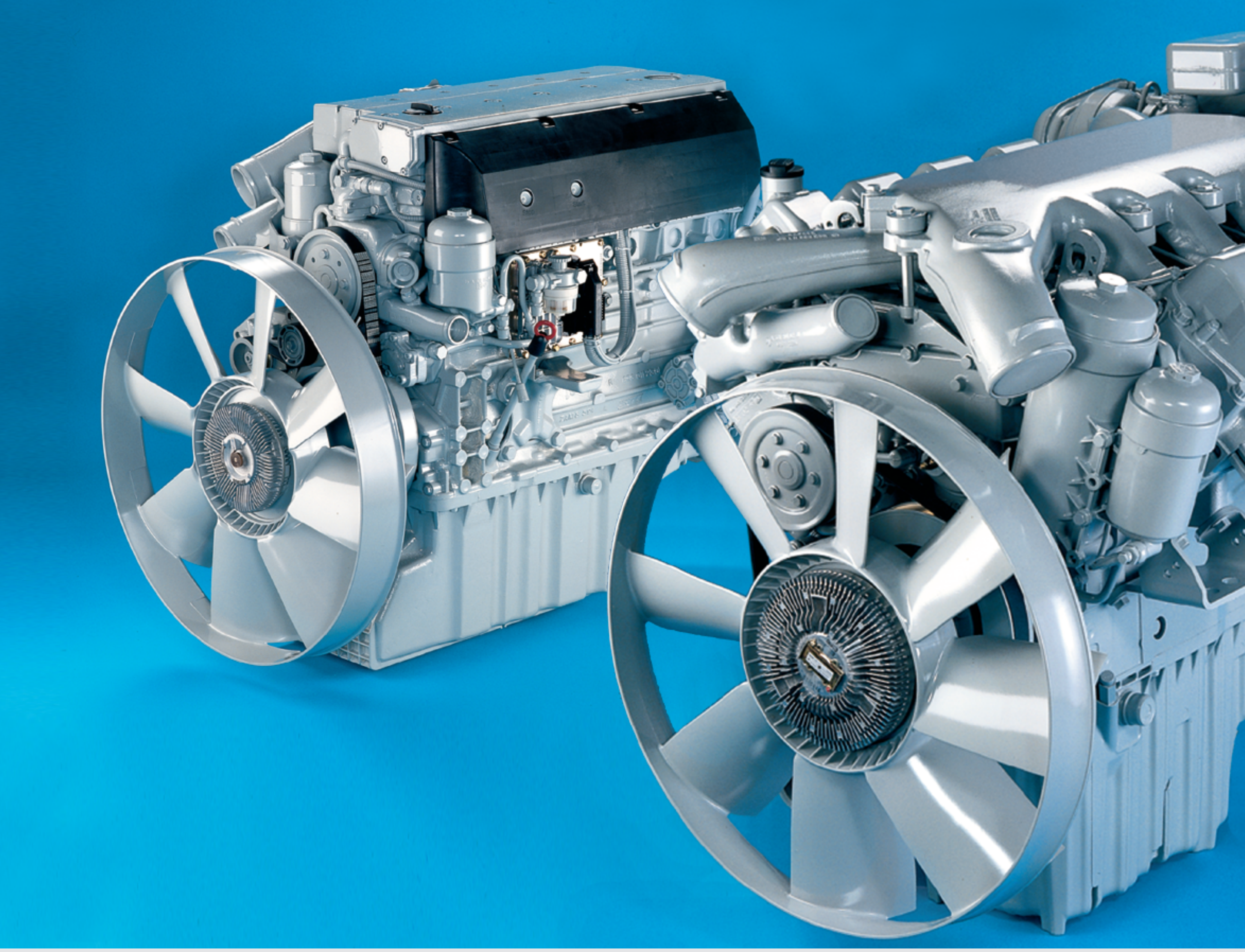


Installation Instructions for Mercedes-Benz Commercial Vehicle Engines

Mercedes-Benz

Installation Instructions for Mercedes-Benz Commercial Vehicle Engines

1 INTRODUCTION

1.1 General

These installation instructions are aimed at OEMs which install a DaimlerChrysler power train or DaimlerChrysler power train components in their vehicles or equipment. These installation instructions describe the prerequisites to be noted on installation and therefore the suitable intended usage.
Observing and adhering to these instructions are essential to ensure that the power train and its components function optimally in both a technical and economic sense. Defects in the power train or its components do not lead to the assertion of claims against DaimlerChrysler AG if they arise from non-adherence to these instructions.

1.2 Specifications for Service Products

Adherence to DaimlerChrysler AG's Specifications for Service Products and service interval specifications (see current DaimlerChrysler service manuals) is the prerequisite of flawless operation of the entire power train and the individual major units, and forms part of the DaimlerChrysler warranty conditions.

• Lubricants:	Diesel engine	Sheet 228.1, 228.3, 228.5 (multigrade oils) Sheet 228.0, 228.2 (single grade oils)
• Lubricants:	Gas engine	Sheet 226.9 (multigrade oils)
• Coolants:		Sheet 312.0, 325.0, 325.2, 325.3, 326.0, 326.2, 326.3
• AdBlue- NOx Reducing agent		Sheet 352.1
• Preservation:		Sheet 381.0
• Transmission	Mechanical:	Sheet 235.1, 235.4, 235.5, 235.10, 235.11, 236.2
	Automatic:	Sheet 236.1, 236.6, 236.7, 236.8, 236.81
• Torque converter clutch		Sheet 227.0, 235.12
• Transfer case:		Sheet 235.0, 235.1, 235.5, 235.6, 235,11
• Retarder (Voith):		Sheet 227.0
• Front/rear axles:		Sheet 235.0, 235.1, 235.6, 235.8
• Steering gear:		Sheet 236.2, 236.3, 236.6, 236.7
• Greases (if required)		Sheet 266.2, 267.1

1.3 Operating and Servicing Major Units

Observe the specifications in the applicable DaimlerChrysler operating and servicing instructions as regards operation and maintenance.

1.4 Installation Appraisal

To rectify any existing and recognizable installation defects, which may lead to damage to the power train or its components, before series production begins, installation appraisal and, if desired by the customer, an on-site check with measurements, is carried out by DaimlerChrysler AG following initial installation of a power rain or an individual major unit. These are based on the DaimlerChrysler AG installation requirements resulting from these instructions, the technical documentation, the service literature and the Specifications for Service Products, etc.

The vehicle or equipment manufacturer bears sole responsibility for the flawless function of the vehicle or device, proper installation and flawless interaction of the power train or power train components supplied by DaimlerChrysler AG with other components which the vehicle or equipment manufacturer has installed - even following such an installation appraisal by DaimlerChrysler AG.
DaimlerChrysler AG bears no liability for defects or damage to the supplied major units caused by non-contractual use of the vehicle or equipment or due to the design of the installation in the vehicle or equipment.

Parts supplied by the OEM (Original Equipment Manufacturer), such as brackets, carriers, auxiliary attachments may only be mounted on the engine if this does not impede the function or durability of the relevant engine components. If in doubt, the OEM must offer proof of the fact that auxiliary attachments not released by the engine manufacturer do not have a deleterious effect on engine components.
Loosening threaded connections on the engine to install brackets, etc. is only permissible if the harmlessness of this has been expressly confirmed by the engine manufacturer.
When installing a transmission or bell housing on the engine's flywheel housing and on installing engine support arms on the flywheel housing or crankcase, the threaded connection design (bolt and nut contact surface, etc.) must be suitable to ensure that no impermissible preload force losses occur. Loosening these threaded connections may lead to severe damage to engine housing parts.

1.5 Safety and Initial Commissioning

Note the specifications in the relevant operating instructions before first commissioning the power train or individual major units in the vehicle.

1.6 Proper Use of a Major Unit

The major unit is intended exclusively for the contractually specified purpose. Any other or exceeding use is not according to the terms of the contract. DaimlerChrysler AG accepts no liability for damage which occurs as a result of this. The risk is borne solely by the user.

1.7 Trademarks

Affixing DaimlerChrysler AG trademarks (e.g. three-pointed star or Mercedes-Benz logo) onto products produced by the manufacturer is impermissible without the approval of DaimlerChrysler AG.

2 ENGINE

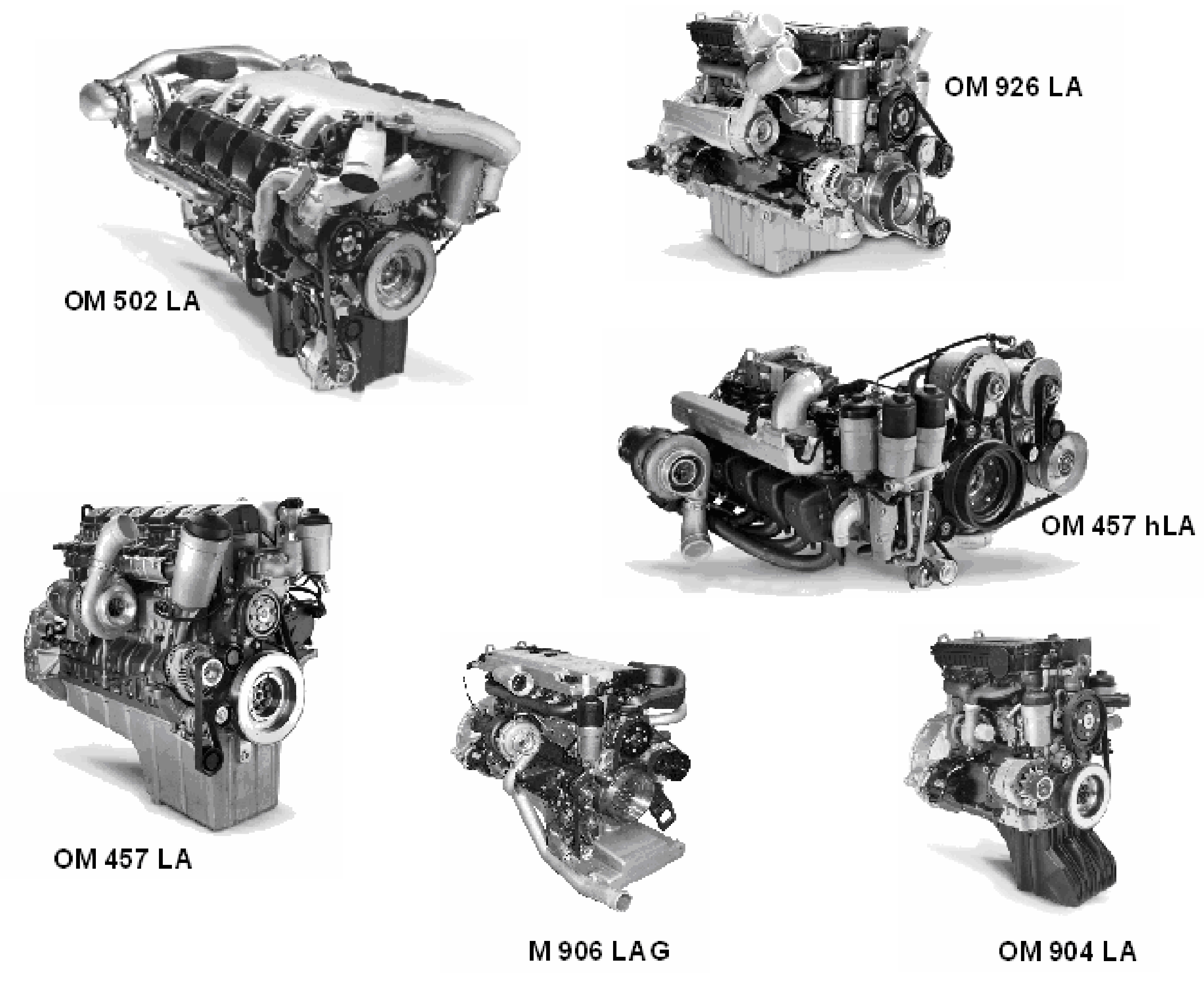
2.1 Introduction

The current engines of medium (inline engines) and heavy-duty (V + inline engines) diesel engines and the gas engines have an output range from 75 to 480 kW.
The diesel engines are fitted with a high-pressure fuel injection system with individual injection pumps (unit pumps) which are driven by the camshaft. Short high-pressure pipes link these to the injection nozzles, which are located centrally in the cylinder head.
Injection regulation is carried out via an electronic engine management system.

The gas engine is fitted with a fully-electronic control system, which regulates the gas injection quantity and time via solenoid valves, as well as the timing, and has particularly low-pollutant emission behavior.

The engines, which are charge air-cooled, offer the potential to meet even more stringent exhaust emission and noise regulations in the future.

These current engines are fitted in trucks, buses, municipal vehicles, agricultural equipment, cranes and other industrial applications.



Mercedes-Benz engines (examples)

2.2 Legal Regulations

Mercedes-Benz engines are certified according to the applicable guidelines. The limit values defined in the engine certificate must be adhered to during operation. Changes to parts which determine emissions (e.g. parts which conduct air and exhaust gas, etc.) require approval and must basically be coordinated with DaimlerChrysler AG.
In order to reduce pollutant emissions in the exhaust gas of diesel engines and in order to be able to fulfill the exhaust standards Euro 4 and future, DaimlerChrysler has developed exhaust after treatment with BlueTec diesel technology, see Section 3.

2.3 Transport and Storage

The engine is fitted with suspension points in the factory; these ensure safe and flawless handling when installing and removing the engine.
The suspension points are dimensioned according to the engine geometry (center of gravity) and weight, and must not be changed or modified.

In the case of the transport of the engines it is to be made certain that they are filled with oil in the factory
The engines must be stored in the transport pallets (steel or wood) or in corresponding trestles.
Placing the engines down on the oil pan should generally be avoided. If this is unavoidable, ensure that the floor is even in the case of engines fitted with plastic oil pans.

Engines which are put into storage or not operated for a period in excess of 12 months must be preserved, even if already installed. The measures described in the preservation chapter of the DaimlerChrysler operating instructions must also be observed.

2.4 Cooling System

In Mercedes-Benz engines, the heat passed from the engine to the coolant is dissipated by means of forced circulation cooling in an enclosed circuit. External flow cooling for the engine is impermissible.

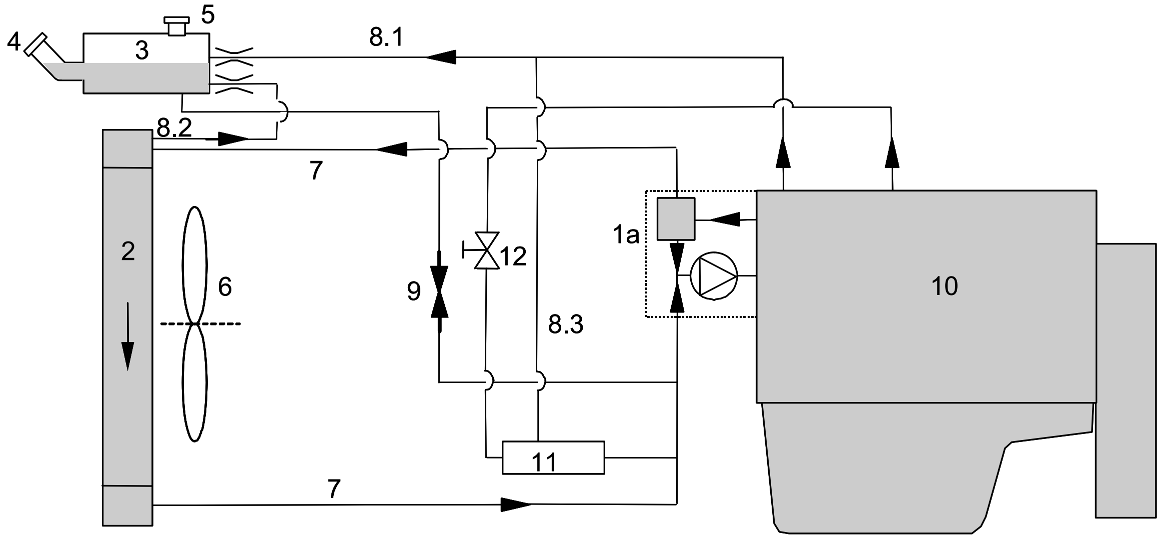
The engines are fitted with a centrifugal pump for circulating the coolant. The engine coolant circuit is fitted with a coolant thermostat, which closes the link to the cooling system located in the outer circuit below the engine operating temperature. As a result of this, the engine rapidly reaches its operating temperature. The coolant thermostat begins to open at a specified temperature and conducts the hot coolant to the cooling system. The cooled coolant is then fed back to the engine.

The design of the cooling system and the basics to be observed is dealt with in section 2.4.3.

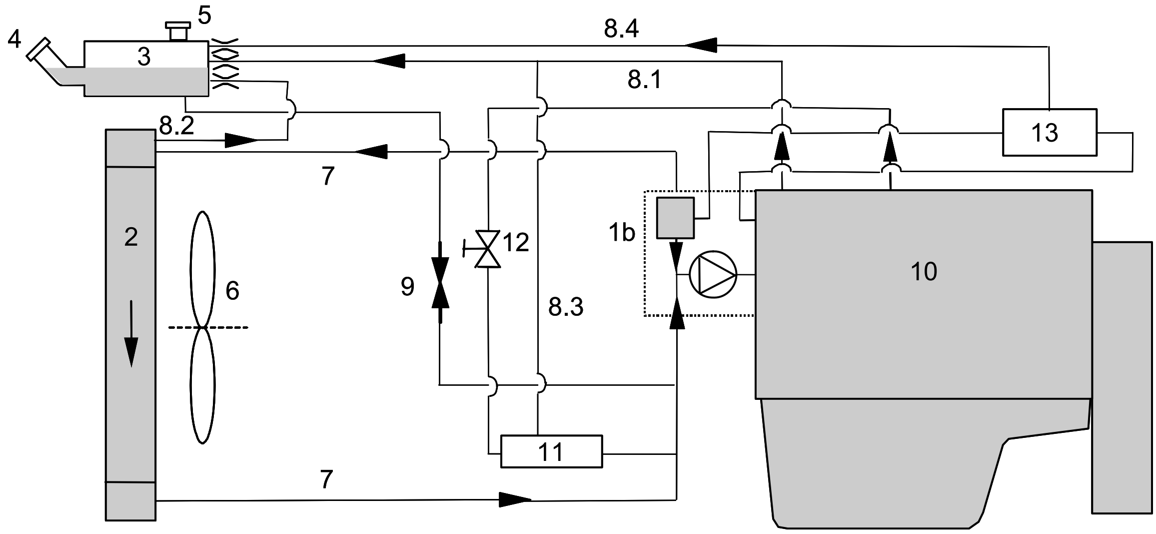
As cooling exerts a significant influence on the engine's operating safety and service life, cooling circuit schematics are shown and described in the following.

2.4.1 Coolant Schematic for Diesel Engines

Standard coolant schematic



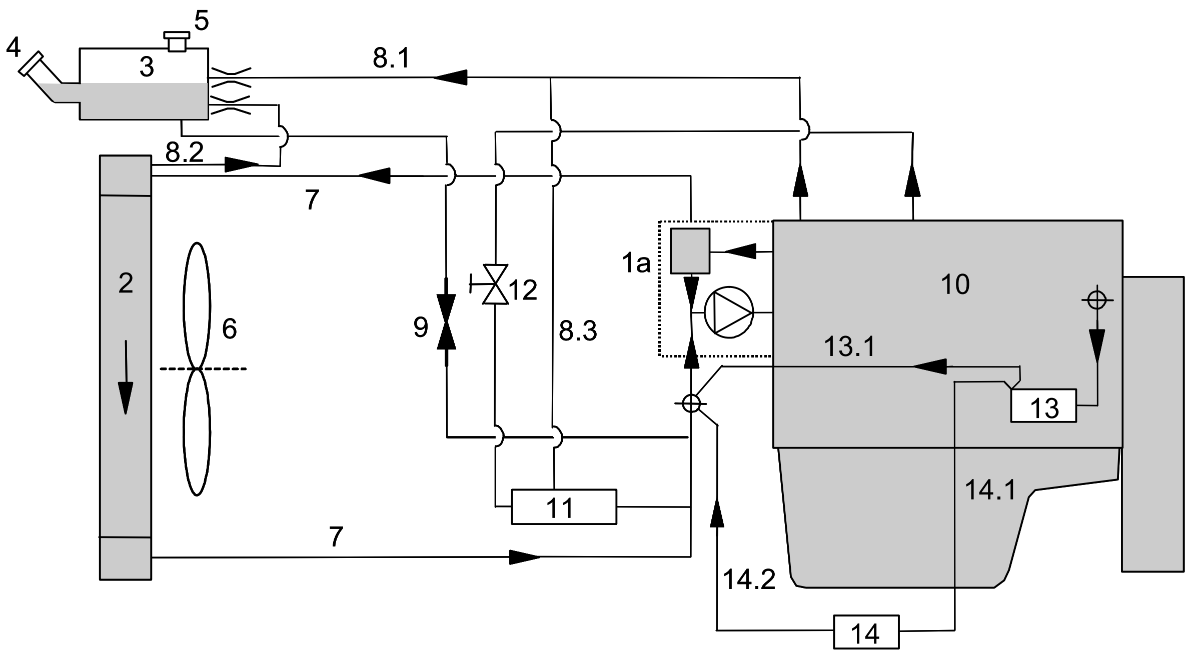
Coolant schematic with retarder/transmission oil cooler inside cooling circuit



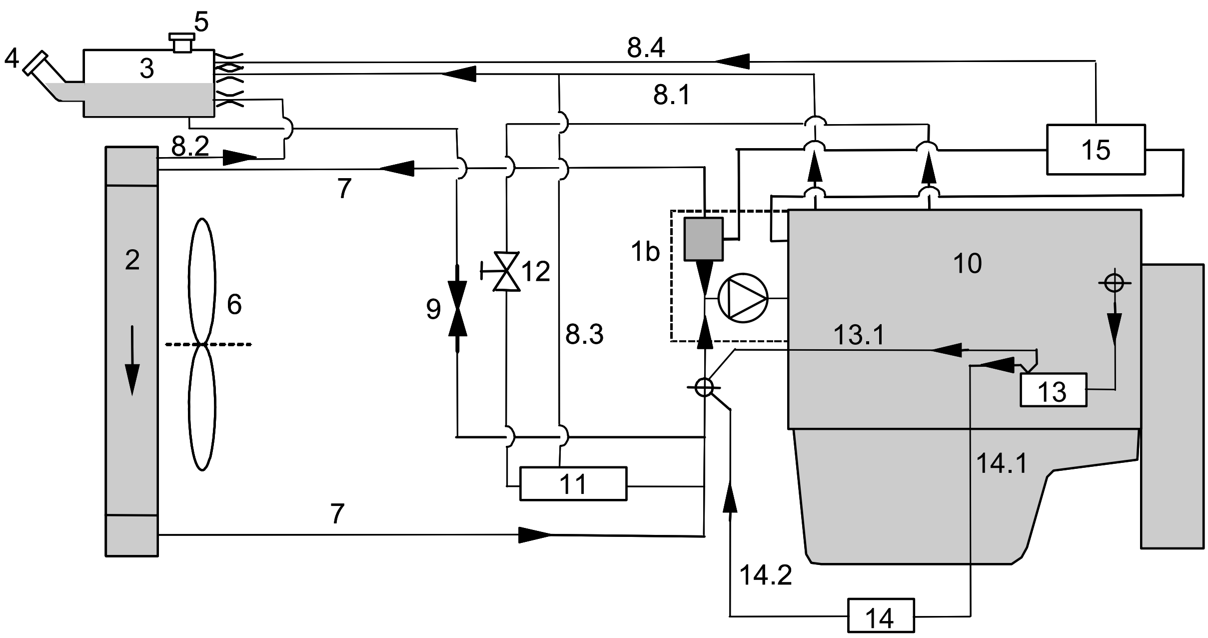
1a Coolant pump with integrated coolant thermostat
1b Coolant pump with integrated coolant thermostat
(100% coolant quantity to the retarder/transmission oil cooler)
2 Radiator
3 Compensation tank, located elsewhere or integrated onto the radiator, but always separate and not in the radiator tank, 50% coolant/ 50% air volume
4 Filler neck with cap, externally impermeable.
5 Cap with 1.0 bar pressure relief valve and 0.1 bar vacuum valve (protected against opening).
6 Fan
7 Coolant pipe, nominal width (NW) at least corresponding to the connection cross-sections on the engine
8 Ventilation pipe
8.1 From the engine NW 8-12 mm (with throttle 4.5 mm), into the air space of the expansion tank
8.2 From the radiator NW 8-12 mm (with throttle 4.5 mm) into the water space of the expansion tank
8.3 From the heater (with throttle 4.5 mm) NW 8-12 mm, **as required only**,
e.g. high-mounted heater
8.4 From the transmission / retarder heat exchanger, poss. at the highest point of the supply and return pipe NW 8-12 mm (with throttle 4.5 mm) , **as required only**
9 Filling and expansion pipe, min. NW 25 mm
10 Engine
11 Vehicle heater
12 Heater shutoff valve
13 Retarder/transmission oil cooler

2.4.2 Coolant Schematic for Gas Engines

Standard coolant schematic



Coolant schematic with retarder/transmission oil cooler inside cooling circuit



1a Coolant pump with integrated coolant thermostat
1b Coolant pump with integrated coolant thermostat
(100% coolant quantity to the retarder/transmission oil cooler)
2 Radiator
3 Compensation tank, located elsewhere or integrated onto the radiator, but always separate and not in the radiator tank; 50% coolant/ 50% air volume
4 Filler neck with cap, externally impermeable.
5 Cap with 1.0 bar pressure relief valve and 0.1 bar vacuum valve (protected against opening)
6 Fan
7 Coolant pipe, nominal width (NW) at least corresponding to the connection cross-sections on the engine
8 Ventilation pipe
8.1 From the engine NW 8-12 mm (with throttle 4.5 mm), into the air space of the expansion tank.
8.2 From the radiator NW 8-12 mm (with throttle 4.5 mm) into the water space of the expansion tank
8.3 From the heater (with throttle 4.5 mm), NW 8-12 mm
as required only, e.g. high-mounted heater
8.4 From the transmission / retarder heat exchanger, poss. at the highest point of the supply and return pipe NW 8-12 mm (with throttle 4.5 mm) , **as required only**
9 Filling and expansion pipe, min. NW 25 mm
10 Engine
11 Vehicle heater
12 Heater shutoff valve
13 Air compressor
13.1 Coolant outlet pipe NW 10 mm
14 Gas control unit
14.1 From the air compressor coolant discharge pipe to the gas control unit, NW 8 mm
14.2 From the gas control unit to the coolant inlet, NW 8 mm
15 Retarder/transmission oil cooler

2.4.3 Design / Dimensioning

The following factors must be taken into consideration for adequately dimensioning the cooling system:

- The entire volume of heat to be dissipated by the coolant from the engine, retarder, transmission oil radiator, etc.
- Coolant pump performance map
- Fan performance map
- Ensuring power output at ambient temperatures from 30°C to 35°C and with flow speeds, wherever possible for the specific vehicle,
  > 6 kW/t = 30 km/h or < 6 kW/t = 15 km/h
- Dimensions and position of the pipe connections, nominal widths at least corresponding to the connection cross-sections on the engine
- Type and use of the vehicle / equipment in which the cooling system is installed (World-wide / altitude, etc.)
- Cooling air ducting (inlet and outlet apertures, optimally 100% of the radiator surface, at least 75% required)
- Max. permissible coolant operating temperature at the engine outlet
- System pressure 1,0 bar at T_{max} 100 ° C

The limit value for designing the coolant side is a temperature gradient (coolant temperature at the radiator inlet minus air inlet temperature at the radiator) according to the max. ambient temperature in which the vehicle/equipment is operated (e.g. 60 K at an ambient temperature of 35°C).

The cooling system is to be laid out in such a way, that T_{max} 100 ° C as constant temperature does not exceeded.

In the engine, adherence to a temperature difference of 3 k to max. 11 k (engine nominal output) is required between the engine outlet and inlet, measured with a blocked coolant thermostat.
In all installed components, it must be ensured that the entire cooling system volume is completely filled with coolant. The pipes should be routed and dimensioned so that no air pockets occur in the system, continuous venting is guaranteed and the ventilation pipes are routed upslope, see section 2.4.9. At least two ventilation pipes are generally necessary, one for engine ventilation (inner circuit) and one for radiator ventilation (outer circuit).

For the design of the charge air cooling system, see section 2.8.5.

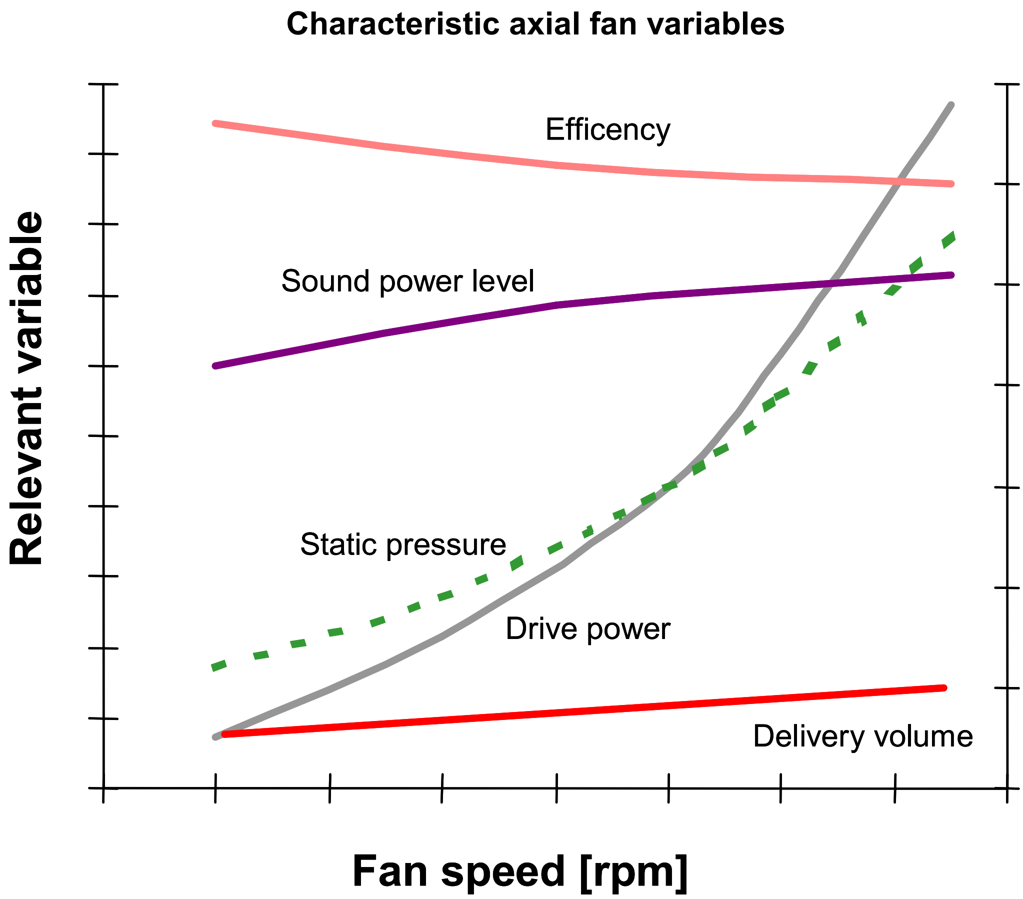
Adherence to the engine / installation limit values for on- and off-highway (request up-to-date values from the sales department) is vital, as these also form part of the engine installation inspection and certification.

2.4.4 Coolant Pump and Axial Fan Characteristic Curves

Flow machines such as coolant pumps (centrifugal pump = radial machine) and cooling air blowers (fan = axial machine) provide the radiator system with deliveries which are extremely dependent on backpressure (suction head) and must be taken into consideration for the overall requirements of the output to be installed.
The formulae (laws of similarity) listed in the formula sheet (see appendix) apply to radial and axial machines in existing systems in the event of speed changes.

In the case of moderate diameter differences (unchanged geometry), the correlations between the dimensions and operating data are given by the laws of proportionality (see appendix).

Considerable noise levels can be anticipated in flow machines of a corresponding size and speed; the formulae listed in the formula sheet apply only to axial machines in the case of outputs between 10 kW and 1300 kW.



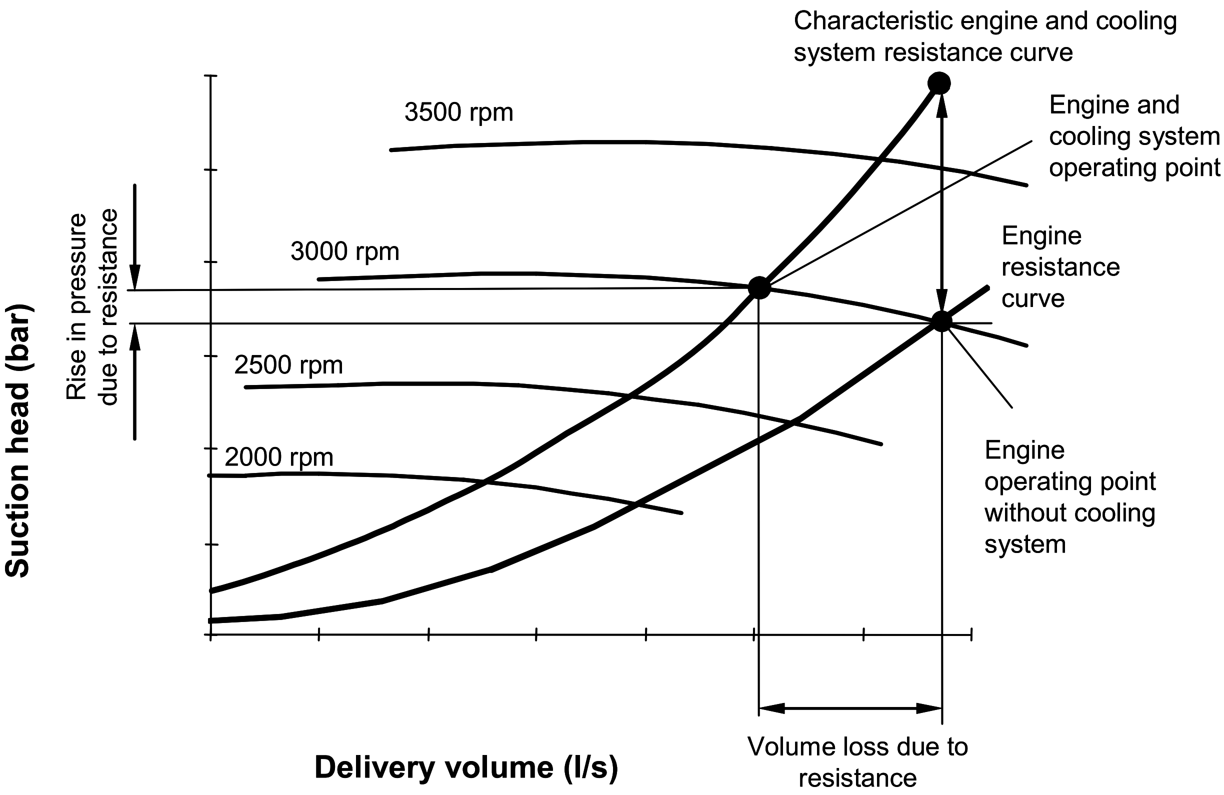
2.4.5 Coolant Pump

The suction head is regarded as the pressure difference between the suction and pressure side of a flow machine. This pressure is required to overcome pipe resistance in the case of a corresponding flow volume. A change in speed causes a change in all characteristic values (flow volume, flow resistance, efficiency, output and noise development). These characteristic values are design-dependent.

The coolant pump's performance map, with the engine's resistance curve entered, is required to design the coolant side. The pressure differences of additionally installed components (radiator system(s), pipes, retarder, etc.) are added in the case of a certain volumetric flow. The new operating point is the point at which the characteristic resistance curve which occurs intersects with a constant speed curve.

If the resistance data are only known for one flow volume, these can be calculated for other operating points using laws of similarity, resulting in a curve for the entire cooling system. The corresponding circulation volume can be read off from this for each coolant pump speed.
For maximum cooling capacity, the gear ratio of the coolant pump should be checked in continuous operation deviating from the rated rpm.

Performance map for a coolant pump with external resistance

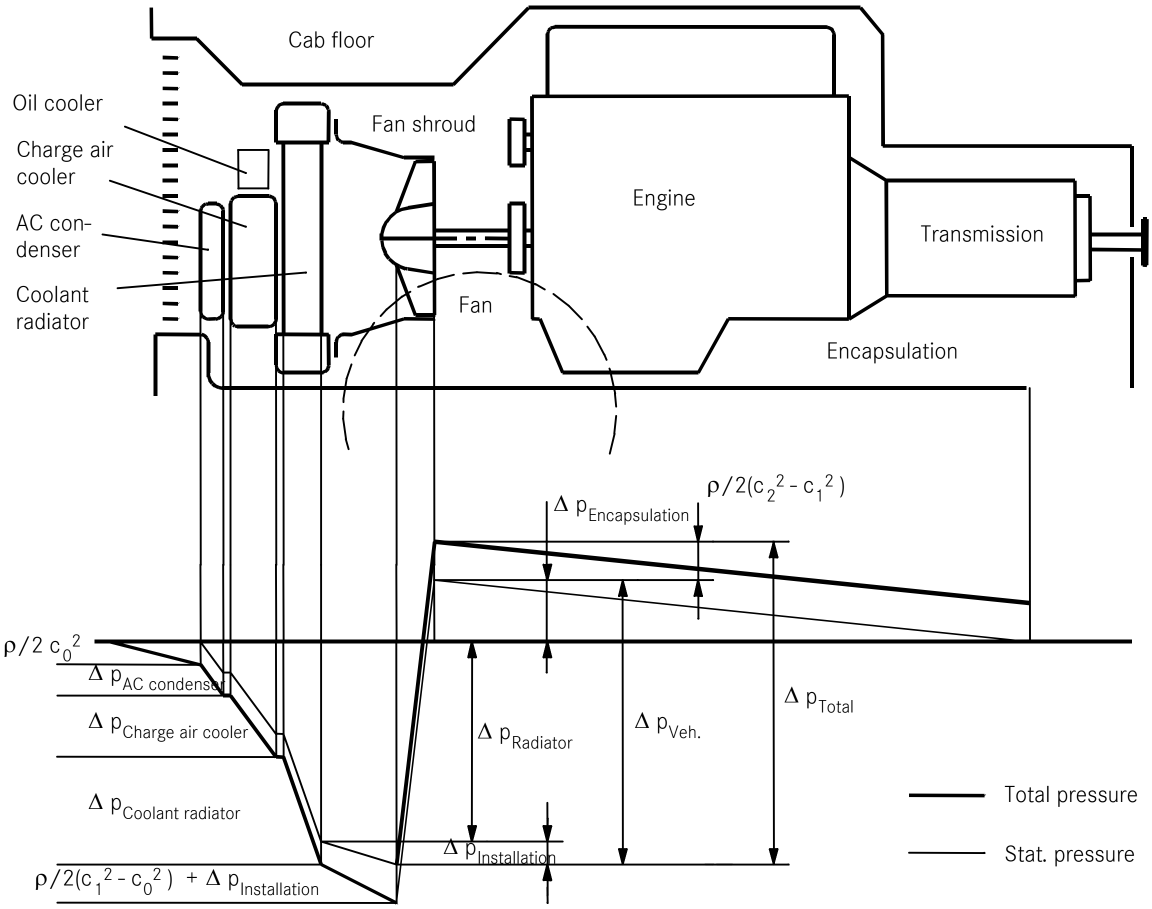


The circulation volume is vital for dissipating the volume of heat on the coolant side

2.4.6 Fan

Outside the cooling systems, an air flow has to be generated by a fan in extreme situations (driving at full-load on gradients and at high ambient temperatures), because this cannot be adequately achieved by the headwind alone.

Schematic pressure conditions when the vehicle is stationary (without headwind speed for suction fans)



In the case of vehicles without headwind flow, the fan must maintain the flow through the cooling systems during all operating stages.

Throttling on the pressure side of an axial fan has a more favorably effect on the characteristic delivery curve than throttling on the suction side. However, higher drive outputs are offset by high technical and financial expenditure.

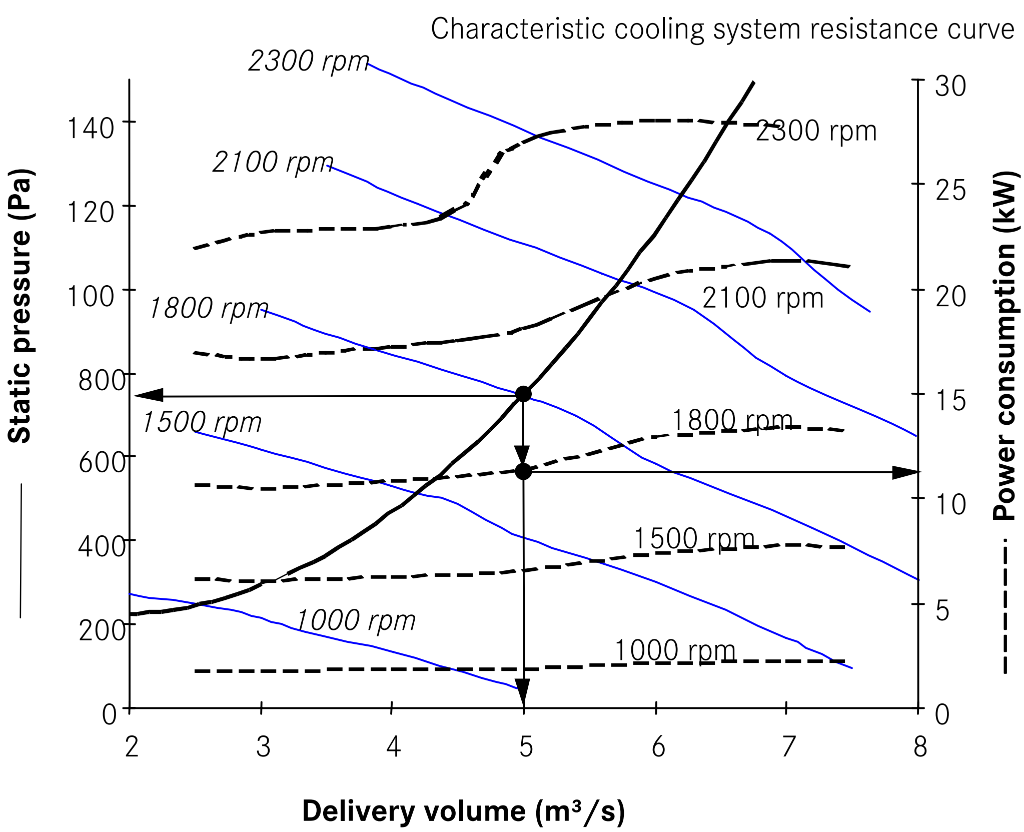
Generally, it must be noted that the power needed by the fan is also taken from the drive unit, which increases the fuel consumption and emission output.

Therefore, fans are usually connected by temperature-controlled clutches, such as viscous couplings, electrically initialized friction clutches as well as hydrostatic clutches. The switching points are to be selected according to our recommendation and examined.

In this case, consideration must be given to the permitted acceleration for the fan during the switching phase. Also, the maximum admissible circumferential speeds of the outer tips of the fan blades (usually max. 100 m/s for short glass fiber-reinforced plastic fans) must be maintained.

If fan drives are mounted on the crankshaft, adequate decoupling from torsional vibrations must be ensured. This can be achieved by a viscous coupling or by special elastomer couplings with a high natural frequency.
With belt-driven fans, adequate isolation is provided by the belt.
Specifically request information regarding fan behavior at low temperatures.
Generally speaking, the efficiency of axial fans is reduced by resistance such as radiator systems on the suction side and clearances between engine and frame, as well as the cab floor and organization of the engine compartment on the pressure side because - typically for axial fans - power consumption increases as throttling increases.
Consequently, maximum importance should be attached to achieving flow in both directions with as little disturbance as possible and with suitable distances between the fan and the radiator and engine so that during normal operation, cut-in frequency is as short and infrequent as possible and there are no disadvantages as regards fuel consumption.

Performance map for an axial fan



A fan performance map is drawn up in the same way as for the coolant pump, but with the restriction that radiator system resistance data have to be obtained from the radiator manufacturer and fan data from the fan supplier.
The appendix contains a corresponding approximation formula for roughly calculating the power required by fans in vehicles with headwind flow.

In general, such designs should only be carried out by qualified specialist companies, particularly as the surfaces of water and charge air coolers and the resistance on the fan side affect fuel consumption and these specialist companies are able to evaluate installation on the basis of their experience.

2.4.7 Transport, Storage and Installation of the Fan

Fans with viscous couplings must be stored and transported in the upright position so that external loads cannot change the design gaps between the viscous drive and output and also to prevent the possible loss of viscous medium.

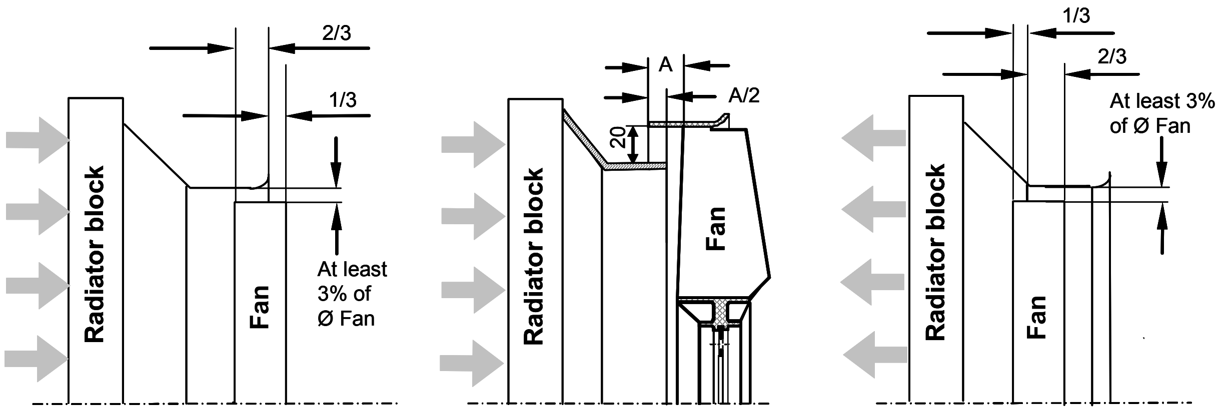
The difference between the maximum speeds on the input side and the drift side with viscous coupling in the connected enterprise is defined as slip, lies between 5% and 10%, and causes heating of the hub. Heat dissipation from the fan hub therefore limits output and must be carried out via outer cooling fins with the fan air flow.

The surfaces of the plastic fans should not be painted, as this affects the balance. Solvents may additionally attack the plastic. For the tenacity relevant absorption and delivery abilities (usually between 5% and 18%), which is important from the point of view of its toughness, may alter considerably during its service life and cause embrittlement.

To guarantee reliable fan operation, a certain gap is needed between the fan and the fan shroud. This gap must be kept as small as possible so that a good level of efficiency can be achieved (fuel consumption).
The gap for engine-mounted fan shrouds can be kept small because it does not change due to relative engine movements. The main disadvantage of this layout is the need for an elastic bellows seal with sufficient vacuum stability between the radiator system and the fan shroud.
With the employment of the radiator-mounted shrouds the axial distances can be minimized and be void the flexible bellows dealings.
One major disadvantage of such designs is the relatively large gap between the fan and the shroud, as settlement of the engine and transmission mounts and the relative movements arising from the load reversal reactions between the vehicle frame and power train also have to be taken into account. A more stable operation can be achieved by the use of jacket fans with high air resistances

The minimum distance for fans from the radiator system should not be less than minimum 1/5th (20%) of the fan diameter and must be central in order to guarantee the formation of acceptable fan air flow; on the other hand, the engine interference contour may be slightly nearer (because it is on the pressure side) in the case of the suction fan.
The minimum distance from axial collision edges (protective grille, engine parts) must be at least 20 mm in the case of suction fans and 45 – 55 mm in the case of pressure fans (when the engine is switch off). This is reduced during operation via deflection of the fan blades as a result of the axial thrust for pressure and suction fans on the suction side.
The installation of a fan to the engine side by the OEM must be examined and/or released by DC specialized division

Depending on installation, protective grilles must be fitted to protect the fan (penetration of foreign objects) and prevent injury as prescribed by the labor safety regulations.



Axial suction fan | Shrouded suction fan | Axial pressure fan

2.4.8 Radiator Installation

The radiator must be protected from the vibrations, shocks and forces generated by the engine and frame. It must therefore be elastically mounted and supported. The coolant pipes must be connected using elastomer connections, as described in section 2.4.9.

The radiator must be installed so that it is protected from external soiling as far as possible and is also accessible for occasional cleaning as required.

An easily removable mesh grille has proved ideal for protecting the radiator against soiling and blockage in critical applications. If it is fitted at an angle, any dirt which has accumulated falls off automatically at low engine speeds and when the engine is switched off.
Whether a pressure fan or suction fan is the right choice depends on the type of vehicle or equipment. Compared with a suction fan, the pressure fan generates a lower air temperature in the engine compartment. It must be noted that the air heats up at the engine and on the exhaust pipe, so that it enters the radiator at a higher temperature. Therefore, the pressure fan either has to deliver a higher volume of air or a radiator with higher performance has to be used.

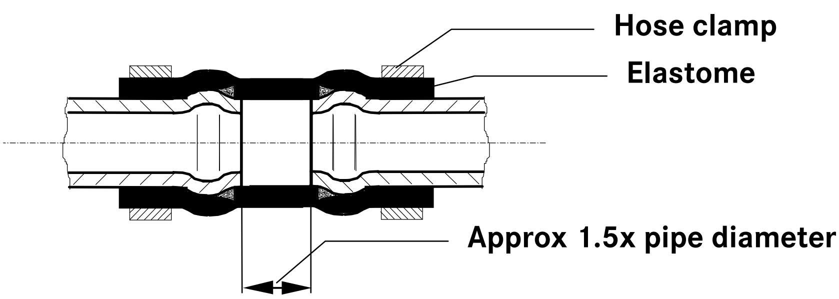
In the case of vehicles and equipment with a cooling system at the front, the air is usually sucked through the radiator from the front by a suction fan and blown back into the engine compartment. From there, the air is removed downwards or sideways.

Vehicles and equipment with a rear-mounted engine may be equipped with a suction fan or pressure fan. The suction fan sucks the air through the radiator and forces it into the engine compartment, from where it is then removed downwards or to the side. The direction of flow is reversed with the pressure fan.

If the radiator is installed at a distance of more than 3 meters from the engine, pipes to and from the radiator require a larger internal diameter. Consultation with DaimlerChrysler AG is required in individual cases.

2.4.9 Coolant Pipes

Coolant pipes must be as short as possible, and must be routed with the minimum diameter specified and without sharp pipe bends (r = 2.5....3 x d).
Pipes which descend from the engine must be vented at their highest point if possible. Venting and filling pipes must be routed with a continuous incline to the expansion tank.
The internal diameters of the coolant pipes must at least correspond to the connection cross-sections at the engine.
Standard, commercially available steel pipes may be used for the coolant pipes. Copper materials are not permitted in the cooling circuit, because these have a detrimental effect on the life of certain engine components.
The ends of all coolant pipes must have beads as specified by DIN 71 550. The pipe ends must be deburred. The pipes must be clean and free from mill scale inside. The pipes must be elastically connected to the connections on the engine with oil-resistant, compression-proof elastomer connections as specified by DaimlerChrysler.
The sleeves must be secured with two hose clamps (screw thread clamps) according to DaimlerChrysler specifications and the pipe end distance should be approximately 1.5 times the pipe diameter.



A drainage point must be provided at the lowest point (or points) of the cooling system. It must be guaranteed that no water pockets remain when the coolant has been drained off. Additional drainage points, to be identified by suitable reference plates, may be necessary.

2.4.10 Expansion Tank

Because of high coolant delivery volumes and the increasingly smaller coolant volumes in the system, satisfactory bubble separation and the enhanced demands on the cooling system can only be achieved by using a separate expansion tank.
The high power density of Mercedes-Benz engines requires a bubble-free cooling system.
The following points need to be taken into account when choosing the expansion tank:

- Operating angle of the vehicle / equipment (design height of the expansion tank)
- Mechanical strength for max. operating pressure and pressure at temperatures of 120°C
- Designing the pipe socket connections with beads as prescribed by DIN 71 550
- System protection 1.0 bar at T_{max} 100 ° C.
- Total tank volume between 20% + 30% of the total coolant volume of the cooling system.
- Content divided into 50% coolant, 50% air volume
- Coolant stock in the tank must be at least 10% of the total coolant volume
- No coolant ejection with hot shut down
- Operation monitoring (e.g.: electric level monitoring)
- Filling limited by position or shape of the filler neck
- UV resistance of plastic tanks continuously exposed to direct sunlight.
- Surge plates in the tank prevent coolant surge when braking, accelerating and cornering.
- The distance between the venting pipe inlet and the filling and expansion pipe must be designed so that no air can penetrate into the filling and expansion pipe; it may be necessary to provide a bulkhead.
- When filling the system, the venting pipes must not be shut off by the coolant (avoid “water lock”).
- Place the filling and compensation pipe as near to the center of the tank floor as possible.

All venting pipes must rise without siphon in the direction of the expansion tank and have a nominal width of 8 - 12 mm and a 4.5 mm diameter throttle in the tank filler neck.

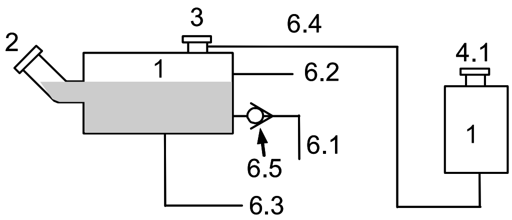
Filler necks and coolant filling and expansion pipes (minimum nominal width 25 mm) must be chosen so that the system can be filled at a minimum rate of 8 - 10 l/min.

The bottom edge of the expansion tank should be above the highest point of the cooling system. The tank must be installed so that easy access is guaranteed for filling and checking.

3 coolant expansion tank systems are illustrated below with their advantages and disadvantages:

System 1

Optimum design
Twin chamber system
(with additional expansion tank)

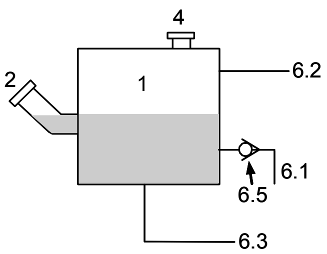


Advantages:

- relatively small main tank, therefore fast pressure build-up to 0.5 bar (good operating reliability in long-term operation)
- Reduced reserve pressure remains if valves 3 or 4.1 fail
- Short engine warm-up time
- The additional expansion tank can be positioned lower than the engine or radiator (favorably with small building area over engine or radiator).

System 2

Simplified version of system 1
Single chamber system



Advantages:

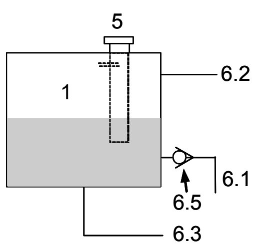
- Short engine warm-up time
- No return flow from the compensation tank to the radiator

Disadvantages:

- Pressure build-up takes much longer
- The entire compensation tank volume must be positioned above the engine or radiator.

System 3

Simple system
Single chamber system



Advantage:

- Simple, cheap construction

Disadvantages:

- Pressure build-up takes much longer
- The entire compensation tank volume must be positioned above the engine or radiator.
- Much longer engine warm-up time
- Over filling the compensation tank is possible, a ventilation bore is therefore required in the pipe socket.

1 Expansion tank, total content 20% - 30% of the coolant volume contained in the complete system, partitioning: 50% air, 50% coolant
2 Filler neck with cap, sealed to the outside
3 Cap, sealed to the outside, with pressure relief valve 0.5 bar and vacuum valve 0.1 bar (cannot be opened)
4 Cap with 1.0 bar pressure relief valve and 0.1 bar vacuum valve (protected against opening).
4.1 Cap with 0.5 bar pressure relief valve and 0.1 bar vacuum valve (protected against opening).
5 Filler neck with cap, with pressure relief valve min. 1.0 bar and vacuum valve 0.1 bar
6 Pipes
6.1 Vent pipe from the radiator NW 8-10 mm (with throttle 4.5 mm)
6.2 Vent pipe from the engine NW 8-10 mm (with throttle 4.5 mm))
6.3 Filling and expansion pipe (min. 25 mm ǿ)
6.4 Expansion pipe to the additional expansion tank, NW 8-10 mm
6.5 Non-return valve (for better heating output)

2.4.11 Coolant Grade

To guarantee adequate corrosion/frost protection, the cooling system must be filled with a mixture of 50% approved corrosion protection/antifreeze (see DaimlerChrysler Specifications for Service Products) and 50% water, which at least corresponds to normal drinking water quality. Coolant according to sheet 325.0/326.0 as well as 325.2/326.2 must be replaced every 3 years, and according to sheet 325.3/326.3 every 5 years, as the corrosion protection deteriorates.
However, it should always be remembered that anticorrosion/antifreeze agents or coolants conforming to sheet 325.3 and 326.3 must not be mixed with those conforming to sheet 325.0 and 326.0 or 325.2 and 326.2.
No improvers may be added. In isolated cases, if no anticorrosion agent/antifreeze is available, and/or no antifreeze is required (tropical countries), an approved coolant additive without antifreeze requirement acc. to Sheet 312.0 of the service fluid regulations must be used, with the following concentration of 10 vol -% + / - 1 vol - %, if not stated otherwise.
In these cases the coolant must be exchanged every year.
The use of released corrosion protection/antifreeze or coolant additives is an integral part of the warranty conditions.
Severe damage must be anticipated on non-adherence to these specifications or if non-released products are used.

2.4.12 Acceptance Points for Additional Systems

In the case of additional systems which influence the cooling system (e.g. retarder, heater, additional radiator, etc.), the position of the connection points and also the pipe dimensions and routing must be chosen so that the engine cooling circuit is not permanently affected either in the warm-up stage or in the operating stage.
In this case, the pressure conditions in the system must be taken into account in all operating modes.
We recommend a visual inspection of the installation and a cooling output measurement by our specialist personnel.
Cooling systems in which the hydraulic cooler is located in the air stream between the radiator and the intercooler (side-by-side cooling systems), and which are to be operated with a fan having a standard DaimlerChrysler viscous fan clutch**, are not accepted by DC**.
The viscous fans used as standard by DaimlerChrysler are configured for a cooling system in which the radiator and intercooler are positioned in series in the air stream, thereby ensuring that the appropriate temperature for control of the viscous fan clutch always prevails.
Control of the viscous fan clutch is not possible as required in the case of side- by- side cooling systems where the hydraulic cooler is located between the radiator and the intercooler, as the air extracted from the hydraulic cooler is usually colder than the air extracted from the radiator and intercooler. Owing to the low level of heat from the hydraulic cooler, the viscous fan clutch sets inadequate fan speeds and therefore increases the operating and charge air temperatures unacceptably.

2.4.13 Engine Preheating/Holding Mode

If the engine is to immediately deliver its full output after starting, the outside temperature should be no lower than 15° C.
If adherence to this condition is impossible, the coolant must be preheated. An electric pre heater, which is fed by the existing electrical supply network whilst the engine is turned off, is suitable for this.
Medium and heavy-duty inline engines offer the option of installing a coolant pre heater
- available as special equipment (SA) - in the engine block. An external pre heater - available from various manufacturers - must be used for model series 500. The pre heater must be installed in the cooling circuit.
The heater is either controlled by a temperature switch set to a water temperature of around 40°C or must be in-regulate to keep the water at a temperature between 40° C and 60° C. This constant state must be determined in measurements. A heater with adjustable heater output is recommended in this case.
Water circulation generally occurs independently due to lift on heating the coolant (thermal siphon effect). A special circulation pump is not normally required.
The coolant heated by the heater should enter the engine at its highest point via an ascending pipe, be distributed over the cylinder heads and sink in the engine housing. Via a point at the bottom of the engine, the coolant is fed back to the pre heater and flows back into the circuit.

To obtain good cross-flow for the heated coolant at the engine block, the coolant should enter at the rear left retarder fitting on the engine and exit at the coolant drain fitting upstream of the coolant pump.
Hoses with at least NW 16 mm ǿ are used as connection pipes (engine to heater unit connection). The unit must be installed as low as possible to achieve the greatest possible recirculation effect. The coolant pipes must not contain any tight pipe bends. The connection pipe from the pre heater to the heater connection must ascend.
A non return valve is required at the engine outlet. This prevents the coolant from being short-circuited by the pre heater pipes when the engine is running. Circulation in the opposite direction is also possible with slightly lower preheating.
The temperature switch must be installed in the return pipe from the engine to the pre heater.
According to the engine's use, installation-specific requirements, e.g. vibration strength, must be observed.

2.4.14 Engine Compartment Ventilation

Flawless operation requires that the heat emitted by the engine, the exhaust pipes and the driven equipment can be passed to the ambient air in the engine compartment and dissipated from the compartment. In the majority of cases, natural air circulation due to fan air exchange is sufficient. In individual cases (e.g. radiators outside of the engine compartment), forced ventilation is necessary.
The air forced through the radiator by the fan must be able to flow off without hindrance. The flow of cool air from the fan enables good engine compartment ventilation and avoids heating and heat build-up. The exhaust manifold, in particular, should lie within the air flow.
Positive and negative deviation from engine ambient temperatures of + 100° C and - 40° C must not occur.
Adequate engine compartment ventilation is particularly required in the case of encapsulated engines as, besides the above mentioned parts which conduct exhaust gas, fuel lines, wiring harnesses, sensors, seals and belt drives, etc. are at risk of failure at temperatures in excess of + 100° C.
Surface temperatures up to 750° C may occur at parts which conduct exhaust gas (exhaust manifold, turbocharger, etc.)

2.5 Fuel

2.5.1 Diesel Engine

According to the ordinance regarding combustible liquids (VbF), diesel fuel belongs to hazard class A III. The fuel grade must meet the requirements listed in the Specifications for Service Products.
Mercedes-Benz diesel engines are designed for diesel fuels which meet the relevant national and international requirements (EN 590 in Europe). At temperatures below 0°C, winter fuel (Specifications for Service Products, sheets 137.0 and 137.1) which has a lower viscosity at low temperatures must be used.
If this is not available, flow can be improved by adding a max. 50 % petroleum (kerosene). The durable admixture of petroleum is not permissible
The use of gasoline is prohibited due to reasons of poorer fuel lubrication capability and safety reasons (lower flash point)

- **Bio diesel**

Bio diesel may be used as an alternative to diesel.
3 abbreviations are used to describe bio diesel

FAME	Fatty acid methyl ester Generic term to be used in EU standardization EN 14214
PME	Vegetable oil methyl ester Generic term previously used in German-speaking regions
RME	Rape methyl ester Bio diesel made from rapeseed oil

Since the introduction of EU standardization, bio diesel is basically referred to as “FAME“

The model series 500, 900, as well as OM 457/460 engines have been released for operation with FAME. The vehicle's fuel filter, standard fuel lines and seals must be replaced with ones which are resistant to FAME.
The hygroscopic behaviour of FAME leads in the operation to water portions which should be separated.
An inadequate supply of this fuel (often only provisional filling stations) in various areas leads to an increased risk of dirt entrainment and water in the fuel. For this reason it is to be inserted necessarily a pre-screener with water trap
This water would lead with renouncement of water separation to damage to the injection system, would lead to oil sludging, and thus the engine would destroy

The FAME must comply with DIN EN 14214. Operation with lower-grade fuel may lead to damage and malfunctions. DaimlerChrysler AG bears no liability for irregularities or damage arising as a result of lower grade fuels.

FAME or diesel fuel may be used as desired. The different FAME and normal diesel fuel mixtures which occur in the vehicle's fuel tank are harmless. In Germany, mixing FAME and normal diesel fuel outside of the vehicle's fuel tank is, apart from the tax aspects (subsequent taxation), not permitted.

The DIN EN 14214 standard demands the following low-temperature stability for FAME

15.04. – 30.09.	0°C
01.10. – 15.11.	- 10°C
16.11. – 28.02.	- 20°C
01.03. – 14.04.	- 10°C

Fuel preheating is required in the event of insufficient low-temperature stability or low ambient temperatures. The addition of flow enhancers for diesel fuel or petroleum additives does not change the low-temperature stability of FAME.

We essentially reject the use of pure vegetable oils as an alternative to diesel fuel due to negative experience (engine damage due to coking, deposits in the combustion chambers and oil sludging).

Engine oils according to MB Specifications for Service Products sheet 228.5 or 228.3 are preferable for use in FAME operation.
Via pistons and cylinders, a certain percentage of fuel always finds its way into the engine oil. Due to its high boiling point, FAME does not evaporate and is retained in full in the engine oil.
In both pure FAME and in mixed FAME–diesel operation, the engine oil and filter change intervals must therefore be reduced in comparison with the normal interval.(Request current intervals within the various model series from the sales department). The fuel filter must be replaced each time the engine oil is changed.
An extension of the engine oil change intervals with FAME operation is possible for special versions. The engines must be equipped with the special versions corresponding to code MK21 (ZPD unit pump) and code MK04 (fuel pre filter with heated water separator).

Suction Height / Tank / Tank Strainer

When installing the tank, make sure that it is clean and that it contains no machining residue or dirt, water, etc.
The fuel feed pump attached to the engine has a suction height of 1.5 m. As a result of this, the bottom of the fuel tank may be located max. 1.5 m below the fuel feed pump. An electric fuel pump is needed for greater suction heights and must be installed at the lowest point near the fuel tank. The delivery rate must be at least that of the fuel pump attached to the engine, otherwise an engine power lost is to be expected; if necessary install a small buffer tank at the level of the engine.
When starting a model series 900 engine after running the tank empty, the attached fuel feed pump delivers so much fuel that the engine starts after approx. 50-60 sec. In all applications involving an increased base load or operation at great altitudes or extremely low temperatures, a manual fuel feed pump must be provided, as the starting process exceeds the battery's capacity.

Fuel should be withdrawn approx. 30 to 50 mm below the bottom edge of the tank via a 300 μm coarse tank strainer. If the fuel return and removal points are close together in the tank, this reduces the risk of jellification at the suction point at low temperatures. Due to the heated fuel return, the temperature is higher than in the rest of the tank in the case of an appropriate tank strainer flow geometry.
A recess on the bottom edge of the tank prevents sludge deposits and condensation from mixing with the fuel again. A sludge drain must be provided at the lowest point.
Tank for additional fuel AdBlue for the BlueTec technology - see section 3.3.8 - AdBlue tank.

- **Quality / Filter / Pre filter**

With the introduction of fuel injection systems equipped with electronically controlled solenoid valves, the fuel purity requirements have risen. The fuel filter elements therefore have a higher separation rate and filter gage.
Filtration is carried out using a pre-filter with a 10 - 30 µm mesh, which is either integrated into the engine (model series 900) or has to be attached to the vehicle, and a main filter integrated onto the engine. Measured according to ISO/TR 13353 (1994), the filter fineness is

Degree of separation: at 3 – 5 µm > 95 %

As fuel cleanliness is not always guaranteed due to varying fuel storage in different operating regions, condensation / deposits may occur. Installing a pre-filter with a water separator is vital in these regions in order to extend the life of the filter.
DaimlerChrysler recommendation: in principle insert a pre filter with water separator

Selection of the pre-filter should be based on the following criteria:
-- For necessary servicing work, the filter must be located in an easily accessible and visible place.
-- The strainer should have a 10 - 30 µm mesh.
-- The container should be transparent (level of contamination visible).
-- Option of connecting pipes with a nominal width of 10 – 12 mm.
-- Integrated water separator, shutoff valve, manual fuel feed pump should be available.
-- If necessary, (continuous use < 15°C ambient temperature) give consideration to a pre heater.

In cooperation with companies Racor and Mann & Hummel, a pre filter has been developed specifically for the separation level, rated flow, service life, etc. requirements of the specified engine model series.

Racor type 490R-D-MB-06
With fuel pre heating**, manuel fuel feed pump** Part number: 000 470 04 69
and shut off valve (cartridge replacement)

Mann & Hummel Pre Line (without shut of valve)
With fuel preheating Part number 000 470 09 69
Without fuel preheating Part number 000 470 08 69

Technical data:
- Installation length 380 mm
- Fastening flange grid dimension 50 mm, 13 mm Ø
- Connecting thread for fuel M 16X 1.5

There must be no pressure when the fuel filter is opened (open the tank cap if necessary).
Corresponding instructions and service intervals are specified in the engine operating instructions / service manual.
Filter for the AdBlue fuel, see to section 3.3.7 - pump module / supply unit AdBlue.

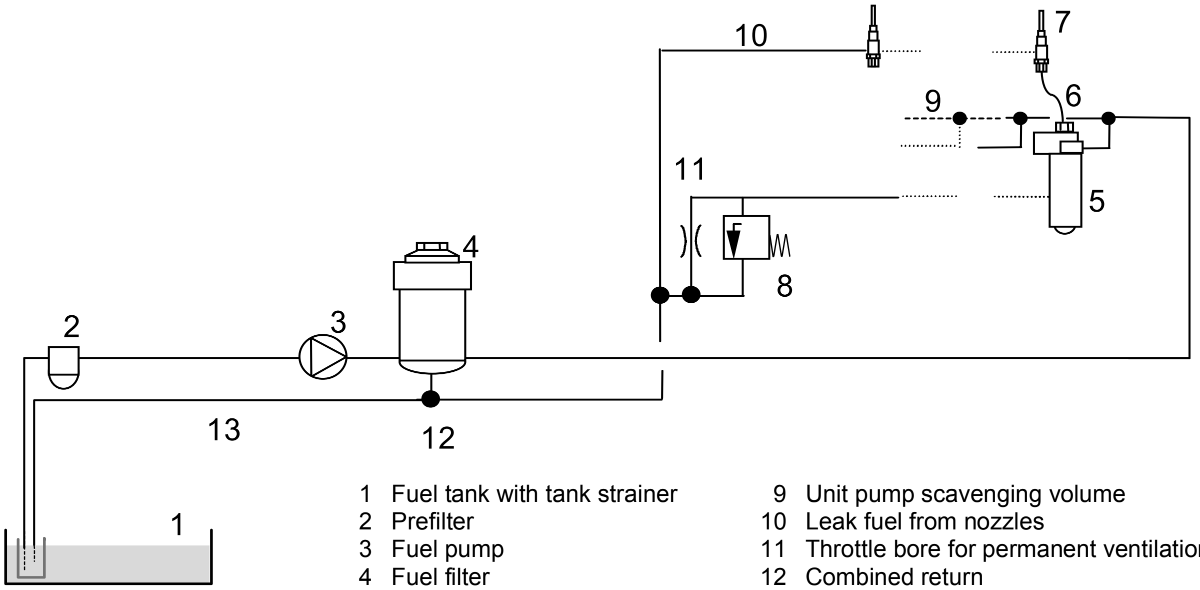
- **Pipes / Connections**

The pipes leading from the fuel tank to the engine (pre-filter) must be designed as scale-free steel or plastic pipes, i.e. polyamide 11, abbreviated to PA in accordance with DIN 7728, or as hoses. Steel pipes may have to be used, depending on the ambient temperature in the engine compartment.
On engines with fuel cooler on the PLD (pump-line-nozzle) / MR 2(engine control) it must be ensured that they are electrically isolated if steel tubes are used. We recommend that elastomer hoses (polyamide or rubber hoses) are used for some sections.
The steel tubes are to be connected preferentially by light pipe joints with conical nipple. Heavy and middle hydraulic screw connections should be if possible avoided, since thereby flow narrowing are produced. For plastic tubes and hoses fir tree connections are used. Elastomer hoses must be fastened with clips on the pipe unions

The fuel hose must be pressure -, vacuum -, temperature -, oil/fuel -, and aging-resisting. The hose must be finished fabric-wrap or with woven fabric inlay.
The position and dimensions of the connections are shown on the corresponding engine installation drawings.
The pipes must be routed so that they are protected against mechanical and thermal influences.
The diameter of the fuel pipe from the fuel tank to the engine and from the engine to the fuel tank must be at least NW 10 mm ǿ ; however, pipes over 6 m in length must have a diameter of at least 12 mm. ǿ.
Throttles (narrowing of the cross-section) due to unsuitable connections must be avoided in the fuel supply and return pipes under all circumstances. The pipes must be routed so that the prescribed intake pressures in the fuel intake pipe are not exceeded.
When the fuel filter is opened, the fuel contained in the cup must run back into the tank. If this cannot be ensured, a draining device must be attached to the fuel filter and a note made on the engine and in the operating instructions referring to this device.
Lines and connections for AdBlue see to section 3.3.10 - AdBlue supply lines.

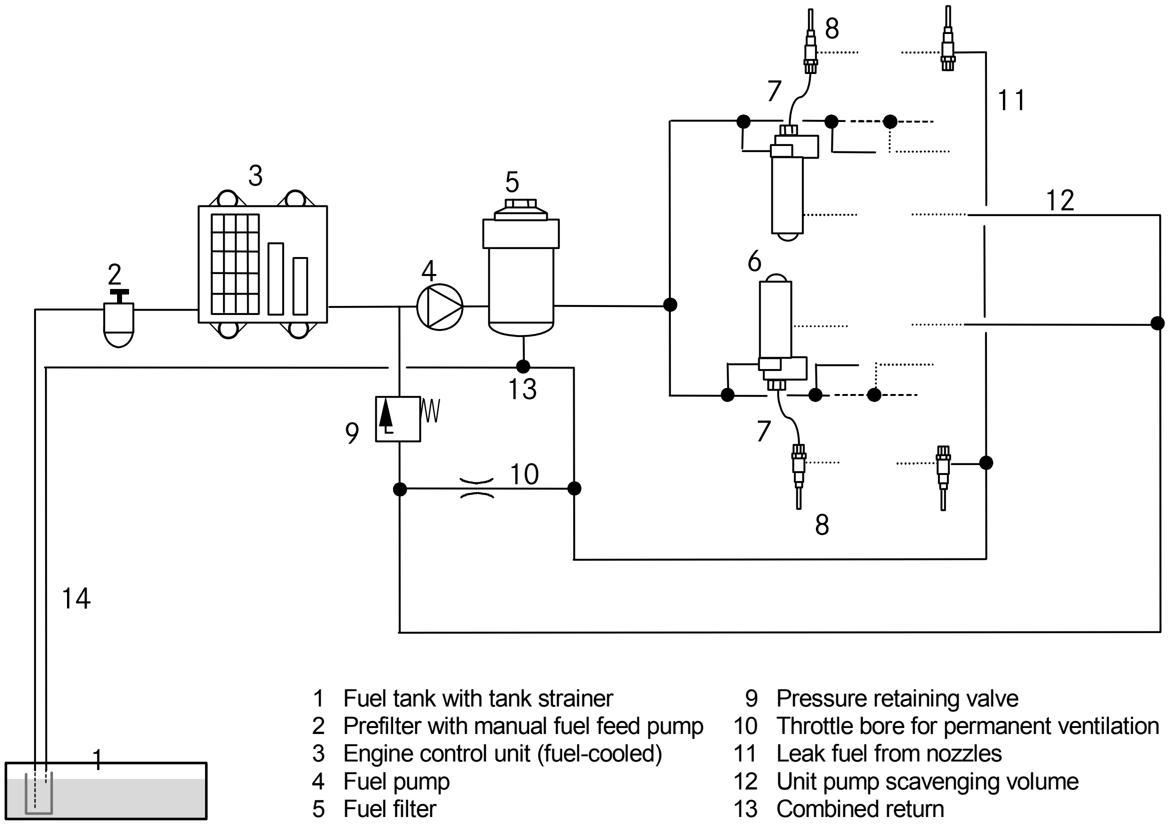
- **Fuel schematics**

Fuel schematic for model series 900



1 Fuel tank with tank strainer
2 Prefilter
3 Fuel pump
4 Fuel filter
5 Unit pumps
6 High-pressure pipes
7 Injection nozzles
8 Pressure retaining valve
9 Unit pump scavenging volume
10 Leak fuel from nozzles
11 Throttle bore for permanent ventilation
12 Combined return
(incl. filter drainage pipe for servicing and filter ventilation)
13 Return to the tank

Fuel schematic for model series 500



1 Fuel tank with tank strainer
2 Prefilter with manual fuel feed pump
3 Engine control unit (fuel-cooled)
4 Fuel pump
5 Fuel filter
6 Unit pumps
7 High-pressure pipes
8 Injection nozzles
9 Pressure retaining valve
10 Throttle bore for permanent ventilation
11 Leak fuel from nozzles
12 Unit pump scavenging volume
13 Combined return
(incl. filter drainage pipe for servicing and filter ventilation)
14 Return to the tank

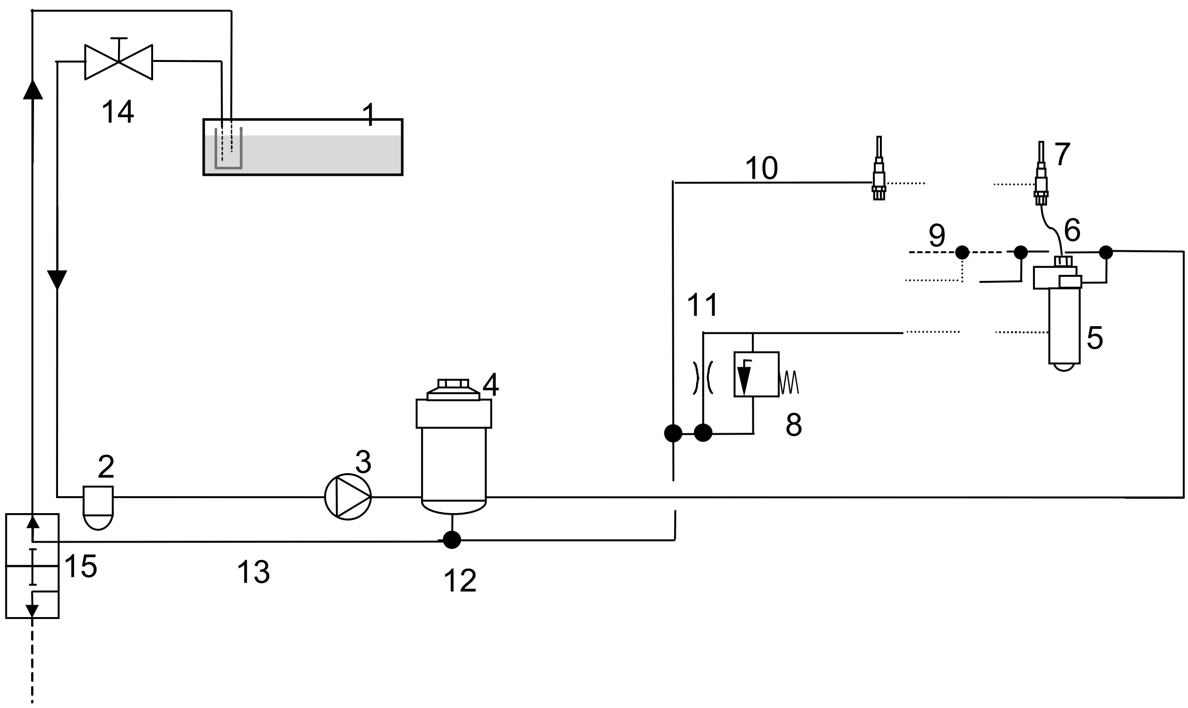
- **High-mounted Fuel Tank**

Definition:
If the top edge of the fuel tank or the highest point of the fuel pipe connections is higher than the bottom edge of the fuel filter on the engine.

In the case of a high-mounted fuel tank, a fuel-resistant “3-way valve“ with L bore (e.g. ARGUS three-way block ball valve, series 349, type DBK, with a nominal width corresponding to the fuel pipes) must be installed at the lowest point of the fuel return pipe. This 3-way valve must be installed so that it guarantees free passage from the engine to the fuel tank in the operating position. In the service position, however, the pipe to the fuel tank must be blocked and the pipe from the engine open to allow the fuel filter housing to drain. To simplify servicing, a hose may be installed on the outlet side so that the draining fuel can be easily collected in a container.

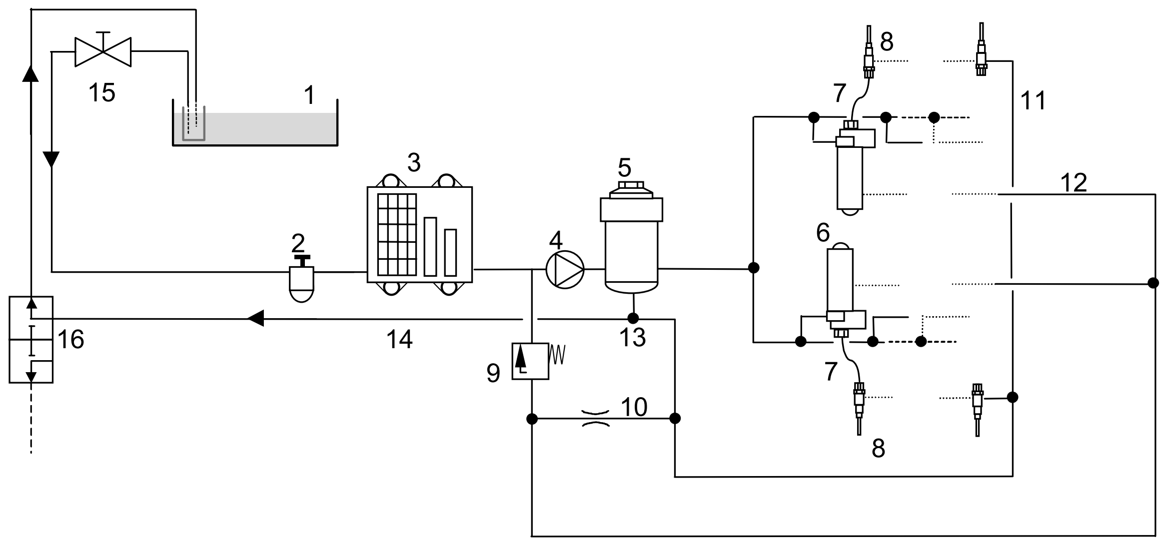
To prevent fuel from flowing on when the fuel filter is open during filter servicing, a simple shutoff valve must be installed in the fuel intake pipe, and must remain closed during filter servicing. On installation of the shutoff devices, it must be ensured, under all circumstances, that the nominal width of the shutoff device is not less than the nominal width of the fuel pipe.

Fuel schematic with high-mounted fuel tank for model series 900



1	Fuel tank with tank strainer	11	Throttle bore for permanent ventilation
2	Pre filter	12	Combined return (incl. filter drainage pipe for servicing and filter ventilation)
3	Fuel pump	13	Return to the tank
4	Fuel filter	14	Shutoff valve (for filter servicing only)
5	Unit pump	15	3-way valve (must be installed at lowest point of the fuel return pipe)
6	High-pressure pipes		
7	Injection nozzles		
8	Pressure retaining valve		
9	Unit pump scavenging volume		
10	Leak fuel from nozzles		

Fuel schematic with high-mounted fuel tank for model series 500



1	Fuel tank with tank strainer	11	Leak fuel from nozzles
2	Pre filter with manual fuel feed pump	12	Unit pump scavenging volume
3	Engine control unit (fuel- cooled)	13	Combined return (incl. filter drainage pipe for servicing and filter ventilation)
4	Fuel pump		
5	Fuel filter		
6	Unit pumps	14	Return to the tank
7	High-pressure pipes	15	Shutoff valve (for filter servicing only)
8	Injection nozzles	16	3-way valve (must be installed at lowest point of the fuel return
9	Pressure retaining valve		
10	Throttle bore for permanent ventilation		

2.5.2 Gas Engine

- **Natural gas – C-N-G (Compressed Natural Gas)**

Natural gas is the fossil fuel with the highest hydrogen and the lowest carbon content. Accordingly, the use of natural gas in motor vehicles causes far less environmental pollution than comparable operation with gasoline or diesel fuel

Adherence to the following characteristic natural gas values is vital for use in Mercedes-Benz gas engines

Characteristic values	Minimum	Maximum
Density	0.72 kg/m^3	0.83 kg/m^3
Calorific value	40 MJ/kg	50 MJ/kg
	33 MJ/m^3	37 MJ/m^3
Minimum air requirement	13.5 kgL/kgBr	17.2 kgL/kgBr
	8.5 m^3L/m^3Br	11 m^3L/m^3Br
Methane number	> 75	

- **Gas Supply System**

The gas supply system in CNG engines is comprised of a high-pressure system including tank system with a gas pressure of up to 200 bar and a low-pressure system of up to 8.3 bar. Reduction of the gas pressure from the variable tank pressure in the high-pressure system to an almost constant operating pressure in the low-pressure system is carried out by a pressure regulator.
Due to technical safety reasons, the high-pressure system must be vehicle-mounted.
The natural gas system is subject to special technical safety requirements and therefore requires acceptance according to the relevant national and international regulations

In order to make use of the M 906 LAG gas engine as extensive as possible, those parts of the high-pressure system required for gas processing and those parts of the low-pressure system not required for mixture formation have been comprised to form a compact gas control unit module, which is supplied together with the gas engine. The parts of the low-pressure system required for mixture processing have been integrated into the charge air housing.
(The gas high-pressure system is not supplied by DaimlerCrysler AG and is the responsibility of the vehicle manufacturer).

- **Tank**

When installing the high-pressure tank, make sure that it is clean and that it contains no machining residue or dirt, water, etc.

Observe the vehicle/tank/system manufacturer's guidelines/regulations.

- **Gas Filter**

Since the various countries cannot always ensure properly clean gas, a commercially available gas filter must be installed in the high-pressure circuit.
The filtration efficiency of the filter should be 0.3 – 0.6 µ > 99.9%.
It is absolutely necessary that oily water emulsions be separated by the filter, collected in the filter bowl and drained if required.

- **Pipes / Connections**

The pipes from the high-pressure tank to the vehicle-mounted gas control unit (high-pressure system) must be designed as seamless, stainless steel pipes, 12x1.5 in material 1.4571 according to DIN 17458 and DIN 2391 Parts 1 and 2. The steel pipes must be connected with SWAGELOK threaded pipe connections.
Note: A pressure relief valve must be installed upstream from the gas pressure regulator (slow reduction of pressure must be ensured) for depressurizing the gas pressure regulator for the removal.
From the gas control unit to the engine (low-pressure system), a SWAGELOK SS-PB-8 hose must be used; this must be routed sufficiently loosely to compensate all relative movements without material deformation. The maximal length of the hose must not exceed 1.5 m. The hose and gas pipe system are connected using the SWAGELOK SS-PB8-TM12 fir tree connection. The steel pipes and hose connections must be connected using SWAGELOK threaded pipe connections. Installation must be carried out according to SWAGELOK regulations (see address list).
The pipes and hoses must be routed so that they are protected against mechanical and thermal influences.

- **Gas Control Unit**

The gas control unit contains all assemblies required for gas processing.
It electrically opens the gas supply to the pressure regulator on starting the engine; it regulates the gas pressure (tank pressure), which fluctuates between 30 and 200 bar, in the high-pressure system to a constant operating pressure, which can be varied by means of compressed air initialization from 2.3 bar at idle speed to 8.3 bar at rated output, and ensures that the gas injection valves integrated into the engine are protected via a safety valve (pressure relief valve).
To avoid unacceptable pressure fluctuations in the pressure regulator, care must be taken when configuring the drive train to ensure that the engine speed does not fall more than a maximum of 100 rpm below the permitted idling speed at any operating point.

The gas control unit is equipped with a safety valve, which blows off the surplus gas if the pressure in the low-pressure system is too high. To do this, the gas control unit is fitted with a fir tree connection for a hose with a nominal diameter of 12 mm. The hose must be routed so that the gas is dissipated upwards into non-critical areas (outside of the actual engine compartment).

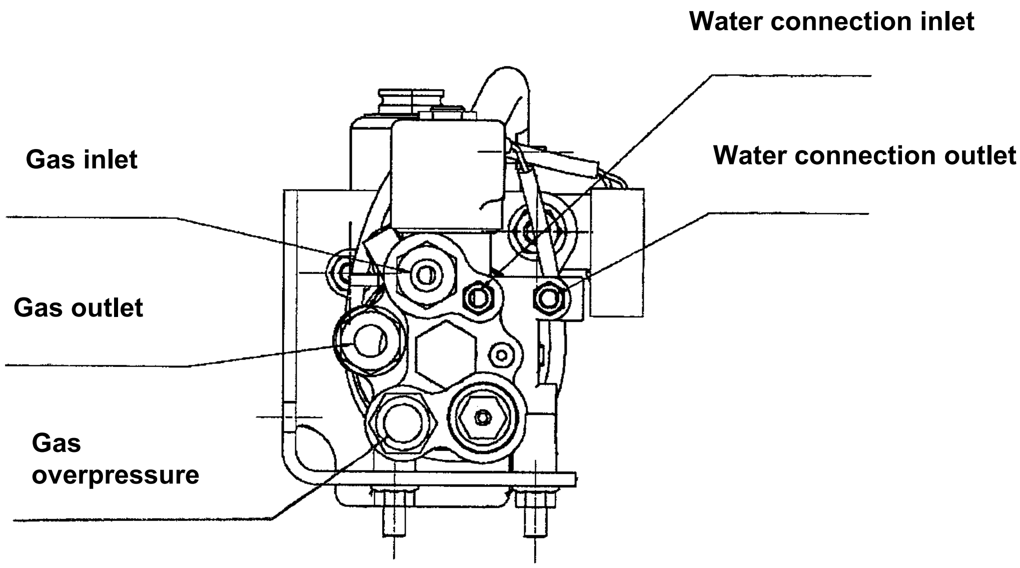
Owing to the heating of the pressure regulator, the gas controller must be connected to the coolant system of the engine on the air compressor output side using a double hollow screw or a double ring piece with a two-way fitting. The return flow to the intake side of the water pump is enabled by a double ring piece; for this purpose tensioned connectors for hoses with a nominal diameter (hose inside diameter) of 8 mm are attached to the gas controller.
To ensure sufficient heating of the gas controller, the following water flow rates (measurable at the engine inlet of the return line) must obtain.

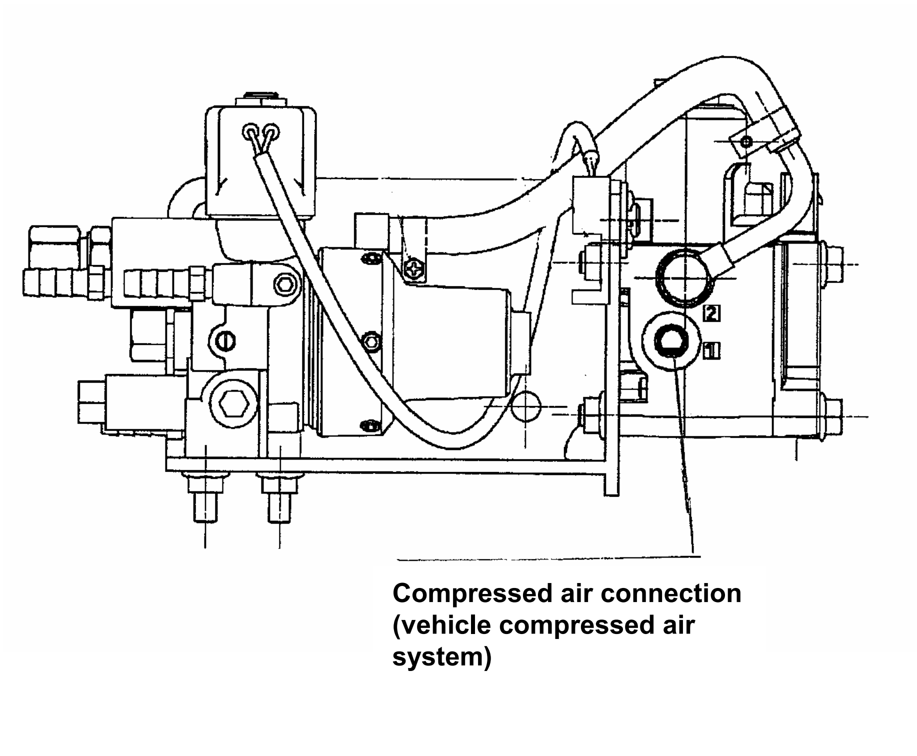
Engine speed	approx. l/h
600	18
1000	40
1500	80
2000	110
2500	135

The gas control unit is supplied with compressed air by the vehicle's compressed air system.

On installation of the gas control unit, protection against mechanical and thermal influences must be ensured. The gas control unit must be installed horizontally, whereby the solenoid valve must not be installed pointing down.

Gas control unit drawings





2.6 Extreme Cold Starting Mode

Cold starting mode without a corresponding pre heater is only basically permissible if full output is not required from the engine immediately after starting. If this prerequisite is not given, corresponding pre heaters must be installed at air temperatures below -15° C, see section 2.4.13.

Three basic prerequisites must be met for cold starting at extreme temperatures.
- The fuel must be free-flowing
- The engine oil must be free-flowing
- The compression temperature required to ignite the diesel fuel must be reached.

The following points must generally be noted for starting and operation at extremely low temperatures:

- **Fuel System**

The Fuel System must be hermetically sealed; already small leakages can lead to starting problems.

Use low-temperature-resistant fuel.
Depending on the operating region and ambient temperatures which occur, special winter diesel fuels with improved low-temperature flow behavior must be used.
If corresponding special winter fuels are not available, flow capability can be improved by adding petroleum (max. 50 vol %) or flow improver. (Information on released flow improvers is available from any DC Service Station).
Durable admixture of petroleum is not permissible
Gasoline must not be mixed with the diesel fuel (see operating instructions).
Starting assistance such as ether or Start Pilot, etc. is prohibited.
Fuel suction pipe of the tank and return at least 30-50 mm above the tank floor.
The fuel tank must have a drainage facility.
The filler neck must be fitted with a strainer.
The fuel system must be sufficiently insulated.
Steel pipes with an increased diameter must be routed in straight lines wherever possible.
Flame-proof pipes must be used for the elastic links between the pipes routed on the frame and the fuel connections on the engine.
Wherever possible, cross-section constrictions must be avoided at connection points with threaded connections.

AdBlue System

For the perfect function of the AdBlue system at low temperatures, a heating of the whole AdBlue system is necessary, see section 3.3.3 and 3.3.9.

- **Flame Starting System/Grid Heater (Option)**

To shorten the starting time and reduce white smoke emissions on cold starting and in the subsequent warm-up phase, the combustion air is heated in the charge air pipe downstream of the charge air cooler. A flame starting system or grid heater is used to do this.
The flame starting system/grid heater switches on automatically on negative deviation from a specified temperature and remains on after starting until the engine runs without misfiring and without white smoke.
The starter and battery are additionally protected by shortening the starting time.

The wiring (supply line) of the grid heater must come directly from the battery. The line thickness (cross section) depends on the version (current consumption) of the grid heater. The control line is via PLD / MR 2 or ADM.

- **Electrical System**

MB series production starters are suitable for use at temperatures down to - 30° C with starting assistance; for lower temperatures, a starter with higher output can be assigned via a code.

Cold starting capability of the engine without starting assistance (flame starting system/grid heater) and 75% battery state of charge.

Vehicle electrical system	Model series 900	Model series 500 OM 457/460
12 V	- 12 ° C	- 18 ° C
24 V	- 20 ° C	- 20 ° C

Below these temperatures, a flame starting system or grid heater and batteries with increased low-temperature test current must be fitted.
If the engines are operated at high altitudes or with a hydraulic system, only the grid heater must be used as starting assistance.

- PTO
The PTO must be disengaged during starting. If this is impossible in the case of hydraulic systems, low-viscosity or preheated hydraulic fluid must be used in the internal circuit to keep cranking resistance to a minimum.
If the hydraulic fluid cannot be heated, the min. cold starting temperature is increased by + 5° C.
A more powerful starter and a battery with a higher low-temperature test current may be necessary.

- Engine Oil

Only suitable, low-temperature-resistant engine oils with a viscosity of 5 W 30 are approved for ambient temperatures below – 20° C (see Specifications for Service Products).

- Coolant

50% fresh water mixed with 50% released corrosion protection/antifreeze is the prescribed coolant – see Specifications for Service Products – guaranteeing frost protection down to – 37°C.

- **Coolant Preheating**

Depending on operating conditions and the relevant, minimum temperatures which occur, the coolant must be kept warm or pre heated prior to starting, see section 2.4.13.

- **Elastomer Parts**
-
The elastomer parts required for engine installation, e.g. engine mounts and coolant hoses (DC series production parts) are suitable for operation down to – 50° C.
This does not apply to standard hydraulic cylinders, viscous fan couplings and V-belts. When the devices are switched off and no dynamic requirements are made on the elastomer parts, storage temperatures down to – 60° C are permissible.

- Fans

Plastic fans may only be used at extremely low temperatures as of – 30° C with the approval of the fan manufacturer.
As of – 40° C, viscous fans with special rubber hubs must be used.
The precise designs must be clarified with the fan manufacturer.

- **Engine Brake**

As of – 40° C, special low-temperature-resistant working cylinders with corresponding seal materials must be used.

2.7 Lubrication

Mercedes-Benz diesel engines have pressure feed lubrication and a wet sump, i.e. the oil pan is also the lubricating oil tank.
Generally speaking, Mercedes-Benz diesel engines are equipped with a vertical oil filter attached to the engine. When the engines are installed, it must be ensured that the lubricating oil filter and the oil drain plug in the oil pan are easily accessible. If the oil drain plug is not easily accessible, we recommend extracting the oil via the dipstick tube.

Corresponding oil pan designs must be used for vehicles operated at extreme angles. Ask DaimlerChrysler AG about availability.

If oil sumps with oil level sensors are fitted, it must be ensured that the sensors function correctly in engines in the approved oblique positions only.

2.7.1 Lubricant Grade

The oil grades specified in the Specifications for Service Products must be used. This is an integral part of the warranty conditions.

2.7.2 Automatic Oil Replenishment

If an automatic oil replenishment system is used, it must be ensured that the connecting hoses to the oil tank on the vehicle side are routed without kinks and chafe points, and are positioned sufficiently far away from hot engine parts (e.g. exhaust manifold).
The hose qualities used must comply with DaimlerChrysler specifications. Ensure that no dirt or machining residue enters the oil circuit. Installing an additional oil filter upstream may be necessary.

2.8 Combustion Air System

Essentially, an engine's output is determined by the combustion air volume, which is influenced by air temperature, air pressure and intake air resistance and also the flow resistance of the charge air cooler.
The intake vacuum, the resistance of the charge air cooler and also the exhaust gas backpressure influence the engine’s gas cycle, and therefore its output, fuel consumption, exhaust gas temperature and emissions as well as the engine’s response when accelerating, see section 2.9 .

2.8.1 Filter Design

The aspirated combustion air always contains impurities. As impurities cause increased wear and therefore reduce the life of the engine, the combustion air must be adequately filtered. The use of a dry air filter is recommended for this purpose. It guarantees a uniformly high degree of dust separation in all load ranges.
With coarse test dust AC, the filter system's level of separation must be 99.9%.
All the information provided here relates exclusively to the use of dry air filters.

Oil bath air filters must not be used in Mercedes-Benz engines!

Pulsation in the suction pipes can be ignored in supercharged engines.

The combustion air requirements are given in the technical specifications for the engine concerned.
Dry air filters must be designed so that, when new, the intake air resistance of the entire air intake system meets the value specified at the rated engine speed and full-load.
The flow resistance increases as contamination increases. Consequently, the engine output is only guaranteed if, when the filter is contaminated, the maximum permissible intake vacuum (static) of 55 mbar is not exceeded downstream of the filter and as close to the engine as possible at rated engine speed and full-load.
The intake vacuum must be measured upstream of the turbocharger inlet at the engine connection point at rated engine speed and full-load.
The specific limit values for the relevant engine model must be observed.

As the paper air filter's flow resistance rises as paper cartridge contamination increases, installing a service indicator to monitor the intake vacuum is necessary. This is positioned on the clean air side. A corresponding connection is generally provided at the filter outlet by the filter manufacturer.

2.8.2 Air Filter Layout

Dry air filters must be installed horizontally or vertically depending on the type and according to the manufacturer's instructions. It must be ensured, that no dirt can get into the intake pipe when removing the filter cartridge. In dry air filters with a dust extraction valve, the removal aperture must be located at the bottom.
Use dry air filters with safety cartridges to prevent dirt from entering the intake duct during servicing work. Since this safety cartridge increases the intake resistance, this must be taken into account when designing the filter.

Install the filter as near to the engine as possible so that the connecting pipe is as short as possible.
For maintenance work the air cleaner must be well accessible and the cartridge without additional disassembly work replaceable
If possible, the intake point should lie in the area of low-dust cold air and must be protected against the ingress of rainwater and splash water.

Use a smooth, clean, scale-free pipe for the intake pipe. Plastic pipes must not be deformed by the partial vacuum which occurs. The pipe must be connected to the engine and filter with rubber collars so that it is not exposed to major forces and adequate freedom of movement is maintained. The connecting points between the engine and filter must be sealed so that no unfiltered secondary air can enter the engine. The pipe connections must be designed to the same specifications as the coolant pipes.

2.8.3 Crankcase Ventilation System

Together with its pipes, the crankcase ventilation system is firmly integrated into the engine.
If, however, changes to the pipes downstream of the vent valve become necessary, adherence to the following is vital on re-routing.

- The pipes must always be routed to prevent oil from collecting in the pipe.
- In the case of a sealed crankcase ventilation system, the vented volume must always be fed back to the clean air pipe between the air filter and compressor.
- If a compressor intake pipe is additionally installed in the clean air pipe, this pipe must be installed in the direction of flow towards the compressor upstream before the crank case ventilation system laterally or from above

In the case of continuous operation involving extensive full-load use at altitudes in excess of 2000 meters, request special regulations pertaining to the relevant engine model from DaimlerChrysler.

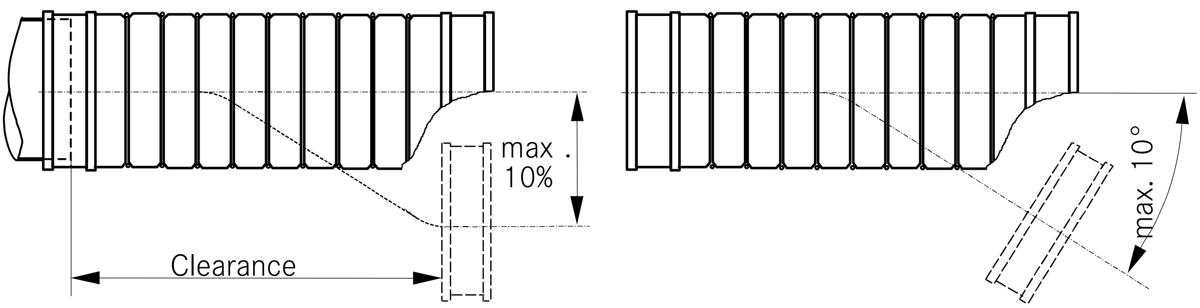
2.8.4 Charge Air

Since the charge air temperature is an important criterion for meeting the emission limits (Certificate) and achieving optimum consumption values, the design data in the limit value tables and the information in the relevant expert opinions for engine design approval must be observed.
The charge air upstream of the charge air cooler - hot side - can reach temperatures of up to 230°C and pressures of 2.5 bar depending on the specific engine. Therefore, a suitable hose quality must be used.

Charge air hoses are particularly elastic air ducting pipes which elastically connect the engine and charge air cooler in supercharged engines, and compensate relative movements between these major units. The charge air hoses are intended for transporting oiled air. They are generally equipped with an internal oil barrier layer. Depending on the choice of material, their operating range lies between – 55°C and + 235 °C. Charge pressure hoses are pressure hoses which are also vacuum-resistant to a minor degree - as required for engine operation.

Installation instructions:
- CV boot hoses must be installed under pre-loading
- For the corrugated hoses to be fastened with an integrated wire coil, they must have cylindrical ends. The wire coil may not be used to install the hose clamps.
- Spring hose clamps compensating for settling must be used on all charge air hoses. Tightening torques of the hose clamps according to manufacturer's specifications.
- The charge air pipes must be provided with beads and with a plug-on limit.
- In general, follow the hose manufacturer's installation specifications and use spring-loaded hose clamps.

Since a lower hose quality can be used for the charge air downstream of the charge air cooler (cold side), ensure that the accordingly marked hoses are not interchanged during installation.
(DC specification: hot side = red hoses, cold side = black hoses)
DC recommendation: Use uniform hose quality.
Temperature expansion (cold/hot side) must be guaranteed by suitable design measures.
When installing the charge pressure hoses, the maximum static displacement (parallel or angular displacement of the fittings in relation to each other) must not exceed the following values. The deviations may be superimposed, but must not exceed the individual value.
The 10% angular displacement is based on the clearance between the pipes to be interconnected.



The permitted dynamic displacement with normal vehicle usage is ±15% of the clearance in the axial direction and ±10% in the lateral direction (see above).
Bellows hoses may not be used as elbow replacement
The charge air pipe should generally be routed without bends or radii. If this is unavoidable, these bends (r = 2.5...3 x d) must be secured with accordingly dimensioned brackets in order to absorb the reaction forces from the charge pressure.

2.8.5 Charge Air Cooler lay out Design

The following engine-specific data must be obtained for designing the charge air cooler (based on the ambient temperature):

- Maximum cooling air inlet temperature into the charge air cooler (according to operating conditions)
- Maximum air mass flow at rated output (P_{max}) and rated torque (M_d)
- Maximum charge air temperature (t_2) downstream of the turbo charger at P_{max} and M_{dmax}
- Maximum permissible charge air temperature (t_2') downstream of the charge air cooler
- at P_{max} and M_{dmax}
- Maximum permissible pressure drop (Δp) in the charge air cooler + pipes

The most unfavorable case, particularly with regard to the lower fan speed at M_{dmax}, must be determined during design work.

2.8.6 Installing the Charge Air Cooler

The charge air cooler must be suitably bracketed to absorb the reaction forces form the charge pressure.
The charge air cooler must basically be installed in such a way as to prevent oil collecting in the charge air cooler. A drain plug must be provided at the most deeply part of to ensure this.
Flat lying installation, lower than the engine must be avoided.
Due to the high temperature differences length building equal one demand
For further information on installing the charge air cooler, see section 2.4.8.

2.9 Exhaust System

When designing the exhaust system, the noise and exhaust emission laws and regulations must be met for the relevant application.

In order to achieve flawless operating and output behavior, the limits given in the table and the approved certification values from the expert opinions for engine design approval must be met.
The permitted exhaust backpressure - measured at the exhaust turbine outlet at rated engine speed and full-load - must be met. Different limits apply to specific engines and these must be adhered to. DaimlerChrysler AG will provide information on request.

2.9.1 Design

Large pipe diameters, short pipe lengths and a small number of pipe bends as possible reduce the exhaust gas backpressure, as does a generously dimensioned muffler.
The mufflers are built as reflection or absorption mufflers or as a combination of both designs. To achieve normal muffling, the muffler must have a volume which corresponds to at least 6 to 8 times the swept volume. Muffling is improved by increasing the volume. This is approximately 5 to 6 dB (A) when the volume is doubled, for example.

The exhaust pipe design must be based on the diameter of the turbocharger outlet.
Extending the diameter - depending on the engine output and pipe length in the vehicle - downstream of the exhaust gas turbocharger must be carried out using corresponding transitional sections with a taper angle of 15°.

The position of the muffler in the exhaust pipe and the choice of exhaust outlet are vital factors for achieving optimum muffling.

The pipe resonance excited by the engine should not be the same upstream and downstream of the muffler, i.e. the pipe between the engine and muffler should be shorter (system closed at one end with resonant frequencies at c/4l, 3c/4l, 5c/l,..) than the pipe downstream of the muffler (pipe open at both ends with resonant frequencies at c/2l, 2c/2l, 3c/2l,...).

c: sound velocity
l: pipe length

The best effect is achieved if the tailpipe has the greatest muffling effect at the resonant frequencies of the front pipe.

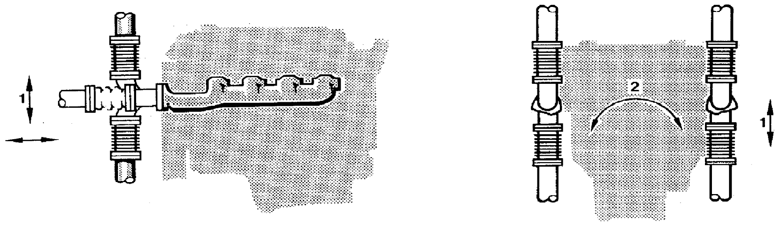
The information and instructions provided by the muffler manufacturer must be observed to achieve optimum exhaust system coordination and design.

2.9.2 Installation

Expansion pipes, which compensate both the thermal expansion and movement of the engine, must be installed for the connection between the engine – immediately after the exhaust gas turbocharger outlet - and the exhaust pipe.
The exhaust pipes between the exhaust gas turbocharger and the expansion pipe/elastic link should be no longer than 300 mm.
The exhaust pipe must be fitted immediately downstream of the expansion pipe in order to minimize the effect of exhaust pipe vibration on the expansion pipe. It must be ensured that the expansion pipe axis is transverse to the engine’s vibration axis (vibration and expansion must not be in the same direction).
The installation instructions provided by the compensator manufacturer must be followed.

Layout of the expansion pipe with an elastically mounted engine:

1 Direction of thermal expansion
2 Direction of engine vibrations



The exhaust pipe connections should be accessible to facilitate servicing work. Before fitting, coat the connecting bolts at the exhaust pipe with graphite grease or similar (to prevent sticking).

Choose the exhaust gas outlet so that
- the exhaust gases cannot be aspirated by the engine's air intake point
- no rain or splash water can enter the exhaust pipe
- third parties are not endangered or unnecessarily annoyed or hindered
- standard workshop exhaust extraction systems can be installed.

2.9.3 Exhaust Gas Aftertreatment

The vast majority of Mercedes-Benz diesel engines comply with current emission legislation without exhaust gas after treatment systems.
If such systems are nevertheless used, this is carried out at the responsibility of the equipment/ vehicle manufacturer.
If exhaust gas after treatment systems are used by the vehicle/equipment manufacturer
the following, maximum exhaust gas backpressures are permissible at full-load and rated speed for model series 900/500/450 engines:

Static pressure (mbar)

	New condition	Maximum (loaded exhaust gas after treatment system)
Model series 900/500 OM 457/460	150	250

This pressure of 150 mbar in new condition also applies to exhaust systems with spark arrester (refinery operation).
The increase in gas cycle work can increases consumption by up to 3%.

The vehicle/equipment manufacturer must implement suitable regeneration systems to ensure adherence to the above engine limit values.

If adjustments to the vehicle operating permit are required, these must be arranged by the OEM.

In the case of Mercedes-Benz engines which only meet the legal requirements with exhaust gas after treatment systems, these systems are supplied exclusively by DaimlerChrysler, as homologation exists for the entire system only.

Exhaust systems and exhaust gas after treatment for engines with BlueTec diesel technology (euro 4 and future exhaust stages) see to section 3.3.4 and 3.3.5

Gas engine

- **Oxidation Catalytic Converter**

To meet the prescribed emission limits according to Euro 4, an oxidation catalytic converter is required for the installation.
Depending on the OEM's installation situation, the ceramic catalytic converter supplied by DC must be installed in a state-of-the-art muffler by the muffler manufacturer. Ensuring even pressurization and flow through the catalytic converter is vital in this case.
To reach the necessary operating temperature, the catalytic converter must be integrated max. 3.0 m down stream of the exhaust companion flange into the exhaust system.
The temperature sensor (supplied by DC) must be installed in the exhaust gas flow max. 300 mm down stream of the catalytic converter. A connection cable must be installed between the connector on the engine (branched-off at the 55-pin connector) and the connector on the temperature sensor.

The permissible exhaust gas backpressure must not exceed 100 mbar.

2.10 Engine Brake/Constant Throttle

To increase braking power, the engine may be fitted with a brake flap after the turbocharger in combination with constant throttle valves in the cylinder heads. The constant throttles are small valves which are integrated into the cylinder heads. When open, they create an additional link between the combustion chamber and the exhaust port and increase thereby the engine brake performance. When the engine brake is switched on, the constant throttle valves are simultaneously opened and the brake flap after the turbocharger closed.
When using constant throttles and exhaust air brake these can be operated both individually and together.

2.10.1 Initialization

When the engine brake is switched on in the vehicle, the exhaust brake and the constant throttle valves (except OM 906/926 LA) are pressurized with compressed air via the vehicle control unit (FR/ADM1/ADMR). This is carried out via 2/3-way valves and compressed air lines.
To ensure flawless constant throttle valve function, the minimum initialization pressure of 7 bar must be built-up or dissipated within 0.25 seconds of the solenoid valve's being electrically initialized when the engine is turned off, regardless of the choice of compressed air lines and solenoid valves.
In the case of pressure measurement, it must be ensured that the pressure sensor is installed, wherever possible, at the furthest point from the compressed air induction point into the lines connecting the individual cylinders. The connection line's hollow screw at the first cylinder is usually suitable.
If the switching times cannot be checked as part of sign-off, or the values are not attained, we demand the following compressed air components for constant throttle initialization.

- Solenoid valves:	Wabco	(Nominal width 4 mm, part No. A 005 997 12 36 -- 24 V
	EKS	(Nominal width 4 mm, part No. A 004 997 55 36 -- 24 V

- Compressed air line, plastics line: e.g. Tecalan line (8 X 1 mm, part No. A 000 987 27 27)

The following line lengths should not be exceeded:

Model series 500, OM 457/460
- Maximum line length between compressed air supply (1. air chamber) and solenoid valves: 4000 mm
- Maximum line length between solenoid valve and engine transfer point: 1600 mm

The constant throttle and brake flap must be initialized via separate solenoid valves. Simultaneous initialization via just one solenoid valve is not permissible!
Electrical initialization of the 2/3-way valves must be carried out via the vehicle control unit. Direct initialization, bypassing the control unit, is not permitted and may lead to heavy damage to the engine.

Model series 900

In the OM 904 LA/924 LA engines, the engine brake flap and the constant throttle are initialized jointly via the compressed air supply using a 2/3-way solenoid valve. In the OM 906 LA /926 LA engines, the engine brake is also initialized via the 2/3-way solenoid valve, but the constant throttle is initialized hydraulically over the engine oil pressure.

The above mentioned solenoid valves from Wabco and EKS must be used for compressed air initialization:

- Maximum line length between compressed air supply and solenoid valve: 4000 mm
- Maximum line length between solenoid valve and engine transfer point: 1600 mm

2.11 Engine Mounts

General

A correctly designed elastic engine mount is basically preferable to other mounts. An elastic mount is optimally designed if the natural frequency of the vibration system comprised from the engine mass and the elasticity of the mount is at least 40% lower than the engine's lowest excitation frequency.

Low natural frequency necessitates soft, elastic elements. These have the disadvantage of severe shifts under the influence of external forces, as may occur e.g. in the case of inclined positions or shocks.

Elastic Mounts

The prerequisite of flawless elastic mount designs are bases whose stiffness must be significantly higher than that of the elastic elements. Otherwise, the base acts as an additional spring.

Ensure sufficient clearance (> 20 mm) between the elastically mounted engine (engine periphery) **and chassis.**

To compensate the responses which occur with elastically mounted engines, all pipes leading to the engine must be of an elastic design. Stiff connections deteriorate the elastic mount by increasing its natural frequency and create body-borne sound bridges to the downstream structures.

When attaching clutches, transmissions, converters or hydraulic pumps to the engine, the mounting load must be checked.

Even Mounting Load

When designing an elastic mount, it must be ensured that the mounting elements

- are stressed approximately evenly and jouncing at the mounting points is approximately the same.
- are geometrically arranged in such a way that bending moment in the area of the engine – transmission / working machine connection is kept as low as possible.
- We recommend having the engine mounts manufacturer calculate the mounts load.

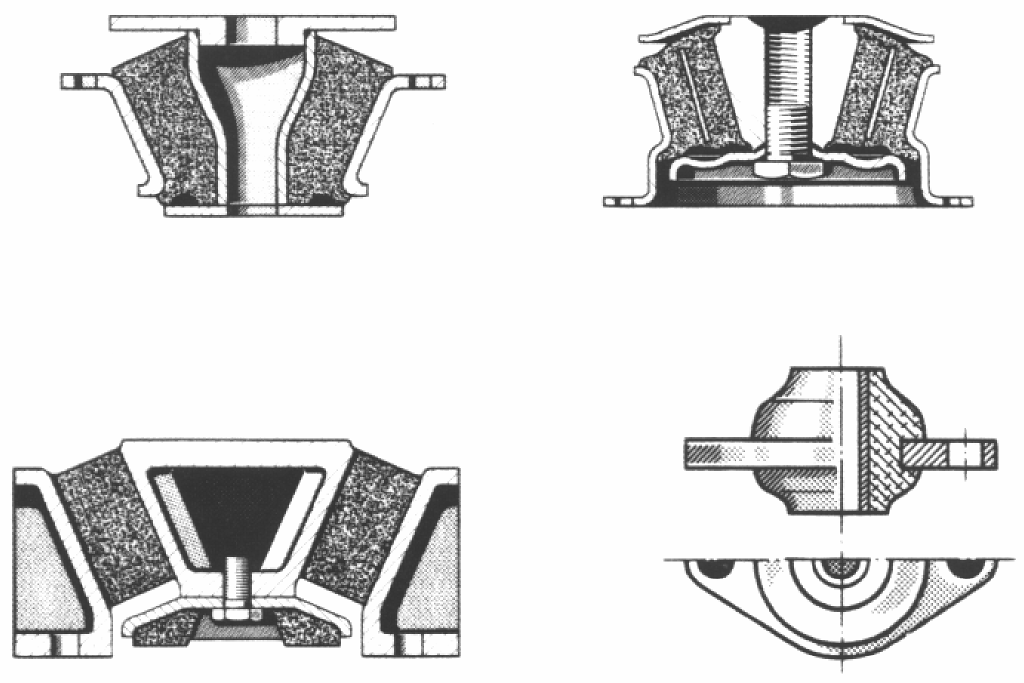
Bending Moments

In calculating the engine mounts, the following block bending moments are permissible for the different model series.

Model series 500	2000 Nm
Model series 900	1200 Nm
OM 457 / 460	2000 Nm

If tandem or multiple pumps are attached directly, a check must be carried out to determine whether a support is necessary.

Elastic mounting designs
Design examples



2.12 Electrical System

2.12.1 General

12V and 24V (single-pin components) are used in model series 500 and 900 engines and OM 457/460 engines.
With the introduction of electronically controlled engine control systems, three-phase alternators with integrated over voltage protection are specified. These guarantee that even temporary interruption of the connecting cable between the alternator and the starter battery does not result in the destruction of electronic components as the result of over voltage.

The three-phase alternator regulator must (like external battery chargers) be suitable for the charge voltage permissible for the battery. In order to limit gas development and the consumption of distilled water, the charge voltages for continuous and maintenance charging, as specified by the manufacturer, should not be exceeded for lead batteries.

Since it is impossible to prevent small quantities of acid vapor and electrolytic gas from escaping completely, the battery compartment must be ventilated. This helps to prevent corrosion and electrolytic gas explosions. Electric switches and control relays in the vicinity of the battery must be avoided for the same reason.

2.12.2 Starter Battery

DaimlerChrysler only uses lead batteries in accordance with DIN 72310 and DIN 72311, Parts 18, 20 and 21 HD (heavy-duty/vibration-resistant) types as starter batteries.
The individual elements (cells) have a rated voltage of 2 V/cell. Higher voltages are achieved by connecting several individual cells in series.

The capacity of a battery indicates the amount of power which can be tapped. It is expressed in Ah and depends on plate area, discharge current, temperature of the electrolyte and the charge (electrolyte density).

In the case of vehicles which work at low temperatures, ensure that a sufficiently high battery capacity is installed, as a fully-charged battery only has approximately 60% of its rated capacity at -10°C (preheating is recommended if necessary).

If the standby times of lead batteries are not used for a long time, self-discharging must be taken into account at the rate of a daily capacity loss of between 0.2% and more than 1% of the rated capacity, depending on the age, temperature and purity of the electrolyte. In the case of long standby times (without recharging), this may lead to inability to start the vehicle. Therefore, components with long standby times (electrolyte density <1200 kg/m^3 or open-circuit voltage < 2.03 V/cell), require apparatus for continuous or maintenance charging to prevent freezing (preferably with IU characteristic curve).
Battery terminals must be protected against corrosion using terminal grease (acid-free grease).
Further information must be obtained from the corresponding manufacturers. The installation and maintenance instructions of the battery manufacturers must also be observed.

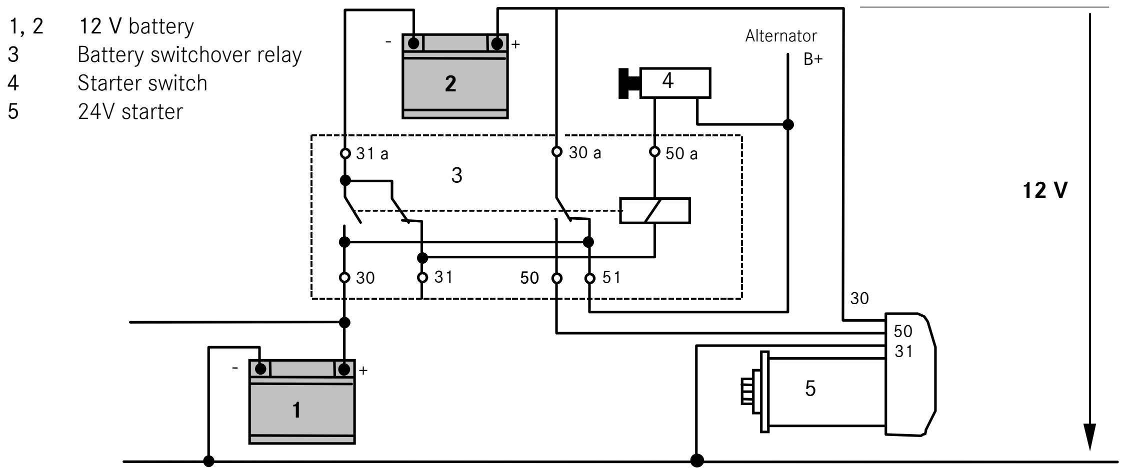
The manufacturers specify the allocation of the battery size to starters in order to prevent starter overloading and to guarantee starting capability at minus temperatures. The minimum battery capacity must be chosen according to the relevant application (temperature) and the type of engine.

The battery capacity is not relevant for the starter. The important aspect is that the maximum permissible low-temperature test current is not exceeded. If a larger battery nevertheless has to be used, the cable resistance must be increased accordingly.

2.12.3 Special Applications for Mixed-voltage Systems

In order to exploit the advantages of the 24V starters (achievable output, availability and also smaller currents and cable cross-sections) on the one hand and the advantages of the 12V lighting and signal system and alternator (availability and price) on the other, mixed-voltage systems with battery switchover relays are often used.
In these mixed-voltage systems, two 12V batteries are charged in parallel and only discharged in series (24V) for the starter if required.

Starter system circuit with battery switchover relay



2.12.4 Installation Requirements

To ensure short distances between the battery, the starter and the alternator, the battery should be located as closely as possible to the engine. Unprotected installation immediately next to the engine and its exhaust pipe must be avoided. The ambient temperatures of over 55°C prevailing there greatly reduce its service life (internal corrosion).
The charging cable from the three-phase alternator (B+) should be looped through to the starter cable connection (terminal 30) with an insulated silicone cable with a suitable cross-section, avoiding chafing, so that the existing main starter cable can also be used for charging the battery with low resistance and therefore low voltage drop.

When calculating the cable strength of the charging cable from terminal B+ of the 3-phase alternator to terminal 30 of the starter, a voltage drop of max.

0.8 V at 24V system voltage
0.4 V at 12V system voltage

is permissible.

The voltage drop on the ground cable is disregarded. If the ground cable is insulated, however, the length of the outward and return lines is used as the basis.

On calculation of the **main starter cable** for the starters supplied by DaimlerChrysler for engine model series 500 / 900 / OM 457/460, the total resistance of the main starter cable, including transition resistance, must lie in the following range.

- At 24V system voltage 1 – 2.0 mΩ
- At 12V system voltage 1 – 1.8 mΩ

The battery negative cable must be connected directly to the starter, the extended starter fastening pin (series 500, OM 457/460) or the negative cable fastening point on the timing case (series 900). The usage of the vehicle frame ground (ground cable) is not permitted.

Generally the feed supply lines (terminal 30) should be routed as closely as possible and parallel to the return supply lines (terminal 31).
Only then is it ensured that the interferences (EMC) will mutually eliminate each other.

2.12.5 Alternator

The vehicle power is supplied by an alternator, which is normally mounted on, and driven by, the engine. It must be ensured that there is always sufficient power in reserve to charge the battery even with all consumers connected continuously or for a long time.

Examples of electrical consumers with weighting factors

Consumers connected continuously or for a long time	Output (W)	Weighting factor	Evaluated output (W)
Dipped/main beam	110	1	110
Clearance lamps	50	1	50
Tail lamps	10	1	10
License plate lamps	10	1	10
Instrument lighting	20	1	20
Engine and vehicle control units	80 - 120	1	115
Trailer tail lamps	10	1	10
Trailer license plate lamps	10	1	10
Trailer clearance lamps	50	1	50
Vehicle radio	25	1	25
Σ evaluated output			400 W

Consumers connected for a short time		Output (W)	Weighting factor	Evaluated output (W)
Blower/fan for heater		80-160	0.5	80
Windshield wipers		120	0.25	30
Brake lamps	without trailer	42	0.1	10
	with trailer	84		
Turn signal lamps without/with trailer		10	1	10
Additional headlamps		110	0.1	11
Fog lamps		110	0.1	11
Rear fog lamp		35	0.1	3.5
Backup lamps		55	0.1	5.5
Heated mirrors		50	0.1	5.0
Elec. window winders		50	0.1	5.0
Grid heater		1900	0.1	190
Σ evaluated output				361 W

Current required for the evaluated total output:

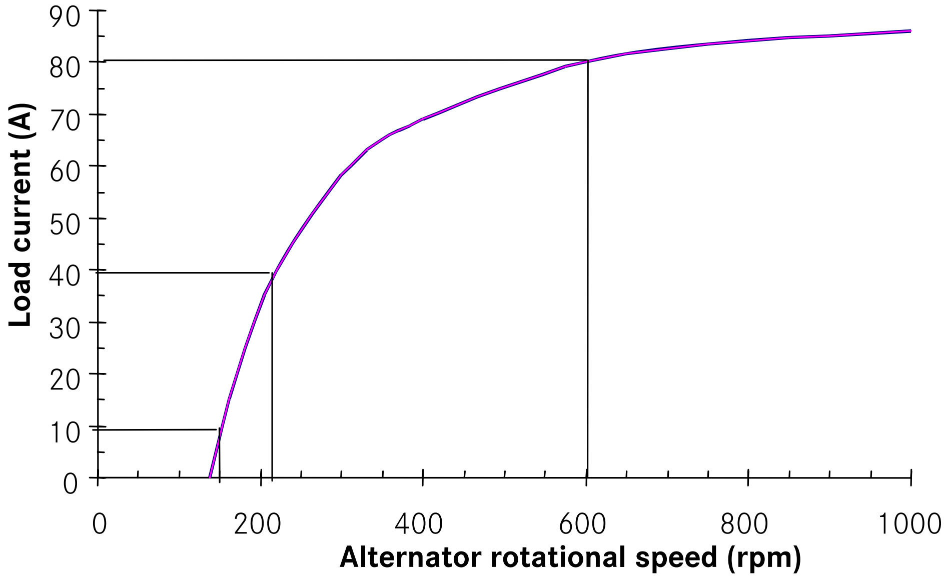
$$I = (400\ W + 171\ W) / 28\ V = 20.4\ A$$

In the example of the characteristic alternator curve illustrated below, the alternator rotates, with a corresponding transmission ratio at engine idle speed, at a speed of approximately 2050 rpm and generates a current of approximately 39 A, i.e. it covers the required 20.4A current.

On selection of the transmission ratio $n_{engine}/\ n_{alternator}$, the limit speed of the alternator must not be exceeded at maximum engine speed (see manufacturer's specifications).

Example

NCB 3-phase alternator characteristic curve
28V 35/80A



The maximally permissible ambient temperature and/or sucking in temperature of the generator fan are with at the most 80 °C. In order to guarantee their functional reliability and avoid damage to heat-sensitive parts such as soldered joints, insulation, semiconductors and bearings, etc., the alternators are equipped with an integrated fan wheel.
As the result of the heat radiated by the engine, temperatures of >80°C may occur, particularly in the case of an encapsulated engine compartment and alternator self-heating. If this temperature is exceeded, an air intake fitting and a hose must be implemented to intake cool air from outside of the engine compartment. If it is not possible to lower the temperature to 80 ° C with these measures, Bosch must grant the approval
The alternator must be protected against dirt, splash water, shock, impact, etc.
It should be easily accessible for servicing work.
For further specifications and instructions, refer to DaimlerChrysler standard 22100.

2.12.6 Starter Actuation

General reference

It is imperative to observe that when starting the engine (via PLD / MR 1) there is a delay of min. 500 milliseconds between terminal 15 on and Terminal 50 on.

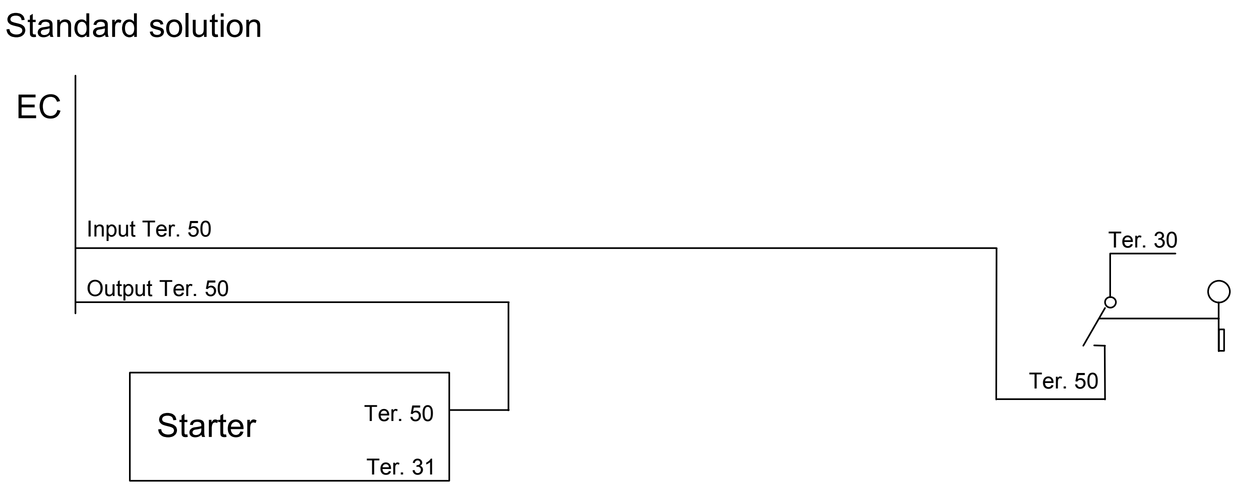
Limits of the additional starter relay:

- Maximum current I_{max} = 2 A (through the entire temperature range)
- Maximum resistance R_{max} = 400 ohms
- Minimum resistance R_{min} = 19 ohms at room temperature
- Maximum inductance L_{max} = 900 mH

Standard solution

The standard solution affords the greatest availability of the engine, since limp-home functions of the engine also analyze the starter actuation (terminal 50). Here the ignition switch establishes the connection between terminal 50 to the input of the engine control ECU. The engine control ECU actuates the starter auxiliary relay via monitoring functions.

For 12 V systems no starter is currently available that has a starter auxiliary relay with the permissible specifications.

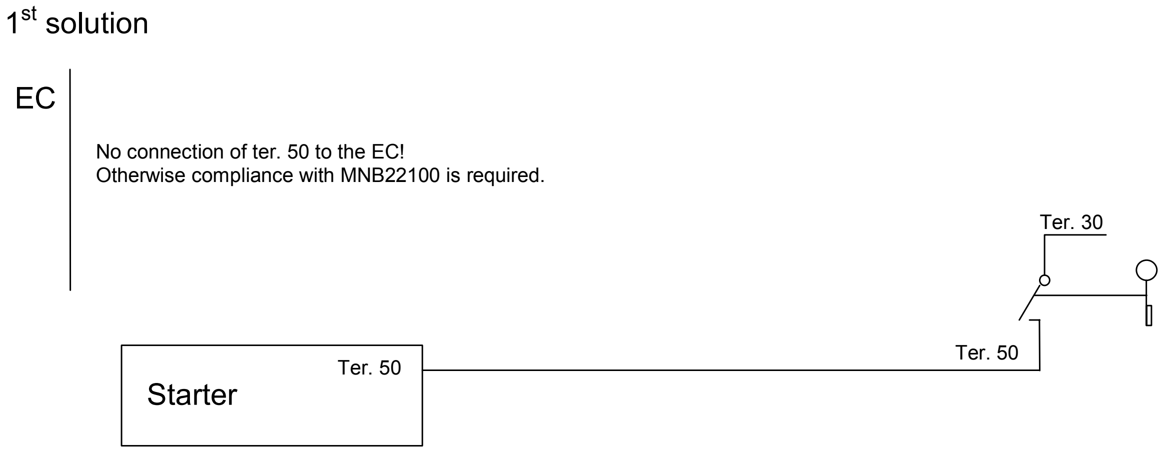


First solution

The 12 V starter is directly actuated by the ignition switch in the classical way. No connection to the engine control ECU exists.

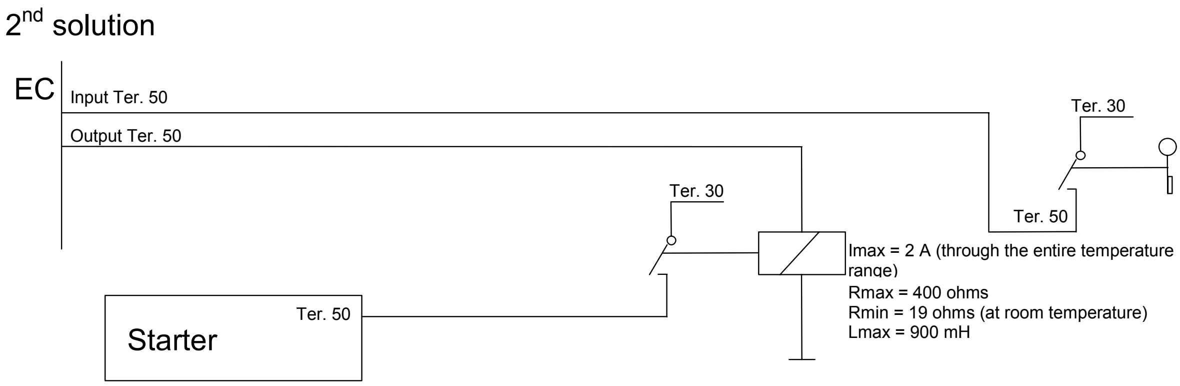
Disadvantage: no limp-home functions and no monitoring of the starter actuation are used.

Here a start anti-repeat function is urgently required.



Second solution

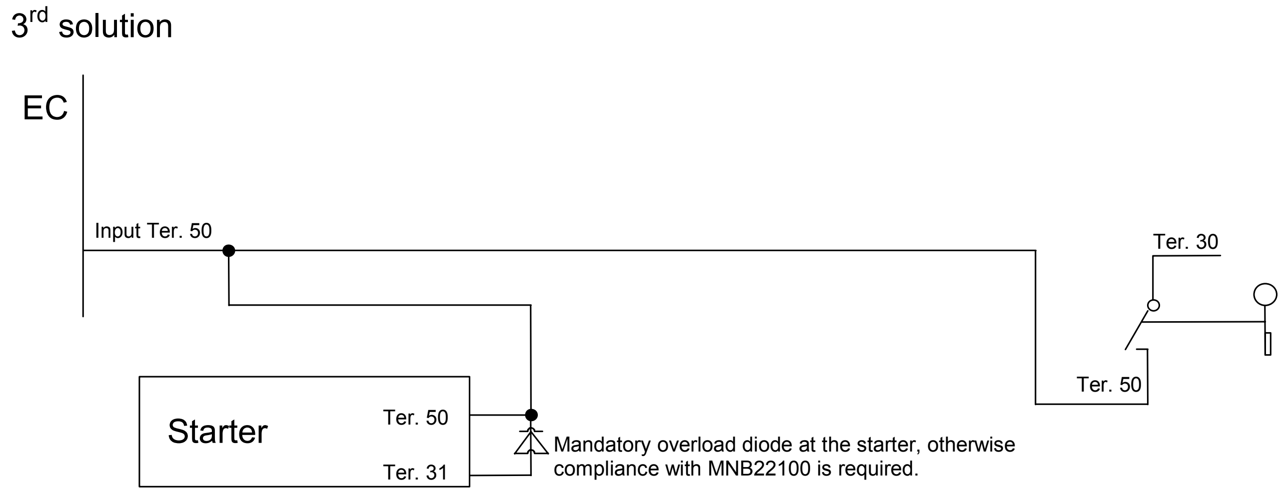
To have the limp-home functions and monitoring functions available for 12 V systems, the standard solution can be used, but a relay must be integrated in the circuit, to avoid destroying the engine control ECU.



Third solution

Should the extra labor of wiring an additional relay not be practical, but the limp-home functions still be available at the expense of the starter monitoring functions, an alternative is to arrange the ignition switch parallel at the input of the engine control ECU and at the starter. In this case, however, compliance with MBN22100 is required. In any event an overload diode at the starter auxiliary relay is then necessary for limiting the voltage spikes. This diode must have the appropriate size for not being destroyed under any operating conditions and accordingly for compliance with MBN22100. This diode must be attached as close as possible to the starter relay.

Here a start anti-repeat function is urgently required.



2.13 Electronics

The electronic engine control system for built-in engines is based on the **I**ntegrated **E**lectronic **S**ystem (IES) of our commercial vehicle range.

On implementation of this system, the control units were divided into engine-oriented and vehicle-oriented electronics.

2.13.1 Engine Control Unit

Diesel Engine

The main task of this control unit, which is oriented specifically to the requirements of the current engines, is precise electronic initialization of the solenoid valves at the injection pumps.
Optimum start of injection and the injection volume required for the torque demanded by the vehicle control unit are calculated according to the performance map via the sensed engine and environmental conditions.

Gas Engine

The main task of this control unit, which is oriented specifically to the requirements of the gas engines, is precise electronic initialization of the ignition electronics and the solenoid valves at the gas injection valves.
Optimum ignition timing and start of gas injection and the gas injection volume required for the torque demanded by the vehicle control unit are calculated according to the performance map via the sensed engine and environmental conditions.
All of the sensors and actuators on the engine side are connected to the control unit via a 55-pin connector and an engine wiring harness.
To prevent engine overload, various protective functions are implemented in the control unit; these influence the requested torque. E.g.:

- Reduction as a function of coolant temperature
- Reduction depending on atmospheric pressure
- Output reduction in the event of malfunctions

In order to avoid a ground offset, it is imperative to ensure that during the assembly of the ignition modules and PLD the ground cables are fastened to the starter ground star point using battery terminal grease.

Control unit for SCR frame module (BlueTec technology)

The control unit for the SCR frame module receives the analogue signals from the connected sensors, converts them into digital CAN (Control Area Network) signals and transfers these to the engine control unit (MR) see Section 3.2.6 .

2.13.2 Vehicle Control Units

The vehicle control unit has the task of processing vehicle-specific requirements, i.e. recording the accelerator pedal position, limiting the speed, reducing the torque, initializing the engine brake, etc. and transmitting the desired torque request and the start/stop command to the engine via the CAN interface.
DaimlerChrysler offers various control units for this purpose; the functions of these vary and enable them to be used according to the level of equipment required.

2.13.3 Voltage Supply

The engine control unit is equipped as a 12V or 24V version depending on the type of engine and application. The relevant voltage ranges are given below:

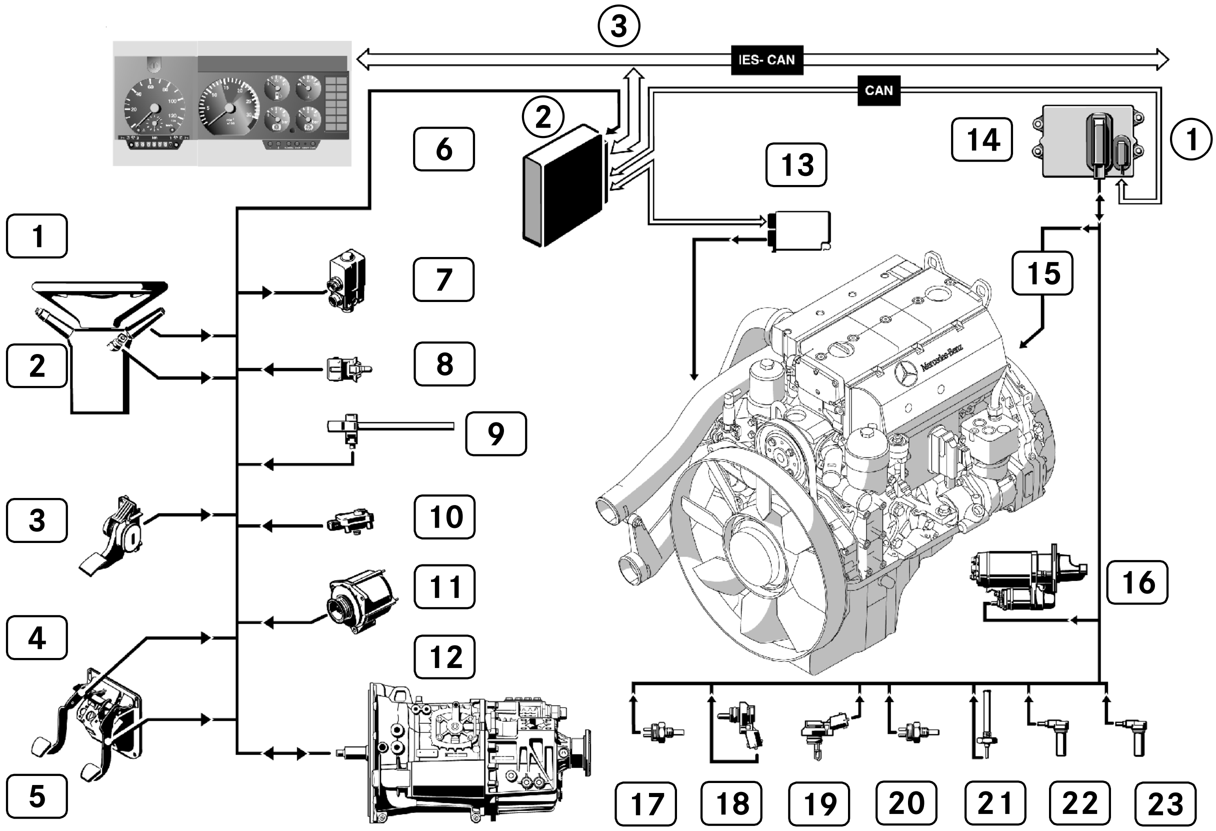
Rated voltage	12V	24 V
Operating voltage	11 - 16V	22 - 30V
Under voltage (limited operating range)	6.5 - 11V	8 - 22V
Over voltage cutout	> 33V	> 33V

2.13.4 Interfaces

3 interface definitions are conceivable, as illustrated in the following graphic:

- Interface ① directly at the engine control unit (16 pins plug)
- Interface ② at the vehicle control unit
- Interface ③ at the IES / SAE J 1939

The responsible DaimlerChrysler AG department should be consulted when deciding on the best interface to use for the relevant application.



1	Cruise control/permanent brake	13	Flame starting system control unit
2	Ignition key	14	MR engine control system
3	Accelerator pedal	15	Fuel quantity/start of delivery
4	Clutch pedal	16	Starter
5	Brake pedal	17	Coolant temperature
6	FR – vehicle control system	18	Oil pressure/temperature
7	Engine brake solenoid valve	19	Charge air pressure/temperature
8	Ambient temperature sensor	20	Fuel temperature
9	Coolant level sensor	21	Oil level
10	Air filter sensor	22	Crankshaft position
11	3-phase alternator	23	Camshaft position
12	Transmission signals		

2.13.5 Installation

The following basic points should be observed on installing DC control units:

- Branch off a positive connection directly from the battery positive terminal (or the central voltage connection, e.g. on the starter)
- Branch off a negative connection directly from the battery negative terminal (or the central negative point, e.g. on the starter) (**do not use the vehicle frame ground!!**).
- Use the same cross-sections for the positive and negative connection cable.
- Common ground point for all on-board electronics (engine/vehicle)
- **Central main battery switch as a 1-pin switch permissible in the positive connection cable only.**
- Minimum control unit switch-off time approx. 10 s after terminal 15 off before the central main switch is switched off (And stick stickers on main switches take up reference in manual of the equipment).
- In the case of a central main switch the oil level measurement must not be carried out during run-down (suitable parameter setting is required)
- IES CAN (vehicle CAN bus link).
  The Mercedes star point connector must be used as the central terminating resistor for all control units connected to the IES CAN if more than two subscribers are present on CAN.
- If the CAN is cascaded, this must be done with the passive star point (without terminator resistance). The same procedure as with the IES CAN applies for other CAN, such as: frame module, OBD2 diagnosis module etc
- SAE J 1939 CAN with terminating resistors in accordance with J 1939 regulation

In order to guarantee correct data transmission and ensure EMC, the CAN cables between the engine control unit and the vehicle control unit must accordingly be designed as twisted cables with defined cross-sections and lengths. For the CAN link, we recommend using a four-core, twisted cable (star quad cable) from DaimlerChrysler with a maximum length of 15 m. If possible, the CAN cable should not be interrupted by connectors, as signal reflections may otherwise occur. If a cable from another manufacturer is used, we recommend a four-core cable with an adequate cross-section (1 mm²) and adequate insulation and twisting, due to mechanical strength, so that interference irradiation can be compensated.

Under no circumstances may shielded cable be used, as the capacity between the individual cores and the shielding would attenuate (abrade) the signals.

When installing the major unit, particularly ensure that the plug connections, sensors and wiring are not damaged.
Any inductance must be limited by means of an overrunning diode or an equivalent protective circuit. (Limit value: no pulse must exceed a voltage of 80 V. A voltage change by 10 V as compared to the original voltage caused by this pulse should not last longer than max. 1µs).
Any start/stop switch installed on the engine must be easily accessible for servicing work.

2.13.6 Engine Control System - MR

The MR control unit is the electronic engine control system mounted on the engine; it controls all of the engine's functions.

The main task of this control unit is to control diesel engine fuel injection.

- The 16-pin connector must be wired by the OEM.
- All of this connector's (assigned and non-assigned) connections must be fitted with seals, so that no humidity can penetrate into the patch cords
- Cross-section 2.5 mm² per current supply core
- Current supply must be branched off directly from the battery positive terminal (or the central voltage connection e.g. on the starter).
- The ground must be branched off directly from the battery negative terminal (or the central negative point, e.g. on the starter).
- No fuse may be inserted between the wiring harness and MR; the control unit is intrinsically protected.
- In the engine wiring harness integrated fan control/connections must be clarified before use with DC specialized division

Diagnostic functions for first start-up of the MR (with Minidiag 2 hand-held device)

MR parameter setting has been carried out in the engine production plant → does not have to be changed.

Reading out and deleting the MR fault memory; no current fault code should be displayed.
For further specifications and setting options, refer to the operating instructions “Engine control system with PLD- **MR"**

2.13.7 Vehicle Control System - FR

The FR control unit is the vehicle's central cab and drive control unit.

The main task of this control unit is to calculate and select the required torques and engine speeds, which are transmitted to the engine via CAN.

- The control unit must be installed in the cab or in an electrical compartment (ambient temp. = max 85°C - housing is not watertight). **Protection class IP 30**
- Unit installation position = connector pointing down
- All 4 connectors must be wired by the OEM.
- The signal "ignition ON" from the ignition switch, terminal 15, must be switched in parallel with all other control units installed in the cab and the MR.

Diagnostic functions for the first start up of the FR (with Minidiag 2 hand-held device)

- Setting FR parameters
- Programming of FR accelerator pedal positions
- Programming of the CAN environment
- Programming of the terminal W value.
  This is only possible when the transmission is set to neutral, i.e. the diagnostic routine for the transmission (“major teach-in process”) must be completed.
  Reading out and deleting the FR fault memory, no current fault code should be displayed.

2.13.8 ADM - FR

The ADM-FR control unit is the vehicle's central cab and drive control unit.

The main task of this control unit is to calculate and select the required torques and engine speeds, which are transmitted to the engine via CAN.

- The control unit must be installed in the cab or in an electrical compartment (ambient temp..= max 85°C. - housing is not watertight). **Protection class IP 30**
- Unit installation position = connector pointing down
- All 4 connectors must be wired by the OEM.
- The signal "ignition ON" from the ignition switch, terminal 15, must be switched in parallel with all other control units installed in the cab and the MR.

Connection Options

- Outputs for standard instruments, lamps and engine speed indicator, K line (diagnosis)
- PTO (operating speed control) and limit values.
- General limit values (M max, n min, n max, v max).

Diagnostic functions for the first start up of the ADM-FR (with Minidiag 2 hand-held device)

- Setting ADM-FR parameters
- Programming of ADM-FR accelerator pedal positions (if connected)
- Reading out and deleting the ADM-FR fault memory, no current fault code should be displayed.
- For further specifications and setting options, refer to the operating instructions “Adaptation module as ADM vehicle control system“

2.13.9 ADM - AR

- The control unit must be installed in the cab or in an electrical compartment (ambient temp.= max 85°C. - housing is not watertight). **Protection class IP 30**
- Unit installation position = connector pointing down
- All 4 connectors must be wired by the OEM.
- The signal "ignition ON" from the ignition switch, terminal 15, must be switched in parallel with all other control units installed in the cab and the MR.

Connection Options

- Outputs for standard instruments, lamps and engine speed indicator
- K line (diagnosis) gateway to the vehicle CAN (IES)
- PTO (operating speed control) and limit values
- General limit values (M max, n min, n max, v max).
- Gear selection / upper vehicle travel (ADM2 – AR only)

Diagnostic functions for the first start up of the ADM-AR (with Minidiag 2 hand-held device)

- Setting ADM-AR parameters
- Programming of ADM-AR accelerator pedal positions (if connected)
- Reading out and deleting the ADM-AR fault memory, no current fault code should be displayed.
- For further specifications and setting options, refer to the operating instructions “Adaptation module as ADM vehicle control system“

Safety instructions for ADM – AR / FR
Due to safety-relevant reasons, we recommend that you install the following onboard diagnosis.

Yellow diagnostic lamp

The ADM – AR / FR yellow alarm is triggered if impermissible engine operating states and active faults are present and these are detected by the MR and ADM – AR / FR control units.
Yellow alarm triggers include:
- Engine speed < 300 rpm
- Coolant temperature too high or temperature signal not available
- Oil pressure too low or oil pressure signal not available
- Oil level too low
- No CAN link to the engine electronics or CAN data implausible
- Active faults in the MR fault memory, fault priority medium-high
- Active faults in the ADM – AR / FR fault memory, fault priority medium-high

Red diagnostic lamp

The red ADM – AR / FR alarm is triggered if severe faults which necessitate immediate engine shutoff are present. If the engine is not shut off, major damage may occur and may lead to destruction of the engine.
Red alarm triggers include:
- Over speed
- Oil level impermissibly low
- Oil pressure impermissibly low
- Coolant temperature impermissibly high

2.14 Ancillary Assemblies

When operating the engine, it must be noted that the output at the flywheel is reduced by the power drawn by the ancillary assemblies.
During the test rig run, only the idling power drawn by the ancillary assemblies is taken into consideration when determining the output at the flywheel.
In the case of belt-driven major units, the belt tension must not exceed the maximum permissible bearing strain.
The power drawn by ancillary assemblies must not exceed the levels specified for the relevant engine.

2.14.1 Power Take-off

The engines are fitted with an optional, one or two gear-driven power take-off (PTO).
Both propeller shaft connections and flanged connections (SAE A, SAE B) with toothed sleeves for the corresponding hydraulic pumps are available for the PTO.

The specifications in the “Propeller shafts” section must be taken into consideration for PTO via propeller shafts.

When attaching hydraulic pumps, greasing the tooting off the adapter with lubricating paste (Optimol White T, DBL 6880.10, DC No. A 000 989 80 51) is vital.

All engines are supplied without hydraulic pumps. These must be installed by the vehicle manufacturer.

The hydraulic pipes for the pumps must compensate relative movements between the engine and vehicle (body), be vibration-resistant and be located sufficiently far away from hot parts; a shield to the hot exhaust gas leading components may be necessary.

All PTO leading from the engine must be calculated or checked by DaimlerChrysler in terms of technical, torsional vibrations.

Retrofitting a PTO involves a great deal of effort, because the engine has to be dismantled to do this.

Output Torques

The engine scope of delivery must contain the codes specified for the maximum possible output torques listed in the following.

OM 904/906 LA	**OM 924/926 LA**
OM 457 LA,	**OM 460 LA**
OM 501/502 LA	

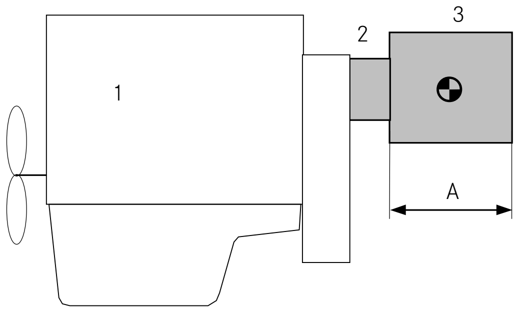
- Maximum rated torque ≤ 600 Nm on continuous operation
- Maximum peak torque ≤ 720 Nm for short-term operation (e.g. starting and shifting)

To prevent the maximum permissible torque from being exceeded, suitable overload protection must be fitted (e.g. pressure limitation, blocking protection, overload clutch).

PTO Layout

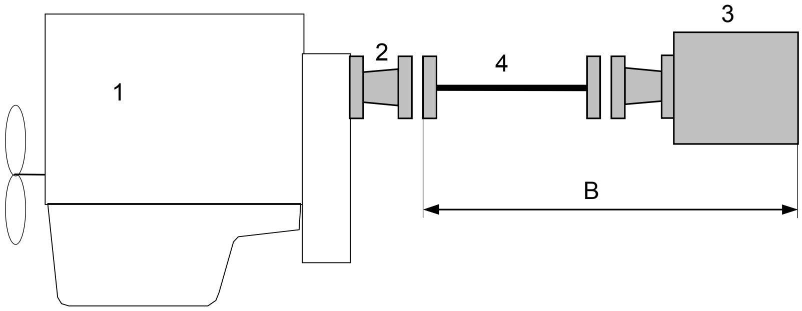
Variant 1

Rigid attachment



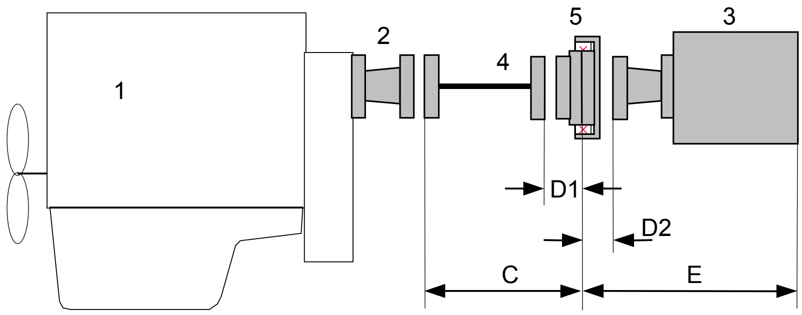
Variant 2

With propeller shaft



Variant 3

With propeller shaft and elastic clutch



1 Engine
2 Power take-off

3 Driven unit

Model series 900/500, OM 457/460

4 Propeller shaft

5 Elastic clutch, drawing
Model series 900: A 906 250 00 01
OM 457/460: A 444 250 00 01
Model series 500: A 444 250 00 01

A Mass moment of inertia of driven major unit
B Mass moment of inertia of driven major unit plus propeller shaft
C Mass moment of inertia of propeller shaft plus propeller shaft-side part of the elastic clutch
⊕ Consider permissible block bending moment (max. 60 Nm), from rear edge flywheel housing
D1 Mass moment of inertia of propeller shaft-side part of the elastic clutch
D2 Mass moment of inertia aggregate-lateral part of the elastic clutch
E Mass moment of inertia of flange plus driven aggregate plus aggregate lateral part of the flexible clutch.

Maximum permissible mass moments of inertia

	Variant 1	Variant 2	Variant 3			
Engine	**A (kgm²)**	**B (kgm²)**	**C (kgm²)**	**D (kgm²)**		**E (kgm²)**
				D1	**D2**	
OM 904 LA	0.01	0.01	0.024	0.014	0.034	0.06
OM 906 LA	0.01	0.01	0.026	0.014	0.034	0.08
OM 924 LA	0.01	0.01	0.022	0.014	0.034	0.05
OM 926 LA	0.01	0.01	0.024	0.014	0.034	0.08
OM 501 LA	0.01	0.01	0.026	0.014	0.034	0.11
OM 502 LA	0.01	0.01	0.028	0.014	0.034	0.13
OM 457 LA	0.01	0.01	0.026	0.014	0.034	0.11
OM 460 LA	0.01	0.01	0.026	0.014	0.034	0.11

Table values are applicable only with key data for the released clutch A 906 250 00 01 or A 444 250 00 01

Attachment with elastic clutch (variant 3)

Model series 900 Clutch A 906 250 00 01
Model series 500, OM 457/460 Clutch A 444 250 00 01
In model series 500 and OM 457/460 engines, note:
Both flexible clutches must be arranged on unit side

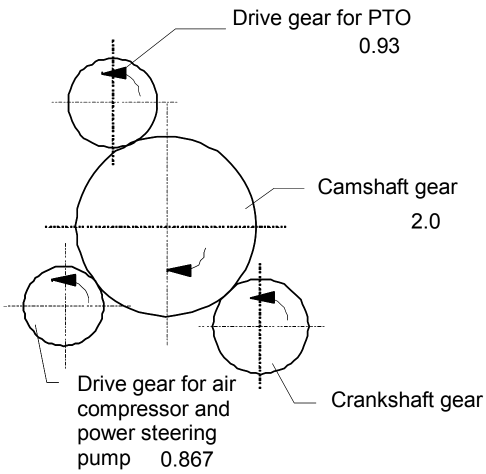
Consider with the engines series 500 as well as OM 457/460:
When the power take-off is running at full capacity, the engine's speed must not fall below 1200 rpm.

Gear Drive

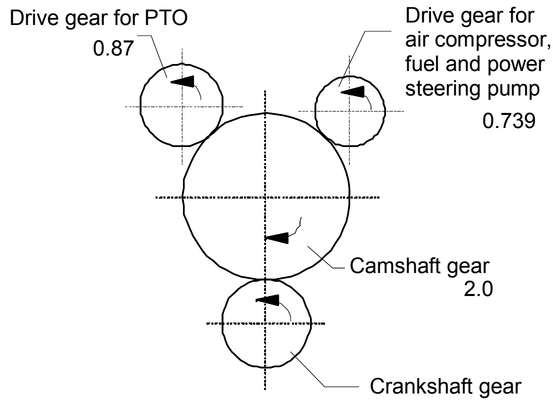
Rotational direction and transmission ratios (looking at the flywheel)

Definition of the transmission ratio: $i = n_{driving} / n_{driven}$ (over engine speed)
or $i = z_{driven} / z_{driving}$ (over the number of teeth)

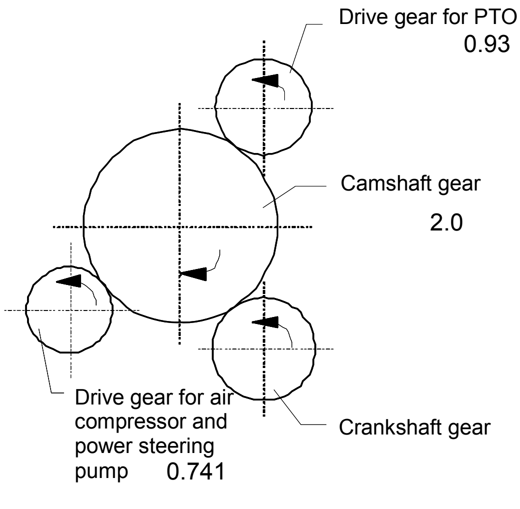
Model Series 900



Model Series 500



OM 457 LA / OM 460 LA



2.14.2 Refrigerant Compressor

Depending on their size, power consumption and the installation case, refrigerant compressors are integrated into the engine's poly-V belt drive or are driven via a separate belt level.
If a refrigerant compressor is connected to the engine by the OEM, this connection must be calculated and checked by DaimlerChrysler in terms of technical vibrations.

2.14.3 Power Steering Pump

The power steering pump is flanged with the engines of the series 900 as well as with the engines OM 457/460 directly at the air compressor. In series 500, the power steering pump is located on the timing case before the fuel pump.
In general, pumps must not be operated without medium. The power steering pump's max. operating temperature is 100°C.
The pressure limiter valve can be integrated either into the power steering pump or the steering circuit.
Disadvantages:
- Increased temperature if the valve is integrated into the power steering pump
- Increased noise if it is installed in the steering circuit

The pump manufacturers' installation instructions must be observed precisely.

2.14.4 Air Compressor

Compressed air consumers must be operated with pure (engine air filtration level) air which is as oil-free as possible, consider arrangement crank case exhaust. As the air always contains a certain amount of oil due to the design, the intake pipes for the air compressor should be positioned on the clean air side between the air filter and the compressor inlet.
The connection on the engine's intake side must lie in the direction of flow upstream of the engine vent, but not in its immediate vicinity (recommendation: at least 300 mm away) sucking laterally or from above but not down.

Since temperatures of up to 250°C may occur at the air compressor pressure fitting and the maximum inlet temperature of the compressed air into the compressed air dryer must not exceed 65°C, a suitable cooling facility of the compressed air must be provided (cooling coils).

The air compressor duty cycle – at a maximal operating pressure of 10.5 bar – should not exceed max. 35%. Higher operating pressures and duty cycles must be approved by DaimlerChrysler, if necessary twin air compressor must be used

Care must be taken to ensure that in engines equipped with the BlueTec system, an additional air requirement of 25 litres /min is available, see Section 3.2.12.

To prevent trigger noises and harmful compressed air vibrations in the compressed air pipe, the pipe must be designed so that a head pressure of 1.0 bar and pulsation of 0.3 bar are not exceeded.

To keep air compressor vibrations (also due to its attachment to the elastically mounted engine) from the downstream compressed air system and to avoid damaging the connections and pipe breaks, part of the compressed air pipe must be of an elastic design, either as a helical pipe (which can also be used simultaneously as a compressed air cooler) or as a hose line.
If pressure hoses are attached directly at the compressor outlet, their pressure stability as well as temperature resistance must also with 250°C compressed air temperature to be ensured. Connecting pieces at the air compressor with cross-section contractions are not permissible.

To avoid high intake shutter opening speeds, which reduce their life, the following design rules must be observed for air compressors:

Intake Pipe:

Model series 500	Pipe length between intake point and resonator	Pipe diameter	Damper volume (resonator)
Minimum requirement:	370 mm	28 mm	550 cm
Recommendation:	500 mm	28 mm	3.0 l

	Pipe length	Pipe diameter
OM 457/460	≤ 1.0 m	min. 25 mm
Model series 900	max. 1600 mm	min. 25 mm

Pressure Pipe

Basically, for 1-cylinder air compressors pressure pipes with an internal Ø of 15 mm must be used. Those pipes used for 2-cylinder air compressors must have an internal Ø of at least 18 mm. For 2-cylinder air compressors, though, single pipes having an internal Ø of 15 mm may be passed up to a merging. After merging the shared pipe must be passed having an internal Ø of at least 18 mm. The merging of both single pipes may not take place on opposite sides e.g. on a - **T**- connection, but in an angle of 90°.
If air driers are used, the pressure pipes must be designed in a manner that is suitable for adherence to the following temperature conditions at the air drier inlet.

- In the loaded movement phase > 28° C over ambient temperature with consideration of the risk of freezing
- Mean inlet temperature < 70° C in the loaded movement phase with consideration of air drying efficiency.
- Maximum short-term inlet temperature < 110° C with consideration of thermal loading capability of the air drier's components.

Additional components in the pressure pipe between the air compressor and air drier (such as damper, cyclone separator, etc.) must be checked and approved by DC.

All elastomer pipes must be free from kinks; steel pipes must be routed so that they cannot vibrate.

When using power reduction (PR) air compressors, it is essential to install the two-way valve by Wabco (Wabco part no. 884 011 110 0) in the control line from the APU (air processor unit) to the compressor

Example of the delivery curve of an air compressor

Air compressor characteristic curve