTE

The sealing plug on the water pump shows downwards.

➢ Install the reflection pulley (2) and tighten the fastening bolt (1) (replace).

Torque: 40 Nm and ¼ turn (90°).

➢ Install, tension the toothed belt.

➢ Install the ribbed V-belt.

➢ Top up coolant.

Water pump - check wear

Required special tools

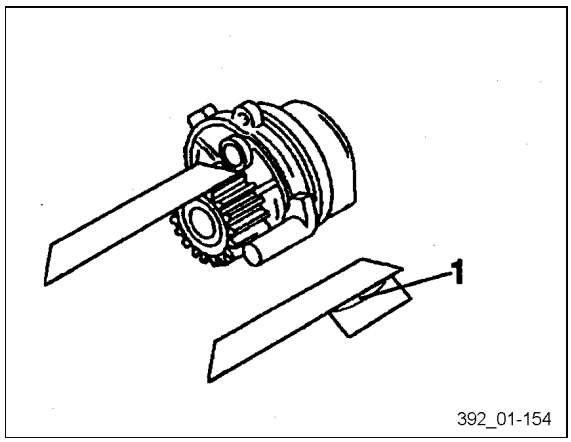
- Straight edge
- Feeler gauge

Water pump - check

➢ Turn drive wheel by hand.

The movement should not be sluggish, nor should there be too much play in the bearing.

➢ Use the straight edge and feeler gauge to determine the wear (1) along the tooth length.



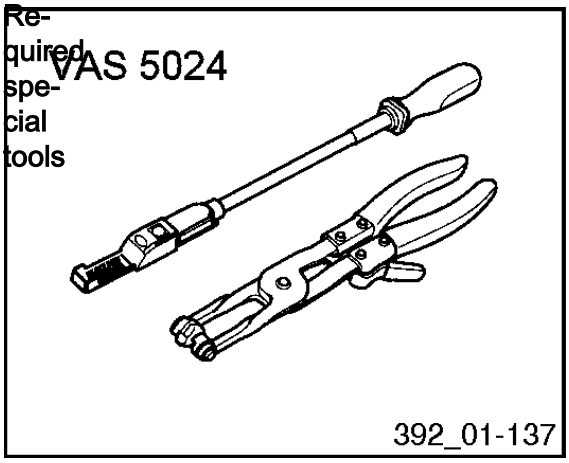
If the wear exceeds 0.30 mm, the water pump must be replaced.

Always replace together with the crankshaft pinion.

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Coolant - draining and filling

- Pliers for spring clamps VW VAS 5024
- Antifreeze tester



Coolant - draining

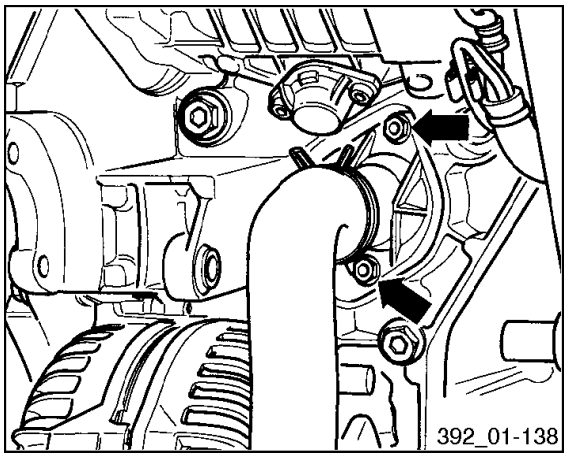
WARNING

When the expansion reservoir is opened, hot steam may escape, causing severe scalding. Cover the cap with a cloth and open it carefully!

➢ Open the sealing cap of the coolant expansion reservoir.

➢ Use the pliers for spring band clamps VW VAS 5024 to pull off the lower coolant hose at the radiator.

➢ To drain the coolant from the engine also remove the connecting piece with the coolant regulator (arrows).



NOTE

Please observe the regulations for discarding coolant!

Coolant - filling

NOTE

- *Only use G 12 acc. to TL VW 774 D as coolant additive. Characteristic feature: red colour.*
- *Never mix G 12 with other coolant additives. If the fluid in the recovery tank is brown, G 12 was mixed with an other coolant. In this case the coolant must be changed.*
- *G 12 and coolant additives with the note "in accordance with TL VW 774 D" prevent damage caused by frost and corrosion, lime deposits and also raise the boiling temperature. For these*

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reasons, the cooling system should always be filled with antifreeze and anti-corrosion agent all the year round.

- *Especially in countries with a tropical climate, the coolant contributes, due its higher boiling point, to operational reliability at high engine loads.*
- *The antifreeze protection must be guaranteed down to approx. -25 °C (in countries with Arctic climate down to approx. -35 °C.*
- *Even during the warm season and in warm countries, never reduce the concentration of the coolant by adding water. The coolant additive portion should be at least 40 %.*
- *If, for climatic reasons, a stronger frost protection is required, the amount of G 12 can be increased, but only up to 60 % (frost protection down to approx. -40 °C), since this would reduce the frost protection again and also the cooling effect.*
- *If the radiator, heat exchanger, cylinder head or cylinder head gasket were replaced, do not reuse the coolant.*

Recommended mixing ratio:

Frost protection to	Percentage of antifreeze	G 12[3]	Water[4]
-25°C	40 %	2.4 L	3.6 L
-35°C	50 %	3.0 L	3.0 L

➢ Close the coolant drain plug.

➢ Fill in coolant up to the maximum mark on the expansion reservoir.

➢ Close the expansion reservoir.

➢ Run the engine until the fan starts operating.

➢ Check the coolant level, adding coolant if necessary.

When the engine is at operating temperature, the coolant level must be at the max mark; when the engine is cold, it must be between the min and max mark.

[3] The coolant quantity may vary depending on the truck equipment.

[4] The coolant quantity may vary depending on the truck equipment.

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Engine electrical system

Alternator

To exchange the three-phase alternator, the freewheel pulley must be removed and installed again.

Freewheel pulley - removal and installation

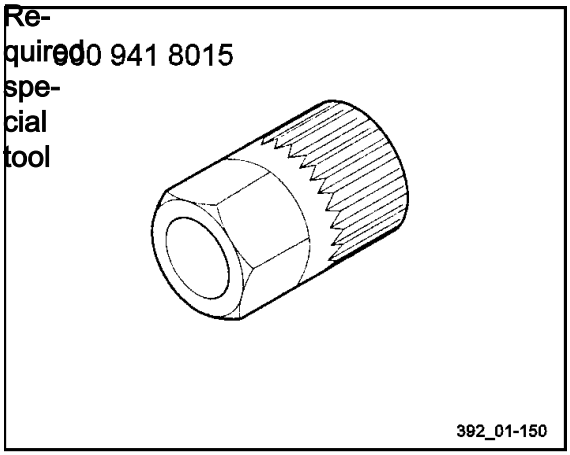
- Polygon head adapter 000 941 8015

Freewheel pulley - removal

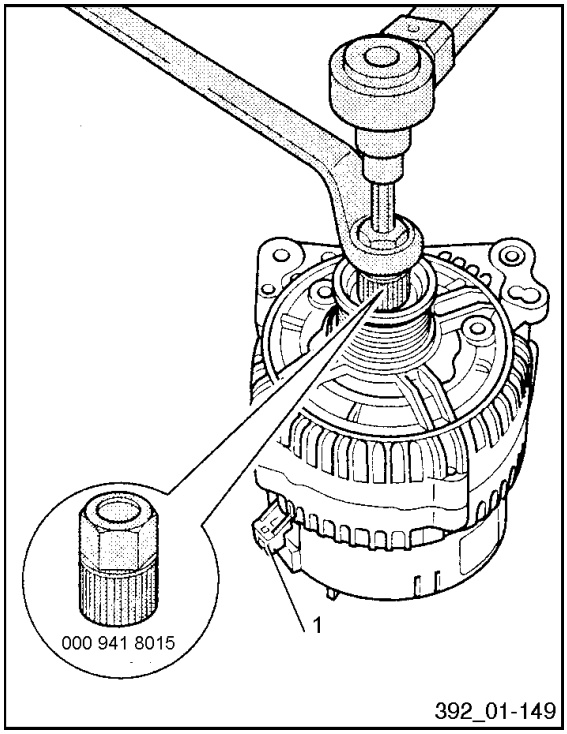
➢ Remove the ribbed V-belt.

➢ Remove the protective cap on the freewheel pulley.

➢ Put the hexagon socket (6 mm) on the drive-shaft of the three-phase alternator.



➢ Support the polygon head adapter 000 941 8015 17 with a ring spanner (17 mm) and release freewheel pulley by turning the driveshaft of the three-phase alternator anticlockwise.



Freewheel pulley - Installing

➢ Insert the polygon head adapter 000 941 8015 in the freewheel pulley.

➢ Screw the freewheel pulley - at first manually - against the stop onto the driveshaft of the three-phase alternator.

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- Support the polygon head adapter 000 941 8015 with a ring spanner (17 mm) and tighten freewheel pulley by turning the three-phase alternator anticlockwise with the torque wrench.

Tightening torque: 80 Nm

- Refit the protective cap on freewheel pulley.
- Install the ribbed V-belt.

Terminal DFM on three-phase alternator

The signal at terminal DFM is only evaluated in connection with the auxiliary heater. The signal for free charging capacity is applied to alternator terminal DFM.

Self-test

Lack of plausibility or interruption are stored as possible error causes.

Terminal DFM - additional signal

Contact 38 at controller 0N1

The DFM line connects the electronic control unit 0N1 with the combined processor in which the electronic immobilizer 0N2 (terminal W) is integrated. The immobilizer signal is transmitted over this cable. After each replacement of the control unit the new code must be read into the combined processor.

Self-test

The electronic control unit detects the interruption of this line. The engine can no longer be started in this case.

Replacing the engine control unit / immobilizer

Immobilizer - malfunctions

The engine starts, but goes off again after about 1 second. In addition, the engine warning light comes. This can last up to 30 seconds.

Prerequisites

- Voltage supply correct
- Test adapter cable OK
- Valid wiring diagram and repair instructions available

Cause of fault

Error code 17978 "Engine control unit disabled" is stored in the fault history, ie the immobilizer has not enabled the engine control unit

Correction

Replacement of immobilizer

Immobilizer - replacement

A defective immobilizer has to be replaced. In an immobilizing system of the third generation, the immobilizer has an automatic engine control unit

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recognition feature. Encoding the control unit is not necessary.

NOTE

An immobilizer can only be replaced by a new type of immobilizer.

Engine control unit - replacement

If the engine control unit is damaged or was stolen, the immobilizer and engine control unit must be replaced. It is not possible to adapt the new engine control unit to an early type of immobilizer because the new engine control unit sends a new code to the early-type immobilizer. This new code does not correspond with the previously agreed code of the immobilizer. The immobilizer does not recognize the new engine control unit and therefore does not respond

Adaptation possibilities

Engine control unit	Immobilizer	Adaptation
New	New	Possible
New	Old	Not possible
Old	New	Possible
Old	Old	Not possible if taken from different trucks
Old	Old	Possible if taken from different trucks

After one or both control units have been replaced, make sure that the immobilizer and the engine control unit are correctly connected with each other to enable communication. The immobilizer solution for industrial engines does not require a diagnostic unit after installation for adjustments. Both units automatically recognize each other when they are first put into operation after replacement. The user only has to switch on the ignition, and the immobilizer is automatically adapted to the engine control.

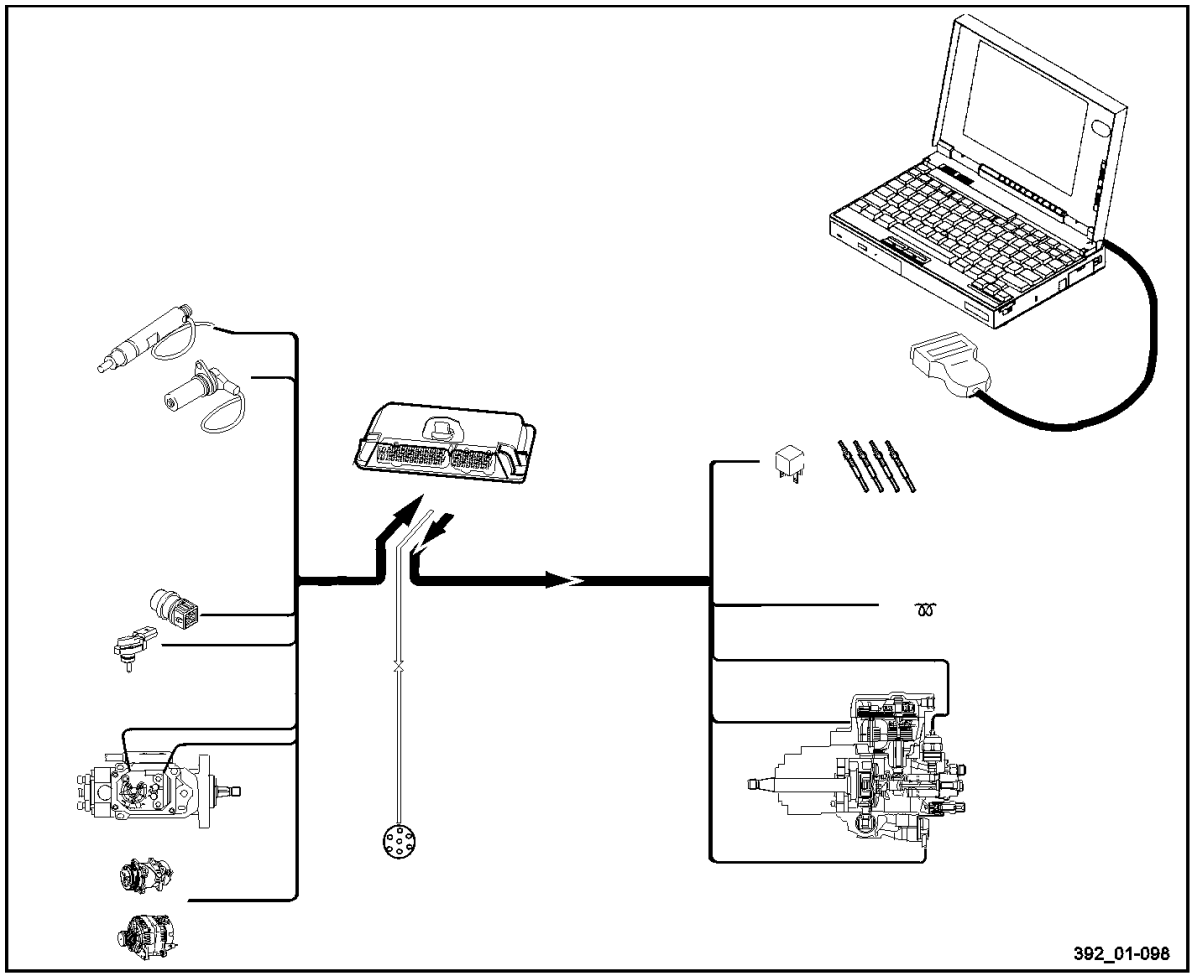
NOTE

The immobilizer can only be adapted once. After the engine control unit has been replaced, the start-up has to be performed by the diagnostic software.

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Self-test

Self-test - introduction



Self-test and safety concept of the diesel engine with Electronic Diesel Control "EDC"

During operation, the control unit has the following functions:

- Comparison of the readings supplied by sensors for plausibility.
- Monitoring of the electric and mechanical working order of the actuators. This is done with a comparison of desired values and actual values (variance comparison). The results must meet the specified requirements.
- Monitoring of the state of the cable connectors and connections for interruption and shorts.

If faults occur in the system, the EDC responds in stages, depending on the significance of the fault:

Level 1: In the event of sensors with corrective functions failing, the control continues to operate with default values or evaluable data from other sensors. The operator does not notice this generally and it is only detected during maintenance.

Level 2: Important faults involving the failure of subfunctions lead to a drop in performance. The operator is warned by the flashing preheating time indicator light.

Level 3: If the operator can no longer influence the power output of the engine with the accelerator, the EDC lets the engine run at idling speed. In this way the truck can be moved out of rolling traffic.

Level 4: If a safe operation of the engine is no longer ensured, the engine is stopped by the quantity regulating mechanism. If this is not possible due to the fault, the engine is stopped with the fuel shut-off valve (double safety).

The control unit for the injection system has a permanent fault history. This allows a check of faults which occurred at earlier starts. This allows

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a quick detection of the causes for problems. The self-test of the electronic engine control unit is carried out in operating mode "1 - Vehicle system test". The evaluation is carried out with the laptop. All sensors/actuators are monitored.

Self-test - fault finding

Required special tools

- Laptop
- Interface converter cable 300 365 2503
- Diagnostic program "Pathfinder"
- Test adapter 7 917 299 010

Prerequisites for testing

- Fuse F12 (2 A) is okay
- The battery voltage must be at least 11.5 V.
- Earth connections between engine and truck frame okay

Test procedure

➢ Connect the laptop computer.

➢ Connect the diagnostic cable to the diagnostic connector 6X2 (central electrical system, at the bottom left looking towards the forks).

➢ Start the diagnostic program.

Depending on the desired function, you must:

➢ switch on the ignition

or

➢ start the engine,

➢ follow the instructions of the diagnostic program.

After the repair, always read out the fault history of the engine control unit and clear its contents, check any other stored faults and eliminate and clear them, if possible.

NOTE

Distinction between "static" and "sporadic" faults. ***Static faults:*** *A fault is recognized as static if it is active for at least 2 seconds. If a static fault does not occur again within 2 minutes after the beginning of a driving cycle (ignition is on for at least 2 seconds), it is stored as sporadic.* ***Sporadic***

Starting the diagnosis

➢ Connect the laptop with the interface converter cable (300 365 2503) on the 7-pin truck diagnostic connector (6X2).

➢ Ignition "ON".

➢ Start the diagnostic program"Pathfinder".

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fault: *If a sporadic fault does not reoccur during 50 driving cycles (ignition is on for at least 2 seconds), it will be cleared. Before replacement of the components which have been detected to be defective, first check the lines and connectors to these components and the earth connections in accordance with the wiring diagram. Check the connectors for correct latching and correct seating on the relay plate.*

Possible causes of faults

NOTE

Check the engine control unit before testing.If a test of the engine control unit is possible, it may be assumed that the lines and connections are okay.

Problem	Possible cause	Correction
Control unit does not respond	Supply voltage too low	Check supply voltage and correct, if necessary (terminal 15 to immobilizer and engine control)
	Short between the cables of 5-pin connector ("W" and "K" at the control unit for the immobilizer or short circuit to earth)	Check connector and correct the fault, if necessary, according to the wiring diagram.
Control unit does not respond	Cable defective	Check and replace the cable, if necessary
	Immobilizer defective	Replace the immobilizer
	Control unit defective	Replace the control unit

The control unit identification is automatically checked after ignition "ON".

Fault table

The fault table is arranged in the order of the 5-digit fault code number shown on the left (eg 16500). If components are indicated to be defective:

- Check the lines and connectors to these components.
- Check the earth connections according to the wiring diagram.

Only replace the component if this check does not reveal any faults. This applies in particular to faults reported as "sporadic".

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Fault code	Possible cause	Possible effect	Correction
16485			
Mass air flow sensor 0B6	Line interruption or line-to-earth short circuit	Reduced power	Check 0B6 (see section "Checking the components and functions")
		Black smoke	
Implausible signal	0B6 defective		
16500			
Coolant temperature sending unit 0B1			
Implausible signal	Line interruption or line-to-positive short circuit	Black smoke at start	Check 0B1
	0B1 defective	A preheating of about 20 s is always carried out.	Check coolant regulator (see section "Checking the components and functions")
16684			
Misfires detected			
16685			
Cylinder 1 misfires detected			
16686			
Cylinder 2 misfires detected			
16687			
Cylinder 3 misfires detected			
16688			
Cylinder 4 misfires detected			
16705			
Engine speed sensor 0B2			
Implausible signal	Line interruption or line-to-earth short circuit	Engine can stall	Check 0B2 (see section "Checking the components and functions")
	0B2 defective	Engine runs erratically	
	Metal chips at 0B2	Indicator light for preheating time flashes	
	0B2 loose	Higher emission values	
	Gap between speed sensor/sensor wheel too big		
16706			
Engine speed sensor 0B2			

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Fault code	Possible cause	Possible effect	Correction
No signal	Line interruption or line short circuit	Engine does not start	Check 0B2 (see section "Checking the components and functions")
	0B2 defective	Engine stalls	
		Indicator light for preheating time flashes	
16985			
Control unit 0N1 defective	Control unit 0N1 internally defective	Poor driving characteristics	Replace 0N1 (see section "Checking the components and functions ")
		Engine stop	
16989			
Control unit 0N1 defective	Control unit 0N1 internally defective	Poor driving characteristics	Replace 0N1 (see section "Checking the components and functions ")
		Engine stop	
16990			
Control unit 0N1 defective	Control unit 0N1 internally defective	Poor driving characteristics	Replace 0N1 (see section "Checking the components and functions ")
		Engine stop	
17568			
Intake pipe temperature sending unit 0B4			
Short circuit to earth	Line-to-earth short circuit	Goes to default value 136.8°C	Check 0B4 (see section "Checking the components and functions ")
	0B4 defective		
17569			
Intake pipe temperature sending unit 0B4			
Interruption/short circuit to positive	Line interruption or line-to-positive short circuit	Goes to specified value 136.8°C	Check 0B4 (see section "Checking the components and functions ")
	0B4 defective		
17570			
Fuel temperature sending unit 0B3			
Short circuit to earth	Line interruption or line-to-positive short circuit	Goes to specified value 136.8°C	Check 0B3 (see section "Checking the components and functions ")
17571			
Fuel temperature sending unit 0B3			
Interruption/short circuit to positive	Line interruption or line-to-positive short circuit	Goes to specified value -5.4°C	Check 0B3 (see section "Checking the components and functions ")
		Higher emission values	

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Fault code	Possible cause	Possible effect	Correction
17656			
Start of injection control			
System deviation	Fuel tank empty	Engine runs erratically	Fuel filter or fuel line clogged
	Fuel supply defective, lack of fuel	Reduced power	Dynamically check and adjust start of injection
	Start of delivery not correct	Higher emission values	Check 0Y2, actuator diagnosis
	Start of injection valve 0Y2 defective	Poor cold start behaviour	Check 0B5 (see section "Checking the components and functions ")
	Needle stroke sensor 0B5 defective		
17659			
Start of injection valve 0Y2			
Short circuit to positive	Line-to-positive short circuit	Engine knocks at idle because start of injection is constantly "advanced"	check 0Y2 (see section "Checking the components and functions"
	0Y2 defective		
17660			
Start of injection valve 0Y2			
Interruption/short circuit to earth	Line interruption	Engine knocks at idle because start of injection is constantly "advanced"	check 0Y2 (see section "Checking the components and functions"
	0Y2 defective		
	Line-to-earth short circuit	Not enough power because start of injection is constantly "retarded"	
	0Y2 defective		
17663			
Coolant temperature sending unit 0B1			
Short circuit to earth	Line-to-earth short circuit	Black smoke at start	Check 0B1 (see section "Checking the components and functions")
	0B1 defective	A preheating of about 20 s is always carried out	
17664			
Coolant temperature sending unit 0B1			
Interruption/short circuit to positive	Line interruption or line-to-positive short circuit	Black smoke at start	Check B1 (see section "Checking the components and functions")
	0B1 defective	A preheating of about 20 s is always carried out.	
17762			

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Fault code	Possible cause	Possible effect	Correction
Control sleeve position sensor 0B3			
Electrical fault in circuit	Line interruption or line short circuit	Indicator light for preheating time flashes	Check 0B3, check sensor for control sleeve position and fuel quantity positioner (see section "Checking the components and functions")
	Injection pump defective	Poor driving characteristics	
		Engine stop	
17945			
Fuel shut-off valve 0Y1			
Malfunction	0Y1 leaking or jamming	Reduced power	check 0Y1 (see section "Checking the components and functions")
	0Y1 defective	Engine stop	
17946			
Fuel shut-off valve 0Y1			
Interruption/short circuit to earth	Line interruption or line-to-earth short circuit	Reduced power	check 0Y1 (see section "Checking the components and functions")
	0Y1 defective	Engine stop	
17969			
Fuel quantity positioner			
System deviation	Line interruption or line short circuit	Indicator light for preheating time flashes	Check 0B3, check sensor for control sleeve position and fuel quantity positioner (see section "Checking the components and functions")
	Injection pump defective	Poor driving characteristics	
		Engine stop	
17970			
Fuel quantity positioner			
Upper limit stop	Upper limit stop value reached	Reduced power	Check 0B3, check sensor for control sleeve position and fuel quantity positioner (see section "Checking the components and functions")
	0B3 defective/blocked	Bucking	
17971			
Fuel quantity positioner			
Lower limit stop	Lower limit stop value reached	Black smoke	Check 0B3, check sensor for control sleeve position and fuel quantity positioner (see section "Checking the components and functions")
	0B3 defective/blocked	Rough idling	
17978			

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Fault code	Possible cause	Possible effect	Correction
Engine control unit 0N1 disabled			
	Line interruption or short circuit of communication line	Engine starts running for a short time and then stalls	Check line between engine control unit and immobilizer control unit acc. to wiring diagram
		Indicator light for preheating time flashes	
	Engine control unit 0N1 not replaced together with control unit of immobilizer		Replace 0N1 (see section "Checking the components and functions")
	Engine control unit 0N1 defective		
	Immobilizer 0N2 defective		
18008			
Voltage supply terminal 15			
Voltage too low	No voltage at "Ignition ON" (terminal 15)	Engine does not start	Checking the voltage supply of the injection system
		Poor driving characteristics up to engine stop	
18009			
Voltage supply relay terminal 30			
Implausible signal	No voltage at "Ignition ON" (terminal 15)	Engine does not start	Checking the voltage supply of the injection system
		Poor driving characteristics up to engine stop	
18020			
Engine control unit			
Wrong coding	Invalid control unit coding	Indicator light for preheating time flashes	Encode control unit
18026			
Glow plug relay 0K1			
Short circuit to positive	Short circuit to positive	No preheating	check 0K1 (see section "Checking the components and functions")
	0K1 defective	Poor cold start behaviour	
		Indicator light for preheating time flashes	
18027			
Glow plug relay 0K1			
Interruption/short circuit to earth	Line interruption or line-to-earth short circuit	No preheating	Check 0K1 (see section "Checking the components and functions")
		Poor cold start behaviour	
		Indicator light for preheating time flashes	
18033			

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Fault code	Possible cause	Possible effect	Correction
Drive data bus			Encode control unit
18034			
Drive data bus			Encode control unit
18048			
Control unit 0N1 defective	Control unit 0N1 internally defective	Poor driving characteristics Engine stop	Replace 0N1 (see section "Checking the components and functions")
18056			
Drive data bus			Encode control unit
19456			
Indicator light for preheating time			
Fault message from display	Faults in data lines to the display		Check connective resistance for data bus

Standardised data blocks

Safety measures

CAUTION

The use of gauges and test instruments, which can fall off the truck falling and be destroyed, may be required for test drives.

Always fasten testers and gauges well

If necessary, block up the truck

Data blocks - Prerequisites for testing

- The coolant temperature must be at least 80°C.
- All electrical loads such as rear window heating must be switched off.
- The air conditioning system of the truck, if fitted, must be switched off.
- Display the fault history.

No fault should be stored in the fault history.

Test procedure

➢ Start the diagnostic program"Pathfinder".

➢ In the menu "Inputs and outputs" select the button "Standardised data blocks".

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Display Group	Display field 1	Display field 2	Display field 3	Display field 4
01	Engine speed xxxx/min	Injection quantity xx.x mg/stroke	Pump voltage x.xx V	Coolant temperature xxx.x°C
03	Engine speed xxxx/min	On/off ratio of EGR valve	Desired exhaust gas recirculation xxx mg/stroke	Actual exhaust gas recirculation xxx mg/stroke
04	Engine speed xxxx/min	On/off ratio of start of injection valve 0 - 100%	Desired start of injection xx.x° BTDC (ATDC)	Actual start of injection xx.x° BTDC (ATDC)
05	Engine speed xxxx/min	Coolant temperature xxx.x°C	Actual start of injection xx.x° BTDC (ATDC)	Start quantity xxx mg/stroke
07	Fuel temperature xxx.x°C	Coolant temperature xxx.x°C	Intake pipe temperature xxx.x°C	
10	Mass air flow xxx mg/stroke	atmospheric pressure xxxx mbar	Intake pipe pressure xxx mbar	
11	Engine speed xxxx/min	On/off ratio of charge pressure limitation 0 - 100%	Actual charge pressure xxxx mbar	Desired charge pressure xxxx mbar
12	Preheating time xx.xx s	Coolant temperature xxx°C	Controller battery voltage xx.x V	
13	Deviation of cylinder 1 x.xx mg/stroke	Deviation of cylinder 2 x.xx mg/stroke	Deviation of cylinder 3 x.xx mg/stroke	Deviation of cylinder 4 x.xx mg/stroke

Data block 01 - evaluating

- Warm engine, coolant temperature not under 80°C
- Idle

Data block	Number	Display field	Desired value
01	1	Engine speed	960 - 1050 rpm
	2	Injection quantity	7.0 -13.0 mg/stroke
	3	Pump voltage	1.92 - 2.19 Volt
	4	Coolant temperature	80 - 110°C

Evaluation "of injection quantity"

Display	Possible cause	Correction
Under 7 mg/stroke	Mixture too rich	Replace injection pump
Over 9 mg/stroke	Engine too cold	Warm up engine at increased speed and repeat test
	Mixture too lean	Replace injection pump

Evaluation of pump voltage

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Display	Possible cause	Correction
under 1.6 Volt	Mixture too rich	Replace injection pump
Over 2.1 Volt	Engine too cool	Warm up engine at increased speed and repeat test
	Mixture too lean	Replace injection pump

Data block 04 - evaluating

- Warm engine, coolant temperature not under 80°C
- idle

Data block	Number	Display field	Desired value
04	1	Engine speed	960 - 1050 rpm
	2	On/off ratio of start of injection valve	2 - 80%
	3	Desired start of injection	0° ATDC to 4° BTDC
	4	Actual start of injection	0° ATDC to 4° BTDC

Evaluation "Desired start of injection"

Display	Possible cause	Correction
over 4° BTDC	Engine too cool	Warm up engine at increased speed and repeat test

Evaluation "Actual start of injection"

Display	Possible cause	Correction
over 4° BTDC	Engine too cool	Warm up engine at a higher speed and repeat the test
	Injection pump stands too "early"	Dynamically check and adjust start of injection
	Start of injection valve (N108) defective	Check 0Y2, actuator diagnosis
after TDC	Injection pump stands extremely too "late"	Dynamically check and adjust start of injection
	Injection timing inhibited	Check 0Y2, actuator diagnosis
	Start of injection valve (N108) defective	actuator diagnosis

Data block 04 - evaluating

- Full load
- Warm engine, coolant temperature not under 80°C

Data block	Number	Display field	Desired value
04	1	Engine speed	approx. 2700 rpm
	2	On/off ratio of start of injection valve	70 - 95%
	3	Desired start of injection	5.0 to 10° BTDC
	4	Actual start of injection	about desired start of injection

Evaluation "Actual start of injection"

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Display	Possible cause	Correction
If deviation from the desired value (approx. 5°) is too large	Start of injection valve 0Y2 defective	Check 0Y2, actuator diagnosis
	Injection pump stands extremely incorrectly	Dynamically check and adjust start of injection
	Air in the fuel system	Check fuel supply

Evaluation "On/off ratio of start of injection valve"

Display	Possible cause	Correction
under 10% or over 95%	Start of injection valve 0Y2 defective	Check 0Y2, actuator diagnosis
		Dynamically check and adjust start of injection
		Check fuel supply

Data block 05 - evaluating

- Ignition switched on

The values indicated describe the conditions at engine start.

Data block	Number	Display field	Desired value
05	1	Engine speed	
	2	Coolant temperature	
	3	Actual start of injection	
	4	Start quantity	

Data block 07 - evaluating

- Ignition switched on
- Cooled, stationary engine

Data block	Number	Display field	Desired value
07	1	Fuel temperature	about ambient temperature
	2	Coolant temperature	about ambient temperature
	3	Intake pipe temperature	about ambient temperature
	4	free	

A specification of desired temperature values is not possible. With the engine cooled down, the temperature values of fuel, intake air and coolant have to be approximately the same as the ambient temperature. Check the relevant sensor if there are significant deviations.

Evaluation "Fuel temperature"

Display	Possible cause	Correction
-5.4°C	Short or fuel temperature sending unit (G81) defective	Check 0B3. In case of a fault the data block indicates a fuel temperature of -5.4°C.

Evaluation "Intake pipe temperature"

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Display	Possible cause	Correction
approx. 136.8°C	Intake pipe temperature sending unit (G72) defective	Check 0B4. In case of a fault the data block indicates a fuel temperature of -136.8°C.

Evaluation "Coolant temperature"

Display	Possible cause	Correction
Large deviation from the ambient temperature	Short-circuit or coolant temperature sending unit(G62) defective	Check 0B1. In the event of a fault, the fuel temperature is indicated instead.

Data block 12 - evaluating

- Ignition switched on

The values indicated describe the conditions at engine start.

Data block	Number	Display field	Desired value
12	1	Preheating time in seconds	
	2	Coolant temperature	
	3	Battery voltage	
	4	free	

Data block 13 - evaluating

Data block	Number	Display field	Desired value
13	1	Deviation of cylinder 1	-1.9 up to +1.9 mg/stroke
	2	Deviation of cylinder 2	
	3	Deviation of cylinder 3	
	4	Deviation of cylinder 4	

Evaluation "Idle adjustment"

Display	Possible cause	Correction
-xx mg/stroke	Drop in cylinder performance	The cylinder is supplied with more fuel
+xx mg/stroke	Rise in cylinder performance	The cylinder is supplied with less fuel

The injection system has an idle speed control, which detects and balances any differences in performance between the individual cylinders (component tolerances, nozzle throughput, compression, etc) by a selective metering of the injected fuel at idle speed.

Differences are detected at idle speed with the signal from the engine speed sensor, which supplies four signals per crankshaft revolution to the control unit. If all signals are received at the same rhythm, all cylinders perform the same work. If one cylinder has a poorer performance, the crankshaft needs more time for the next half

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crankshaft revolution.On the other hand, a powerful cylinder accelerates the crankshaft so much that it needs less time.

Once the control unit has detected a difference, the relevant cylinder will be supplied with a larger or smaller amount of fuel until the engine runs "smoothly" again.

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Technical data about travel drive

Variable-displacement pump	
Manufacturer	Linde
Type	HPV 75 -02
Number of pistons	7
Maximum working pressure	430+20 bar
Supply and control pressure	18 bar
Swash plate angle	0 - 19,7°
Pump speed	2800 rpm
Oil flow after flow control valve	16 - 17 l/min
Control of pump	hydraulic
Control of pump adjustment	via Linde Truck Control (LTC)
Positive connection to engine	Elastic coupling
Drive axle	
Manufacturer	Linde
Type	AH 35 -03
Hydraulic displacement motor	HMF 550 R, two pieces
Number of pistons	11
Swash plate angle	20.8° constant
BRAKE	
Oil pressure - multi-disk brakes	on extended motor shaft fully encapsulated acting only as a parking or emergency brake
Tandem gear pump	
Pump V1 for working hydraulics and steering	q_1 = 23 cm^3/U
Pump V2 for charging, servo control and hydraulic drive of fan	q_2 = 14 cm^3/U

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Linde Truck Control (LTC)

Digital electrohydraulic control unit

The trucks of series 39X come equipped with the latest control technology. Instead of a hydraulic accelerator, which was used in the previous truck series, a compact electronic control unit featuring a highly efficient microcontroller performs all control functions of the travel drive and the working hydraulics.

Adaptation for various trucks

The electronic control unit is capable of controlling trucks of various series and different engines. To take into account deviating truck parameters, every truck cable harness is coded for the definite identification of the truck.

Fault detection

The processor of the electronic control unit evaluates analogue and digital signals. It detects non-logical states and system faults and outputs a fault message on the test instrument via the serial interface. The control unit also initiates various measures, depending on the hazard potential of the fault:

- Warning light flashes.
- RPM limitation of IC engine.
- Truck brakes with normal deceleration and does not move off again.
- Truck brakes with emergency function and IC engine shuts down.
- Error code appears on the display.

These measures can be reversed by shutting down the truck with the ignition switch. When restarting, the control unit checks whether there is still a fault. If there is no fault, the truck continues to drive as in normal operation. If there is still a fault, the error code re-appears on the display and one of the above-mentioned measures will be taken.

Brake

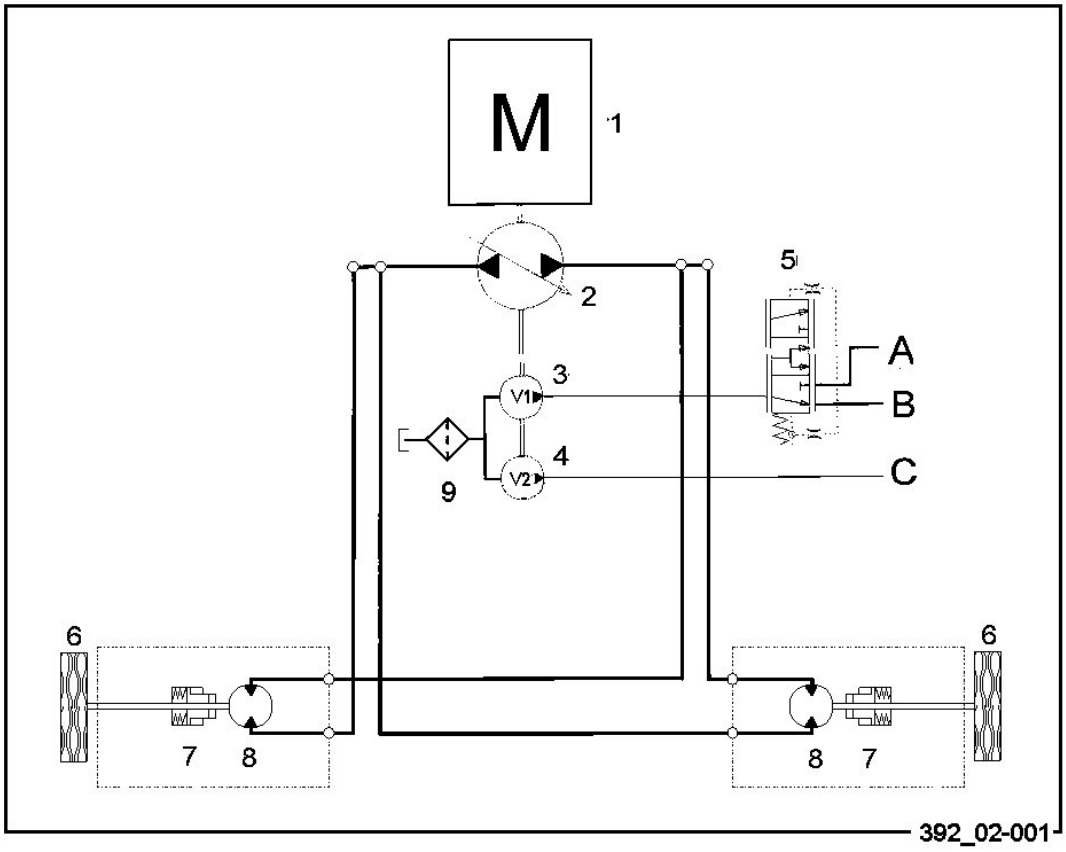
The brake is designed as a parking and emergency brake. It is operated mechanically and hydraulically by a valve. A microswitch is actuated at half and full brake pedal travel.

Release valve

The release valve is a safety valve which, in the event of a failure of the activation of the pump control, automatically decelerates the truck or prevents the truck from moving off at all. The valve is closed when the accelerator is depressed and opens when the truck is standing still.

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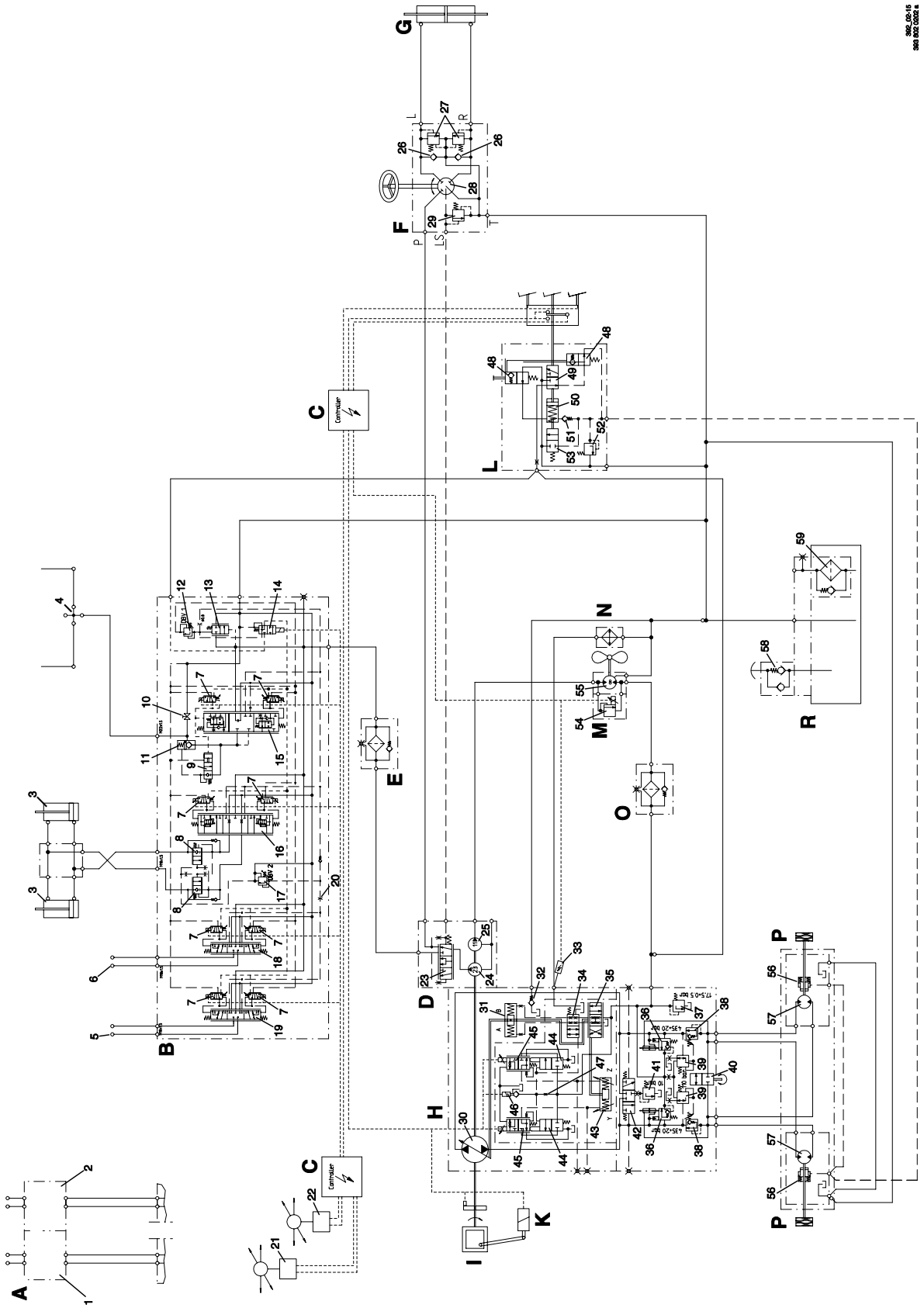
System overview



1	Engine	7	Multiple disc brake
2	Variable-displacement hydraulic pump HPV 75 -02	8	Fixed-displacement hydraulic motor HMF 550 R
3	Gear pump V1, q_1 = 23 cm^3/rev	9	Suction filter
4	Gear pump V2, q_2 = 14 cm^3/rev	A	Working hydraulics
5	Priority valve	B	Steering
6	Traction wheels	C	Supply

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Wiring diagram, with brake valves



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A - Auxiliary hydraulics with duplex or triplex mast
1 Hose reel, left
2 Hose reel, right

B - Working hydraulics
3 Tilt cylinder
4 Standard mast
5 Connection for auxiliary hydraulics 2 with standard mast
6 Connection for auxiliary hydraulics 1 with standard mast
7 Solenoid valve
8 Tilt brake valve
9 Slow lowering valve
10 Emergency lowering valve
11 Check valve
12 Pressure relief valve 1
13 2/2-port directional control valve
14 Release valve
15 Lift/lower directional control valve
16 Tilt directional control valve
17 Pressure relief valve 2
18 Directional control valve for auxiliary hydraulics 3
19 Directional control valve for auxiliary hydraulics 4
20 Restrictor

C - Linde Truck Control
21 Central control lever for working hydraulics
22 Central control lever for auxiliary hydraulic systems 1 and 2

D - Tandem pump
23 3/3-port directional control valve (priority valve)
24 Gear pump V_1, q_1 = 23 cm^3/rev
25 Gear pump V_2, q_2 = 14 cm^3/rev

E - Working hydraulics pressure filter

F - Steering control valve
26 Make-up valve
27 Secondary valve p = 180^{+20} bar for H 30, p = 205^{+20} bar for H 35
28 Steering control valve
29 Primary valve, p = 120^{+5} bar for H 30, p = 150^{+5} bar for H 35

G - Steer cylinder

H - Variable-displacement hydraulic pump
30 Variable-displacement pump HPV 75 -02
31 Control piston A = forward direction, B = reverse direction
32 Pressure relief valve p = 1 bar
33 Sensor (hydraulic oil temperature)
34 4/2-port directional control valve
35 Pilot valve
36 Combined feed/pressure relief valve p = 435^{+20} bar
37 Boost pressure valve p = $17.5^{+0.5}$ bar
38 Brake valve (main control valve)
39 Brake valve (pilot valve)
40 Bypass valve
41 Purge valve
42 4/3-port directional control valve
43 Servopiston, Y = forward direction, Z = reverse direction
44 2/2-port directional control valve
45 Proportional valve
46 Release valve
47 Nozzle

I - IC engine
n = 1000 - 2800 min

K - Speed actuator in injection pump

L - Brake release valve
48 Towing device
49 3/2-port directional control valve
50 Pump for releasing brake
51 Check valve
52 Pressure relief valve p = 20 bar
53 2/2-port directional control valve

M - Fan drive

N - Cooler
54 Solenoid valve
55 Hydraulic motor q = 8 cm^3

O - Boost pressure filter

P - Fixed-displacement hydraulic motor
56 Multiple disc brake
57 Fixed-displacement hydraulic motor HMF 550 R

R - Oil reservoir
58 Breather filter with suction strainer and pressurising valve p = 0.35±0.15 bar
59 Suction filter with bypass valve 0.25 bar

Travel drive - introduction

Control of truck speed

The truck speed of a hydrostatically powered truck results from the speed of the IC engine and the hydraulic ratio (output of the variable-displacement pump to input of the hydraulic motors). The output volume of the variable-displacement pump depends on the pump speed, swash angle and the specific output volume of the pump.

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To maintain a speed specified by the accelerator, the electronic control regulates the speed of the IC engine and the swash angle of the pump.

In the case of a speed specified by the accelerator (desired speed), each change in the engine speed is compensated by a change in the swash angle of the pump. This is only possible as far as power limit of the IC engine, beyond this the speed is reduced. The various control situations at different accelerator positions will be discussed below.

Moving off on a slope

The parking brake is operated mechanically and hydraulically with the brake pedal via a valve. In addition, two microswitches (1 and 2) are also actuated with the brake pedal.

When the brake pedal is released half way, microswitch 1 is actuated, while the brake is still applied. If the accelerator is depressed at the same time, the electronic control unit only allows a limited pump swash angle as the truck is accelerating against an applied brake.

When the brake pedal is released fully, microswitch 1 actuates (microswitch 2 remains in its initial position) and the limitation of the pump swash angle is removed, the brake is released and the truck moves off without rolling back.

Driving

When the accelerator is depressed, the variable-displacement pump strokes up proportionally to the pedal stroke and the speed of the traction motor increases. The truck speed reaches the desired speed specified by the accelerator.

Depressing the accelerator further and thus specifying a faster truck speed increases, proportionally to the pedal travel, the engine speed and the pump swash angle. When the maximum engine speed is reached, the truck speed and the pump swash angle are at their maximum values. The power control prevents the maximum available engine power from being exceeded.

Power control - travel drive

The swash angle of the variable-displacement pump and the speed of the IC engine are automatically controlled by the electronic control unit in accordance with the pedal travel.

A speed sensor reports the engine rpm to the control unit. A variance comparison is carried out in the control unit and the variable-displacement pump is destroked in case of a deviation.

If the engine power is exceeded (engine overload too high), the electronic control unit reduces the pump swash angle (reduced power demand) until the engine speed (actual value) again corresponds to the value specified with the accelerator. Through this variance comparison of the engine speed, the power demand of the working hydraulics is also included in the control unit.

Speed control - working hydraulics

When the tilting and auxiliary hydraulic system functions are operated, the central control lever for working hydraulics (joystick) supplies a signal via a potentiometer to the electronic control unit which increases the speed of the IC engine.

When the lifting function is performed, a signal is given to the electronic control unit which increases the speed of the IC engine to the maximum value.

Truck speed governing

The swash angle of the variable pump and the speed of the IC engine are automatically controlled by a variance comparison with the accelerator via the electronic control. If a higher speed of the IC engine is requested through a signal supplied to the control unit by the working hydraulics, the control unit responds to the higher value and allows the engine speed to increase. As the actual speed is now higher than the desired speed specified by the accelerator, the electronic control unit immediately reduces the angle of the pump swash plate to prevent an increase in the driving speed.

The governing occurs so fast that the driver does not notice a change in speed.

Braking

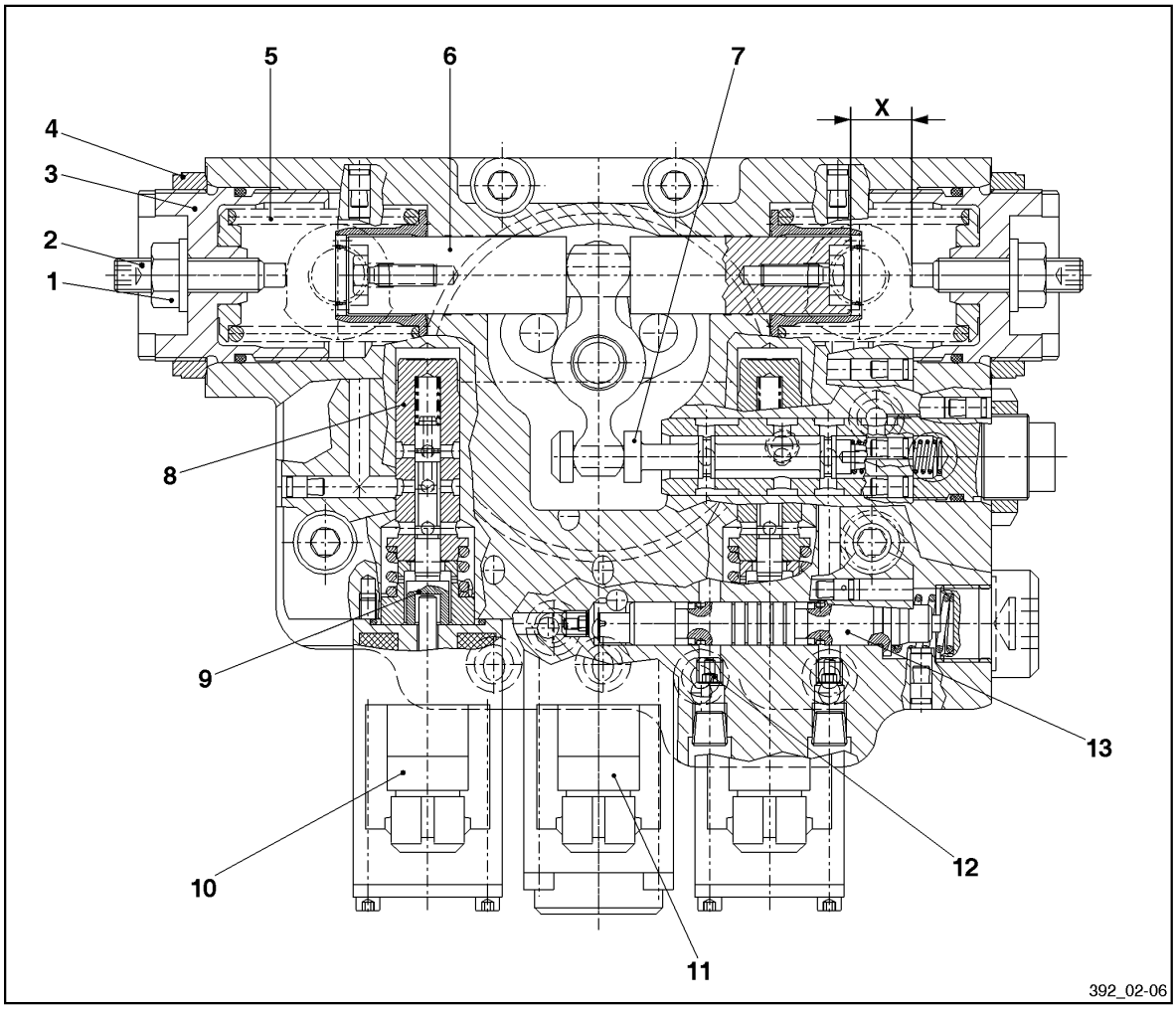
The minimum and maximum swivelling time of the variable-displacement pump from Q_{min} to Q_{max} or from Q_{max} to Q_{min} is specified by the electronic control unit. It controls the swivelling speed of the variable-displacement pump within this range depending on the engine speed. This achieves a braking deceleration, which is (almost) unaffected by the load condition of the truck.

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Reversal of the direction of travel

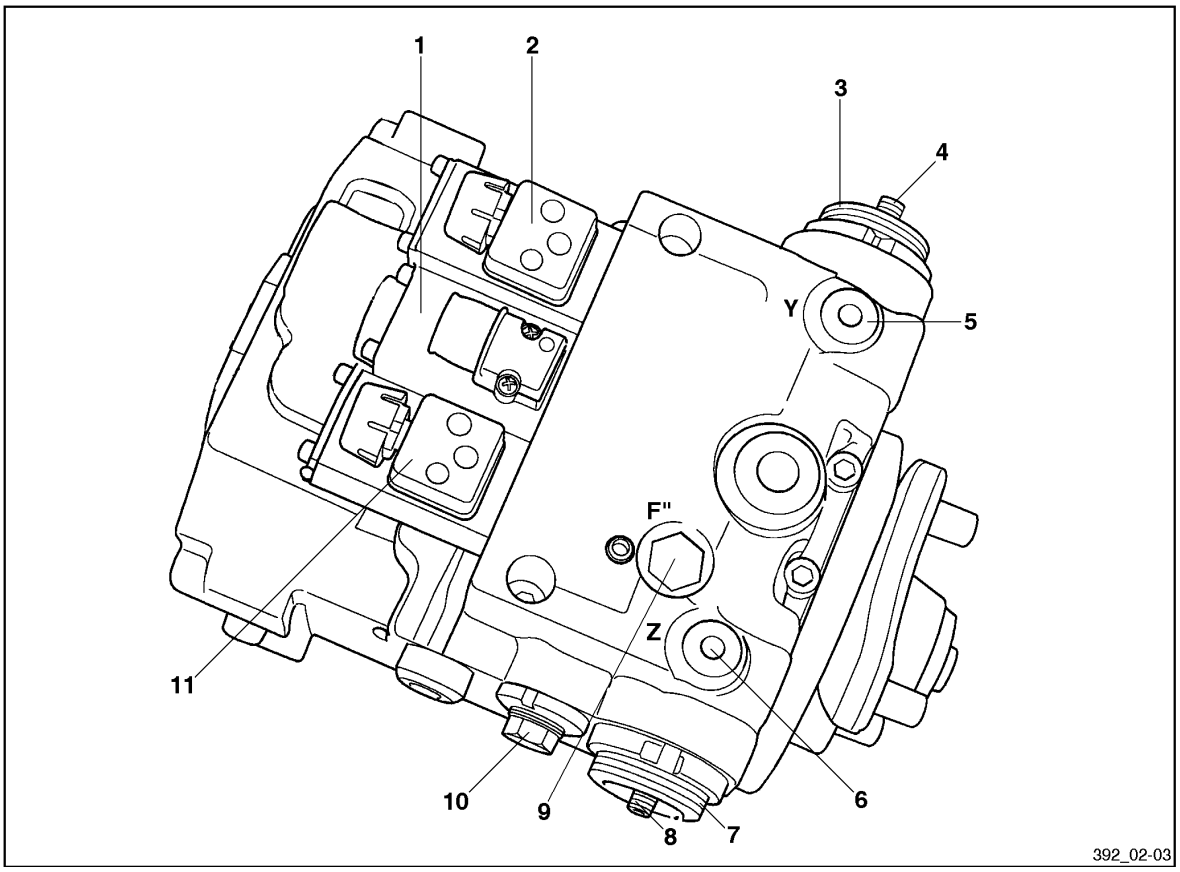
When reversing the direction of travel, the signals for the new direction and the engine speed are only released when the electronic control unit has sensed the neutral (zero) position of the variable-displacement pump. This ensures that the engine speed drops to low idle speed and increases only when the new direction has been selected.

Hydraulic pump control with electronic control



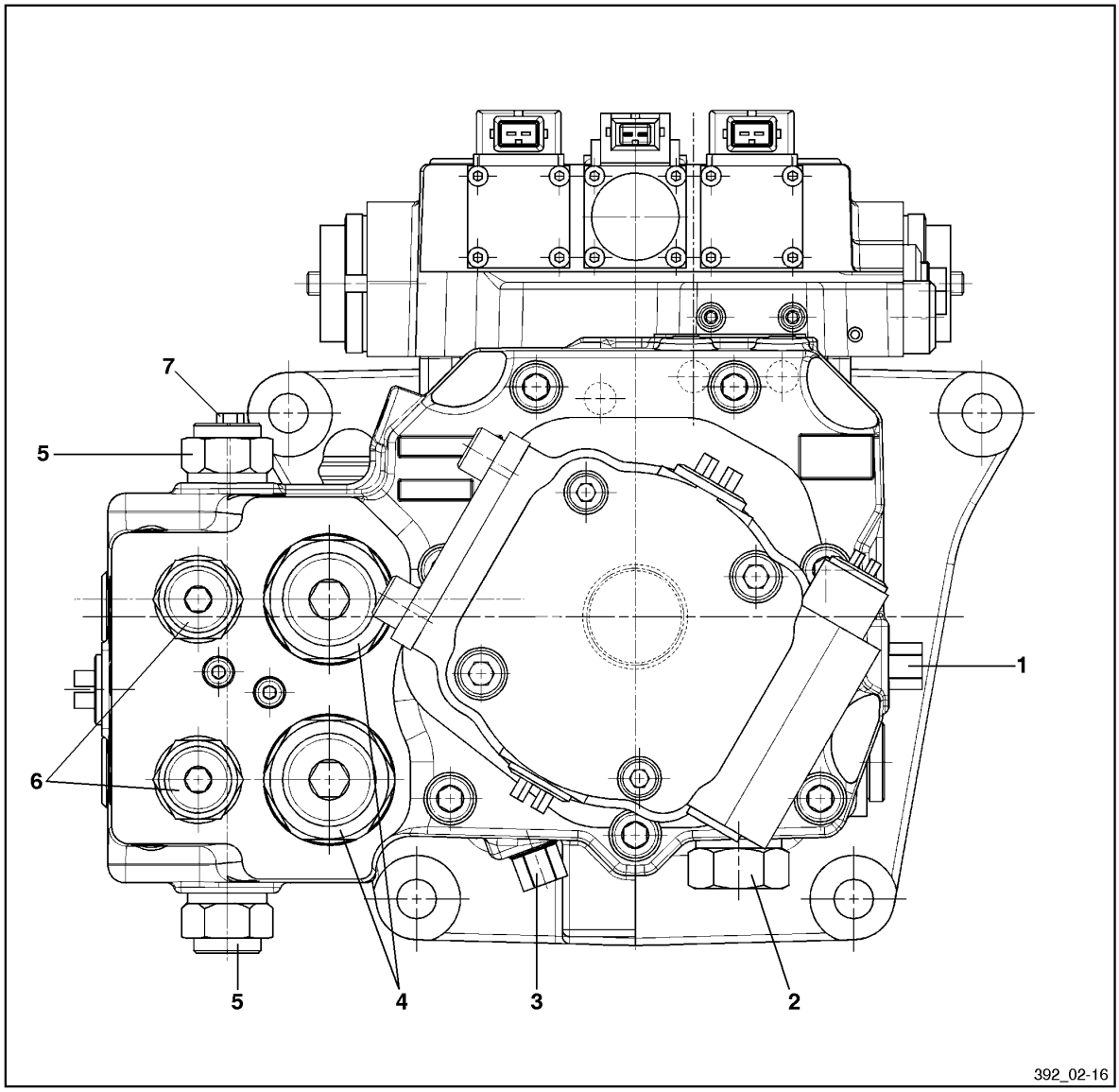
1	Locknut	8	Way valve
2	Swash angle adjustment screw	9	Proportional valve
3	Setting bush - start of delivery	10	Solenoid
4	Locknut	11	Release valve
5	Control springs	12	Nozzles
6	Servopiston	13	Way valve
7	Control pilot	x	max travel of servo piston 15.1 mm

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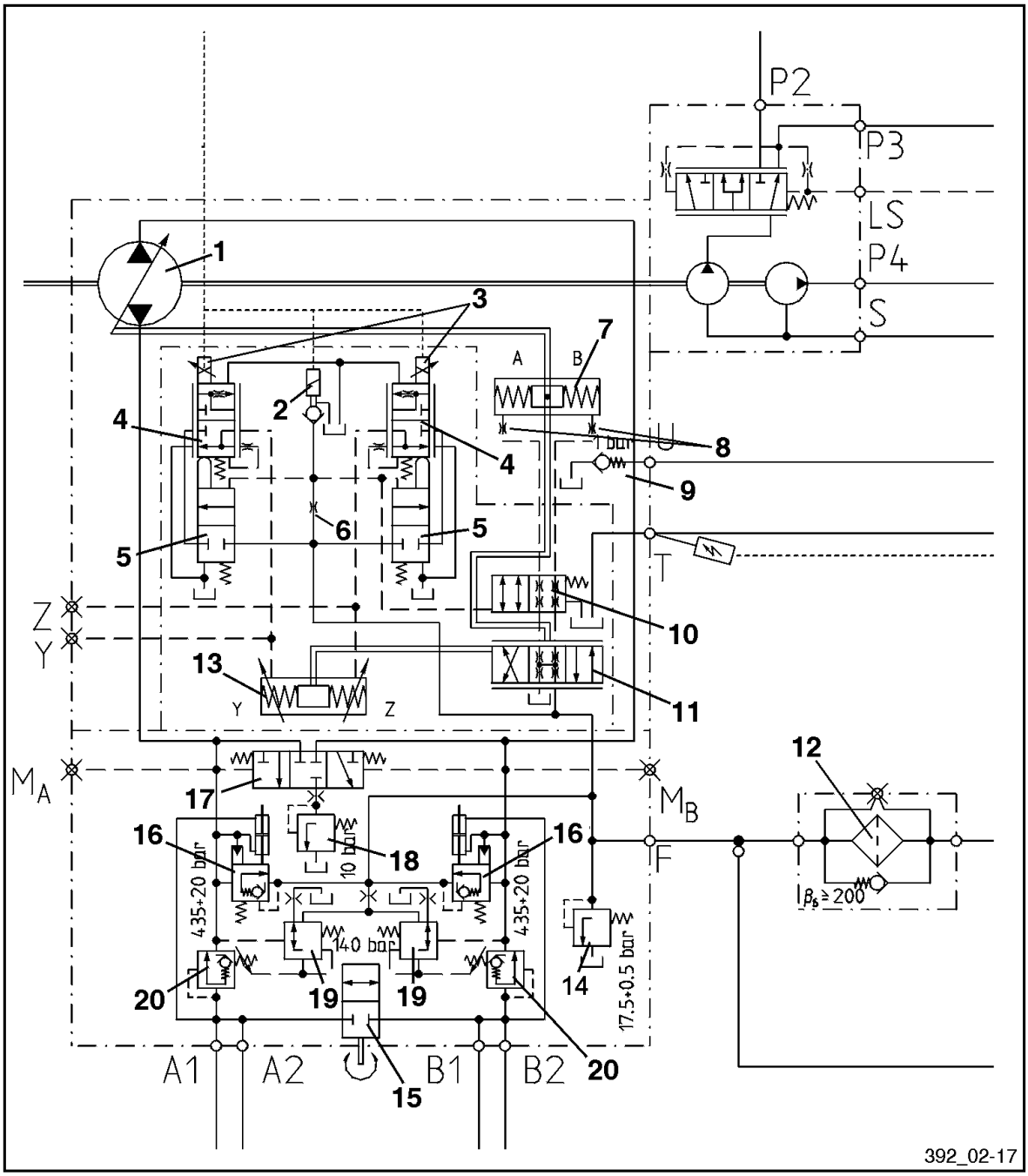
1	Release valve	7	Adjustment start of delivery - forward direction
2	Proportional valve, forward	8	Swash angle adjustment screw, forward direction
3	Start of delivery adjustment, reverse direction	9	Test port for pilot oil pressure F? upstream of the release valve
4	Swash angle adjustment screw, reverse direction	10	Hydraulic zero position
5	Test adapter Y - pilot oil pressure, forward direction	11	Proportional valve, everse
6	Test adapter Z - pilot oil pressure, reverse direction		

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1	Purge valve	5	Pressure relief valves
2	Switch-over valve	6	Brake valves (pilot valve)
3	Boost pressure valve	7	Bypass valve
4	Brake valves (main control valve)		

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1	Variable-displacement hydraulic pump	15	Bypass valve
2	Release valve	16	Combined feed/pressure relief valve p = 435^{+20} bar
3	Proportional solenoid	17	4/3-port directional control valve
4	Proportional valve	18	Relief valve
5	2/2-port directional control valve	19	Brake valves (pilot valve)
6	Nozzle Ø 1 mm	20	Brake valves (main control valve)
7	Cradle control piston	A1/A2	High-pressure port, forward
8	Control circuit nozzles	B1/B2	High-pressure port, reverse
9	Pressure reliefvalve 1 bar	P2	Working hydraulics port
10	4/2-port directional control valve	P3	Steering port
11	Pilot valve	P4	Hydr. fan motor and feed port
12	Change filter	T	Oil reservoir port
13	Servopiston	F	Feed port
14	Boost pressure valve p = $17.5^{+0.5}$ bar		

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U Protective valve/oil reservoir port

Hydraulic pump control -functional description

When the engine is running and the brake pedal depressed, the solenoid of the release valve (2) is de-energised. Boost pressure is applied from port F to nozzle (6); the passage downstream of the nozzle is connected with the reservoir via the open release valve (2) and therefore pressureless. The control piston (7) is connected to port F on both sides via the pilot valve ((11), the directional control valve (10) and the control circuit nozzles (8), thus holding the variable pump (1) in the hydraulic neutral position.

After receiving a switching signal from the electronic control, the release valve (2), the valve closes the connection to the reservoir so that boost pressure also builds up behind the nozzle (6).The two directional control valves (5) are set to the open position so that supply pressure from passage F is applied to the unactuated proportional valves (4).Simultaneously, the directional control valve (10) is shifted from the throttled to the unthrottled position.

Depressing an accelerator controls the respective solenoid (3) with a pedal-stroke dependent signal. A pressure corresponding to the signal value of the solenoid is applied through the downstream proportional valve (4) to the servopiston (13).The servopiston (13) moves and pushes the oil flowing off at the opposite end through the related proportional valve (4) into the reservoir. The movement of the servopiston (13) adjusts the pilot valve (11) through which the control piston (7) is supplied with pressure, and the pump starts delivering.

Releasing the accelerator towards zero stroke reduces the signal at the solenoid. As a result, the proportional valve reduces the pressure going to the servopiston, the pump reduces the swash angle and the truck is braked.

When the electronic control unit detects a Clear fault in the speed control, the truck is brought to a stop, independent of the position of the accelerator.

To do this, the release valve (2) is de-energised so that the pressure behind the nozzle (6) will drop to 0 bar. The directional control valves (5) move to the closed position, thus removing the supply pressure going to the proportional valves (4).This action also shifts the proportional valve (4), which is controlled by the solenoid (3), mechanically to the home position. The pressure applied to the servopiston (13) is removed. The piston is pushed mechanically to the zero position, which also shifts the pilot valve (11) to the zero position. The opening of the release valve (2) and the concomitant pressure drop to 0 bar at F" also switches the directional control valve (10) from the unthrottled to the throttled position.

The reset time of control piston (7) is delayed via the control circuit nozzles (8) and the throttling via directional control valve (10).This arrangement prevents sudden braking and initiates controlled braking deceleration.

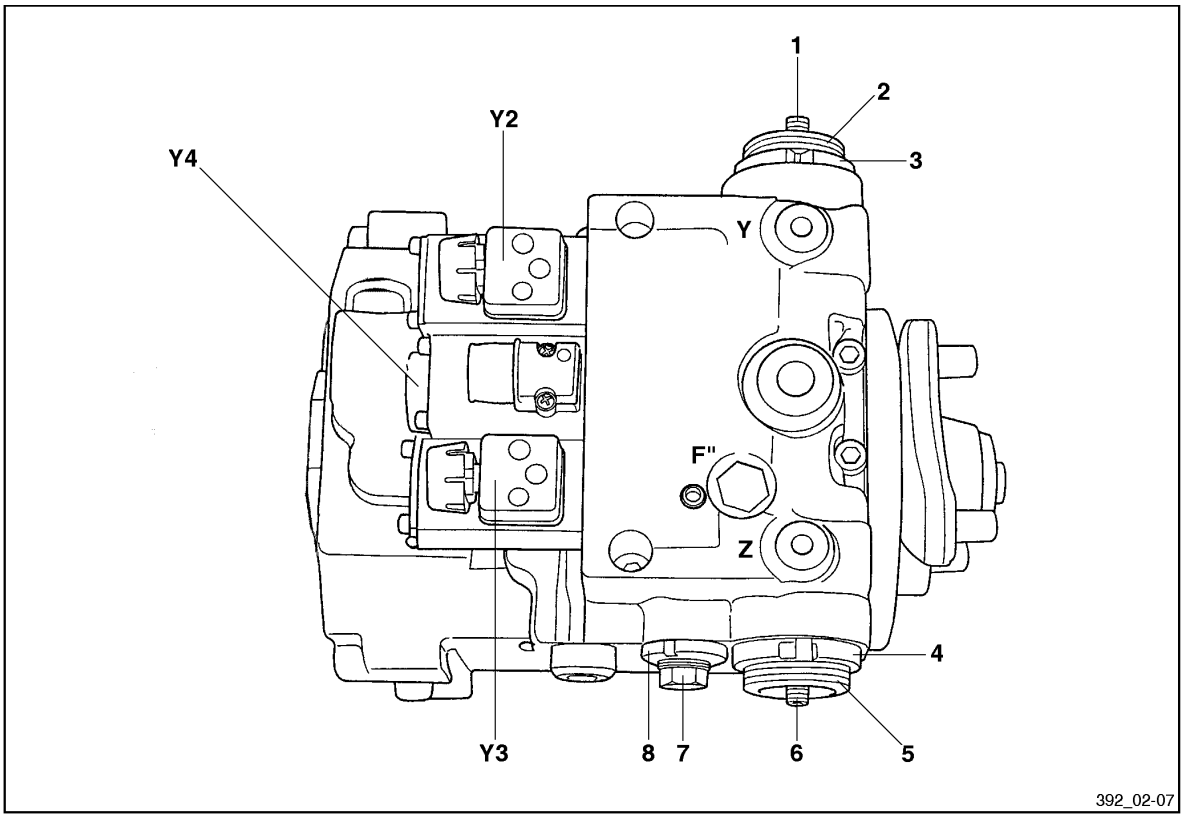
Emergency stop with the brake pedal

If, due to a failure, the truck can not be braked with the accelerators, an emergency stop with the brake pedal is possible.

The two microswitches in the pedal box are actuated together with the brake pedal, thus de-energizing the release valve (2) and the truck decelerates as with a fault in the controller. At the same time the lift pressure of the multiple disc brakes drops and the truck is also braked mechanically.

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Start of delivery of the pump



Adjustment of start of delivery and swash angle for reverse direction

1 Setscrew (swash angle)
2 Set ring (start of delivery)
3 Slotted nut (start of delivery)

Adjustment of start of delivery and swash angle, forward direction

4 Slotted nut (start of delivery)
5 Adjustment ring (start of delivery)
6 Setscrew (swash angle)

Setting the hydraulic zero position

7 Pilot housing
8 Slotted nut
F Servo pressure upstream of release valve (test point)
Y Pilot oil pressure, forward direction
Y2 Solenoid, forward
Y3 Solenoid, reverse
Y4 RELEASE VALVE
Z Pilot oil pressure, reverse direction

Start of delivery of the variable-displacement pump - check

Prerequisite: Jack up the truck and block 1 wheel.

- Start the engine and release the brake pedal.
- Connect the laptop and select "Inputs & Outputs/Traction/Currents".
- Depress the forward or reverse accelerator until iY2 or iY3 = 440 - 460 mA.
- Hold the accelerator in this position and iY2 = 440 - 460 mA loosen the slotted nut (4) and turn the adjustment ring (5) until the wheel just begins to turn.

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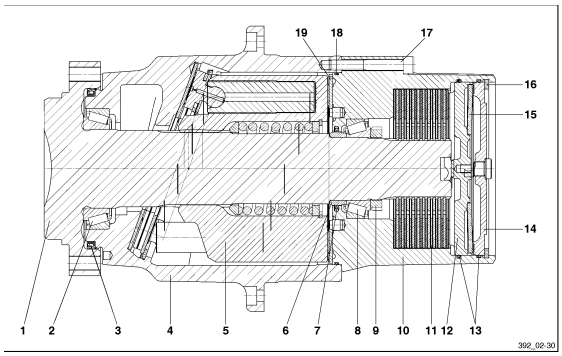
- ➢ Then lock the slotted nut (4) again.
- ➢ If iY3 = 440 - 460 mA, perform the same adjustment at adjustment ring (2).
- ➢ Release the blocked wheel.
- ➢ Fully depress the accelerator. A value of 1220 mA must be displayed via the tab "Currents" of the diagnostics software (preset by the control).
- ➢ Measure maximum wheel speed

Measure maximum wheel speed by taking the mean of the speed of both drive wheels.

Desired speed n = 200 rpm.

Start of delivery - diagram

▷



Q	Volume flow
s	Accelerator stroke
I	Release valve shifts
II	Drive wheels start to turn
II	Max speed of drive wheels

NOTE

If the electric values are correct but the full wheel speed is not reached, then check and adjust the stroke of the servopiston (swash angle of pump).

Swash angle - adjustment

- ➢ Jack up the truck and lock 1 wheel.
- ➢ Start the engine and release the brake pedal.
- ➢ Loosen the setscrew locknut (1) on the Y side of the control and turn in the setscrew (1)) until the free wheel just begins to turn.
- ➢ Then turn the setscrew (1) out for 12 turns and relock the locknut.
- ➢ Repeat the same procedure on side Z.

Hydraulic zero position - adjustment

- ➢ Jack up the truck and lock 1 wheel.
- ➢ Start the engine and release the brake.
- ➢ Mediate the position of the pilot housing (7). Loosen the grooved nut (8) and turn the pilot housing (7)) to one side until the free wheel just begins to turn.
- ➢ Repeat the procedure in the opposite direction.
- ➢ Measure and halve the distance between both positions and turn the pilot housing (7) towards the centre exactly by this value.
- ➢ Lock the pilot housing (7) with the slotted nut (8).
- ➢ Release the locked wheel.

Repeat the adjustment if a drive wheel is still turning.

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Bypass valve

Towing

In order to tow the truck, two requirements must be met:

- the bypass valve must be in the towing position
- the multiple disc brake must be released

WARNING

The truck can not be braked when the multiple disc brake is released.

For towing, an additional vehicle of sufficient pulling power and braking force is required for the unbraked trailing load.

The fork truck may only be towed with a solid connection (tow bar)

Opening the hydraulic bypass valve

➢ Open the bonnet.

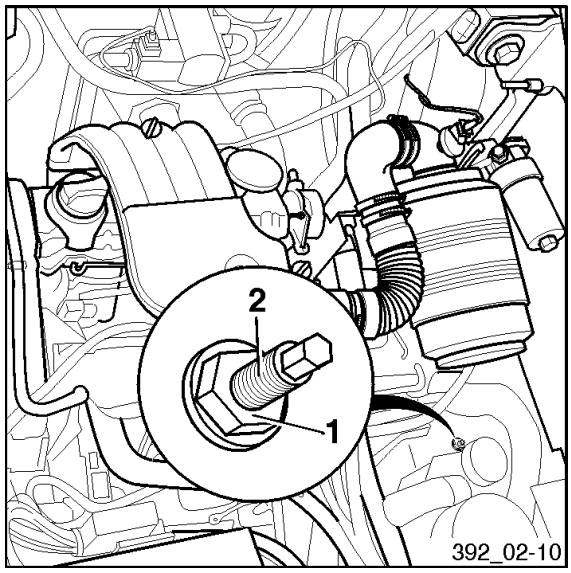
➢ Use a socket to loosen the collar nut (1) on the housing on the left of the variable-displacement pump.

➢ Turn the setscrew (2) out 2 turns with a socket.

➢ Lock the setscrew with collar nut (1), retighten to 60 Nm.

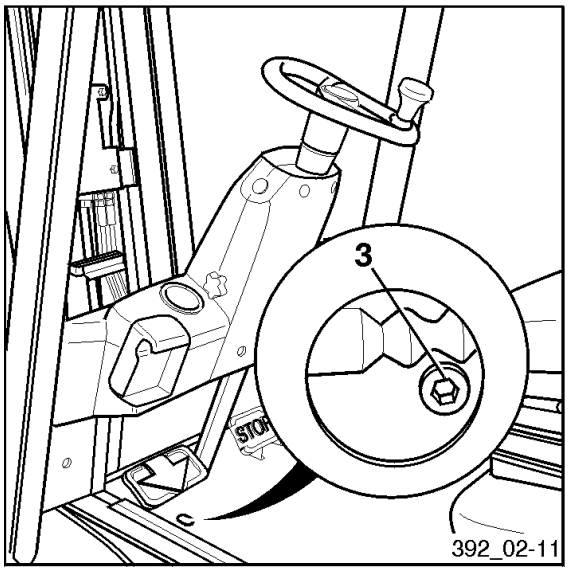
➢ Close the bonnet.

▷



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Releasing the multiple disc brake



NOTE

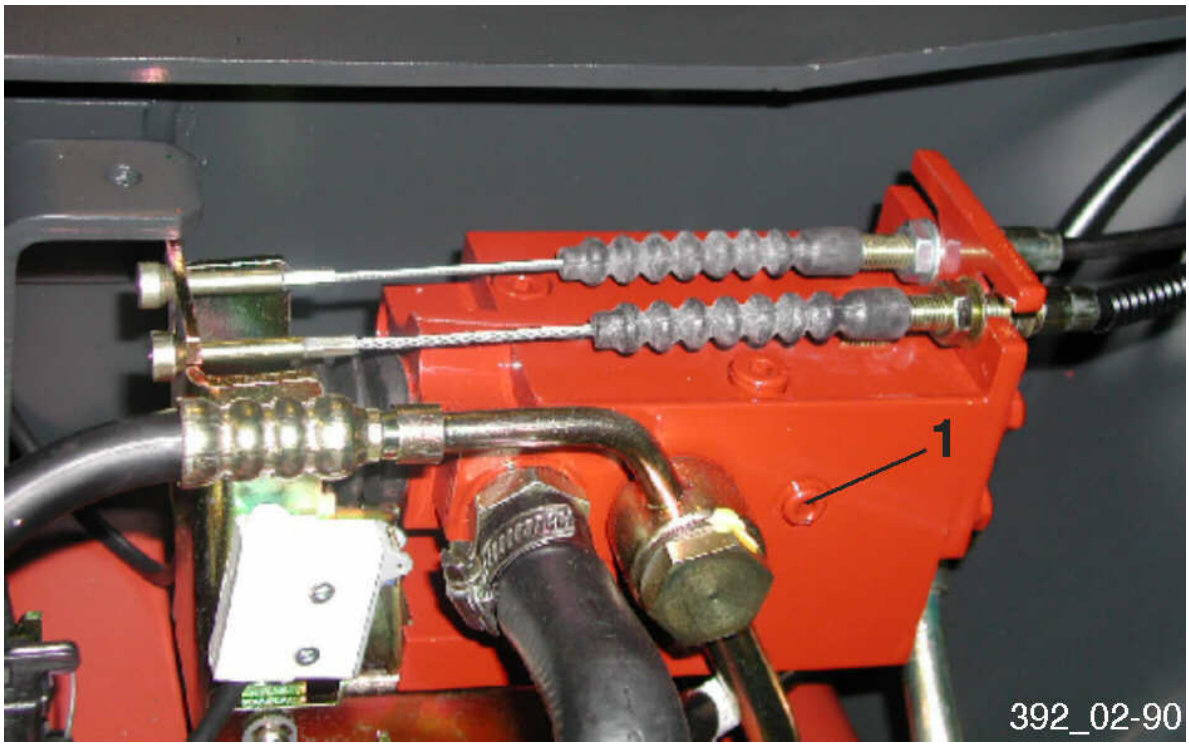
The brake release valve is located below the floor plate on the left of the truck frame.

- Remove the floor mat.
- Stick an Allen wrench through the floor plate and loosen the cheese head screw (3) by approx. 6 turns.
- Sit down on the driver's seat.
- Depress (pump) the brake pedal about 20 times in the easy range up to noticeable resistance until the brake is released.

Discharge device

To ensure a certain degree of cooling, it is necessary to exchange the oil in the closed circuit. By means of a switch-over valve, a certain volumetric flow is always discharged from the low pressure side.

Switch-over valve - function



If both high-pressure lines are depressurised or under charging pressure (zero position of pump), the two switch-over pistons A1 and B1 are in the spring-centred central position. No hydraulic oil

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can flow to the discharging valve, neither from high-pressure port A nor from B.

However, if high pressure builds up, e.g., on the A-side, this piston A1pushes into the direction of port B and takes the piston B1 with it.

The poppet at piston A1 is used as a limit stop, preventing high pressure from escaping from spring chamber A1 to the discharging valve. From port B, oil may now flow to the restrictor Ø 1.4 mm.

Discharging valve - function

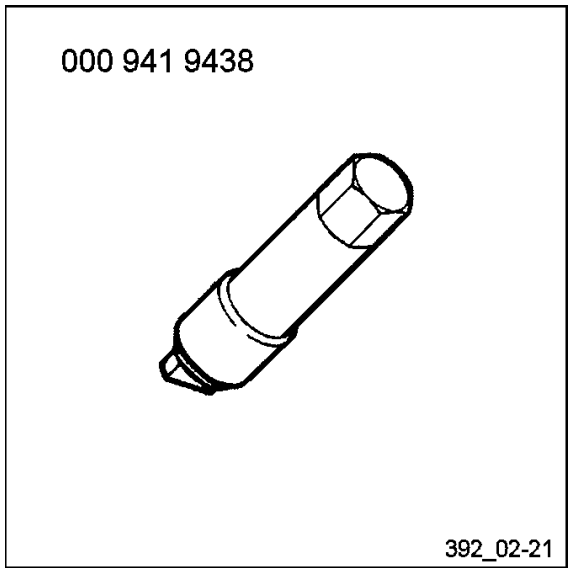
Via the restrictor Ø 1.4 mm, a volumetric flow passes from the low pressure side of the closed circuit to the oil reservoir.

The discharging valve p = 13 bar with the serially connected restrictor maintains the charging pressure at p = 18.0^{+05} bar.

Switch-over valve - remove and install

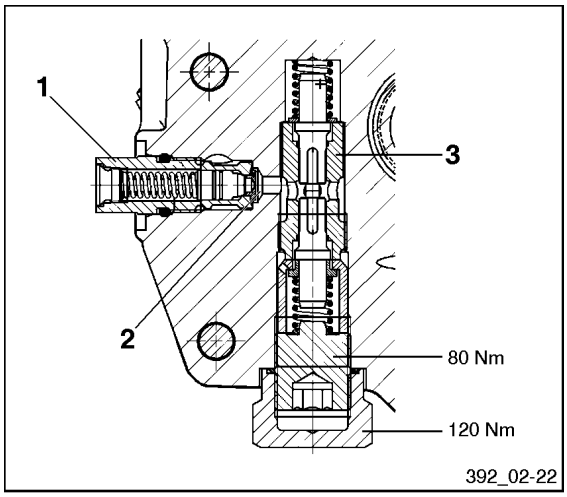
Required special tools

- Key for switch-over valve 000 941 9438



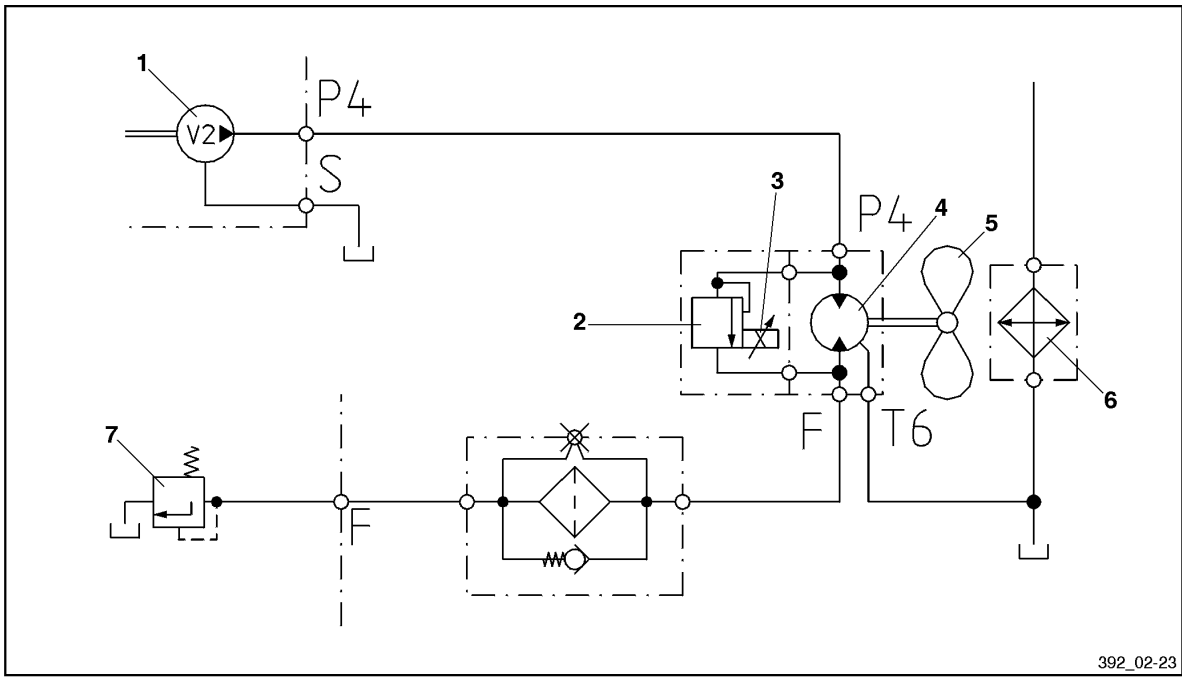
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Discharge device - sectional drawing



1 Pressure limiting valve p = 13 bar
2 Restrictor Ø 1.4 mm
3 Switch-over valve

Hydraulic fan drive



1 Gear pump V_2, q_2 = 14 cm^3/rev
2 Bypass valve
3 Proportional solenoid Y5
4 Hydraulic motor q = 8 cm^3/rev
5 Impeller
6 Cooler
7 Boost pressure valve p = 17.5 $^{+0.5}$ bar
S Suction line
P4 Pressure port
F Boost pressure port
T6 Return to reservoir

Fan drive - method of operation

The hydraulic fan drive is a hydraulic motor (4) with a displacement of q = 8 cm^3 and supplied by boost pressure pump V2 (1). The hydraulic motor (4)is fitted with an impeller (5) which draws the cooling air from the engine compartment and delivers it to the outside. The fan speed depends

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on the speed of the engine and the coolant and hydraulic oil temperatures.

Temperature transmitters sense the temperatures of the coolant and hydraulic oil and send them to the LTC control unit. The LTC controls proportional valve Y5 (3), which in turn controls a bypass valve (2) mounted on the fan motor (4). The speed of the fan motor (4) is influenced by the controlled oil flow. If the coolant temperature is lower than approx. 95°C and the hydraulic oil temperature is lower than approx. 68°C, the bypass valve (2) is open and the fan motor (4) is stationary. The fan only starts to run to approx. 1000 rpm if these temperatures are exceeded. Then the speed rises proportionally to the temperature.

This cooling concept achieves the optimum operating temperature within a shorter time, reduces noise development and eliminates peak temperatures better.

WARNING

When maintenance work is carried out with the bonnet open, the still stationary fan motor can suddenly start running at a relatively high speed due to the temperature control.

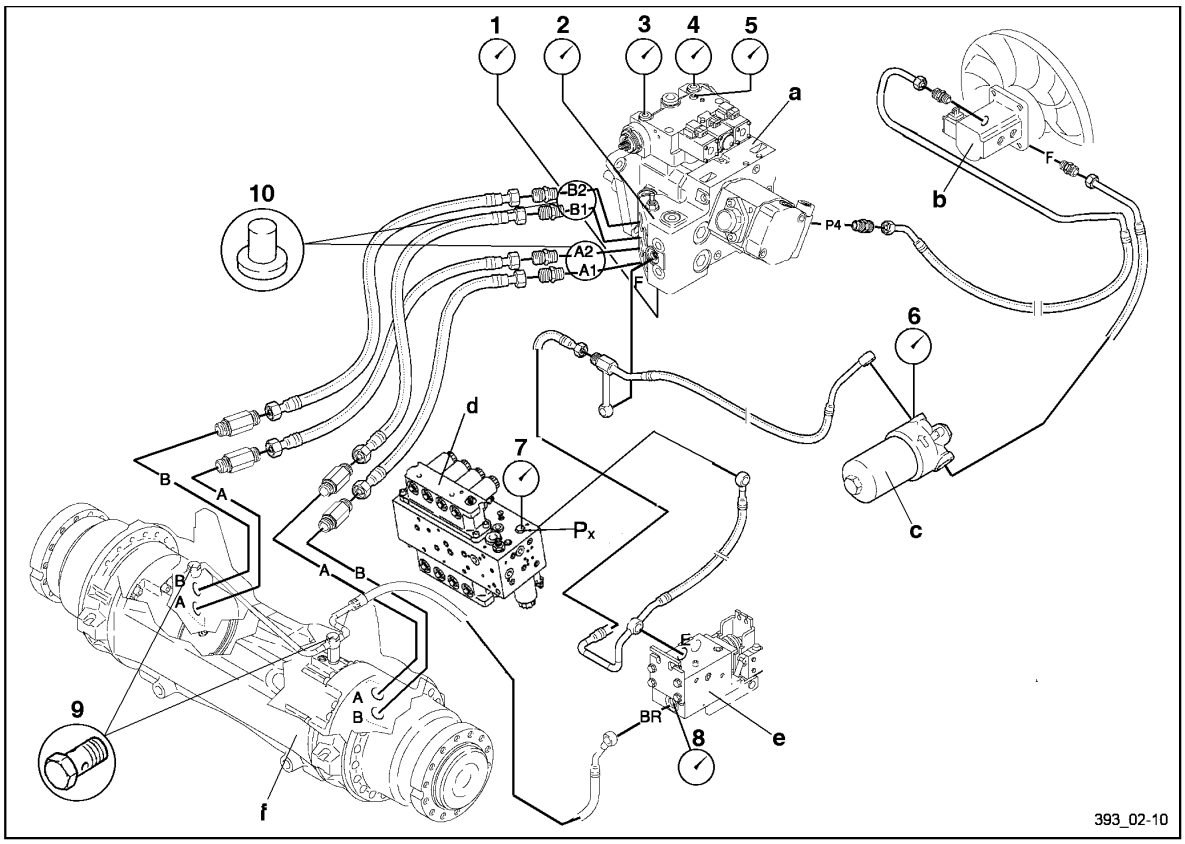
Do not put your hands in the fan.

Keep your distance.

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Overview and explanations of diagnosis

Pressure test points - overview



1	Pressure test point HP forward	9	Sealing point brake pressure right/left
2	Pressure test point HP forward	10	Sealing point HP
3	Pressure test point Y (forward)	a	HPV 75 -02
4	Pressure test point Z (reverse)	b	Fan motor
5	Pressure test point F" (supply pressure)	c	Low-pressure filter
6	Pressure test point (supply pressure)	d	Control valve of working hydraulics
7	Pressure test point MP (working hydraulics)	e	Brake valve
8	Pressure test point BR (brake pressure)	f	Drive axle AH 35-03

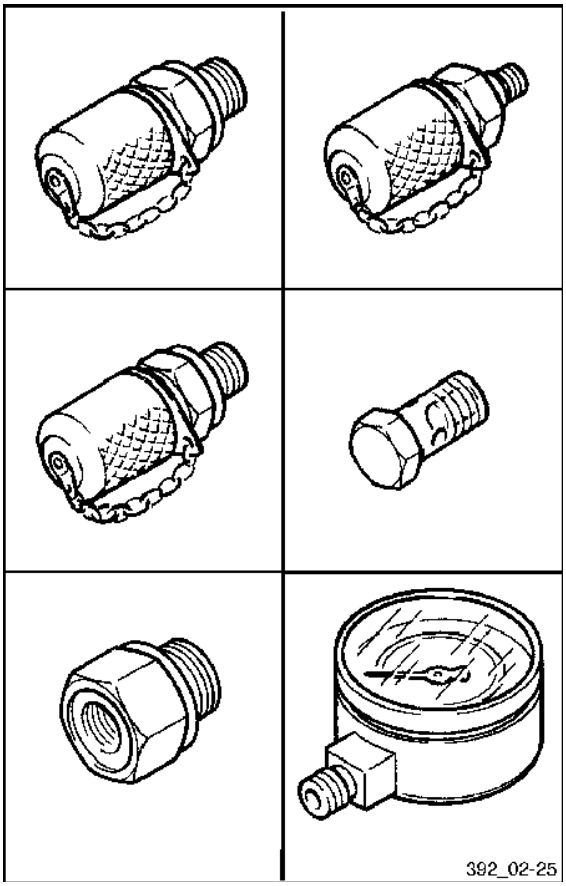
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Required special tools

- Screw coupling M14 x 1.5, ET No. 000 951 6400
- Screw coupling M10 x 1, ET No. 000 951 6407
- Screw coupling M8 x 1, ET No. 000 951 6402
- Screw coupling with sealing plug, ET No. 000 903 1126
- Pressure gauge 0 - 40 bar, ET No. 000 943 0106
- Pressure gauge 0 - 600 bar, ET No. 000 943 0107
- Banjo screw, ET No. 000 903 1126
- Banjo screw, ET No. 000 903 1130
- Screw coupling M12 x 1.5, ET No. 000 951 6410
- Sealing plug, ET No. 000 951 3900
- Digital tachometer from

  Horn GmbH
  P. O. Box 1162
  D-7036 Schönaich

The screw couplings, adapters, measuring wires and pressure gauges required for the measurements are in the measuring box 000 941 6000.



Pressure values - overview

Position of accelerator pedal	Position of brake pedal	Test point	Pressure (bar)
0-position	released	F	$18{,}0^{+05}$
0-position	released	F"	0
actuated by approx. 4 mm	released	F"	$18{,}0^{+05}$
Forward pedal fully actuated	released	Y	$18{,}0^{+05}$
Reverse pedal fully actuated	released	Z	$18{,}0^{+05}$
0-position	released	BR	$18{,}0^{+05}$
0-position	actuated	BR	0

Troubleshooting - explanations

The functional tests and possible trouble-shooting procedures are performed separately for the individual main groups and refer to the following components or functions:

- Hydraulic brake system
- Power-assisted steering
- Beginning of swing-out of the HPV 75 -02
- Hydrostatic travel drive

Prior to performing the work described below, the oil level must be checked and corrected if necessary.

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If a test procedure requires the installation of a pressure gauge or a screw cap, the ventilation valve of the hydraulic oil tank must be screwed out. This reduces the pretension in the oil reservoir.

The installation positions of the pressure gauges/screw caps are shown in the hydraulic diagram.

Unless specifically mentioned, all pressure measurements are to be performed with the brake pedal released.

For some test procedures, the decoupling of the drive axle AH 35-03 is required. To do so, proceed as follows:

- Screw off the union nut of the HP hoses from the screw necks of drive axle AH 35-03.
- Seal threaded plug with sealing plug (4 pieces 000 951 3900).
- Reconnect hoses.

Abbreviations used

LP gauge	Low-pressure gauge
HP gauge	High-pressure gauge
LP	Low pressure
HP	High pressure
Forward pedal	Accelerator pedal forward
Reverse pedal	Accelerator pedal reverse
Dp	Pressure differential

HPV 75 -02 pressures - tests

Required special tools

- Screw coupling M10 x 1, Part No. 000 951 6407
- Screw coupling M12 x 1.5, Part No. 000 951 6410
- Screw coupling M14 x 1.5, Part No. 000 951 6400
- Pressure gauge 0 - 40 bar, Part No. 000 943 0106

Boost pressure at the filter

Test point: item6

➢ Screw off the plug at the filter (c).

➢ Connect the M12 x 1.5 screw coupling, Part No. 000 951 6410.

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- Connect the low pressure gauge 0 - 40 200 bar, Part No. 000 943 0106.
- Start the engine.

Desired value = 17.5 bar

Boost pressure to HPV 75 -02

Test point: item 5

- Screw off the plug at the servo cover F.
- Connect the M10 x 1 screw coupling, Part No. 000 951 6407.
- Connect the low pressure gauge 0 - 40 bar, Part No. 000 943 0106.
- Start the engine.

Accelerator unactuated	0 bar
Accelerator actuated	17.5 bar

Test start of delivery of HPV 75 -02

Test points 3 and 4 Remove

- plug Y (3) and Z on the servo cover.
- Install the M14 x 1.5 screw coupling, Part No. 000 951 6400.
- Connect the low pressure gauge 0 - 40 bar, Part No. 000 943 0106.
- Start the engine.
- Actuate the forward and reverse accelerator until the wheels start rotating.

Desired value for ?p at Y and Z when the wheels start rotating:

Reversing & reverse: ?p = 4 bar

High pressure test of HPV 75 -02

Test points 1 and 2

- Screw off the plug on the HPV 75 -02.
- Install the M8 x 1 screw coupling, Part No. 000 951 6402.
- Connect the high pressure gauge.
- Release the brake pedal.
- Push in the brake piston of the valve (e) with a long screwdriver.
- Operate the forward and reverse accelerator.

Desired value: $p_{HP} = 435^{+30}$ bar

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Determination of average wheel speed

- Start the engine
- Release the brake pedal.
- Depress the Forward accelerator against the stop.
- Measure the left and right wheel speed.
- Depress the reverse accelerator against the stop.
- Measure the left and right wheel speed.

NOTE

During the wheel speed test keep the particular accelerator against the stop.

Desired wheel speed:

Forward direction	180 rpm
Reverse direction	180 rpm

Example: Calculation of average wheel speed

left side	210 rpm
right side	150 rpm
Total	360
divided by	2
Result	180 rpm

Hydrostatic travel drive - check

Prerequisites for testing - fault finding

- Truck blocked up so that both drive wheels can turn freely.
- The hydraulic power steering is functioning.
- The parking brake is applied.
- The electronic LTC control does not indicate a fault (warning light not flashing).
- Engine can not be started.
- Pedal adjustment OK.
- No fault indicated by electric truck diagnosis with laptop.
- Test readings and settings are OK.

Remove the M8 x 1 screw coupling with high-pressure gauge from test point (1) and connect it to high-pressure test point (2) (low pressure gauge stays on port F?) and then perform the check with the reverse accelerator.

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The readings now refer to the other direction of travel and components.

Fault finding - travel drive

Step Type	Procedure	Yes (Test)	No (Test)
1 Action	Connect screw coupling 000 951 6410 and the low pressure gauge to port F of the filter (C), engine at idling speed, brake applied		
2 Test	Low pressure approx. 17.5 bar?	Go to steps 9 - 12	Go to step 3
3 Action	Seal port E at the brake release valve (e) with a blind plug and repeat the test.		
4 Test	Low pressure approx. 17.5 bar?	Problem in the brake system. Please refer to "Hydraulic brake system"	Go to step 5
5 Action	Check or replace boost pressure valve, repeat test		
6 Test	Low pressure approx. 17.5 bar?	Go to steps 9 - 12	Go to step 7
7 Action	Disconnect axle AH 35 -03 with plug 000 951 3900, repeat the test.		
8 Test	Low pressure approx. 17.5 bar?	AH 25 -03 defective, repair or replace.	HPV 75 -02 defective, repair or replace.
9 Action	Connect the laptop to the test connector. Connect screw coupling 000 951 6407 and the low pressure gauge to port F" (5).		
10 Action	Start the engine, start "Pathfinder".		
11 Action	"Select "Inputs/Outputs/Traction/Output Signals" and release the brake.		
12 Action	Depress the Forward accelerator and reverse accelerator until iY4 is operated.		
13 Test	When iY4 is operated, the pressure at test point 5 rises to approx. 17.5 bar.	Go to steps 14 - 16	Check the operation of the solenoid and hydraulic section of the release valve or replace the valve assembly.
14 Action	Install screw coupling 000 951 6400 with low pressure gauge to port Y.		

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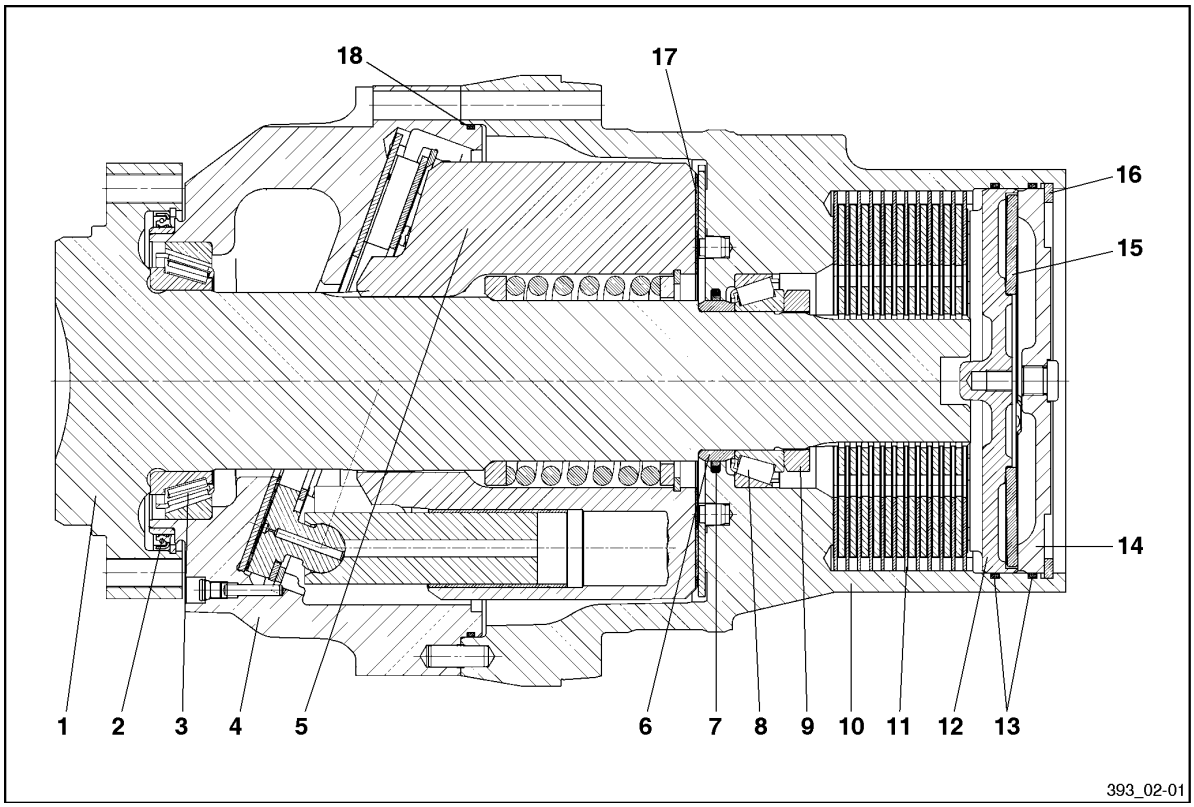
Step Type	Procedure	Yes (Test)	No (Test)
15 Action	Start the engine, release the brake. "Select "Inputs/Outputs/Traction/Flows F/Pump forward (iY2)"and depress the forward accelerator gently while reading the increase in current at iY2 (solenoid, forward direction).		
16 Action	Observe the increase in pressure at port Y and start of rotation of the wheels.		
17 Test	Current at iY2 rises, pressure stays at 0 bar, wheels not turning.	Check or replace proportional valve iY2.	
	Current and pressure rising, wheels not turning.	Check servo control or control piston of pressure balance.	
	Current and pressure rising, wheels turning.	Go to step 18.	
18 Action	depress the forward accelerator again and read rise in current at iY2 at start of wheel rotation.		
19 Test	Wheels start rotating at I = 440 - 460 mA.	Go to step 22.	Go to step 20.
20 Action	Adjust start of delivery, see "Start of pump control ".		
21 Test	Start of delivery can be adjusted.	Go to step 22.	Check hydraulic servo control.
22 Action	depress the forward accelerator as far as the stop.		
23 Test	Current at iY2 approx. 1220 mA.	Go to step 24.	Perform electrical diagnosis with "Pathfinder".
24 Action	Fully depress the Forward accelerator again and read the pressure.		
25 Test	Pressure at stop at least 16 bar or more.	Go to step 26	Check or replace proportional valve and servo control.
26 Action	With Forward accelerator fully depressed, determine avg. wheel speed. Desired speed = 180_{-20}rpm		

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Step Type	Procedure	Yes (Test)	No (Test)
27 Test	Average wheel speed OK.	Go to steps 28 - 31	Check swash angle of the variable-displacement pump, see "Swash angle of the variable-displacement pump".
28 Action	Connect M10 x 1 screw coupling and low pressure gauge to port F? (5).		
29 Action	Connect screw coupling 000 951 6402 with high pressure gauge to HP test point (1).		
30 Action	Block the brake (press brake piston fully in with a long screwdriver).		
31 Action	Depress the Forward accelerator, determine high and low pressure.		
32 Test	High pressure approx. 435 bar Low pressure approx. 17.5 bar	Pressure relief valve for forward travel direction is OK.	
	High pressure far under 435 bar Low pressure approx. 17.5 bar	Internal leakage. Possible causes: feed/relief valves or towing bypass valve leaking.	
	As the high pressure rises, the low pressure drops to 0 bar.	Leakage in the high pressure section for forward travel. Disconnect AH 35 -03 to localise the fault in HPV 75 -02 or AH 35 -03.	

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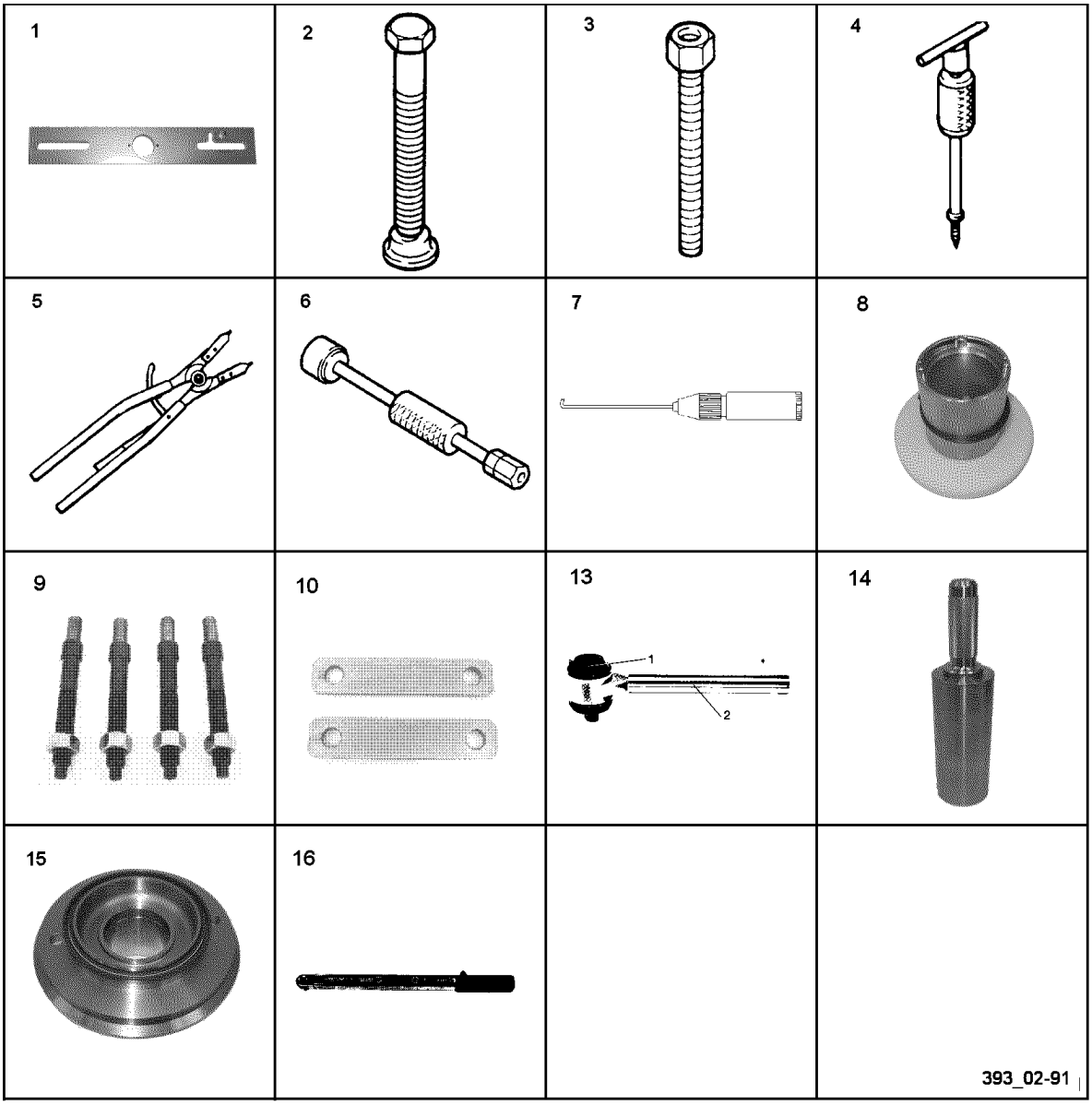
Wheel motor 550 HMF 550 R - sealing



1	Wheel shaft	10	Brake housing
2	Shaft seal	11	Discs
3	Tapered roller bearing	12	Brake piston
4	Hydraulic motor housing	13	O-ring
5	Swash plate with hydraulic motor assembly	14	Cover
6	Distance ring (running ring)	15	Belleville spring
7	Sealing ring	16	Circlip
8	Tapered roller bearing	17	Valve plate
9	Slotted nut	18	O-ring

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Required special tools



1	Extraction bar 000 941 9424
2	Threaded rod with thrust piece 00041 9429
3	Tension bolt M 10 x 250, 2 items 000 941 9104
4	Slide hammer for extraction of shaft seal 000 941 9469
5	Circlip pliers 000 941 9475
6	Slide hammer (extractor) 000 941 9103
7	Extraction hook 000 941 9113
8	Slotted nut spanner 000 941 7000
9	Mounting pin 000 941 8011
10	Fastening straps 000 941 8012
13	Torque multiplier 200 - 3000 Nm, eg from Stahlwille
14	Slide hammer for hammering in intermediate ring and bearing 000 941 8203
15	Press-in device for insertion of shaft seal 000 941 8201
16	Torque spanner 60 - 300 Nm as commercially available

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Wheel motor 550 HMF 550 R - sealing

➢ Screw 4 fastening bolts 000 941 8011 into the wheel hub. ▷

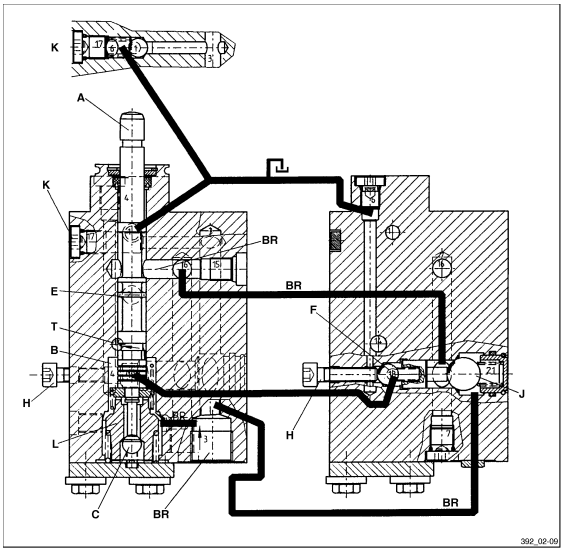


➢ See hole spacing of holding straps 000 941 8012. ▷



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➢ Fasten the oil motor HMF 550 to the forks with holding plates 000 941 8012 12. ▷



➢ Loosen the hexagon socket screws (64 Nm) and remove them. ▷



➢ Remove the plug from the cover. ▷

DANGER

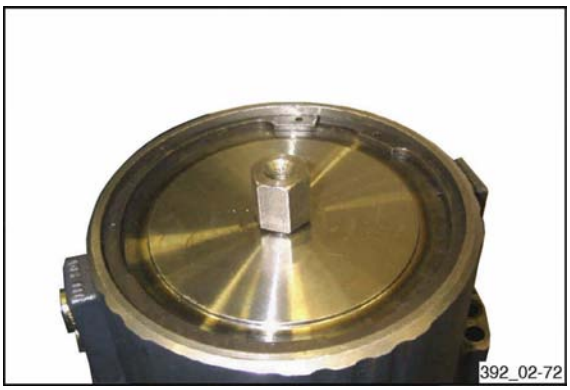
The disc spring is heavily preloaded. Injuries can result through the spring forces released if the work is carried out improperly.

Screw in the tension bolt deeply enough!

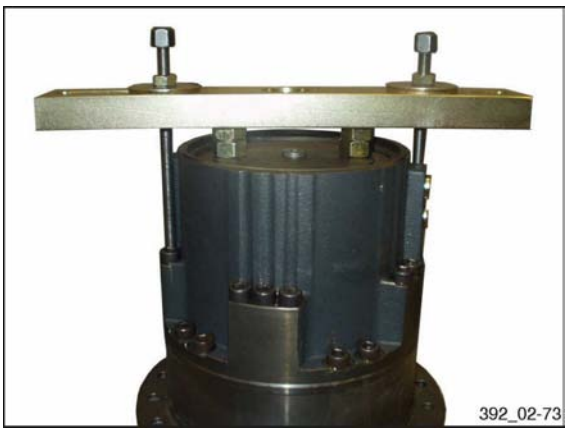


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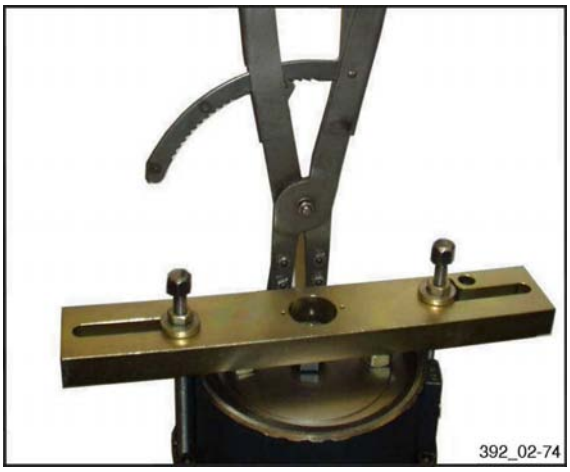
- Install the preload bolt 000 941 8009 09 hand-tight. This tool is used to apply a preload to the disc spring between the cover and piston.
- Remove the two opposite bolts on the brake housing.



- Place two distance pieces, approx. 20 mm, on the cover.
- Put the extraction bar 000 941 9424 on the distance pieces and secure it with two M10 puller bolts 000 941 9104.
- Now screw in the preload bolt completely.



- Remove the circlip with the circlip pliers 000 941 9575 75.
- Remove the extraction bars.



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➢ Screw the slide hammer 000 941 9103 03 into the preload bolt.

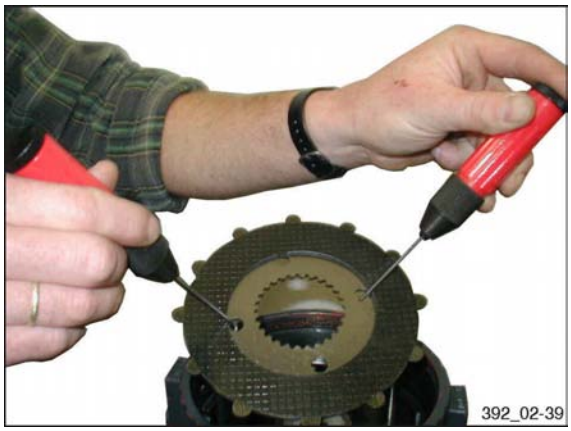
➢ Pull the brake piston out.

NOTE

Apply a tension to the slide hammer and pull it out with the ram.



➢ Remove the brake discs with the extraction hook 000 941 9113.

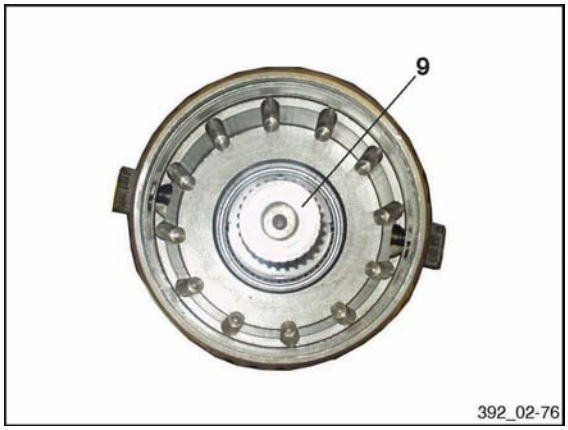


➢ Warm up the slotted nut(9).

NOTE

The slotted nut is secured with Loctite FK2 and tightened to a torque of 1300±50 Nm.

➢ Install the slotted nut spanner.



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➢ Loosen and remove the slotted nut. Use a torque multiplier. ▷



NOTE

When screwing out the loose slotted nut, turn it into the opposite direction from time to time.

➢ Take out the slotted nut. The chamfer of the slotted nut points to the tapered roller bearing (see sectional drawing). ▷

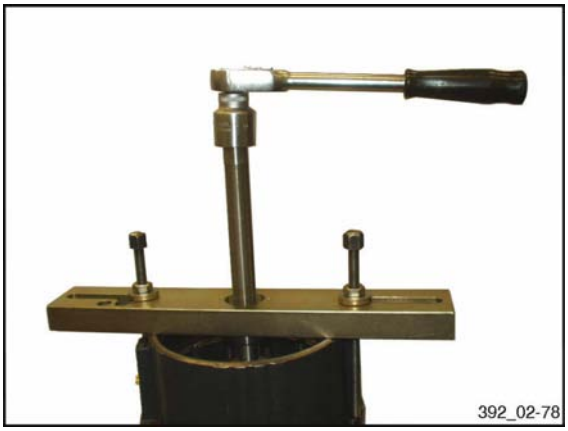


➢ Fasten the puller bolts with the extraction bar. ▷

➢ Insert a distance ring in the extraction bar and press the threaded rod 000 941 9429 29 on to the driveshaft until the tapered roller bearing is free.

➢ Fasten the extraction bar 000 941 94 24 and the threaded rod 000 941 94 29 with two puller bolts.

➢ Pull the housing off the wheel shaft.



➢ Take the tapered roller bearing out. ▷

➢ Screw two wheel bolts into port BR.

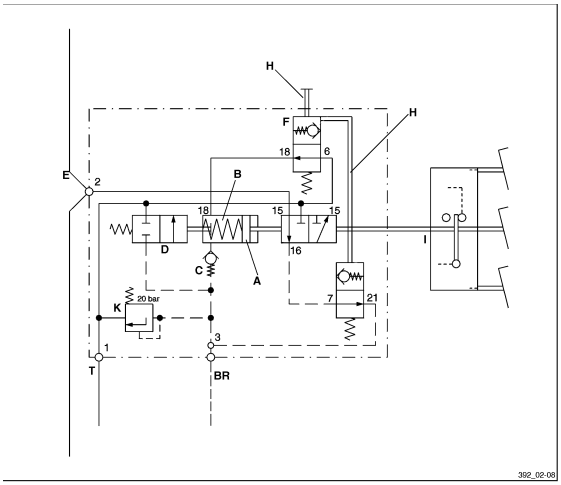


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- Separate the brake housing from the hydraulic motor housing with a plastic hammer.
- Remove the brake housing from the hydraulic motor housing.

NOTE

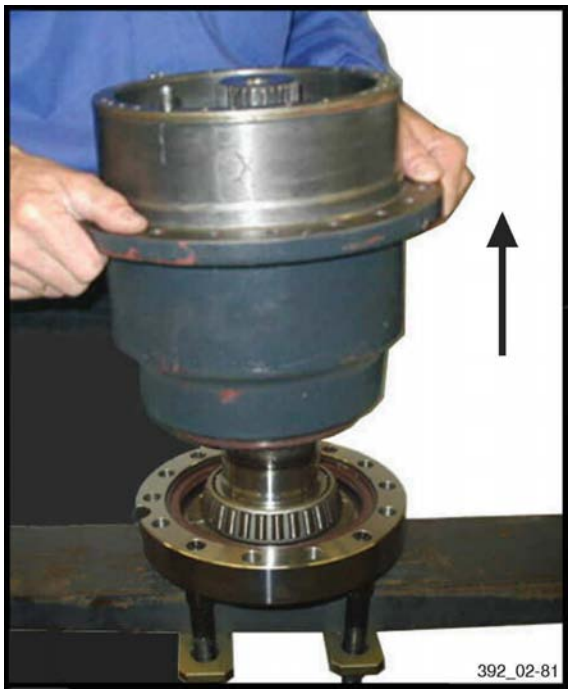
The brake housing must only be dismounted if the seal is untight (leakage in the multiple disc brake).



- Remove the distance ring.
- Take the seal out of the brake housing.

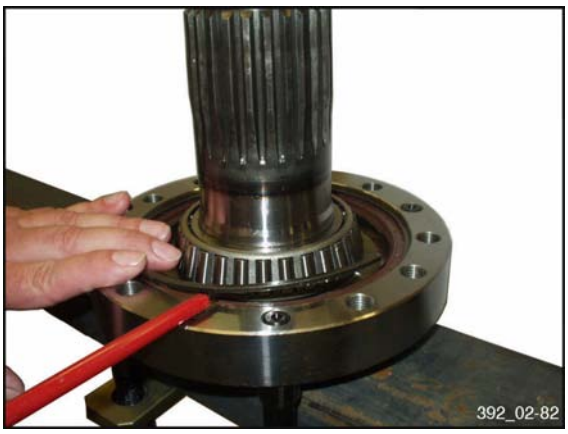


- Pull the oil motor housing 4 from the wheel shaft 1 and put it on the work bench (wood or plastic support.



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➢ Remove the circlip. ▷



➢ Remove the radial shaft seal 000 (extractor with slide hammer 941 9469 9469). ▷

➢ Clean wheel shaft.



➢ Place the shaft seal in the press-in tool 000 941 8200. ▷

CAUTION

The sealing lips can be damaged.

Make sure the sealing lips are installed correctly. See the sectional drawing!

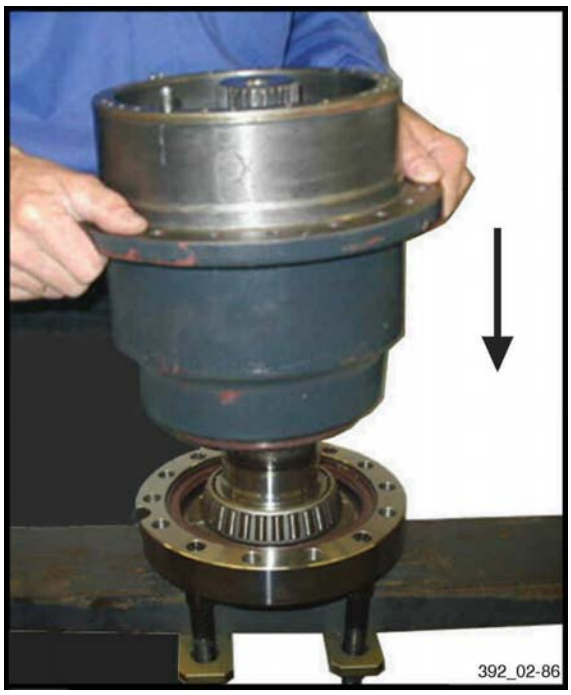


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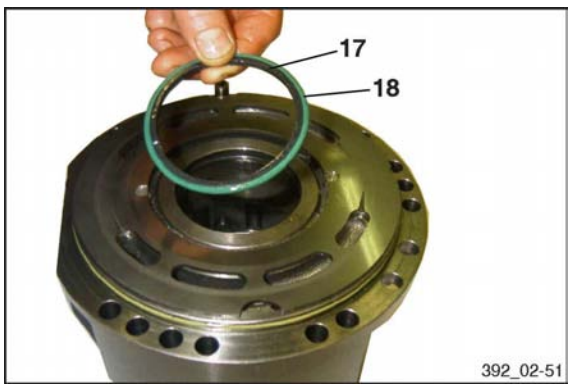
- Position the press-in tool on the wheel shaft.
- Using two wheel bolts, draw it evenly downward.
- Lubricate the sealing lip on the shaft seal.



- Push the hydraulic motor housing onto the wheel shaft.
- Centre the hydraulic motor housing with regard to the shaft seal and press it down.



- Remove the sealing ring(17) with O-ring (18) from the brake housing.
- Clean and blow out the groove in the brake housing.
- Lubricate the new O-ring and seal and install it.
- Apply grease to the back of the valve plate and put the plate in position.
- Replace the outer O-ring.



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➢ Put the brake housing with the valve plate on the hydraulic motor housing and screw them together. ▷

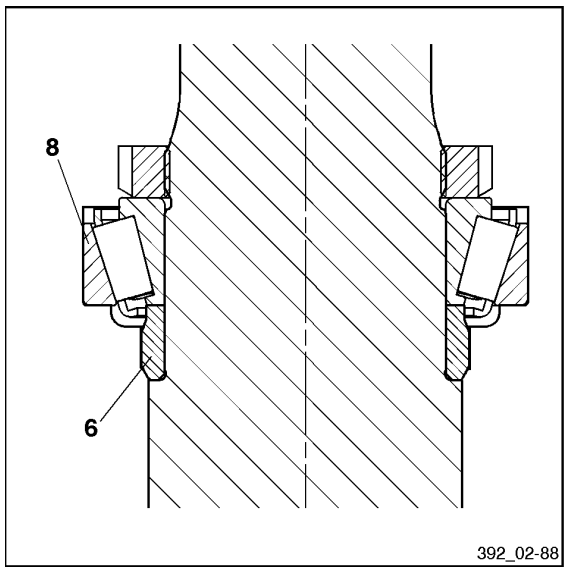


➢ Pull the distance ring 000 (for correct position, see drawing) over the wheel shaft 941 and drive into position with the slide hammer 8202 941 8202. ▷

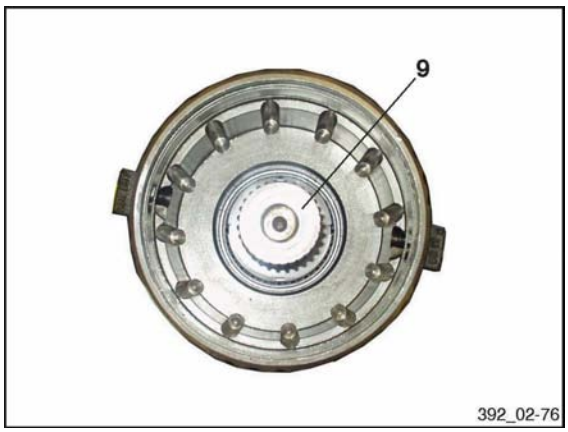


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➢ Insert tapered roller bearing (8) and use slide hammer to drive it against the distance ring (6). ▷



➢ Apply Loctite FK2 to the grooved nut (9) and push it over the wheel shaft.Install the ▷



➢ slotted nut spanner 000 941 7000. ▷

The chamfer on the slotted nut faces the bearing.



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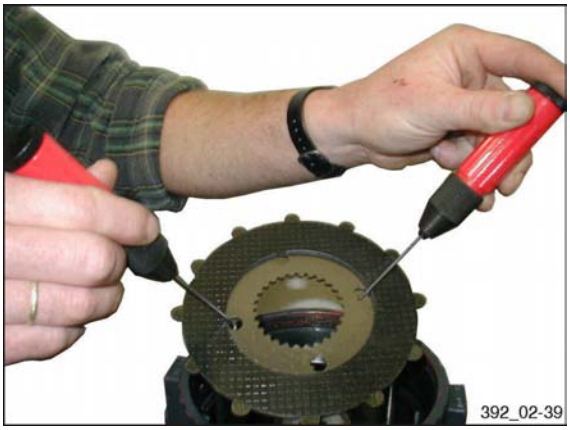
➢ Use the torque multiplier to tighten to 1300 ±50 Nm. ▷

Check starting torque without brake parts: M_d = 15^{+20} Nm



➢ Install the brake discs. Position the holes of the external discs in such a way that they coincide ▷

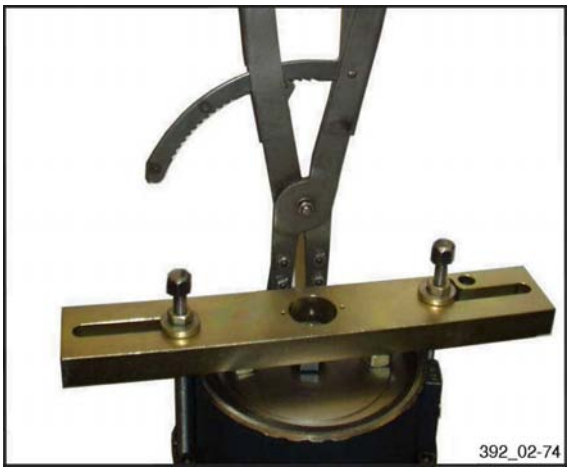
➢ Oil the O-rings and piston



➢ Position the piston, disc spring and cover with the preload bolt. ▷



➢ Put the circlip and two distance pieces on the cover. Use the extraction bar and puller bolt to push the cover down and position the circlip in the groove. ▷



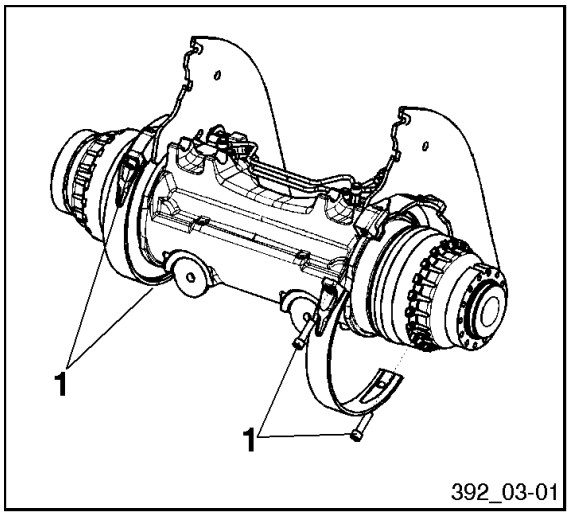
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Axle suspension

➢ Glue the inside of the the bearing half to the axle bearing with Loctite 243 (grease-free).

Torque for M20 screws (1): 385 Nm

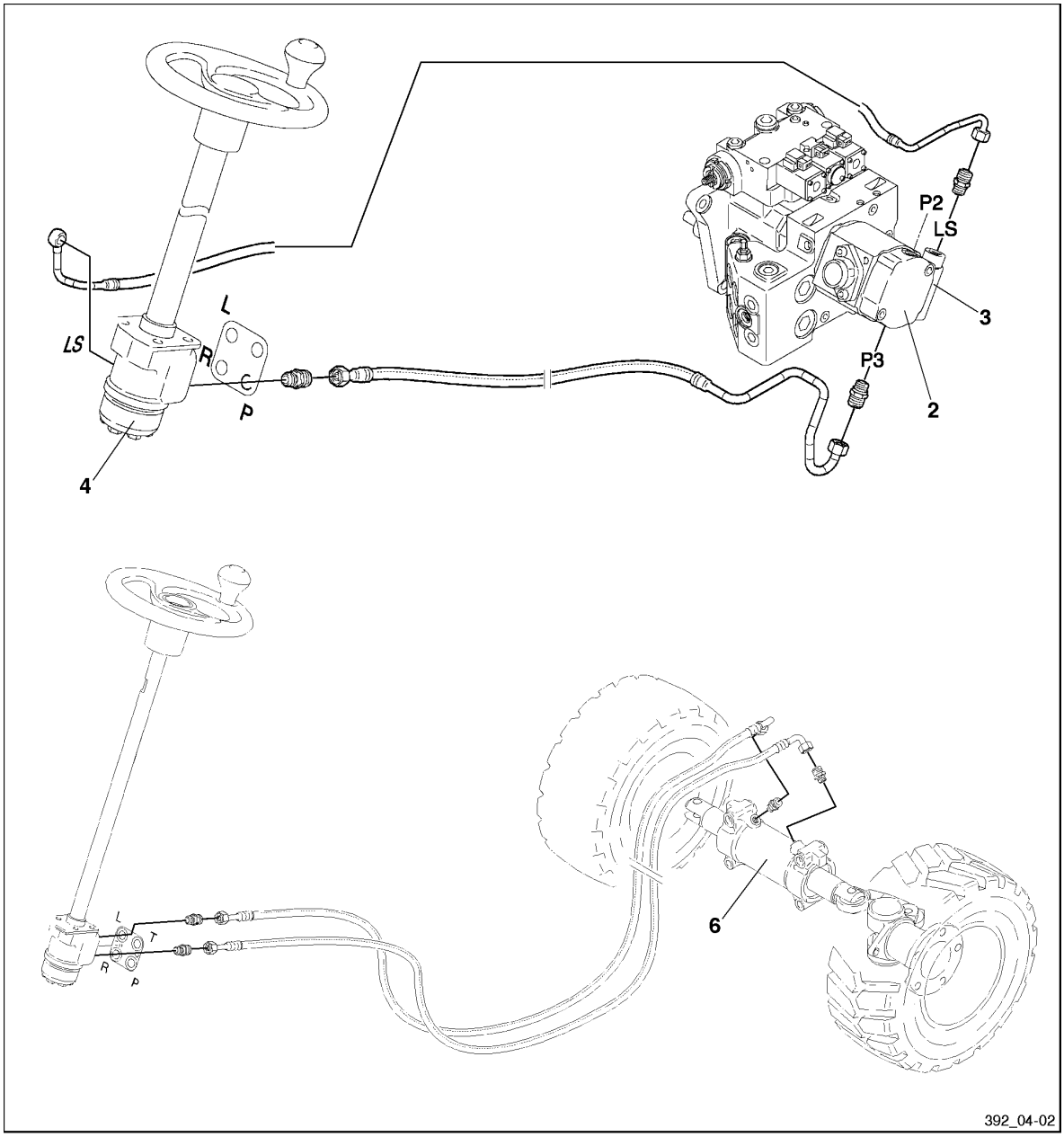


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Chassis

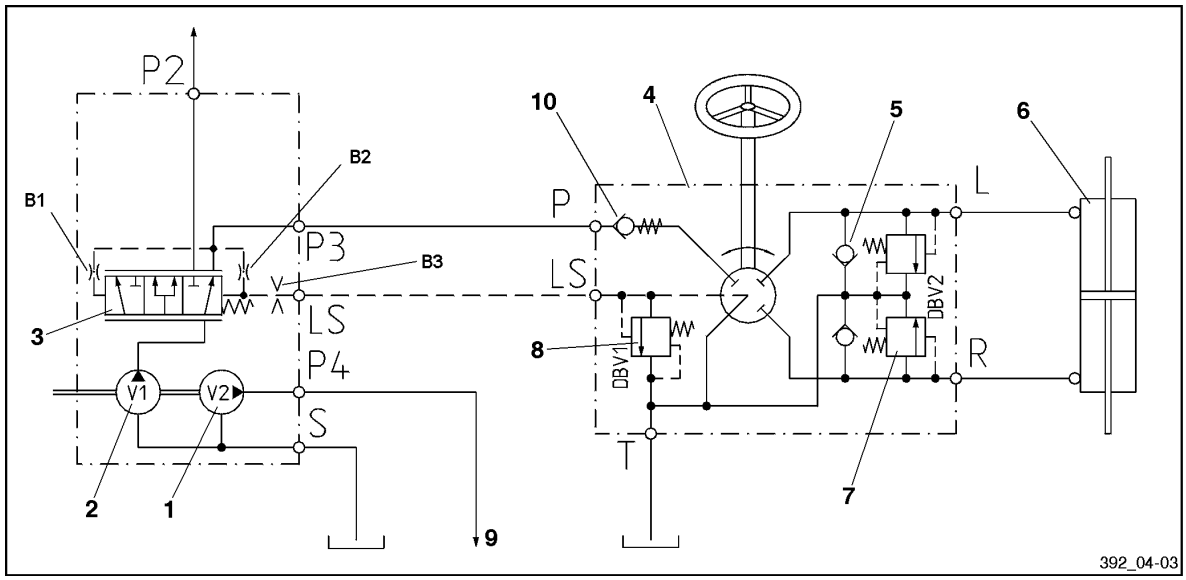
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Steering system - functional description



2	Gear pump V_2 for infeed q_2= 14 cm^3/rev	LS	Load-sensing port
3	Priority valve	P	Pressure port, steering control valve
4	Steering control valve with primary valve, secondary valves and make-up valves	P2	Pressure port, working hydraulics
		P3	Pressure port, steering outlet
6	Steering cylinder	R	Pressure port, right steer cylinder
L	Pressure port, steering cylinder, left		

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1	Gear pump V2 for infeed q_2 = 14 cm^3/rev	10	Check valve
2	Gear pump V1 for steering and working hydraulics q_1 = 23 cm^3/rev	L	Pressure port, steering cylinder, left
3	Priority valve	LS	Load-sensing port
4	Steering control valve	P	Pressure port, steering control valve
5	Make-up valves	P2	Pressure port, working hydraulics
6	Steering cylinder	P3	Pressure port, steering outlet
7	Secondary valves, p = 180^{+20} bar or 205^{+20} bar	P4	Pressure port, infeed
8	Primary valve, p = 120^{+5} bar or p = 150^{+5} bar	R	Pressure port, right steer cylinder
9	To infeed	S	Suction port
		T	Oil reservoir port

Steering system - method of operation

The oil delivered by pump V1 (2) enters the centred priority valve (3).

When the steering control valve (4) is not activated, an oil flow of Q ~ 1 L/min flows via P3 and P through the steering control valve (4) and leaves it at (T). .The main part of the oil flow of pump V1 is available at port P2 of the working hydraulic system. The pressure port for load-sensing (LS) is connected to the reservoir (T) via the steering control valve.

The steering system is protected by the primary valve (8) with p_{max} = 120^{+5} bar on the H 30 and with p_{max} = 150^{+5} bar on the H 35

Steering system - steering

When the steering system is actuated, the reservoir connection of the load-sensing pressure port is cut off by the steering control valve (4). As a result, the pressure in the LS line rises. This pressure rise controls the priority valve (3) in such a way that the delivered oil flow of pump V1 is completely available for the steering system. Depending on the movement of the steering control valve (4), the steering cylinder (6) is supplied with an oil flow via the ports (R) or (L). The oil which is pushed out of the steering cylinder (6) during the steering movement returns to the reservoir via the steering control valve (4) and port (T).

In case self-aligning forces lead to pressure peaks in the steering circuit (eg by driving over obstacles), the secondary valves (7) limit the pressure peaks to p_{max} = 180^{+20} bar on the H 30 and to p_{max} = 205^{+20} bar on the H 35.

Steering system - steering against the stop

When operating the steering cylinder (6) against the stop, the pressure at port (P) of the steering control valve, on the pressure side of the steering cylinder and in the load sensing line (LS) rises to the setting of the primary valve (8) (p_{max} = 120^{+5} bar on the H 30 or to p_{max} = 150^{+5} bar on the H 35). The primary valve opens and reduces the load sensing pressure to the reservoir. As a result, the priority valve moves to a position in which only the oil flow necessary for

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maintaining the maximum pressure is delivered to the steering cylinder. The remaining larger portion of the oil flow delivered by V1 is diverted via the working hydraulics pressure port (P2) to the reservoir.

Emergency steering with the engine stationary

Emergency steering means that a rotor pump in the steering control valve (4) is actuated by the steering wheel. Depending on the sense of rotation, this rotor pump draws oil from one chamber of the steering cylinder and pumps it into the other chamber. In case of an oil loss due to a leak in the circuit, oil is replenished from the reservoir line (T) via the make-up valves (5).

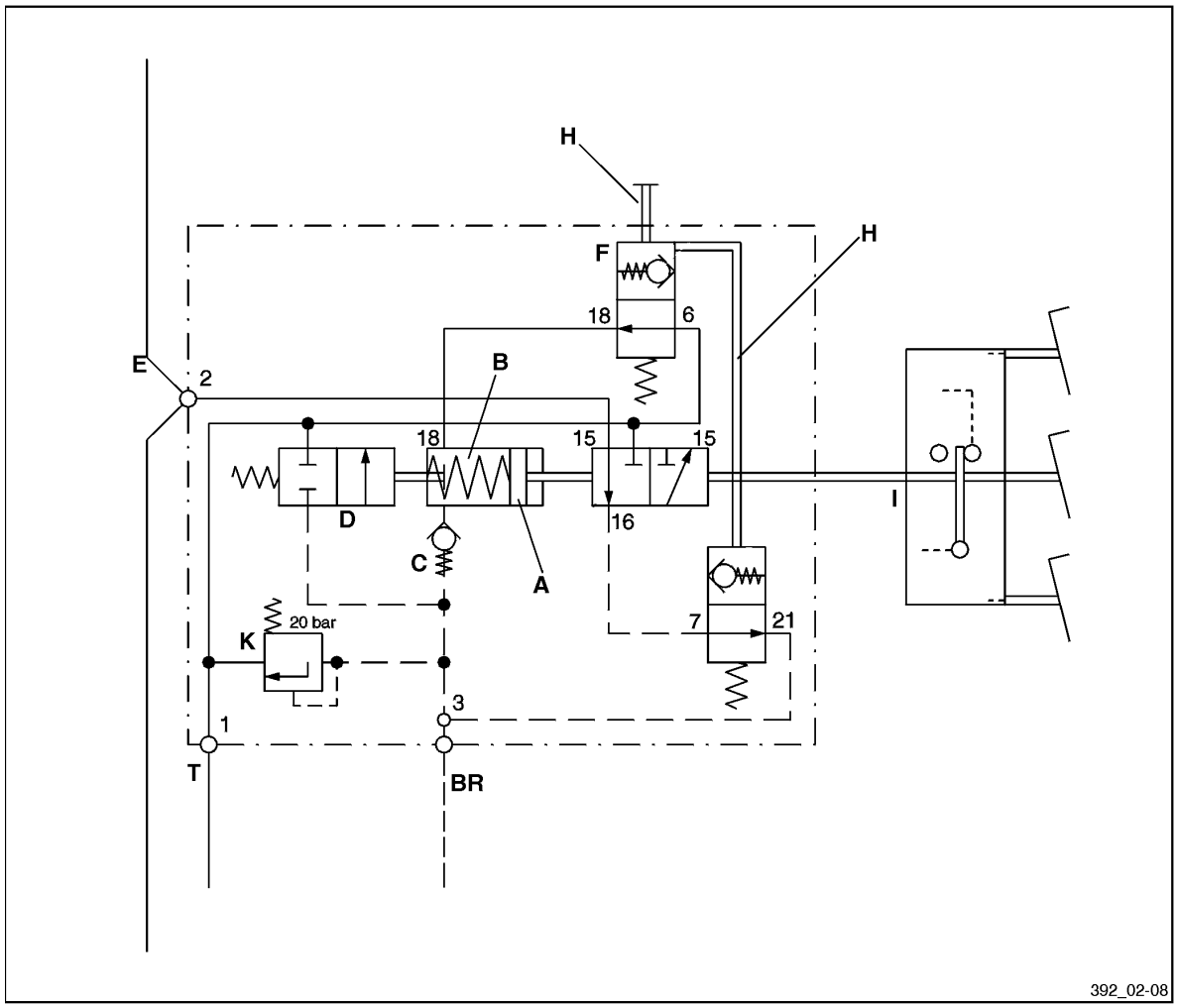
Steering system - pressure settings

	Primary valve	Secondary valve
H 30	120^{+5} bar	180^{+20} bar
H 35	150^{+5} bar	205^{+20} bar

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Brake release valve

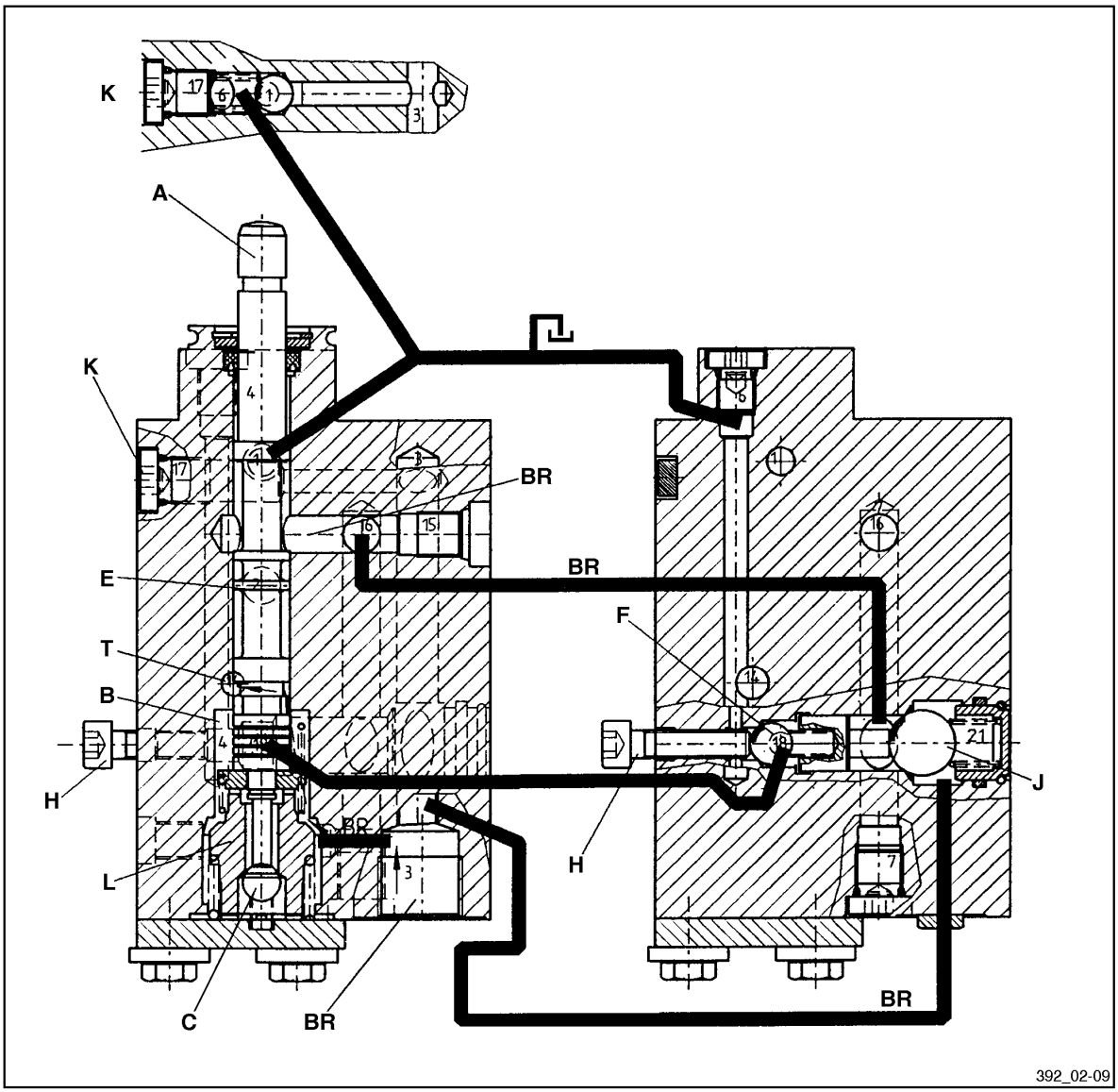
Connection diagram



A	Piston	H	Auxiliary operation valve
B	Pump chamber	I	Brake pedal
C	Auxiliary pump check valve	BR	Brake port
D	2/2-port directional control valve	K	Pressure relief valve brake p = 20 bar
E	Pilot oil pressure port	T	Oil reservoir port
F	Check valve (make-up)		

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Brake release valve - cross section: Brake operation in the towing mode



A	Piston	I	Brake pedal
B	Pump chamber	J	Ball Ø 14 mm
C	Auxiliary pump check valve	BR	Brake port
D	Control edge	K	Brake relief valve, p = 20 bar
E	Pilot oil pressure port	L	Valve cone (not shown on connection drawing)
F	Check valve (suction port)		
G	Ball Ø 9 mm	T	Oil reservoir port
H	Auxiliary operation valve		

Brake release valve - Functional description

Brake released (pressure in brake chamber BR)

- Piston is in not-actuated position (piston travel s = 0 mm).

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- Oil flows from port E (passage 2) via passages 15, 16, 7, 21 to the brake port (passage 3).
- As a result, brake chamber BR is pressurised, the brake is released and does not brake

Brake operates (no pressure in brake chamber BR)

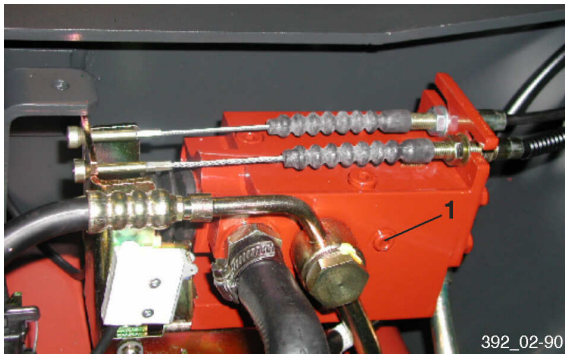
- Piston is in actuated position (piston travel s = 11 mm).
- Oil flows from port BR (passage 3) via passages 21, 7, 16 and 15 to the oil reservoir port (passage 1).
- As a result, brake chamber BR is not pressurised and the brake returns to its operating position and brakes

Towing mode (build-up of pressure in brake chamber BR)

- The auxiliary operation valve screw is screwed out and closes the connection between passage 21 (brake port) and passage 7 (control edge of brake plunger) with the 14 mm ball.
- Simultaneously the 9 mm ball closes the connection of the pump chamber (passage 18) to the oil reservoir (passage 6).
- The auxiliary pump check valve (C) and the valve cone block the connection to the pump chamber.
- A movement of the piston forces oil from pump chamber (B) through the auxiliary pump check valve (C) into the brake chamber or draws the oil from the oil reservoir line into the check valve.
- Pressure builds up in brake chamber (BR).
- The pressure in brake chamber (BR) is limited by the pressure relief valve to p = 20 bar.

Brake release valve - bleed (eg after a replacement)

➢ With the truck running, turn out the screw plug (1) at the side. ▷



➢ Actuate the brake lever several times until oil free of air bubbles emerges (collect the oil).

➢ Screw in the plug while the brake lever is **actuated** (to avoid air entering the system).

Brake cables - adjustment

Two cables with different adjustments act on the plungers of the brake release valve.

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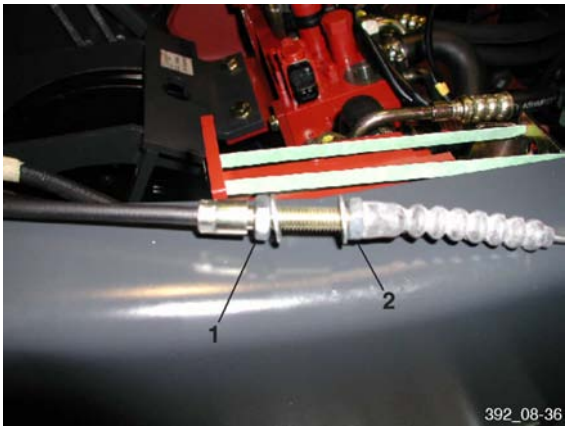
- The parking brake cable is set to a travel of 16 mm. After the travel of 16 mm a noticeable resistance can be felt.
- The service brake cable is set to a travel of 19 mm

Brake cables - location

Parking brake cable: left

Service brake cable: right

Before attaching the brake cables to the yoke of the brake release valve, the nuts must be turned either fully forward (1) of fully backwards (2).



Parking brake cable - adjustment

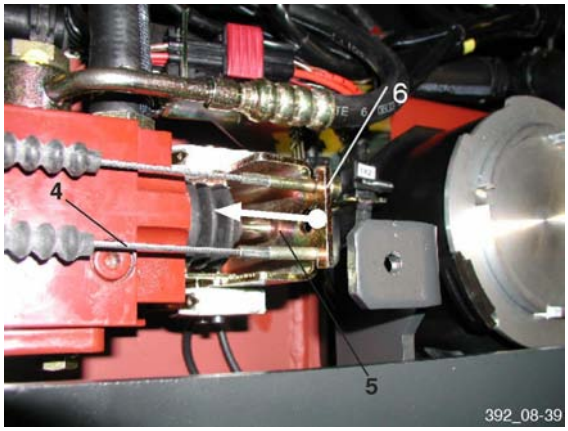
➢ Push the handbrake lever (3) to the position "Release brake".



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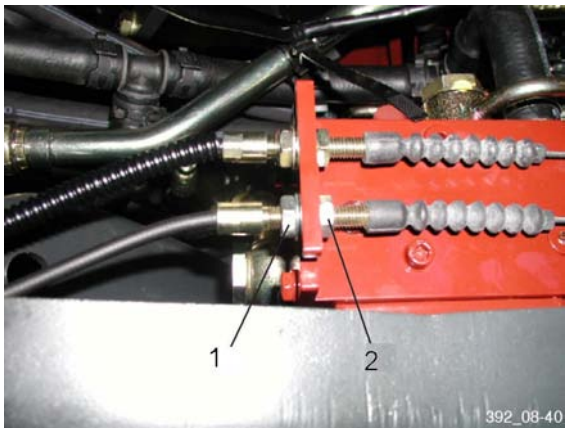
- Hook the cable assembly (4) loosely to the holder of the brake release valve.
- Tighten the front nut until the lever (6) contacts the unactuated piston rod (5) without play.

▷



- Lock with the nut (1)

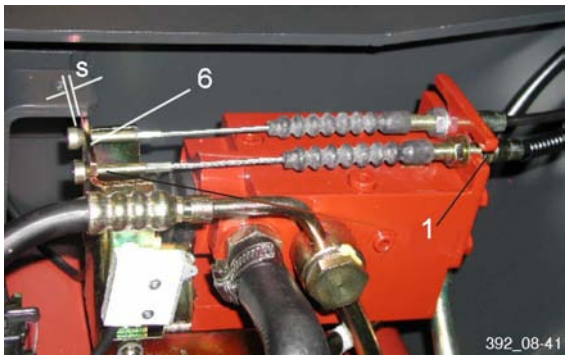
▷



Service brake cable - adjustment

- Hook the cable assembly loosely to the holder of the brake release valve.
- Tighten front nut (1) until the nipple of the cable assembly has a play of approx. 2 mm (s) to the yoke (6) in the neutral position.

▷



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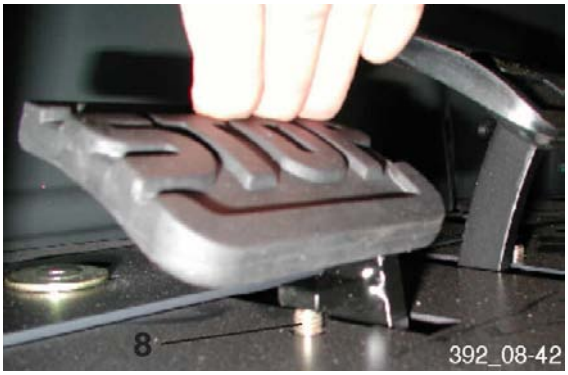
➢ Operate the brake pedal.

About 5 mm before the pedal touches the stop screw (8), you should feel a clearly noticeable resistance.

When the pedal touches the limit stop, the yoke must have a clearance of approx. 0.5 mm to the valve plunger. Correct the adjustment, if necessary.

➢ Lock with the nut (2).

▷



Brake cables - functional test

DANGER

In case of an incorrect adjustment of the brake cables, the truck can possibly no longer be braked with the brake.

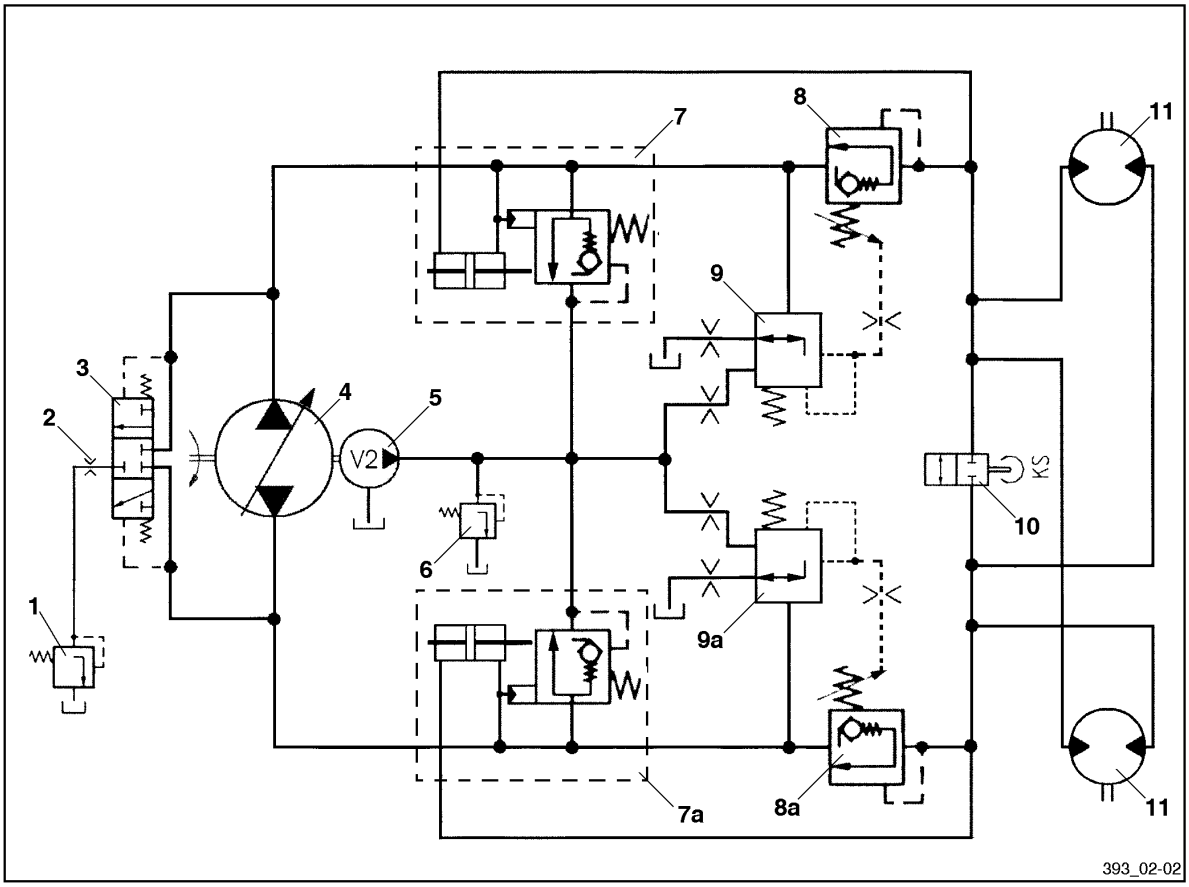
In order to avoid serious accidents, the functional check of the brake must be carried out with the truck blocked up.

After completion of the adjustment, carry out a functional check for:

- easy movement of the brake cables.
- operation of the brake upon actuation of the parking brake.
- operation of the brake upon actuation of the service brake.

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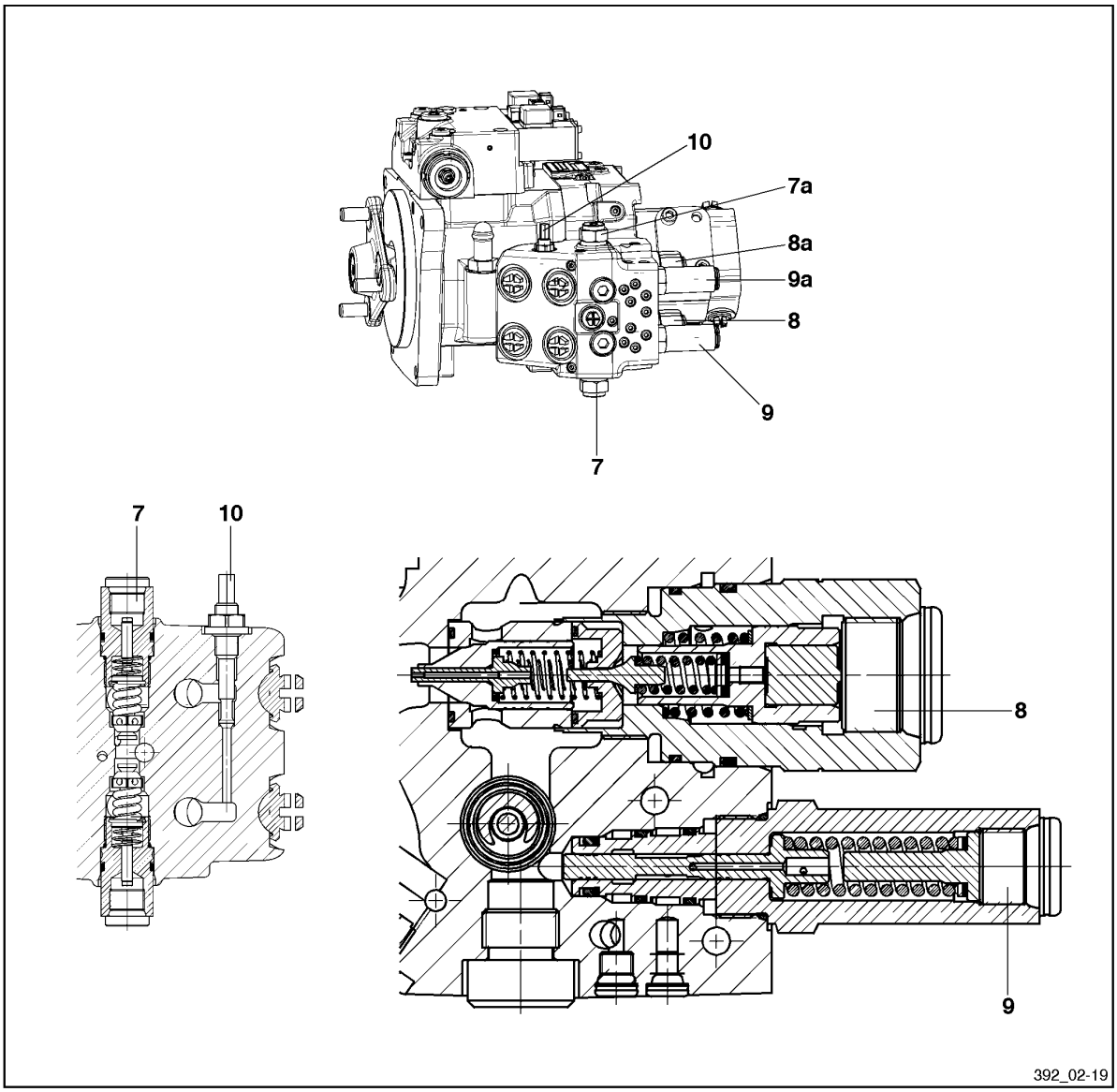
Brake valve



1	Pressure limiting valve p = 13 bar
2	Restrictor Ø 1.4 mm
3	Switch-over valve
4	HPV 75 -02
5	Gear pump V_2, q_2 = 14 cm^3/U
6	Charge pressure valve p = 18.0^{+05} bar
7	Pressure limiting valve forward, p = 435^{+20} bar
7a	Pressure limiting valve backward, p = 435^{+20} bar
8	Brake valve reverse
8a	Brake valve forward
9	Relay valve backward, p = 110 bar
9a	Relay valve forward, p = 110 bar
10	Bypass valve
11	HMF 550 R

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Brake valve functional description



7	Pressure limiting valve forward, p = 435^{+20} bar	8a	Brake valve forward
7a	Pressure limiting valve backward, p = 435^{+20} bar	9	Relay valve backward, p = 110 bar
		9a	Relay valve forward, p = 110 bar
8	Brake valve reverse	10	Bypass valve

To achieve the maximum deceleration in both directions of travel without overspeeding (revving up) the engine, a brake valve for each direction of travel has been installed in the closed circuit. Each of these brake valves is controlled via an additional control valve if the supporting pressure p_{HD1} rises above 110 bar.

Furthermore, the combined charging/pressure limiting valves have been modified in order to ensure a pressure limiting to 435^{+20} bar.

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Forward travel

During traction, the volumetric flow passes through the brake valves which are without function. The relay valves are switched to neutral position at a high pressure below 110 bar. The charge pressure is available at the relay valve and the brake valves have not yet been activated.

The high-pressure traction p_{HD2} is limited to a maximum of 435^{+20} bar by the pressure limiting valve. This function is identical for forward and reverse travel.

Braking (deceleration), forward

Due to the dynamics of the truck mass and the resulting load reversal during braking - traction to overrunning - the oil motors drive the variable displacement pump. The pressure is reversed: LP becomes HP and HP becomes LP. Since the pump is supported on the combustion engine, the speed of the engine is revved up. To counteract the uncontrolled speed increase and thus a reduction of the deceleration and an increase of the noise level, a brake valve is activated at p_{HD1} > 110 bar.

As a result, the supporting pressure p_{HD1} at the variable displacement pump HPV 75 -02 cannot rise above 110 bar, and thus the speed of the engine is limited.

Switching function

If the high pressure p_{HD1} rises to > 110 bar during braking, the relay valve will be activated, the available charge pressure reaches the brake valve, which is adjusted and limits the supporting pressure in the closed circuit at the variable displacement pump HPV 75 -02 to a maximum of 110 bar. The high pressure p_{HD2} on the oil motors can rise up to a max. of 435 bar.

This function is identical for forward and reverse travel.

Brake system - check

Prerequisites for testing - functional test

- Truck blocked up so that both drive wheels can turn freely.
- Pedal adjustment OK.
- Brake pedal in released position "".

➢ Start the engine and push in the brake piston of the brake valve (E) with a long screwdriver.

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➢ Depress the forward and reverse accelerators.

If p_{HP} > 435 bar and the wheels do not turn during this check, the brake system is okay

If the wheels turn during this check, the brake system must be checked

Prerequisites for testing - fault finding

➢ Trucks raised so that both drive wheels can rotate freely.

➢ Bonnet open.

➢ Floor plate raise.

➢ Pedal adjustment OK.

➢ Engine and travel drive at operating temperature.

➢ Brake pedal in the "brake locked" position and applied.

Fault finding - brake system

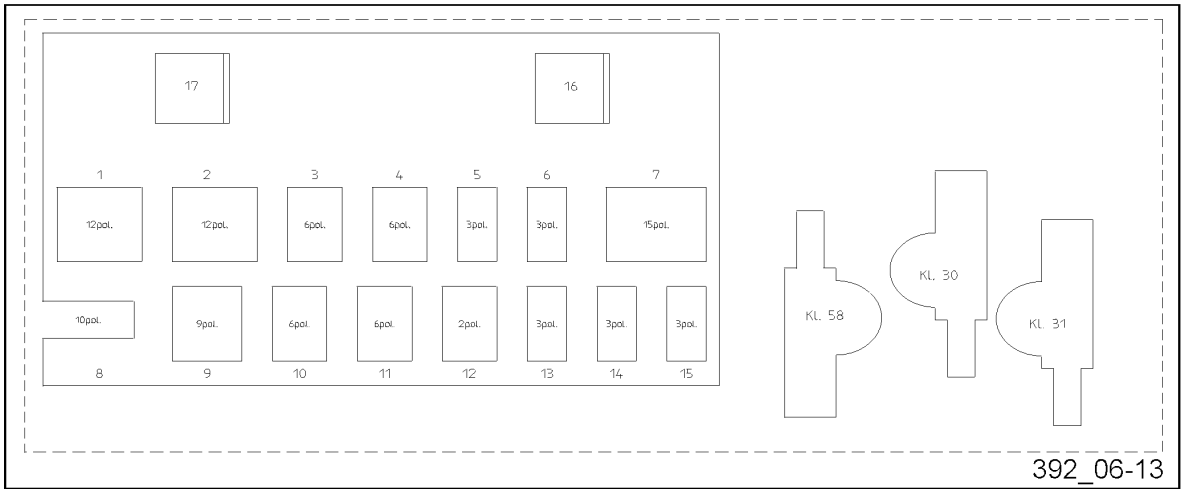
Step Type	Procedure	Yes (Test)	No (Test)
1 Action	Connect M12 x 1.5 screw coupling and LP pressure gauge to port 7 of the LP filter (C).		
2 Action	Start the engine and read the pressure on the gauge		
3 Test	Pressure at least 17.5 bar?	Go to steps 6 - 8	Go to step 4
4 Action	Seal line port E at the brake release valve (E) with blanking plug 000 903 1129 and repeat the test		
5 Test	Pressure at least 17.5 bar?	Brake release valve defective	Check the hydrostatic travel drive
6 Action	Connect an LP pressure gauge with banjo bolt 000 903 1130 and a M14 x 1.5 screw coupling to port BR on brake release valve (E).		
7 Action	Release the brake and check the pressure with the engine running		
8 Test	Pressure at least 17.5 bar?	Go to step 9	Go to step 11 - 12
9 Action	With the engine running, fully depress brake pedal and watch the pressure gauge		

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Step Type	Procedure	Yes (Test)	No (Test)
10 Test	Does pressure drop to approx. 0 bar?	Go to step 11 - 12	Brake release valve does not operate. Repair or replace valve
11 Action	Seal port BR at the brake release valve with blanking plug 000 903 1129.		
12 Action	Start the engine and release the brake.		
13 Action	Depress the forward or reverse accelerator as far as the stop.		
14 Test	Do the drive wheels turn?	The multiple disc brake at the turning wheel is defective. Remove and correct the fault.	Brake system okay.
15 Action	Remove the test adapter at BR and connect an LP pressure gauge with adapter 000 951 2115 and screw coupling 000 951 6400 to port BR on the brake release valve (without brake line).		
16 Action	Check the pressure with the engine running and brake released.		
17 Test	Pressure at least 17.5 bar?	Go to step 18 - 20	Brake release valve defective, repair or replace valve.
18 Action	Remove the test adapter and install the LP pressure gauge again to port BR (with brake line).		
19 Action	Seal port BR at the right-hand brake with banjo bolt 000 903 1126		
20 Action	Check the pressure with the engine running and brake released.		
21 Test	Pressure at least 17.5 bar?	Seal on right-hand brake piston defective	Seal on left-hand brake piston defective

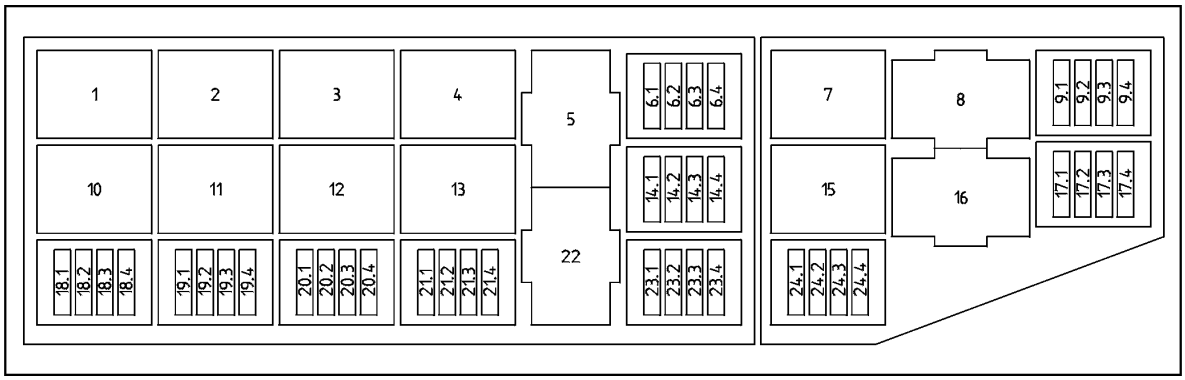
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Arrangement of the interface connectors console - truck



1	5X1/5X4, connector 12 pins (lighting/working lights)	8	6X1, connector 10 pins (composite instrument)
2	7X1, connector 9 pins (soot filter)	9	9X1, connector 9 pins (windscreen wiper)
3	9X5, connector 6 pins (washing system pumps)	10	4X1, connector 6 pins (reversing)
4	4X2, connector 6 pins (reversing signal)	11	
5	5X3/5X9, connector 3 pins (reversing warning light)	12	9X9, connector 2 pins (heating)
6		13	
7	X10, connector 18 pins (interface standard equipment - optional equipment)	14	9X7, connector 3 pins (seat heating)
		15	9X8, connector 3 pins (radio)
		16	X15, connector 2 pins (CAN interface)

Layout of relays and fuses for standard and optional equipment



Fuses			
Location	**Designation**	**Description**	**Rating**
6.1	5F2	Working lights items 3, 4	15 A
6.2			
6.3	5F4	Working light item 7	7.5 A
6.4			
9.1	F5	Composite instrument (terminal 30)	2 A

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Fuses			
Location	**Designation**	**Description**	**Rating**
9.2	F6	Composite instrument (terminal 15)	2 A
9.3	F7	Horn	15 A
9.4	F8	Traction/lift control (terminal 15)	2 A
14.1	5F2		
14.2	9F9	Heater/air conditioning	20 A
14.3	9F6	Seat heating	15 A
14.4	4F3	Hazard warning light/rotating beacon	7.5 A
17.1	F9	Traction/lift control (terminal 30)	15 A
17.2	F10	Power supply for ignition coil	20 A LPG controlled
17.3	F11	VW control unit (terminal 30)	15 A Diesel 20 A LP gas 5 A LP gas controlled
17.4	F12	VW control unit (terminal 15)	2 A Diesel 10 A LP gas 10 A LP gas controlled
18.1	5F8	Headlight left	7.5 A
18.2	5F9	Headlight right	7.5 A
18.3	5F10	Position light left	5 A
18.4	5F11	Position light right	5 A
19.1	5F5/5F1	Lighting/working lights items 1, 2	15 A
19.2	5F6/5F13	Hazard warning flasher	10 A
19.3	5F7	Brake light	5A1
19.4	F	Interior lighting	5A1
20.1	F	Windscreen wiper general	2A1
20.2	F	Windscreen wiper, front	10A1
20.3	F	Windscreen wiper, rear and roof	7.5 A
20.4	9F4	Washing system pumps	10 A
21.1	9F7	Radio terminal 30	5 A
21.2	9F8	Radio terminal 58	10 A
21.3	4F1	Reversing	10 A
21.4	6F1	Truck data management	5 A
23.1	7F1	Soot filter	5 A
23.2	7F2	Soot filter	20 A
23.3	7F3	Soot filter	30 A
23.4			
24.1	F13	Terminal 30	
24.2	F14	Terminal 58	2 A
24.3	F15	Terminal 15	5 A
2.4.4			

Fuse	LMH Part No.
2 A	7 919 086 800
5 A	7 919 086 803
7.5 A	7 919 086 804

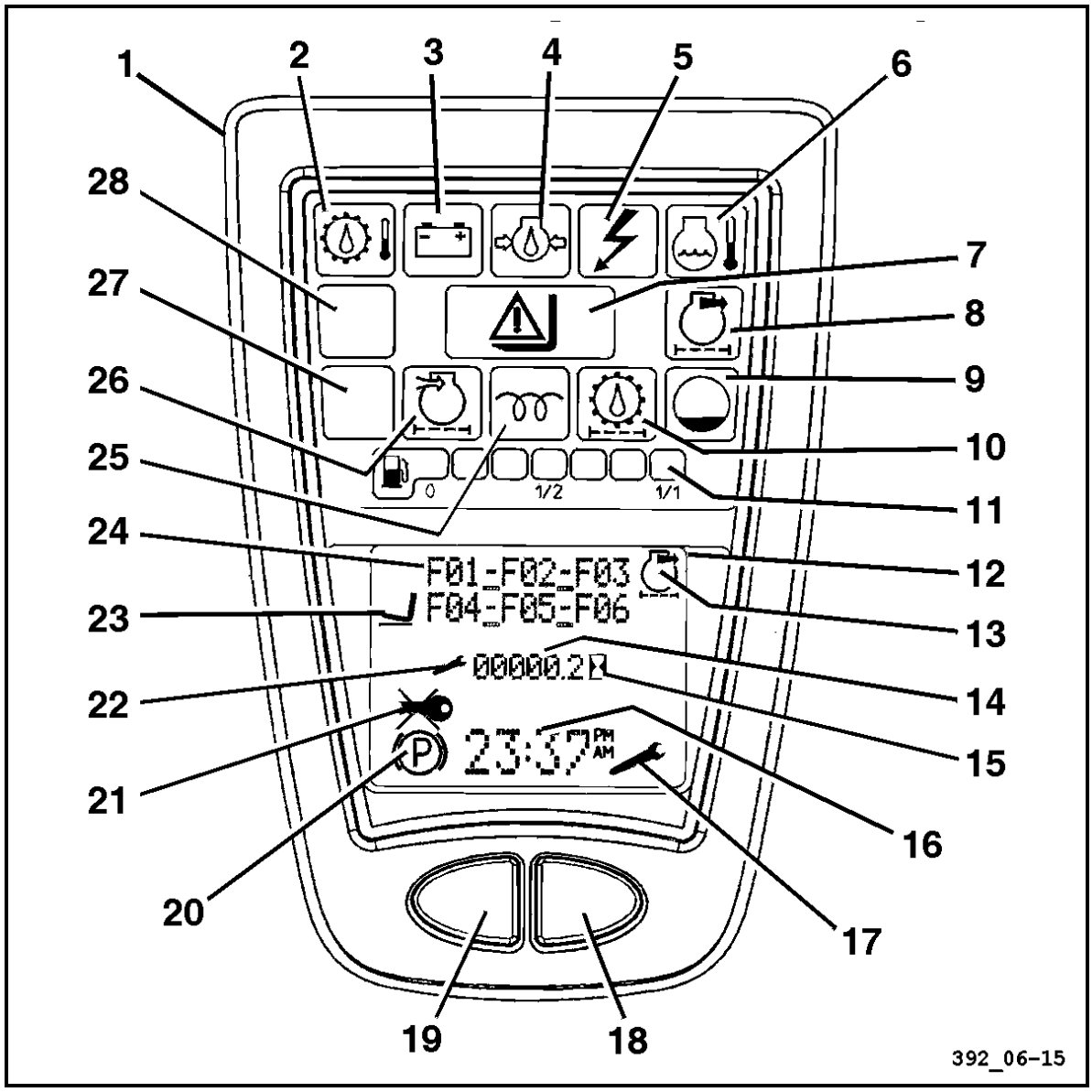
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Fuse	LMH Part No.
10 A	7 919 086 805
15 A	7 919 086 806
20 A	7 919 086 807
30 A	7 919 086 809

Relays		
Location	Designation	Benennung
1	9K1	Windscreen wiper relay, front
2	9K2	Windscreen wiper relay, rear
3	9K3	Windscreen wiper relay, roof
4	4K1	Reversing signal relay
5	K1	Relay terminal 58 (70 A)
7	0K2	Relay VW control unit diesel or
	0K3	Relay control unit LP gas controlled
8	0K1	Glowing relay (70 A)
10	5K2	Relay brake lights
11	5K1	Flasher
	5K5	Hazard warning flasher relay for reversing, vehicle without lighting
12	5K3	Hazard warning flasher relay for reversing, vehicle with lighting
13	5K4	Working light item 7
15		
16	K2	Starter relay (70 A)
22	7B1	Buzzer soot filter

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Composite instrument



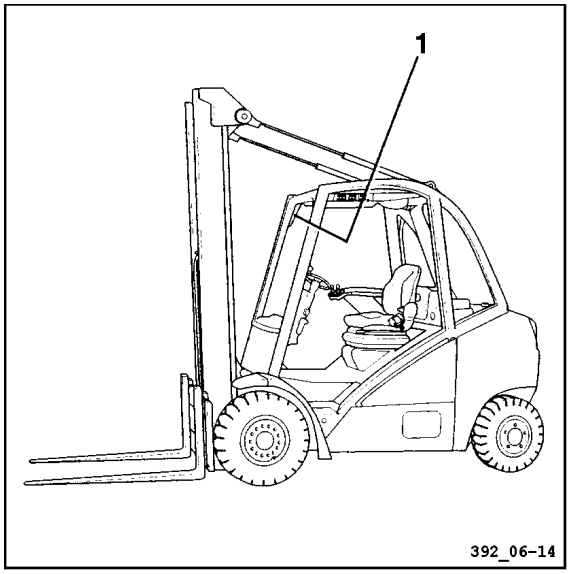
1	Composite instrument	16	Clock
2	Hydraulic oil temperature warning light	17	Service reminder symbol
3	Battery charge warning light	18	Function button
4	Engine oil pressure warning light	19	Reset button
5	Electric controller (LTC) malfunction light	20	Symbol "parking brake on"
6	Coolant temperature warning light	21	Symbol "Do not start engine"
7	Overload warning light*	22	Symbol "Operating hours until next service" (only readable on indicator (14) for 4 seconds)
8	Soot filter warning*		
9	Coolant level warning light*		
10	Hydraulic oil filter warning light*	23	Mast position sensing symbol
11	Fuel level indicator	24	Text field
12	Information display	25	Preheating indicator/fault light (VW engine)
13	Soot filter symbol*	26	Air filter restricted warning light
14	Hour meter	27	Not used
15	Sand glass symbol	28	Not used

* = Optional

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Location of composite instrument

The composite instrument (1) is located at the overhead guard at the top right corner. It serves as a warning indicator and as an information display (12).



Display

DANGER

In case of overload, the load/overload indicator "7"lights up red. The forklift can tip over due to overloading, which can result in severe injuries.

Put the load down immediately.

Observe the load capacity diagram.

Indicator	Purpose	Possible malfunctions Correction
Hydraulic oil temperature warning light (2) (colour: red)	Illuminates if the specified temperature limit is reached. If the admissible temperature limit is reached, a buzzer also sounds.	Not enough oil in hydraulic circuit
		Oil not as specified
		Oil filter clogged
		Accumulation of debris on oil cooler
		Switch off buzzer with reset button (19)
Battery charge warning light (3) (colour: red)	Illuminates in case of malfunctions in the electrical system.	Ribbed V-belt torn or tension too low, tensioner defective.
		Cables defective
		Alternator defective
		Charging regulator or regulator switch defective
Engine oil pressure warning light (4) (colour: red)	Illuminates if the oil pressure of the engine lubrication is too low. A buzzer also sounds.	Not enough oil in crankcase
		Engine overheated
		Oil not as specified
		Internal leak in lubricating oil circuit
		Switch off buzzer with reset button (19).
		Please contact your authorised Linde dealer.
Coolant temperature warning light (6) (colour: red)	Illuminates if the specified temperature limit is reached. If the admissible temperature limit is reached, a buzzer also sounds.	Fan motor defective
		Thermal switch defective
		Radiator blocked
		Leak in cooling circuit
		Coolant level too low
		Switch off buzzer with reset button (19).

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Indicator	Purpose	Possible malfunctions Correction
Overload warning light (7)[1]	Symbol is illuminated orange with a normal load.	
	Symbol is illuminated red in case of overload.	**DANGER** **The load must be put down immediately. Check the load capacity diagram.**
Soot filter warning (8)[2] (colour: red)	Illuminates if the soot filter must be regenerated.	Regenerate soot filter.
Coolant level warning light (9)[3] (colour: orange)	Illuminates if the coolant level drops below the minimum level.	Coolant level too low, refill
Hydraulic oil filter warning light (10)[4] (colour: orange)	Illuminates if the micro-filter requires servicing	Micro-filter restricted, replace
Fuel level indicator (11) (colour: green or red, depending on fuel level)	It indicates the current fuel level.	
Symbol "soot filter" (13)[5]	Illuminates or flashes and shows the remaining capacity by means of 4 symbols in the text field (24).	Soot filter restricted, regenerate
Hour meter (14)	Indicates the operating hours of the truck. This readout serves as proof of the elapsed hours of the truck and of the inspection and maintenance services to be carried out.	If a defective composite instrument has to be replaced, the elapsed operating hours must be recorded. Record the information on durable tape and affix it near the composite instrument. It is also possible to set the new instrument to the actually elapsed time later. Please contact your authorised Linde dealer for this service.
Symbol "sand glass "(15)	Flashes when the hour meter is running (only if ignition is on and the engine speed exceeds 500 rpm)	
Clock (16)	The time is displayed in the 24-hour format. To set the correct time, use the buttons (18) and (19).	The display is changed to 12-hour format with diagnostic unit. Please contact your authorised Linde dealer.
Service reminder symbol (17)	If the number of operating hours until the service interval is 0 or less, the symbol first flashes for 10 s after each start before lighting permanently.	A reset or change of the intervals is only possible with the appropriate diagnostic unit. Please contact your authorised Linde dealer for this service.
Function button (18)	Function depending on model	

1 Option
2 Option
3 Option
4 Option
5 Option

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Indicator	Purpose	Possible malfunctions Correction
Reset button (19)	To set the time, switch off the warning buzzer and for other functions, depending on the model.	
Symbol "parking brake" (20)	Illuminates when the parking brake is operated.	
Symbol "Do not start engine" (21)	Illuminates if the engine has been stalled. In this case, restarting the engine is only possible after a short waiting period.	Start again after a short waiting period.
Symbol "Operating hours until next service" (22)	After switching the ignition on, the operating hours until the next servicing are indicated in the Display field ((14), counting backwards). The symbol (22) is lighted. After 4 seconds the display (14) switches automatically to the operating hours of the truck and the sand glass symbol (15) flashes.	
Symbol "Mast position sensing" (23)[6]	Illuminates if the admissible tilt angle is exceeded.	
Text field (24)	Used for display purposes	
Preheating indicator/fault light (VW engine) (25) (colour: orange)	Illuminates in the preheating time and is then extinguished.	Authorised Linde dealers. Flashing could mean a problem with the VW engine.
Air filter restricted warning light (26) (colour: orange)	Illuminates in case of excessive restriction of the air filter.	Air filter restricted, clean or replace.
Not used (27) and (28)		

6 Option

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Positions of the working lights

Working lights item 1 ▷

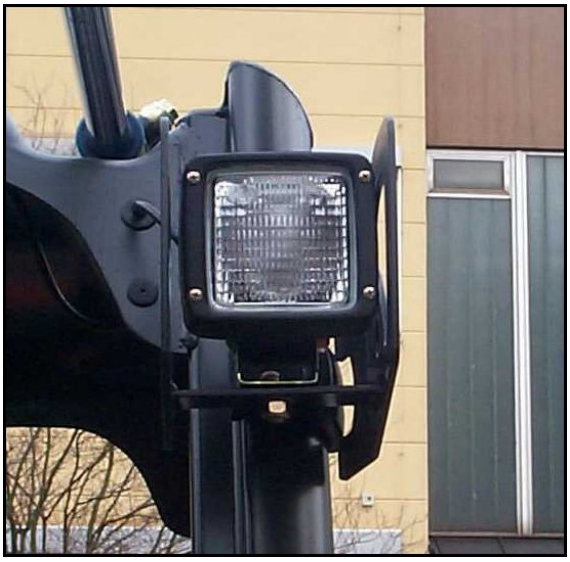


Working lights item 2 ▷



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Working lights item 3 ▷





Working lights item 4 ▷



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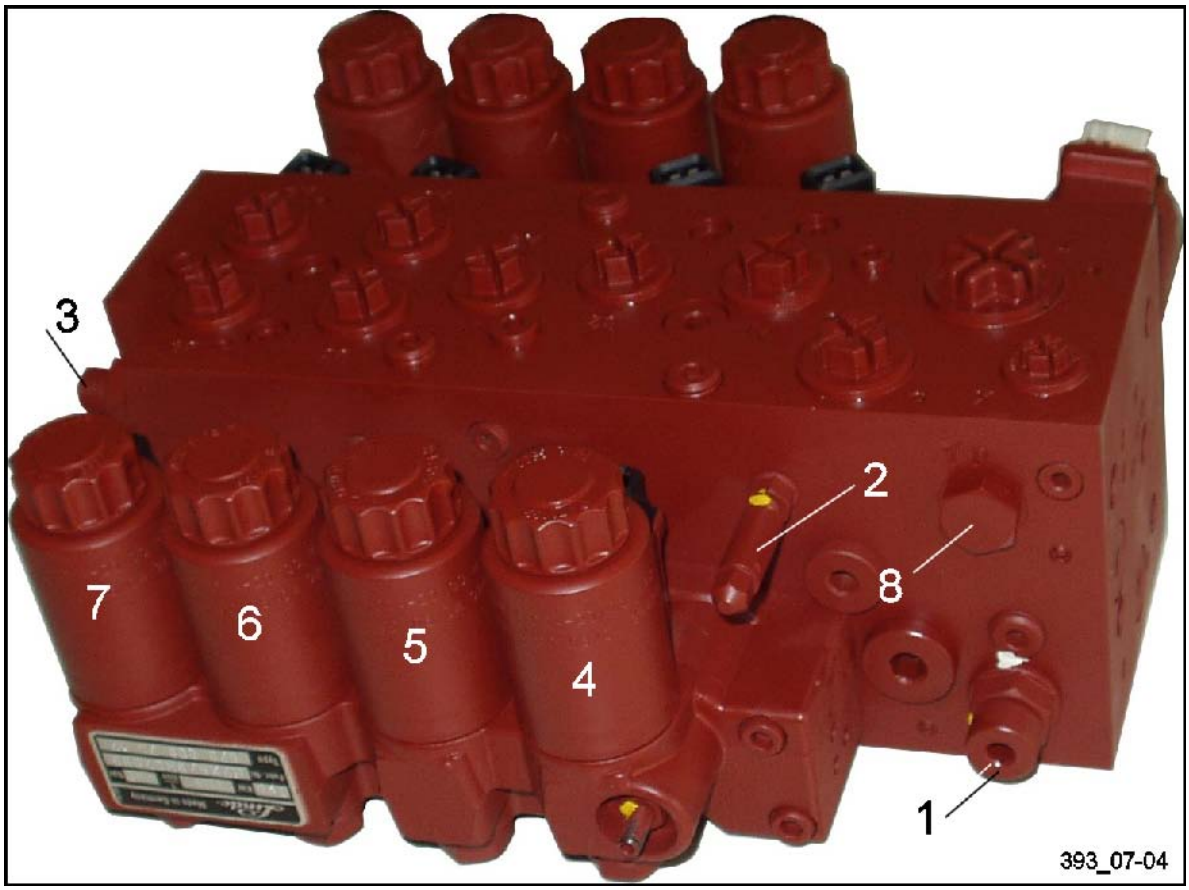
Working lights item 8 ▷





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Functional description of control valve



1	Pressure reducing valve for lifting and tilting
2	Emergency lowering
3	Pressure reducing valve, auxiliary hydraulic system
4	Solenoid valve for lowering
5	Solenoid valve for backward tilting
6	Solenoid valve, auxiliary hydraulic system 1
7	Solenoid valve, auxiliary hydraulic system 2
8	Test point "P"
9	RELEASE VALVE
10	Solenoid valve for lifting
11	Solenoid valve for forward tilting

Introduction

The valve explained in the following paragraphs is an LS control valve with electrohydraulic activation in monoblock design. The control valve is available either as triple monoblock (single auxiliary hydraulic section) or quadruple monoblock (double auxiliary hydraulic sections).

Section 1	Lifting/Lowering
Section 2	Forward and backward tilting
Section 3	Auxiliary hydraulic system 1
Section 4	Auxiliary hydraulic system 2

In the control valve housing, way valves, a balance valve for recirculating oil, pressure reducing valves, a safety valve and various check valves are located.

Release valve, balance valve for recirculating oil, pressure reducing valve

The safety valve is a spool valve which influences both the LS signal path and the control pressure supply. When the joystick is not actuated, port 2Y9 on the safety valve is de-energised. This pushes the safety valve into the following position by means of spring power:

- The LS signal path is connected to the oil reservoir.
- The control pressure supply X is shut off from the supply of the pressure reducing valves.
- The pressure reducing valve supply is placed on the oil reservoir over the solenoid actuating rod.

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Only the oil reservoir pressure is reported to the balance valve for circulating oil in the spring chamber by a flow restrictor in the LS path. With running engine, the balance valve for circulating oil is now set to the position which causes the available pump delivery to flow to the oil reservoir at a D p of approx. 8 bar (corresponding to the spring power at the balance valve). If a joystick is actuated, the solenoid at the safety valve is activated and the valve carries out the following functions:

- The LS path is closed. Thus, the maximum available load pressure acts together with the spring power in the closing direction of the balance valve for circulating oil. The pump pressure rises up to the level at which an equilibrium of forces is restored at the balance valve for circulating oil.
- The control pressure supply X is shut off from the supply of the pressure reducing valves. Only then is it possible to activate the respective way valve axis by means of control signals 2Y1 to 2Y8.

If the signalled load pressure exceeds the max. admissible pressure value of the pressure reducing valve (1), the latter opens a connection to the oil reservoir. A pressure difference is then reduced at the flow restrictor in the LS-path. Now, only the pressure set at the pressure reducing valve (2) and the spring power act on the balance valve for circulating oil. This limits the maximum pump pressure. If the available load pressure is higher, no positive control Dp may arise at the restrictor of the way valve axis and, thus, there is no flow to the load. The excessive volumetric flow of the pump is conducted to the oil reservoir at the balance valve for circulating oil.

Functional description - lifting, lowering and emergency lowering

When the joystick for lifting is actuated, control signal 2Y2 is increased in proportion to the lever excursion. At the same time, the joystick movement switches the above-mentioned safety valve. The control signal acts on the proportional magnet of the pressure reducing valve and limits the maximum available supply pressure X.

Thus the pressure reducing valve creates a control pressure, depending on the control signal. This control pressure displaces the way valve piston (4) against a feedback spring.

The restrictor located in the way valve is enlarged with rising piston stroke. In parallel with the displacement of the piston, the load pressure is reported to the LS path and the balance valve for circulating oil adjusts the pump pressure to a certain pressure level so that a constant control Dp is always available at the restrictor. As a result of this switching logic, the volumetric flow to the load is a function of the variation of the surface area of the restrictor.

As regards the non-return valve (6) during lifting, the oil just passes through it. The excess volumetric flow is fed to the oil reservoir via the balance valve for circulating oil.

When the lowering function is actuated, control signal 2Y1 is transmitted to the pressure reducing valve. The resulting reduced control pressure acts on the way valve piston (4) and at the same time on the unlocking valve (7).

The unlocking valve has an operating point which is below the start of the lowering function. In activated position, the spring chamber of the non-return valve (6) is connected with the main volumetric flow path upstream from the lowering restrictor. The advantage of this switching logic is that the non-return valve opens only at the moment at which the lowering restrictor is opened to the oil reservoir. This allows a very sensitive lowering process even at high loads.

The "lowering stop" function is initiated at each interruption of signal 2Y1 or 2Y9. As soon as the unlocking valve (7) lacks control pressure supply, the above-mentioned connection is closed again and the load pressure in A1 is reflected in the spring chamber of the non-return valve. As a consequence the valve is tightly closed.

An outlet flow controller (5) is integrated in the way valve piston (4). This regulates a Dp at the lowering restrictor, which is adjusted in such a way that the lowering speed never exceeds a maximum of 0.6 m/s even with load. To enable the lowering of a lifted mast also in case of a failure of the control valve, a connection between the load A1 and the oil reservoir may be opened manually via the emergency lowering function. The emergency lowering screw may be opened through a hole in the bottom plate by means of a socket spanner (opening SW 10).

After actuation of this function, the emergency lowering screw must be tightened again to the right tightening torque as shown in the installation drawing before the truck is started again.

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Functional description - tilting and balance valves

When the joystick is actuated, either control signal 2Y3 (forward tilting) or 2Y4 (backward tilting) is transmitted to the corresponding pressure reducing valve (forward tilting or backward tilting). As in case of the lifting function, this causes a displacement of the way valve piston (9). The following switching positions are set one after the other.

- Signalling of load pressure to LS path.
- Opening of outlet to the oil reservoir.
- Opening of restrictor between pump and load.

As long as the forward tilting/backward tilting load pressure is the highest pressure in the LS path, this pressure will be signalled to the balance valve for circulating oil and the pump is set to a value which is higher by the control Dp. As a result, a volumetric flow which is proportional to the excursion of the restrictor flows to the load. In this situation, the balance valves (12) and (13) integrated in the piston are fully opened. As soon as another load signals a higher load pressure, this will be applied to the balance valve located on the inlet side, and the balance valve is pushed into closing position. The balance valve then regulates a position in which the control Dp is still available at the restrictor and the load Dp (differential pressure between the highest load pressure and the tilting pressure) is limited at the control restrictor of the balance valve.

Thus the volumetric flow for the tilting function remains unaffected even in case of parallel operation with other loads.

Functional description - brake valves

Downstream from the way valve (9) in the way valve block are two brake valves (10) and (11). These valves are designed as seat valves (closing without leakage) and each is equipped with a bypass check valve. The principle of operation of the valves is explained with the example of the forward tilting function.

By means of the control signal 2Y3 and the pressure reducing valve, the way valve piston (9) is subjected to an excursion in such a way that a volumetric flow is conducted from the pump via the bypass check valve in the brake valve (10) to load A2. The load pressure in A2 is signalled to the brake valve (11) and pushes it into the opening direction.

The oil pushed out of the cylinders (17) can flow from port B2 to the oil reservoir via the brake valve (11) and the way valve piston (9).

If the mast, due to a drawing load, reaches a speed which is higher than the speed which is determined by the volumetric flow in A2, the pressure in A2 drops and the brake valve (11) is pushed back into closing position by a spring. As a result, the volumetric outlet flow in B2 is accumulated which, together with the cylinder surface, constitutes a force that acts opposite to the direction of traction of the load.

The pressure in A2 rises again and is thus able to open the brake valve (11). Since the brake valve is a regulating valve, a condition arises in which the brake valve regulates the mast speed in such a way that it corresponds exactly to the preset volumetric flow in A2.

The leakage-proof design of the brake valve prevents any mast movement when the control valve is not actuated.

Functional description - auxiliary hydraulics

The principle of operation of the hydraulic attachments (1) and (2) are identical for the A side and B side. Their maximum volumetric flow depends on the corresponding maximum control signal 2Y5 to 2Y8. This value may range from 3 to 48 l/min.

The maximum admissible attachment pressure of the auxiliary function is restricted to a value between 160 and 180 bar by means of the pressure limiting valve (14). The function is explained with the example in attachment A3.

When the joystick is actuated, control signal 2Y6 and simultaneously 2Y9 are released. The safety valve is activated by control signal 2Y9 even before the auxiliary function starts. Control signal 2Y5 acts on the pressure reducing valve and generates a control pressure which, in turn, acts on the valve piston (15). With rising control signal, the control pressure rises and the valve piston is moved against a feedback spring in opening direction. The load pressure in A3 is signalled to the balance valve for circulating oil (3) via the LS path by the displacement of the piston (15). The restrictor at the valve piston links the pump path to hydraulic attachment port A3.

Load B3 is connected to the oil reservoir. Due to the control Dp generated at the balance valve for circulating oil, a volumetric flow proportional to the restrictor excursion is created. The excess volumetric flow of the pump is fed to the oil

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reservoir via the balance valve for circulating oil.

If the load pressure of the hydraulic attachment exceeds the maximum admissible value for the pressure limiting valve (14), the control Dp at a flow restrictor in the LS path will be reduced. Thus, there is no pressure difference between the pump pressure and load pressure A3, and no volumetric flow may flow to the load.

The attachments are **not** provided with any device to maintain the volumetric flow to the load during parallel operation with other functions at a constant level.

Pressure reducing valve setting instructions

Pressure adjustments:

- H 30, standard, duplex and triplex mast: $p = 225^{+5}$ bar
- H 35, standard, duplex and triplex mast $p = 245^{+5}$ bar

➢ Loosen locknut.

WARNING

The pressure increase occurring when the adjusting screw is screwed in happens very quickly and can reach inadmissible levels. The setting is very sensitive.

Very carefully set the adjusting screw in maximum increments of 60° rotation angle.

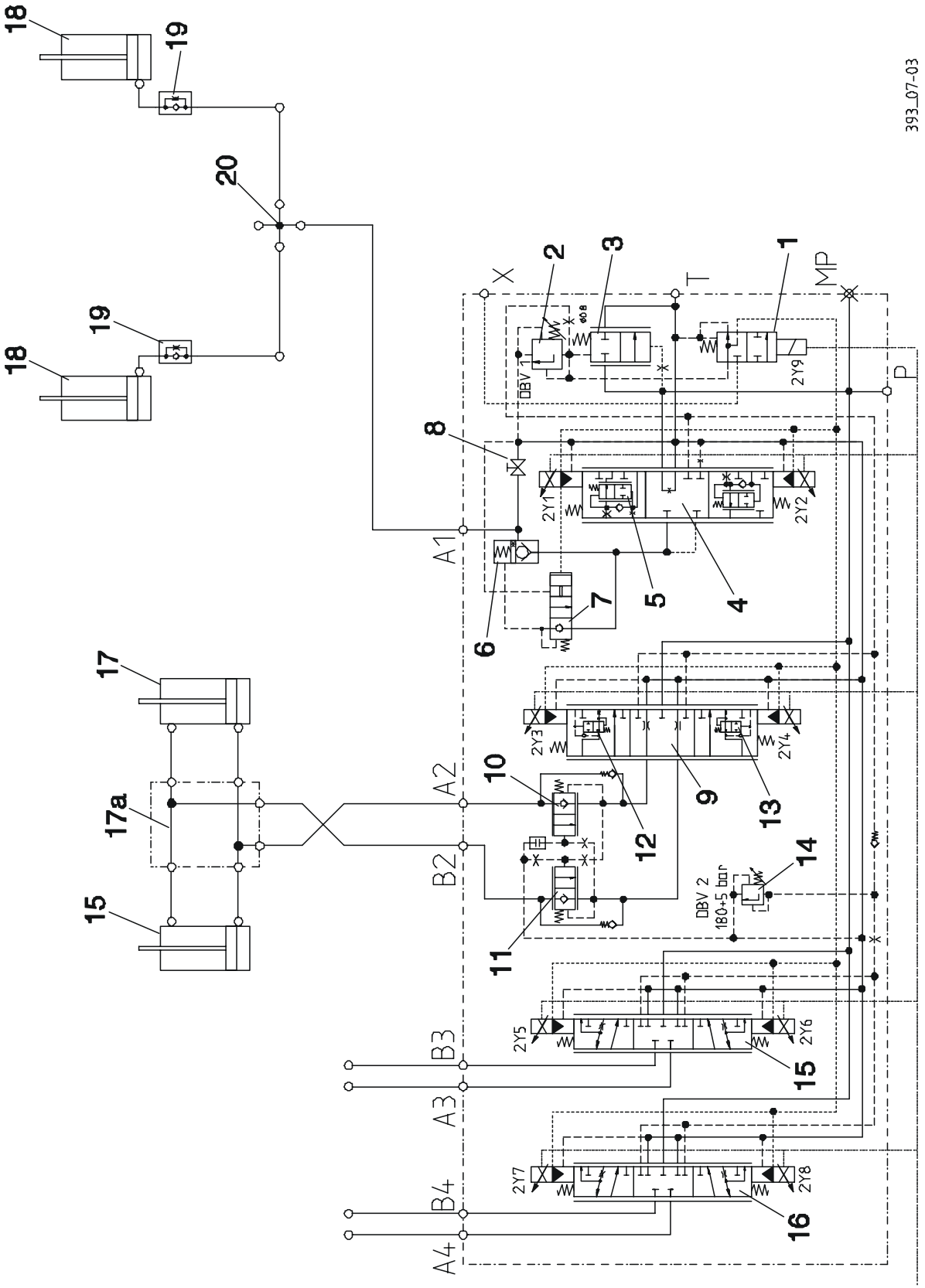
➢ Screw in adjusting screw (pressure increase).

➢ Unscrew adjusting screw (pressure reduction).

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Circuit diagram of working hydraulics



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1	Release valve (safety valve)
2	Pressure reducing valve for lifting, forward tilting and backward tilting
3	Balance valve for recirculating oil
4	Way valve for lifting/lowering
5	Flow control valve
6	Non-return valve
7	Unlocking valve for the non-return valve
8	Emergency lowering, lowering
9	Way valve for forward tilting and backward tilting
10	Brake valve for backward tilting
11	Brake valve for forward tilting
12	Balance valve for forward tilting
13	Balance valve for backward tilting
14	Pressure limiting valve for the auxiliary hydraulics
15	Way valve for auxiliary hydraulics 1
16	Way valve for auxiliary hydraulics 2
17	Tilt cylinder
17a	Distributor
18	Lift cylinder
19	Line breakage protection
20	Distributor

Ports

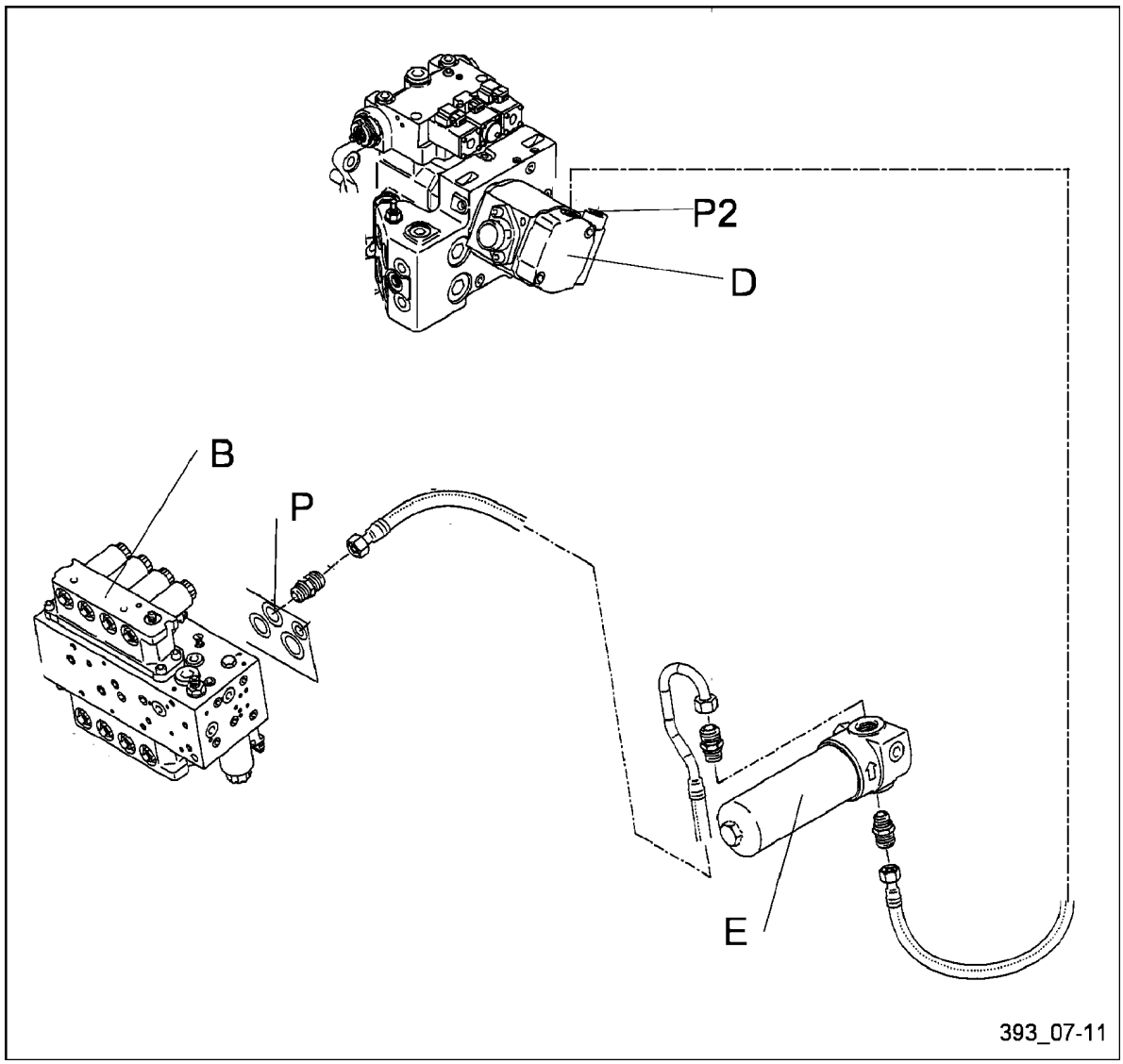
A1	Lift cylinder
A2	Forward tilting
B2	Backward tilting
A3/B3	Auxiliary hydraulic system 1
A4/B4	Auxiliary hydraulic system 2
TP	Test point for recirculating and maximum pressure
P	Pump V1
X	Pilot pressure
T	Return flow / oil reservoir

Valves

2Y1	Valve - lowering
2Y2	Valve - lifting
2Y3	Valve - forward tilting
2Y4	Valve - backward tilting
2Y5	Valve auxiliary hydraulics B3
2Y6	Valve auxiliary hydraulics A3
2Y7	Valve auxiliary hydraulics B4
2Y8	Valve auxiliary hydraulics A4
2Y9	Release valve (safety valve)

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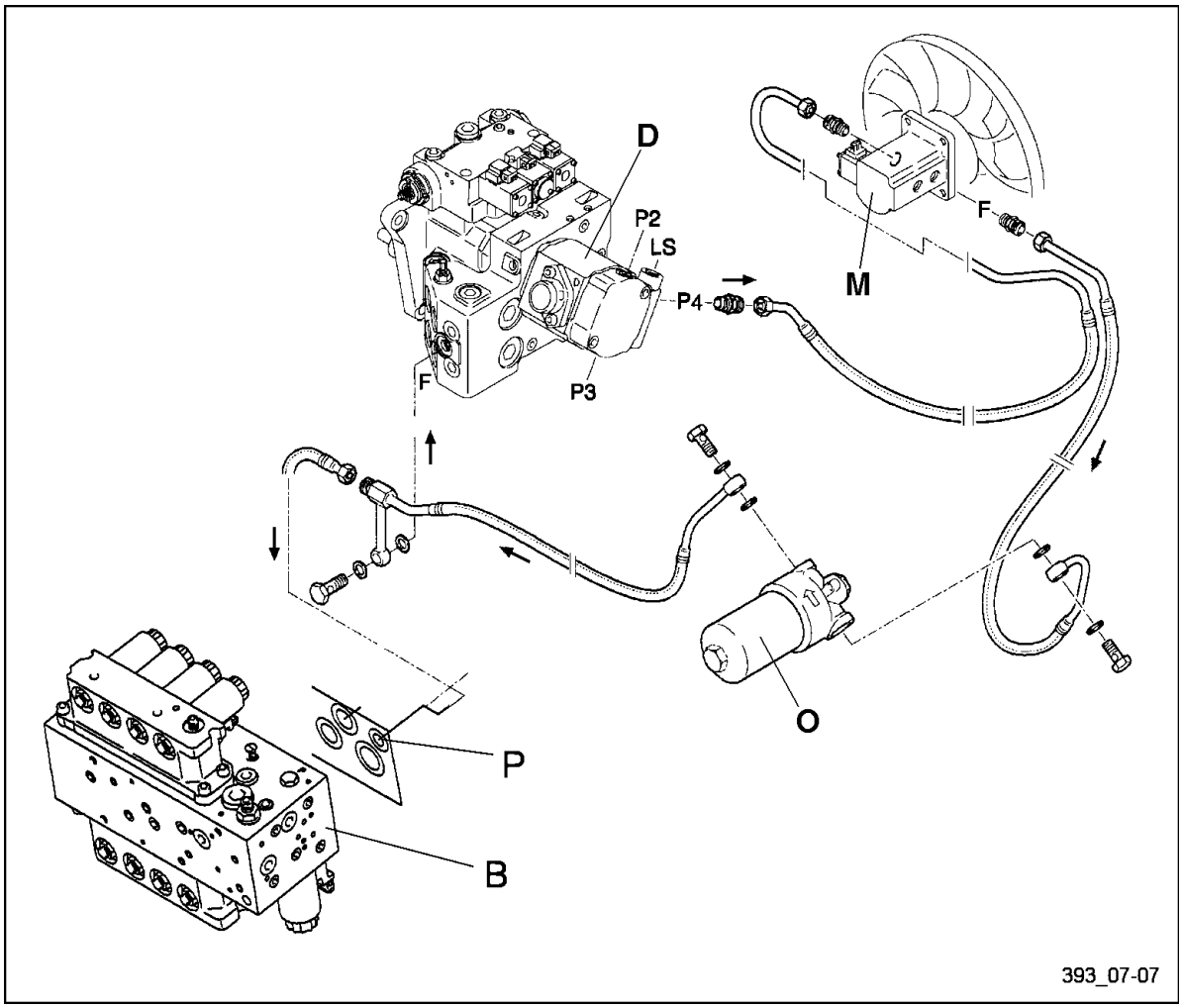
Hose layout pump - control valve



B	Working hydraulic valve
D	Gear pump
E	Filter working hydraulics
P	Pressure port - control valve
P2	Working hydraulics port

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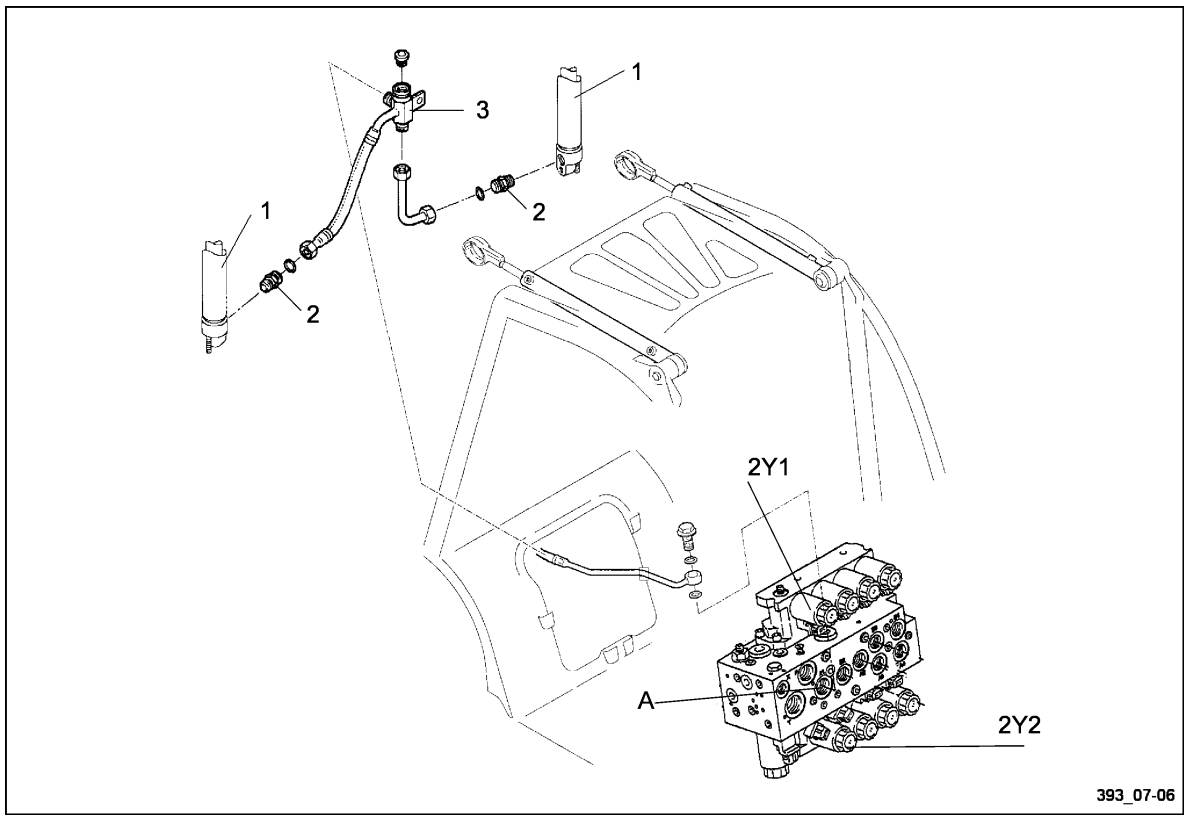
Hose layout control pressure supply



B	Working hydraulic valve	P	Pressure port - working hydraulics
D	Gear pump	P(St)	Pressure port - control pressure
E	Pressure port - control pressure	P2	Pressure port - working hydraulics
F	Supply pressure	P3	Pressure port - steering
M	Fan drive	P4	Pressure port - fan motor
O	LP filter charging pressure	LS	Pressure port, load-sensing

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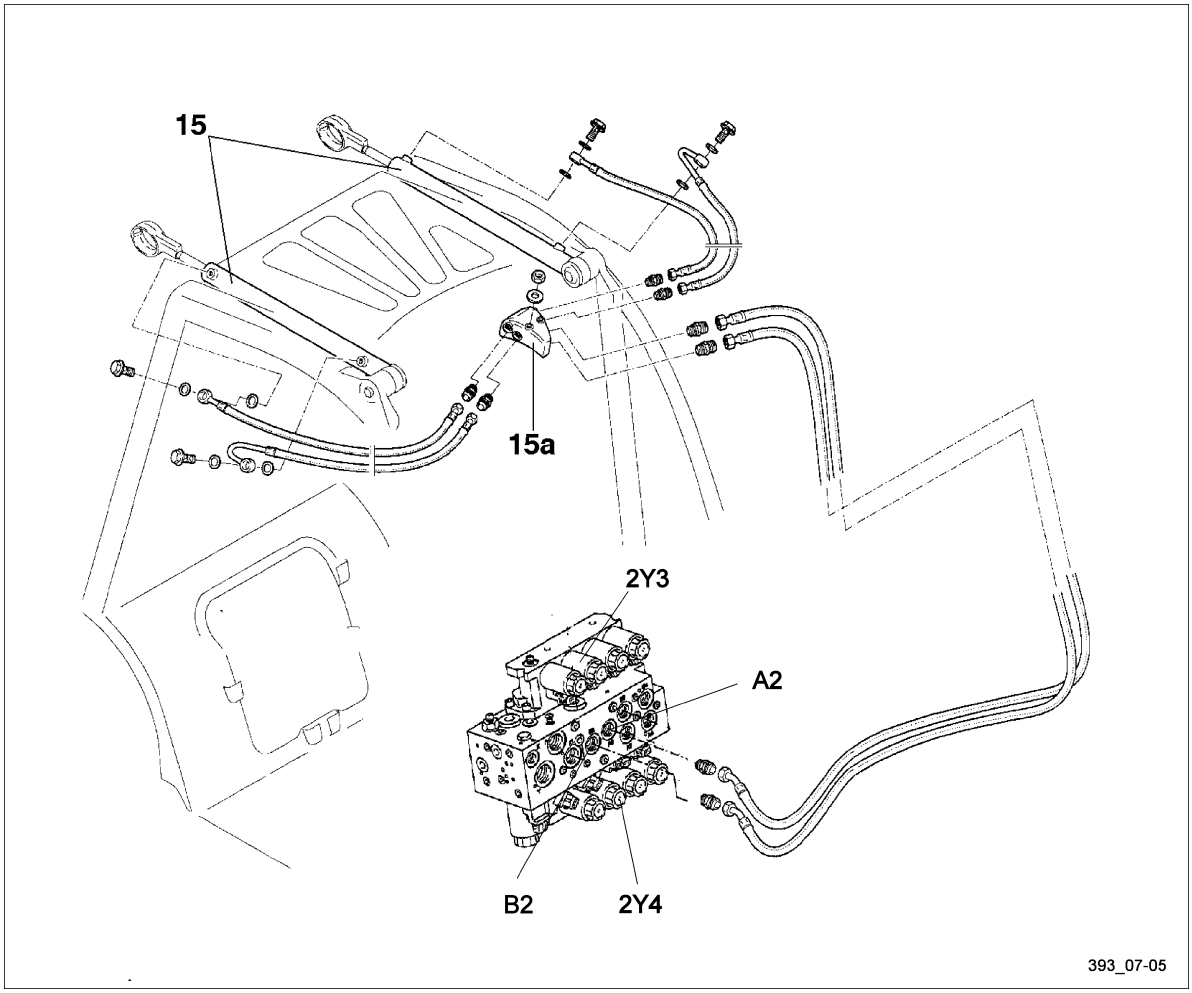
Hose layout for lifting



1	Lift cylinder	A	Lift cylinder/mast
2	Line breakage protection (LBS)	2Y1	Valve - lowering
3	Distributor	2Y2	Valve - lifting

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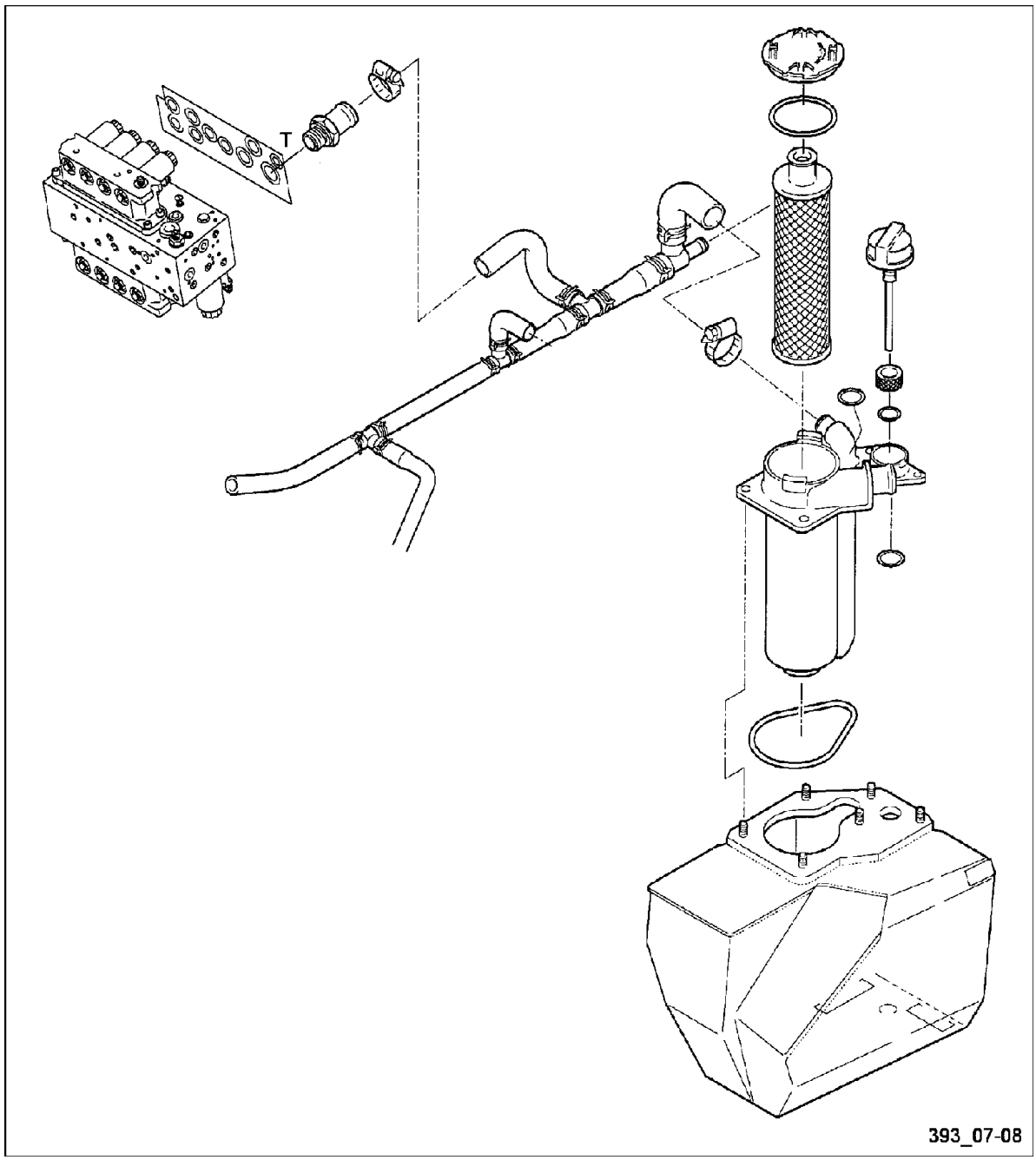
Hose layout for tilting



15	Tilt cylinder	B2	Forward tilting
15a	Distributor	2Y3	Valve - forward tilting
A2	Backward tilting	2Y4	Valve - backward tilting

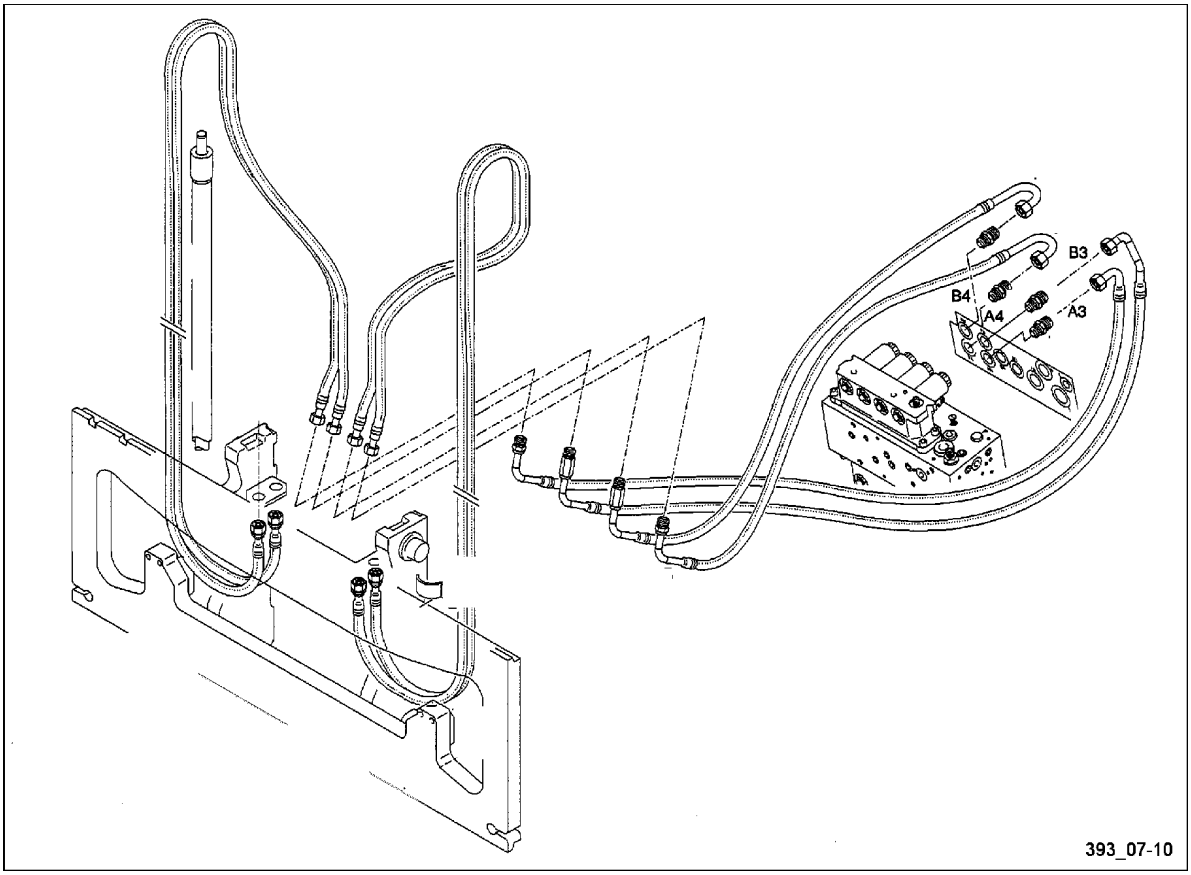
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Hose layout return flow to oil reservoir



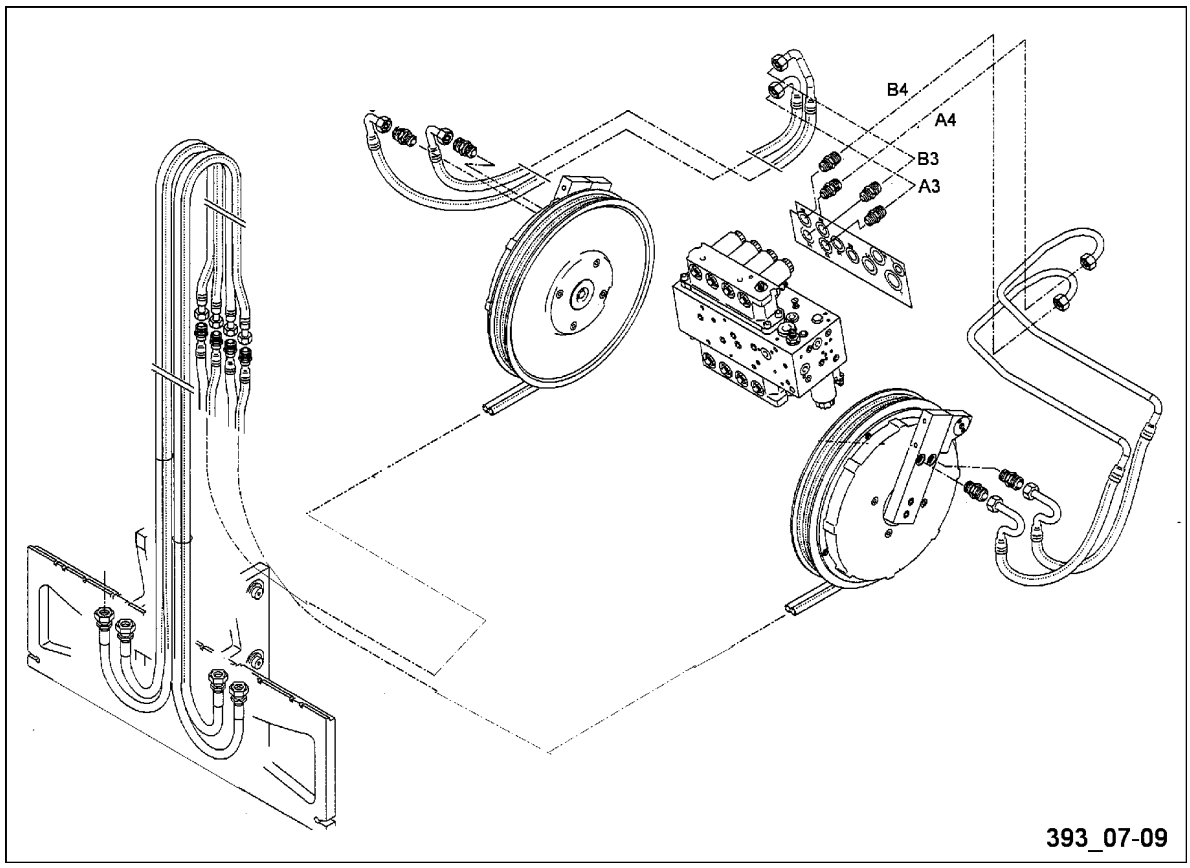
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Hose layout in auxiliary hydraulics for standard mast



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Hose layout in auxiliary hydraulics for duplex and triplex mast



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Mast - identification

For the purpose of mast identification, a 12-digit mast number (serial number) and a type description are attached to the mast channel.

Example of trucks series 393 as well as mast type 188 in standard, duplex and triplex type

Serial number: **MD 30T 01-46-5/393**

M	Mast
D	Mast channel parameter D = 2 to 3 tons
30	Load capacity eg3.0 t
T	S Standard, D Duplex, T Triplex
01	Mast variant 01
46	Height of lift eg4600 mm
5	Load centre eg 500 mm
393	Series 393

Mast - removal and installation (all series)

- Remove the fork arms.
- Lower the fork carriage.
- Tilt the mast back approx 2°.

NOTE

Tilting the mast back by approx. 2° relieves the rubber bushes of the tilt cylinder mounts.

- Disconnect the pressure lines and, if fitted, the auxiliary hydraulics lines between the vehicle and the mast.
- Attach a rope to the top cross member of the outer mast, hook on the hoist and tauten the rope. Do not exceed the load capacity of the hoist and rope.
- Unscrew the hex head bolt on both tilt cylinders at the upper eye bolt.
- Remove the inner and outer clamping piece.
- Unscrew the four hex head bolts at the lower mast bearing.
- Separate the toggle joint (M8) of tilt angle sensor from the mast.
- Lift the mast out.

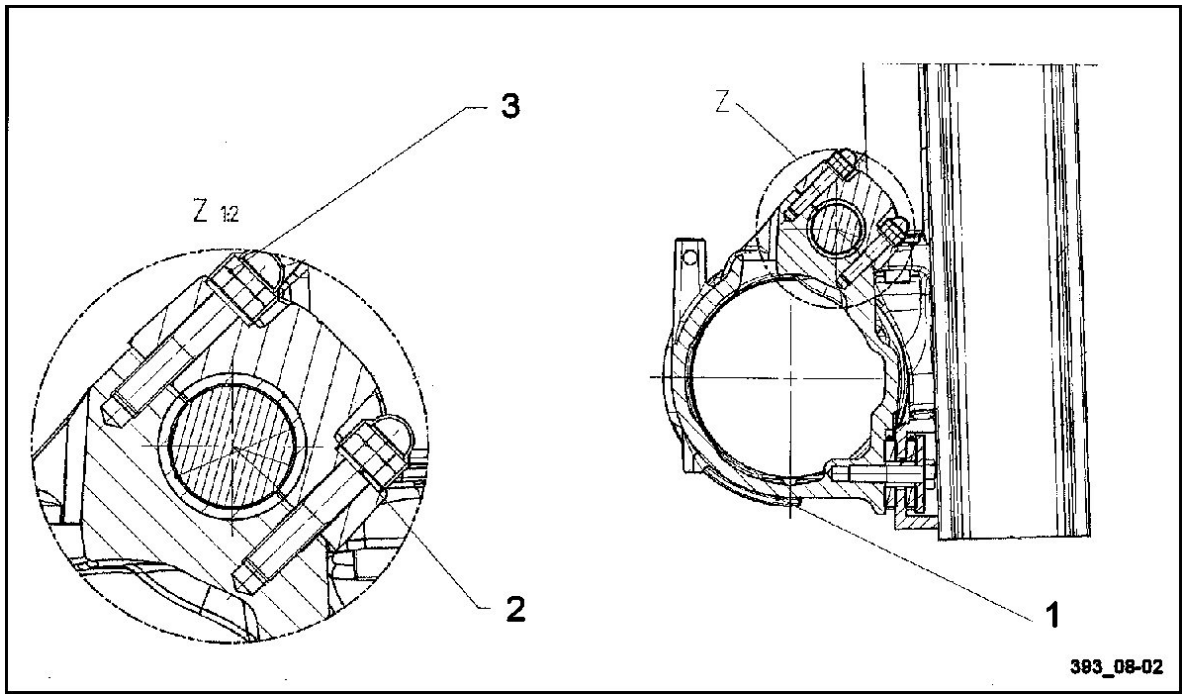
The installation of the mast is carried out in the reverse order.

Masts - Tightening torques

Mast to drive axle	Location	Screw size	Torque M_d
First tightening/retightening torque (type I)	top	M16	205/205
	bottom	M16	275/275
First tightening/retightening torque (type II)	top	M20	430/___
	bottom	M16	275/___
First tightening/retightening torque (type III)	top	M12	110/___
	bottom	M20	385/___
Mounting of tilt cylinder	front	M16	275
	rear		

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Installation of mast type 188

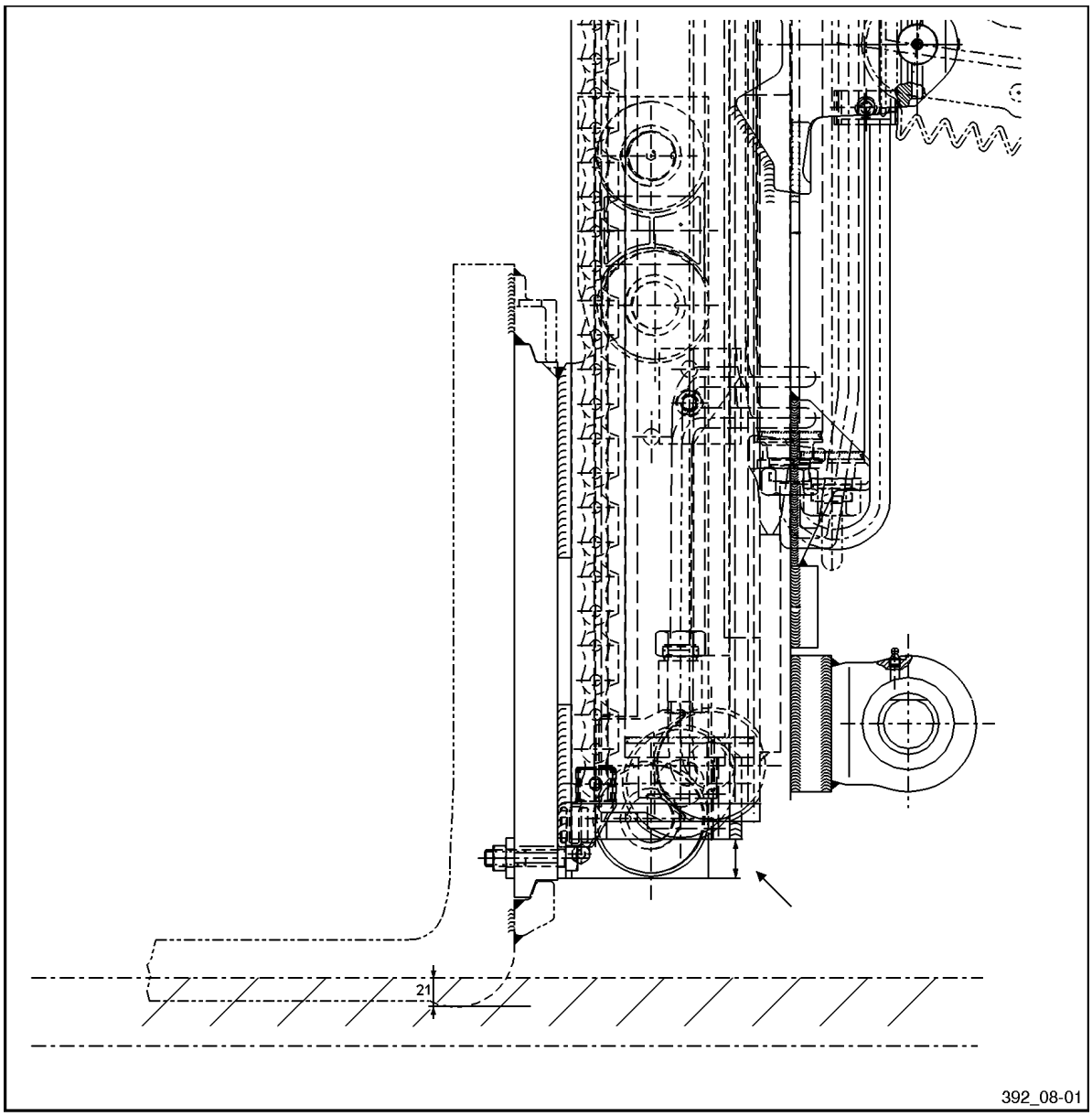


1 Axle housing H 30/ H 40
2 Washer
3 M16 x 70 hex head bolt

Torque for M16 x 70 hex head bolt: M_d = 275 Nm

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A dusting the lift chain (all series)



The lift chain lengthens with operation and must therefore be readjusted.

- Tilt the mast fully back and lower it completely.
- Adjust the chain at the adjusting nut of the chain anchor.
- The lower guide pulley of the fork carriage may project by no more than a third of its diameter from the inner mast channel.
- If two chains are used, make sure that the lengths of the two chains are identical.
- After locking the nuts, extend the mast as far as the stop and check the clearance to the safety stops.

NOTE

If the fork carriage touches the safety stops although the lower rollers project from the profile, a piston head might have become loose, thus increasing the stroke inadmissibly.

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Adjustment of roller clearance

The described settings refer to the installation of new parts. They do not represent maximum allowed wear limits or clearances on masts in use.

Wear on mast channels does not occur evenly over the entire length, it can be found rather in the main work area instead, for example there, where the support rollers are usually located during transport.The mast channels are often so unused in the upper part that they are almost still like new. As a result larger rollers or additional shims cannot be fitted to compensate play without the rollers binding.

Limits for such local wear cannot generally be established as it depends on many factors whether the existing play has a disturbing effect or is scarcely noted. The operating safety of the mast is not reduced hereby. Only if the wear of the roller diameter is approx. 3% does the functionality of the mast have to be checked critically (on long triplex masts maybe slightly earlier, on short standard masts possibly only at 4 %).

The operating safety of the mast lasts much longer as the individual mast components stay nested into each other even with the greatest wear. In case a roller fails or breaks, however, the mast must be taken out of operation immediately.

Roller clearance - fork carrier in the inner mast, type 188

Lateral clearance adjustment

Dimension "RS"		Support rollers positions A, B, C ET No. see Parts Catalogue
from	to	
-	90,3	Support roller size 1
90,3	90,6	Support roller size 2
90,6	-	Support roller size 3

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Lateral clearance (AS)

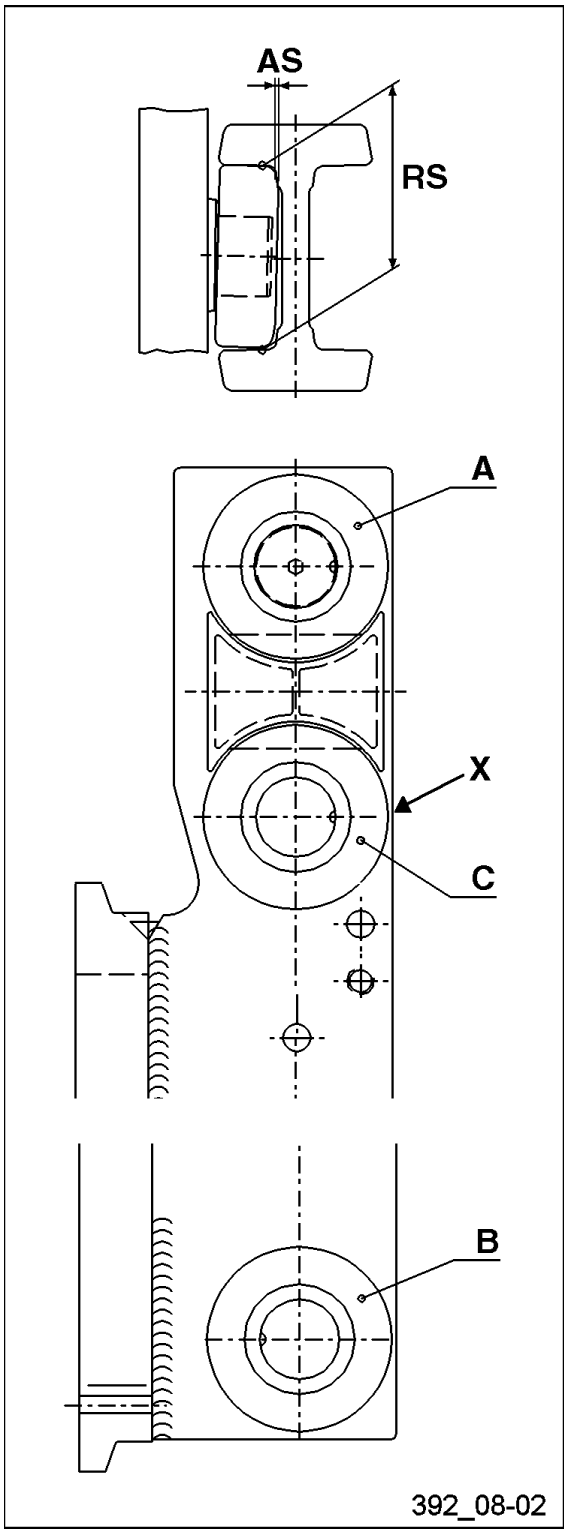
The clearance dimension is adjusted with adjusting shims which are slipped over the centring pivot.

- Support roller A, B: min. 0, max. 0.2 mm at narrowest point.
- Support roller C: Number of adjusting shims same as A + X.

Dimension "X" is embossed on the fork carrier ridge (please refer to the sketch). For the purpose compensation of the tolerances, the contact surface of pivot C is somewhat offset in backward direction in relation to A and B.

For 6-roller fork carriers, the following general rule applies:

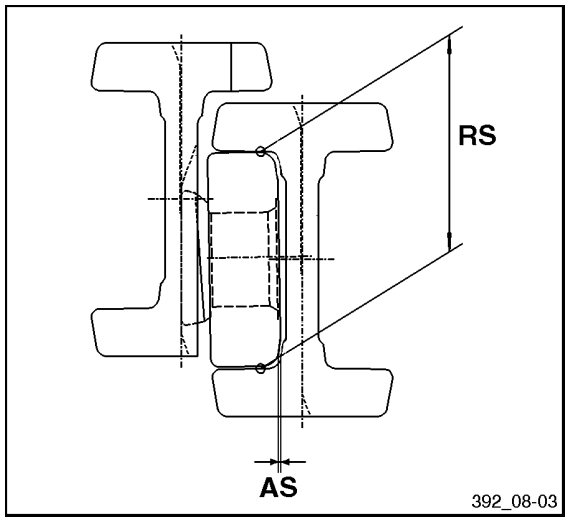
- The third roller pair C should only fulfil its full carrying function when the upper rollers A come out of the mast profile.
- When the rollers A and B contact their tracks, roller C might have a smaller clearance (0 - 0.2 mm).
- Depending on the pivot position, roller C may be one size smaller than A and B.



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Roller clearance - outer, centre, inner mast, type 188 and 189

Shown: Roller on inner mast to middle mast



Radial clearance - adjustment (RS)

Dimension "RS"		Mast rollers Part No. see Parts Catalogue
over	up to	
-	90.3	Roller size 1
90.3	90.6	Roller size 2
90.6	-	Roller size 3

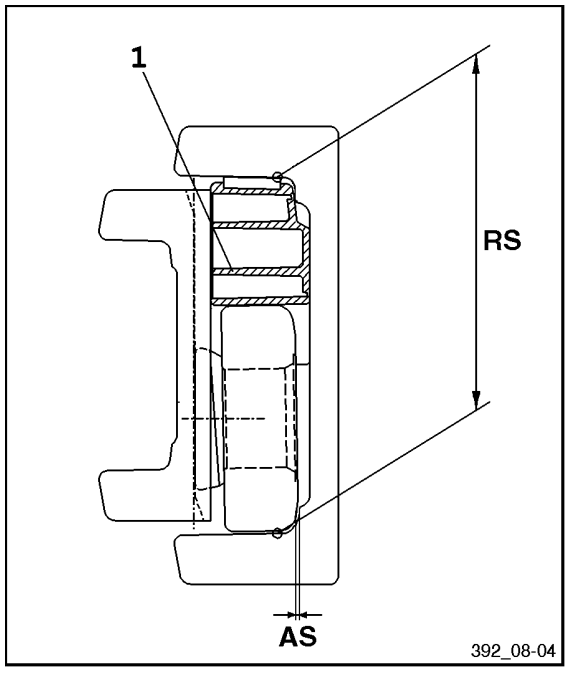
SIDE CLEARANCE (AS)

The clearance is adjusted with shims, which are fitted on the journal.

Clearance at closest point $0^{+0.2}$mm. The clearance is adjusted with adjusting shims.

Outer Mast Roller Clearance, Type 188

Illustrated: Support roller on inner mast to middle mast



Dimension "RS"		Support rollers ET No. see Parts Catalogue
from	to	
-	140,3	Support roller size 1
140,3	140,6	Support roller size 2
140,6	-	Support roller size 3

PERMISSIBLE LATERAL CLEARANCE (AS)

The clearance dimension is adjusted with adjusting shims which are slipped over the centring pivot.

Adjusting clearance at narrowest point $0^{+0.2}$ mm.

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Removal of slide pads - standard mast

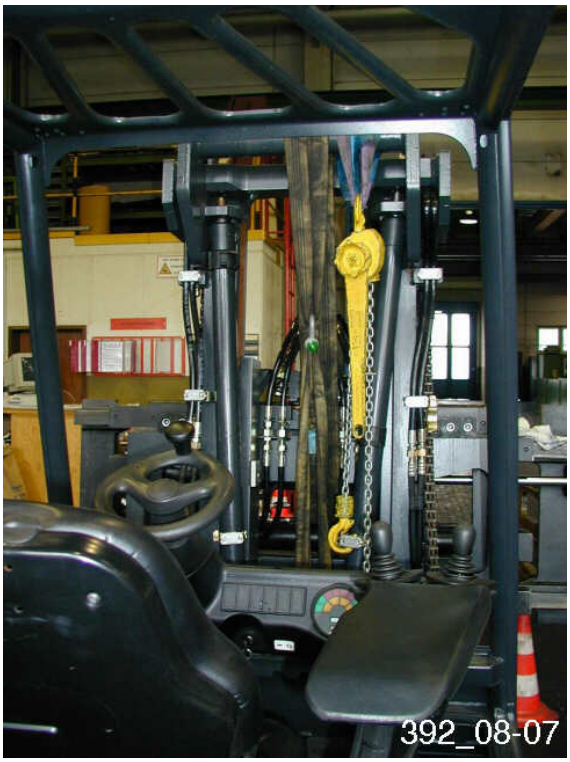
➢ Remove the circlips on the lift cylinders. If an attachment is fitted, remove the upper hose guide to prevent the hose from bending later. ▷



➢ Extend the mast. Support the fork carriage or secure with a chain between the outer mast and fork carriage. Lower the inner mast to approx. 100 mm, while supporting the cross member at the bottom with a lift jack extended approx. 200 mm. ▷



➢ Remove the mast supply lines and seal the cylinders with sealing plugs. Hang the chain on the outer mast cross member, lift the cylinder out of the lower bracket with suitable aids (in this case clamps of the attachment) and put it down towards the truck centre. ▷



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➢ Lower the lift jack until the inner mast rests on the outer mast cross member. Now the slide pads and support rollers can be replaced easily.

▷



Removal of slide pads - duplex mast

➢ Remove the circlips on the outer cylinders. Extend the mast and secure the fork carriage with a chain to the middle cross member.

▷



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➢ Lower the mast and catch the cross member of the inner mast with the jack extended approx. 200 mm. ▷



➢ Remove the pipes at the lift cylinder and close the ports of the outer cylinders at the top. ▷



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➢ Retract the cylinder completely and remove the clamp fittings. Tilt the lift cylinder backward and fix with a wedge, if necessary.

▷



Removal of slide pads - triplex mast

➢ If an hydraulic attachment is fitted, the outer guide must be removed (hoses can remain in the guide). Fasten the guide to the cross member of the outer mast.

▷



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➢ Remove the guide on the right and attach it to the upper cross member of the middle mast. ▷



➢ Extend the mast until the middle cross member of the inner mast is at the level of the upper cross member of the middle mast. Secure both cross members with a chain at this height and lower the fork carriage again. ▷

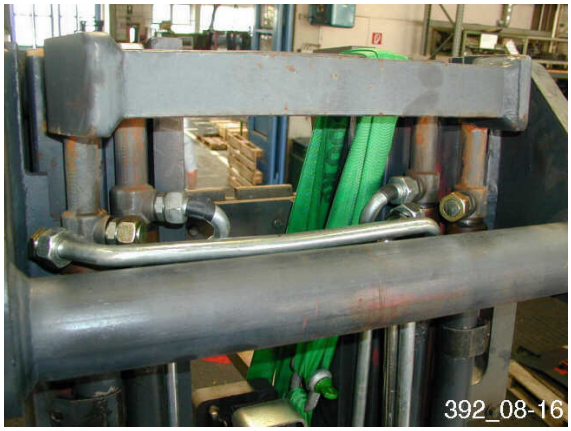


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Mast

➢ Remove the circlips on the outer cylinders and disconnect the pipes at the upper fittings. Then pressure-seal the cylinders with the appropriate screw fittings, as they will be applied with pressure again subsequently.

▷



➢ Lift the mast with the hydraulic system of the truck until the lower fittings on the middle mast cylinders can be removed easily. After the pipes have been removed, seal the cylinders with appropriate sealing plugs.

▷



➢ Completely lower the mast with the help of the cable device and catch the middle mast with the jack, which is extended approx. 200 mm.

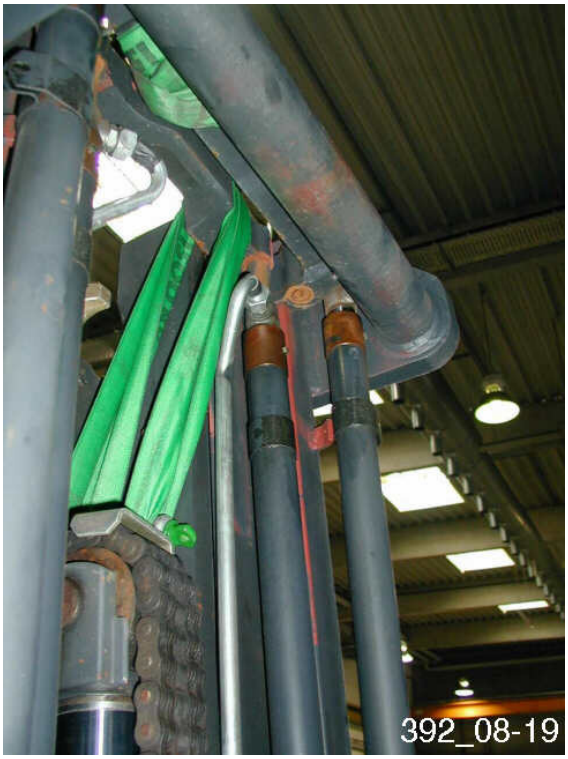
▷



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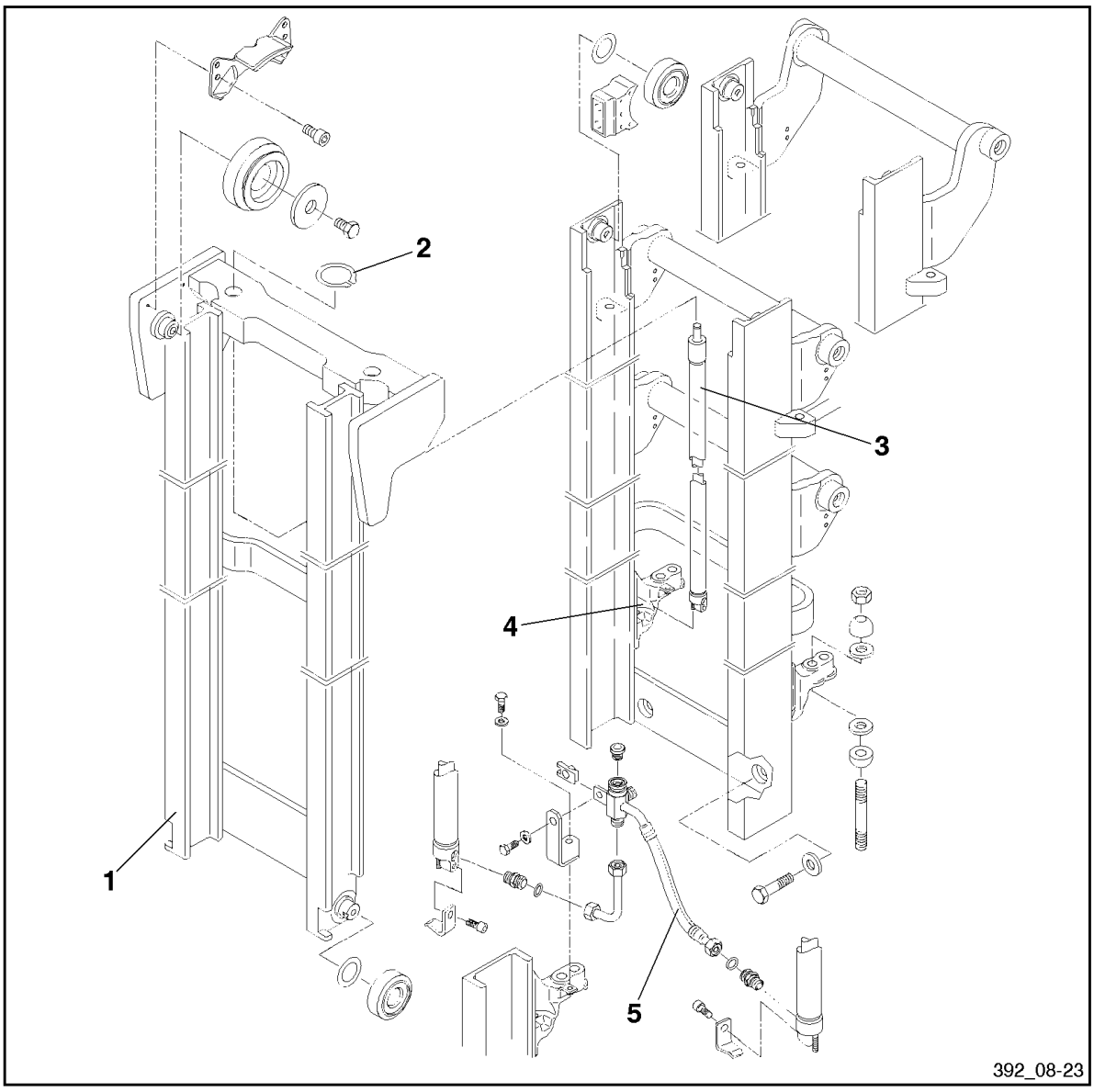
- Remove the clamps on the outer cylinders. Carefully pull the cylinders back and fix them with a wedge, if necessary. The mast lines at the bottom do not need to be removed.
- Use a car jack to lower the middle mast completely. Make sure that the outer cylinders have enough clearance. Now the supporting roller and the slide pad can be dismounted.

▷



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Lift cylinder (outer) - removal and installation



1	Inner mast	4	Bracket
2	Circlip	5	Connecting line
3	Lift cylinder		

CAUTION

When opening boost pressure lines, the inner mast can lower, leading to severe injuries.

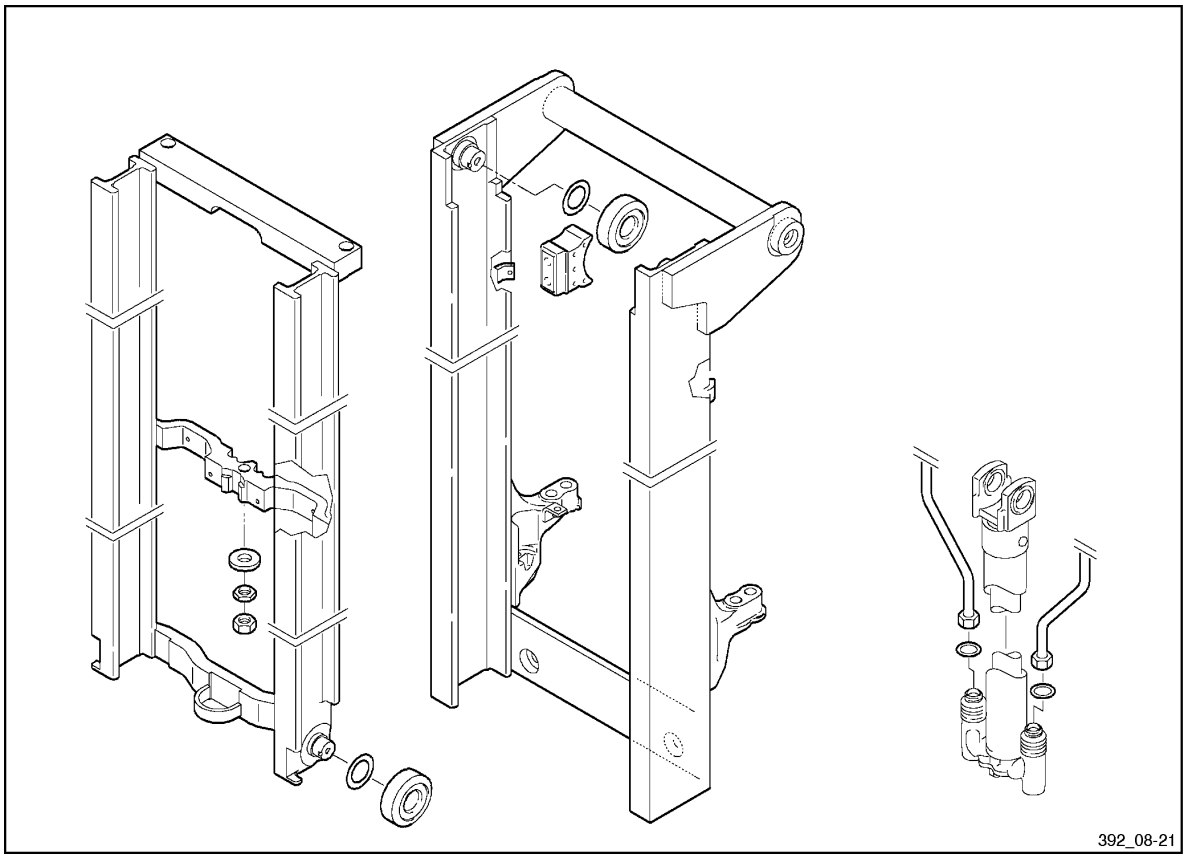
Secure the inner mast against lowering!

- Fully lower the mast and tilt it forward so that no pressure is applied to the system and access is ensured.
- Remove the circlip (2) at the top of the piston rod of the lift cylinder (3).

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- Disconnect the connecting line (5) at the bottom of the lift cylinder and seal the hose opening with a dummy plug.
- Fully extend the inner mast (1) with the operational lift cylinder.
- Remove the bracket and hose clamps, if necessary.
- Unscrew the Allen screws at the base of the cylinder.
- Lift the defective lift cylinder out.
- Installation of the lift cylinder (3) is in the reverse order of removal.
- Install the lift cylinder.
- Remove the safety device securing the inner mast and lower the inner mast.
- Install the circlip (2).
- Connect the connecting line (5).
- Bleed the hydraulic circuit.

Lift cylinder (centre) - removal and installation



- Raise the fork carriage approx. 10 cm with the working hydraulic system.

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- Secure the fork carriage in this position to prevent it from lowering.
- Actuate the working hydraulic system so that the centre lift cylinder retracts again and the chains are loose.
- Remove the clamps on the guide pulleys of the chains.
- Remove the chains from the guide pulleys.
- Remove the line at the base of the lift cylinder.
- Remove the retaining clamp of the cylinder.
- Remove the lift cylinder.

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Lift cylinder - sealing

- Remove the clamp and reflection pulley on the centre lift cylinder. On duplex and triplex masts remove the fitting to the centre lift cylinder on the outer cylinders.
- Clamp the cylinder into a vice at the base.
- Heat the cylinder head (3) (it is secured with Loctite), and unscrew it from the cylinder tube (5) with a pin spanner.
- Remove the scraper (1), the U-cup packing (2), and the O-ring (4) from the cylinder head (3).
- Install a new set of seals.
- Mount the cylinder head (3) and pulley with Loctite 243.

NOTE

The piston rod consists of a tube into which the piston cover is fitted at the upper end and made into a non-detachable unit with the piston tube with the circlip. In the event of an oil loss in the upper piston cover, the lower piston cover is leaky and must be dismantled, cleaned and re-installed with Loctite 243.

Lift cylinder - sealing

CAUTION

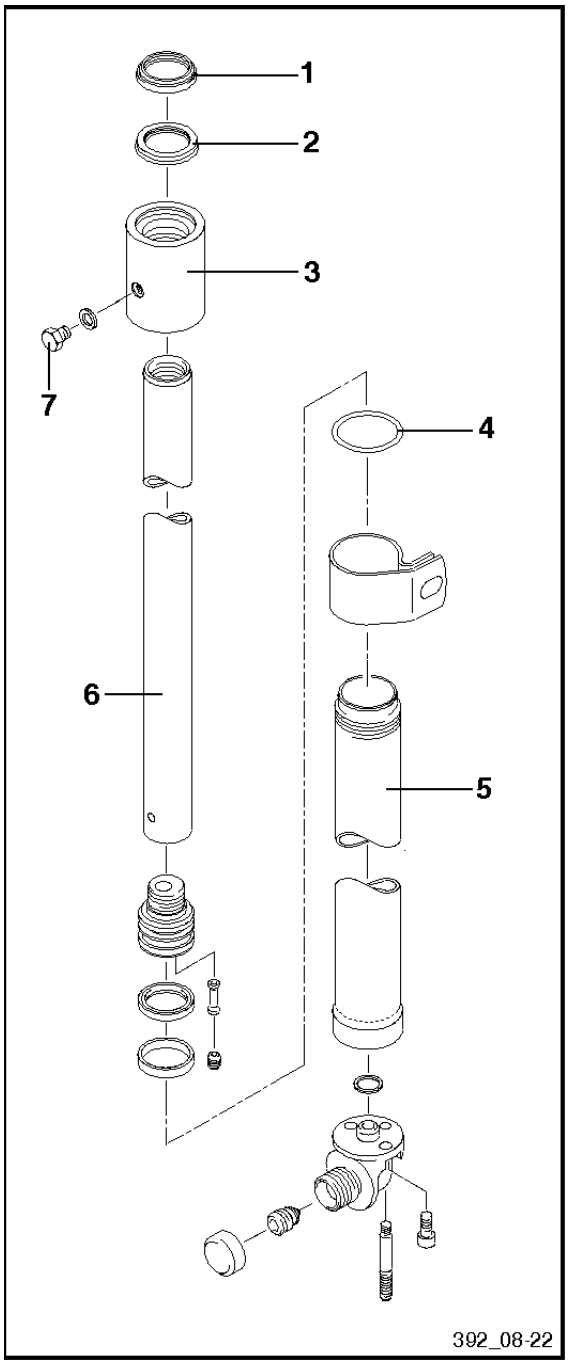
When carrying out the following services, the service engineer can come in contact with hydraulic system oil.

Wear personal protective gear.

Replace the seal at the base of the cylinder.

Prerequisite:

The lift cylinder is removed and the seal kit is at hand.



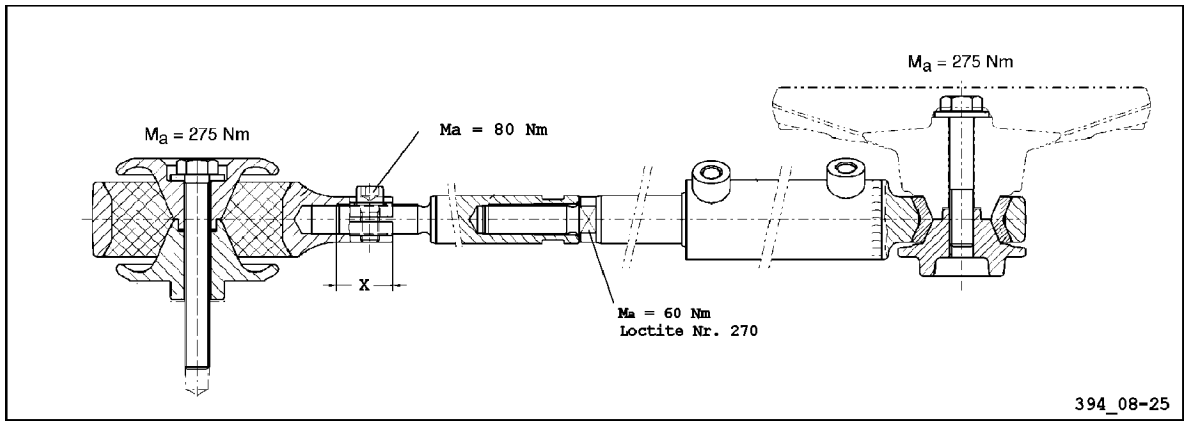
1	Scraper
2	U-cup packing
3	Cylinder head
4	O-ring
5	Cylinder tube
6	Piston rod
7	Bleed screw

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- Remove the 2 hex head screws at the base of the cylinder.
- Remove the base of the cylinder.
- Replace the seal.
- Install the base of the cylinder.



Tilt cylinder



Thread reaches for mechanical adjustment of the tilt cylinders

CAUTION

If the adjustment of the limitation of the tilt angle is incorrect, the guaranteed truck stability can be greatly reduced and the truck can tip over when laden and the mast extended.

In the event of repairs, always be sure the thread reach of the piston rod into the swivel is correct. The thread reach depends on the truck type, the lift height and the mast type.

Thread on piston rod M20 x 1.5

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Mast (Series)	Mast (Type)	Height of lift in (mm)	Thread reach
188	Standard	3050	46 mm
		3150	47 mm
		3250	51 mm
		3350	33 mm
		3450	33 mm
		3550	49 mm
		3650	51 mm
		3750	33 mm
		3850	44 mm
		3950	41 mm
		4150	51 mm
		4250	46 mm
		4350	33 mm
		4450	43 mm
		4550	51 mm
		4650	38 mm
		4750	45 mm
		4850	47 mm
		4950	40 mm
		5050	39 mm
		5150	38 mm
		5250	45 mm
		5350	47 mm
		5450	47 mm
		5950	47 mm
		6450	47 mm

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Mast

Mast (Series)	Mast (Type)	Height of lift in (mm)	Thread reach
188	Duplex	3115	49 mm
		3215	33 mm
		3315	40 mm
		3415	44 mm
		3615	50 mm
		3715	51 mm
		3815	33 mm
		3915	46 mm
		4015	44 mm
		4215	33 mm
		4315 [1]	46 mm
		4415[2]	34 mm
		4515[3]	47 mm
		4615[4]	33 mm
		4715[5]	37 mm

1 CSM
2 CSM
3 CSM
4 CSM
5 CSM

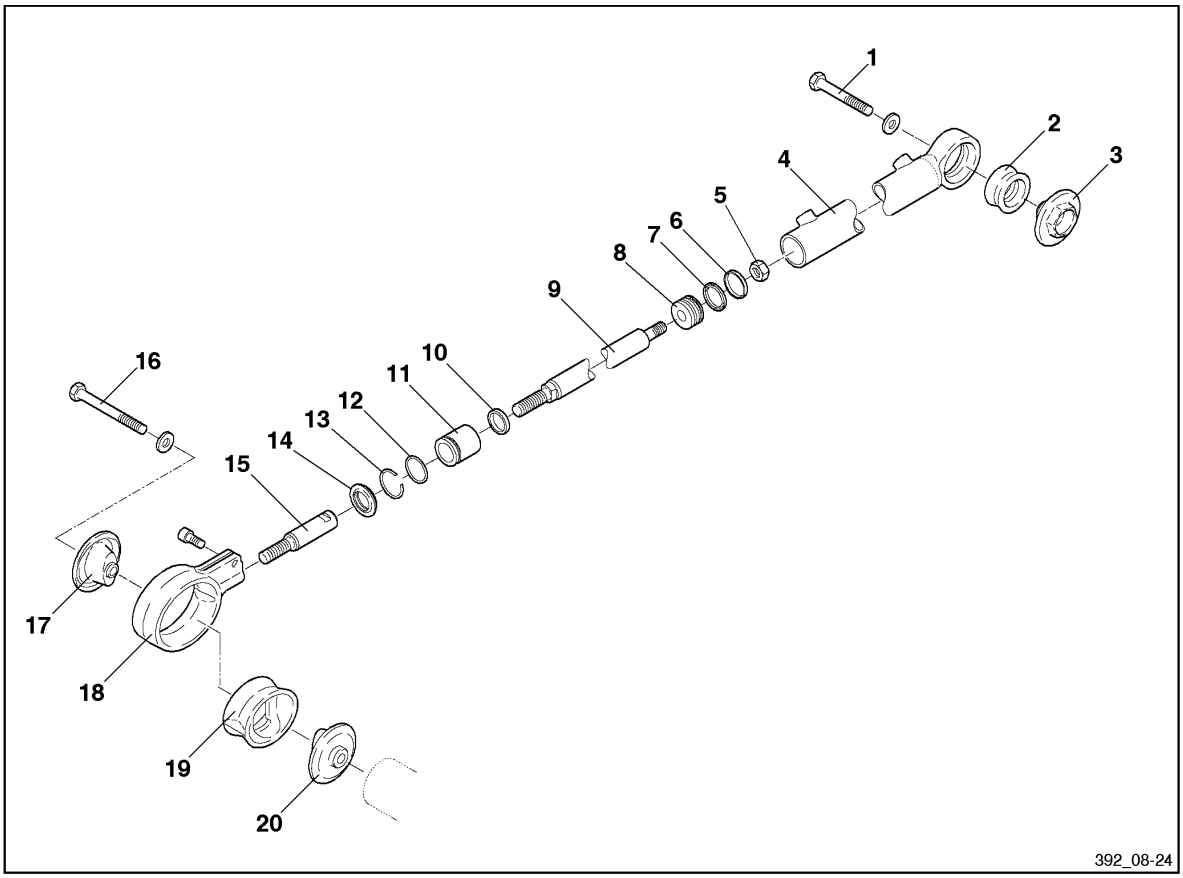
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Mast (Series)	Mast (Type)	Height of lift in (mm)	Thread reach
188	Triplex	4655	49 mm
		4805	33 mm
		4955	40 mm
		5105	44 mm
		5355	50 mm
		5505	51 mm
		5655	33 mm
		5805	46 mm
		5955	44 mm
		6155	33 mm
		6305	46 mm
		6455	34 mm
		6605[6]	47 mm
		6755[7]	33 mm
		6905[8]	37 mm
		7055[9]	41 mm
		7205[10]	41 mm
		7355[11]	41 mm
		7505[12]	44 mm
		7655[13]	44 mm
		7805[14]	44 mm
		7955[15]	44 mm
		8105[16]	44 mm

6 CSM
7 CSM
8 CSM
9 CSM
10 CSM
11 CSM
12 CSM
13 CSM
14 CSM
15 CSM
16 CSM

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Tilt cylinder - removal



1	Hex head screw	11	Cylinder head
2	Rubber bush	12	O-ring 40x3-P90
3	Intermediate piece	13	Circlip
4	Cylinder tube	14	Scraper
5	Hexagon nut M18 x 1.5-10	15	Threaded rod (extension)
6	Guide ring	16	Hex head screw
7	Piston cup	17	Clamping piece
8	Piston	18	Swivel
9	Piston rod	19	Rubber bush
10	U-cup packing	20	Clamping piece

CAUTION

The tilt cylinders are installed on the overhead guard and not accessible without aids.

The services on the built-in tilt cylinders can only be carried out on a suitable ladder.

CAUTION

When working below leaky tilt cylinders, the service engineer can come in contact with hydraulic system oil.

Wear protective clothing.

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- Lower the fork carriage and tilt the mast back by approx. 2°.
- Use a crane to secure the mast against tilting forward.
- Remove the hydraulic fittings at the front and the rear of the tilt cylinder, unscrew the banjo bolts.
- Unscrew the hex head bolt at the front tilt cylinder mount.
- Remove the inner and outer clamping piece.
- Unscrew the hex head bolt at the rear tilt cylinder mount and take the adapter piece off.
- Take the tilt cylinder down from the truck.

NOTE

Tilting the mast back by approx. 2° relieves the rubber bushes of the tilt cylinder mounts.

Tilt cylinder - sealing

Prerequisite:

The tilt cylinder is removed. Seal kit at hand.

NOTE

The seal kit set consists of a guide ring, piston seal, grooved ring, O-ring and scraper.

- Clamp the tilt cylinder into a vice with appropriate jaws.
- Loosen the scraper with a screwdriver and pull it off.
- To release the circlip, push the cylinder head back by approx. 10 mm.
- Release the circlip from the groove and remove it.
- If necessary, remove the burr formed by the circlip with the help of a three-square scraper.
- Pull out the piston rod along with the cylinder head. When doing this, the remaining hydraulic oil in the cylinder will run out through the front port. Put an appropriate receptacle underneath.
- Loosen the clamping screw at the swivel and unscrew it from the threaded rod.
- Slightly lubricate the sealing elements and replace them.
- Insert the piston rod into the cylinder tube.

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- Install the cylinder head. Please make sure that the groove of the cylinder head is aligned with the thread of the front port, but do not slide the cylinder head in too far.
- Mount the circlip.

NOTE

When the hydraulic line is connected, the cylinder head is fixed in position with the help of the banjo bolt.

- Install the scraper with Loctite no. 270.
- Screw the swivel on the threaded rod, taking care to achieve the correct mounting dimension.
- Tighten the locking screw to a torque of M_a = 80 Nm.

Tilt cylinder - installation

- Screw the tilt cylinder with adapter piece and hex head bolt on the rear tilt cylinder mount.

Torque for rear hex head bolt: M_a = 275 Nm

- Put the inner and outer clamping piece onto the front rubber bush.

NOTE

The oval opening of the rubber bush must be in vertical position.

- Fasten to the front tilt cylinder mount on the mast with the hex head bolt.

Torque for front hex head bolt: M_a = 275 Nm

- Install the hydraulic hoses with banjo bolts.
- Carry out a functional check.

Tilt angle sensor - adjustment

DANGER

Disregarding the tilt angle limitation can result in the truck tipping over.

The tilt angle sensor must be adjusted on the unladen truck.

Note any possible tilt angle limitations.

Backward tilt restrictions are specified according to tonnage, type of mast, height of lift, mounted implement and tyres.

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Prerequisites

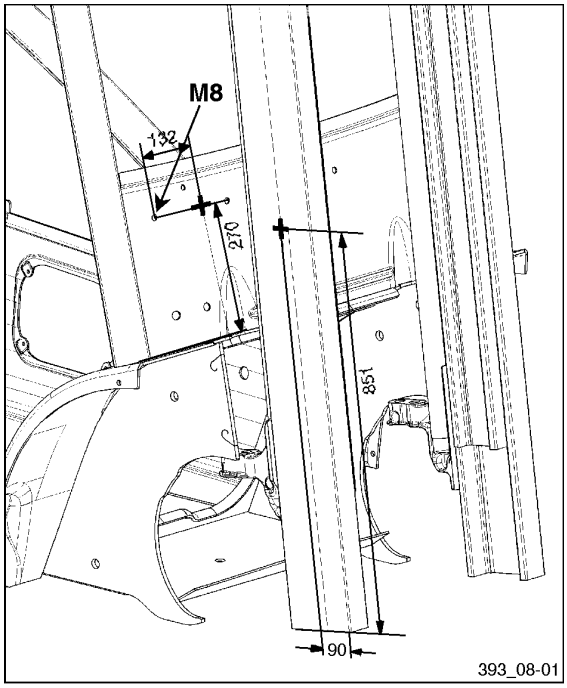
A laptop with the "Pathfinder" software is required for the adjustment (calibration) of the tilt angle sensor.

Reference points - marking

- Draw a line on the face plate, which runs parallel to column A at a distance of 132 ± 2 mm from the centre point of the M8 screw.
- Draw another line on the face plate, which runs horizontally at a distance of 270 ± 2 mm from the wing.

The intersection of both lines is the reference point on the truck side.

- Scribe the reference point on the mast side at a distance of 851 ±2 mm from the lower end and 90 ±2 mm from the side face of the external mast profile.



Tilt angle sensor - calibrating

CAUTION

When the mast is tilted back towards its mechanical stop it could contact the wiper arm if the truck is fitted with a front windscreen and wiper.
Remove the wiper arm.

- Start the diagnostic software "Pathfinder".
- Go to the window "Adjustments (calibration of the tilt angle sensor)".
- Tilt the mast back against the mechanical stop.
- Measure and record distance X_0 (basic dimension) between the truck-side and mast-side reference points.
- Tilt the mast forward by dimension X_R (backward tilt dimension) from the mechanical stop.

Refer to the table "Nominal backward tilt" below for dimension X_R.

Rated backward tilt[17] in degrees	Canopy-level mast type 185 Height of lift 3150 mm X_R in millimetres	Other masts of type 185 X_R in millimetres
0.0	104 ± 1	110 ± 1
0.5	98 ± 1	104 ± 1
1.0	92 ± 1	98 ± 1
1.5	86 ± 1	92 ± 1

[17] Backward tilt limitations are specified according to tonnage, type of mast, height of lift, mounted implement and tyres.

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Rated backward tilt[17] in degrees	Canopy-level mast type 185 Height of lift 3150 mm X_R in millimetres	Other masts of type 185 X_R in millimetres
2.0	81 ± 1	86 ± 1
2.5	75 ± 1	81 ± 1
3.0	69 ± 1	75 ± 1
3.5	63 ± 1	69 ± 1
4.0	57 ± 1	63 ± 1
4.5	51 ± 1	57 ± 1
5.0	45 ± 1	51 ± 1
5.5	39 ± 1	45 ± 1
6.0	33 ± 1	39 ± 1
6.5	27 ± 1	33 ± 1
7.0	21 ± 1	27 ± 1
7.5	14 ± 1	21 ± 1
8.0	13 ± 1[18]	14 ± 1
8.5		13 ± 1[19]

➢ Measure the distance between truck-side and mast-side reference points.

The distance should be $X_0 + X_R$. The value X_R is required by the diagnostic software.

➢ Enter the value.

➢ Calibrate the rear electronic stop.

➢ Press the "Done" button in the diagnosis window.

➢ Tilt mast forward from its mechanical limit stop by the distance X_V (forward tilt dimension).

For X_V see the table below.

➢ Measure the distance between truck-side and mast-side reference points.

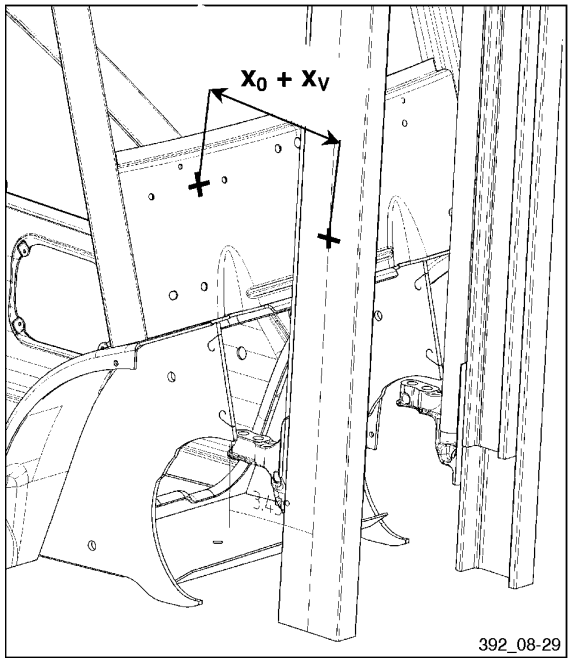
The distance should be $X_0 + X_V$.

➢ Enter the value X_V in the diagnostic software.

➢ Calibrate the front electronic stop.

➢ Press the "Done" button in the diagnosis window.

▷



[18] Standard factory setting if the limitation of the backward tilt is not specified.

[19] Standard factory setting if the limitation of the backward tilt is not specified.

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Nominal forward tilt in degrees	Canopy-level mast Type 185 Height of lift 3150 mm X_V in millimetres	Other masts of type 185 X_V in millimetres
0.0	90 ± 1	96 ± 1
0.5	96 ± 1	102 ±1
1.0	102 ±1	108 ± 1
1.5	108 ± 1	114 ± 1
2.0	114 ± 1	120 ± 1
2.5	120 ± 1	126 ± 1
3.0	126 ± 1	132 ± 1
3.5	132 ± 1	138 ± 1
4.0	138 ± 1	143 ± 1
4.5	143 ± 1	149 ± 1
5.0[20]	149 ± 1	155 ± 1

Hose reel - removal, hose change, sealing, installation

WARNING

The hose reel is prestressed by spring force.
For this reason it is essential to follow the instructions.

NOTE

The hose reel is located underneath the floor plate in the front area of the frame. The description refers to a single auxiliary hydraulic system. As far as trucks with two hose reels must concerned (double accessory hydraulic system), the instructions must be carried out for both hose reels.

Hose reel - removal

NOTE

Before the floor plate is taken out, pull off the plug to the traction potentiometer and unhook the brake cable assembly at the brake valve.

- Open the bonnet
- Take the floor mat out

[20] Standard factory setting

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➢ Remove the floor plate ▷

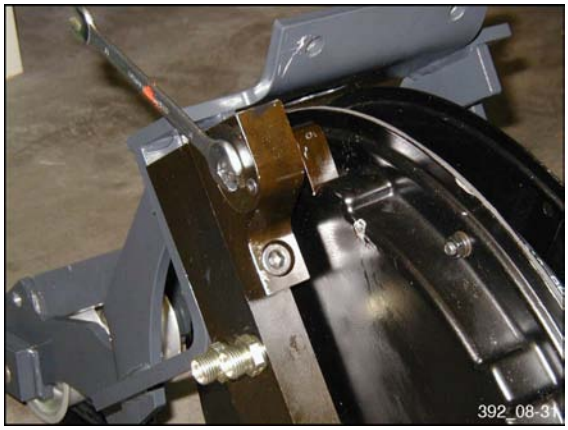


CAUTION

The hose reel is prestressed by spring force. If the hose reel is removed without first securing it, the spring will relive spontaneously, which can lead too severe injuries.

Make sure the pawl engages in one of the cams provided on the circumference of the hose reel so the hose reel does not unwind accidentally.

➢ Lock the hose reel in the prestressed condition by pivoting the pawl in the direction of the hose reel. When doing so, unwind the hose reel a little. This keeps the hose loose in the locked condition. ▷



➢ Release the double hose at the connection to the mast. ▷



➢ Disconnect the supply line from the control valve to the hose reel.

➢ Unscrew the front hexagon head screws (2 items) at the hose reel holder.

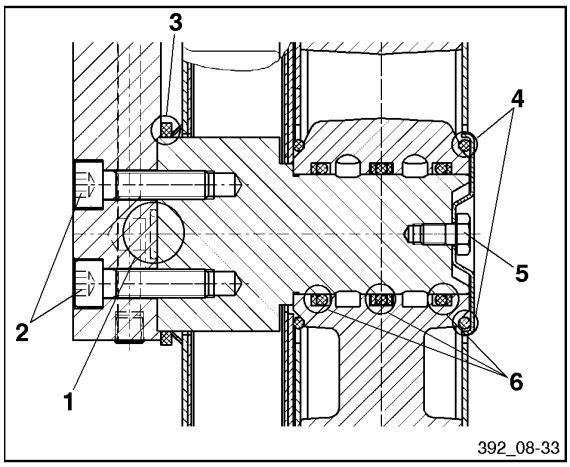
The hexagon head screws are located at the front part of the holder above the pulleys.

➢ Loosen the two hexagon head screws at the side of the hose reel holder.

➢ Unscrew the rear hexagon head screws (2 items) at the hose reel holder.

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- Release the hose reel from the holder.
- To do so, unscrew the Allen screws (2) at the side of the hose reel holder.
- Take the hose reel holder out.
- Take the hose reel out.



Hose change

- Clamp the hose reel into a vice and loosen the 4 Allen screws.
- Remove the cover of the hose reel.
- Unwind the double hose and replace it with a new double hose.
- Wind up the double hose and fasten the hose reel cover with the 4 Allen screws.
- Install the hose reel with the holder into the truck.
- Carry out a functional check.



Hose reel - sealing

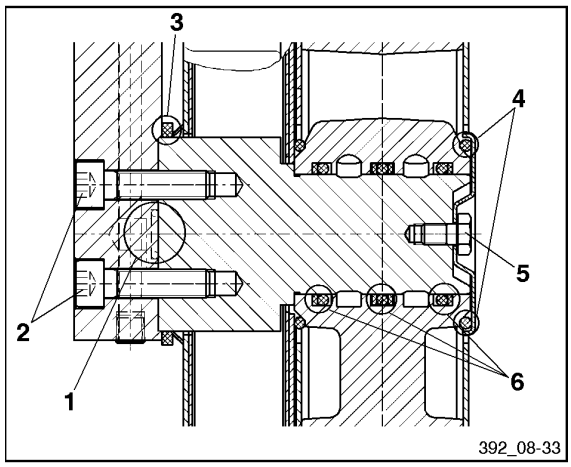
- Clamp the hose reel into a vice.
- Pull the double hose out until the pawl is relieved.
- Swivel the pawl out of the cam while holding the double hose fast.

The hose reel is still taut.

- Hold the double hose fast and carefully release the hose reel against the force of the spring. This will pull the double hose somewhat further on the hose reel.

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- Unscrew a hexagon head screw (5).
- Remove the cover with the O-ring.
- Unscrew 2 Allen screws (2) and remove the holder and the pawl.
- Pull the shaft of the hose reel out.
- Replace the shaft sealing ring (3) on the shaft.
- Take the three O-rings with support rings (6) out and replace them.
- Replace the two O-rings (1) at the holder with a pawl.



Hose reel - installation

- Slightly lubricate the O-rings, the support rings and the shaft sealing ring.
- During the installation, make sure that the tensioning spring of the hose reel is inserted into the groove of the shaft.
- Mount the holder with the pawl.
- Clamp the hose reel into a vice.
- Mount the cover with a new O-ring (4).



CAUTION

The hose reel is prestressed by spring force. A spontaneous release of the spring can lead to severe personal injuries.

The following activities must be carried out with utmost care.

- Preload the hose reel.
- To do so, turn the hose reel manually against the force of the spring.
- Lock the pawl at the circumference of the hose reel and preload the hose reel by 5 to 6 turns

Starting from the manufacturing date 06/2002 see type plate of hose reel - preload by 8 turns).

- Install the hose reel with the holder into the truck.
- Carry out a functional check.

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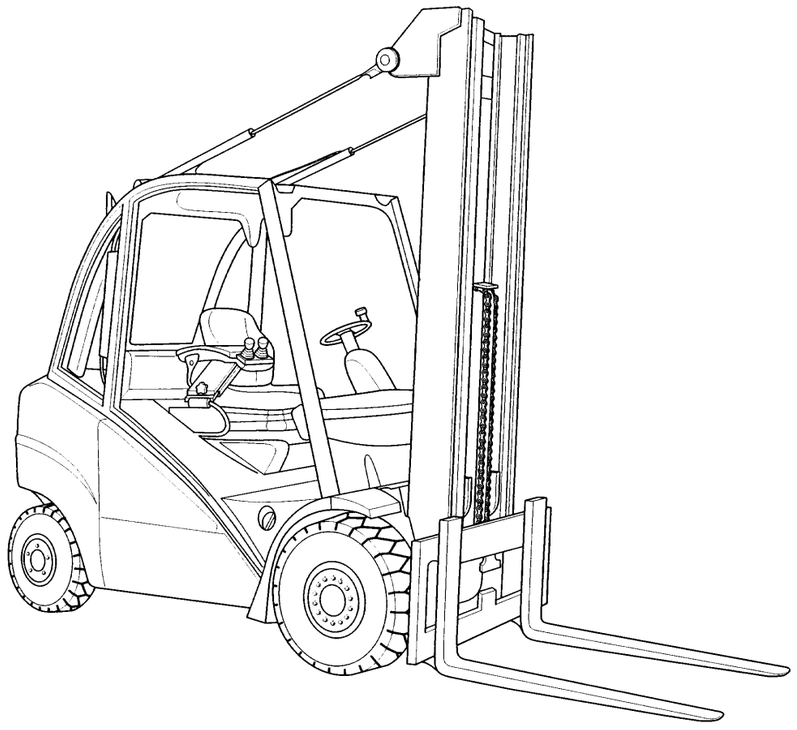
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Linde IC Engined Truck

H30D H30T H35D H35T

Series 393



Edition 01/2005

Annex

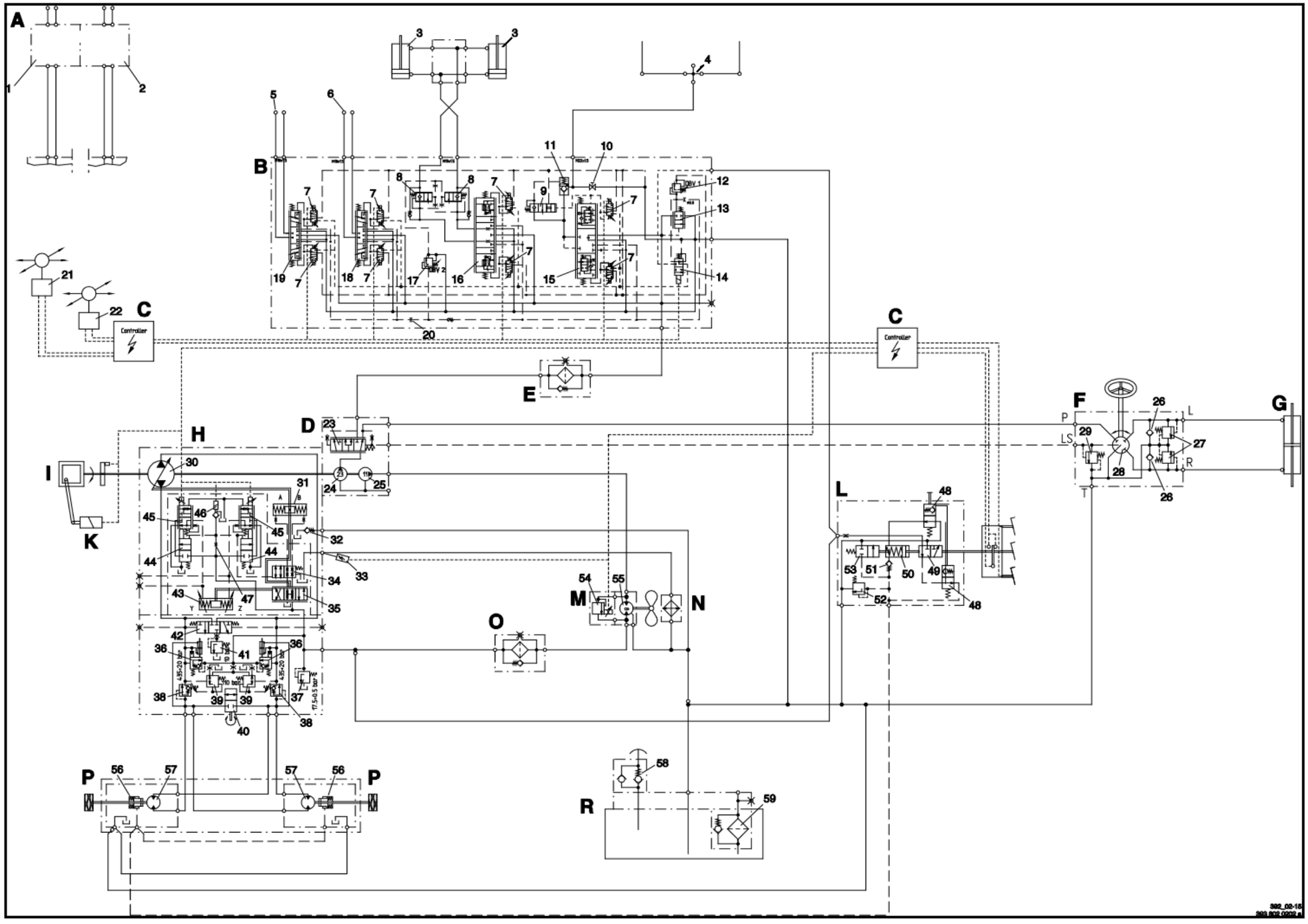
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Wiring diagram, with brake valves



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A - Auxiliary hydraulics with duplex or triplex mast
1 Hose reel, left
2 Hose reel, right

B - Working hydraulics
3 Tilt cylinder
4 Standard mast
5 Connection for auxiliary hydraulics 4 with standard mast
6 Connection for auxiliary hydraulics 3 with standard mast
7 Solenoid valve
8 Tilt brakevalve
9 Slow lowering valve
10 Emergency lowering valve
11 Check valve
12 Pressure relief valve 1
13 2/2-port directional control valve
14 Release valve
15 Lift/lower directional control valve
16 Tilt directional control valve
17 Pressure relief valve 2
18 Directional control valve for auxiliary hydraulics 3
19 Directional control valve for auxiliary hydraulics 4
20 Restrictor

C - Linde Truck Control
21 Central control lever for working hydraulics
22 Central control lever for auxiliary hydraulics 3 and 4

D - Tandem pump
23 3/3-port directional control valve (priority valve)
24 Gear pump V_1, q_1 = 23 cm^3/rev
25 Gear pump V_2, q_2 = 14 cm^3/rev

E - Working hydraulics pressure filter

F - Steering control valve
26 Make-up valve
27 Secondary valve p = 180^{+20} bar for H 30, p = 205^{+20} bar for H 35
28 Steering control valve
29 Primary valve, p = 120^{+5} bar for H 30, p = 150^{+5} bar for H 35

G - Steer cylinder

H - Variable-displacement hydraulic pump
30 Variable-displacement pump HPV 75 -02
31 Control piston A = forward direction, B = reverse direction
32 Pressure relief valve p = 1 bar
33 Sensor (hydraulic oil temperature)
34 4/2-port directional control valve
35 Pilot valve
36 Combined feed/pressure relief valve p = 435^{+20} bar
37 Boost pressure valve p = $17.5^{+0.5}$ bar
38 Brake valve (main control valve)
39 Brake valve (pilot valve)
40 Bypass valve
41 Purge valve
42 4/3-port directional control valve
43 Servopiston, Y = forward direction, Z = reverse direction
44 2/2-port directional control valve
45 Proportional valve
46 Release valve
47 Nozzle

I - IC engine
n = 1000 - 2800 rpm

K - Speed actuator in injection pump

L - Brake release valve
48 Towing device
49 3/2-port directional control valve
50 Pump for releasing brake
51 Check valve
52 Pressure relief valve p = 20 bar
53 2/2-port directional control valve

M - Fan drive

N - Cooler
54 Solenoid valve
55 Hydraulic motor q = 8 cm^3

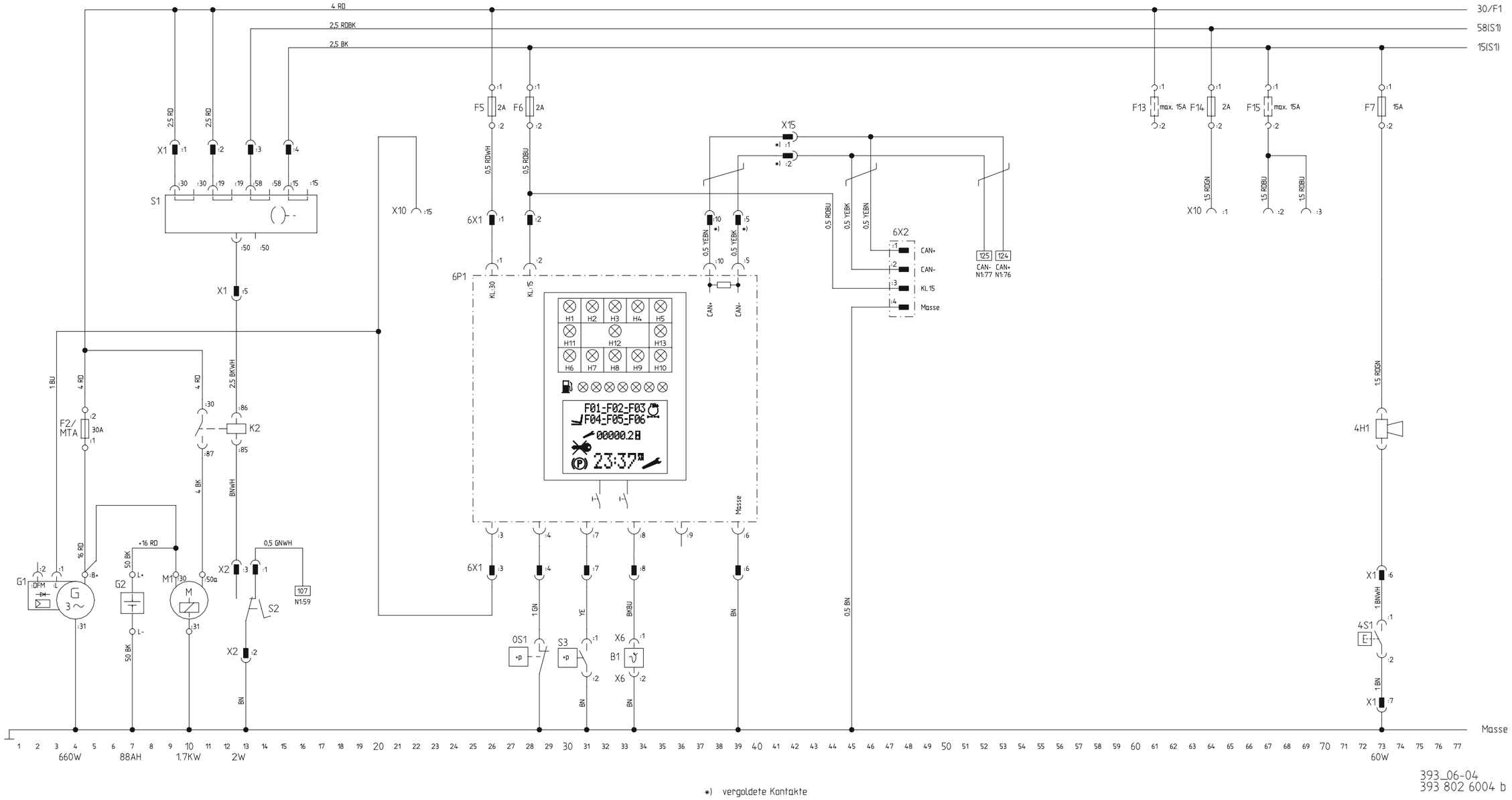
O - Boost pressure filter

P - Fixed-displacement hydraulic motor
56 Multiple disc brake
57 Fixed-displacement hydraulic motor HMF 550 R

R - Oil reservoir
58 Breather filter with suction strainer and pressurising valve p = 0.35±0.15 bar
59 Suction filter with bypass valve p = 0.25 bar

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Wiring diagram for standard equipment, sheet 1

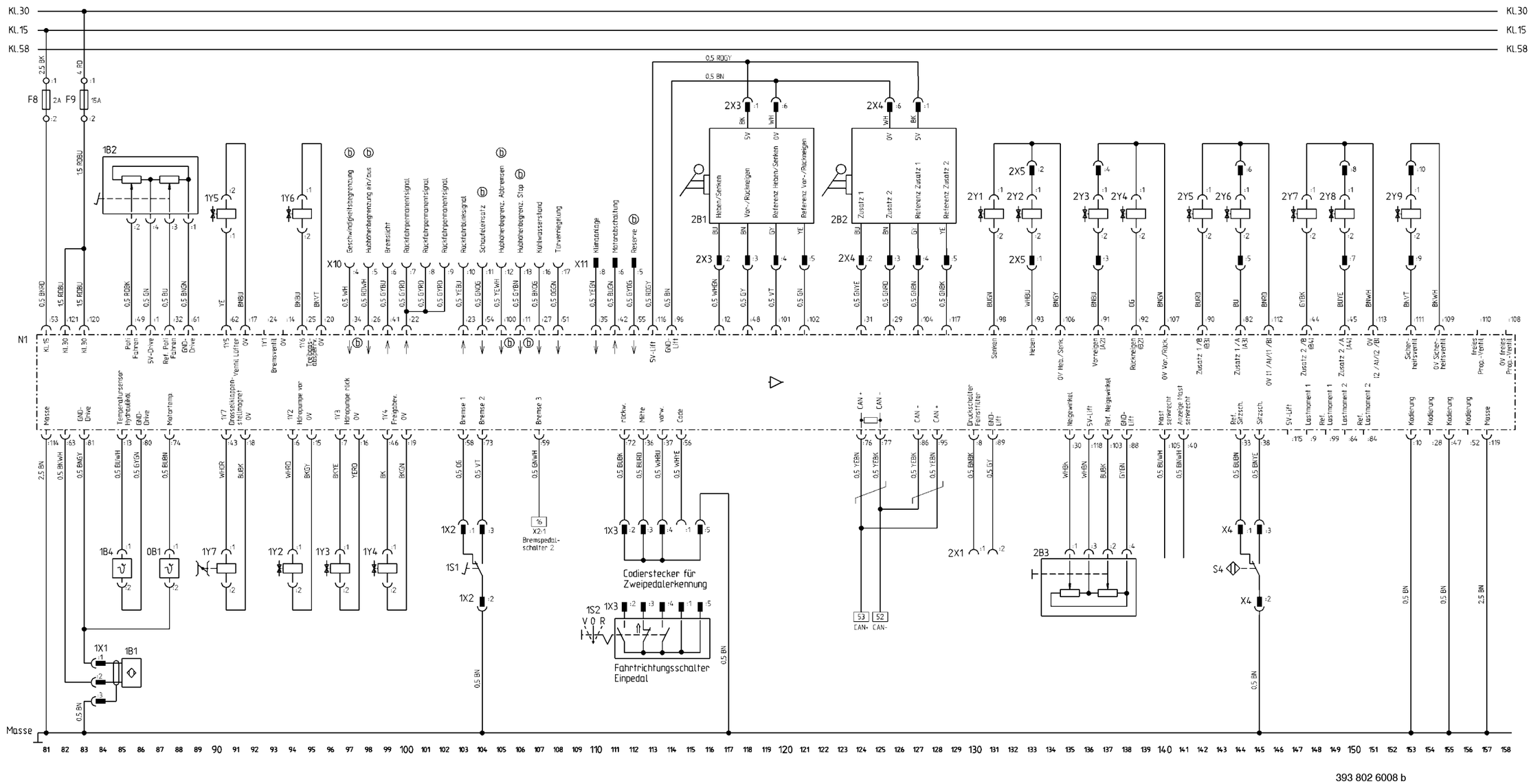


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B1	Fuel level sending unit/pressure switch, 33
F2	Fuse MTA 30 A, 4
F5	Fuse, 26
F6	Fuse, 28
F7	Fuse, 73
F13	Fuse, 61
F14	Fuse, 64
F15	Fuse, 67
G1	Three-phase alternator with regulator, 1-5
G2	Battery, 7
4H1	Horn, 73
K2	Starter relay, 10-13
M1	Starter, 9-11
6P1	Composite instrument, 25-40
S1	Ignition switch, 9-17
S2	Brake pedal switch 2 (start inhibit), 12-14
S3	Suction filter vacuum switch, 31
0S1	Oil pressure switch, 28
4S1	Horn push, 73
X1	Connector 10 pins (S1), 9-16, 73
X2	Connector 3 pins (S2), 12, 13
X6	Connector 2 pins (1B1), 33
X10	Connector 18 pins (central electrical system), 22, 64-69
X15	Connector 2 pins (CAN), 42
6X1	Connector 10 pins (6P1), 26-39
6X2	Connector 7 pins (diagnosis), 48

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Circuit Diagram Standard Equipment LPG Engine, Sh. 2



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0B1	Engine temperature sensor, 87
1B1	Actual speed sensor, 85, 86
1B2	Electronic truck speed controller - double potentiometer, 84-89
1B4	Temperature sensor for hydraulic oil, 85
2B1	Joystick for basic functions, 116-121
2B2	Joystick for auxiliary functions, 123-129
2B3	Double potentiometer for mast tilt angle, 134-138
F8	Fuse, 81
F9	Fuse, 83
N1	Electronic truck speed control LHC, 81-158
S4	Seat switch, 144-145
1S1	Brake pedal switch 1, 103-104
1S2	Travel direction switch - single-pedal model, 110-116
X4	Connector 3 pins (seat switch), 144, 145
X10	Connector 18 pins (central electr. system), 97-108
X1	Connector 9 pins (central electr. system), 110-112
1X1	Connector 3 pins (1B1), 84
1X2	Connector 3 pins (1S1), 103, 104
1X3	Connector 6 pins (single-pedal model), 112-116
2X1	Connector 2 pins (micro-filter), 130, 131
2X3	Connector 6 pins (2B1), 116-121
2X4	Connector 6 pins (2B2), 124-129
2X5	Connector 10 pins (valve block), 133-153
1Y2	Solenoid valve Y forward, 94
1Y3	Solenoid valve Z reverse, 96
1Y4	Release valve, 99
1Y5	Valve - fan, 90
1Y6	LPG shut-off valve, 94
1Y7	Throttle valve positioning magnet, 90
2Y1	Valve - lowering, 131
2Y2	Valve - lifting, 133
2Y3	Valve - forward tilting, 136
2Y4	Valve - backward tilting, 138
2Y5	Valve - option 1B, 142
2Y6	Valve - option 1A, 144
2Y7	Valve - option 2B, 148
2Y8	Valve - option 2A, 150
2Y9	Release valve, 153

5-Volt sensors	
Lift	**Drive**
:115	:1
:116	:2
.118	:3

Earth sensors	
Lift	**Drive**
:88	:61
:89	:80
:96	:81

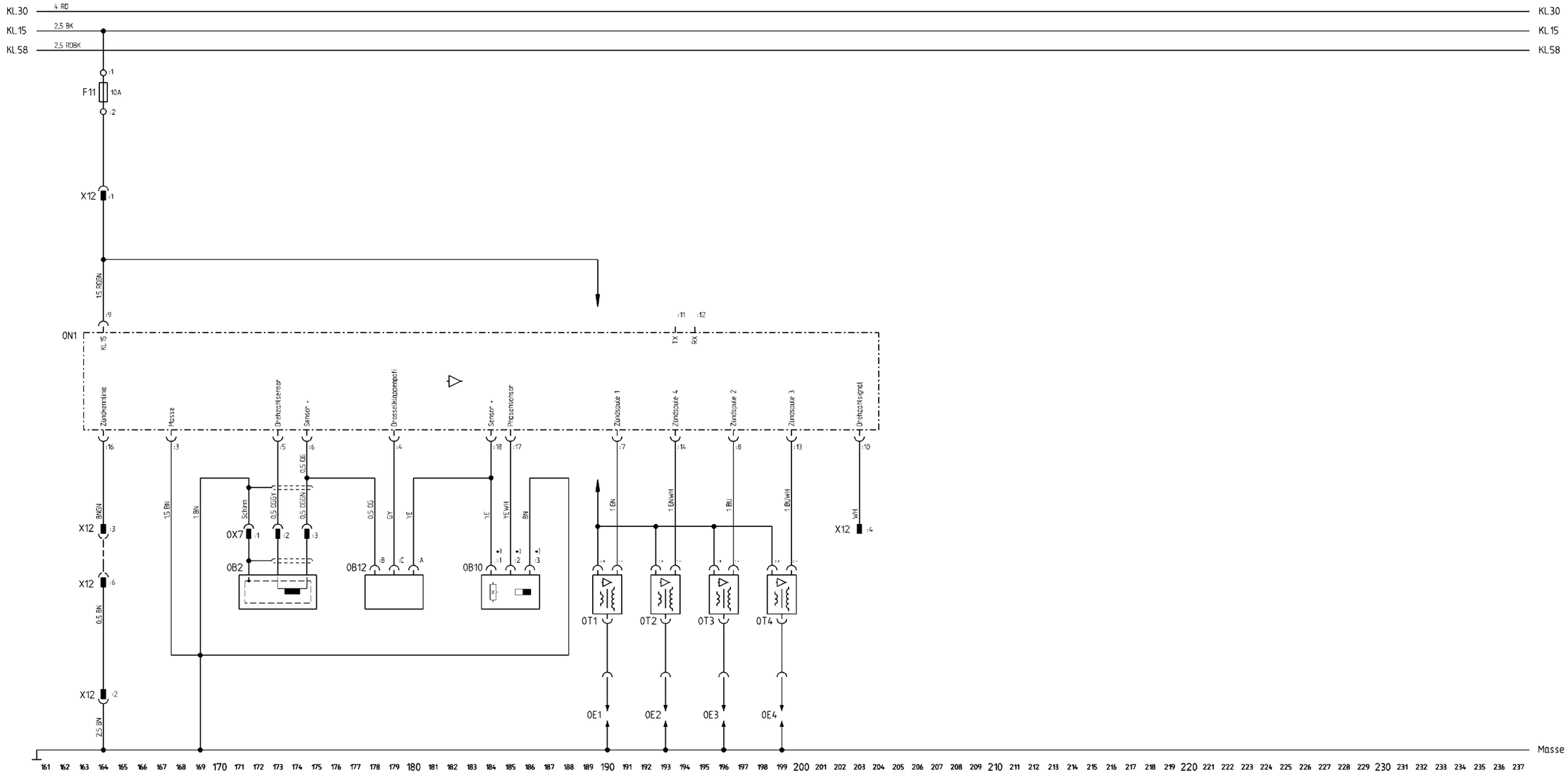
Colour primary	Code
black	BK
white	WH
blue	BU
orange	OG
brown	BN
green	GN
violet	VT
red	RD
yellow	YE
grey	GY

The number before the line colour corresponds to the line cross-section.

Lines without cross-section information: F = 0.75 mm^2

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Circuit Diagram Standard Equipment, LPG Engine, Sh. 3



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0B2	Engine speed sensor, 171-175
0B10	Phase sensor, 184-186
0B12	Throttle valve potentiometer, 178-180
0E1	Glow plug cylinder 1, 190
0E2	Glow plug cylinder 2, 193
0E3	Glow plug cylinder 3, 196
0E4	Glow plug cylinder 4, 199
F11	Fuse 10 A, 164
0N1	Ignition system controller, 163 -204
0T1	Ignition coil cylinder 1, 190
0T2	Ignition coil cylinder 2, 193
0T3	Ignition coil cylinder 3, 196
0T4	Ignition coil cylinder 4, 199
X12	Connector 6 pins (engine cold start), 164-203
0X7	Connector 3 pins, 171 -175

Colour primary	Code
black	BK
white	WH

Colour primary	Code
blue	BU
orange	OG
brown	BN
green	GN
violet	VT
red	RD

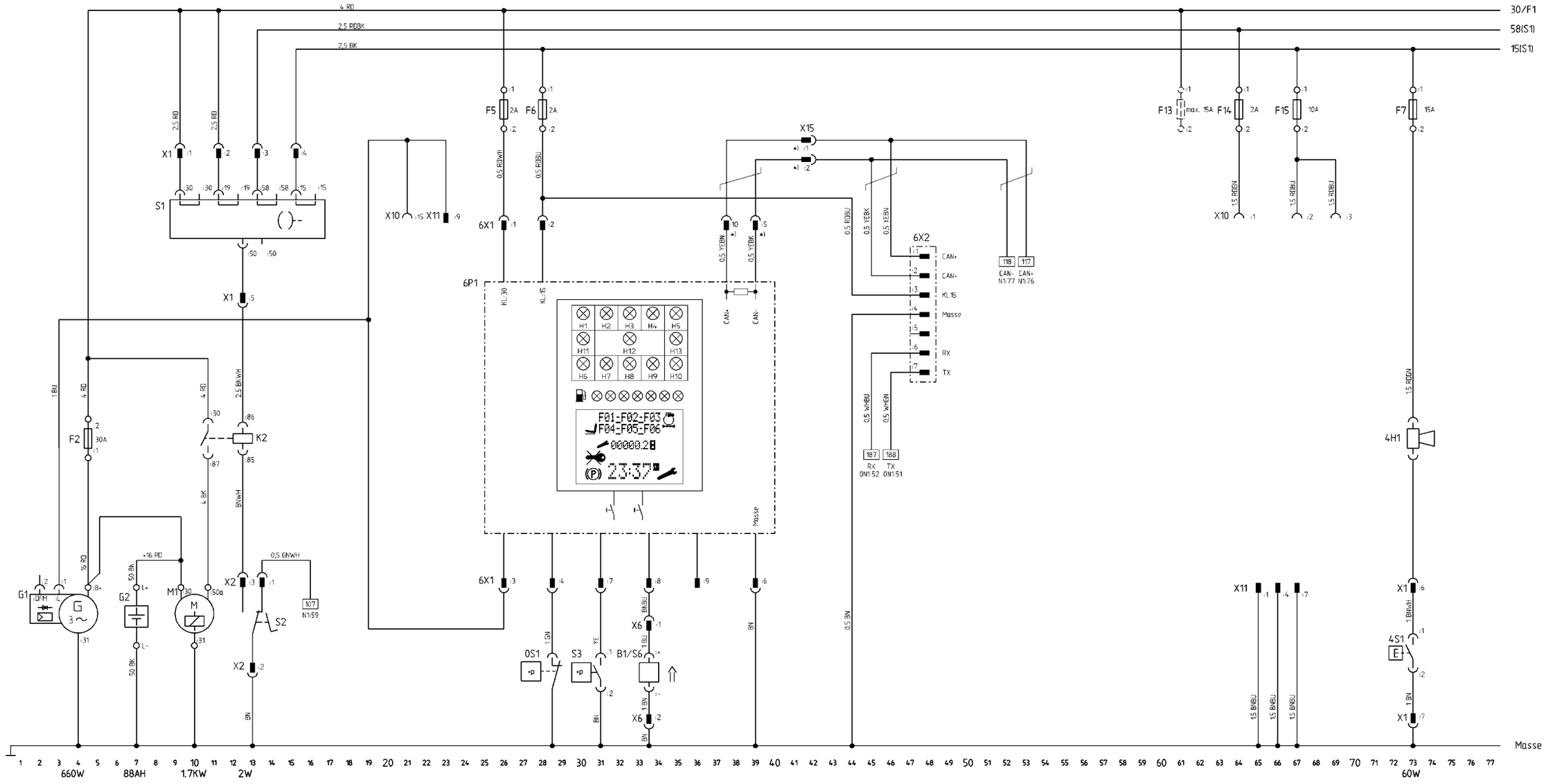
Colour primary	Code
yellow	YE
grey	GY

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Lines without cross-section information: F = 0.75 mm^2

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Circuit Diagram Standard Equipment, LPG Engine, Sh. 1, controlled catalytic converter



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B1	Tank level sensor (40-250 ?), vol. filling, 33
F2	Fuse, 4
F5	Fuse, 26
F6	Fuse, 28
F7	Fuse, 73
F13	Fuse, 61
F14	Fuse, 64
F15	Fuse, 67
G1	Three-phase alternator with regulator, 1-5
G2	Battery, 7
4H1	Horn, 73
K2	Starting relay, 10-13
M1	Starter, 9-11

6P1	Composite instrument, 25-40
S1	Ignition switch, 9-16
S2	Brake pedal switch 2 (start inhibit), 12-14
S3	Suction filter vacuum switch, 31
S6	Residual quantity switch (pressure switch), 33
0S1	Oil pressure switch, 28
4S1	Horn button, 73
X1	Connector 10 pins (S1), 9-15, 73
X2	Connector 3 pins (S2), 13, 14
X6	Connector 2 pins (S6), 33
X10	Connector 18 pins (central electr. system), 21, 64-69
X1	Connector 9 pins (control centre), 23, 65-67
X15	Connector 2 pins (CAN), 41

6X1	Connector 10 pins (6P1), 26-39
6X2	Connector 7 pins (diagnosis), 48

Colour primary	Code
black	BK
white	WH
blue	BU
orange	OG
brown	BN
green	GN

Colour primary	Code
violet	VT
red	RD
yellow	YE
grey	GY

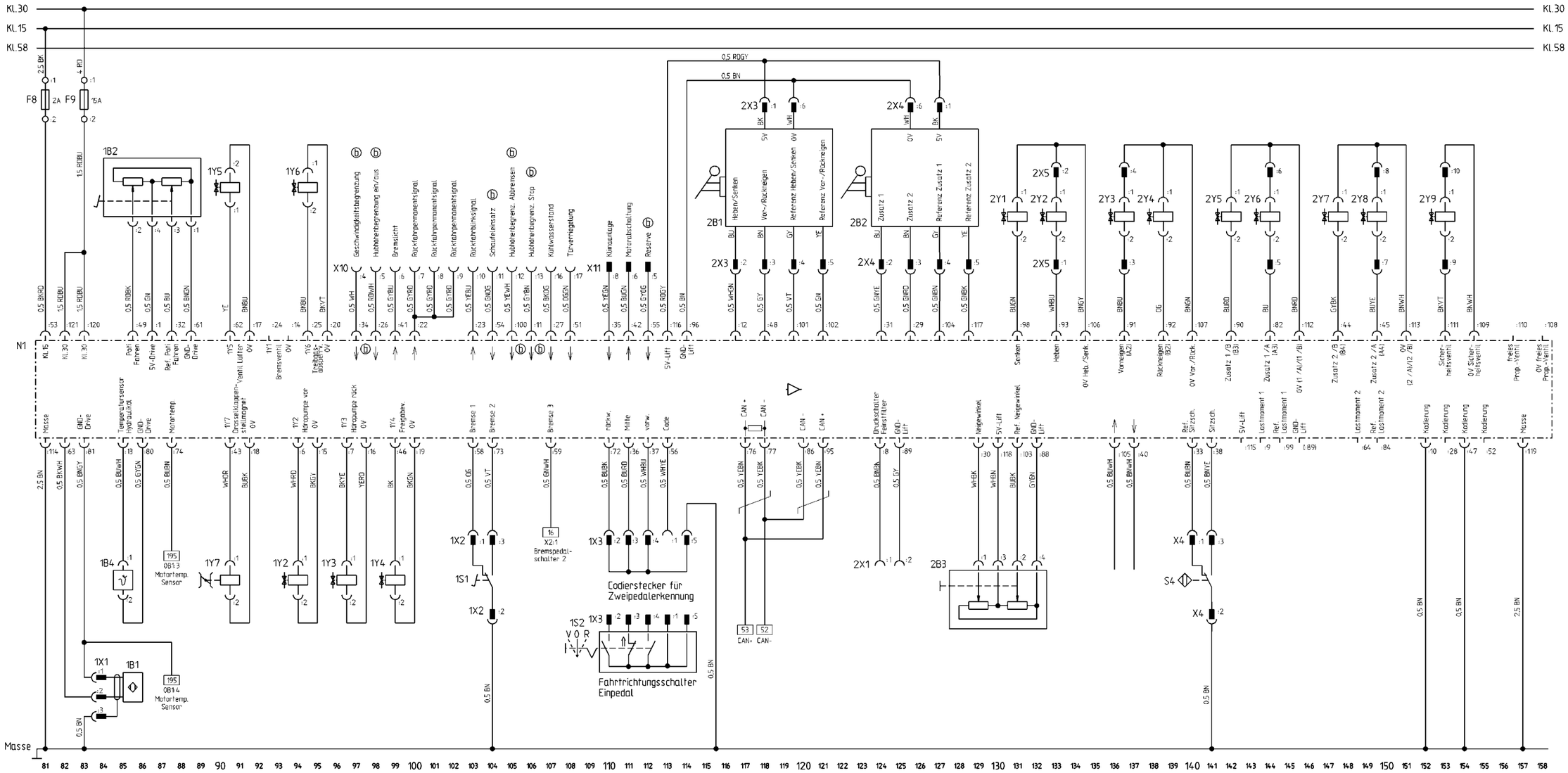
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Switch S6 closes when depressurised

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Circuit Diagram Standard Equipment, Sh. 2, controlled catalytic converter



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1B1	Actual speed sensor, 85, 86
1B2	Electronic truck speed controller - double potentiometer, 84-89
1B4	Temperature sensor for hydraulic oil, 85
2B1	Joystick for basic functions, 116.121
2B2	Joystick for auxiliary functions, 123-129
2B3	Double potentiometer for mast tilt angle, 127-132
F8	Fuse, 81
F9	Fuse, 83
N1	Electronic truck speed control LHC, 81-158
S4	Seat switch, 140-141
1S1	Brake pedal switch 1, 103-104
1S2	Travel direction switch - single-pedal model, 108-114
X4	Connector 3 pins (seat switch), 140, 141
X10	Connector 18 pins (central electr. system), 97-108
X1	Connector 9 pins (central electr. system), 110-112
1X1	Connector 3 pins (1B1), 84
1X2	Connector 3 pins (1S1), 103, 104
1X3	Connector 6 pins (single-pedal model), 110-114
2X1	Connector 2 pins (micro-filter), 124, 125
2X3	Connector 6 pins (2B1), 116-121
2X4	Connector 6 pins (2B2), 124-129
2X5	Connector 10 pins (valve block), 133-153
1Y2	Solenoid valve Y forward, 94
1Y3	Solenoid valve Z reverse, 96
1Y4	Release valve, 99
1Y5	Valve - fan, 90
1Y6	LPG shut-off valve, 94
1Y7	Throttle valve positioning magnet, 90
2Y1	Valve - lowering, 131
2Y2	Valve - lifting, 133
2Y3	Valve - forward tilting, 136
2Y4	Valve - backward tilting, 138
2Y5	Valve - option 1B, 142
2Y6	Valve - option 1A, 144
2Y7	Valve - option 2B, 148
2Y8	Valve - option 2A, 150
2Y9	Release valve, 153

5-Volt sensors	
Lift	**Drive**
:155	:1
:116	:2
.118	:3

Earth sensors	
Lift	**Drive**
:88	:61
:89	:80
:96	:81

Colour primary	Code
black	BK
white	WH

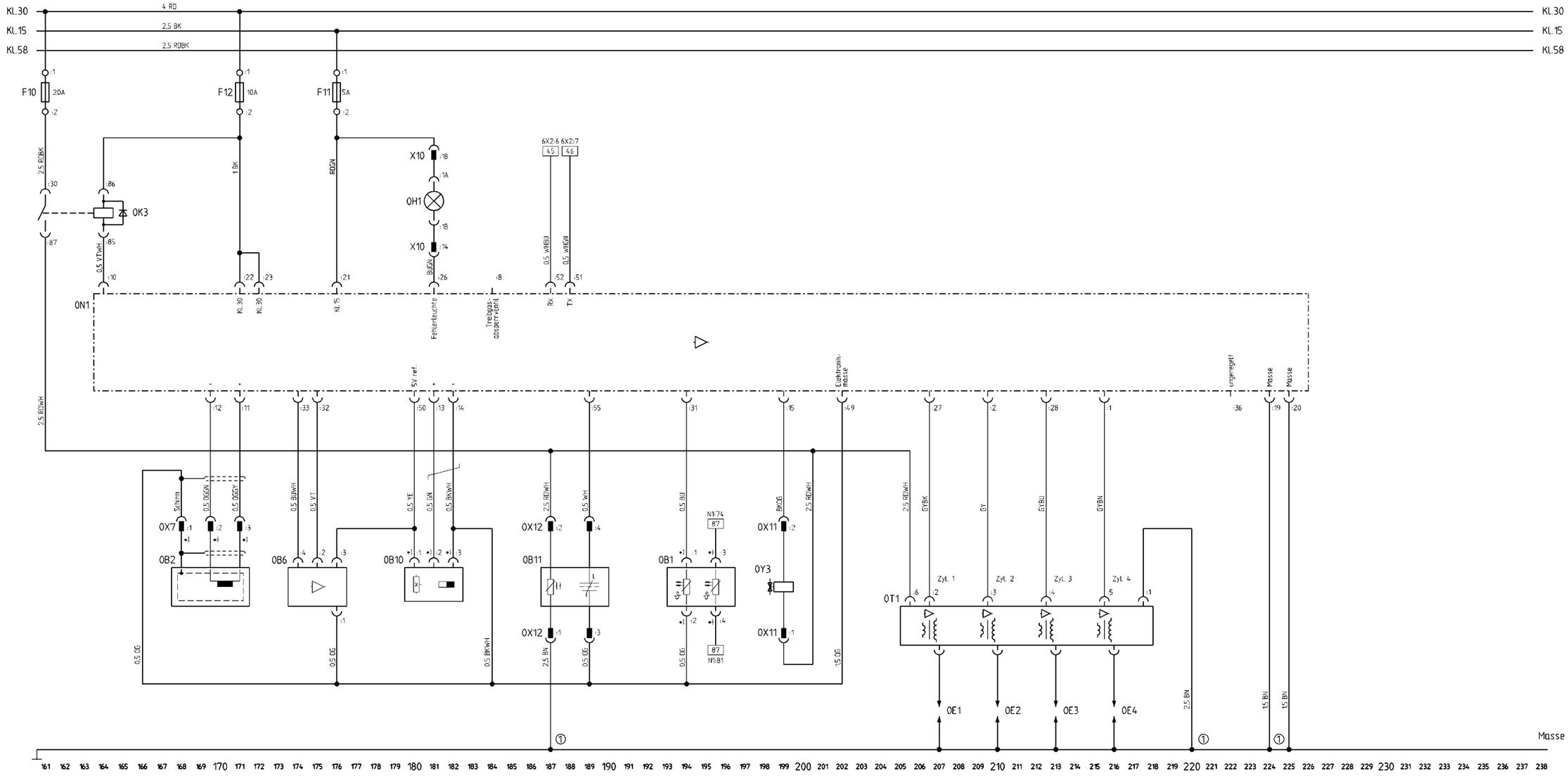
Colour primary	Code
blue	BU
orange	OG
brown	BN
green	GN
violet	VT
red	RD
yellow	YE
grey	GY

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Lines without cross-section information: F = 0.75 mm^2

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Circuit Diagram Standard Equipment LPG Engine, Sh. 3, controlled catalytic converter



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0B1	Coolant temperature sensor, 193-196
0B2	Engine speed sensor, 168-171
0B6	Intake air pressure and temperature sensor, 174-176
0B10	Phase sensor, 180-182
0B11	Lambda probe, 187-189
0E1	Spark plug, 207
0E2	Spark plug, 210
0E3	Spark plug, 213
0E4	Spark plug, 216
F10	Fuse, 161
F11	Fuse, 176
F12	Fuse, 171
0H1	Fault light, 181
0K3	Supply relay, 161-164
0N1	LPG installation controller, 163 -226
0T1	Quadruple ignition module, 205-218
X10	Connector 18 pins (central electr. system), 181
0X7	Connector 3 pins (engine speed), 168-171
0X10	Connector 2 pins (LPG quality), 229
0X11	Connector 2 pins (timing valve), 199
0X12	Connector 4 pins (Lambda probe), 187, 189
0Y3	Timing valve, 199

Colour primary	Code
black	BK
white	WH
blue	BU
orange	OG
brown	BN
green	GN
violet	VT

Colour primary	Code
red	RD
yellow	YE
grey	GY

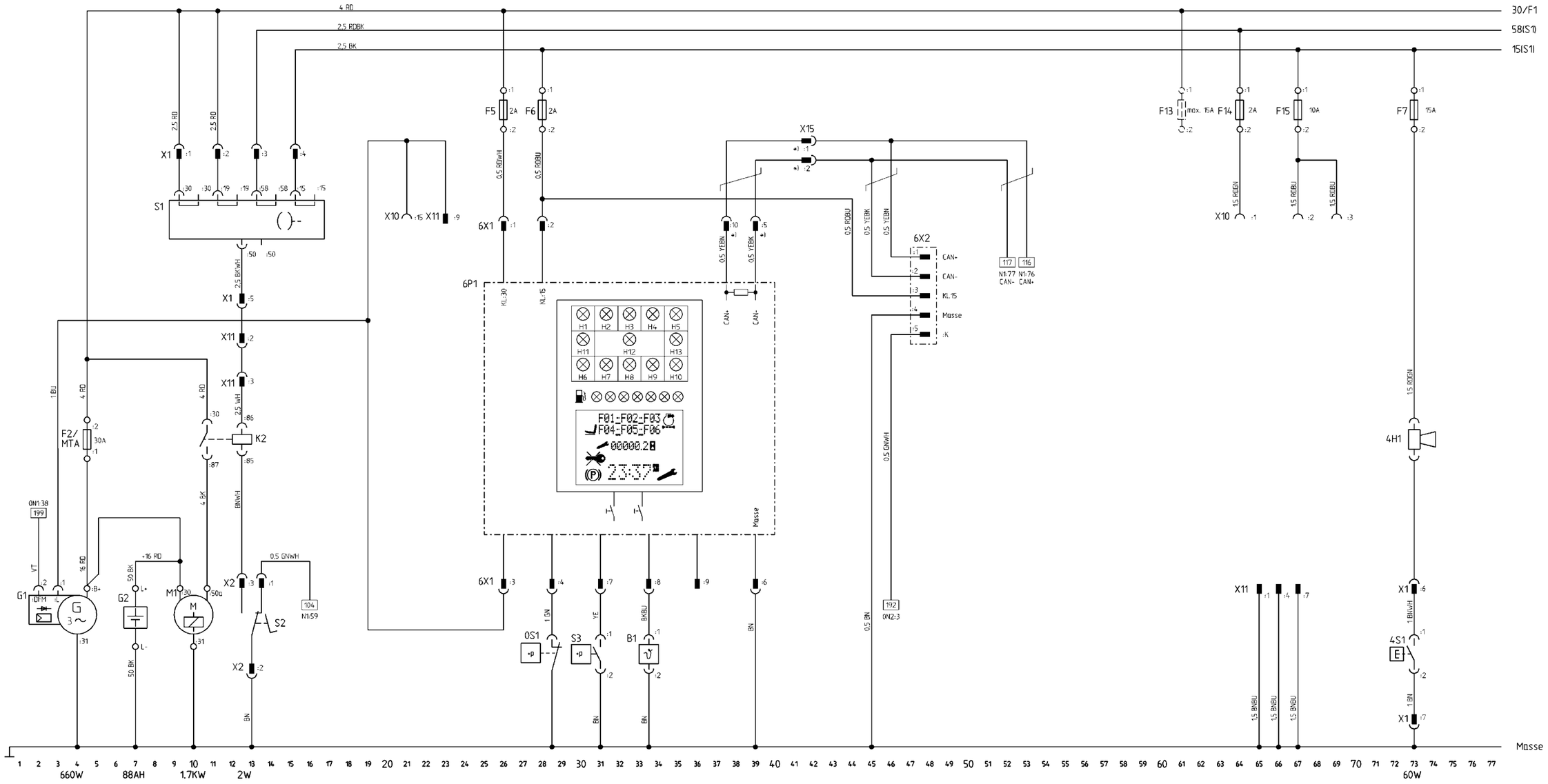
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Lines without cross-section information: F = 0.75 mm^2

(1) Mass point engine block

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Circuit Diagram Standard Equipment, Diesel Engine, Sh. 1



393 802 6007 b

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B1	Tank level sensor, 33
F2	Fuse 30 A MTA, 4
F5	Fuse, 26
F6	Fuse, 28
F7	Fuse, 73
F13	Fuse, 61
F14	Fuse, 64
F15	Fuse, 67
G1	Three-phase alternator with regulator, 1-5
G2	Battery, 7
4H1	Horn, 73
K2	Starting relay, 10-13
M1	Starter, 9-11
6P1	Composite instrument, 25-40
S1	Ignition switch, 9-17
S2	Brake pedal switch 2 (start inhibit), 13-14
S3	Suction filter vacuum switch, 31
0S1	Oil pressure switch, 28
4S1	Horn button, 73
X1	Connector 10 pins (S1), 9-15, 73
X2	Connector 3 pins (S2), 13, 14
X5	Connector 1 pin (starting relay), 12
X10	Connector 18 pins (central electr. system), 22, 64-69
X15	Connector 2 pins (CAN), 42
6X1	Connector 10 pins (6P1), 26-39
6X2	Connector 7 pins (diagnosis), 48

Colour primary	Code
black	BK
white	WH
blue	BU
orange	OG
brown	BN
green	GN

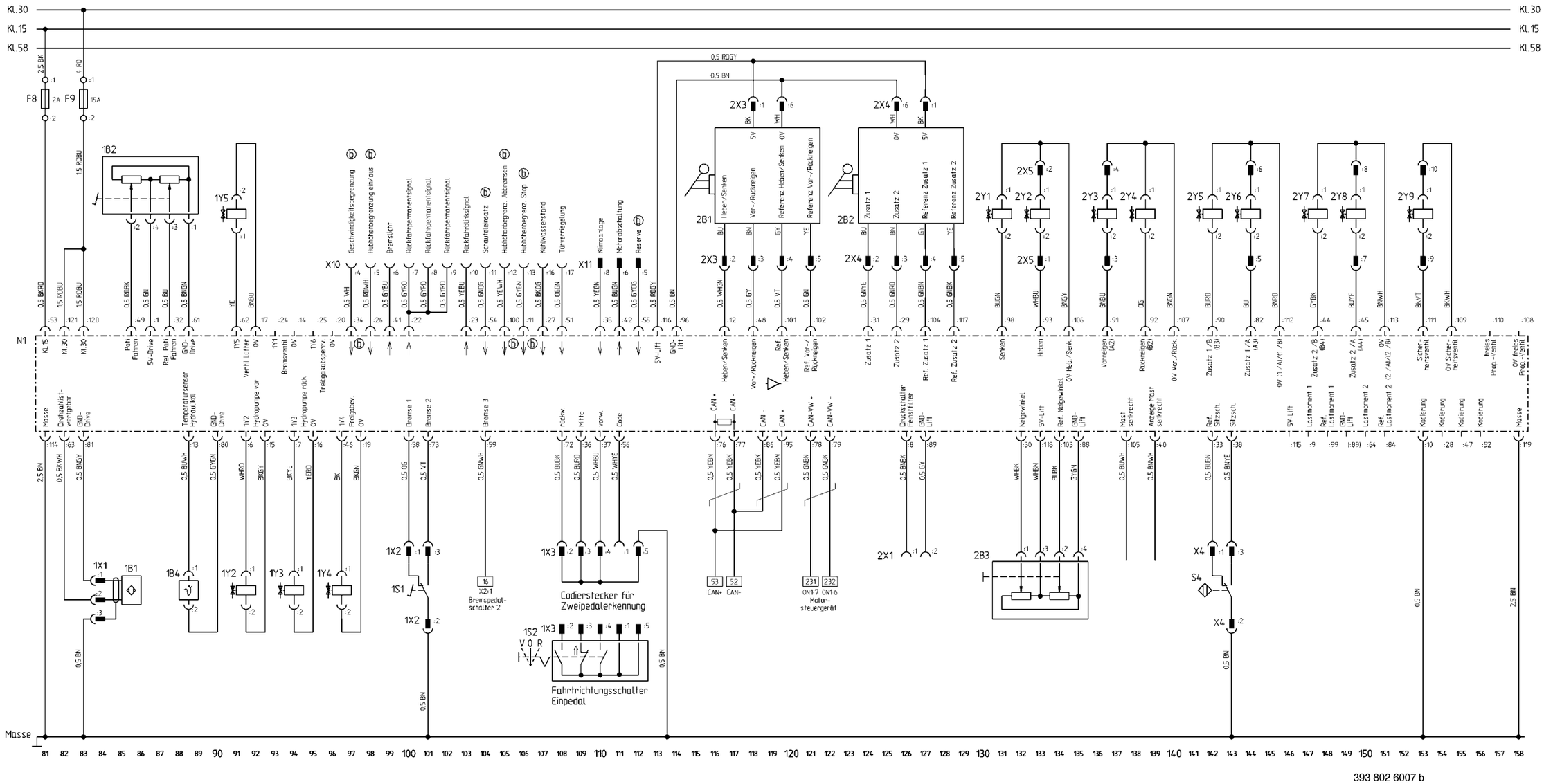
Colour primary	Code
violet	VT
red	RD
yellow	YE
grey	GY

The number before the line colour corresponds to the line cross-section.

Lines without cross-section information: F = 0.75 mm^2

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Circuit Diagram Standard Equipment, Diesel Engine, Sh. 2



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1B1	Actual speed sensor, 85, 86
1B2	Electronic truck speed controller - double potentiometer, 84-89
1B4	Temperature sensor for hydraulic oil, 88
2B1	Joystick for basic functions, 116-121
2B2	Joystick for auxiliary functions, 123-129
2B3	Double potentiometer for mast tilt angle, 130-136
F8	Fuse, 81
F9	Fuse, 83
N1	Electronic truck speed control LTC, 81-158
S4	Seat switch, 142, 143
1S1	Brake pedal switch 1, 100-101
1S2	Travel direction switch - single-pedal model, 107-112
X4	Connector 3 pins (seat switch), 142, 143
X10	Connector 18 pins (central electr. system), 97-108
X1	Connector 9 pins (central electr. system), 110-112
1X1	Connector 3 pins (1B1), 84
1X2	Connector 3 pins (1S1), 100, 101
1X3	Connector 6 pins (single-pedal model), 108-112
2X1	Connector 2 pins (micro-filter), 126, 127
2X3	Connector 6 pins (2B1), 116-121
2X4	Connector 6 pins (2B2), 124-129
2X5	Connector 10 pins (valve block), 133-153
1Y2	Solenoid valve Y forward, 91
1Y3	Solenoid valve Z reverse, 94
1Y4	Release valve, 97
1Y5	Valve - fan, 91
2Y1	Valve - lowering, 131
2Y2	Valve - lifting, 133
2Y3	Valve - forward tilting, 136
2Y4	Valve - backward tilting, 138
2Y5	Valve - option 1B, 142
2Y6	Valve - option 1A, 144
2Y7	Valve - option 2B, 147
2Y8	Valve - option 2A, 149
2Y9	Release valve, 153

5-Volt sensors	
Lift	**Drive**
:115	:1
:116	:2
.118	:3

Earth sensors	
Lift	**Drive**
:88	:61
:89	:80
:96	:81

Colour primary	Code
black	BK
white	WH

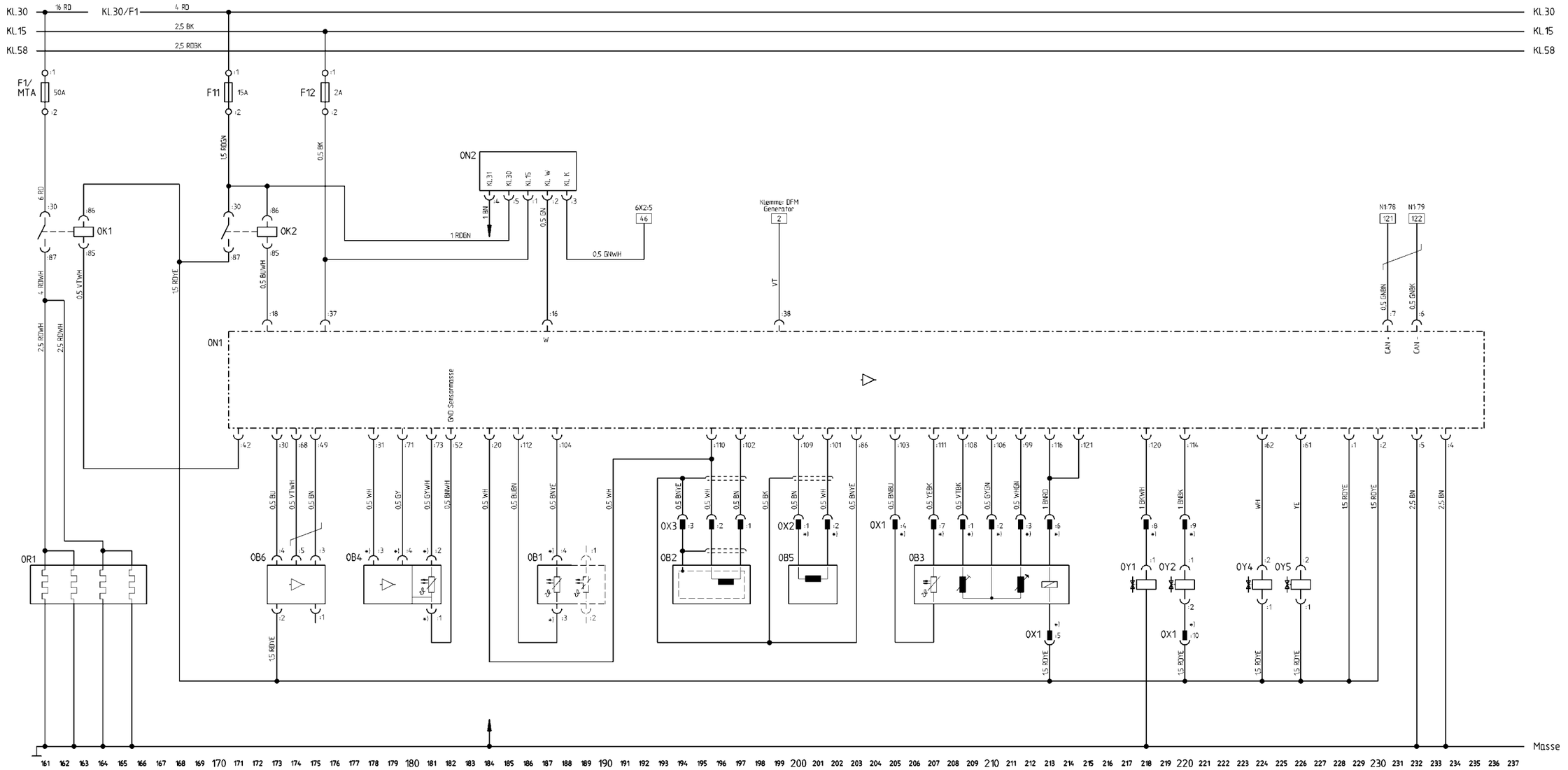
Colour primary	Code
blue	BU
orange	OG
brown	BN
green	GN
violet	VT
red	RD
yellow	YE
grey	GY

The number before the line colour corresponds to the line cross-section.

Lines without cross-section information: F = 0.75 mm^2

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Circuit Diagram Standard Equipment, Diesel Engine, Sh. 3



393 802 6007 b

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0B1	Coolant temperature sensor, 187-190
0B2	Engine speed sensor, 194-197
0B3	Sensor for fuel temperature/control collar, 206-214
0B4	Sensor for inlet pipe pressure/inlet pipe temperature, 178-181
0B5	Needle lift sensor, 200-202
0B6	Air flow sensor, 173-175
F11	Fuse, 170
F12	Fuse, 175
0K1	Glow plug relay, 161-163
0K2	Relay terminal 30 for VW control unit, 170-173
0N1	Control unit for direct diesel injection system, 171-235
0N2	Electronic system for VW immobiliser, 184-188
0R1	Glow plugs, 161-166
0X1	Connector 10 pins, 205-220
0X2	Connector 2 pins, 200, 202
0X3	Connector 3 pins, 194 -197
0Y1	Fuel shut-off valve, 218
0Y2	Valve for start of injection, 220
0Y4	Valve for VTG charger adjustment, 224
0Y5	Valve for exhaust gas recirculation, 226

Colour primary	Code
black	BK
white	WH
blue	BU
orange	OG
brown	BN
green	GN
violet	VT

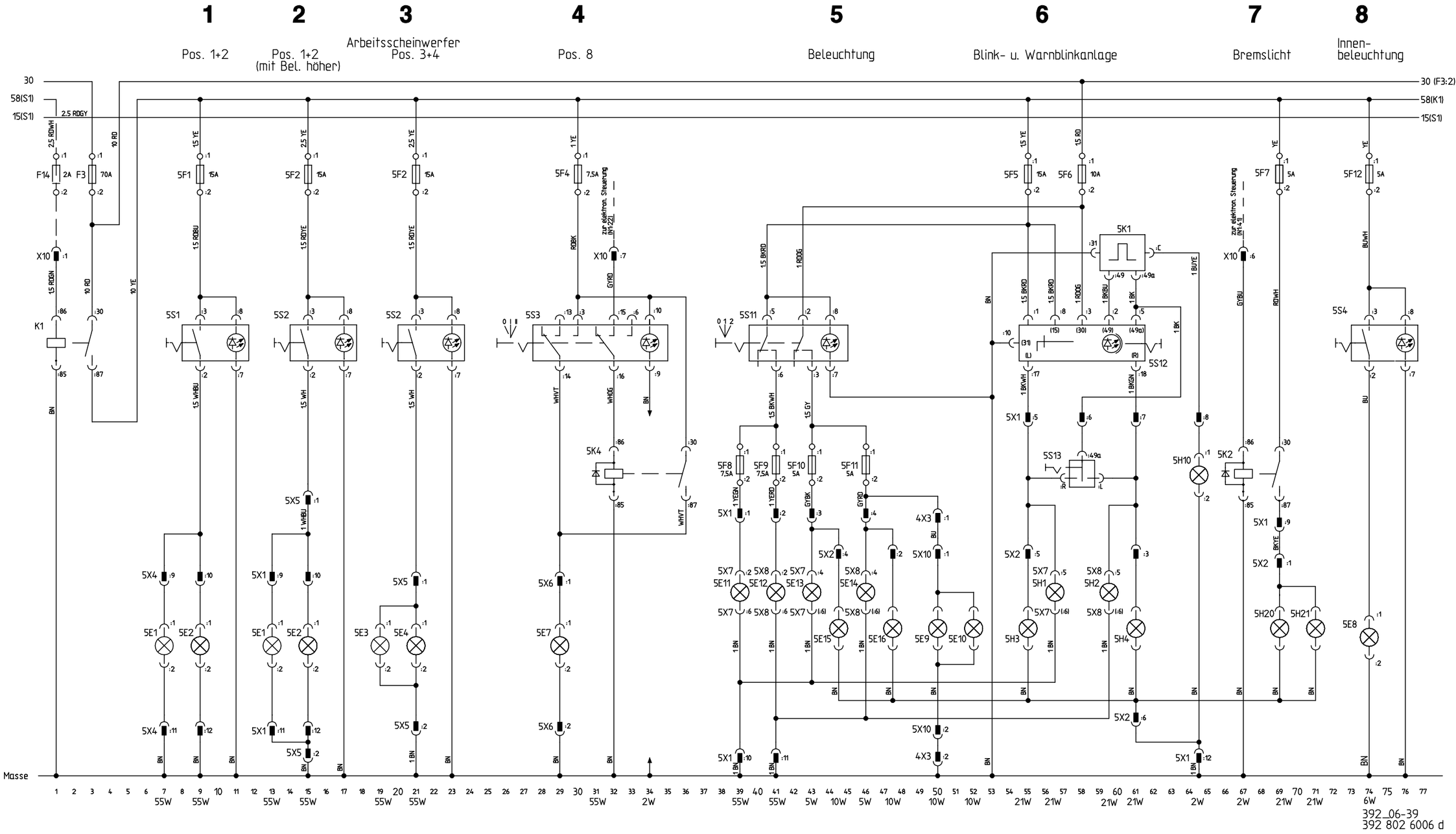
Colour primary	Code
red	RD
yellow	YE
grey	GY

The number before the line colour corresponds to the line cross-section.

Lines without cross-section information: F = 0.75 mm^2

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Wiring diagram for lighting options

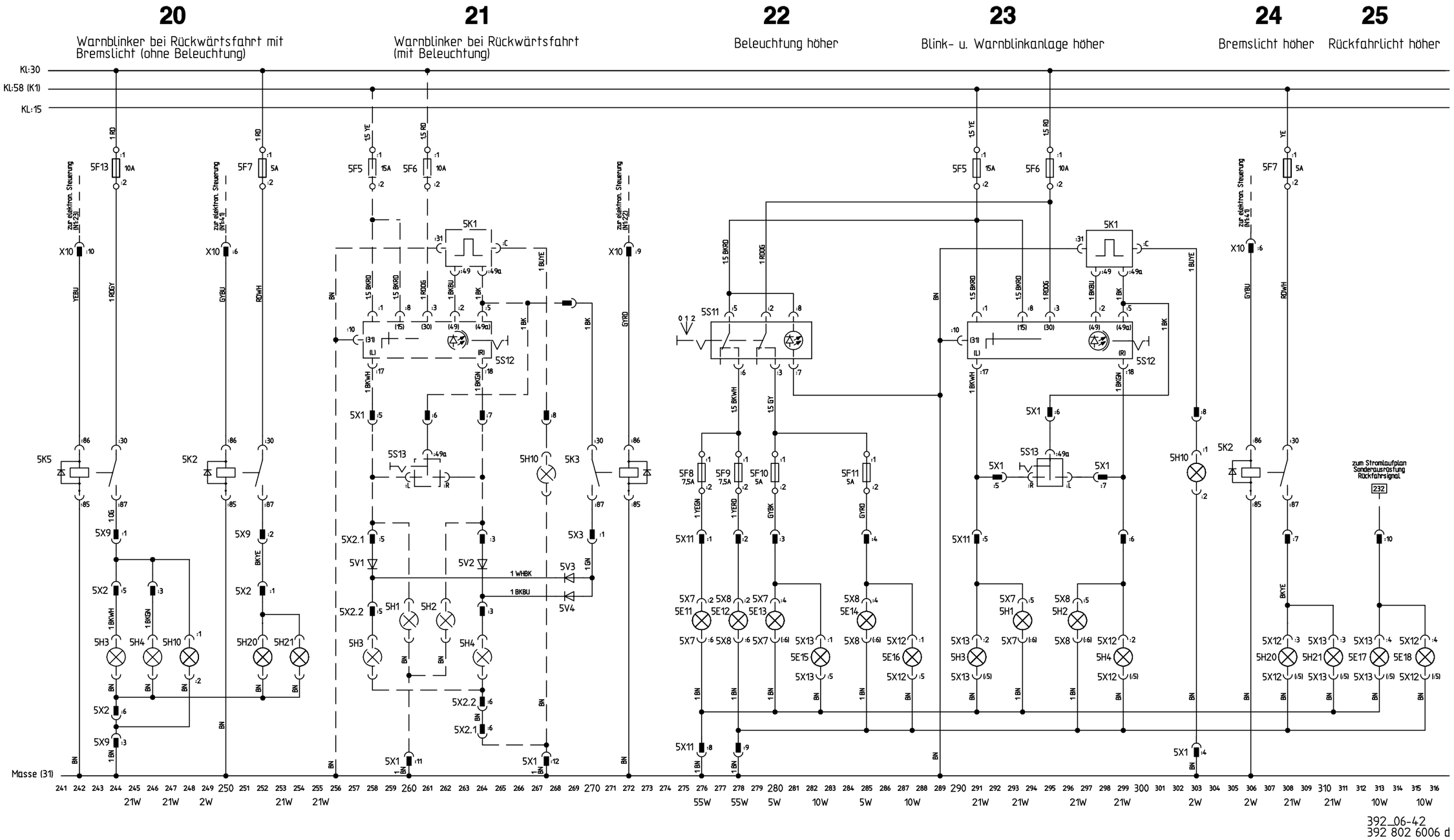


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1	Working lights, items 1 and 2
2	Working light, item 1 and 2 (lighting higher)
3	Working light, item 3 and 4
4	Working light, item 8
5	Lighting
6	Turn signal and hazard warning flasher system
7	Brake light
8	Interior lighting
5E1	Working light, front left, bottom (item 1), 7, 13
5E2	Working light, front right, bottom (item 2), 9, 15
5E3	Working light, front left, top (item 3), 19
5E4	Working light, front right, top (item 4), 21
5E7	Working light, rear, top (item 8), 29
5E8	Cabin lighting, 74
5E9	Number plate light, left, 50
5E10	Number plate light, right, 52
5E11	Dip beam, left, 39
5E12	Dip beam, right, 41
5E13	Side marker light, front left, 43
5E14	Side marker light, front right, 46
5E15	Side marker light, rear left, 44
5E16	Side marker light, rear right, 47
F3	Fuse MTA 70 A (terminal 58), 3
F14	Fuse 2 A (terminal 58), 1
5F1	Fuse 2 A (working lights items 1 and 2), 9
5F2	Fuse 15 A (working lights items 3 and 4), 15, 21
F	Fuse 7.5 A (working lights item 8), 30
5F5	Fuse 15 A (lighting terminal 15), 55
5F6	Fuse 10 A (lighting terminal 30), 58
5F7	Fuse 5 (brake light), 69
5F8	Fuse 7.5 A (headlight, left), 39
5F9	Fuse 7.5 A (headlight, right), 41
5F10	Fuse 5 A (side marker light, left), 43
5F11	Fuse 5 A (side marker light, right), 46
5F12	Fuse 5 A (interior lights), 74
5H1	Turn signal light, front left, 56
5H2	Turn signal light, front right, 59
5H3	Turn signal light, rear left, 55
5H4	Turn signal light, rear right, 61
5H10	Turn signal indicator light, 64
5H20	Brake light, right, 69
5H21	Brake light, left, 71
K1	Auxiliary relay terminal 58, 1-3
5K1	Flasher, 59-62
5K2	Relay, brake light, 67-69
5S1	Working lights items 1 and 2, 9-11
5S2	Working lights items 3 and 4, 15-23
5S3	Working lights items 8, 27-35
5S4	Switch for interior lights, 74-76
5S11	Light switch, 39-45
5S12	Hazard warning light switch, 55-61
5S13	Turn signal switch, 57-59
X10	Connector 18 pins (to standard equipment), 1, 34, 67
4X3	Connector 2 pins (strobe/rotating beacon/number plate light), 50
5X1	Connector 12 pins (overhead guard lighting), 13
5X2	Connector 6 pins (lighting, rear), 44-69
5X4	Connector 12 pins (working lights items 1 and 2), 7, 9
5X5	Connector 2 pins (working lights items 3 and 4), 15, 21
5X6	Connector working lights item 8), 29
5X7	Connector 6 pins (headlight, left), 39, 43, 59
5X8	Connector 6 pins (headlight, right), 41, 46, 59
5X19	Connector 2 pins (number plate light), 50

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Wiring diagram for options, lighting higher

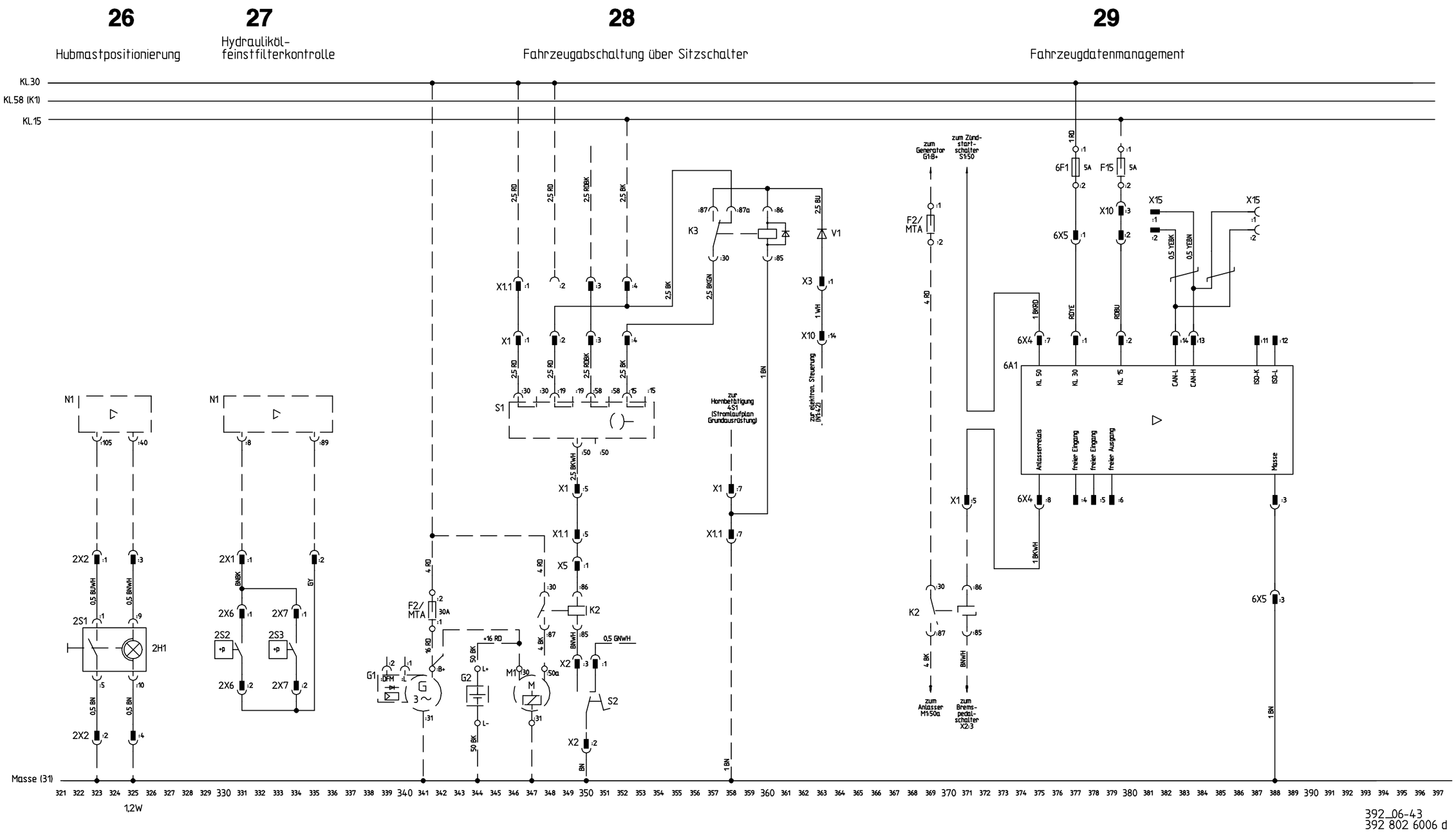


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20	Hazard warning flasher for reversing with brake light (without lighting)
21	Hazard warning flasher for reversing (with lighting)
22	Lighting higher
23	Turn signal and hazard warning flasher higher
24	Brake light
25	Reversing light higher
5E11	Dip beam, left, 276
5E12	Dip beam, right, 278
5E13	Side marker light, front left, 280
5E14	Side marker light, front right, 285
5E15	Side marker light, rear left, 282
5E16	Side marker light, rear right, 287
5E17	Reversing light, left, 313
5E18	Reversing light, right, 315
4F1	Fuse 10 A (reversing signal, 217
4F3	Fuse 7.5 A (hazard warning flasher/rotating beacon), 200, 206
5F5	Fuse 15 A (lighting terminal 10), 291
5F6	Fuse 10 A (lighting terminal 10), 295
5F7	Fuse 5 A (brake light), 252, 308
5F8	Fuse 7.5 A (headlight, left), 276
5F9	Fuse 7.5 A (headlight, right), 278
5F10	Fuse 5 A (side marker light, left), 280
5F11	Fuse 5 A (side marker light, right), 285
5F13	Fuse 10 A (hazard warning flasher), 244
2H1	Warning light, mast position preselection, 325
5H1	Turn signal light, front left, 293
5H2	Turn signal light, front right, 296
5H3	Turn signal light, rear left, 244, 291
5H4	Turn signal light, rear right, 246, 299
5H10	Turn signal indicator, 248, 303
5H20	Brake light, right, 252, 308
5H21	H21 Brake light, left, 254, 310
5K1	Flasher, 297, 300
5K2	Relay, brake light, 250-252, 306-308
5K3	Relay, reversing warning flasher, 270-272
5K5	Relay, hazard warning flasher, 242-244
5S11	Light switch, 276-282
5S12	Hazard warning light switch, 291-300
5S13	Turn signal switch, 294-296
5V1	Decoupling diode, 258
5V2	Decoupling diode, 264
5V3	Decoupling diode, 269
5V4	Decoupling diode, 269
X10	Connector 18 pins (to standard equipment), 242, 250, 263, 272, 275
5X1	Connector 12 pins (overhead guard lighting), 292-303
5X2	Connector 6 pins (lighting, rear), 244-252
5x2.1	Connector 6 pins (lighting, rear), 258, 264
5x2.2	Connector 6 pins (lighting, rear), 258, 264
5X3	Connector 3 pins (interface reversing signal), 270
5X7	Connector 6 pins (headlight, left), 276, 280, 293
5X8	Connector 6 pins (headlight, right), 278, 285, 296
5X9	Connector 3 pins (hazard warning flasher), 244, 252
5X11	Connector 12 pins (lighting higher), 276-313
5X12	Connector 5 pins (tail light, right), 287, 299, 308, 315
5X13	Connector 5 pins (tail light, left), 282, 290, 310, 313

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Wiring diagram for optional equipment, truck data management

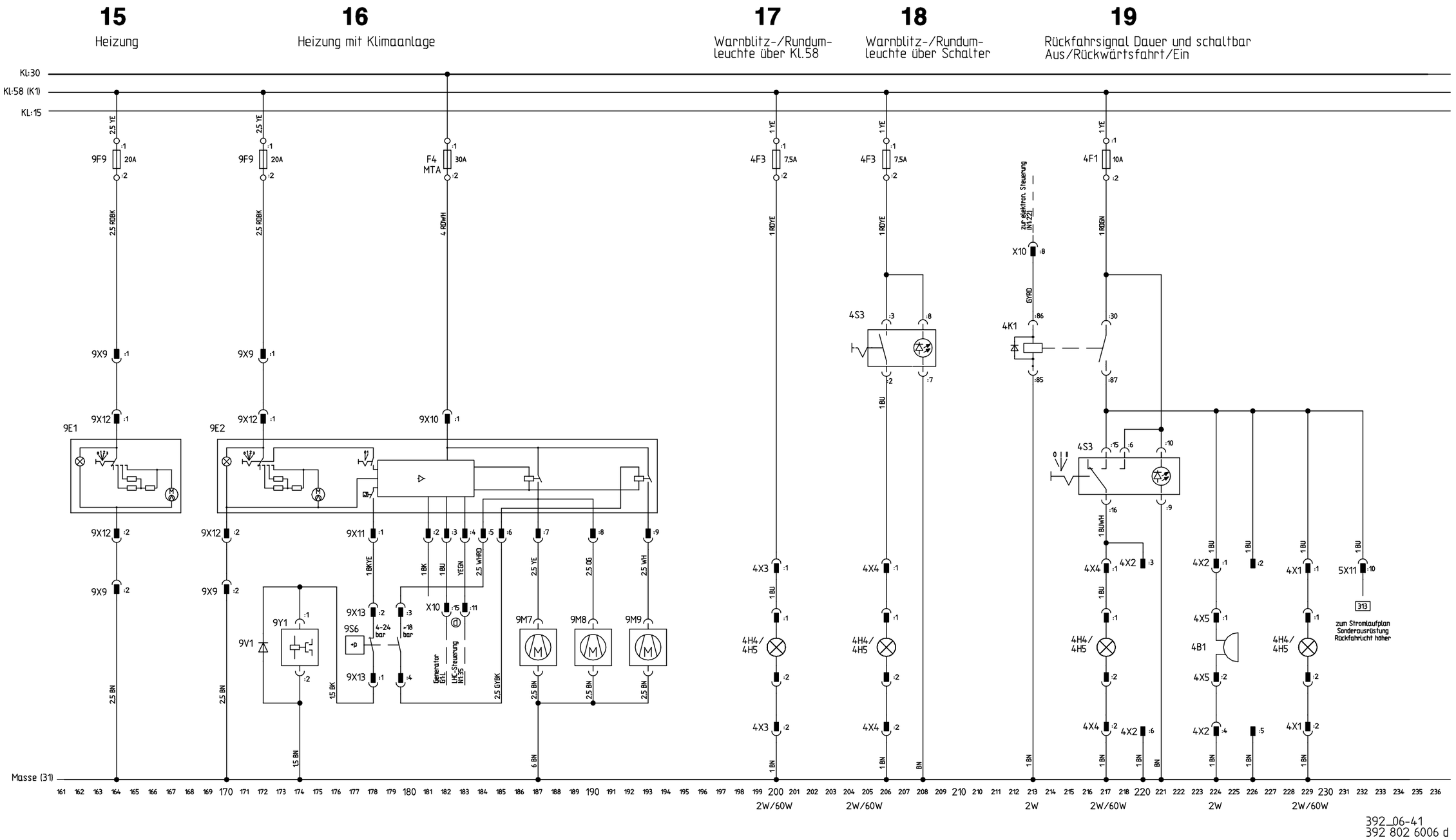


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26	Mast positioning
27	Hydraulic oil micro-filter monitor
28	Truck shutdown with seat switch
29	Truck data management
6A1	Data logger with keypad, 374-389
F15	Fuse 5 A, 379
6F1	Fuse, 377
2H1	Warning light, preset mast position, 325
K2	Auxiliary relay terminal 58, 369-371
K3	Engine cut-off relay, 357-361
N1	Electronic control LTC, 322-326, 330-336
S1	Ignition switch, 346-354
2S1	Mast position preselection switch, 323, 325
2S1	Pressure switch boost oil filter
2S3	Pressure switchhigh pressure filter
V1	Decoupling diode, 363
X1	Connector 10 pins (connection of main cable loom - engine cable set), 346-352, 358, 371
X1.1	Connector 10 pins (connection of main cable loom - engine cable set), 346-352, 358
X3	Connector 2 pins, 363
X10	Connector 18 pins (to standard equipment), 379
X15	Connector 2 pins (CAN connection), 381, 387
2X1	Connector 2 pins (micro-filter), 331, 335
2X2	Connector 4 pins (mast position), 323, 325
2X6	Connector 2 pins (pressure switch), 331
2X7	Connector 2 pins (pressure switch), 334
6X4	Connector 14 pins (data logger), 375-388
6X5	Connector (connection of data logger), 377, 379, 388

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Wiring diagram for optional heater

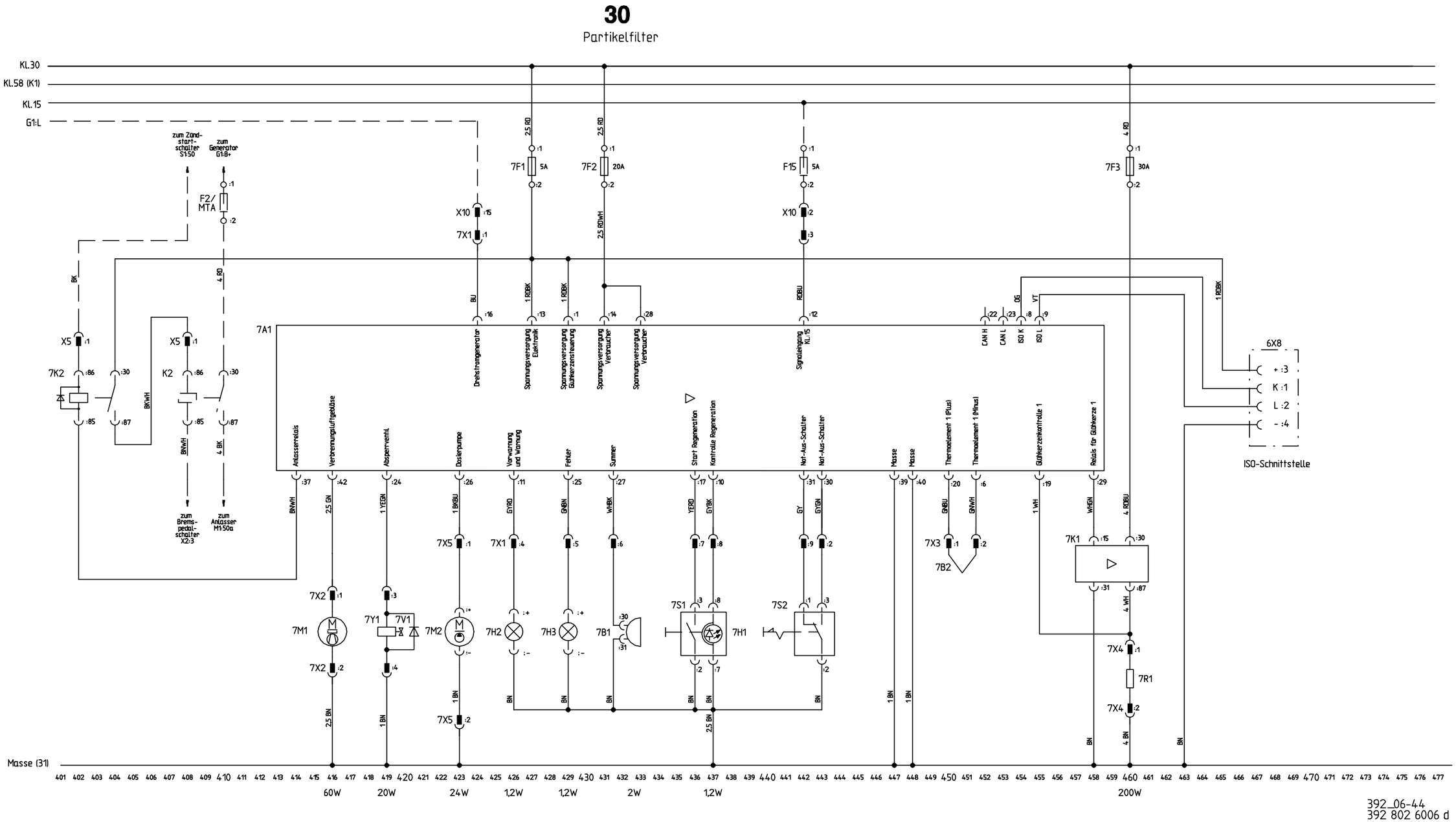


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15	Heater
16	Heater with air conditioning
17	Strobe/rotating beacon via terminal 58
18	Strobe/rotating beacon via switch
19	Acoustic reversing warning signal - continuous and switchable: Off/reversing/on
9E1	Heater, 161-167
9E2	Heater with air conditioning, 170-193
F4	Fuse MTA 30 A (air conditioning), 182
4F1	Fuse 10 A reversing signal, 217
4F3	Fuse 7.5 A (hazard warning strobe/rotating beacon), 200, 206
9F9	Fuse 20 A (heater), 164, 172
4H4	Strobe, 200, 206, 217, 229
4H5	Rotating beacon, 200, 206, 217, 229
4K1	Reversing signal relay, 213-217
9M7	Fan motor 1 air conditioning, 187
M9	Fan motor 2 air conditioning, 190
M9	Fan motor, air conditioning, 193
4S3	Strobe/rotating beacon switch, 205-208, 215-222
9S6	Pressure switch, air conditioning, 177-179
9V1	Free-wheel diode (electric coupling), 172
X10	Connector 18 pins (to standard equipment), 182-183, 213
4X1	Connector 2 pins (hazard warning strobe/rotating beacon), 229
4X2	Connector 6 pins (buzzer), 220-226
4X3	Connector 2 pins (hazard warning strobe, rotating beacon, number plate light), 200
4X4	Connector 2 pins (hazard warning strobe/rotating beacon), 206, 217
4X5	Connector 2 pins (buzzer), 224
5X11	Connector 12 pins (lighting higher), 232
9X9	Connector 2 pins (heater, air conditioning), 164, 170, 172
9X10	Connector 1 pin (air conditioning), 182
9X11	Connector 6 pins (air conditioning), 178-193
9X12	Connector 2 pins (heater), 164, 170, 172
9X13	Connector 4 pins (air conditioning pressure switch), 178-180
9Y1	Electric coupling for air conditioning, 174

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Wiring diagram for optional soot filter

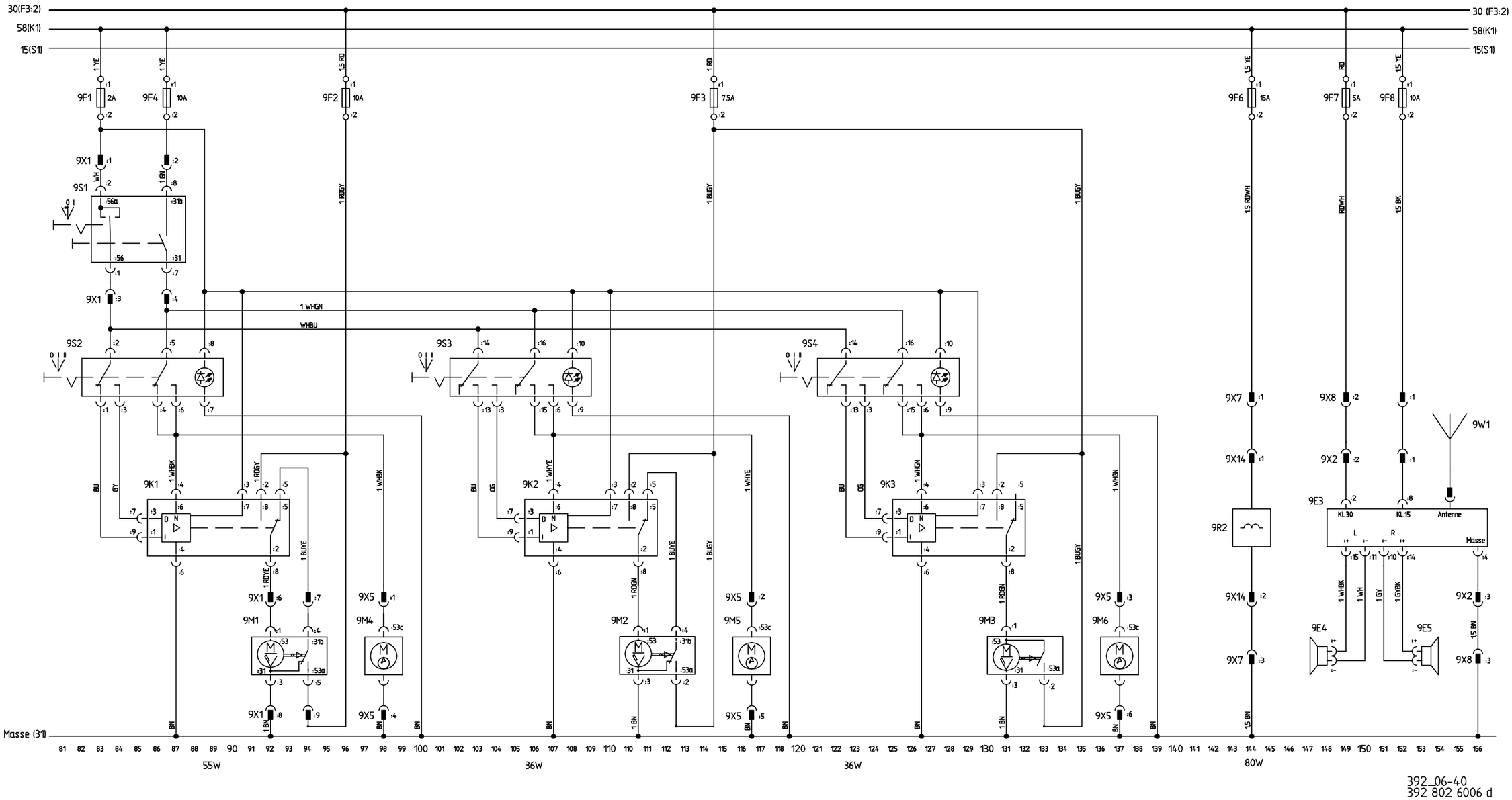


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30	Soot filter
7A1	Control unit for soot filter , 413-458
7B1	Buzzer, 432
7B2	Flame sensor, 451
7F1	Fuse 5 A, 427
7F2	Fuse 20 A, 431
7F3	Fuse 30 A, 460
7H1	Warning light, regeneration, 437
7H2	Prewarning and warning light (orange), 426
7H3	Fault light (red), 429
K2	Starter relay, 407, 411
7K1	Glow plug current regulator, 427-461
7K2	Auxiliary starter relay, 401-405
7M1	Fan, 416
7M2	Metering pump, 423
7R1	Glow plug, 460
7S2	Starter switch, 436-437
7S2	Emergency isolator switch, 442-443
7V1	Decoupling diode, 420
X5	Connector 1 pin (start inhibit), 402, 408
X10	Connector 18 pins (to standard equipment), 424, 442
X6	Connector 4 pins (diagnosis), 467
7X1	Connector 9 pins (interface to central electr. system), 424-443
7X2	Connector 4 pins (blower shut-off valve), 416, 419
7X3	Connector 2 pins (flame sensor, 450, 451
7X4	Connector 2 pins (glow plug), 460
7X5	Connector 2 pins (metering pump), 423
7Y1	Shut-off valve, 419

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Wiring diagram for optional wipers



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9	Windscreen wiper	9E4	Loudspeaker, left, 147	9F6	Fuse 15 A (seat heating), 144	9M1	Wiper motor, front, 91-95
10	Windscreen wiper, front	9E5	Loudspeaker, right, 154	9F7	Fuse 5 A (radio terminal 30), 149	9M2	Wiper motor, rear, 110-113
11	Windscreen wiper, rear	9F1	Fuse 2 A (windscreen wipers, general), 83	9F8	Fuse 10 A (radio terminal 15), 152	9M3	Wiper motor, roof, 130-134
12	Windscreen wiper, roof	9F2	Fuse 10 A (windscreen wiper, front), 96	9K1	Wiper relay, front, 85-93	9M4	Washing system pump, front, 98
13	Seat heating	9F3	Fuse 7.5 A (windscreen wiper, rear and roof), 114	9K2	Wiper relay, rear 106-111	9M5	Washing system pump, rear, 116
14	Radio	9F4	Fuse 10 A (washing system pumps), 86	9K3	Wiper relay, roof, 125-132	9M6	Washing system pump, roof, 137

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