Installation Manual

Series TD/TCD 2012
TD/TCD 2013

Directions for the installation of Liquid-cooled high-speed Diesel engines

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1st. Edition 05.2006
Order-No. 0399 1969 en

These guidelines are not meant to serve as operating instructions for the end user of machinery but refer to all equipment manufacturers using a DEUTZ diesel engine as prime mover in their products. The guidelines are therefore no user information according to DIN Standard 8418; they fulfill a similar purpose, however, because their compliance ensures operability of the engines and thus also protects the user of the end product against risks which may arise from operation of the engines.

A high degree of operational reliability and a long service life can only be expected from properly installed engines allowing also quick and easy servicing. The present guidelines supply you with the respective instructions for an appropriate installation and make reference to the limit values to be complied with.

In this connection, the guidelines exclusively refer to the engine functions involved and not to any laws and regulations applicable to the equipment in which the engines are installed. These will have to be observed by the original equipment manufacturers.

The great variety of installation conditions makes it impossible to lay down any rigid rules that would apply universally. Experience and specialized knowledge are required to achieve an optimized installation under the given conditions.

We therefore recommend early consultation with Installation Engineering already in the planning stage. All relevant contacts should be arranged through the appropriate sales division.

In the electronic pocket-book ELTAB all necessary changes and supplements will be registered at short notice. A list showing the request of modification, date and modification index see next page.

List of Modification

Modification Index	Date	Chapter	Request of change / modification
00			
01	2006-06-07	00	P/N changed from 0399 1965 to 0399 1969

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1. ENGINE COOLING SYSTEM

Deutz diesel engines of series BFM1012 and BFM1013 as well as their further developments BFM 2012 / 2013 are liquid-cooled engines. Water admixed with additives as anti-corrosion, anti-cavitations and anti-freezing agents is used as coolant, further information is provided in the operation manuals of these series – also see chapter "Enclosure" under engine coolant.

Note: The water treated in such way actually cannot be called water any more; this is considered by continuing to speak of it as coolant.

The engine heat produced during the combustion process taking place in diesel engines is absorbed by the coolant and dissipated to the atmosphere through a cooler (indirect cooling system).

All cooling circuits of the Deutz diesel engines described below are closed circuits (forced circulating cooling system); open-circuit cooling of the diesel engines is not permitted.

Permanent breathing should take place in a secondary circuit with the thermostat both opened and closed for which a permanent flow through the compensation tank is absolutely essential for these engines.

1.1 Arrangement of cooling system

Only the separate arrangement of the engine coolers exists in the engine series TD/TCD 2012/2013 so that the designation with the letter "E" is omitted.
Both series are usually charge air cooled engines with air / air charge air coolers (CAC). Variants without charge air coolers are being planned, however.

Engines with external cooler,

- i.e. conventional mounting of a fan to the engine with external upstream cooler of conventional design or
- a freely standing conventional cooling system comprising fan and cooler
- with the fan driven by an electric or hydraulic motor.
- The charge air cooler (LLK) is arranged upstream the radiator core (MFK) or side-by-side with the cooler

However, it can also be used as a separate cooling unit with a separately driven fan.

1.2 Circuit of engine coolant

The external cooling systems are cooling systems of conventional design with fan + air/water cooler

Two-circuit liquid cooler systems (water / water) have not been designed because a charge air cooler must always be taken into account and therefore a so-called multi-parallel cooling system (see marine installation regulation) would have to be provided.

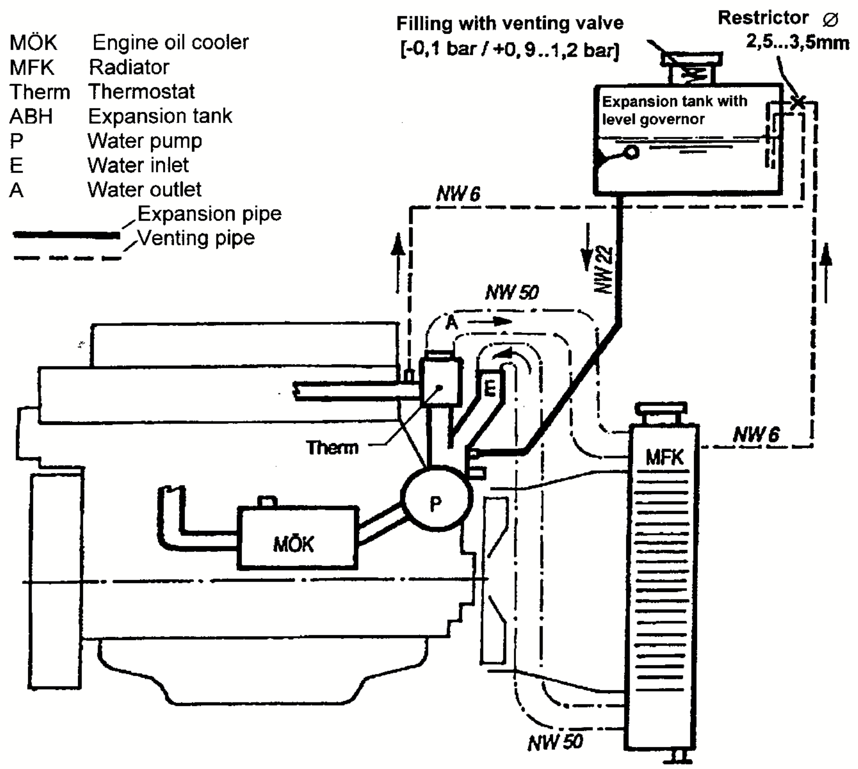
The coolant thermostat is installed on the outlet side of the engine (OUTLET CONTROL), the control range is 87°C to 103°C.

The coolant system must be protected by a pressure relief valve in the cover of the compensation tank.
Opening overpressure 0.9 to 1.2 bar Opening underpressure 0.1 bar.

The highest permissible permanent temperature for the TD/TCD engines is 110°C, (exception TCD 2013 L06 2V, performance group II and higher as well as Pgr. 1 above 2100 rpm = 105°C)

The engine temperature is monitored by the control unit of the electronic engine control (ECU 3) and, depending on the selected scope of performance, exceeding of the temperature leads in steps to warning, power reduction, adjustment of start of injection and shutdown.

FIGURE 1-1: Schematic of the outlet controlled cooling system [TCD 2012 / 2013]



Short description:

The coolant pump ("water pump") draws in the coolant via hose lines directly from the cooler and delivers it first via the engine-integrated lube oil cooler. Thereafter, the coolant enters the engine, flows along the cylinders, upwards into the cylinder head and to the thermostat at the coolant outlet. From there, the coolant is directed via special lines to the cooler inlet.

When the engine is still cold, the coolant is first short-circuited through the engine, until the thermostat response temperature has been reached (starting opening); according to the volume of hot coolant flowing off, the water pump draws in cold coolant from the cooler.

1.3 Layout of fan and cooler

1.3.1 Fan-Layout

For the engines with separately mounted cooling systems, conventional components may be used with

- Fan mounted on coolant pump or
- Fan mounted on crankshaft (only with viscous clutch) or
- Fan fitted to engine on mounting bracket

and one cooler, each, mounted upstream.

With these cooling systems, it is up to the customer to choose a system solution from DEUTZ (Gen-set only) or to procure a relevant system himself.

Fans can be operated as pusher-type fan or suction-type fan. As pusher-type fan, the cooling air is withdrawn from the engine compartment and, thus, heated up – this must be observed when designing a cooler or a fan.

Alternatively, the fan drive can be an electric or hydraulic motor, in particular, if the cooling system is arranged remote of the engine.

The associated fan speed regulation independent of the engine speed also brings advantages in the satisfaction of noise regulations depending on the equipment test cycle to be used.

If the fan is supplied by DEUTZ, fan characteristic fields can be provided with the technical data such as conveyed air volume (m^3/s), conveying height (mbar, cooler and installation resistances), speed, power, direction of conveying and external diameter.

If the fan is delivered by an external company, this company must be provided with the technical data for design of the fan.

1.3.2 Radiator-Layout

If the external cooling system is laid out by a specialist company, the cooling unit can be tailored to the engine operating point in accordance with the specific application. In this case, the coolant temperature must not exceed the maximally permissible coolant temperature at engine outlet in continous operation.

It is generally recommended to design the cooling system for at least an application temperature of 45°C.

The following data must be observed for the design of an engine liquid cooler :

• Amount of engine heat to be dissipated ○ a. via the coolant: ○ b. via the charge air cooling:	c ≅ 0.53...0.60 x engine performance [kW] * c ≅ 0.17...0.25 x engine performance [kW] *
• Amount of heat to be dissipated from auxiliary devices such as retarder, gear transformer oil cooler:	Customer specification

• Performance of the coolant pump: • • The heating circuit must be closed for checking the measurement.	TCD2012L04/06 2V ≅ 180** l/min, 2400/min TCD2013L04/06 2V ≅ 200** l/min 2300/min TCD2012L04/06 4V ≅ 185** l/min, 2400/min TCD2013L04/06 4V ≅ 295** l/min, 2300/min
• Maximum permissible pumping resistance for the coolant pump through liquid cooler and pipes: (Recommended value for the total resistance at rated speed 2400 or 2300 rpm)	0.35bar ** Recommendation: Pipe 0.11bar, Cooler 0.24bar
• Maximum permissible permanent temperature of the engine coolant:	Every 110°C, TDC2013L06 2V, Pgr. I, 2300 and 2200rpm and other performance groups 105°C
Maximum permissible cooling of the coolant by the cooler:	Limit value ΔT = 8°C
• Minimum volume of coolant in the cooler:	According to designed cooler size
• Cooler pressure resistance on the coolant side:	Operating pressure = max. 1.2 bar Bursting pressure........=2.0 bar The possible pressure in the cooler and pipes is approximately the cover opening pressure + the flow resistance of the cooling system.
• Minimum nominal sizes of the pipe connections on the cooler:	50mm The connections on the top and bottom cooler end boxes should be arranged as offset as possible to each other (network diagonally)
• Air throughput through the cooler network:	[m³/s, kg/s] This is specified by the cooler manufacturer.
• Air-side flow resistance:	[mbar] Is made up of the cooler network resistance (manufacturer specification) and the installation resistance (general 2mbar). Necessary for fan design among other things.
• Air inlet temperature on the cooler network:	Heating up in relation to the outside temperature reduces the application limit, avoid heating.
• Air flow direction cooler -> engine: • Air flow direction engine -> cooler:	Suction cooling Note pressure cooling, heating as a result of engine and generator exhaust etc. 8-12°C
• Max. cooler position above engine:	10m
• Coolant drain	Provide drainage possibility on the cooler and at the lowest position in the cooling system

*** The exact value depends on the engine speed and performance setting and must be taken from the electronic pocket book (ELTAB).**

**** The exact value depends on the engine speed, coolant pump version and transmission and must be taken from the electronic pocket book (ELTAB).**

1.3.3 Cooling constant (inlet temperature difference ETD)

The so-called cooling constant refers to the temperature difference Δt between coolant inlet temperature $t_{coolant\ in}$ and inlet temperature $t_{air\ in}$ of the cooling air at the cooler:

$$\Delta t = t_{coolant\ in} - t_{air\ in}\ [C°] = ITD$$

These temperatures are determined under engine full-load conditions; here, the coolant thermostat (fully opened) as well as the viscous clutch of the fan drive must be bridged. In the case of suction-type fans, the air temperature is measured about 0.25 m before the radiator core.

If specific application conditions cause heating up of the cooling air $\Delta t_{heat\ up}$ from the environment up to the cooler, the ambient temperature limit up to which reliable engine operation is possible drops.

In the case of pusher-type fans (where the air is drawn from the engine compartment and is thus preheated by engine radiation heat), the air temperature is measured at the point where the cooling air enters the engine compartment.

With the help of the cooling constant thus determined, it is possible to decide for the respective continuous operation temperature of the coolant of e.g. 110°C, up to which ambient temperature the installed cooling system guarantees reliable back cooling.

$$t_{environment\ limit} = t_{coolant\ limit} - \Delta t - \Delta t_{heat\ up}.$$

It is recommended that the influence of cooler contamination is taken into account when determining the ambient temperature limit by deducting additional degrees in temperature (e.g. 3…5°C) as a safety margin (Δt_S).

$$t_{environment\ limit} = t_{coolant\ limit} - \Delta t - \Delta t_{heat\ up} - \Delta t_S$$

Example:

$t_{coolant\ in}$ = 95°C
$t_{air\ in}$ = 40°C
Cooling constant Δt = 95°C - 40°C = 55 °C = ITD
$t_{coolant\ limit}$ = 110 °C
$t_{ambient\ limit} = t_{coolant\ limit} - \Delta t$ = 110 – 55 = 55°C

The cooling system can be operated up to an ambient temperature of 55°C (here calculated without contamination factor and heating up of air).

NOTE:
The calculation example shows an average determination of the application limit for the cooler on the basis of measured temperature data. In view of the strong dependence of the cooling capacity of the cooler from the air flow rate, always a correcting calculation will be necessary considering the influence of the air density in connection with geodetic altitude and temperature – beyond the factors glycol contents in the cooling water, engine load, engine compartment temperature and cooling air temperature at the mains inlet. If required, contact our Application Engineering.

1.3.4 Additional coolers

1.3.4.1 Converter, transmission and retarder oil coolers in engine coolant circuit

In view of the higher oil temperature level in the case of converters and retarders (except for hydrostatic transmissions), the temperature difference to the engine coolant temperature is high enough to justify the operation of additional coolers of that kind in the engine coolant circuit.

Such additional coolers must be arranged in the main flow of the engine coolant (supply or return) (counter-flow principle , if possible), as these additional coolers require a coolant flow of abt. 1.3 to 1.6 l/min. per kW engine power. This coolant flow rate corresponds to the standard delivery rates of the coolant pumps used for these engines.

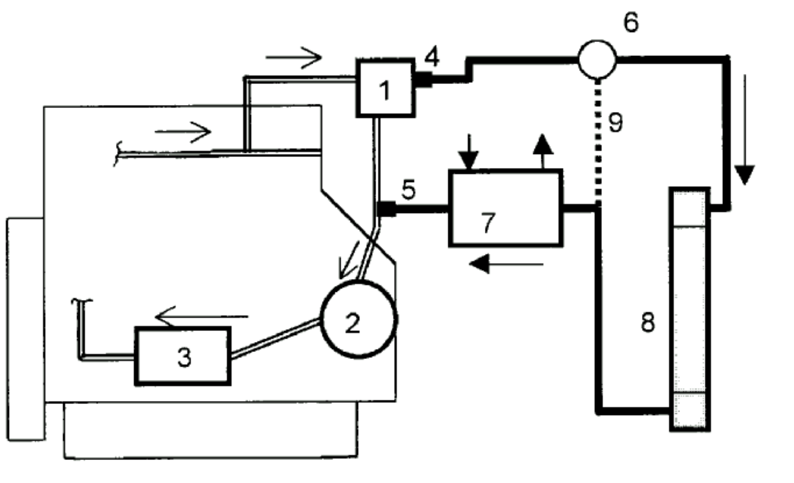
Maximally admissible resistance for the additional coolers: ≤ 0.08 bar, always at maximal coolant flow rate.

To avoid that the recommended overall resistance of the pipeline system between engine and engine radiator is exceeded ($\Delta_{Pipeline} \leq$ 0,11 bar), the pipeline resistance must be reduced by the size of the resistance of these additional coolers.

Especially in the case of retarder operation (engine needs "no" cooling), it must be ensured that the coolant circuit is maintained by the additional cooler (retarder oil cooler).

1.3.4.2 Additional cooler in the supply line (engine inlet – outlet cooler)

FIGURE 1-2

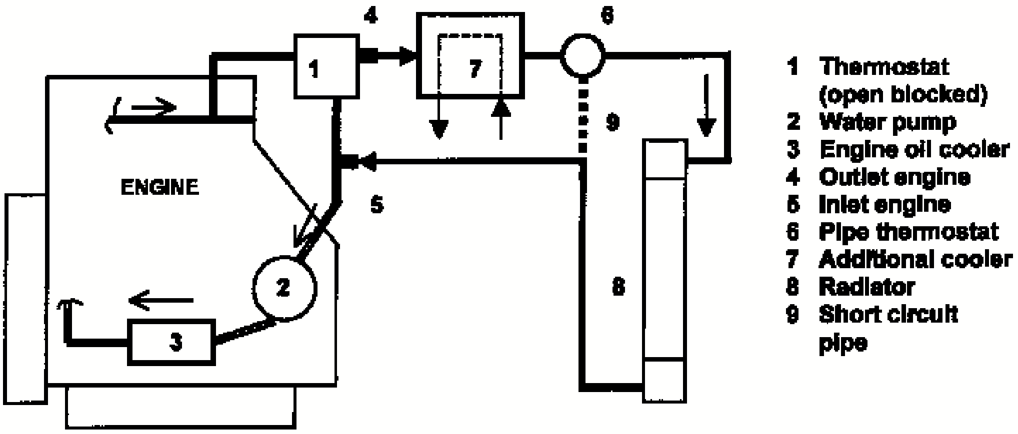


In the case of the **OUTLET CONTROL** of the TCD engines, an open-blocked thermostat is used for the engine and a pipe thermostat installed between engine outlet and engine cooler inlet, if always a maximal coolant throughout must be made sure. The short-circuit line from the thermostat ends in the supply pipe between additional cooler and engine cooler.

Recommended thermostat opening range	83 - 95°C, in only automatic transmission
	71 – 85°C, in automatic transmission with retarder

1.3.4.3 Additional cooler in the return pipe (engine outlet – inlet engine cooler)

FIGURE 1-3

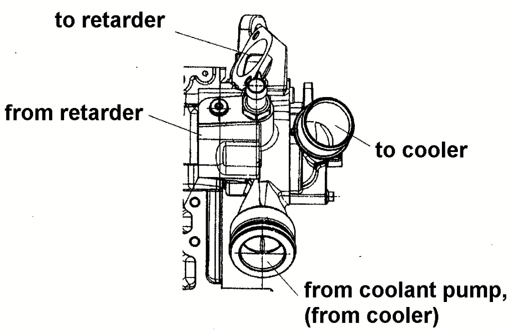


In the case of the **OUTLET CONTROL**, also an open-blocked thermostat is installed in the engine, if the maximally possible coolant flow shall be ensured. The thermal control is taken over by a pipe thermostat arranged in the return pipe between additional cooler (outlet) and engine cooler (inlet). The short-circuit line from the thermostat ends in the pipe between outlet engine cooler and inlet engine.
It is recommended to check the effectiveness of the cooler circuit arrangement by relevant in-service tests.
During such tests, it can also be determined, whether the cooling capacity of the engine-integrated radiator is sufficient or whether it must be modified by increasing the fan speed or providing a larger radiator and fan. It may also be necessary to reconsider the control range of the thermostat.

1.3.4.4 Additional cooler in the TCD2013L04/6 4V

This engine is designed as a vehicle engine. Therefore a thermostat variant is available for this engine to which an additional cooler can be connected directly. The additional cooler is installed between cooler outlet and engine inlet.

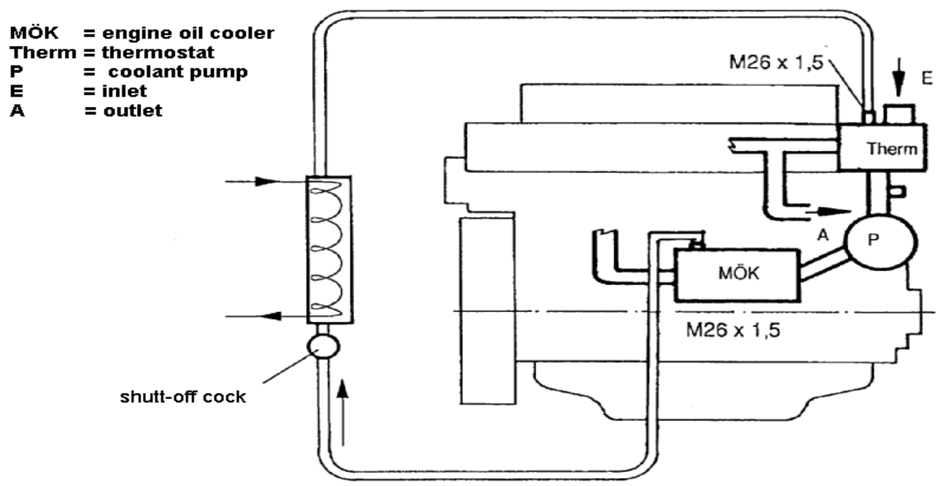
FIGURE 1-4



1.3.4.5 Additional cooler in the heating circuit

In the case of cooler units with a lower cooling requirement, it may be reasonable to connect an additional cooler using the connectors at the engine (provided for the heating system). A forced bridging of the engine thermostat for representing the maximal flow rate is not necessary – see diagram.

FIGURE 1-5



A maximum coolant volume of 18l/min may be fed through the additional cooling system in this circuit in relation to nominal speed in order not to endanger the coolant supply to the engine.

1.3.4.6 Converter, transmission and retarder oil cooling in the cooling air system

The cooling unit will be extended when mounting air/oil coolers besides the engine radiator (side-by-side) or upstream the engine radiator (attached coolers).

In that case, the fan must be adapted (increased speed and/or enlarged fan diameter) in order to reach the necessary higher air volume flow rate.

1.3.5 Charge air cooler installation

The coolers provided for charge air-cooling are so-called air/air coolers, i.e. the charge air is cooled down by the cooling air.

On the engines with integrated cooling system, the charge air coolers are arranged upstream of the blower. The coolers are rigidly mounted to the engine and connected with the blower via an air duct.

In the case of engines with external cooling system, the charge air coolers are mounted upstream of the radiators. For connecting the externally arranged charge air coolers to the combustion air pipe system of the engine, observe the references given in chapter 3.10, "Combustion air".

1.4. Design of the compensation tank, compensation and venting lines, water level check

The compensation tank in the closed coolant circuit has the tasks of

- accommodating the increase in volume resulting from heating up of the coolant.
- accommodating the coolant escaping from the venting lines with the air.
- ensuring the coolant system pressure with the overpressure and underpressure limiting valves in the cover.
- ensuring a positive static pressure on the suction side of the coolant pump through the compensating line (avoidance of cavitation).
- compensating possible water losses in the coolant system.
- displaying the liquid level.
- monitoring the water level in the system (level switch with engine stop)
- acting as a bubble trap, see sect. 2.

The following specifications must be observed for designing the compensation tank:

• size of the compensation tank (ABH):	30% of the total coolant volume, if this is approx. up to 20 ltr. 20% of the total coolant volume, if this is above 20 ltr.
• The compensation tank must be filled up to 50% with coolant. The remaining air-filled space accommodates the expansion of the coolant when heating up. • Narrowly dimensioned compensation tanks lead to a high system pressure and must be protected against leaking of coolant with an appropriately higher opening pressure of the valve in the cover. This also assumes an appropriate pressure resistance of the cooler.	
• The total circulating coolant volume consists of the coolant volumes - in the engine - in the pipes - in the engine liquid cooler - in the additional heat exchanger (heating) - in the additional pipes - in the additional heat exchanger (gear oil) • The following specifications apply for the coolant volumes in the DEUTZ engines (without cooling system): TD/TCD L04 2012 5.6 ltr; TD/TCD L04 2013 7.4 ltr; TCD L06 2012 7.6 ltr; TCD L06 2013 9.8 ltr	
• Position of the compensation tank:	- Above, but at least at the same height as all coolant bearing pipes - Note possible incline, liquid level in the ABH should always be above the then highest engine contour
• Pressure protection of the compensation tank:	For (105°C) 110°C coolant temperature (+0.6bar) +1.0 bar / -0.1 bar
• Strength of the compensation tank:	Temperature strength +120°C at +2.0bar

• Filler neck:	Insert this in the tank up to the "Max" level and drill a hole of ∅ 3mm.
• Level monitoring:	Install level monitor on the ABH
• Pipe connections on the compensation tank: a. Expansion pipe: * If the nominal size of 22mm cannot be kept in individual cases, it must be checked that there is a minimum pressure of +0.3bar before the coolant pump at approx. 95°C coolant temperature (thermostat open). b. Venting lines:	N.B.: - Centrally at the lowest point so that no air can be sucked in inclined positions - Always lay line ascending - Nominal size 22mm, but not less than 12mm ***(because of engine filling)** - Nominal size of the venting lines 6mm - Fit the venting line from the cooler to the ABH with a choke, approx. ∅3mm - The venting line from the engine to the ABH requires no choke, engine-side connection chokes sufficiently - Lay venting lines continuously ascending - Arrange pipes as far away from the compensating pipe as possible so that water/air mixture is not sucked back in. - Feed venting line into the ABH above the coolant level and lengthen below the level on the inside **

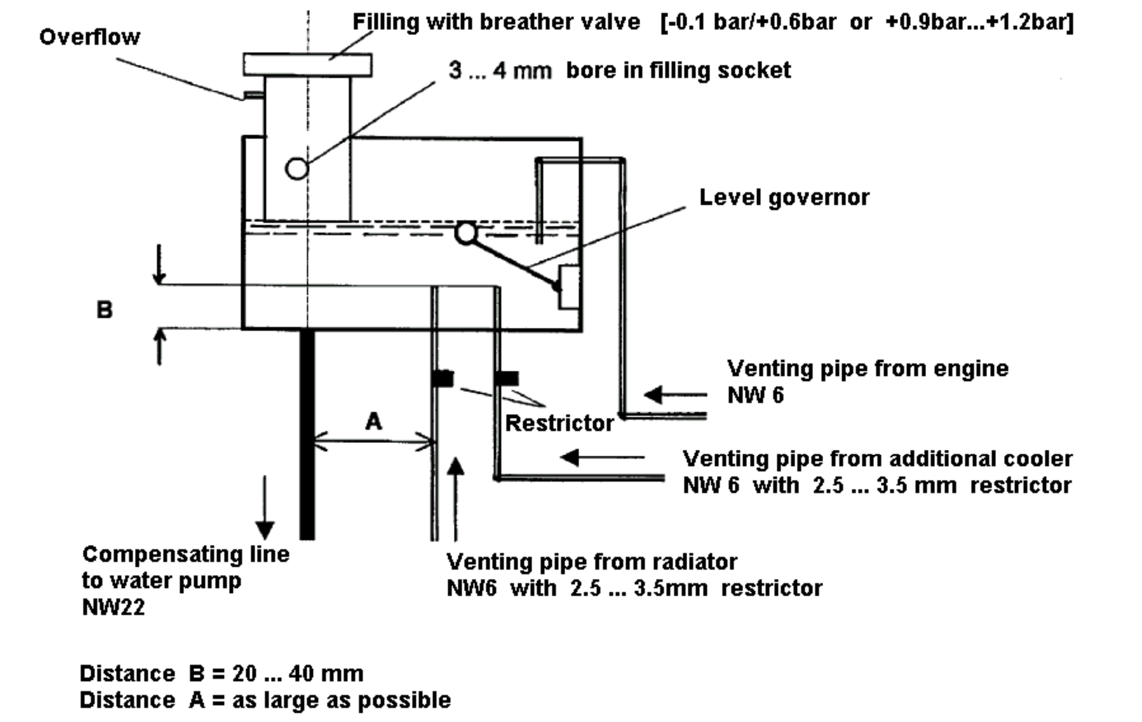
** This simplifies the filling process especially when the expansion pipe is still arranged directly under the filler neck. If this is not possible for constructional reasons, observe the following instruction on line arrangement:

Venting line from the cooler to the ABH:
Always connect below the coolant level in the ABH on the ABH, prevents coolant being sucked out of the cooler when the thermostat is closed.

Venting line from the engine to the ABH:
Always connect above the coolant level in the ABH, prevents the engine venting being blocked when filling.

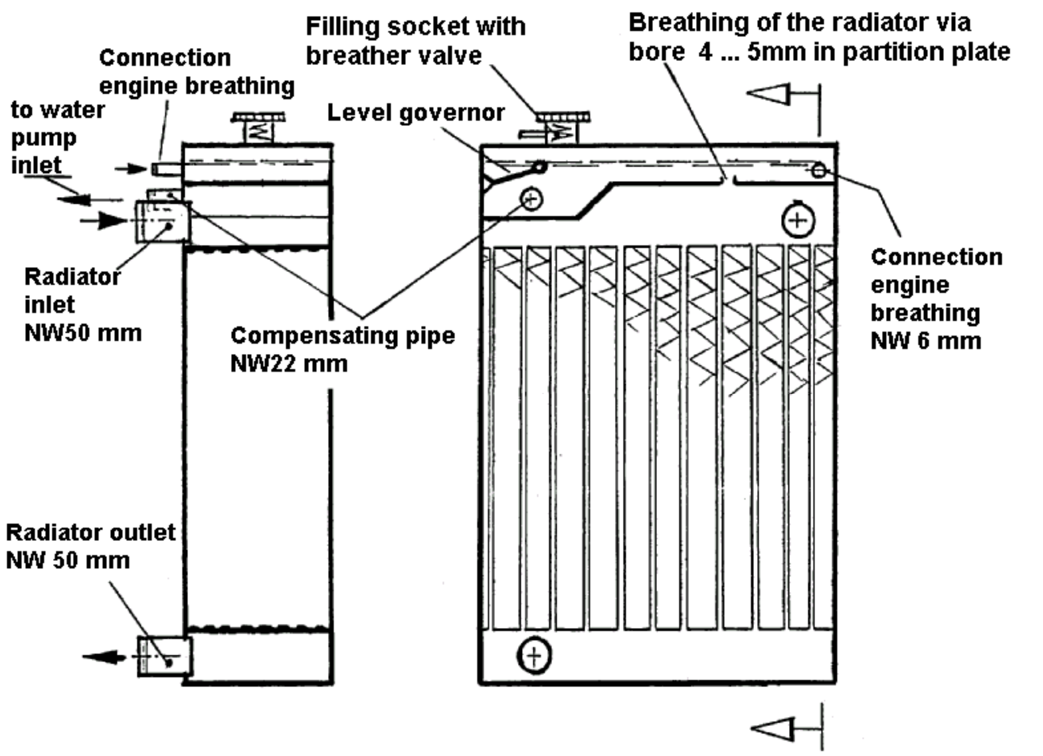
1.4.1 Pipe connections for external expansion tank

FIGURE 1-6



1.4.2 Pipe connections for expansion tank in the radiator end box:

FIGURE 1-7



1.4.3 Water level control in the expansion tank

The water level control in the expansion tank via level governor and electric contact transmission for engine shutdown (lifting solenoid) is the only really effective monitoring method to protect the engine against damage due to lack of water.

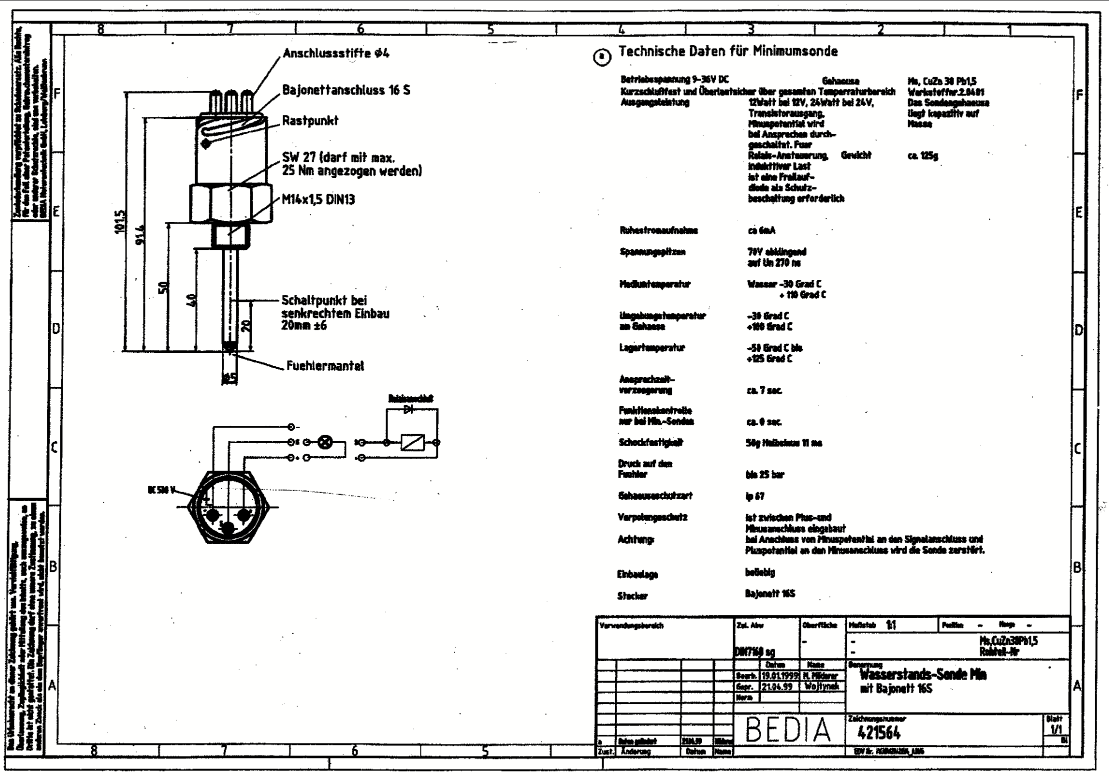
DEUTZ offers an inductive level sensor made by BEDIA for the engine series TCD 2012 / 2013 in the "normally open" function.

A non-recognised lack of water can lead to a total failure of the engine.

Therefore, it is obligatory for every engine to monitor the water level in the expansion tank with a level monitor with electrical contact transmission for engine shutdown.
If a lack of coolant is detected with the engine running, a warning lamp gives a warning.
Alternatively an engine shutdown after 10 s can be programmed if permissible for the application.

Drawing of the coolant level sensor which is available from Deutz:

FIGURE 1-8



DEUTZ Part- / Drawing No. 0118 1474EC

1.5 Heating system

With the liquid-cooled DEUTZ diesel engines, the heat contained in the coolant is used for heating driver cabs and passenger compartments.

In this case, the engine coolant is ducted directly to the system heat exchanger and the heat is dissipated directly to the environment (direct heating system).

Alternatively, the engine heat can be transferred via an intermediate heat exchanger (transfer cooler) into a separate heating circuit with system heat exchanger (indirect heating system). Any leakage in the heating system will not affect engine cooling in this case.

1.5.1 Direct heating system

The engine coolant is directly supplied to the heating system heat exchanger.

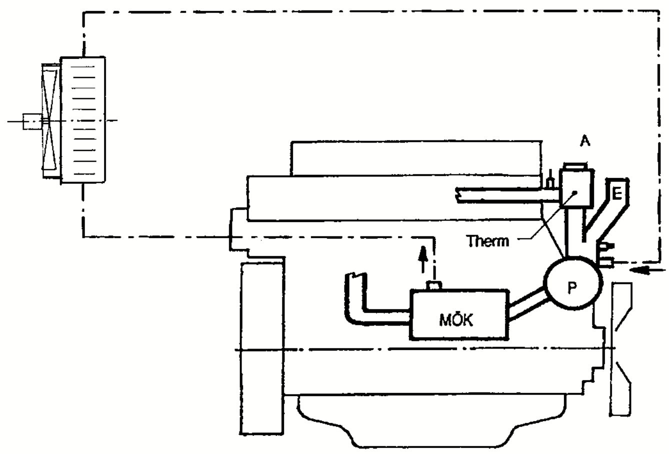


FIGURE 1-9

The tread sizes of the heating connections are M26 x 1,5.

1.5.2 Indirect heating system

The layout of the piping diameter of the heating system including fittings and system heat exchanger (heater fan) are to be adapted according to the electric motor-driven coolant pump and its performance characteristics.
The heating circuit of the intermediate heat exchanger/system heat exchanger must also be provided with an expansion tank fitted with venting and breather valves.

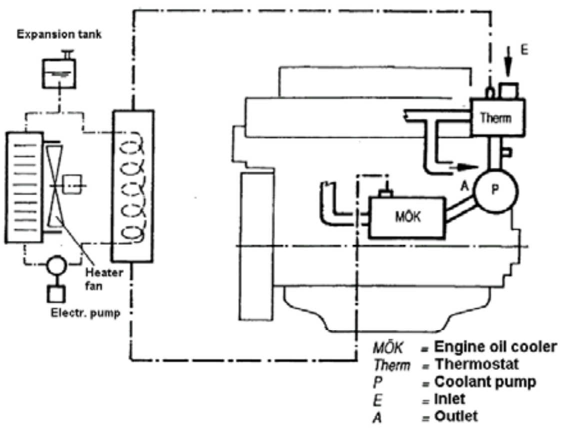


FIGURE 1-10

The engine coolant volume flow rates listed below are available for the heating units, always at maximal rated speed.

The specified engine coolant volumes for the heating system must not be exceeded as, otherwise, the coolant supply to the engine is affected.

If maximum water flow volume is exceeded an additional restrictor has to be installed in the heater circuit.

Admissible coolant volumes for the heating system (withdrawal at the engine cooler housing)

Engine	max. engine coolant volume flow rate for heating unit [l/min]	Engine Speed [min^{-1}]
TCD 2012 L04 2V	18	2400
TCD 2012 L06 2V	18	2400
TCD 2012 L04 4V	18	2400
TCD 2012 L06 4V	18	2400
TCD 2013 L04 2V	18	2300
TCD 2013 L06 2V	18	2300
TCD 2013 L04 4V	18	2300
TCD 2013 L06 4V	18	2300

Piping diameters are to be determined so as not to exceed coolant flow velocities of 4 m/sec.

Recommended piping diameters
for pipe length of up to abt. 10m: 15 to 18 mm (internal width)

In the case of long heating pipes (convector systems in coaches, for instance), the additional flow resistances must be taken into account, which may necessitate an additional enlargement of the pipe diameter. To avoid also here that the uniform distribution of the coolant to engine- and heating circuit is not inadmissibly affected (e.g. if the flow resistance of the heating circuit is considerably smaller than that of the engine), if required, a restrictor must be installed at the heat exchanger of the heating system (alternatively at the outlet).
For restrictor layout, please consult application engineering.

1.5.3 Design of heating exchangers

Maximum coolant volume	18 l/min at nominal engine speed, at reduced speed correspondingly linearly reduced volume
Maximum temperature reduction between heat exchanger inlet and outlet	30°C, heating designs in which the engine no longer reaches operating temperature should be avoided
Cooling system pressure	Note opening pressure of the valve in the cover

1.5.4 Auxiliary heating systems

Auxiliary heating systems are heaters with which cabs or other spaces can be heated when the engine is shut off.

The auxiliary heater is interconnected in the liquid circuit of the heating system and the coolant is heated up when needed. An electric auxiliary pump circulates the coolant so that – depending on the circuit arrangement – the engine can also be heated up.

If necessary, the auxiliary heating system with the auxiliary pump must also be breathed via the expansion tank – depending on the installation situation.

The heat of the auxiliary heater is generated by the combustion of diesel fuel. It is therefore a complex system and necessitates considerable installation work (exhaust system, combustion air system, electrical equipment, fuel system etc.).

The following companies are well known-manufacturers and suppliers of such heating systems:
Eberspächer, 73730 Esslingen, Tel: 0711 939 00
Webasto, 82166 Gräfelfing, Tel: 089 853983

The manufacturer's recommendations and instructions are to be observed for the installation of such heating systems.

1.5.5 Heating rod

The electrically operated heating rod (the so-called socket heating) as per DEUTZ scope of supply (PN 0419 8898 KZ 0130-63, 230V, 820W)) is predominantly provided for keeping the cooling water warm and is installed at the lube oil cooler housing.

1.6. Pipings and fittings

1.6.1 General

The delivery rate and delivery height of the engine-mounted coolant pump (centrifugal pump, is also dependent on the flow resistance of piping and fittings (cocks, valves). The pipe resistances and the type of pipe laying (number and type of pipe bends) must therefore be determined with utmost care.

The pipes of external cooling systems should therefore be kept as short as possible.

1.6.2 Pipe and fitting resistances

The dimensions of the piping between engine and cooling system are initially determined by the cross sectional area of the coolant pipe connections.
They must not be smaller than the bore diameters of the pipe connections on the engine.

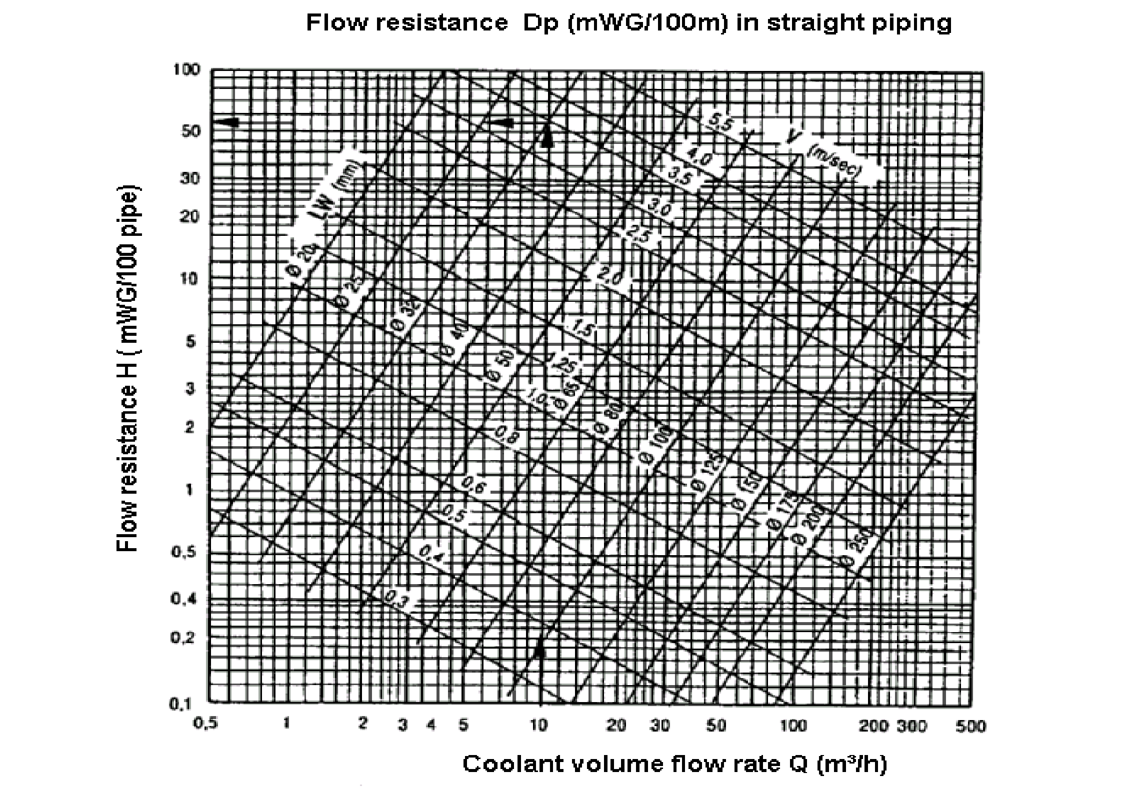
If the permissible radiator resistance is used by 0,24bar, still the following resistance can be set for the lines and armatures due to the restricted suction and delivery resistance of the coolant pump ("water pump"):

$\Delta p_{Rohrsystem} \leq$ **0,11 bar (11 kPa)**

The values refer to the maximum rated speed of the engine 2300/min or. 2400/min

The specific piping resistances relative to delivery rates and nominal pipe widths may be taken from the nomograph (illustration below). The absolute piping resistance is the result of the specific piping resistance and laid pipe length.

FIGURE 1-11



From the table (following picture), the equivalent pipe lengths in metres for fittings and shaped pipe elements may be taken.

FIGURE 1-12

Calculated pipe lengths in (m)

Nominal width (mm)	25	50	65	80	100	125	150	200	250	300	350	400	500	600
Intake strainer with foot valve	3	5,9	8	10	13	16	19	26	32	39	45	52	65	79
Slide valve	0,2	0,4	0,6	0,8	1,1	1,4	1,9	2,9	4,2	5,6	7,2	8,9	13	17,4
Check valve	1	2,3	3,4	4,5	6,4	8,9	12	18	26	34	43	54	77	105
Full-bore valve	0,5	1,2	1,5	1,8	2,2	2,9	3,7	5,4	7,3	9,2	11	14	18	22,4
Inclined-seat valve	2	4,1	5,5	6,8	8,5	10	11	13	15	16	17	18	20	22
Standard valve	3	7,5	11	14	20	28	37	57	81	108	139	173	250	336
Angle valve	3,5	7,2	10	13	17	23	31	49	70	95	121	148	207	276
Bend 90° R= 3d	0,3	0,7	0,9	1,2	1,5	1,9	2,3	3,2	4,4	5,7	7,1	8,6	12	15,7
Bend 90° R = 3d	0,5	1,1	1,4	1,7	2,2	2,8	3,5	5	6,7	8,5	11	13	18	23,4
Cast elbow 90°	0,8	2,4	3,4	4,5	6,3	8,9	12	18	26	34	43	53	74	97
Sheet metal elbow 90°	3	5,4	7,5	9	11	14	18	26	36	48	61	77	111	146

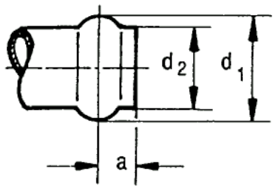
If the sum of resistances from pipes, fittings and coolant heat exchanger exceeds the available pump delivery head, the pipe diameters must be enlarged.

1.6.3 Pipe layouts

Commercial steel pipes (seamless, non-galvanized) are to be used for the engine coolant, which must be descaled at the inside after bending or welding work (pickling, flushing).

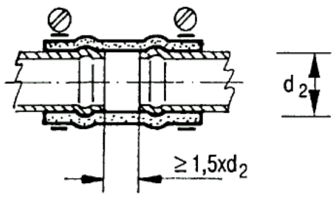
The pipe ends are to be provided with sealing crimps (as per DIN 71550), in order to ensure a permanent and tight rubber sleeve joint.

FIGURE 1-13



d_2	12 bis 22	25	28 bis 80
d_1	d_2+1	d_2+1	d_2+2
a	4	6	6

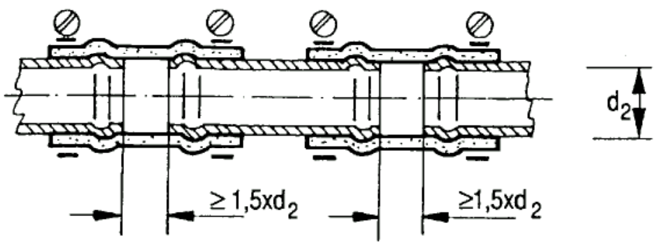
a (mm)
$d_{1,2}$ (mm)



Pipe joint with rubber sleeves and hose clamps

As the above illustration shows, sleeve combinations can also be used for flexible pipe joints. If possible, these should be arranged in parallel to the crankshaft.

FIGURE 1-14



Flexible pipe union with rubber sleeves and hose clamps

As an alternative can be used appropriately shaped rubber moulded parts for radial and axial length compensation.

The following companies are well known manufacturers of such moulded parts and hoses:

Messrs. Mündener Gummiwerke	34334 Hann. Münden	Phone: 05541 70 10
Messrs. Dawson / Rickal	56414 Steinefrenz	Phone: 06435 96 1888
Messrs. Continental	30165 Hannover 1	Phone: 05119 76 01
Messrs. Matzen	19258 Boizenburg	Phone: 03884 76 660
Messrs. Möllerwerke	33626 Bielefeld	Phone: 05214 47 70
Messrs. Gates	407455 Langenfeld	Phone: 02173 79 50

The material for rubber sleeves, moulded parts and corrugated hose pipes (without internal wire coil!) for coolant-carrying pipes must be resistant to corrosion inhibiting oil, engine oil, antifreeze, diesel fuel and be permanently resistant to temperatures between

-40°C and +125°C (also see DIN 73411 Part 1 u.2).
Compressive strength ≥ 6 bars

In the case of conventional cooling systems, the demand placed on permanent temperature resistance may be reduced to 100°C.

Raw water pipes (secondary circuit cooling) must be made of corrosion-proof material.

1.6.4 Fastening by clips

The clips for fastening the sleeves, hoses or moulded parts must absolutely be permanently sealing, i.e. high-quality clips must be used

such as e.g.: PEBRA – clip
Manufacturer: Messrs. Seeger Orbis, 78665 Frittlingen Phone: 07426 94920
or GBS-Norma – clip (clip with hinged bolt and helical spring)
Manufacturer: Messrs. Rasmussen GmbH, 63461 Maintal Phone.: 06181 403-0

The further explanations to the subject of clips in chapter combustion air can analogously be applied to coolant pipes.

1.6.5 Pipe laying

When laying the pipes, attention must be paid that no air pockets can develop in the coolant system.

At those places where air pockets can develop, so-called breather pipes should be connected which are ducted in a continually ascending manner to the expansion tank.

At the lowest point of the cooling system, drain cocks should be provided to dehydrate the system.

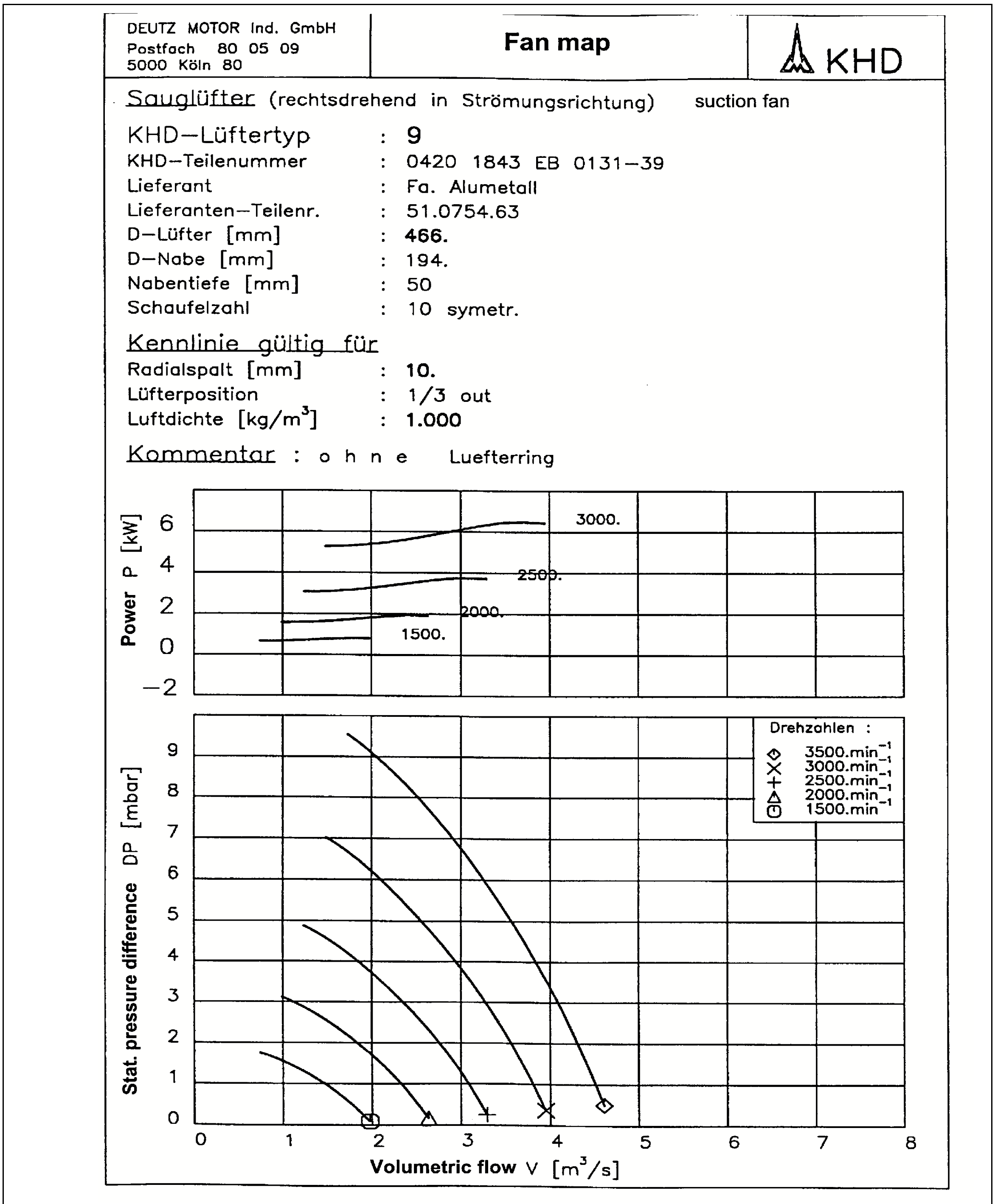
1.7 Fan arrangement

DEUTZ offer fans adapted to the engine scope of supply.

Please contact the head office for air volume flow rate as a function of delivery resistance and fan speed.

If the fans are procured from specialist companies, the layout-specific technical data should be clarified with the cooler manufacturer or with DEUTZ.

FIGURE 1-15 Example of fan diagram:



1.8 Fan arrangements and mounting configurations

The following possibilities are provided for mounting the fan to the engine with separately mounted cooler (external cooling system):

- Fan mounted to coolant pump
- Fan mounted via mounting bracket at face of engine
  (with variable fan mounting heights – see Technical Pocket Book)
- Fan mounted to front crankshaft end
  (fan mounting only with flexible couplings – e.g. viscous clutches)

With the first two mounting alternatives, the fan is belt-driven. The fan speed can be adapted by changing the transmission ratio.

The third configuration is a belt-less fan drive without the possibility of fan adaptation, however, by modifying the fan speed ratios.

The mounting bracket configuration offers the additional possibility to arrange the fan above the crankshaft at different heights to the crankshaft. In this way, the fan can be matched to the position of the radiator.

If the fan is mounted remote of the engine, it is driven by electric or hydraulic motor.

In special cases, mechanical drive solutions will be realised, too, either via belt drive or as auxiliary drives on the transmission. This will necessitate specific fan mounting designs which are to be clarified with the specialist companies.

1.8.1 Fan mounted to coolant pump

When mounting the fan to the V-belt pulley of the coolant pump, the bearing of the coolant pump is exposed to additional stress loads for the shaft bearing of the coolant pump as a result of increased belt forces and additional axial thrusts or axial pressures (suction or pusher-type fans).

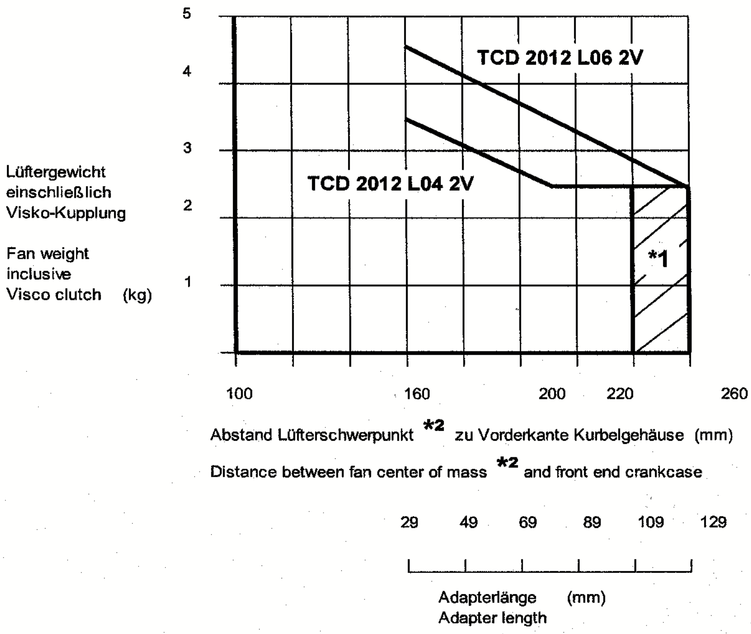
The following marginal conditions must be observed:

FIGURE 1-16

Zulässige Belastung für den Lüfteranbau an der Kühlflüssigkeitspumpe (Lager Ø 40mm)

Admissible stress on fan mounting at cooling medium pump (journal Ø 40 mm)

TCD 2012 2V			i = 1:1,36 n_{Nenn} = 2000 - 2400 1/min	i = 1:1,6 E-Aggregate n_{Nenn} = 1500/1800 1/min
max.Lüfterleistungsauf-nahme	absorbed fan power max	kW	9,2	
max. Unwucht Lüfter	unbalance fan max.	gcm	40	
max. Exzentrizität zwischen Lüfterschwerpunkt und Pumpenwellenmitte	max. eccentricity between fan center of mass and center of line of pump shaft	mm	0,15	
max. Adaptergewicht	max. adapter weight	kg	1,5	
max. Unwucht des Adapters	max. unbalance of adapter	gcm	30	
max. zul. Axialkraft beim Sauglüfter	max. thrust of fan (puller)	N	150	
max. zul. Axialkraft beim Drucklüfter	max. thrust of fan (pusher)	N	350	



*1 Erweiterter Bereich für Aggregate - Motoren bis max. n nenn = 1800 1/min

Increased tolerance for generating set engines up to max. n nom = 1800 1/min

*2 Lüfterschwerpunkt entspricht der Anflanschfläche des Lüfters am Adapter

Fan center of mass corresponds to fan flange at adapter

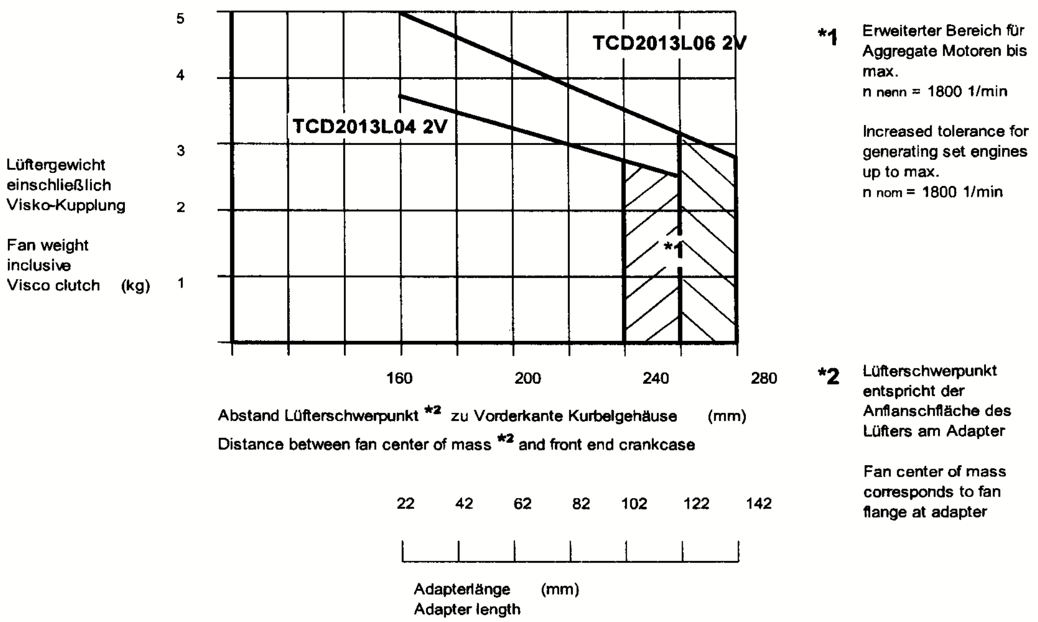
FIGURE 1-17

Zulässige Belastung für den Lüfteranbau an der Kühlflüssigkeitspumpe (Lager Ø 55 mm)

Admissible stress on fan mounting at cooling medium pump (journal Ø 55 mm)

nur / only TCD2013 2V

			i = 1:1,2 n_{Nenn}= 2300 1/min	i = 1:1,73 E-Aggregate n_{Nenn}= 1500/1800 1/min
max.Lüfterleistungsaufnahme	absorbed fan power max	kW	9,2	9,2 / 8,6
max. Unwucht Lüfter	unbalance fan max.	gcm	40	40
max. Exzentrizität zwischen Lüfterschwerpunkt und Pumpenwellenmitte	max. eccentricity between fan center of mass and center of line of pump shaft	mm	0,15	0,15
max. Adaptergewicht	max. adapter weight	kg	1,5	1,5
max. Unwucht des Adapters	max. unbalance of adapter	gcm	30	30
max. zul. Axialkraft beim Sauglüfter	max. thrust of fan (puller)	N	150	150
max. zul. Axialkraft beim Drucklüfter	max. thrust of fan (pusher)	N	350	350



Upon reduced speed, the limit values for unbalance- and axial forces can be extended relative to speed:
- Extended unbalance limit = (rated engine speed / red. speed)^2 x unbalance
- Extended axial force limit = (rated engine speed / red. speed) x axial force

All figures in the table apply to a 1-belt drive {coolant pump, crankshaft, fuel pump)
Rated engine speed for TCD 2012: n_{rated} = 2400min^{-1}
for TCD 2013 n_{rated} = 2300min^{-1}

1.8.2 Fan mounted by means of bearing bracket

For increased fan capacities in respect of the air volume flow rate for the supply of additional coolers in addition to the radiator, DEUTZ supplies an engine-mounted bracket for installation of the fan.
The fan is driven by V-belt, which can be re-tensioned by means of a tensioning device.
When re-tensioning the V-belts, the belt pretension limit as per operation manual or table must be observed.

The following table indicates the marginal values, the observation of which ensures a reliable operation of the fan drive.

FIGURE 1-18

TCD 2012/2013 2V

Zulässige Belastung der separaten Lüfterlagerung

Admissible stress on separat fan mounting

Anzahl Antriebsriemen (AV 13)	Number of V-belts		1	2
max.Lüfterleistungsaufnahme	absorbed fan power max	kW	10	19
max. Unwucht Lüfter	unbalance fan max.	gcm	40	40
max. Exzentrizität zwischen Lüfterschwerpunkt und Pumpenwellenmitte	max. eccentricity between fan center of mass and center of line of pump shaft	mm	0,15	0,15
max. Adaptergewicht	max. adapter weight	kg	1,5	1,5
max. Unwucht des Adapters	max. unbalance of adapter	gcm	30	30
max. zul. Axialschub (Saug/Drucklüfter)	max. thrust of fan (pusher/puller)	N	150	150

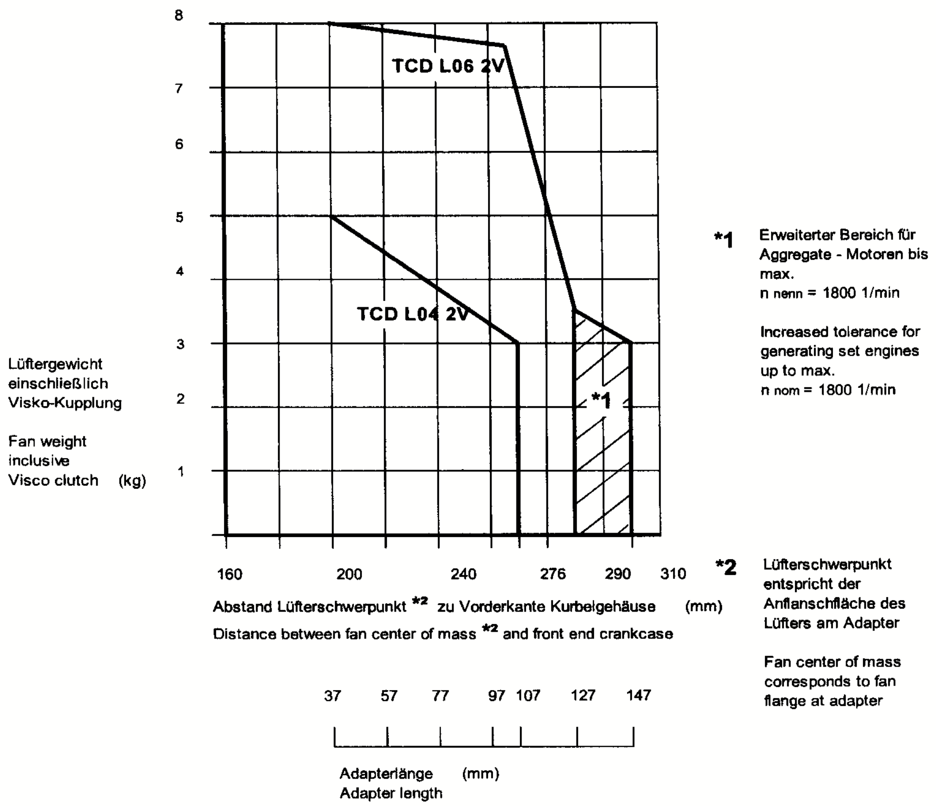


FIGURE 1-19

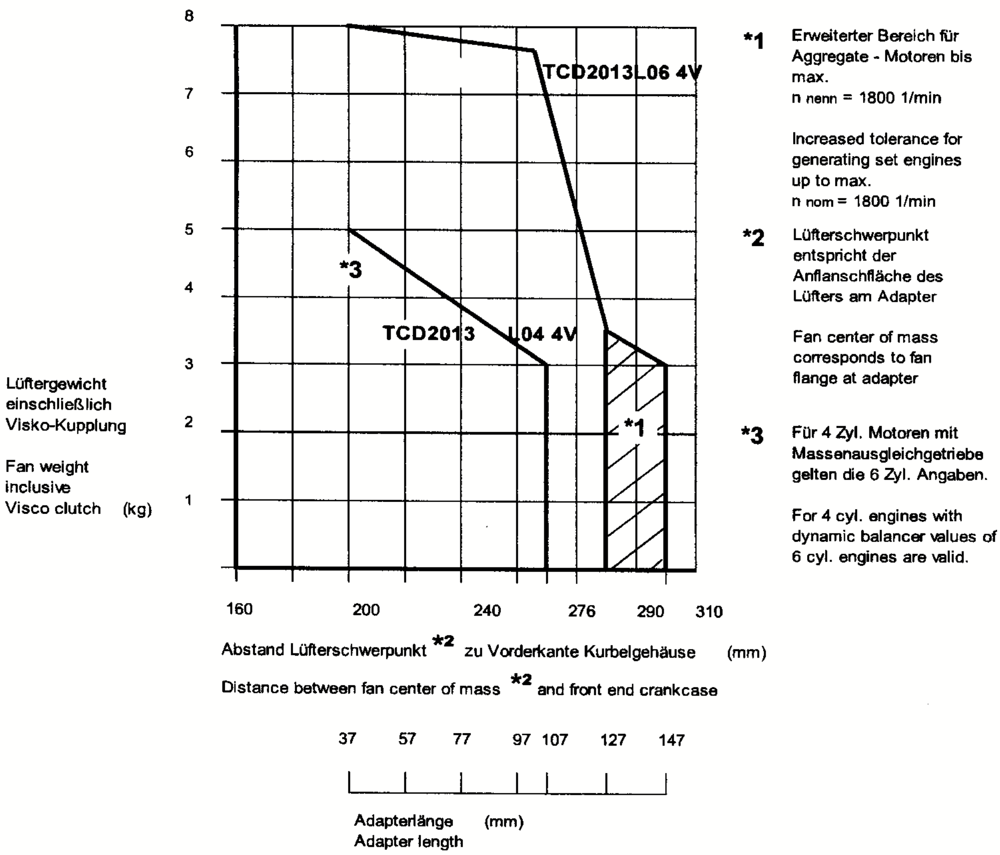
TCD 2013 4V Industrie u. Aggregate

Zulässige Belastung der separaten Lüfterlagerung

Admissible stress on separat fan mounting

Keilrippenriemen 10 PK V-ripped belt			
max.Lüfterleistungsaufnahme	absorbed fan power max	kW	15
max. Unwucht Lüfter	unbalance fan max.	gcm	40
max. Exzentrizität zwischen Lüfterschwerpunkt und Pumpenwellenmitte	max. eccentricity between fan center of mass and center of line of pump shaft	mm	0,15
max. Adaptergewicht	max. adapter weight	kg	1,5
max. Unwucht des Adapters	max. unbalance of adapter	gcm	30
max. zul. Axialschub (Saug/Drucklüfter)	max. thrust of fan (pusher/puller)	N	150

Bei höheren Lüfterleistungen: Rückfrage im Stammhaus!
For higher fan power: Please contact Head Office!



Upon reduced speed, the limit values for unbalance- and axial forces can be extended relative to speed:
- Extended unbalance limit = (rated engine speed / red. speed)^2 x unbalance
- Extended axial force limit = (rated engine speed / red. speed) x axial force

All figures in the table apply to a 1-belt drive {coolant pump, crankshaft, fuel pump)
Rated engine speed for TCD 2012: n_{rated} = 2400min^{-1}
for TCD 2013 n_{rated} = 2300min^{-1}

1.8.3 Fan mounted at front crankshaft end

When mounting the fan at front crankshaft end, torsional vibration characteristics have to be taken into account.

Special attention should be paid to fan assembly and configuration as the fan is exposed to high stress loads due to the tumbling movement at front crankshaft end and the torsional irregularities.

Therefore, fan mounting at front crankshaft end must generally be realised via a flexible coupling or only fans with viscous clutch are permitted to be used

In case of doubt, you should contact application engineering for a torsional vibration evaluation of the fan assembly.

1.8.4 Remote fan mounting arrangement

With the external cooling system comprising fan and cooler, the following fan drives are available:

- mechanically via V-belt directly from the engine
- mechanically - directly or via V-belt from the auxiliary drive on the transmission
- hydraulic motor or electric motor

Fan and cooler form an integral unit together with the duct which is fitted on an auxiliary frame that usually also carries the mounting bracket for the fan.

Such components are available from the specialist companies. Thus, the OEMs can realise their own constructions in respect of the fan drive depending on the given installation conditions. The limit values to be observed for the load acting on the fan mounting should be obtained from the specialist company.

In the case of belt drive on the engine (front crankshaft end), it is necessary to observe the permissible bending moments. Please consult application engineering.

1.9 Mounting of radiators

Proven commercial radiators of fin- and tube type or MC Cord or pack-type design are used for external cooling systems.

Except pack-type design, in view of their design, radiators are not suitable to withstand external forces over an extended period of time without suffering damage. Although such radiators are reinforced for industrial engine applications, it is mandatory to protect them against excessive vibrations and impact loads.

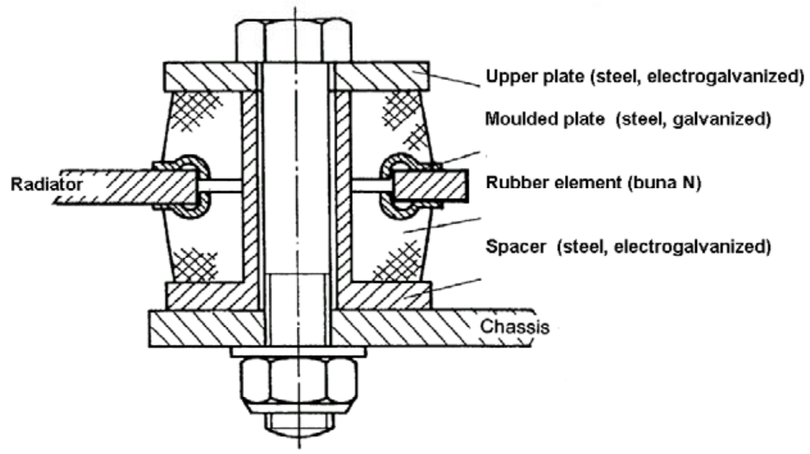
Therefore, the radiators are to be installed with flexible mounting elements and to be supported against the frame also with such flexible mounting elements.

In critical cases, it may also be necessary to provide an intermediate mounting of the radiator on a torsion-proof frame which is flexibly mounted in the equipment. The radiator is provided with an additional flexible mounting in the frame. This will ensure that no deformations will affect the radiator core and the end box connections.

The specialist companies should be consulted in respect of positioning and configuration of the radiator mounting elements.

The following illustration shows the possible composition of a radiator mounting element.

FIGURE 1-20



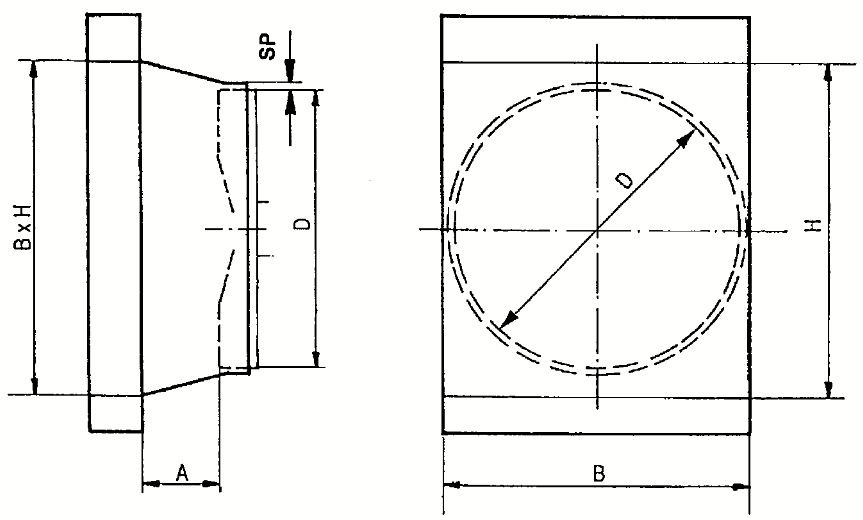
The piping connection to the radiator must also be flexible so as to prevent any forces from being transmitted through the piping.

1.10 Cooler / Fan connections

1.10.1 Cooler/fan connections with sheet duct (scoop)

With optimally laid out cooling systems, cooler and fan are connected via a sheet duct (cooling air supply; short designs also called ducts) and the fan draws in or pushes the air through the cooler core.

FIGURE 1-21



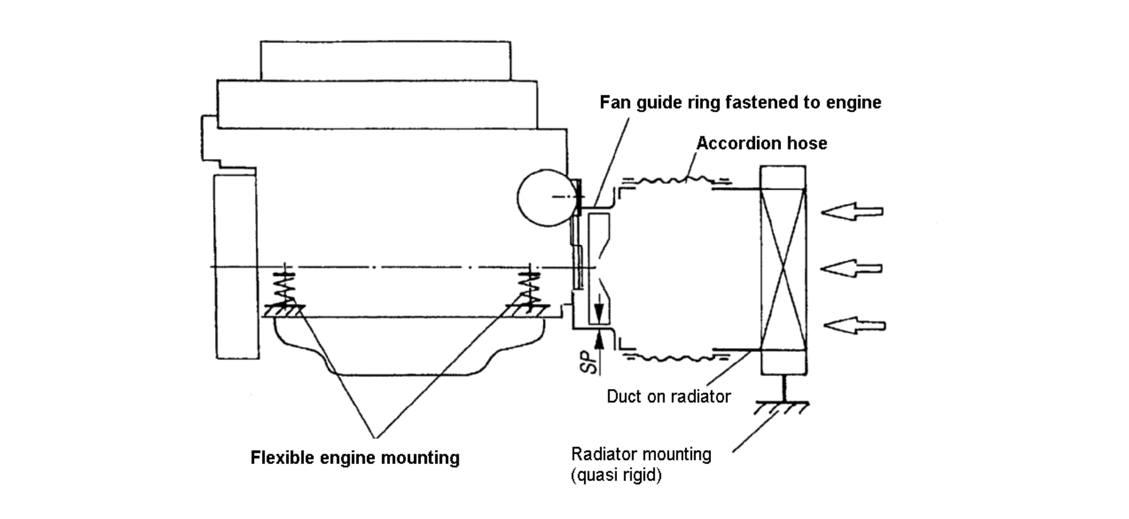
1.10.2 Cooler/fan connections with engine-mounted fan ring

It is decisive for the delivery rate of the fan to what extent the radial clearance SP between fan outer diameter and cooling duct can be minimised. The smaller, the better the fan delivery rate is.

Für die Förderleistung des Lüfters ist entscheidend, wie klein das Radialspaltmaß SP zwischen Lüfteraußendurchmesser und der Kühlluftführung bzw. Zarge gemacht werden kann. Je kleiner desto besser ist das für die Förderleistung des Lüfters.

So-called fan guide rings are used for suction- and pusher-type fans so as to minimise the clearance and still not impede the fan movement. The engine-mounted fans (coolant pump, crankshaft, mounting bracket) run in a sheet metal ring with a minimum annular clearance of SP = 5 mm. This so-called fan guide ring is rigidly mounted to the engine and is large enough in its annular flange to provide sufficient contact surface for a flexible connection.

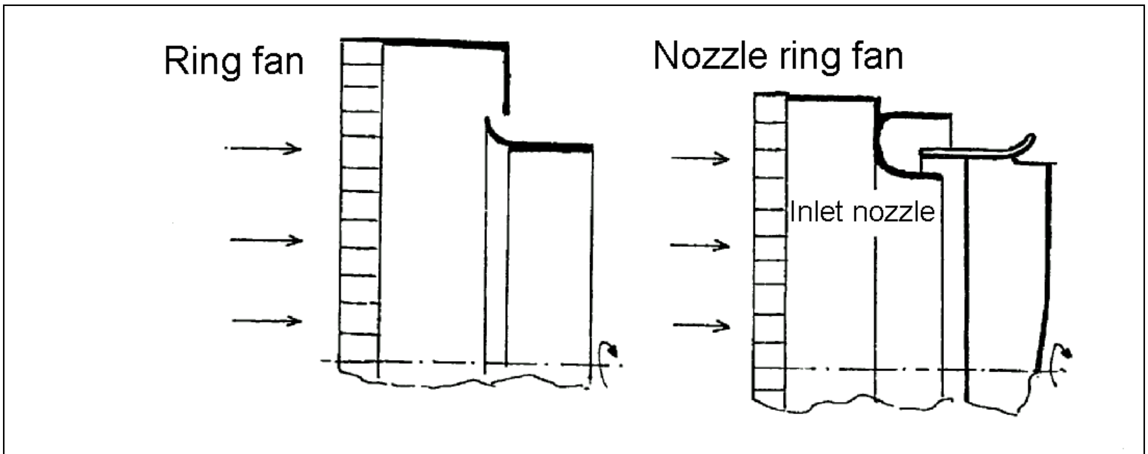
FIGURE 1-22



1.10.3 Cooler/fan connections with ring fan

In the case of the ring fan, the blade ends are rigidly connected to the guide ring. The guide ring has an inlet radius whose contour is moving contactlessly in a matched gap. Thus, the flow is brought into contact and a larger air volume delivered.

FIGURE 1-23

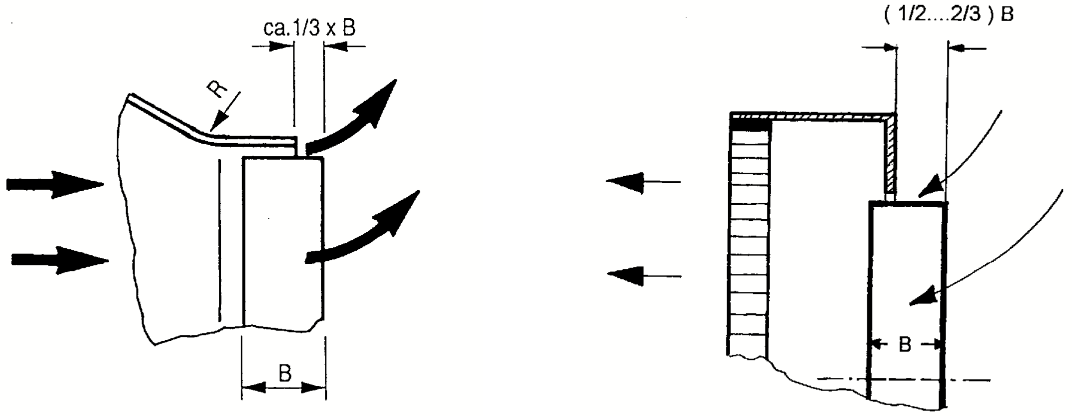


1.10.4 Axial position of the fan in the scoop

Limited installation space usually necessitates a short configuration of the power train, i.e. fan and cooler must be arranged as close as possible to the engine face. The result is a relatively high resistance at the discharge end. This resistance can be reduced, if the fan blades do not rotate over their full width in the cylindrical section of the fixed cooler duct. The same applies to the fan guide ring.
Details see sketch below.

FIGURE 1-24

Suction fan: **Pusher fan:**



1.10.5 Design data for the cooler-fan connection

The following design data must be observed for the arrangement of the fan to the cooler, see also the sketches above):

Ratio of effective cooling area F_K = BxH to fan area $F_D = \pi x D^2/4$	$F_K : F_D < 1.8$ Recommendation: $F_K : F_D \leq 1.5$
Minimum distance of fan from cooler network A	A ≈ 0.5 to 0.2 x D, (D = fan - ∅) 100mm – better ≥ 150mm
Radial gap dimension between fan and sleeve SP	2 to 3% of the fan diameter Recommendation: SP ≥ 15mm
In case of engine-tight fan ring, the gap dimension can be reduced to about 5mm which enables a higher fan performance.	
Distance between fan and engine end face ML	ML ≥ 0.2 x D in suction fans ML ≥ 0.5 x D in pusher fans
Axial fan position in the sleeve	Suction fan: 2/3 within the sleeve Pusher fan: 1/3 to ½ within the sleeve

2. COOLING AIR SYSTEM

2.1 General

The following two major rules must be observed to ensure that the engine-integrated cooling system of the DEUTZ diesel engines as well as the external cooling systems consisting of fan and cooler can feature their cooling capacity:

- Only fresh air is suitable for cooling and combustion purposes, the engine should never take in hot exhaust air or exhaust gas (to avoid that the cooling air is heated up)

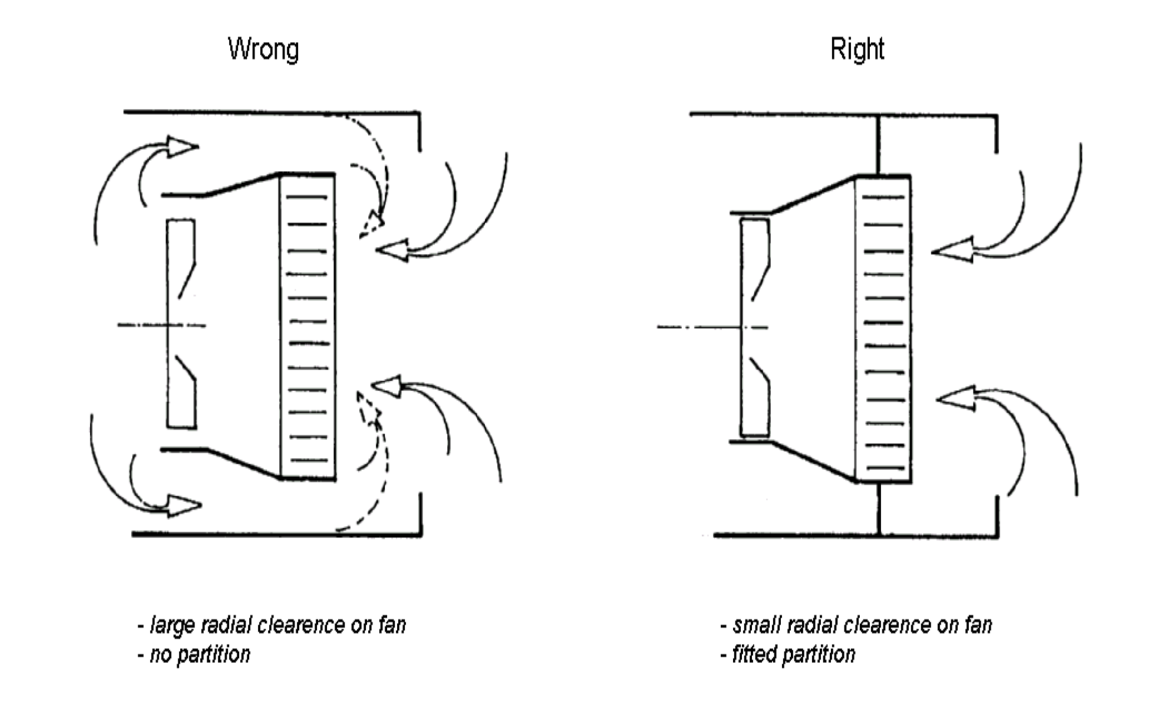
  From this follows: Strict separation from cold and warm air areas is necessary

- Restrictions in the air intake and discharge ducting must be avoided as far as possible (to avoid a loss of cooling air).

2.2 Arrangement of air intake and discharge ducts

The installation of the coolers relative to the fan must be such as to ensure that no hot air is re-circulated.

FIGURE 2-1



The cooling systems may be laid out as suction or pusher-type cooling system so that the above measures are equally applicable.

2.3 Connection of air intake and discharge ducts

In most installation cases, there will be a "flexible" connection between the fan at the engine and the external cooler. Therefore, the air intake or discharge duct (suction- or pusher-type cooling) will be connected to the cooler.

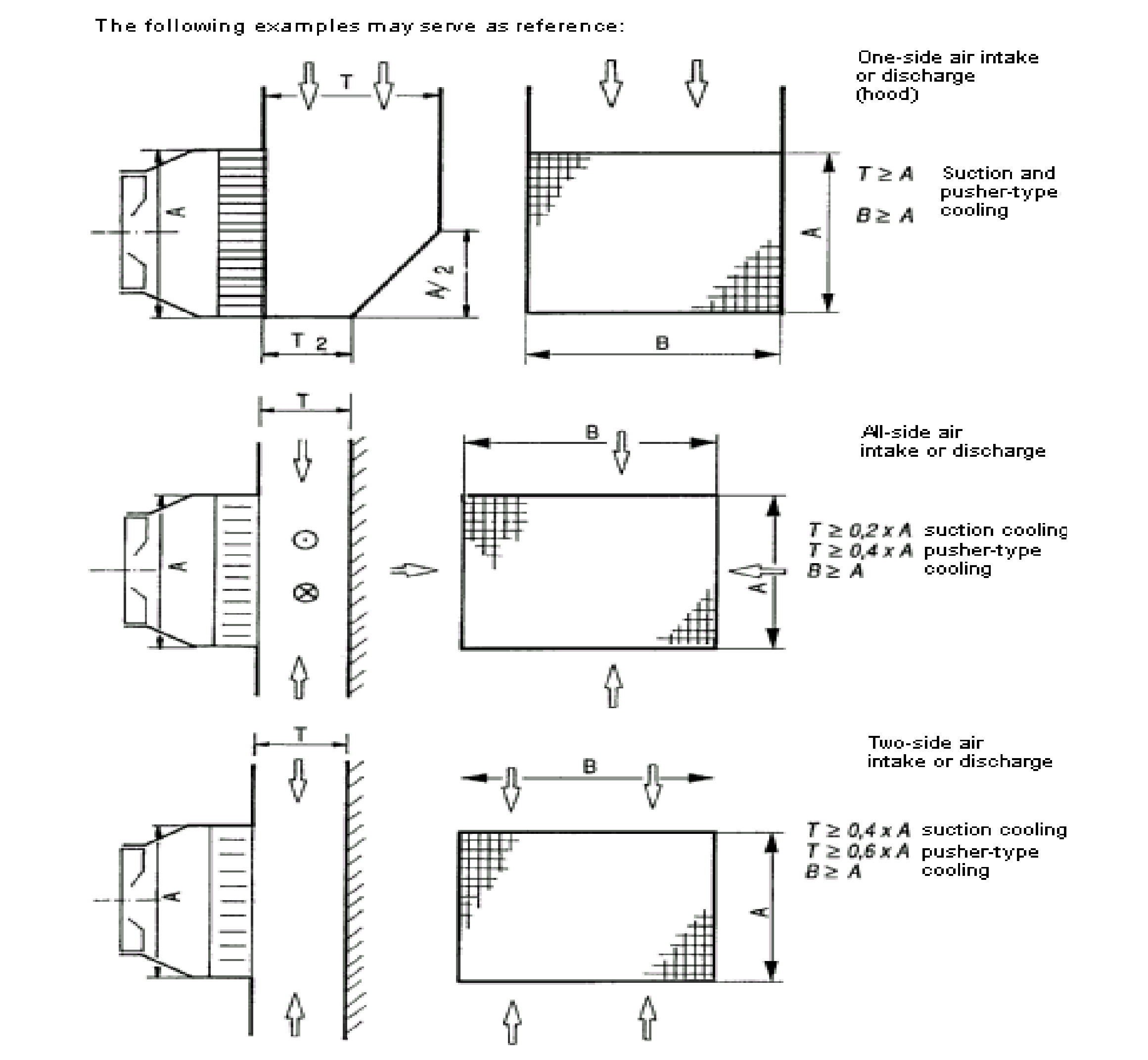
The coolers are mounted with a flexible seal in a recess of a partition. To this partition or frame, hoods or duct extensions can be connected.

2.4 Dimensioning of short air intake ducts

A flow rate of 6 to 8 m/sec. may be assumed for the dimensioning of short air ducts. Please consider the changed volume in the case of hot air.

The respective air volumes should be asked for (acquisition, application engineering). The following examples may serve as reference:

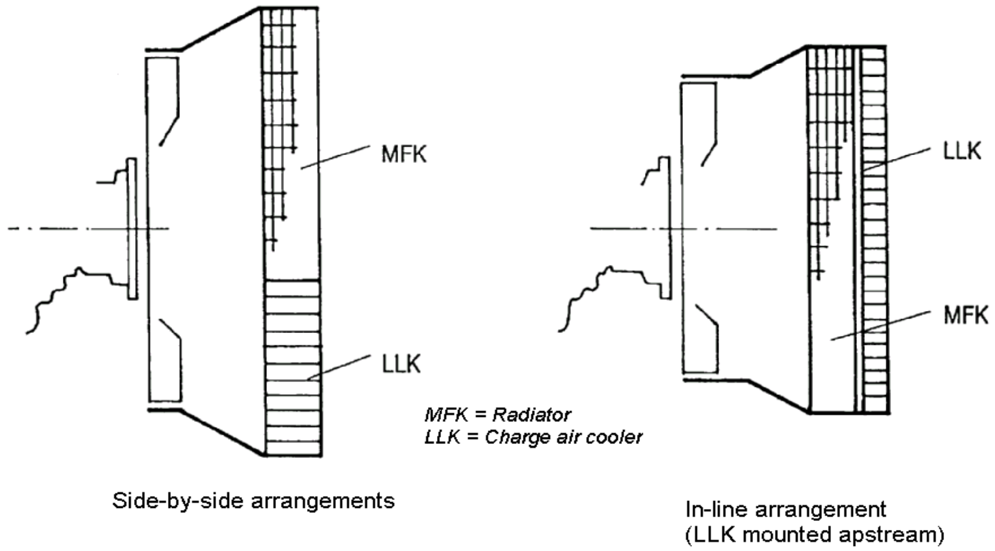
FIGURE 2-2



2.5 Mounting of charge air coolers

The TCD 2012 / 2013 engines are charge air-cooled. As regards the arrangement of the charge air coolers, they may be arranged side-by side or in-line with the radiator.

FIGURE 2-3



In practice frequently in-line arrangement is realized. The cooling air heating developing in the up-stream mounted charge air cooler must be considered when calculating engine radiator size.

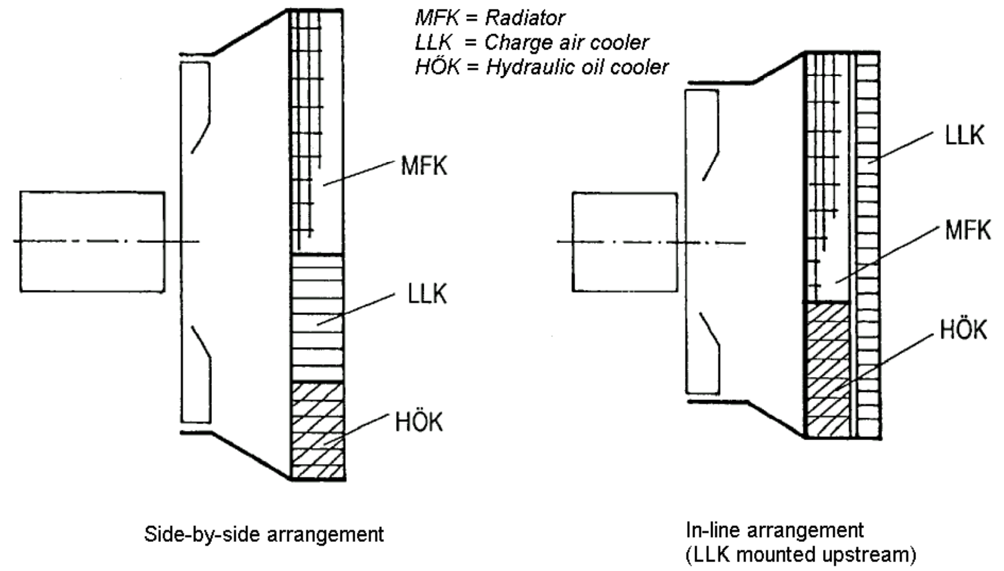
When installing the charge air cooler, it must be ensured that the charge air inlet is always located in the lower end box. The charge air outlet will then automatically be in the upper end box.
Thus, possible condensate water accumulations cannot directly enter the engine combustion chamber.

More information about charge air cooling see chapter 3.10 – Combustion air system -

2.6 Arrangement of auxiliary coolers

Auxiliary coolers, e.g. hydraulic oil -, transmission coolers are to be arranged parallel to the engine liquid radiator because of their usually increased cooling air heating.
It is necessary to adapt the fans (speed, diameter) accordingly to supply the higher additional cooling air volume.

FIGURE 2-4



2.7 Minimum cross sections for air intake and discharge ducts

The pressure losses occurring in the air intake and discharge ducts reduce the cooling air volume flow rate. As a result, the cooling capacity of the coolers decreases so that boiling temperatures may be reached at lower ambient temperatures than intended in the design layout.

The fans of the external cooling systems feature a low delivery height, so that the restriction rates to be measured are very small and can only be evidenced sufficiently precise at a high measuring expenditure. The temperature measurement is decisive for evidencing permissible cross sections of an air intake or discharge duct.

The limit of the minimum cross section in connection with the existing cooling and combustion air temperatures must always be tried out, i.e. it must be determined at which theoretical ambient temperature the maximally admissible water temperature is reached for the practical application and for the application under full load.

The rough calculation of the necessary cross section F can take place according to the following formula if the air volume flow rate is known:

F = V / c	**V** = air volume flow rate [m³/s] **c** = air velocity [m/s], Assumption **5 - 7m/s**

2.8 Heating up of cooling air

With the liquid-cooled engines, heating up of the cooling air reduces the cooling capacity of the cooler. This will lower the ambient temperature-operating limit of the engine without confining, however, the engine's ability to run continuously under full-load conditions. The boiling point of the coolant is just reached earlier. Apart from the temperature rise of the cooling air, attention should also be paid to the cooling airflow resistance after engine installation. Cooling air flow resistance and temperature rise together may have a great influence, which will further reduce the capacity of the cooling system and may drastically lower the permissible ambient temperature limit for the engine.

The same applies to the temperature rise of the combustion air which, however, has a direct influence on the engine component temperature and therefore requires critical observation, i.e. narrow limits for the permissible heating up rate.

If the heating up rate cannot be reduced by installation-specific measures, the capacity of the cooling system can be alternatively increased by:

- Increasing the fan or blower speed or
- Installing larger fans and larger coolers

Such measures require an additional power input that must be deducted from the engine net brake power.

When measuring the cooling air temperatures

- in front of the core of the charge air cooler upstream with engine-integrated cooling system
- in front of the core of the cooler with external cooling systems (suction cooling)
- in front of the air inlet into fan with external cooling systems (pusher-type cooling)

it should be made sure that these come to a steady-state condition only after an extended running time This means that the integrated cooling systems must be operated under the expected equipment operating load conditions, until a constant temperature level has established. Only then, it will be possible to evaluate the permissible ambient temperature limit.

If it is necessary to determine the ambient temperature-operating limit at engine full load, the cooling air temperature must also be measured when the engine is running under full load.

In addition to the cooling air temperatures, it is also necessary to record the ambient temperature and coolant temperature at engine inlet to evaluate the operating suitability.

However, the target for any engine installation remains that heating up of the cooling air and, in particular, the combustion air is avoided.

2.9 Filtration of cooling air

For special applications of the engines, filtering of the cooling air might become necessary in view of the high dust development, e.g. combine harvesting, beet and fish meal handling, slag and dump sites, etc.).

2.9.1 Rigid screen ducts of perforated plating

An intake duct is fitted upstream of the engine blower or in front of the inlet of the cooling system (heat exchanger with fan) whose inlet cross-section is covered by a perforated plate for coarse filtration purposes. The cross section of the perforated plate must be designed to the effect that the cooling air velocity within the cross section area is ≤ 2m/sec.

The required free plating cross section can be determined according to the following formula:

F = V / c	**V** = Cooling air volume flow rate [m³/s]
	c = Admissible air velocity in the plating cross section [m/s]

The customer should either ask the acquisition staff for the cooling air volume flow rate or take the value from the electronic pocket book ELTAB.

The individual hole diameter should be abt. 2 to 3 mm, hole distribution 5 mm.

The perforated plating should be arranged in a vertical position or feature a negative inclination so that air-borne debris can fall down by gravity.

2.9.2 Rotating screens

Rotating screens (drums) upstream of the blower or in front of the core of the heat exchangers offer the advantage that, as a consequence of the centrifugal forces acting on the circumference of the perforated plate drums or rotating screens, dirt deposits (cloggings) will be avoided.

For rotating screens, the perforated plates are dimensioned analogously to the rigid screen box of perforated plate.

However, the screen drum rotation perpendicular to the cooling air flow may have an adverse effect as, depending on the diameter and speed of the rotating drum, high peripheral speeds of 20 to 40 m/s may occur. As a consequence, the flow resistance in the rotating drum will increase and the cooling air volume flow rate will decrease with the risk of insufficient engine cooling. Correspondingly larger cross sections are to be selected. This usually requires proper matching of the screen area/rotating screen speed ratio to ensure an optimum flow.

2.9.3 Cooling air cyclone

On the engines with integrated cooling system, filtration of cooling air is possible via so-called cyclones upstream of the blower (pre-cleaning by air swirl and dust collection by blow-out). As proper functioning of a cyclone is very much dependent on the type of dust and size of dust particles, it might be necessary to consult the head office.

For engines with external cooling system, packages of several small cyclones connected in parallel are a reasonable solution, the dust discharge being realised via a separate scavenging air blower.

Some well-known manufacturers of combustion air filters offer such packages.

Depending on the cooling air volume flow rate, it is urgently recommended to have DEUTZ investigate and evaluate the systems.

2.9.4 Cooling air filter mats

Beyond filtering proper, filtering of the cooling air via so-called filter mats offers the advantage of a certain noise reduction on the intake air side.

Filter mats are partly made of washable, synthetic knitwear or fleece; their dimensioning and rating (permissible air inflow velocities, pressure losses) should be coordinated in cooperation with the respective manufacturers.

Filter mats must be located such to allow easy and simple maintenance, because it may be necessary to clean them several times a day. When contaminated, the cooling air passage will be restricted resulting in thermal overload of the engine, if maintenance is not carried out in time.

A differential pressure gauge is fitted to monitor the actual operating condition. When the pressure difference at the cooling air filter has reached the maximum permissible value, the filter mat has to cleaned or replaced with a new one. Application engineering should be consulted to determine the maximum permissible pressure difference, until filter maintenance becomes necessary.

3. COMBUSTION AIR SYSTEM

3.1 General

Experience has shown that in more than 75% of all cases premature engine wear is attributable to the influence of dust. To avoid this problem, great importance should be attached to filtration of the combustion air and to proper layout of the air cleaners and clean air piping.

In this connection, the following design references should be observed:

- Only fresh air is allowed to be drawn in as combustion air; it must be taken from a dust-free engine environment, which is not heated up.
- Combustion air piping shall have sufficiently large cross sections to keep the flow resistance at a minimum.
- At the raw air side (combustion air piping to filter), high resistances result in increased intake vacuum pressure and reduce the servicing intervals for dry-type air cleaners. The vacuum pressure governor (maintenance indicator) also records the raw air pipe resistance.
- Pipe bends with favourable flow characteristics should be used for any necessary deflections in the combustion air piping.
- Also after an extended period of operation, the intake pipe between the air cleaner and the engine, i.e. the so-called clean air side, must be absolutely tight and shall resist the mechanical stresses caused by engine vibrations and pressure pulsations as well as the temperatures involved.
- The type and size of the filters should be selected according to the expected operating stresses (accumulation of dust).

It is not always possible to realise ideal conditions, i.e. to mount the air cleaner directly on the engine without the need of any air piping. In some cases, it is necessary to install the air cleaners remote from the engine, e.g. if there is the risk of a temperature rise in the compartment or the adverse effect of vibrations or simply because they should be easily accessible for maintenance purposes.

3.2 Intake vacuum pressure

To achieve a practically "complete" combustion of fuel in diesel engines, the cylinders are supplied with an air surplus (oxygen).

If the resistance (intake vacuum pressure) at the combustion air side is too high, combustion will be "incomplete" because of the deficiency of air (lack of oxygen), i.e. the fuel consumption will increase.

This condition is counter-acted by limiting the intake vacuum pressure.

3.2.1 Maximally admissible intake vacuum pressure

The total intake vacuum pressure for engines for "general applications" and engines for "power generating sets" referred to in the following tables 1, 2 are values which, when measured on the engine, must not be exceeded. They apply to the entire intake system (filter resp. cleaner including raw air and clean air piping).

The intake vacuum pressure values indicated separately for filters and piping are reference values which may be handled in a variable manner, if the total intake vacuum pressure is not exceeded. No difference is made between automotive and equipment engines.

Table 1

Admissible intake vacuum pressure for contaminated dry-type air cleaner for engines
Installed in vehicles, equipment and electric power generating sets.

Engine	Filter**			Pipings*			Total intake vacuum pressure		
	mbar	mmWS	kPa	mbar	mmWS	kPa	mbar	mmWS	kPa
from 4-cyl. upwards	50	500	5,0	15	150	1,5	65	650	6,5

* When a pipe is fitted upstream of the dry-type air cleaner (raw air side), the initial resistance of the cleaner is increased by the amount of the pipe resistance. This entails shorter maintenance intervals of the dry-type air cleaner, as the servicing indicator reacts accordingly earlier. If this pipe is installed downstream the dry-type air cleaner (clean air side), the servicing indicator senses the actual cleaner resistance and not the pipe resistance downstream. This must be considered when selecting and arranging the servicing indicator, if the admissible pipe resistance can not be observed.

** The resistance of the cleaners when new is correspondingly lower, depending on the required service life.

Table 2

Admissible intake vacuum pressure on contaminated dry-type filter elements for engines
installed in electric power generating sets with rating categories **COP, PRP, LTP**.

Engine	Filter			Pipings			Total intake vacuum pressure		
	mbar	mmWS	kPa	mbar	mmWS	kPa	mbar	mmWS	kPa
from 4-cyl. upwards	20***	200***	2,0	5	50	0,5	25 35***	250 350***	2,5 3,5***

*** Vacuum pressure governor with switch point 20mbar can be replaced by 35mbar vacuum pressure governor, if the pressure is picked up near the inlet of the turbocharger – still in the large diameter range of the connecting pipe.

If, in individual cases for installation reasons, the total intake vacuum pressure should require to be exceeded, consult application engineering.

Low initial resistance values are recommended to obtain adequately long servicing intervals.

The general layout of the cleaners depends on the laboratory-testing period taking into account the respective engine application (see table under 3.5.5).

To ensure an adequate service life of the filter elements under normal dust conditions, the following intake vacuum pressure at the clean air socket of the filter (without raw air pipe upstream of the filter) should not exceed the following values in new condition:

from 4-cylinder engines	≤ 25 mbar,	≤ 250 mmWS	≤ 2.5 kPa

For genset engines as per table 2:

from 4-cylinder engines	≤ 10 mbar,	≤ 100 mm WS	≤ 1.0 kPa

It is recommended, where possible, to keep the indicated resistance values below the indicated values, as this is positively influencing the power and performance characteristics of the engine.

All indicated values apply to measurements at the engines.

3.2.2 Measuring the intake vacuum pressure

With turbo-charged engines the correct measurement can only take place with rated speed and under full load.
(Measuring point position A: 2.5 x D in front of inlet of combustion air into the charge air elbow of the engine)

FIGURE 3-1

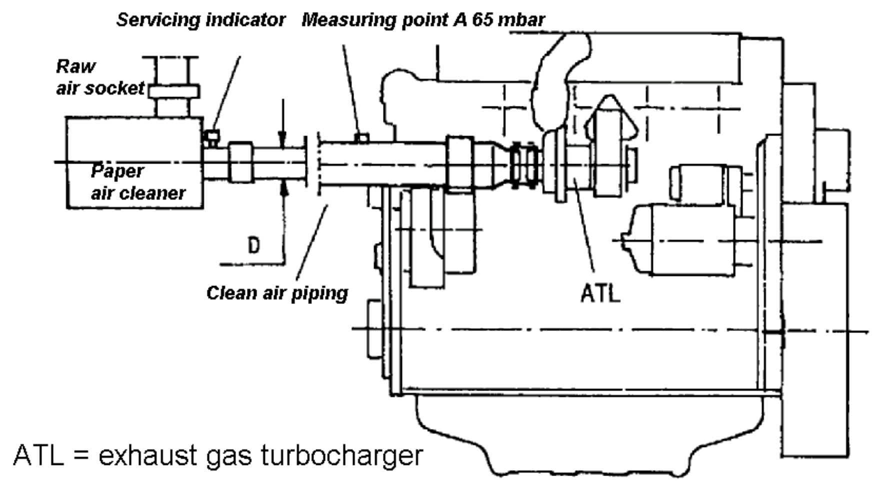
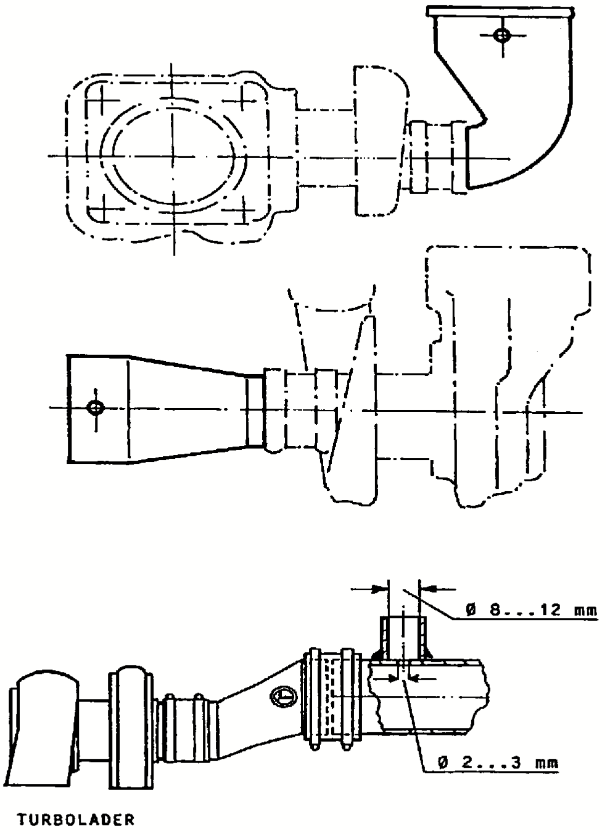


FIGURE 3-2

Alternative positions of measuring points in front of turbocharger



3.2.3 Monitoring the intake vacuum pressure

Contrary to the oil-bath air cleaners, the flow resistance of the dry-type air cleaner considerably rises with increasing contamination of the paper cartridge; therefore a servicing indicator for monitoring the intake vacuum pressure must be fitted when installing dry-type air cleaners. The servicing indicator should be mounted on the clean air side. In most cases, the filter manufacturer provides the cleaner with a connection facility. Wet-type and oil-bath cleaners have no such connection facility for a servicing indicator; for that reason, in practice, servicing indicators are not used for these types of cleaners.

These commercial indicators are supplied with various switch points, e.g. 20, 30, 35, 45, 50 or 65 (mbar).

When determining the switch points, the resistances in the pipes, of the contaminated dry-type air cleaner as well as the arrangement of the servicing indicator in the clean air pipe must be considered.

If the switching point before turbocharger may amounts 65mbar so for the maintenance switch at the filter usually only 50mbar are permitted (minus pure air line resistance 15mbar). With other switching points should accordingly to be proceeded.

3.3 Air cleaner systems

The evaluation of practical experience showed that the issue of combustion air cleaning must be treated with utmost care.

The following statements are generally applicable in this respect:

- The service life expected from today's engines requires the use of dry-type air cleaners with safety element.
- Dry-type air cleaners require careful handling when serviced.
- Dry-type cleaners are dependent on a well-functioning parts supply (replacement filter strainers) at the engine site.

If regional problems must be expected as regards the spare parts supply, the use of a combination of oil-bath- and dry-type air cleaners (ÖTK) is recommended.

3.3.1 Dry-type air cleaners (paper air cleaners)

Dry-type air cleaners with built-in pre-cleaners have a good filtration efficiency (irrespective of engine speed and inclination) and, thus, contribute to a long service life of the engine at low wear.

Dry-type cleaners should be provided with a safety cartridge. The safety cartridge is to prevent dust entering the clean air piping during servicing of the main cartridge or, when further using it by mistake, damaged main cartridges.

Paper quality: With test dust AC coarse-grained, the filtration efficiency of the air cleaner must amount to 99.9% (for filter dimensioning see section 3.5).

3.3.2 Oil-bath air cleaners

Oil-bath air filters must be designed for the rated air volume (combustion air volume in full load operation). If the filters are dimensioned too small, oil will be drawn along.
However, the filter effect of oil-bath air filters is only sufficient when the air throughput corresponds approximately to the design, that is in full load operation.
Since the modern TCD engines in particular have a high charging level, the combustion air volume difference between full load and low load operation do not guarantee sufficient combustion air filtering for a large part of the engine operation.

Oil-bath air filters are therefore not approved for these engines.

3.3.3 Combination oil-bath- and dry-type air cleaner (ÖTK)

In case of operating conditions with a high generation of dust and regional problems with the spare parts supply, we recommend the use of a combination of oil-bath air cleaner with following dry-type air cleaner. Here, the oil-bath air cleaner acts as an excellent preliminary filter.

If required, contact the head office of DEUTZ, as systems of that kind are not available by series.

3.3.4 Wet-type air cleaners

The use of wet-type air cleaners is not admissible.

3.3.5 General references

- The installation instructions of the respective manufacturers must be observed when installing the air cleaners.
- Air cleaners must be mounted such that they are easily accessible for servicing works.
- The servicing indicators must be arranged in a position well visible for the operating staff.
- The combustion air filter versions supplied by DEUTZ are described in detail in the sales documentation of the individual engine series.
- If an air cleaner especially requested by the customer is not part of the DEUTZ scope of supply, the OEM is fully responsible for the correct layout and execution. If the engine should be damaged as a consequence of mistakes in the cleaner system, DEUTZ refuses any claims under engine warranty.

3.4 Servicing

3.4.1 Dry-type air cleaners

The main cartridge of the dry-type air cleaner must always be cleaned when the servicing indicator signals the maximum permissible resistance. The quickest and safest way to service the cartridges is to replace the contaminated main cartridge by a new one.
Clean the main cleaner cartridge as follows:

- Dismantle cartridge,
- hold the open end downward and knock carefully against your flat hand,
- blow out with max. 5 bar compressed air from inside to outside,
- clean seals,
- check condition,
- mount cartridge again.

The main cartridge must be renewed after 5 cleaning operations or after one year of use; if damaged, renew without delay.

When servicing the main cartridge, the safety cartridge at the cleaner bottom remains clamped. The number of main cartridge servicing (exchange or cleaning) should be indicated in the marking spaces on the safety cartridge.

The safety cartridge must be renewed:
- after 5 servicing of the main cartridge,
- after 2 years at the latest,
- if the service signal appears directly upon completed service of the main cartridge,
- after operation with a defective main cartridge.

Safety cartridges must not be cleaned.

Possible dust agglomeration on the evacuator valve should be removed by occasionally compressing it.

3.4.2 Combination of oil-bath- and dry-type air cleaner

The used air cleaner types are serviced as directed by the manufacturers in the operating instructions.

3.5 Calculation data for combustion air volume flow rate

Calculation of the combustion air flow rate "Q_M"

Turbocharged engines whose exhaust gas qualities must meet the **higher** requirements of the recent national and international **exhaust gas regulations** partly require a higher combustion air volume flow rate.
A rough calculation is given below:

$Q_M \approx 0{,}10 \times P$ (m^3/min)	P = Rated engine power (kW)

If necessary, the actual combustion air volume flow rates must be inquired from the head office or can be taken from the electronic pocket book ELTAB.

Air volume flow rate "QW" for determining the initial air cleaner resistance

The combustion air flow is subject to pulsation depending on the number of cylinders, as a consequence of which the filter resistance increases. Therefore, when laying out the combustion air cleaners, the theoretical air volume flow rate is to be multiplied by the pulsation factor "f". For turbocharged engines from 3 cylinders upwards is the pulsation factor 1.

In the first step, the essential air volume "QW" is found which determines the initial resistance of the new air cleaner.

$Q_W = Q_M \times f$ (m^3/min)	for TCD engines f = 1

The initial resistance is taken from the diagram of characteristic resistance lines. Such diagrams may be obtained from the manufacturers of the air cleaners.

Air volume "Q_S" for determining the service life of the air cleaner (lab test life)

For the air cleaner layout in the second step, the air volume Q_S is required. This value must be used in all assessments concerning air cleaner service life and lab test life

The load factor **"k"** considers the reduced pulsation intensity upon increasing air cleaner contamination. For turbocharged engines from 3 cylinders upwards is the load factor 1.

$Q_S = Q_M \times k$ (m^3/min)	for TCD engines k = 1

From the diagrams – resistance behaviour when cleaner is passed by contaminated air at laboratory dust concentration (1000 mg dust per m^3 air) – of the manufacturers, the dust volumes are resulting accumulated, until the declared air cleaner resistance is reached.

With the aid of this dust volume related to the air volume flow rate, the lab test life (h) of the air cleaner can be calculated.

Alternatively, the manufacturers indicate the lab test life curves of the air cleaner as a function of the air volume flow rate.

Determining the practical service life an air cleaner

Before determining the filter size, the dust concentration must be estimated expected for the respective engine application. The table of the reference examples is a selection aid for dimensioning the dry-type air cleaner.

The practical service life of the filter can be determined using the following relation:

$$\text{Pratical service life [h]} = \frac{\text{Lab dust concentration x 1000}}{\text{Actual dust concentration x Air Volume } Q_s \text{ x 60}}$$

Lab dust concentr. [mg/m³] from the filter manufacturer
Air volume Q [m³/min] from the engine manufacturer or corresponding to the calculation
Actual dust concentr. [mg/m³] experience or see table 6

From the laboratory service life, the practical service life of the filter can be determined using the following relation:

$$\text{Pract. service life } [h] = \frac{\text{Lab dust concentration } 1000 \text{ or } 880 \text{ mg/m}^3}{\text{Actual dust concentration mg/m}^3} \times \text{Lab service life}$$

In the case of vehicles, normally servicing of the air cleaner depends on the km-performance. For converting the practical hours into driven kilometres, the following relation shall be used.

Driven kilometres [km] = Practical service life [h] x mean velocity [km/h]

Reference examples for dimensioning the dry-type air cleaners including preliminary filter

Table 3

Group	Engine application	Mean dust concentration in mg/m³	Lab test life in hours as per SAE at 880 mg/m³	Lab test life in hours as per ISO at 1000 mg/m³
Normal dust load				
1	Trucks, long-distance Gensets Marine propulsion units Rotary snow ploughs	up to 4	2.3 – 4.5	2 - 4
2	Trucks, distributor traffic Rail-mounted vehicles Crane trucks Concrete mixers Pump sets Welding sets	up to 8	4.5 – 9.1	4 - 8
3	Trucks, building site traffic Busses in urban traffic Light fork lifts Small compressors Concrete pumps Rubber-tyres rollers Sweeping machines	up to 12	9.1 - 14	8 - 12
Medium dust load				
4	Tractors for agriculture and forestry Field choppers Dump trucks Trenchers Contractor's gensets Vibratory rollers	up to 20	14 - 23	12 - 20
5	Heavy fork lifts Large compressors Light hydraulic excavators Wheel loaders Graders Combine harvesters	up to 30	23 - 34	20 - 30
Severe dust load				
6	Busses, interurban traffic Road grooving machines Underground equipment Drilling machines	up to 40	34 - 45	30 - 40
7	Heavy hydr. excavators Dozers Track-laying machines Off-road tractor trucks	up to 50	45 - 57	40 - 50
Extreme dust load				
8	Dust development up to zero visibility	up to 1000	Special measures	Special measures

In actual servicing, the indicated laboratory test life values allow filter change intervals of about 1000 operating hours (with the maximum possible filter resistance being reached), if the indicated mediums dust concentration values are not exceeded at site.
As the engine application examples can only be regarded as a rough reference it may be possible that different air cleaner dimensioning values will be required to reach the 1000-hour maintenance intervals.

3.6 Combustion air pipings

3.6.1 General remarks to the pipings

Combustion air pipings between air cleaner and engine ("clean air piping") must be absolutely air-tight and resist the mechanical stresses caused by engine vibrations and pressure pulsations. The same applies to the charge air piping between turbocharger/charge air cooler/engine air intake manifold.

Seamless steel tubes are suitable for this purpose, welded sheet metal pipings may also be used, provided they are seal-welded and internally trimmed. The inner surfaces must be cleaned and be free from welding beads, rust, scale and similar (can be removed by etching) and must be protected against corrosion.

Stove pipes, folded, spot-welded or riveted tubes are not permissible.

Surface treatment of sheet tubes (e.g. of steel as per DIN EN 10025):

For pipings between air cleaner and engine:
Externally: Immersion-painting
Internally: Immersion-painting

For pipings between turbocharger and intercooler (hot side):
Externally: Prime surface
Internally: Preserve surface with water-displacing oil
or
galvanise and chromize yellow (Attention: only reasonable, if the air temperatures are below 100°C, as otherwise the zinc layer is damaged

For pipings between intercooler and engine (cold side):
Externally: Prime surface,
alternatively, galvanize and chromize yellow.
Internally: Preserve surface with water-displacing oil
or
galvanize and chromize yellow

Self-supporting pipes or lines are to be checked for their vibration characteristics in accordance with the equipment installation and may have to be supported on the equipment or engine.

In the case of flexibly mounted engines, it is often necessary to rigidly fasten the air cleaning system to the equipment. In this case, a flexible element must be incorporated in the combustion air pipe (ribbed hose, bellows).

Plastic tubes may be used as combustion air piping at the raw air side. Observe the admissible ambient temperatures for the plastic tubes – also regarding fatigue strength and light effect.

For the clean air piping system (tubes between air cleaner and engine or between engine and intercooler or turbocharger and engine), plastic tubes must not be used without previous laboratory examinations regarding temperature / compressive strength and permissible vibration

NOTE:
According to the present state of development, the TCD 2012 / 2013 engines are equipped with open crankcase ventilation. Therefore a special oil barring layer (e.g. of fluoride silicone rubber) can be dispensed with in the hoses and sleeves of the charge air pipes.
However, it is foreseeable that the legislator will demand the closed crankcase breathing for certain applications. Hoses and sleeves with an oil barring layer will be used in the charge air pipes for these applications; plastic pipes must be oil-resistant.

3.6.2 Ribbed hoses

Ribbed hoses for clean air pipings between air cleaner and engine

- Ribbed hoses are used to connect two pipes which vibrate against each other as a result of engine movement.
- Attention should be paid to engine movements due to external impact.
- If possible, the main direction of vibration should be across the longitudinal axis of the ribbed hose. Minimum distance between the pipes 150 mm, maximum distance without supporting and/or fastening devices 500 mm.
- The hose should be fitted without any prestressing, i.e. straight or with only a slight bend. The folds must not have any contact with each other so as to prevent chafing through. Highly flexible ribbed hoses with permanent Teflon sheathing may have slight contact in an environment with a very low dust concentration. In this connection, the detailed installation instructions of the hose manufacturers are referred to.
- Ribbed hoses as per DEUTZ specification * H3482 - 2 have proved in service.

* Among other items, the DEUTZ specification is as follows:
Hose to be composed of two rubber layers with textile reinforcement.
Layer 1 (inside) of high-quality rubber / Neoprene 55 $\pm$ 5 Shore, lube oil- and temperature-resistant from –35°C to + 110°C. Ribbed hoses to be provided with a wire spiral embedded in layer 1.
Textile reinforcement wound around layer 1.
Layer 2 (outside) Neoprene, 55 $\pm$ 5 Shore, lube oil-resistant and resistant against cracking under the influence of light.
The ends of the wire spiral must not be within the sleeve area of the ribbed hose.
Resistance against vacuum pressure: -0.2 bar at + 110 °C.

The material and configuration of the plastic and rubber ribbed hoses available on the market in most cases do not comply with the requirements with regard to vibration and temperature resistance. They should only be used after extended endurance tests.

Ribbed hoses for charge air pipes of intercoolers:

- If intercoolers are mounted remote of the engine, ribbed hoses are also used as flexible pipe connections between turbocharger and intercooler as well as between intercooler and air intake piping of the engine.
- Because of the high combustion air temperatures and pressures behind the turbocharger, the requirements to these hoses are high.
- These ribbed hoses are provided with external, exposed metallic supporting rings and are meeting the DEUTZ Works Standard H 3482 – 5 (Part 5*)

* Among others, the DEUTZ works standard specifies the following:
Wall structure of silicon caoutchouc with four spiral-wrapped textile layers of aramide fabric.
Inner and outer surface totally made of silicon caoutchouc (colour red).
Admissible operating temperature range – 50°C up to + 230°C (shortly up to 260°C) at an operating pressure of up to 3 bar, (shortly up to 4 bar) .
Resistance against the influence of light and ozon, resistant when being wetted with diesel fuel and engine lube oil. …………
Inner lining with an oil-locking layer (e.g. fluorine silicon)
The outer supporting rings are made of steel (similar to X5 Cr Ni Mo 1810 as per D1N 17440).

- The ribbed hoses are supplied for example by:

Fa.Thermopol Ltd.	Tel. +44 1293 543 615
Woodborough Lane	Fax. +44 1293 844 720
Crawley, Sussex	e-mail: dstyles@thermopol.co.uk
Rh 10 2UW	
United Kingdom	

- When installing these ribbed hoses in the charge air pipe, the axial hose expansion must be considered which might require additional support of the sheet metal pipes and/or the intercooler.

Note: Because of the low resistance to tear-off propagation of the material silicon caoutchouc, the risk of surface damage must be avoided.

Ribbed hoses for charge air pipes behind intercooler:

- Analogously to H 3482-5, similar requirements are made to the material; however, the temperature resistance can be reduced to 100°C (a works standard has not been prepared up to now).
- Wall made of four layers of spiral-wound silicon caoutchouc fabric of aramid.
  Outer surface continuously made of silicon caoutchouc(colour black).
  Admissible operating temperature range –50°C up to +100°C (shortly up to 110°C)
  at an operating temperature of up to 3 bar (shortly up to 4bar).
  Resistance against light and ozone, resistant when being wetted with diesel fuel or engine lube oil.
  Inner lining with an oil-locking layer (e.g. fluorine silicon).
  The outer supporting rings are made of steel (similar to X5 Cr Ni Mo 1810 as per DIN 17440).

- These ribbed hoses are supplied for example by:
  Fa.Thermopol Ltd. Tel. +44 1293 543 615, see before

- When installing these ribbed hoses in the charge air pipe, the axial hose expansion must be considered which might require additional support of the sheet pipes and/or of the intercooler.

3.6.3 Rubber sleeves

Rubber sleeves are only used to connect two pipes in alignment and which do not move against each other. Also the rubber sleeves must meet the material requirements as per DEUTZ specifications, however without wire coil. Spacing between pipe ends 5 to 15 mm. The fabric insert is not required for wall thicknesses ≤5 mm.

Rubber sleeves for intake lines (raw and clean air lines)

- For the connection of pipes in the clean and raw air system (in front of and behind air cleaner), sleeves or rubber hoses must be used, the material of which meets the requirements of the DEUTZ Works Standard H 3407 – 1.

Temperature resistance:	-40°C ... +110°C	
Overpressure resistance:	max. 1 bar	(at 110°C)
Vacuum pressure resistance:	- 0.1 bar	(at 110°C)
Material:	Chloroprene rubber	
Insert:	Fabric insert	
Resistant against:	light, ozone, fuel, lube oil	

Rubber sleeves for charge air lines, hot (between turbocharger and intercooler)

- The rubber sleeves in this pipe area must meet the requirements of the DEUTZ Works Standard H 3407 – 8.
- In particular, these sleeves must have an inner locking layer against oil penetration.

Temperature resistance:	-50°C ... +230°C (shortly 260°C)
Overpressure resistance:	max. 3 bar (at 200°C)
Material:	Silicon caoutchouc MVQ (outer layer red) with inner layer of fluorine silicon FMVQ.
Insert:	Fabric of aramid fibre material, 4 layers plus oil locking layer
Resistant against:	light, ozone, fuel, lube oil

Rubber sleeves for charge air lines, cold (between intercooler and engine)

- In Anlehnung an die H 3407 - 8 gelten für diese Faltenschläuche analoge Vorgaben an das Material bezüglich Druck- und Öl- Licht- und Ozonbeständigkeit, jedoch kann die Temperaturfestigkeit auf 100°C abgesenkt sein.
- Eine Hausnorm ist derzeit noch nicht erstellt.
- DEUTZ liefert diese Muffen mit einer Ölsperrschicht.

Temperaturbeständigkeit:	-50°C ... +100°C (kurzzeitig 110°C)
Überdruckfestigkeit:	max. 3 bar (bei 100°C)
Material:	Etylenacrylatkautschuk (EAM)
Einlage:	Gewebe aus Aramid-Faser-Material, 4 lagig, plus Ölsperrschicht
Beständigkeiten:	gegen Licht, Ozon, Kraftstoff, Schmieröl

- **Suppliers of the sleeves mentioned here are for example**:
  The above-mentioned suppliers of ribbed hoses are also specialised suppliers of shaped elements.

3.6.4 Shaped rubber elements

- Shaped rubber elements (e.g. transition pieces or elbows) as connection elements in air pipes must also comply with the mentioned DEUTZ specifications for materials – depending on their position in the pipe system for the combustion air.
- Shaped rubber elements in air intake lines (vacuum pressure) must comply with the DEUTZ delivery instructions 0161 0093 US 8093-35 which, among others, specify the following:

Material:	Chloroprene rubber
Pressure resistance:	-0.1 bar at +110 °C (here, absolutely tight)
Restriction:	maximally 10 % of outer diameter
Hardness:	55 to 75 Shore A
Behaviour upon cold temperatures	At -40 °C, the shaped rubber element must permit to be compressed to half the inner diameter without cracking or rupture formation
Temperature resistance:	-40 °C to + 110 °C

- Suppliers sees above

- Shaped rubber elements are not suitable for accepting relative movements of the engine, unless they are suitably designed.

- **Attention:**
  The temperature resistance of a shaped rubber element which is mounted to the turbocharger socket (intake side) must at least be + 130°C.

3.6.5 Hose clamps

The ribbed hoses, rubber sleeves and shaped rubber elements, if any, are fastened to the pipe ends with hose clamps.

Admissible are hose clamps with clamping jaws and screw-nut union:

- Width of the clamp strap at least 15 mm.
- Hose outer diameter and hose clamp inner diameter must correspond, as the clamping range of the clamping jaw clips is small.
- Minimum tensile strength for the clamp strap: 400 N/mm2

Table 4: Tightening torques:

Strap width in **mm**	15	20	25
Tightening torque in **Nm**	4	12	30

The indicated tightening torques were determined on rubber sleeves with fabric insert.

Hose clamps with screw drive are also admissible:

- Width 13 mm
- Minimum tensile strength for the clamp strap: 400 N/mm2

Table 5: Tightening torques:

Clamping diameter in **mm**		Tightening torque in **Nm** for rubber sleeves and rubber hoses	
above	up to	without fabric insert	with fabric insert
8	18	2	2
18	30	3	3
30	48	4	4
48	78	4	5
78	108	4	5
108	158	4	6

Note:

- The hose clamp strength permits a 1.5-fold increase of the tightening torques indicated in the table.
- The initial tightening forces obtained with the tightening torques may be affected by the temperature-dependent settling properties of the rubber sleeves and rubber hoses. In these cases, it is recommended to re-tighten the clamps to the required torque so that a permanently constant preload is ensured.

Hose clamp design:

- Clamps made of stainless steel or provided with anti-corrosion coating, embossed,
- non-perforated strap material.
- Sharp edges on the inside of the clamp are not permissible.
- Lock and strap to be of same material.
- Continuous lock fastening.
- The hose clamps must match the hose diameter.
- By no means, a hose binder cut from a roll and tightened by a cotter pin must be used at these points.

To ensure proper seating of the rubber sleeves or ribbed hoses, observe the following:

- The connecting ends of sheet metal pipes are to be provided with a sealing crimp a per DIN 71550 (plug-on length of the rubber element 35 mm, hose clamp arranged behind sealing crimp).
- Cast iron or steel pipings with a wall thickness of more than 2 mm do not require a sealing crimp, if the seat for the rubber sleeves is machined (cast tube) or drawn seamlessly (steel pipe) and the surface quality corresponds to Rt = 40.

Of course, the connecting pipe ends must be smooth, round and free from burrs. In the case of welded sheet metal pipes, it is necessary to smooth the weld seams.

Hose clamps with self-adjustment of the screw drive:

In the case of these screw clamps, the settling behaviour of the sleeves or hoses is compensated by a self-adjustment of the screw drive via plate springs or helical springs. In this way, a permanent uniform preload is made sure.
Hose- and sleeve connection with clamps of this kind are characterised by an excellent permanent tightness.

These clamps are supplied by:

Messrs. Breeze Pebra GmbH PEBRA-Schellen (Type HKFK)	78665 Frittlingen,	Phone: 0742694920
Messrs. Rasmussen GBS-Norma-Schellen	63461 Maintal,	Phone: 06181 403-0

Spring-loaded clamps as self-adjusting hose clips:

Recently developed type of hose clamp are spring-loaded clamps of spring steel 50 Cr V4 as per DIN 3021-1 and -4. These clamps are suitable for sealing silicon- and fluorine silicon sleeves and hoses used in the temperature range between -50 °C and +150 °C. Thanks to its resilient characteristics, this clamp can adapt to the change of the hose due to the settling and creeping behaviour of the elastomer

Hose- or sleeve connections with spring-loaded clamps are also characterised by an excellent permanent tightness.

These spring-loaded clamps can be used in the following areas:
- Coolant circuit (up to 3bar overpressure)
- Fuel system (up to 7bar overpressure)
- Air intake system vacuum pressure
- Charge air system (up to 2bar overpressure)

These clamps are available with diameters of 13mm to 90mm and in widths of 12mm and 15mm.
These clamps are supplied by: Messrs. Rasmussen 63461 Maintal, Phone.: 06181 403-0

Hose clamps with TWIN clamping jaws:

This is a split clamp with two screw-nut connections (Type B2 as per DIN 3017-2).

These clamps are particularly suitable for fastening the sleeves and hoses in the charge air pipes between turbocharger – intercooler – engine inlet to generate suitably high pressing forces for sealing.

Note:
Because of the high pressures and the high temperatures in the charge air system of the TCD engines, DEUTZ recommends only using the double clamping jaw clip in addition to the V-band clamp.
Clamps and hose material must be carefully matched. The user is responsible for a durable and tight connection.

V-band clamp :

The charge air pipe connection on the turbocharger is made by a V-band clamp. DEUTZ supplies adapters which allows conventional clamps to be used for the further pipes and the charge air cooler. The possible variants can be taken from the electronic pocket book ELTAB. Fig. 3-3 shows an excerpt.

The whole charge air pipe system can be equipped with V-band clamps on the customer side (not supplied by DEUTZ).

...FIGURE 3-3

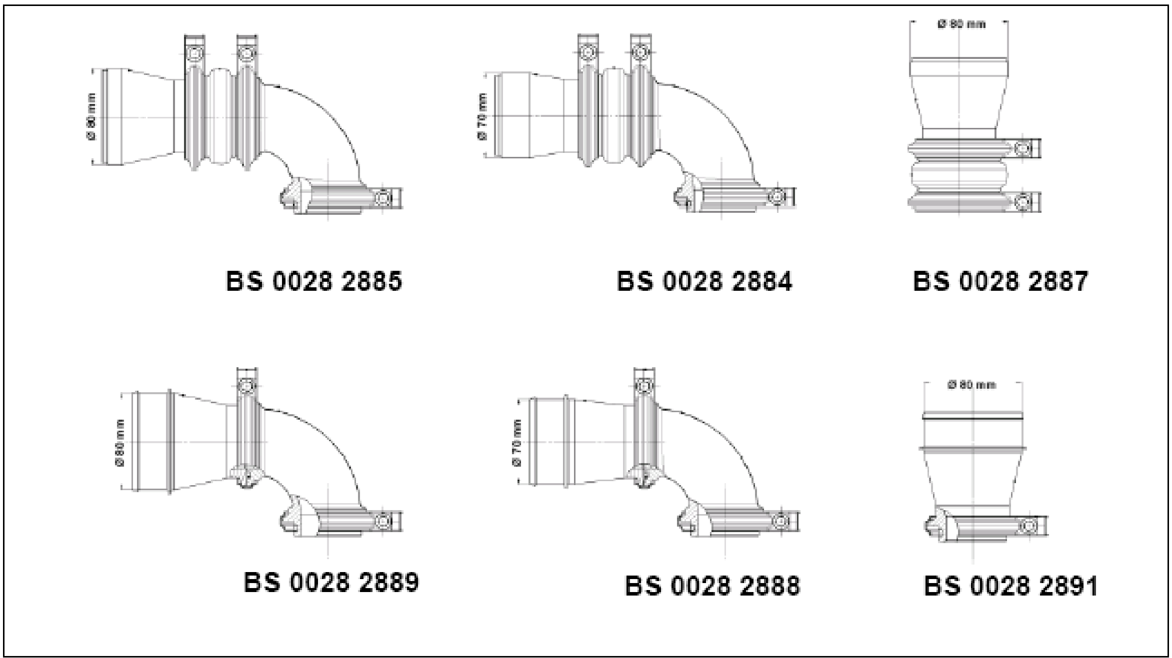
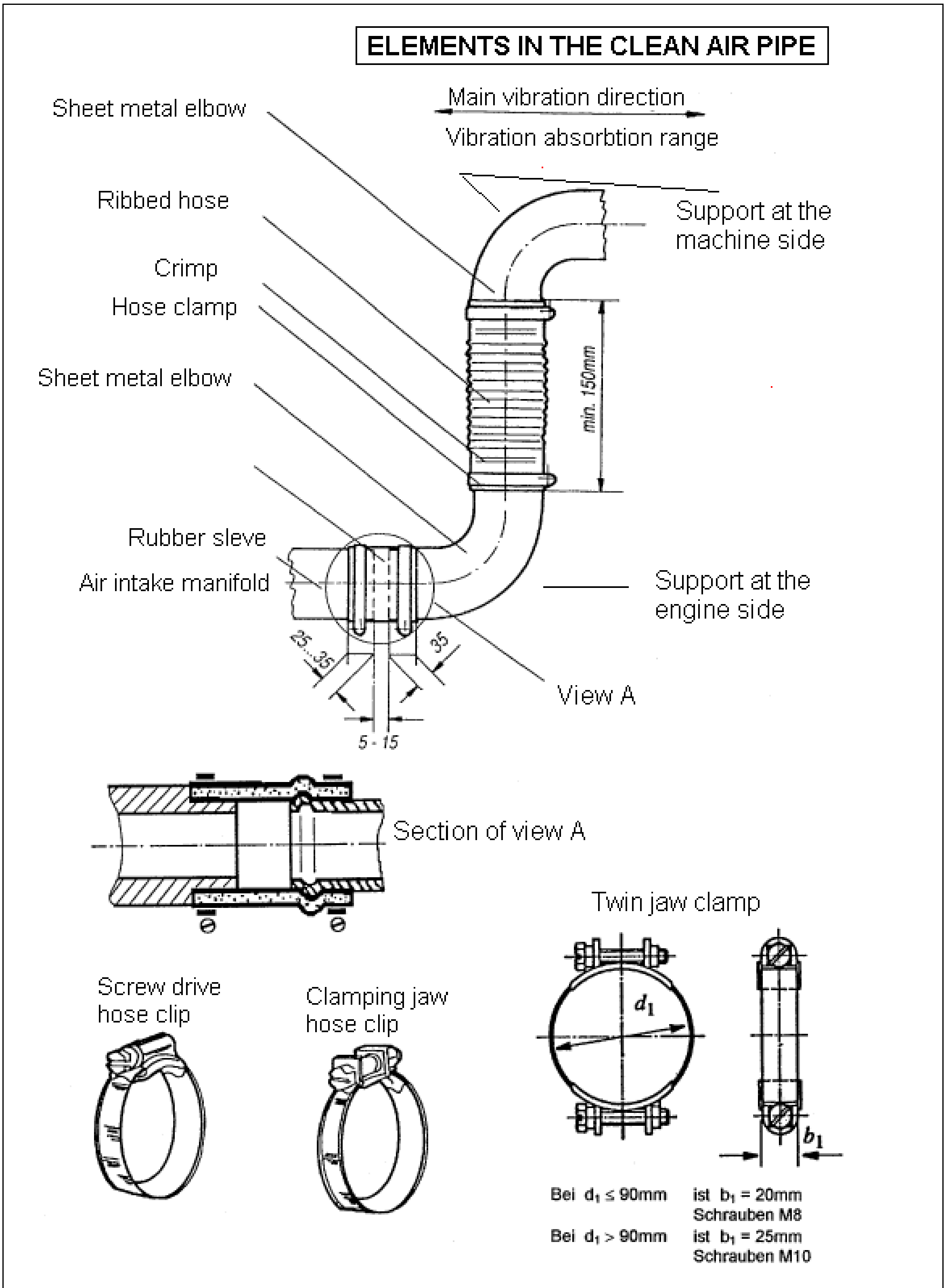


FIGURE 3-4


ELEMENTS IN THE CLEAN AIR PIPE
Sheet metal elbow
Main vibration direction
Vibration absorbtion range
Ribbed hose
Support at the machine side
Crimp
Hose clamp
min. 150mm
Sheet metal elbow
Rubber sleve
Air intake manifold
Support at the engine side
25...35
35
View A
5 - 15
Section of view A
Twin jaw clamp
Screw drive hose clip
Clamping jaw hose clip
d1
b1
Bei d1 ≤ 90mm ist b1 = 20mm Schrauben M8
Bei d1 > 90mm ist b1 = 25mm Schrauben M10

3.6.6 Passages of clean air pipes

The passages of clean air pipes through engine cowlings or sound insulating walls must be executed such that the pipes cannot chafe through. Check for reciprocal vibrations; if necessary, increase the passages for the piping and fill the annular gap towards the pipe with foam rubber or a similar material.

3.6.7 Layout of the combustion air pipes

In the case of turbocharged engines with charge air cooling, the compressed combustion air behind the turbocharger is forced under pressure through a cooler (air/air cooler) to the cylinders.

For dimensioning of the cross sections of these charge air pipes (tubes from turbocharger to intercooler and from cooler to engine intake pipe), the following reference values can be taken as a basis:

Table 6:

Theoretical pipe length	Required minimum cross sections of the charge air line	
	turbocharged engines with intercooler including Euro I	turbocharged engines with intercooler for Euro II and higher
to 2 m	0.29 cm²/kW	0.32 cm²/kW
over 2 to 4 m	0.33 cm²/kW	0.36 cm²/kW
over 4 to 6 m	0.37 cm²/kW	0.40 cm²/kW
over 6 to 10 m	0.42 cm²/kW	0.46 cm“/kW
over 10 to 15 m	0.47 cm²/kW	0.52 cm²/kW

If, on that basis, a pipe diameter is resulting which is smaller than the diameter of the pipe sockets of the intercooler, the diameter of the cooler pipe socket is selected as pipe diameter for the charge air pipe.

3.7 Heating up of combustion air

In exceptional cases, the combustion air may be heated up to max. 10°C above the ambient temperature. The measurement is to be made at the inlet of the combustion air intake manifold or before the turbocharger inlet. In cases where any heating up between the air cleaner inlet and intake manifold can be excluded, it is sufficient measure at the air cleaner inlet.

3.8 Combustion air noise

The combustion air noise is often very annoying on road vehicles and construction equipment with cab because of its low-frequency portions.

A possible remedy is the installation of resonators or Venturi-pipes, if the position of the combustion air intake or of the cleaner or the pipe routing cannot be changed.

3.9 Crankcase breathing system

During the combustion process of the diesel engine, certain quantities of leakage gas enter the crankcase through the piston ring gaps. The crankcase breathing system serves for disposing of such leakage gases.

The TCD engines are equipped to standard and at the moment exclusively with **open crankcase breathing**. The oil in the leakage gas is largely fed back to the engine through a crankcase breathing valve with oil trap device.

If, in future, a **closed engine breathing** is offered alternatively or generally, hoses and sleeves with an oil barring layer must be used in the charge air piping system.

The crankcase breathing pipe is then normally permanently installed on the engine so that no further installation measures need to be considered in the engine installation.

3.10 Charge air cooling system

3.10.1 Design data for the charge air cooling system

Table 7

• Amount of heat to be dissipated via the charge air cooling (CAC)	0.17 – 0.25 x engine performance
• Permissible combustion air temperature after charge air cooler *	50 / 46* °C related to 25°C outside temperature
• Pressure resistance of the charge air cooler	Operating pressure 2.5bar at 230°C Bursting pressure 8 bar
• Installation of the charge air cooler	in flow direction before the water cooler or side by side cold air must flow through the CAC first
• Connection to the engine piping system	Chapter 3.6 Note combustion air pipes
• Oil and water condensate	Provide drain possibility on CAC
• Combustion air outlet to the CAC	Inlet always at the bottom if possible
• Other design data such as: air throughput, volume of heat to be dissipated – engine performance-related, etc.	Consult DEUTZ Technical Support

* 46°C for the engine TCD 2013L06 4V, power variant 261kW / 2200 rpm

**The specification refers to the engine full load operation at nominal speed. At lower engine speeds, lower temperatures may apply for compliance with exhaust gas laws. Especially when using controlled fan drives, compliance with the charge air temperature over the engine speed range must be checked. Fan control and charge air cooler size must be adapted so that the permissible charge air temperature is complied with in all operating points.
The equipment manufacturer is responsible for compliance with the permissible charge air temperature.

3.10.2 Admissible pressure loss in the charge air cooling system

To permit that the compressed combustion air flows through the coolers and pipings of the charge air cooling system, the following resistance values must not be exceeded

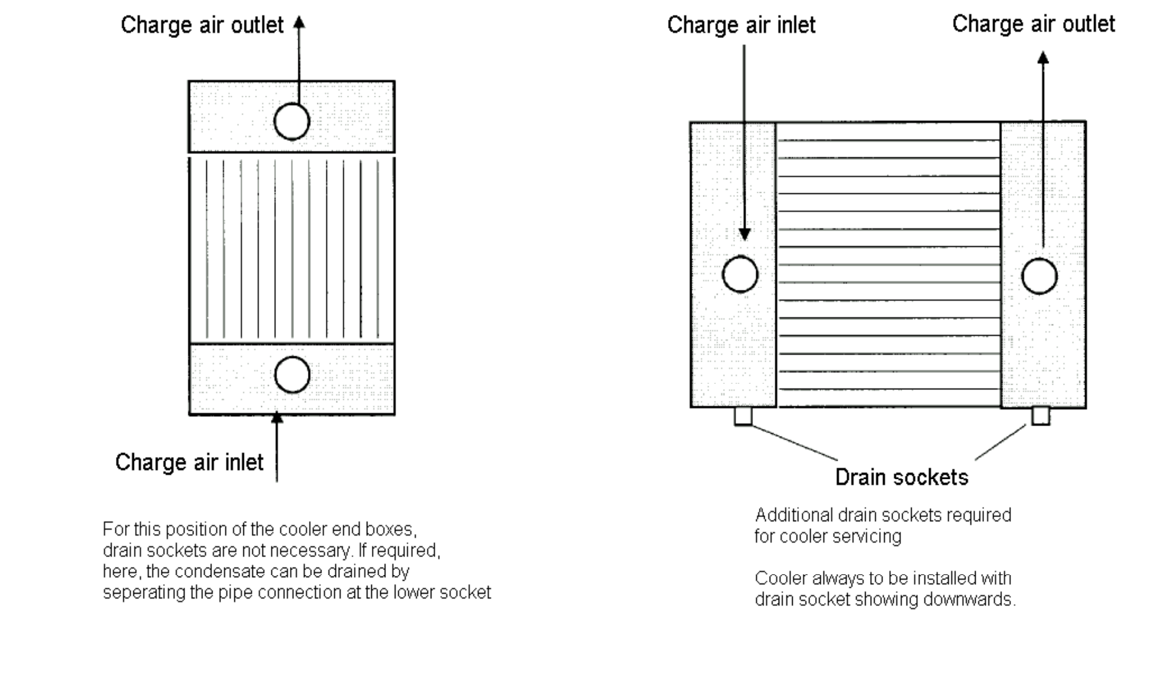
Table 8:

Engine	Piping			Cooler			Total resistance		
	mmWS	mbar	kPa	mmWS	mbar	kPa	mmWS	mbar	kPa
TCD 2012 2V / 4V	500	50	5,0	1000	100	10,0	1500	150	15,0
TCD 2013 2V / 4V	500	50	5,0	1000	100	10,0	1500	150	15,0

3.10.3 Intercooler (air-air cooler)

The coolers used for cooling the charge air are so-called air-air coolers, i.e. the charge air is back-cooled with the cooling air.

FIGURE 3-5



3.10.4 Intercooler (air-water cooler)

Cooling of the charge air with Engine coolant from the engine coolant circuit or with raw water via separate raw water pump, e.g. of a supply station.

Charge air cooling with engine coolant:
For establishing a water / charge air cooling with the engine coolant, a partial volume of the engine coolant is used (circuit integrated in the engine). Here, due to the lower inlet temperature difference between charge air and engine coolant, the effect of the charge air back-cooling is smaller than when cooling with cold raw water.

Charge air cooling with raw water:
Via an additional water pump, essentially cooler raw water is pumped through a water / charge air cooler.

For the layout of such an intercooler, the following data are required:

- Charge air volume flow rate (combustion air volume at turbocharger inlet)
- Charge air inlet temperature to cooler (mostly abt. 100°C ... 200°C)
- Heat volume from charge air to be dissipated (abt. 18 .. 25% of the engine power)
- Outlet temperature charge air (normally abt. 50°C related to 25°C ambient temperature or after the respective exhaust air regulations have been met)
- Coolant volume flow rate
- Coolant inlet temperature

Arrange drain plug in the intercooler at the deepest possible point.

After the layout of such an intercooler, an examination by measurements is absolutely required.

3.11 Pre-loading of hydraulic oil tanks

To reduce to the tendency of hydraulic systems to form cavitations, closed circuits are used, where the hydraulic oil is pressurized in the hydraulic oil tank (pre-loaded oil). To that end, normally an air compressor is required.

When using charged engines for driving hydraulic systems, the charge air pressure has been used for pre-charging the hydraulic oil in a few cases.

This should no longer be used for TD /TCD engines in order to guarantee compliance with the emission regulations.

4. EXHAUST GAS SYSTEM

4.1 General

The exhaust gases are routed off the engine in pipes. To reduce the noise in this connection, a silencer is required. This necessarily leads to resistances in the exhaust gas system which, however, must not exceed the permissible total resistance as stated in the table. The total resistance of an exhaust system comprises the resistance due to the piping including elbows plus the silencer and other components, e.g. exhaust brake.

4.2 Permissible resistance in the exhaust gas system

The resistance data given in the following tables represent values which must not be exceeded when measured on the engine at rated power and rated speed. They apply to the entire exhaust system. No difference is made between automotive and equipment engines.

The following table only applies for industrial engines. For vehicle engines in the EURO IV – version the permissible exhaust gas recirculation is defined separately for every engine version by the necessary adaptation of the SCR system (SCR = Selective Catalytic Reduction, urea injection).
Ask DEUTZ Technical Support for the applicable values.

Table 1: Admissible exhaust back pressure for **equipment engines as well as genset engines***

Engine	**only silencer**			**Overall exhaust gas system** (incl. silencer, pipes, catalytic converters, particulate traps etc.)		
	mmWS	**mbar**	**kPa**	**mmWS**	**mbar**	**kPa**
4 and 6 cyl. 2 and 4 valve TD/TCD 2012	**600**	**60**	**6,0**	**1000**	**100**	**10,0**
4 and 6 Zyl. 2 and 4 Ventile TD/TCD 2013	**600**	**60**	**6,0**	**1000**	**100**	**10,0**

* Engine power for genset engines as per power class VIc.

Table 2:
Admissible exhaust back pressure for **genset engines with COP, PRP, LTP power**

Engine	**only silencer**			**Overall exhaust gas system** (incl. silencer, pipes, catalytic converters, particulate traps etc.)		
	mmWS	**mbar**	**kPa**	**mmWS**	**mbar**	**kPa**
4 and 6 cyl. 2 and 4 valve TD/TCD 2012	**200**	**20**	**2,0**	**300**	**30**	**3,0**

* In individual cases a higher exhaust back-pressure can have been certified. Information for this can be inquired at the technical support DEUTZ.

Table 3: BHKW
If the engines are used as genset engines in block-type thermal power stations (BHKW), matched exhaust gas back pressure values will apply for engines above 4 cylinders:

TD TCD 2012 / 1013	**500mmWs**	**50mbar**	**5,0kPa**	**for the complete exhaust gas system**

The values for the exhaust gas back pressure of the silencers or other systems for the after-treatment of exhaust gas are reference values and can be variably handled, provided the exhaust gas back pressure of the overall exhaust gas system is not exceeded. It must not be exceeded with the exhaust brake flap opened, should an exhaust brake be installed or in case of other resistance-increasing components.

Due to the prevailing installation conditions, in the individual case, it cannot be avoided to exceed the exhaust gas back pressure.

In such cases, the head office, application engineering, must be contacted to verify whether the existing exhaust gas back pressure values are still admissible.

4.3 Measuring the exhaust gas back pressure

Measuring conditions: at full load and rated speed
Measuring point: immediately behind the exhaust gas manifold

If the engine cannot be run at full load, the measurement can also be made at high idling speed. The exhaust gas backpressure value measured then must be multiplied with a factor b and the resulting value must not exceed the admissible full load value.

b = 2.8 for turbocharged engines without charge air cooling
b = 3.6 for turbocharged engines with charge air cooling

This method only permits a rough estimate of the exhaust gas back pressure to be expected upon full load operation of the turbocharged engine at its rated speed.

The following must be considered during the exhaust back-pressure measurement:

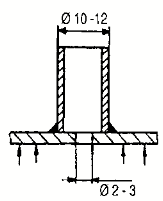
- If an exhaust brake is fitted, the flap must always be open
- If the exhaust brake is directly mounted to the turbine, the pick-up point is to be located behind the exhaust brake. The measured value will then be added to the resistance value of the exhaust brake.
- Engines fitted with PTO's that cannot be uncoupled may have to yield high drag powers when operating at high idling speed or idling at rated speed. When measuring the exhaust back pressure, increased values may result which, multiplied by the above factor "b", may exceed the specified limit values. To have an estimate of the actual exhaust gas back pressure, it is therefore recommended to measure, at the same time with the exhaust gas back pressure, also the exhaust temperature (within the area of the pressure pick-up point) as well as the combustion air temperature at (the inlet of the intake pipe). Technical support DEUTZ will assess, whether the measured exhaust gas back pressure is permissible.

Exhaust gas pick-up point (execution):

A bore with a diameter of 2 to 3 mm must be provided for measuring the exhaust gas back pressure. The burs resulting from drilling must be removed and the inside of the bore must remain sharp-edged.

FIGURE 4.1

Measures in mm

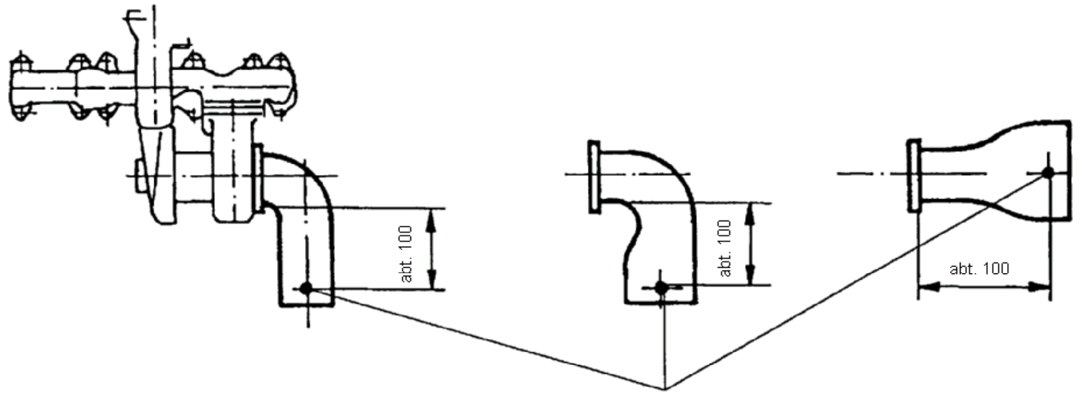


Exhaust gas pick-up point (measuring point):

See the following sketch

FIGURE 4-2

Measures in mm



4.4 Dimensioning of exhaust gas pipes and determination of the piping resistance

The reference value for laying out the exhaust gas piping is the internal diameter of the engine exhaust gas pipe; it is not permissible to reduce the diameter beyond this value.

In the case of the turbocharged engines, the pipe diameter of the connected pipe extension (see 4.2) at the exhaust gas outlet of the turbocharger must be taken as a basis.

The nomographs at the end of this chapter indicate the mostly used pipe diameters that must be observed as far as possible.

Diameter increases between exhaust gas manifold or turbocharger outlet and ongoing pipe or to the silencer must be bridged by suitable adapters (angle of taper 15°). Such adapters are considered in the calculation as piping length when calculating the pipe resistance. The pipe resistance may also be taken from the graphs in chapter 4.8.

The graphs are sub-divided as follows:

for turbocharged engines: Stroke of up to 280 mm – engines with and without charge air cooling

When laying out the exhaust gas system, the total of the individual resistances for silencer, piping, compensators etc. must not exceed the total resistances listed in the tables under section "Admissible resistances". it is only permissible to choose between an increased pipe resistance and a decreased silencer resistance and vice versa.

From the graphs, the specific resistance Δp_s [mbar/m-pipe] can be read at a specific engine power in [kW] and a specific pipe diameter [mm]. Moreover, with the graphs, the "extra pipe lengths" for elbows at different bend radii can be determined for the individual pipe diameters, i.e. an elbow with a specified bend r_m/D corresponds to a certain straight pipe length. When determining the pipe resistance, these "extra" pipe lengths" must be added to the existing straight pipe run.

Examples for determining the piping resistances may be taken from the graphs.

For given lengths and resistances, the necessary pipe diameters can be similarly determined with the aid of the graphs.

4.5 Silencer and end pipe lengths

The silencers offered in the respective scope of supply are matched to our engines in respect of noise and resistance. In the case of other silencers, it is necessary to check at least the resistance so as to avoid power losses.

The length of the end pipe considerably influences the acoustic effect of the silencer. For silencers used under normal conditions, an end pipe length of 700 – 1200 mm is normally sufficient.

Where large-volume, multiple-chamber heavy-duty silencers are used with internal matching, the influence of the end pipe length can normally be neglected.

4.6 Flexible exhaust pipe joints

Where engines are flexibly mounted or the exhaust pipe is not fixed directly to the engine, a "flexible element" must be provided in the exhaust pipe behind the engine (turbocharger) for the absorption of relative movements, shock-induced spring deflections or thermal expansion. The following "flexible elements" are suitable for that purpose:

a) Metal hoses:

They are suitable for the absorption and/or compensation of bending stresses (induced by engine movement) and thermal expansion.
When installing metal hoses, it must be ensured that they are fitted in parallel to the crankshaft. In this way, primary stress will always be a bending stress. Depending on the design, the direction gas flow must be observed.
Metal hoses are not gas-tight.

b) Corrugated pipes (axial compensators)

Corrugated pipes can absorb tensile, compressive and bending stresses. When engines are flexibly mounted, make sure that the following items are considered:

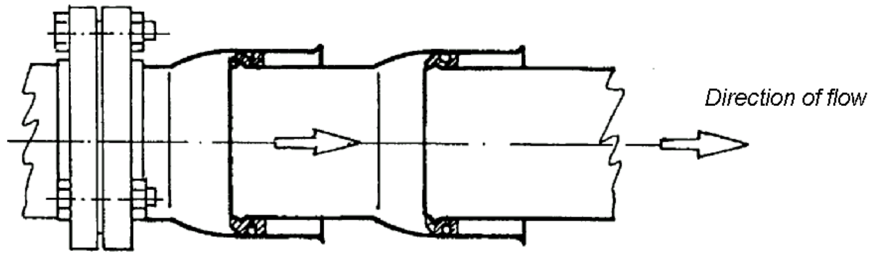
1. When installing corrugated pipes, make sure that these are mounted, if possible, directly behind the exhaust gas manifold or turbocharger and in parallel to the crankshaft. Thus, it is avoided that the direction of thermal expansion is in line with the direction of vibration stresses.
2. Install the corrugated pipes with tensile preload, i.e. length to be increased by about 40% of the expansion to be expected on the straight pipe section to follow. With the exhaust gas temperature to be expected, steel pipes, for instance, will expand by about 5 to 6 mm of pipe length.
3. Install mating flange screw connection by means of a loose, turnable flange so as to avoid torsional installation stresses when aligning the flange hole patterns.
4. Corrugated pipes can emit an intense air-borne sound. To reduce this sound emission, use corrugated pipes with internal shield tube.
5. If possible, stress should be limited to bending.

Corrugated pipes are gas-tight.

c) Exhaust joints:

Exhaust joints are a system of pipe elements plugged one into the other, which are connected by multiple-disc seals (see diagram).

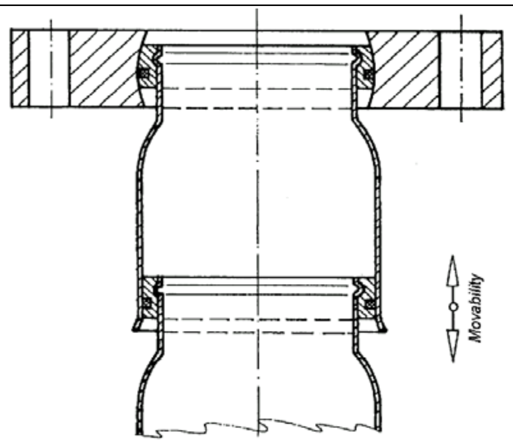
FIGURE 4-3



When installing the joints, ensure that the central piece remains easy to slide and to turn.
For an optimal compensation of relative movements, avoid excessive misalignments of the opposing pipe openings.
Positioning of the joints should always be horizontal or suspended (with expanded end down to avoid the penetration of water) with the gas flow always in the direction of pipe-to-pipe extensions. This will ensure stability of the central piece because of the gas force (and the natural weight) and avoid vibrations (destruction).

With a second version of exhaust joints, the movable central piece is mounted directly in the flange so as to allow turning and pivoting, see diagram; thus, no characteristic movements can be induced due to gas forces or natural weight.

FIGURE 4-4



Silencer joints are not gas-tight and must, therefore, not be used in rooms.

4.7 Exhaust brake (exhaust brake flap)

On actuating the engine brake flap, the fuel injection is interrupted up to a specified minimum speed to increase the engine braking performance. This is controlled by the electronic engine control unit (ECU). Therefore the engine brake actuator must be connected accordingly to the engine control unit .
See the valid DEUTZ connection diagrams of the engine control units.

Normally, the exhaust brake flap is actuated by a control lever with pivoted cylinder serving as actuator.

The integrated air cylinder for actuating the brake flap is exposed to high thermal stresses.

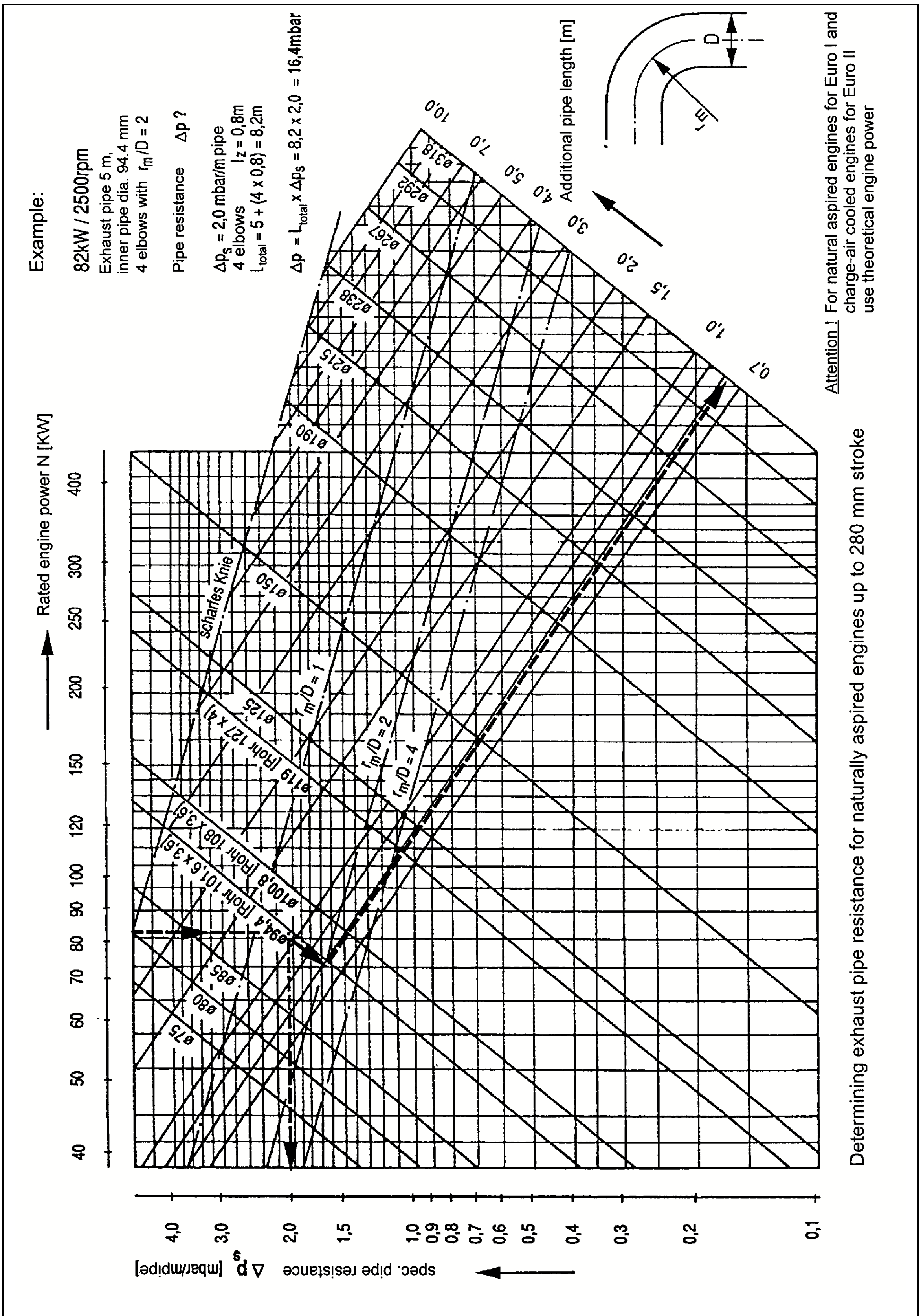
As exhaust flaps are matched to the relevant engine design, it is recommended to only use such flaps which are included in the DEUTZ scope of supply.

Installation conditions:

Permissible mechanical load of the turbocharger:	The turbocharger manufacturer provides no concrete load values **Therefore all installations must be agreed with DEUTZ Technical Support**
Thermal load of the pressure cylinder	145°C
Installation location:	• Engine brake flaps are usually installed directly at the exhaust gas turbocharger outlet, minimum distance from the turbocharger 25mm • An additional support is usually necessary, ask DEUTZ AG • Installation after the elastic element in the exhaust pipe is usually not permitted.

4.8 Nomographs for determining the exhaust gas pipe resistance

FIGURE 4-5



4.9 Water scrubbers

In the case of water scrubbers, the exhaust gas is directed through a water bath in which the exhaust gas is cooled and some particles are washed out.

Water scrubbers are water tanks with several inner baffle plates and separating facilities connected behind, which feature a considerable flow resistance even without water filling.

Therefore, upon measurements of the exhaust gas back pressure, the scrubbers must be examined with and without water filling.

When assessing the resistance, the remaining water level in the scrubber must be regularly topped up.

Dimensioning of the water scrubber (water volume and separating chamber) will be up to the equipment manufacturer, as this will mainly depend on the installation space available for the water scrubber. The water storage capacity should be approximately the same as the fuel tank capacity. The water filler neck of the scrubber should be largely dimensioned to permit rapid filling.

4.10 Exhaust gas catalytic converters

When using catalytic converters, the manufacturer shall give suitable instructions for the design, the determination of the size and for the installation as well as for monitoring and servicing.

Depending on the design and material used, the flow resistance of the catalytic converter will change in the course of time. Therefore, we recommend providing a lockable exhaust back pressure pick-up point in front of the catalytic converter so that the back pressure can be checked from time to time.

Catalytic converters should be connected to the engine as close as possible to minimize exhaust heat losses. If necessary, the exhaust gas piping behind the engine or the turbocharger must be insulated against the catalytic converter.

Catalytic converters have a good silencing effect so that it may be possible to install them instead of the standard exhaust silencer. for verification purposes, the noise emission at the exhaust outlet should be measured.

The limit values determined for the exhaust gas back pressure also apply to the use of the catalytic converters. When laying out catalytic converters and the relevant piping system, it must be ensured that the exhaust gas back pressure limits are not exceeded.

4.11 Exhaust gas heat exchangers

For utilising the exhaust gas heat, heat exchangers can be used to transmit the exhaust gas heat to the media of heating circuits.

For dimensioning of the exhaust gas pipes of an exhaust gas system, the additional exhaust gas resistance due to the exhaust gas heat exchanger must be observed. The maximally admissible exhaust gas back pressure limits for the engine must not be exceeded.

Exhaust gas heat exchangers have a certain silencing effect which can be considered for the layout of the silencer.
The technical data of an exhaust gas heat exchanger must be inquired from the manufacturer.

- Exhaust gas heat exchangers must always be provided with a controllable bypass so that, in case of a failure (clogging, pipe rupture in the heat exchanger etc.) the exhaust gas flow can be directed around the heat exchanger to protect the engine.

- When installing exhaust gas heat exchangers, it is absolutely necessary to provide for pick-up points in the line system for measuring the exhaust gas back pressure. Via these pick-up points, cyclical exhaust gas back pressure measurements are made to monitor the exhaust gas back pressure and to determine the time for cleaning of the exhaust gas back pressure of the exhaust gas heat exchanger.

- Exhaust gas heat exchangers are maintenance parts – they must be cleaned (removing of soot deposits). Therefore, the installation must be made such that the servicing works can be performed without any problem.

- Exhaust gas heat exchangers must not be operated in the engine coolant circuit.

4.12 Exhaust gas end pipe/water penetration guard

With the exhaust gas end pipe, the exhaust gas flow of an exhaust gas system is directed into the open atmosphere so that operator and engine are not hindered.

The end opening of the exhaust gas end pipe must be designed such that no water (rain, snow) can enter.

Therefore, exhaust gas end pipes must be equipped with a water penetration guard in the form of exhaust gas flaps or 90° pipe elbows. Alternatively, at the lower end of an end pipe, a water draining slot (Venturi-type) can be provided for.

4.13 Condensed water separator

In the case of very long, vertical exhaust gas end pipes (stack), separators of condensed water are necessary (cooling down of the exhaust gas and condensation of the water steam).

The condensed water separator must be arranged at the deepest point of an exhaust gas system to ensure that the collected water cannot flow back and/or clog pipe cross sections (icing with the engine standing still).

Condensed water separators must be provided with a drain cock for draining the water.

The volume of a condensed water separator depends on the water volume to be expected in view of the mode of operation of the engine (engine load, exhaust gas temperature) and the insulation of the exhaust gas end pipe – the manufacturer of the system is responsible here and gives suitable recommendations, also regarding servicing.

4.14 Heat insulation

A heat insulation of the surfaces of exhaust gas manifolds at the engine and the following exhaust gas turbochargers is generally not permitted and always require a consultation with DEUTZ.

Partial insulation especially at a low engine output setting may be permissible but DEUTZ Technical Support must always be consulted first .

However, in the case of partial insulation of the turbocharger, the oil lubricated shaft connection between the compressor and the power turbine must always be left free for cooling (free radiation).

The insulation of the exhaust gas manifold and the turbochargers must always be seen as a function of the engine application and the blocked engine power. Therefore, in the individual case, always technical support DEUTZ must be consulted.

4.15 Particulate traps

The exhaust gas emission of a diesel engine contains solid matter – so-called particulates – the size of which varies predominantly between 0.05 and 15 microns. These particulates do not only consist of particulate carbon, but also of hydrocarbons from the fuel and lube oil residues, which are partly adsorbed by the particulate carbon. Further particulates result from the sulphur content in the fuel as well as from metallic abrasion.

The particulate trap serves for filtering the exhaust gas with 99% of the soot particles being retained. With reference to the overall particulate matter, the retention efficiency is about 70%.

Among others, ceramic monoliths are used as filtering elements; their channels are alternating closed forcing the exhaust gas to flow through the porous partitions where the particulate matter is filtered out.

The ceramic monolith is gas-tight and shockproof and designed as a honeycomb accommodated in a stainless steel housing.

The filter size depends on the exhaust gas volume flow rate and a maximally permissible retention of solid matter (soot), which is also limited by the exhaust gas back pressure.

Maximally admissible exhaust gas back pressure:

The limit values as per 4.2 apply.

For engines with strongly intermittent operation, a temporary increase of the overall exhaust gas back pressure of an exhaust gas system due to the particulate collection of the filter is admitted up to a limit of 200 mbar (from 4-cylinder engines). For the related deterioration of the engine parameters (fuel consumption, engine power, exhaust gas quality, reliability and service life), DEUTZ will not be liable.

When the limit for particulate loading has been reached, the filter must be regenerated by exchanging the filter element or burning off the filter loading which mainly consists of soot.

For further details on the particulate trap technology and the existing regeneration systems, contact the manufacturer.

For the installation of the particulate trap, the following essential items should be considered.

- Particulate traps are excellent exhaust gas silencers thanks to their design. The silencing effect corresponds to that of resonance and absorption silencers. Therefore, when installing particulate traps, it is not necessary to install standard silencers.

- Particulate traps are available in various sizes and are matched to specific engine series to keep the exhaust back pressure within acceptable limits for the engine.

- Particulate traps are to be mounted in the equipment or chassis free from stress. If necessary, flexible elements have to be provided.

- The pipe connection between engine exhaust gas manifold and particulate trap must always be highly flexible and gas-tight to reduce the transmission of engine vibrations to the filter.

- End pipes behind the particulate trap should be kept as short as possible to reduce the exhaust back pressure.

- Pipe connections between engine and particulate trap should also be kept as short as possible, as long pipes increase the exhaust gas back pressure acting on the engine. To make up for this, the particulate trap-loading rate would have to be reduced (shorter particulate trap loading rate before regeneration of the filter).

- In the case of particulate trap systems with automatic regeneration, the position of the exhaust gas end pipe outlet at the equipment or the vehicle must be in accordance with the safety requirements. During filter regeneration, exhaust gas temperatures existing at the end pipe may reach 500 to 550°C at the end pipe outlet (basis: ambient temperature 25°C).

- The particulate trap and the electronic control box must be installed such that they are easily to service.

More detailed and specific installation instructions will be provided with the respective particulate trap supplied with accessories and descriptions.

4.16 SCR System (Selective Catalytic Reduction)

The permissible exhaust gas emission limits for vehicle engines in accordance with EURO IV, especially the NOx reduction can only be observed cost effectively at present with the SCR System (Selective Catalytic Reduction, urea injection).

Details and installation instructions for this system are shown in a separate installation regulation.

4.17 Exhaust gas recirculation

To achieve the exhaust gas emission values, the DEUTZ engines TD / TCD 2012 /2013 are equipped with exhaust gas recirculation systems.

The following systems are used:

- **Internal exhaust gas recirculation, uncontrolled:**
  Application in industrial engines, moderate emission reduction, specific engine output is limited, low-cost. No installation measures necessary.
- **Internal exhaust gas recirculation, controlled, Jacobs System:**
  Special application for industrial engines, advantages with regard to specific engine output, more expensive. No installation measures necessary .
- **Externally cooled exhaust gas recirculation, controlled:**
  Agripower engines, high specific engine output, high emission reduction, high costs.
  The permissible AGR actuator temperature of a max. 110 °C must be observed from an installation point of view for the external exhaust gas recirculation. The temperatures are saved in the AGR control unit.

5 FUEL SYSTEM

5.1 General

An adequate supply of the injection pump with fuel at all times is a pre condition for proper starting behaviour and satisfactory performance of diesel engines.

DEUTZ diesel engines are laid out for the diesel fuels as per DIN EN 590.

Release is granted for:

- Diesel fuel with additives according to EN 590, added by the oil company, as far as the EN 590 /2004 will be complied.
- Diesel fuel according to JIS K 2204: 1 and 31), with lubricity according to EN590 /2004 (positive test results required).
- Diesel fuel according to ASTM D 975:1D and 2D 2), with lubricity according to EN 590 (positive test results required).

1) Japanese Standard 2) US-Standard

Fuels for which no general release is granted. Individual testing with possible additional measures on components is necessary for these fuels. Testing is only carried out at the customers' request.

Release is granted after positive testing:

- Low lubricity diesel fuel with HFRR-value > 460 µm ≤ 570 µm (measuring method according to ISO 12156-1).
- Fatty Acid Methyl Ester (FAME) in accordance with EN 14214 as well as admixtures to diesel fuel > 5 % (V/V).

Fuels for which there is no release:

- Gasoline *
- Petroleum and other kerosene types *
- Alcohols (methanol, ethanol, isopropylalcohol for antifreeze, etc.) *
- Diesel fuel with additives, available in the accessory trade (e.g. lubricity-, flow-, cetan-improvers, etc.)
- Diesel fuel with undissolved water (free water)
- Emulsions of diesel fuel and water (Aquazole)
- Diesel fuel with admixture of used engine oil
- Diesel fuel with admixture of biocides

* including admixtures to diesel fuel

The respective legal regulations must be observed for the installation and operation of systems for storage, filling and conveyance of inflammable liquids.

5.2 Fuel conveyance (System Tank – Supply Pump - Tank)

5.2.1 Permissible resistances

The engine integrated fuel supply pumps are gear pumps which are driven, depending on the engine type, by V-belts, poly V-belts or toothed gears. Due to the different drive types, deviations in the transmission ratios occur with slight effects on the supply volumes. The installation notes given below and the values to be observed apply for all drive variations.

Maximal permissible overpressure at the pump inlet (suction side):	up to + 0.1 bar at engine nominal speed and maximum engine output
Maximum permissible underpressure at the pump inlet: (suction side) including suction height and pipe resistance of the suction pipe, pre-filter with hand supply pump in **new condition of the filters**:	- 0.35 bar *
Maximum permissible underpressure at the pump inlet: (suction side) including suction height and pipe resistance of the suction pipe, pre-filter with hand supply pump at maximum **soiled condition of the filters:**	- 0.55 bar *

Suction height:
With a low-lying fuel tank, the suction height (height difference) between the suction point in the tank and the inlet of the fuel supply pump is given by the difference:

[0.35 bar – actual underpressure (bar) at the pump inlet in filter new condition] x 10 = suction height (m)

Example:
At 5 l/min throughput, the internal resistance of the new pre-filter is approx. 0.1 bar

If the pipe resistance including pipe bend and screw union were at approx. 0.02 bar

There would be a total resistance of the suction pipe of approx. 0.12 bar.

This would give as a suction height: 0.35 - 0.12 = 0.23 x 10 = 2.3 m

Maximum permissible counterpressure on the return pipe of the fuel control unit (FCU)	+ 0.5 bar *

* The greatest fuel volume is conveyed in the TD/TCD 2012 / 2013 engines at low idling speed. Therefore the pressure measurements in the fuel lead and fuel return must always be made at low idling (NL).

5.2.2 Permissible temperatures

Component, medium, environment	Permanent temperature °C	Brief temperature °C
Fuel in normal operation " in case of fault briefly in the return up to *The fuel temperature may never exceed 90°C in the lead*	70	90 125
Fuel pipes	-40 / 100	125
Ambient temperature: Fuel pressure sensor Rail pressure sensor	 -40 / 140 -40 / 130	

Ambient temperature: FCU, (storage -) / op. temperature Rail, injection system, (storage -) / op. temperature Fuel supply pump, (storage -) / op. temperature	 (-40) / -30/120 (-40) / -30/120 (-40) / -30/120	 140 140 140
Ambient temperature: Fuel pre-filter (Racor) Fuel main filter	 -40 / 90 -40 / 100	 120

5.2.3 General installation instructions

The ignition temperature, the temperature at which fuel in contact with air can self-ignite and burns continuously is approx. 220°C for diesel fuel but may deviate considerably due to contamination.

Fuel wetted components and pipes therefore represent a source of danger in the engine compartment because damages and leaks can cause fires with considerably damage to property and persons.
This must be taken into account in the constructional design of the engine installations and the fuel-wetted parts, i.e. **no fuel may get onto “hot” parts**.

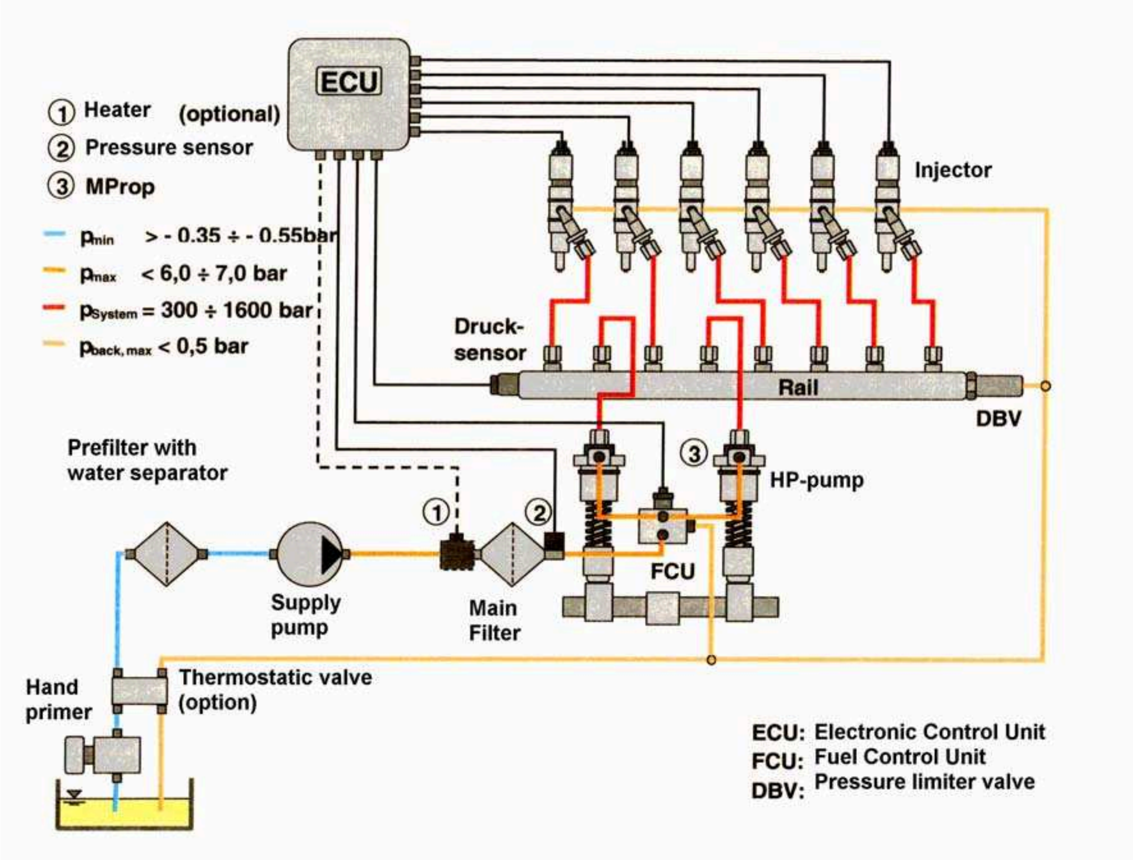
Therefore:
- Only lay exhaust pipes on the “hot” side of the engine
- Lay fuel system components, fuel pipes on the “cold” side of the engine

If this is not possible in exceptional cases, ensure with shielding and pipe insulation that no fuel can get onto hot parts or that the surface temperature of the hot parts is reduced to an uncritical value.

Note:
The equipment manufacturer is responsible for a safe engine installation and observation of the valid specifications.

DCR - DEUTZ Common Rail System, Übersicht:

FIGURE 5-1



Remarks:

- Pressure specifications are related to the standard reference condition 1000mbar, 25°C.
- Only fuel pre-filters released by DEUTZ may be used, only RACOR at present.
  The fuel pre-filter can be obtained optionally as a variant with thermostat valve. For this, the fuel return pipe is fed through the thermostat valve installed in the fuel pre-filter. This divides the fuel from the engine return depending on the fuel temperature to the engine lead or return to the tank to prevent blocking of the fuel filter.
  Without the thermostat valve, the return pipe is connected to the return pipe manifold near to the FCU. The return pipe is not fed through the pre-filter head but directly into the tank.
- The hand pump is integrated in the fuel pre-filter.
- The following variants are possible as a fuel main filter:
  - Environmentally friendly bowl filter installed in the engine
  - 1.4 ltr. exchange filter installed in the engine
  - 2 x 1.4 ltr. exchange filter, installed on the customer side remote from the engine

  The standard equipment is the 2 x 1.4 ltr. exchange filter. For TIER III engines, there are greater demands on the fuel main filter. Only filters released by DEUTZ may be used.
- The distance "a" between the return and suction pipe in the tank must be chosen as great as possible. Recommendation: a > 500mm or > 150mm in return pipe with 90° deflection, see sketch on page 05 - 9.
- Hot, foamy fuel must be prevented from flowing back directly from the return pipe to the suction pipe.
- The pipe cross sections specified in the fuel schematic diagram of engines TD/TCD 2012 and TCD 2013 may not be exceeded at any point in the system outside the engine!
- The recommendations for the supply pipe (suction pipe) must be observed to avoid the formation of steam bubbles in the fuel – as a result of which cavitation damage may occur in the injector components – see chapter 5.3

5.2.4 Tank arrangement in relation to the engine

Tank underneath engine

At greater suction heights a higher operating tank can be used which can be filled for example with a vane pump or an electric tank supply pump from the main tank.
An overflow pipe can be laid between the high tank and the main tank or the tank supply pump of the main tank is switched on intermittently after float contact in the high tank.
Alternatively, a ring line can be provided in place of the operating tank or for example in case of a greater tank distance or multi-engine systems. The pressure in the ring line may act fully on the inlet of the fuel supply pump as long as + 0.1 bar is not exceeded.
If this pressure is exceeded, a choke must be installed between the tapping point on the ring line and the fuel supply pump. A maximum throughput of 5 l/min must be guaranteed.

Tank above engine

On high-lying fuel tanks the top edge of the tank may not be more than 1 m above the fuel supply pump.
If the tank has to be mounted higher, the installation of a choke is unavoidable (pressure limiting to +0.1 bar before fuel supply pump of the engine in engine full load operation).
In the fuel pipes leading to the engine, shutoff valves must be provided near to the tank if the top edge of the tank is above the fuel supply pump (avoidance of leaks when changing filter or during maintenance work).

Remark:
It is principally recommended to close the fuel pipes with the shutoff valves in fuel systems with pre-pressure for longer engine shutdowns.

Maintenance instructions for the bowl filter

The diesel engine series TD/TCD 2012 / 2013 are offered with a bowl filter or exchange filter as a fuel main filter for the fuel circuit.
For maintenance work on the bowl filter system (filter change), a return from the bowl filter to the fuel tank ensures that fuel can drain and the filter elements can be disposed of in an environmentally friendly way.
This pipe also serves to vent the fuel system and must be connected to the fuel tank to guarantee this function of the bowl filter.
In the case of the fuel filter, the fuel drain only works via the internal return as long as the drain opening of the bowl filter for the fuel is above the fuel level in the tank.
If the drain for the fuel from the bowl filter (through which the fuel return line is also fed) is below the general fuel level in the tank (especially for tank systems above the engine), then a tap with a separate drain must be installed in the drain pipe for filter maintenance through which the fuel can be drained from the housing of the bowl filter and collected in a vessel.
(At the same time, the supply pipe must be blocked by a second shutoff tap so that no fuel can flow out of the tank.

Notes

- If a shutoff valve has been installed before the fuel pre-filter anyway for a high tank position, the shutoff valve in the feed before entering the bowl filter can be omitted.
- If there is also a shutoff valve in the fuel return to the high tank, the shutoff tap on the fuel drain of the bowl filter is not necessary.

5.3 Laying and dimensioning of the fuel pipes

The scale-free steel fuel pipes not included in the delivery of the engine must be cleaned carefully before laying.
When laying the pipes, make sure that they are protected against mechanical and thermal influences.
Tube fittings with sealing cones and union nuts are best suited as connecting elements.
Flexible hoses with a fabric inlay must be used for the connection between the metal pipes from the tank and the fuel connections on the engine.
Any installation parts provided, e.g. shutoff fittings, must be adequately dimensioned with regard to their flow resistance.

Rubber hoses should be used preferably which offer a number of advantages in the installation due to their flexibility, simple handling and robustness. Plastic fuel pipes can also be used conditionally on the suction side. Because of the limited temperature resistance (approx. 120°C permanent temperature) due care and attention must be paid when laying the rubber hoses and especially the plastic pipes (note thermal ambient influences).

Well-known manufacturers are:

Voss Co.	D-51688 Wipperfürth	Tel: (02267) 63-0
ContiTech Techno-Chemie GmbH	D-61184 Karben	Dieselstrasse 4

Pay attention to the following when laying fuel pipes:

5.3.1 Suction pipe

For the suction pipe from the tank to the fuel supply pump a pipe length up to 6 m with a clearance of at least 12 mm must be chosen.
For lengths greater than 6 m the clear pipe widths of the suction pipe must be adapted in accordance with table 1. The screw unions should be selected with a low resistance. The permissible suction underpressures must be observed on the fuel supply pump in any case.

Pipe length [m]	Pipe diameter, inside [mm]
≤ 6	12
≤ 15	14
≤ 25*	16*

* screw unions provided by customers

Table 1: Inside pipe diameter of the suction pipe depending on the pipe length

For the connection of the suction pipe
- to the tank,
- to the pre-filter and
- to the fuel supply pump

screw unions included in the Deutz scope of delivery must be used.

When using standard-compliant pipes, makes sure you select pipes which do not exceed the required inside pipe diameter.

Also make sure that the cross-section of the suction pipe is not restricted by the installation of additional elements.

The suction pipe should be laid as straight as possible without sharp elbows. Angled screw unions and hollow screw unions are not permissible in the suction pipe.

All pipe connections must be made air-tight.

The suction opening of the suction pipe in the fuel tank must be about 40 mm away from the bottom of the tank so that no residue water or sludge can be sucked in.

5.3.2 Pipes in the low pressure system

The hoses between the supply pump – main filter – engine (pressure side) must be equipped with a fabric inlay (pressure resistance 20 bar, temperature resistance –40°C / +100°C, briefly 125°C).
The instructions in chapter 5.9 must be observed for assembly and maintenance work.

5.3.3 Return pipe

The fuel return pipes must be dimensioned so that the pipe cross section corresponds to about 70% - 100% of the suction pipe cross section. The flow resistance of the whole fuel return pipe – measured directly after the engine – may not be greater than 0.5 bar.

The fuel return pipe through which excess supplied fuel in the fuel measuring unit (as well as leakage fuel from the injectors) must be drained, must be laid up to the minimum permissible fuel level if the lowest possible fuel level in the tank is below the top edge of the fuel injector (see figure).
This avoids air penetrating the suction system through this pipe during engine standstill and causing starting difficulties and poor performance.
By feeding in the return fuel below the fuel level, additional foaming of the fuel is also prevented.
Connection of the fuel return pipe to the suction pipe is not permissible.
The return pipe must always be fed into the fuel tank separately.
All connections must be made air-tight.
Simplified pipe laying must be agreed with head office.

5.3.4 Requirements for fuel hoses

Suction pipe: Underpressure strength: Max. permissible constriction of the inside diameter: Temperature strength: Material:	 -0.8bar at 80°C (fuel, air) 10 % -40°C / +100°C, briefly 125°C Flexible hoses with fabric inlay or plastic pipes
Low pressure pipe: Pressure strength: Temperature resistance: Material:	 20bar -40°C / +100°C, briefly 125°C Flexible hoses with fabric inlay

Return pipe: Temperature strength. Material:	 -40°C / +100°C, briefly 125°C Flexible hoses with fabric inlay or plastic pipes

Remark:
In case of a defect in the fuel control unit (FCU) fuel can be fed through the pressure relief valve of the rail for a limited time until switching off the engine. Temperatures up to 125°C may occur for which the fuel pipes and the fuel tank must be designed, at least at the inlet position of the return pipe into the tank.

5.4 Fuel heater, fuel cooler

As a maximum permissible permanent fuel temperature before entering the engine-internal fuel supply pump, 70 °C are permissible. On exceeding the permissible temperature, components of the fuel injection system may be damaged which can be proved to have been caused by non-compliance with the installation regulation.
Brief exceeding of this limit is only allowed for weakly loaded engine operation whereby fuel temperatures up to 90 °C are tolerated.
Modern day engines with their high pressure injection require a higher fuel temperature level which, however, is strongly dependent on the application conditions of the engine. By appropriate design and choice of material in the construction of the fuel tank and its installation position in the device (good ventilation, avoidance of additional heating), influence can be exerted on the temperature behaviour of the fuel but reliable and defined heat dissipation is only guaranteed by an appropriately dimensioned fuel cooler.
Such fuel coolers are integrated most easily in the engine's cooling system (air side) and the returning fuel flows through them. The installation location in the fuel system is **in the return pipe.**
If the pre-filter with thermostat valve is used the installation location of the cooler is between the pre-filter and the tank in this case. The installation in the return pipe after the fuel control unit is then not permitted.

Recommendation:

Max. permissible flow resistance of the fuel cooler **(fuel side):**	≤ 0.15 bar
At a fuel volume flow of (at nominal speeds between 2300 - 2400 rpm):	3 to 5 l/min
Recommended return cooling power	2.0 to 3.0kW

The limit value for the total resistance of the return system may not be exceeded by the fuel cooler.

5.5 Fuel tanks

Fuel tanks must have adequate ventilation. Do not use galvanised materials or materials containing zinc because fuels may form zinc soap in connection with the zinc depending on its composition which could endanger the injection system.
In devices which are sometimes operated at steep angles, the ventilation must be designed so that proper ventilation is possible in any position.

Residue water and dirt collect in the fuel tank. It is therefore necessary to provide a sludge drain screw at the deepest point.
The fuel tank should have a tank volume of > 30 litres. The fuel tanks must be built so that as large a surface as possible results at every fuel level. This promotes degassing of the fuel

To support degassing and avoid sucking back in fuel containing air directly, the fuel pipes should be laid in the tank as follows:

Note:
To avoid damage **to the pre-filter with thermostat** a filter insert on the suction pipe must guarantee that no fuel with particles bigger than 600 - 1000 µm may be sucked in through the fuel pipes.

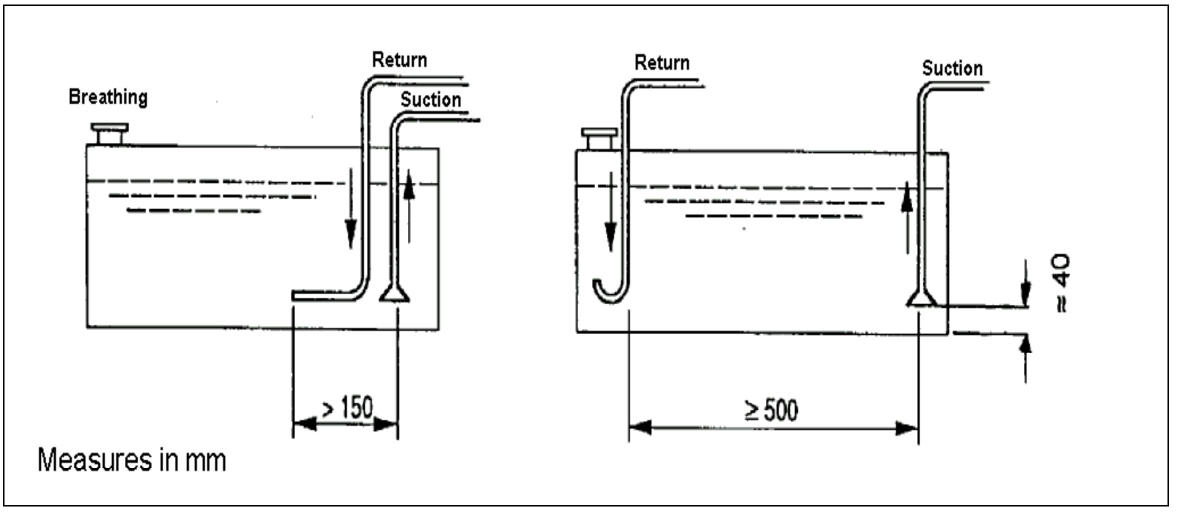


Figure: Representation of arrangement of suction and return pipe in the tank

When using plastic fuel tanks, consult the fuel tank manufacturer concerning the permissibility of the used plastic with regard to the fuel and temperature.

5.6 Fuel filtering / water trapping

5.6.1 Main filtering:
The following main filter variants are available for the engine series:

FIGURE 5-2 Bowl filter

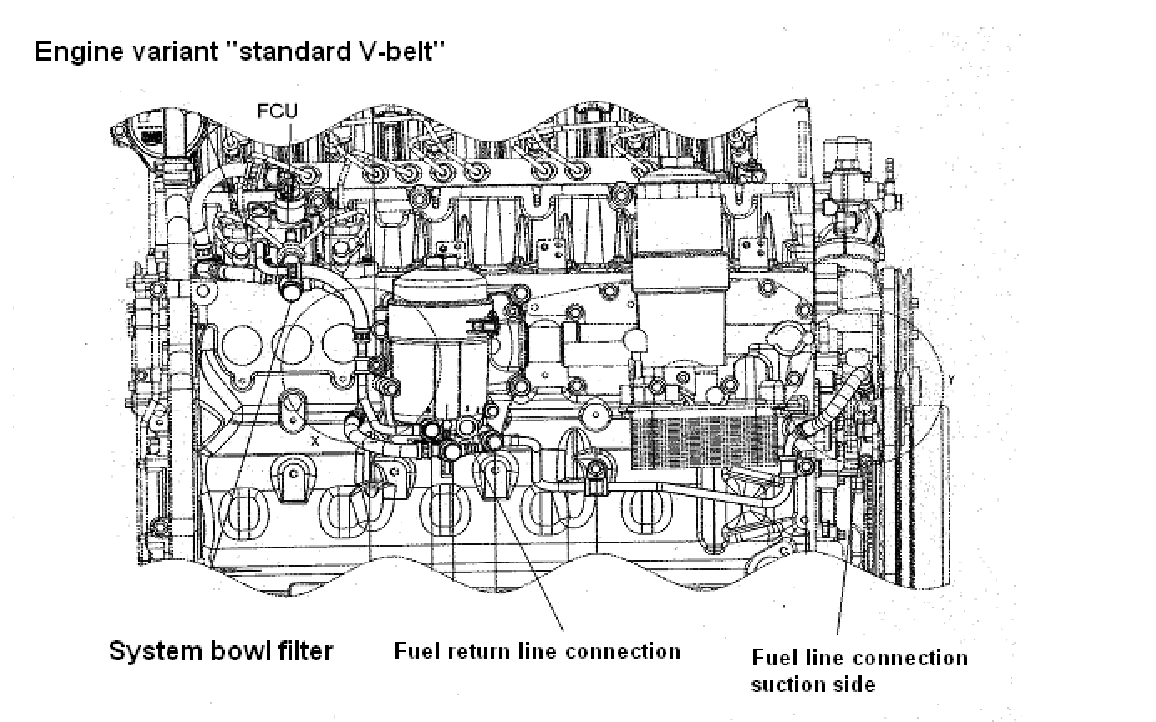


FIGURE 5-3 Mounted main filter

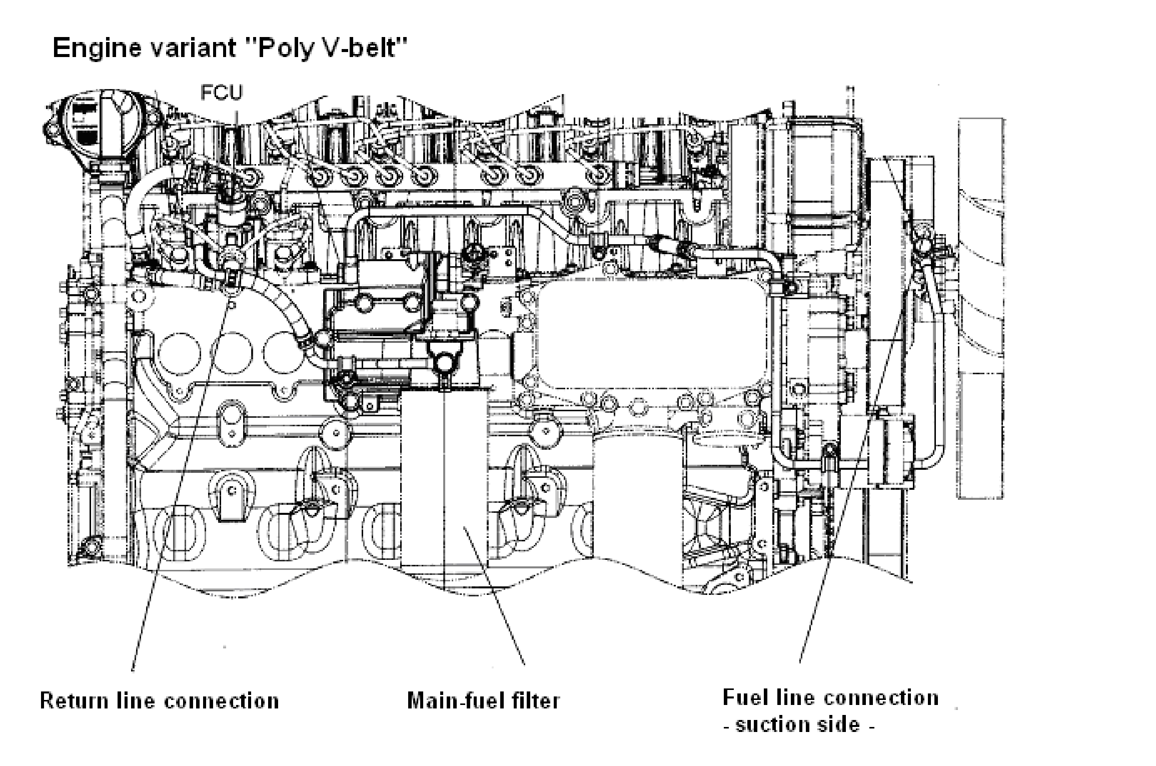
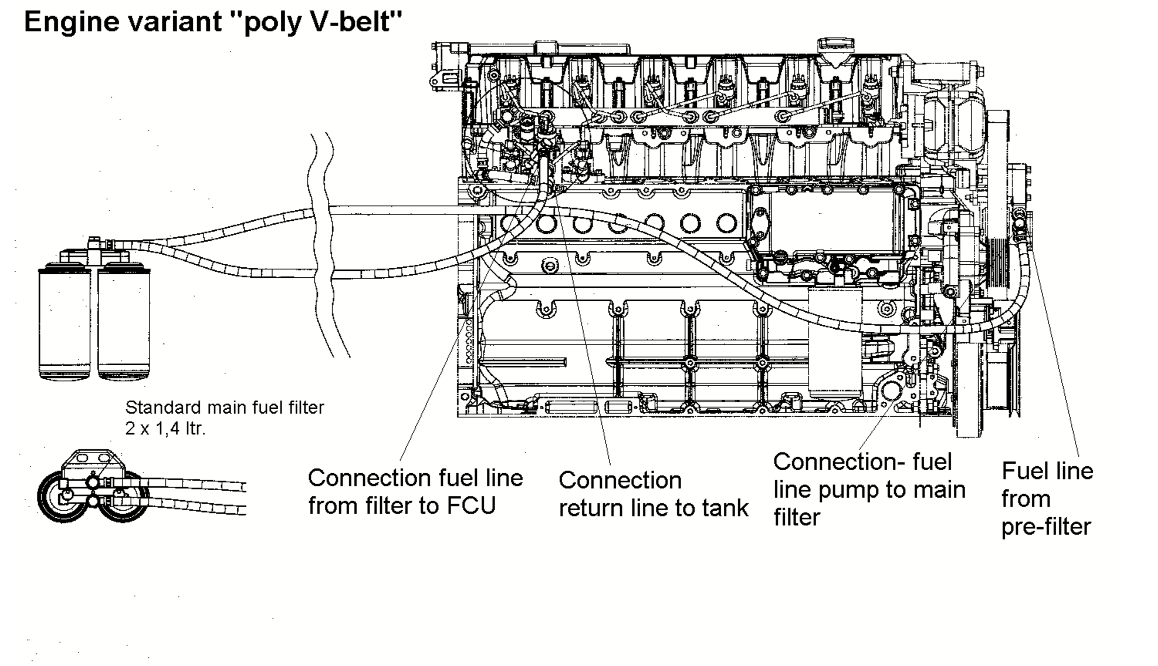


FIGURE 5-4 Double filter installed remotely from engine



As a standard the fuel double filter to be mounted remotely from the engine must be used. It is equipped with 2 x 1.4 ltr. exchange filters.

All main filters for TIER III engines require a filter fineness of 3 µm with a separating factor of 97%. The 3 µm filters used on TIER II engines only have a separating factor of 85% and are therefore unsuitable.
The fuel supply pipe is connected to the supply pump. Its mounting position varies depending on the type of belt drive or in the toothed wheel driven variant.
The appropriate DEUTZ engine drawings are decisive.
The cleanliness regulations for mounting and changing the filter must be observed, see chapter 6.2 of the operating manual, Care and Maintenance Work.

5.6.2 Pre-filtering:

The fuel filtering and water trapping on the suction side (= fuel pre-filtering) is absolutely essential to guarantee the durability of the injection system and prolong the service life of the main filter .
The common rail injection system must be equipped with a pre-filter with water trap and high filter fineness so only filters released by Deutz should be used.

Supplier of pre-filters with integrated water trap:

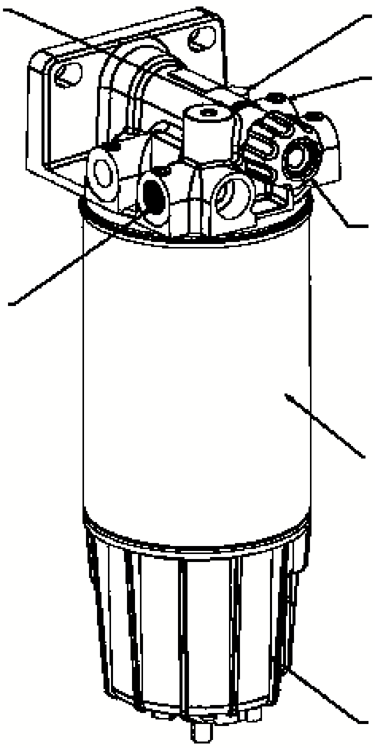
- Parker Hannifin, filter type RACOR * 41564 Kaarst Tel: (02131) 513357

The above mentioned filter exists in the DEUTZ scope of delivery and is prescribed bindingly for engine applications:
According to the DEUTZ scope of delivery the filter version has a water collecting vessel with an electric water level monitor to initiate timely disposal of water.
A water level monitoring must always take place. It is connected to the electronic engine control unit.
The filter manufacturer also offers the filter with a heating device for Winter operation.

Installation instructions:

- Always make sure this fuel pre-filter is installed where it can be easily maintained, i.e. easily visible and accessible for the operator as well as sufficient room for assembly work.
- Installation position of this fuel pre-filter always standing vertically, water drainage from bottom.
- The fuel pre-filter must always be installed in the pipe between the tank and the fuel supply pump, the hand supply pump is integrated in the pre-filter.
- When selecting and installing the fuel pre-filter, always make sure that the maximum permissible suction resistance for the engine's own supply pump is not exceeded.
- If the filter is located underneath the fuel tank, a shutoff valve must be installed in front of the filter inlet otherwise the fuel can flow out when the filter is opened (maintenance).
- There must be a free space of 50 mm under the RACOR filter to be able to remove the filter element (maintenance).
- The water level sensor passes on a signal to the engine control unit which is processed further there and an error message is sent to the operator. The plug of the cable harness must therefore always be connected to the sensor on the pre-filter for trouble-free operation. If a message is output, the collection tank must be emptied with the manual water drain valve to prevent damage to the injection system.
- The maintenance instructions of the manufacturer of the pre-filter with water trap manufacturer must be observed.

FIGURE 5-5 Fuel pre-filter for TIER III engines, TYP RACOR



5.6.3 Fuel filtering in extreme applications

In engine and equipment applications under very difficult conditions such as

- poor fuel quality, i.e. increased soiling of the fuel,
- large amount of dust in the atmosphere or when refuelling,
- high workload of the engines,

the filter change intervals must be reduced to a max. 500 operating hours (half the normal change interval).
The same applies when the mounted fuel main filter 1 x 1.4 ltr. or the engine variant with the bowl filter is used due to restricted installation space conditions.

The fuel pressure in the low pressure system is monitored continuously by a pressure sensor on the main filter and an error message sent to the operator by the control unit if necessary when the permissible pressure drop is exceeded.
This pressure monitoring is **not** a filter maintenance indicator, the filters must be changed according to the specified maintenance interval.

5.7 Representation of fuel connections with regard to air tightness

When screwing the pipes of the LP system, always make sure that the connections guarantee air tightness during the engine operation. FIGURE 5-6 gives constructional hints which must be observed when fastening.

FIGURE 5-6

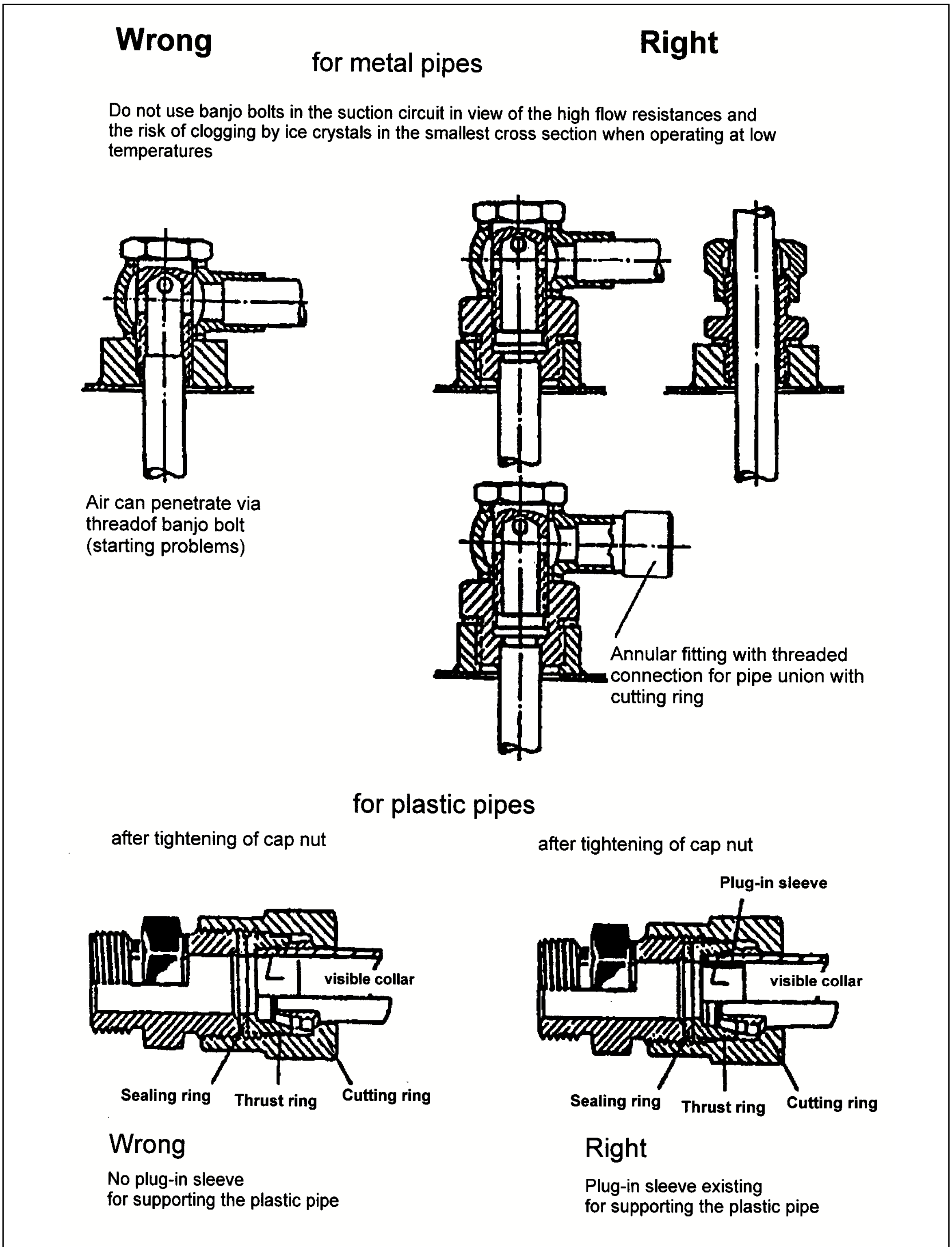


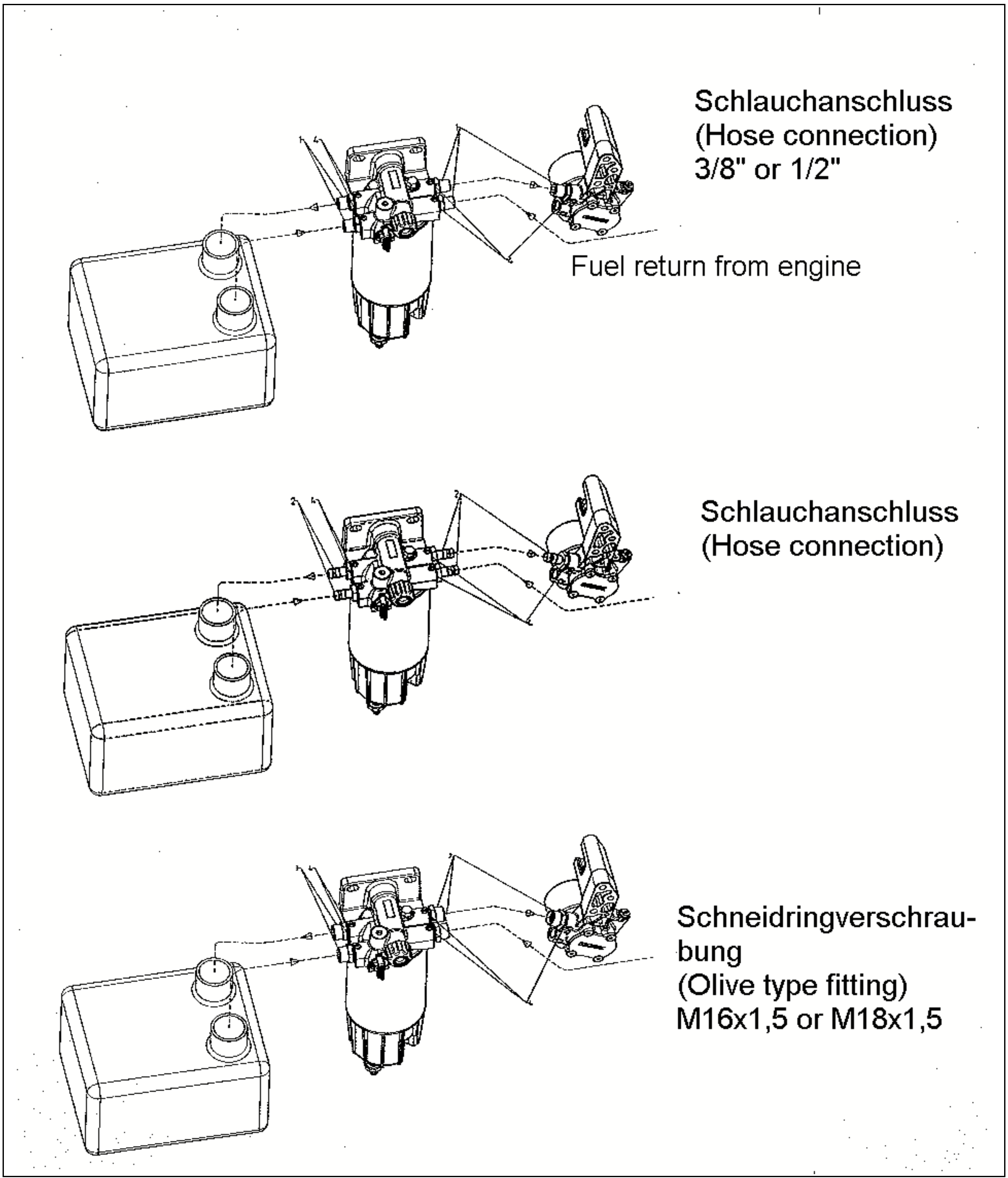
Figure: Representation of fuel connection with regard to air tightness

5.8 Connecting elements in the suction pipe

In fig. 5-7 examples of the connecting elements are shown which are necessary for setting up a low resistance suction pipe system – such elements belong to the DEUTZ scope of delivery for inside pipe diameter 12 mm and 14 mm and can therefore be used up to a pipe length of 6m or 15m as a rule. Consult DEUTZ Technical Support to find out about the individual availability.

The pre-filter variant with thermostat valve is shown. The standard pre-filter used has no thermostat valve, the return pipe from the engine is fed directly back to the tank. The corresponding connection points on the pre-filter are sealed.

FIGURE 5-7



5.9 Assembly instructions for working on the low pressure system

5.9.1 Customer installation of the removed fuel main filter (double filter 2 x 1.4 ltr.)

The aforementioned filter is enclosed loosely with the engine. At least the fuel pipe from the filter to the fuel control unit (FCU) is assembled. This hose pipe which is available in different lengths may no longer be opened when installing the filter in the device to avoid finest particles of dirt penetrating the high pressure fuel system.
The assembly work on the fuel system should only be carried out in a clean environment.

Information about the applicable requirements is available from the DEUTZ Technical Support.

5.9.2 Maintenance and repair work on the low pressure system

Maintenance and repair work on the low pressure system, including changing the fuel main filter, is only allowed under absolutely clean environmental conditions because the finest particles of dirt getting into the high pressure fuel system can damage it. Air pollution such as dust, dirt, moisture etc. must be avoided.
Before working on the fuel low pressure system (also filter change), the engine and engine compartment must be cleaned thoroughly and dried (steam jet). Engine compartment areas from which dirt may come loose should be covered with a new, clean foil.
When working outdoors, protective measures may have to be taken against dust being blown in by the wind.
More information can be requested from DEUTZ Technical Support / DEUTZ Service.

5.10 Engine operation at low temperatures

In addition, special measures for the fuel supply are necessary in engines working in extremely cold regions which have to be taken into account partly in the construction of the device .
This especially concerns:

- the dimensioning and laying of the pipes
- the design of the pipe connections and bends.
- The filter system and its arrangement
- The fuel tank arrangement and heating if necessary

A heater is required to avoid blockage of the filter by flocking of the fuel, especially on dropping below the minimum application temperature according to specification of the used fuel quality. A pre-filter with an additional heating cartridge must be used for this. Similar solutions are possible for the fuel main filter in cartridge version or bowl filter whereby the fuel should preferably already be heated in the pre-filter.
The heating cartridge cannot be screwed in later but the complete filter head must be changed. This is not offered by DEUTZ and can be ordered from the following address if required :

See next page:

Parker Hannifin
- Filterdivision –
Pat-Parker-Platz 1
D 41564 Kaarst

Phone: +49 2131 4016 9 271
Fax: +49 2131 4016 9 149

This filter is available at the moment under the following part number: MD 5790R-DTZ-02.

Heating power: 300W in 28V systems, 225W in 14V systems.

Changes are not tracked by DEUTZ. Agreement with Parker Hannifin may be necessary. DEUTZ Technical Support offers help with application questions.

6. LUBE OIL SYSTEM

DEUTZ engines are laid out for forced-feed oil lubrication. Oil pressure and oil volume flow rate ensure lubrication of the engine and also, to a considerable extent, cooling of the engine.

Any modifications to the lube oil and cooling oil system require the previous approval of the head office. In this connection, the following reference values must be observed.

6.1 External lube oil systems in the main flow

Where engine-integrated elements such as lube oil filters in the main flow are mounted remote to the engine, for servicing or installation reasons, the resistance from pipes, filter brackets and filters must not restrict the engine lubrication.

The permissible resistance values of the components used are determined on the basis of oil volume flow rate and selected pipe diameter. If the permissible system resistance is exceeded, the calculation should be carried out once again using a larger pipe diameter.

6.1.1 Lube oil flow rate

With the engine warmed up to service temperature, the oil volume flow rate "Q_G" is at rated speed:

$$Q_G = \varphi_P \times \varphi_B \times \frac{n_n}{1000} \; [ltr / min]$$

with n_n = rated engine speed (min^{-1})
φ_P = pump factor (depending on pump size)
φ_B = operating factor (depending on application)

The factors φ_P and φ_B are dependent on the engine and given in Table 1.

Table 1: Factors for oil volume flow rate

Engine type	φ_B	φ_P
DC 2012 L04 2V	0,9	29
TDC 2012 L04 2V	0,9	29
TDC 2012 L06 2V	0,9	40
TDC 2012 L04 4V Agripower	0,9	29
TDC 2012 L06 4V Agripower	0,9	40
DC 2013 L04 2V	0,9	29
TDC 2013 L04 2V	0,9	29
TDC 2013 L06 2V	0,9	40

TDC 2013 L06 4V	Industrial engine	0,9	29
TDC 2013 L06 4V	Agripower	0,9	40
TDC 2013 L04 4V TDC 2013 L06 4V	Automotive engine Automotive engine	0,9 0,9	

6.1.2 Layout of the pipe diameter

When considering the reference value of approx. 5 (m/s) for the maximum volume flow rate in the system elements (piping, banjo bolts etc.), the theoretical design diameter will be:

$$D_A = 2 \times \sqrt{Q_G} \text{ [mm]}$$

If possible, the actually existing diameters „D_R" or „D_D" or „D_N" of the system elements (see Table 2) should be equal or larger than „D_A".

6.1.3 Determining the system resistance

Resistance $\Delta p_{element}$ to be determined according to Table 2 for each individual element of the external lube oil filter system.

The system resistance must not exceed the permissible total resistance Δp_{total} (sum of the individual resistances) of

$$\Delta p_{gesamt} \leq 1,0 \text{ [bar] for all engines}$$

Considering the overall resistance, we generally recommend for all engines that the limit value $\Delta p_{total.} \leq 0.5$ bar should be observed.

We recommend using renewable filters of the types designated for the individual engine model. If other filter types are used, the flow resistance must not exceed that of the original filter.

Table 2: Element - resistances

Element	**Resistance Δe_{lement} [bar]**
Lines (piping or hose)	$\Delta p_R = \frac{L_R}{300 \times D_R} \times \left(\frac{D_A}{D_R}\right)^4$
Lines (corrugated hose pipe with internal wire reinforcement)	$\Delta p_R = \frac{L_R}{180 \times D_R} \times \left(\frac{D_A}{D_R}\right)^4$
Lines (corrugated hose pipe without internal wire reinforcement)	$\Delta p_R = \frac{L_R}{100 \times D_R} \times \left(\frac{D_A}{D_R}\right)^4$
Pipe bend 90° ; $r > D_R$	$\Delta p_B = 0{,}01 \times \left(\frac{D_A}{D_R}\right)^4$
Pipe elbow 90° ; $r \approx D_R$	$\Delta p_K = 0{,}03 \times \left(\frac{D_A}{D_R}\right)^4$
Local restriction	$\Delta p_D = 0{,}07 \times \left(\frac{D_A}{D_D}\right)^4$
Pipe angle	$\Delta p_W = 0{,}12 \times \left(\frac{D_A}{D_N}\right)^4$
Banjo bolt	$\Delta p_H = 0{,}16 \times \left(\frac{D_A}{D_N}\right)^4$
Lube oil filter bracket, other device or element	$\Delta p_G = \Delta p_N \times \left(\frac{Q_G}{Q_N}\right)^2$

With:

D_A = Theoretical design diameter [mm]
D_D = Restrictor diameter (local restriction) [mm]
D_N = Nominal diameter (e.g. pipe angle, banjo bolt) [mm]
D_R = Internal width of the selected line [mm]
L_R = Pipe length (hose length) [mm]
Q_G = Oil volume flow rate through system [ltr/min]
Q_N = Nominal volume flow rate through element (e.g. filter bracket, change-over lever, etc.) [ltr/min]
r = Radius (mean value) of the bend or elbow [mm]
Δp_N = Nominal resistance of element at QN [bar]

Note to Q_N:
If for the external lube oil filter system the same design is used as for the engine main filter, the filter element resistance may be neglected when determining the external system resistance. For determining the filter element resistance, please consult the technical support DEUTZ.

Example: **System resistance of external filter assembly**

Engine	TCD 2012 L04 2V bei n_n = 2300 min^{-1}
Equipment	Lube oil filter bracket: Q_N = 33.3 ltr/min Distance: LR = 700 mm ;Δp_N = 0.09 bar
Oil volume flow rate	$Q_G = 0{,}9 \times 22 \times \frac{2300}{1000} = 45{,}5$ ltr/min ?
Design diameter	$D_A = 2 \times \sqrt{45{,}5} = 13{,}5$ mm
Selected	D_R = 14 mm diameter for the system
2 pipes	$\Delta p_R = 2 \times \frac{700}{300 \times 14} \times \left(\frac{13{,}5}{14}\right)^4$ = 0,29 bar
2 bends	$\Delta p_K = 2 \times 0{,}03 \times \left(\frac{13{,}5}{14}\right)^4$ = 0,05 bar
4 banjo bolts	$\Delta p_H = 4 \times 0{,}16 \times \left(\frac{13{,}5}{14}\right)^4$ = 0,55 bar
Filter bracket	$\Delta p_G = 0{,}09 \times \left(\frac{45{,}5}{33{,}3}\right)^2$???? = 0,17 bar
Sum	Δp_{total} = 1,06 bar

As can be seen in the theoretical example, the use of banjo bolts produces high pressure losses. We therefore recommend not to use banjo bolts and to use a clamping ring or Ermeto-type pipe unions instead. This will reduce the loss of flow rate in our example by 0.5 bar.

6.1.4 Installation instructions

All pipes of the external lubrication system must be laid out for a minimum pressure of 45 bar (burst pressure). The pipes are to be carefully cleaned prior to installation.

The rubber tubes installed must be resistant to a permanent temperature ranging from -40 °C to +125 °C (temporarily up to +140 °C).

6.2 Lube oil micro-filter in bypass flow

If lube oil micro-filters in bypass flow are relocated remote from the engine, the lube oil lines are to be designed with an actual diameter that amounts to at least 2/3 of the design diameter D_A as per section 6.1.2.

It is absolutely necessary to consult the head office, if a micro-filter must be subsequently fitted to the engine. As the lubrication system is precisely matched in respect of oil volume flow rates and pressures, retrofitting of a bypass micro-filter may affect the piston spray cooling. The engine warranty can only be maintained, if such retrofitting are carried out in consultation with the technical support DEUTZ.

6.3 External oil tank

Engines with extremely flat oil pans (so-called dry sump oil pans) will be equipped with separate oil tanks to accommodate the necessary oil volume. These oil tanks are mounted in the engine compartment remote from the engine and are connected via flexible hoses. The actual engine lube oil pump draws in the oil from the oil tank through a pipe (suction oil pipe), while a second oil pump delivers the oil accumulated from the engine through a pressure oil pipe back to the tank.

Engine crankcase and oil tank interior are connected with each other via another pipe for gas balancing (breathing).

You should consult application engineering for pipe dimensioning and installation of such a system

6.4 Changing the oil dipstick marks for inclined engine installations

The oil level must always be checked with the engine in horizontal position. Permissible deviation is 2°.

If an engine is installed with a permanent inclination for stationary application, the oil dipstick must be matched to the relevant angle of inclination, i.e. maximum and minimum marks must be changed.

When determining the new marks, it is best to proceed as follows: Place the engine in a horizontal position prior to the inclined installation, top up with oil up to "minimum" mark and note the quantity filled in. Now top up to "maximum" mark and record the difference in quantity.

Close the old mark at the oil dipstick by soldering.

Now, install engine in inclined position with the oil level at "maximum", introduce dry oil dipstick and mark wetting level with a new groove.
Drain off differential oil volume, i.e. the minimum volume measured in the engine must be available. Insert dry dipstick and mark wetting level with a new groove.

For engine commissioning, proceed as specified in the operation manuals.

7. ENGINE MOUNTING

7.1 General

Basically, a properly designed flexible mounting is preferable to other mounting configurations.

A flexible mounting is optimally designed, if the natural frequency of the vibrating system comprising the engine mass and the elasticity of the mounting is at least 40% lower than the lowest exciting frequency of the engine.

A low natural frequency calls for soft flexible elements. These have the disadvantage of allowing considerable deflections under the action of external forces that may arise with inclined installations or under shock loads.

On 4-cylinder engines, the configuration of a completely stiff connection between engine and foundation is practically impossible when taking into account the exciting inertia forces of 2nd order. Therefore, it is recommended to generally use a flexible mounting.

7.2 Flexible mounting

A pre-condition for the proper execution of flexible mountings are foundations whose stiffness must be clearly higher than that of the flexible elements. Otherwise, the foundation acts as an additional spring.

The elements must be arranged such that hey can deflect under the influence of forces acting during operation (ensure a sufficiently free movement between engine and chassis, i.e. abt. 15…25mm).

Flexible mounting systems matched to our engines are part of the scope of supply of the individual engines. They are space-saving and can absorb thrust within certain limits, which is very useful for marine installations to absorb the propeller thrust.

Therefore, we recommend making use of the flexible mountings offered in the respective scope of supply.

To balance vibration deflections occurring in the case of flexibly mounted engines, all pipes leading to the engine must be of flexible design, which also applies to air intake and discharge ducts.

Rigid connections to the foundation or the side panels will deteriorate the flexible mounting by increasing the natural frequency and may cause damage due to insufficient resilience.

When flexible elements are properly dimensioned, coupling, torque converter, transmission etc. can be flanged to the engine.

These attachments can be mounted to the engine in an overhung position, if the following limits for the reversed bending moment between engine crankcase and flywheel housing (SAE housing) are not exceeded:

FIGURE 7-1

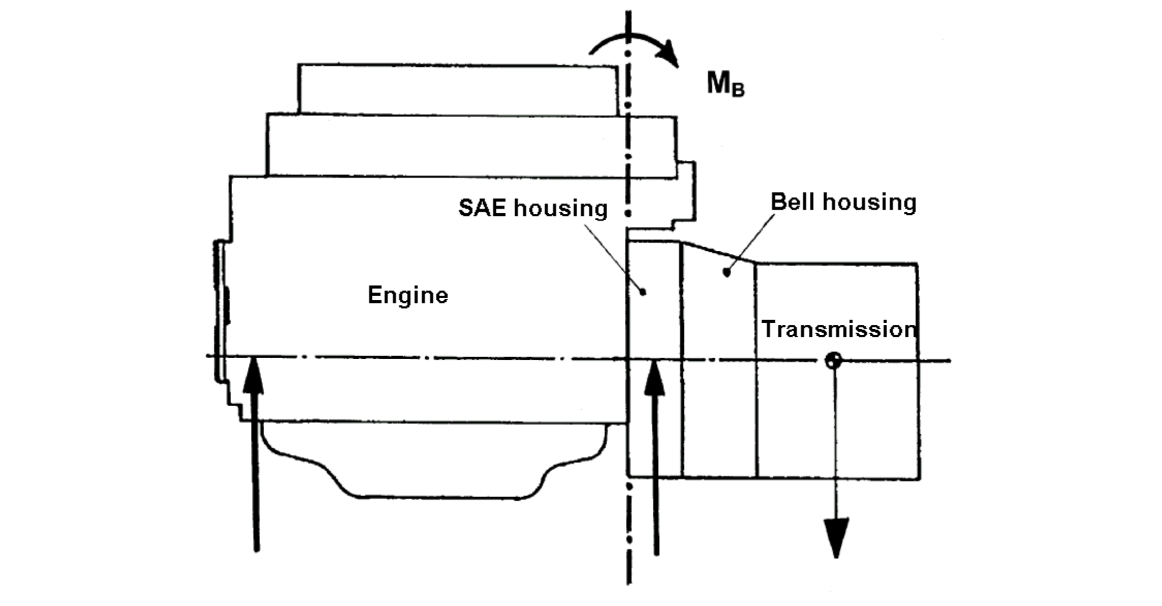


Table 1

Engine series	max. admissible reversed bending moment M_B(Nm)
TD 2012 L04 2V TDC 2012 L04 2V TDC 2012 L06 2V TDC 2012 L04 4V, Agripower TDC 2012 L06 4V, Agripower TD 2013 L04 2V TDC 2013 L04 2V TDC 2013 L06 2V TDC 2013 L06 4V, Industrial engine TDC 2013 L06 4V, Agripower TDC 2013 L04 4V, Automotive engine TDC 2013 L06 4V, Automotive engine	$\leq \pm$**5000**

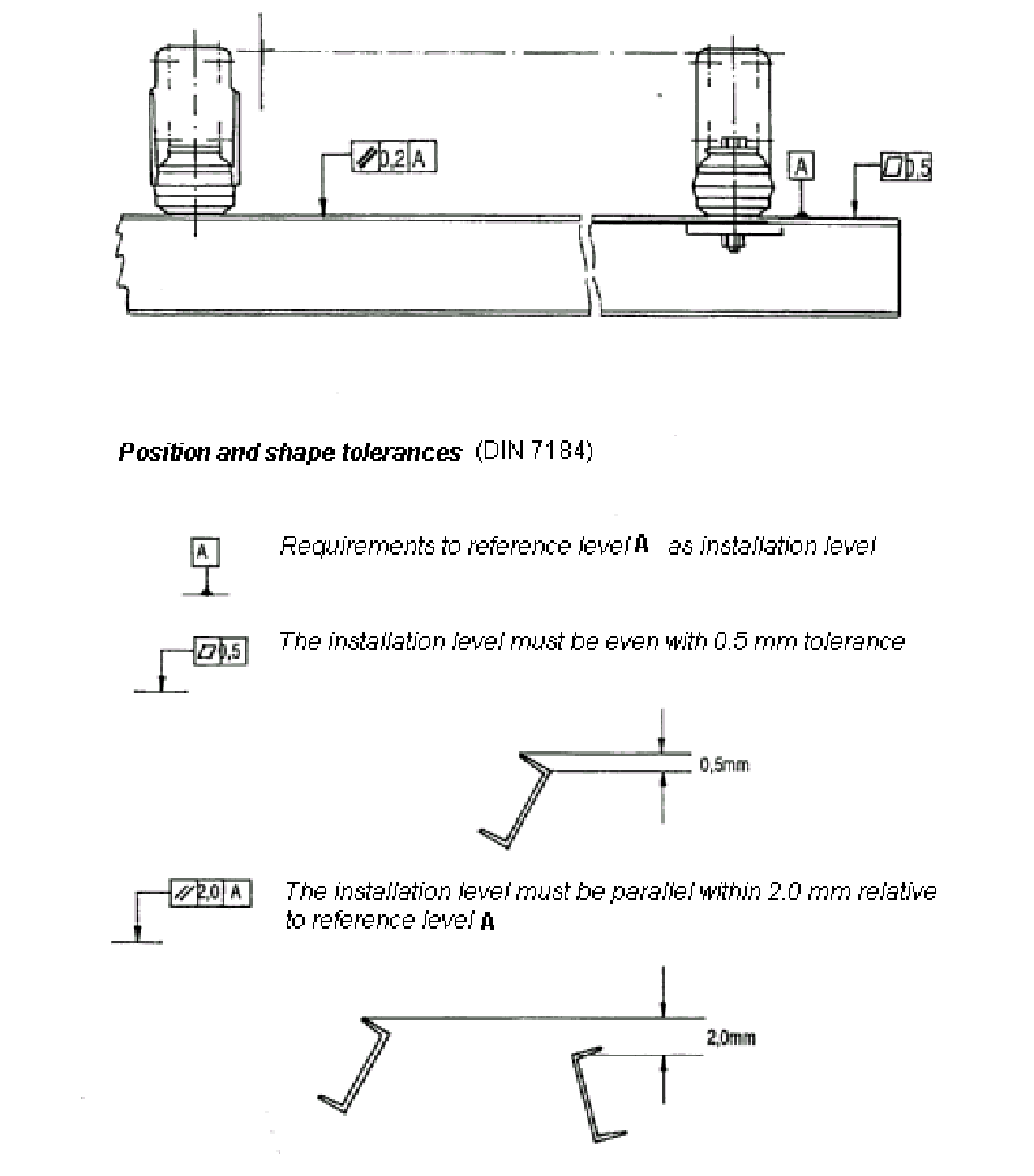
When installing the engine or the engine/transmission driveline with the fitted mounting elements, it must be ensured that the base is plane parallel and even and the connecting surface is not painted.

The bore pattern must be within the specified tolerances of longitudinally ± 2 mm and transversely ± 1 mm. Through holes must be larger by 4 mm than the bolt diameter.

The required washers must be made of grade St 60, at least 6 mm thick and with ∅26 mm at M12, ∅40 mm at M16.

Unequal stress loads or distortions of the mounting elements will be avoided in this way, as distorted rubber elements will affect the noise damping and vibration absorbing properties.

FIGURE 7-2

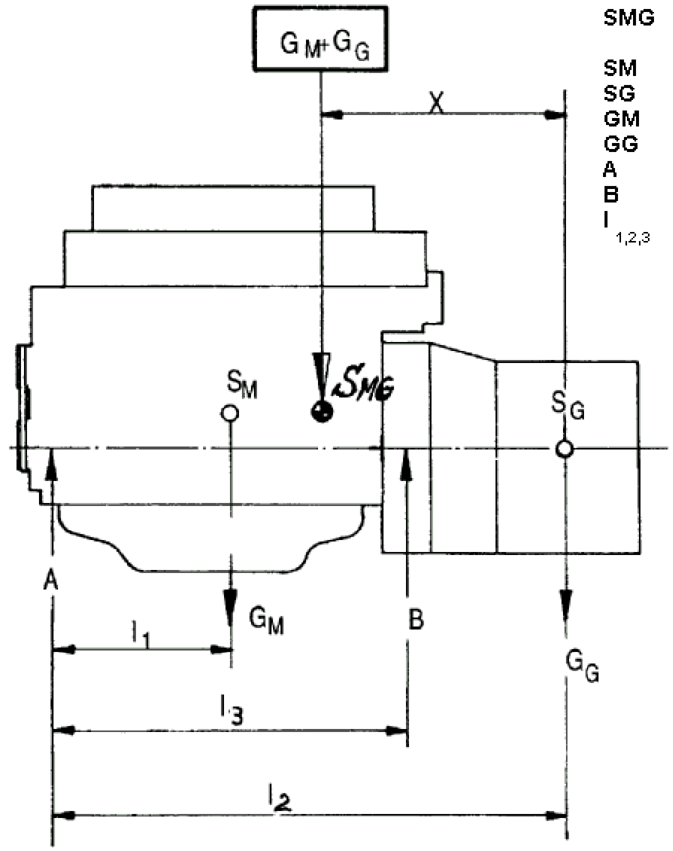


Uniform loading of mounting elements.

When arranging the mounting elements, ensure uniform loading. This can be achieved by balanced distribution of forces acting on the mounting elements, by changing the distances between the mounts or by changing the number of mounts. The variation in the number of mounts is in most cases the more appropriate approach.

When centers of gravity of engine and transmission and their weights proper are known, the forces acting on the mounts can be determined as follows:

FIGURE 7-3



SMG	Center of gravity engine + transmission
SM	Center of gravity engine
SG	Center of gravity transmission
GM	Weight engine [N]
GG	Weight transmission [N]
A	Mount load at A [N]
B	Mount load at B [N]
$l_{1,2,3}$	Distances [m]

The following mount load results:

$$A = \frac{G_M \times (l_3 - l_1) - G_G \times (l_2 - l_3)}{l_3} \; [N]$$

$$B = \frac{G_M \times l_1 + G_G \times l_2}{l_3} \; [N]$$

The position of the overall center of gravity S_{MG} (engine and transmission weight) relative to the transmission center of gravity can be determined with the following equation:

$$x = \frac{l_2 - l_1}{1 + \frac{G_G}{G_M}} \; [m]$$

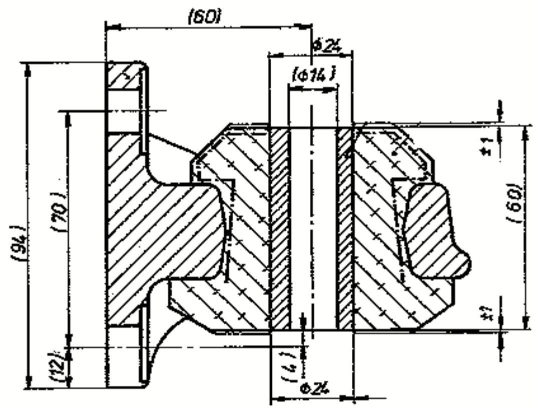
Elastic mounting versions:

The DEUTZ scope of delivery offers a “hard” and “soft” version of the engine mounting for the different engine variants which are distinguished by low assembly effort and space requirements. The material is identical, the hardness is determined by the form. Flywheel-side double bearings can be arranged especially depending on the load.
The soft mounting should be chosen as standard for reasons of comfort, a “mix” is also permissible.

Other mounting types must be designed and provided by the customer. The well-known mounting manufacturers can advise you in this matter.

FIGURE 7-4

"Strong" type, 56°Sh



"Soft" type, 55°Sh

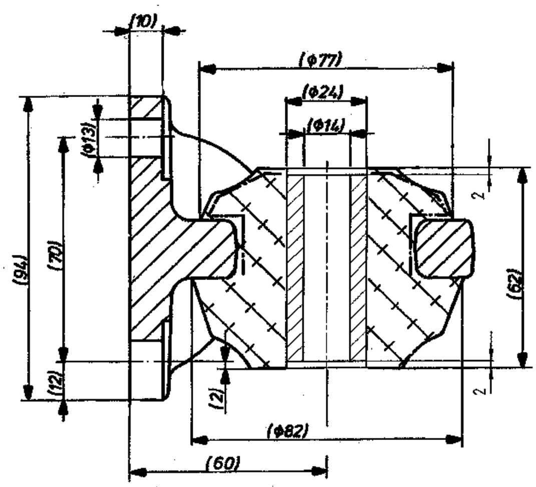


Table 2: Admissible mount loads

Fig.	Design	Material	Engine type	Load per mounting bracket [N]	Max. admissible temperature [°C]
1	Strong cast mounting	Natural rubber 56°+/-3° Shore	TD/TCD 2012 / 2013	2200	-40 / +120
2	Soft cast mounting	Natural rubber 55°+/-3° Shore	TD7TCD 2012 / 2013	2200	-40 / +120

Notes to Table 2:

To maintain proper functioning of the mounts, even when higher transverse forces are acting, stops should be provided in horizontal direction (5 mm max. deflection from neutral).

Further technical details on flexible mounting elements are given in the detail drawings and can be obtained from the acquisition staff or the head office.

7.3 Rigid mounting

The foundation for the rigid mounting system shall be stiff and heavy enough to prevent resonance-type vibrations from acting on the engine/foundation system. This means that the mount is to be designed as a sub-critical system so that the maximum exciting frequency occurring will be sufficiently away from the natural frequency.

Where chassis frames are not absolutely resistant to bending and torsional stresses, four-point mount are particularly critical and may lead to engine damage.

It is therefore necessary to ensure a precise plane-parallel alignment of the rigid mounting points on the foundation or on the frame structure.

The most appropriate way would be to place the engine with the rigid mounting system on the frame and to measure the gap below the mounting brackets at several points using a feeler gauge.

Within the free bore gap, the suspension angles can be aligned by steps after having loosened the fastening bolts of a suspension angle.

Attention: Use the specified torque when tightening the bolts.

Should this not result in proper, full-contact seating, insert spacer plates.

In the case of a rigid mounting, the drive configuration can be freely chosen, as it is not subject to any restrictions as a consequence of the mounting system, e.g. setting of the rubber pads.

7.4 Bending moment on the SAE housing

Which bending torque may be exerted into the SAE housing through the engine mounting is not specified.
If the customer provides the engine mounting, the distance from its centre to the SAE housing or engine block may not exceed the distances of the corresponding DEUTZ engine series, i.e. DEUTZ track width must also be observed by engine mountings provided by the customer.

If this is not possible in individual cases please consult head office.
Release of an engine mounting arrangement with a greater track width generally requires longer field trials.

8. POWER TRANSMISSION

- Torque-transmitting components must be centred as per DIN ISO 7648 – also see SAE J 617A and SAE J 1033.
- The dynamical (subject to time-dependant changes) loads of torque-transmitting components in shaft systems of machine units must be determined via a torsional vibration calculation and compared with the admissible values. Here, not only the influence of the dynamical forces developed by the diesel engine, but also the influence of the dynamical forces developed by the working machine must be considered.
  If necessary, the manufacturer of the working machine must make available the data required for the calculation. For details, see VDI-regulation 3840.
  The engine-related data for a torsional vibration calculation can be made available by DEUTZ – please contact the purchase department or the technical support of the head office.

8.1 Clutches / couplings

The design of the clutch/coupling for transmitting the engine power to a drive element, e.g. generator or transmission, is mostly dependent on the drive element involved. Among others, it depends on the following:

- the arrangement (flanged or detached),
- the design of the drive element, e.g. single-bearing or two-bearing generator,
- the mounting of the engine and the drive element on the base,
- the design of the base,
- the requirements regarding torsional vibrations.

If a major centre offset must be overcome, a cardan shaft has to be installed in addition to a flexible coupling.

As a suitable clutch/coupling has to be provided for each particular case of application, this issue cannot be dealt with here because of the great variety involved. We recommend that you select the clutch or coupling for your particular application from the clutch/coupling suggestions included in our scope of supply We prepared installation drawings for these clutches/couplings in which we also entered the data being of importance for you.

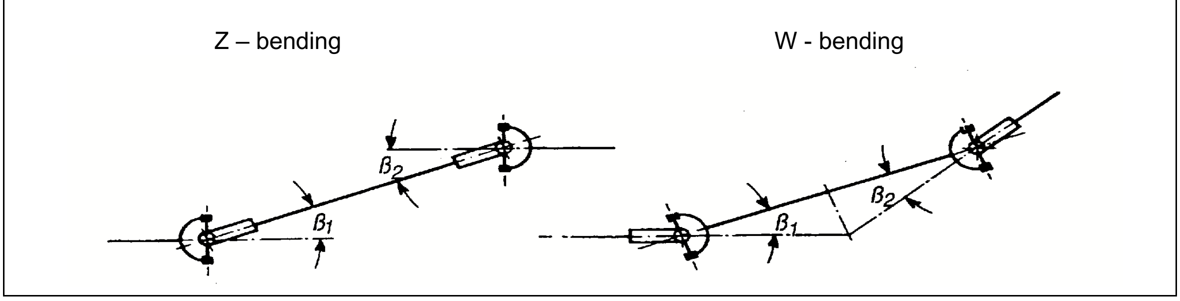
Torsional vibration analyses have already been made for the flexible couplings. If the data indicated in the drawings are not complied with, a specific torsional vibration analysis will be required, which we will carry out upon request and against reimbursement of the costs involved.

8.2 Installation of cardan shafts

The following pre-conditions must be met to avoid the transmission of different angular velocities:

- the two yokes of the cardan shaft must be located in the same plane,
- the bending angles β_1 and β_2 must also be in one plane and of equal size.

FIGURE 8-1



Due to the torque and bending angle of the joints, a bending moment depending on their size is transmitted to the engine and to the drive element.

The size of the bending moment is dependent on the torque induced and the bending angle of the joints. The bending moment deviates twice per revolution between zero and the maximum value.

$M_{Bmax} = T_d \sin ß$ [Nm] T_d = induced torque [Nm]
ß = bending angle of the joint [°]

On the input and output side of the cardan shaft, radially rotating forces are generated by this bending moment. Vibrations are resulting which have the size of twice the engine speed and can lead to resonance phenomena depending on the mounting of the engine or the drive element.

With rigid mounting, the foundation should be as sturdy as possible and the bending angle kept as small as possible. To avoid damage to the needle bearings of the cardan joint, this angle should at least be 1°.

8.3 Power take-offs

8.3.1 Auxiliary power take-offs at the engine

For the DEUTZ diesel engines TD/TCD2012 and TD/TCD2013, beyond the normal power take-offs such as

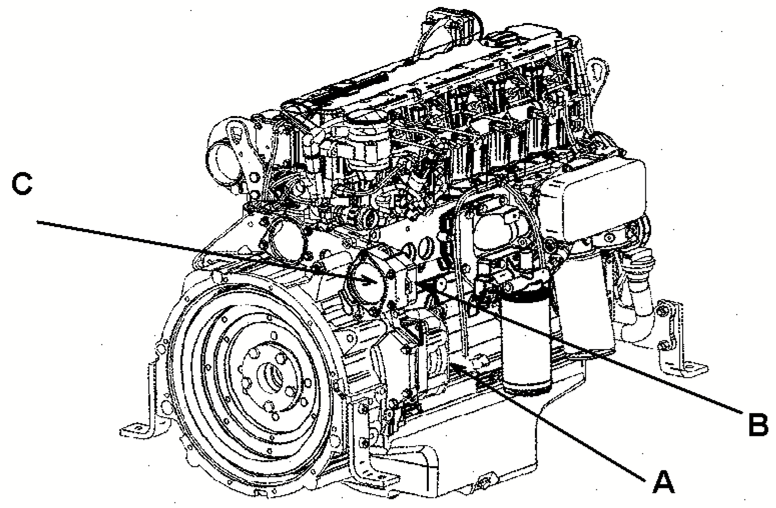
axial and radial power take-offs at the flywheel
axial and radial power take-offs at the front crankshaft end,

the following auxiliary power take-off points for hydraulic pumps and compressors are existing:

Auxiliary power take-off A,	at bottom close to SAE-housing
Auxiliary power take-off B,	at top close to engine side
Auxiliary power take-off C,	at top close to SAE-housing with connection from rear engine side.

The admissible power take-offs at the auxiliary drives A, B and C are explained in the following pictures:

FIGURE 8-2



TC/TCD 2012

Nebenabtriebe **Accessory drives**			**A**	**B**	**C**
Übersetzung I = Kurbelwelle : Nebenabtrieb	ratio I = crankshaft : acc. drive		**1 : 1,023**	**1 : 1,189**	**1 : 1,189**
Drehrichtung	mode of rotation		links/left	links/left	rechts/right
max. Leistungsabnahme	max. output	kW	48	19	19
		Mdmax/Nm	**187**	**64,5**	**64,5**
max. Leistungsabnahme **B + C**	max. output **B + C**	kW		19	
		Mdmax/Nm		**64,5**	
max übertragbare Leistung **A** ohne B + C	max. output **A** without B + C				
Boschflansch und Zahnwelle	Bosch flange and serrated shaft	kW	29		
DIN 5482 - B 17 x 14	DIN 5482 - B 17 x 14				
SAE A - 9 T 16/32 DP	SAE A - 9 T 16/32 DP				
SAE B - 13 T 16/32 DP	SAE B - 13 T 16/32 DP	kW	48		
Boschflansch und Konus	Bosch flange and cone	kW	19		

Hinweise:

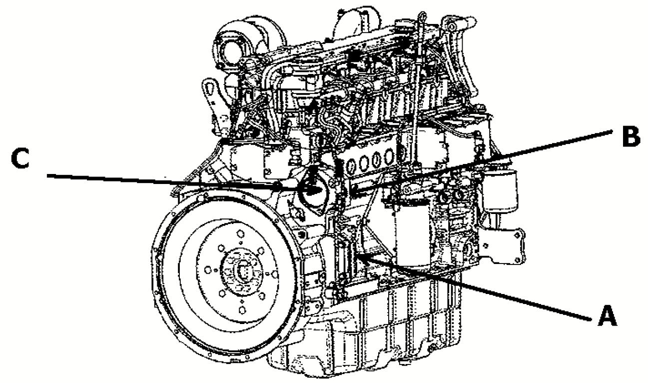
1. Maximale Abnahmeleistung gilt immer nur für den einzelnen Abtrieb. Sind die anderen Abtriebe im Eingriff, dann gilt:
   A + B + C = 48 kW max.; Mdmax = 187 Nm
2. Drehrichtung ist definiert mit Blick auf das freie Wellenende der Pumpe
3. Die angegebenen Leistungen gelten für:
   n = 2400/min für TC/TCD 2012
4. Übersetzung i = KW : Nebenabtrieb
5. Für n < 2400/min ist die Leistung linear im Verhältnis der Drehzahlen zu reduzieren.

Notes:

1. Maximale output valid only for single drive. In case of other drives engaged, it applies as follows:
   A + B + C = 48 kW max.; Mdmax = 187 Nm
2. Mode of rotation ist defined as and when facing the free shaft end of the pump.
3. The output indicated are valid for:
   n = 2400rpm for TC/TCD 2012
4. Ratio i = crankshaft : accessory drive
5. For n < 2400rpm the power should be reduced linearly relative to the speed

All auxiliary drives are geared up

FIGURE 8-3



TD/TCD 2013

Nebenabtriebe **Accessory drives**			**A**	**B**	**C**
Übersetzung i = Kurbelwelle : Nebenabtrieb	ratio i = crankshaft : acc. drive		**1 : 1,116**	**1 : 1,297**	**1 : 1,297**
Drehrichtung	mode of rotation		links/left	links/left	rechts/right
max. Leistungsabnahme	max. output	kW	**50**	**20**	**20**
		Mdmax/Nm	**187**	**64,5**	**64,5**
max. Leistungsabnahme **B + C**	max. output **B + C**	kW		**20**	
		Mdmax/Nm		**64,5**	
max übertragbare Leistung **A** ohne B + C	max. output **A** without B + C				
Boschflansch und Zahnwelle DIN 5482 - B 17 x 14	Bosch flange and serrated shaft DIN 5482 - B 17 x 14	kW	**30**		
SAE A - 9 T 16/32 DP	SAE A - 9 T 16/32 DP				
SAE B - 13 T 16/32 DP	SAE B - 13 T 16/32 DP	kW	**50**		
Boschflansch und Konus	Bosch flange and cone	kW	**20**		

Hinweise:
1. Maximale Abnahmeleistung gilt immer nur für den einzelnen Abtrieb. Sind die anderen Abtriebe im Eingriff, dann gilt: **A + B + C = 50 kW max.; Mdmax = 187 Nm**
2. Drehrichtung ist definiert mit Blick auf das freie Wellenende der Pumpe
3. Die angegebenen Leistungen gelten für: n = 2 300/min. bei TD/TCD 2013
4. Übersetzung i = KW : Nebenabtrieb
5. Für n < 2300 min^{-1} ist die Leistung linear im Verhältnis der Drehzahlen zu reduzieren.

Notes:
1. Maximale output valid only for single drive. In case of other drives engaged, it applies as follows: **A + B + C = 50 kW max.; Mdmax = 187 Nm**
2. Mode of rotation ist defined as and when facing the free shaft end of the pump.
3. The output indicated are valid for: n = 2 300/min. for TD/TCD 2013
4. Ratio i = crankshaft : accessory drive
5. For n < 2300 min^{-1} the power should be reduced linearly relative to the speed

All auxiliary drives are geared up

Number of teeth for auxiliary drive C of TC/TCD 2013:
Crankshaft = 48
Auxiliary drive C = 37

The connection flanges of the auxiliary drives correspond to the following versions:

Auxiliary drive A:

a) 2-hole flange SAE-A / shaft 9T-16132 DP (for 30 kW)
b) 2-hole flange SAE-B / shaft 13T 16/32 DP as per SAE J 733c (for 50 kW)
c) Bosch through-bolt version DEUTZ, pilot dia. 50∅,
toothed shaft profile as per DIN 5482 B 17x4 (for 30 kW)

All items a, b, c with pre-bearing

d) Bosch through-bolt version DEUTZ, pilot dia. 50∅, cone 1:5 with adapter (max. 20 kW)

Air compressors are normally connected to auxiliary PTO A, e.g. 225 m^3 compressor, also with straight drive shaft for steering booster pump.

Auxiliary power take-off B:

Bosch through-bolt version DEUTZ, pilot dia. 50∅, cone 1:5

Auxiliary power take-off C:

Bosch through-bolt version DEUTZ, pilot dia. 50∅, cone 1:5

8.3.2 Axial power take-off at crankshaft

8.3.2.1 Axial power take-off, flywheel side

At the flywheel end of the crankshaft, a maximum of 100% of the maximally possible engine power or the maximally possible torque are permitted to be taken.

The necessity of the installation of flexible couplings between the flywheel and the following power take-off unit must be decided from case to case. The design of the flexible coupling must be checked with the aid of a torsional vibration analysis. The respective technical data are made available by DEUTZ. Please contact the purchase department or the technical support of the DEUTZ head office.

The following table from the electronic pocket book ELTAB indicates the permissible attachable masses and mass moments

FIGURE 8 - 4

Technische Daten
Technical data
EPA / COM III

TCD 2012

Seite/Page
2.620

Axiale Kraftabnahme , Schwungradseite
Axial power take-off , flywheelside

TCD 2012 L04/06 2V	
m_{zul}	< 95 kg 1)
m*l	< 14 kg*m 1)

1) Diese Werte gelten für eine Sicherheit gegenüber Biegebruch von 2,5
These data apply for factor of safety against bending rupture of 2.5

Schwungradanbau: Schwungrad plus starr angekoppelte Massen
m_{zul} : Masse Schwungradanbau
m*l: Massenmoment Schwungradanbau bezogen auf Mitte Hauptlager 1 (Masse * Schwerpunktsabstand)

Hinweis
Aufbringung eines Biegewechselmomentes (radiale Kraftabnahme), z.B. durch Keilriemen ist nicht zulässig.

Flywheel installation : Flywheel plus rigid coupled dimensions
mzul : Dimension flywheel installation
m*l: Dimension torque flywheel installation based on centre of main bearing 1 (dimension * distance from centre of gravity)

Note
Application of alternating torque (radial power take-off) e.g. via a v-belt , is not permissible.

$l = l_1 + 0,0275m$

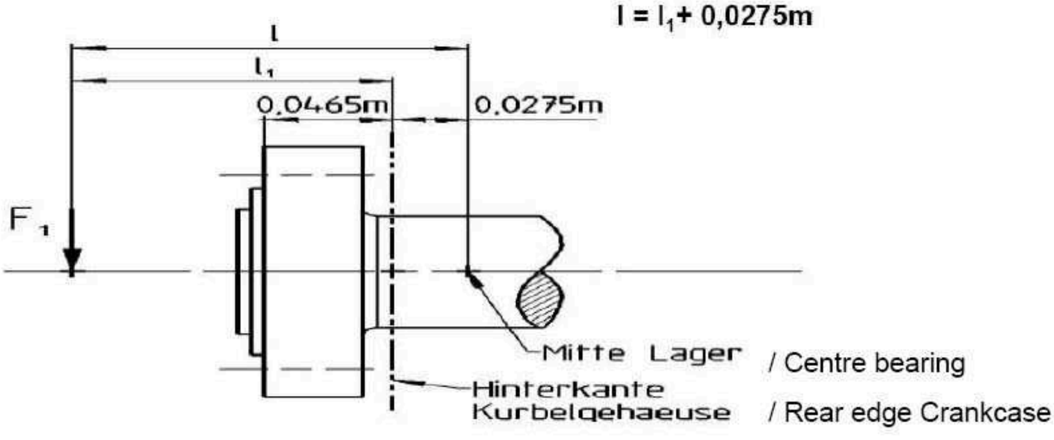


FIGURE 8-5

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Axiale Kraftabnahme , Schwungradseite

Axial power take off , flywheelside

TCD 2013 L06 2V	
m_{zul}	< 95 kg
m*l	< 20 kg*m

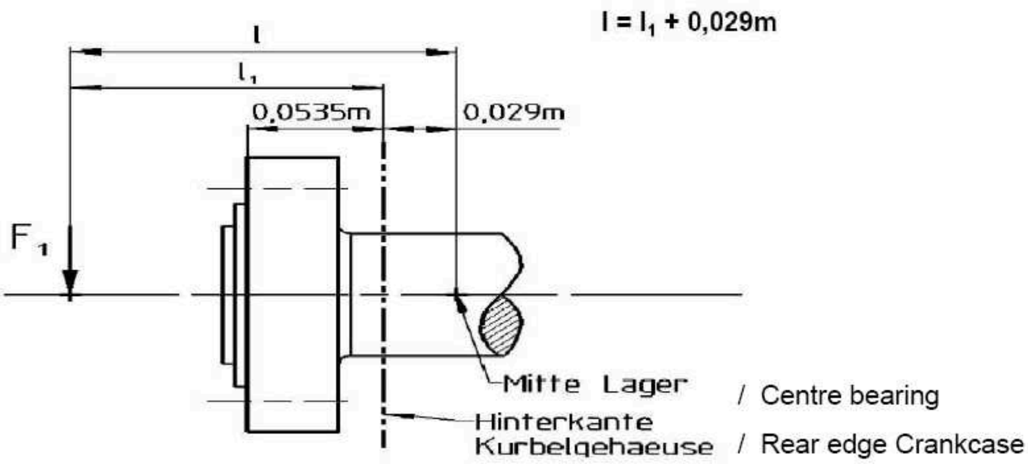
Diese Werte gelten bei Zünddruck Pz < 160 bar bis Motordrehzahl 2300 min-1
These data apply for ignition pressure Pz < 160 bar till engine speed 2300 rpm

Schwungradanbau: Schwungrad plus starr angekoppelte Massen
m_{zul} : Masse Schwungradanbau
m*l: Massenmoment Schwungradanbau bezogen auf Mitte Hauptlager 1 (Masse * Schwerpunktsabstand)

Hinweis
Aufbringung eines Biegewechselmomentes (radiale Kraftabnahme), z.B. durch Keilriemen ist nicht zulässig.

Flywheel installation : Flywheel plus rigid coupled dimensions
m_{zul} : Dimension flywheel installation
m*l: Dimension torque flywheel installation based on centre of main bearing 1 (dimension * distance from centre of gravity)

Note
Application of alternating torque (radial power take-off) e.g. via a v-belt , is not permissible.



8.3.2.2 Axial power takeoff, damper side (opposite side to clutch)

In the **axial** and **radial** power takeoff on the opposite side to the clutch of the crankshaft, the power takeoff is limited with regard to additional mass moments of inertia and masses to be mounted and the resulting additional mass moments according to table A, fig. 8-8, (excerpt from the electronic pocket book ELTAB, chapter 2.6xx).

In compliance with the basic conditions specified in table A, the following engine power can be taken off axially on the damper side:

TD/TCD 2012: 100%

TD/TCD 2013: 100%

8.3.3 Radial power takeoff on the crankshaft

8.3.3.1 Radial power takeoff, flywheel side

Radial power takeoffs produce an oscillating bending stress of the crankshaft as well as an additional load on the crankshaft mounting by the effective cross force. It is not permissible to apply such oscillating bending stress to the flywheel side.

It follows that:

Radial power takeoff without flange-on outer bearing is not permissible on the flywheel side, see FIG. 8-4 / FIG. 8-5.

For the assessment of such drives / constructions, always consult the technical support of the DEUTZ head office.

8.3.3.2 Radial power take-off, damper side (opposite side to clutch)

Radial power takeoffs produce an oscillating bending stress of the crankshaft as well as an additional load on the crankshaft mounting by the effective cross force.
The following charts are showing the calculation program.
Limits for evaluation of the adaptation are shown on the diagram "Admissible additional bending moment" as well in chart "A", figure 8-8, and also see ELTAB for engine models TD/TDC 2012 and 2013.

FIGURE 8–6

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Determination of permissible additional bending moment

Designations:

$J_{additional}$ = mass moment of inertia of all parts additionally mounted at free crankshaft end (except for torsional vibration damper) in [kgm²]

$M_{m\ additional}$ = moment of inertia of parts mounted in addition to V-belt pulleys and torsional vibration damper according to sub assembly in [kgmm] (V-beltspulleys, fans, etc.)

m_1 = mass of part additionally mounted by customer in [kg]

l_1 = centre of gravity distance of mass m_1 in [mm]

a = distance from centre of main bearing up to connecting surface in [mm], see Table A

l_1 = centre of gravity distance of mass m_1 in [mm] from connecting surface

Mb_x = permissble bending moment in [Nm] dependent on angle α

Mb_rad_PTO = F*LF = additional bending moment due to radial PTO in [Nm]

F = resulting force due to radial PTO in [N]

LF = Distance main bearing centerline to force application point in [m]

Step 1: Permissibility mass inertia
Determine $J_{additional}$
Compare with permissibility value of Table A

Step 2: Permissibility moment of inertia
Determine $M_{m\ additional}$
Compare with permissibility value of Table A

Step 3: Permissibility bending moment
Permissibility value Mb_rad_PTO ≤ Mb

Step 4: Permissibility transverse force
Permissibility value F ≤ 5000 N

FIGURE 8-7a Example

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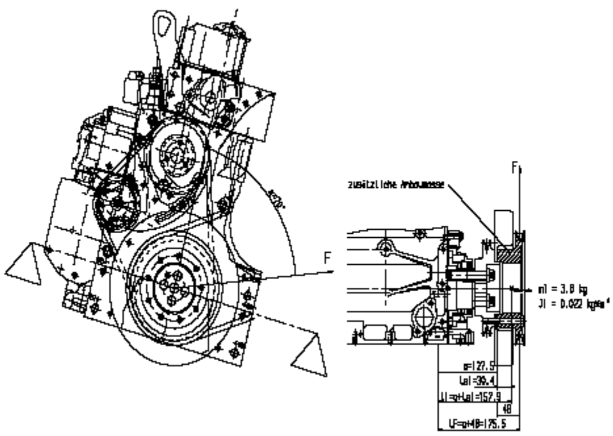
Example:

Engine TCD 2012 L06 2V
Sub assembly gear belt pulley at crankshaft: 0028 2487
n = 2300 rpm
a =127,5 mm
Diagram 1
$\alpha = 70°$
F = 900 N
$J_{additional.}$ = 0,022 kgm²
m_1 = 3.8 kg
L_{s1} = 30.4 mm



Step 1:
$J_{additional}$ = 0,022 kgm²
$J_{additional}$ (0,022 kgm²) < $J_{additional\ max.}$ (0,38 kgm²)

Step 2:
$M_{m\ additional}$ = m1 *(a + L_{s1})
= 3.8 kg * (127,5 mm + 30,4 mm) = 600 kgmm
$M_{m\ additional}$(600 kgmm) < $M_{m\ additional\ max}$ (7780 kgmm)

Step 3:
$\alpha = 70°$

FIGURE 8-7b Example

Technical data
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Diagram 1

Permissible additional bending moment
(radial power take off , free end)
for all radial power take offs excepted basic belt pulleys

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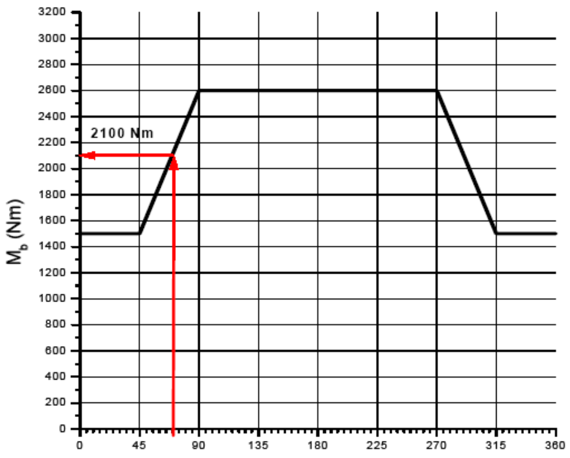
Maximum permissible transverse force = 5000 N



Direction angle α (°)

Mb = 2100 Nm

Mb_rad_PTO = 900 N * (127,5 mm + 48 mm) = 158,0 Nm

Mb_rad_PTO < Mb
Mb_rad_PTO (158,0 Nm) < Mb (2100 Nm)

Step 4:

F = 900 N < 5000 N

FIGURE 8-8

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Table "A"

TD/TCD 2012 2V

cyld. No.	Assembly (Section 32) belt pulley at the crankshaft 0028	$M_{m\ additional\ max.}$ [kgmm]	a [mm]	J additional $_{max.}$ * for rated speed [kgm²] 1500	1800	2000	2400
L04	2854; 2855; 2856; 2857 2858; 2859; 2860; 2861 3117	8000	163,5	0,3	0,3	0,3	0,3
	2789; 2791; 2792; 2794 2822	9000	137,5	0,22	0,22	0,22	0,22
	2790; 2793	9000	127,5	0,23	0,23	0,23	0,23
	2798; 2800; 2823	9400	131,5	0,15	0,15	0,11	0,05
	3216; 3217; 3218; 3219 3220; 3221; 3222; 3223 2776	9300	163,5	0,15	0,15	0,11	0,05
	2799	9500	121,5	0,16	0,16	0,12	0,06
L06	1816, 1817, 1818, 1819 1820, 1821, 1822, 2026 2027, 2453, 2462	7950	163,5	0,28	0,28	0,28	0,28
	2487	7780	128	0,38	0,38	0,38	0,38
	1795, 1796, 2482, 2484	7530	138	0,37	0,37	0,37	0,37
	2195, 2483, 2485	7400	138	0,36	0,36	0,36	0,36

TCD 2013 L06 2V

Assembly (Section 32) belt pulley at the crankshaft 0028....	Mm add. Max. [kgmm]	a [mm]	Transverse force F [N]	P ≤ 170 kW						P ≤ 200 kW					
				JFLY ≤ [kgm²]	Bending moment [Diagram]	J additional max. [kgm²] for rated speed rpm [min⁻¹] 1500	1800	2000	2300	JFLY ≤ [kgm²]	Bending moment [Diagram]	J additional max. [kgm²] for rated speed rpm [min⁻¹] 1500	1800	2000	2300
1954;1955;1956;1957 1958;2036;2037;2038 2039;2040;2041;2042 2056;2386	7000	181	5500	2,0	1	0,35	0,35	0,2	0,15						
2181;2182;2183;2184 2185;2186;2187;2188 2189;2190;2191;2192 2193;2385	7000	181	5500							2,0	5	0,3	0,3	0,15	0,15
1952;2180	7500	130	6000	2,0	4	0,28	0,28	0,18	0,13	1,5	7	0,28	0,28	0,18	0,13
2414;2464;2544	6500	131,5	6000	2,0	3	0,28	0,28	0,28	0,18						
1532;1951;2179;2975	7000	147	6000	2,0	2	0,27	0,27	0,17	0,12	1,5	6	0,27	0,27	0,17	0,12
2529	6000	148,5	6000	2,0	2	0,27	0,27	0,27	0,17						
2435	7000	147	6000	2,0	2	0,26	0,26	0,16	0,11	1,5	6	0,26	0,26	0,16	0,11
2420	5500	191,2	6000	2,0	2	0,25	0,25	0,15	0,1	2,0	6	0,25	0,25	0,1	0,05

* Containing all additionally torsion-proof front end-mounted masses
  mass inertia of flywheel and accessories <= 2,5kgm²

FIGURE 8-9, DIAGRAMM 2012

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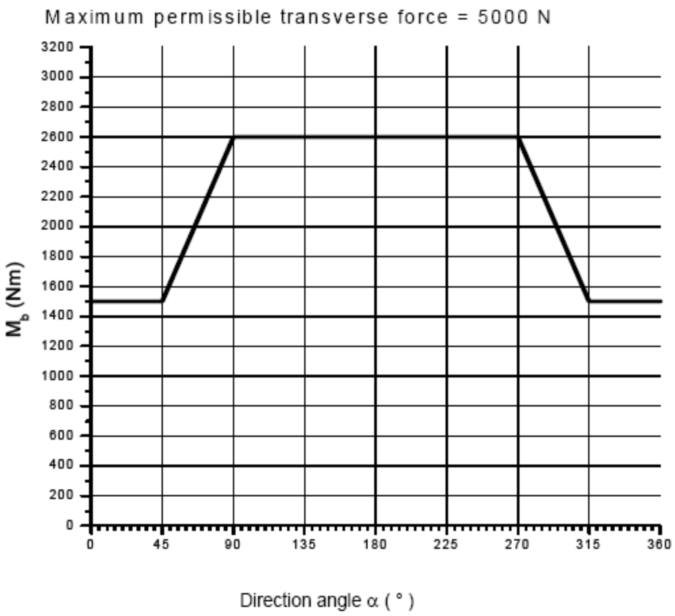
Permissible additional bending moment
(radial power take off , free end)
for all radial power take offs excepted basic belt pulleys

TCD 2012 L04 / 06 2V



The angle is counted by observation of the " front end power take off " side from the Z axis in clockwise direction (direction of rotation).
The Z axis points in cylinder axis direction and is permanently fixed to the engine. Reference level of the bending torque : centre of the crank shaft bearing.
If the engine is installed tilted, this does not affect the direction angle α because the angle is counted started from the tilted Z axis.

FIGURE 8-10 **2013 DIAGRAMM 1-7**

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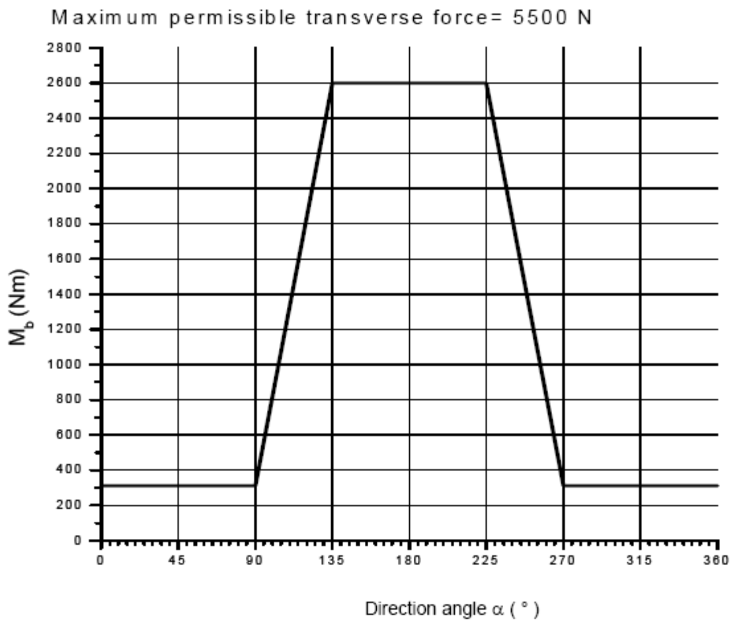
2.60x

Diagram 1

Permissible additional bending moment
(radial power take off , free end)
for all radial power take offs excepted basic belt pulleys

TCD 2013 L06 2V



The angle is counted by observation of the " radial power reduction " side from the Z axis in clockwise direction (direction of rotation).
The Z axis points in cylinder axis direction and is permanently fixed to the engine. Reference level of the bending torque : centre of the crank shaft bearing.
If the engine is installed tilted, this does not affect the direction angle α because the angle is counted started from the tilted Z axis.

Lettering for the following diagrams 2-7 see diagram 1

Diagramm 2

Zulässiges zusätzliches Biegemoment

(Radiale Kraftabnahme , Kupplungsseite)

für alle radialen Kraftabnahmen ausser Grundriemenscheiben

TCD 2013 L06 2V

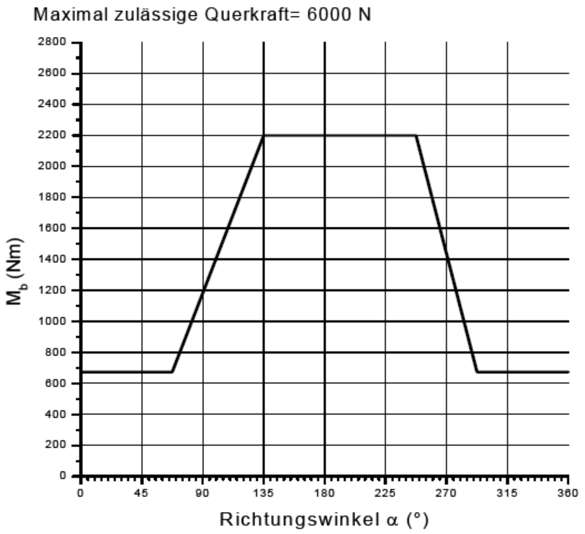


Diagramm 3

Zulässiges zusätzliches Biegemoment

(Radiale Kraftabnahme , Kupplungsseite)

für alle radialen Kraftabnahmen ausser Grundriemenscheiben

TCD 2013 L06 2V

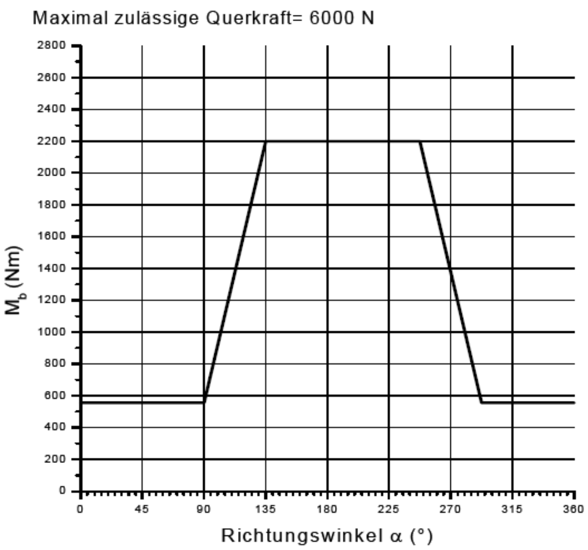


Diagramm 4

Zulässiges zusätzliches Biegemoment

(Radiale Kraftabnahme , Kupplungsseite)

für alle radialen Kraftabnahmen ausser Grundriemenscheiben

TCD 2013 L06 2V

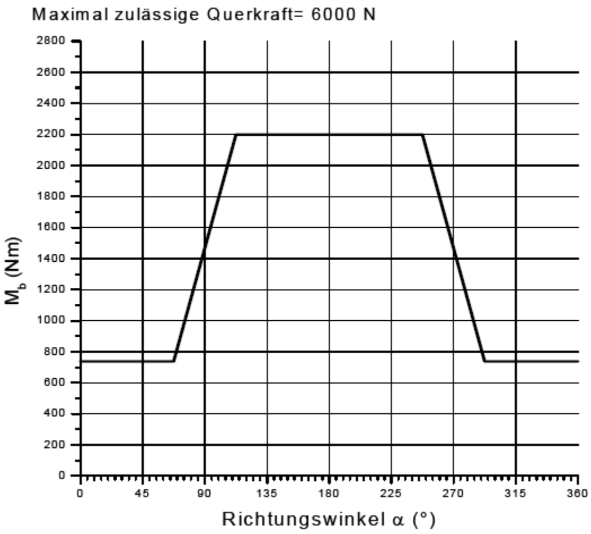


Diagramm 5

Zulässiges zusätzliches Biegemoment

(Radiale Kraftabnahme , Kupplungsseite)

für alle radialen Kraftabnahmen ausser Grundriemenscheiben

TCD 2013 L06 2V

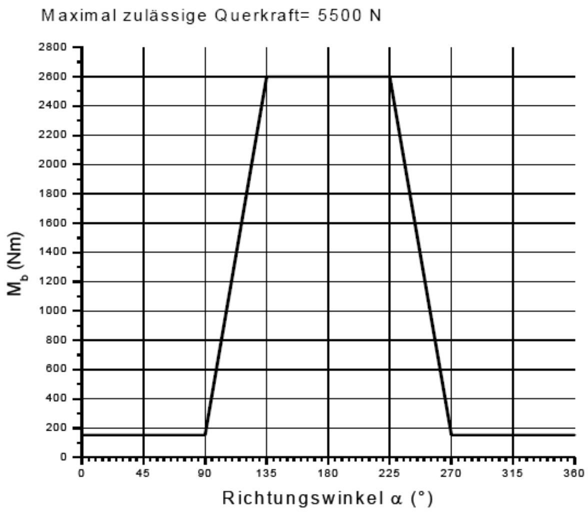


Diagramm 6

Zulässiges zusätzliches Biegemoment

(Radiale Kraftabnahme , Kupplungsseite)

für alle radialen Kraftabnahmen ausser Grundriemenscheiben

TCD 2013 L06 2V

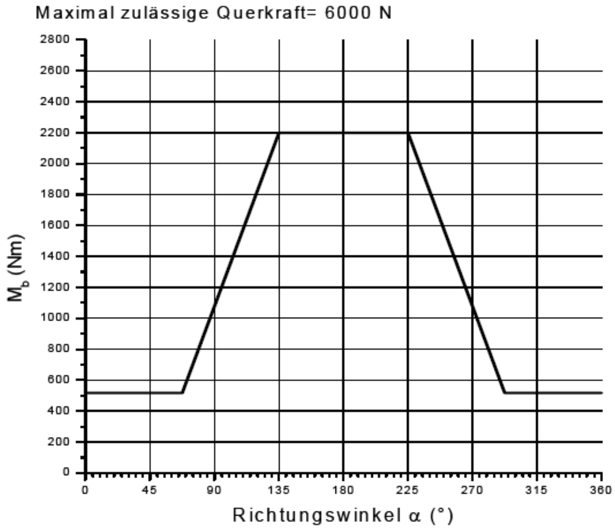


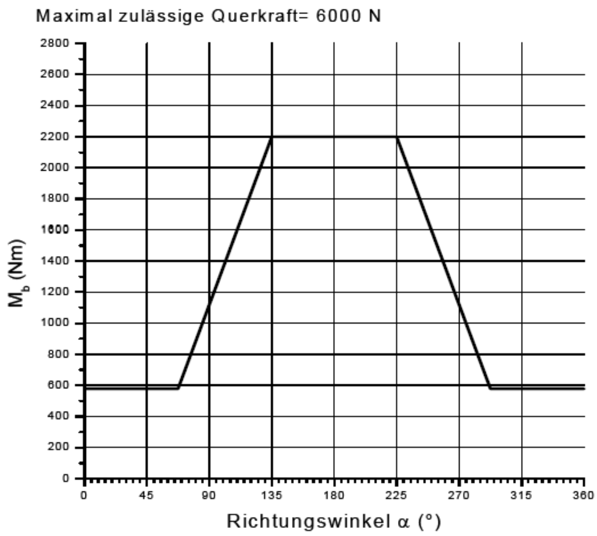
Diagramm 7

Zulässiges zusätzliches Biegemoment

(Radiale Kraftabnahme , Kupplungsseite)

für alle radialen Kraftabnahmen ausser Grundriemenscheiben

TCD 2013 L06 2V



At the time of printing of these "Installation Instructions", the respective data for the engines 2012/2013 were not yet completely available.
Therefore, please contact our purchase department or the technical support of the DEUTZ head office.
Due to technical changes and further developments, it is generally recommended to always check the validity of the technical data given here in connection with power take-off by consulting our purchase department.

8.4 Installation references

If drive systems are flanged to the engine, the contact surfaces must ensure a correct fit; remove the preservation agent.

When tightening the fastening screws, make sure that no axial force is acting onto the fitting bearings of the crankshaft.

Articulated shafts must permit easy displacement.

By no means, the axial clearance of the crankshaft must be influenced by clutches or connection elements between engine and drive system. Prior to first starting up, check the axial clearance of the crankshaft.

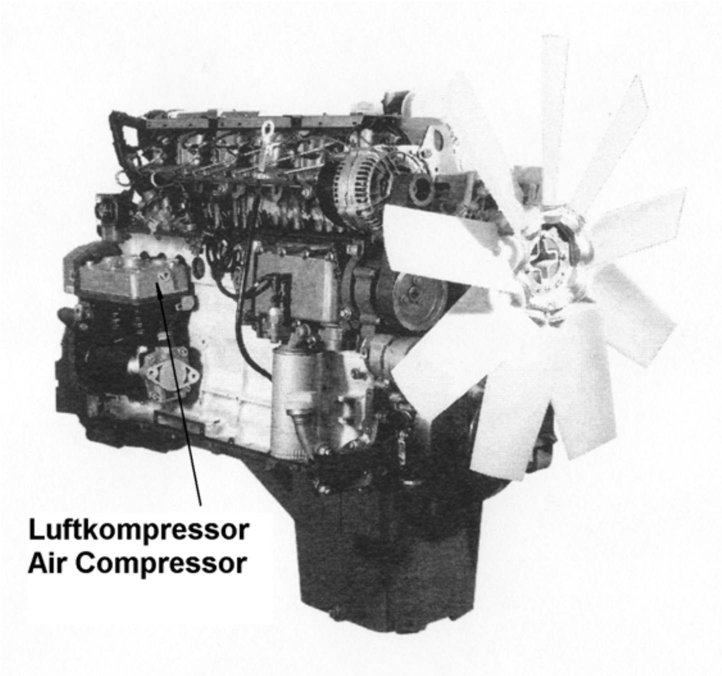
Admissible axial force load for the fitting bearing:	3600 N permanently 6000 N short term

9. COMPRESSOR

9.1 Place of installation

Normally, the compressors attached to the DEUTZ diesel engine TD/TCD 2012/2013 for supplying the compressed air systems is driven via the gearwheel drive at the flywheel-side wheel drive of the engine (power take-off A).

FIGURE 9-1



9.2 Compressor / sizes

The compressors are used as

Single-cylinder compressor	(225cm³, 360cm³ stroke)
Two-cylinder compressor	(720cm³ stroke)

The compressors offer the possibility of a hydraulic pump assembly on the powertrain, design details can be found in the electronic pocket book ELTAB or agreed with DEUTZ Technical Support.

9.3 Pipe connections / pipe design

All pipes connected to the compressor must be connected in a permanently sealing and air-tight manner; they must be laid torsion-free and must internally be absolutely clean (free from foreign bodies rust, scale and similar).

Intake line (connection 0 at cylinder head -. see circuit diagram compressor)
The intake air for the compressor must always be taken from the combustion air line (if, possible, always vertically from the top) between combustion air filter and exhaust gas turbocharger. On one hand, this point must always be arranged in front of the connection for

crankcase breathing (as distant as possible) (seen in the direction of flow of the combustion air) to avoid that oil is sucked in by the compressor. (The TIER III engines are supplied with open crankcase breathing system, so that this point is not relevant for the moment.

On the other hand, the distance to the exhaust gas turbocharger is then sufficiently large to keep the influence of the pulsating compressor intake air on the exhaust gas turbocharger as small as possible.

The necessary distance amounts about 150mm.

Following references are to be considered when designing the intake pipe.

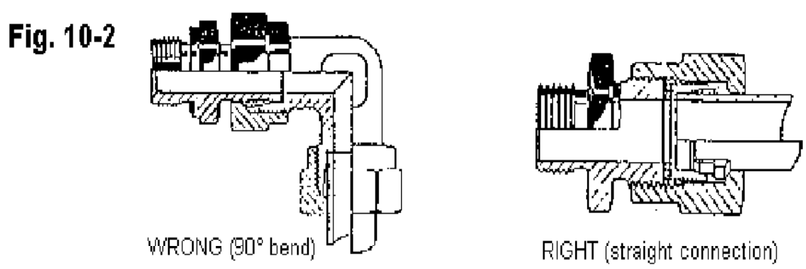
Table 1:

Intake pipe length [m]	Diameter [mm]
up to 0.3	≥ 18
more than 0.3 up to 1.0*	≥ 22
* Lengths exceeding 1 m are not permitted and require consultation of the compressor manufacturer.	

Max. admisdsible intake vacuum: 50mbar

Pressure pipe (connection 2 at cylinder head – see circuit diagram compressor)
The customer via a straight pipe screw union as per DIN with metallic sealing ring shall make the connection of the pressure pipe to the cylinder head of the compressor. In its first section, the further pressure line should be laid as straight as possible or, at least, without sharp bends as, otherwise, coke deposits can form in the bends.

FIGURE 9-2



To keep vibrations of the compressor (also due to its attachment to the flexibly mounted engine) off the compressed air system arranged behind, part of the pressure line must be flexibly executed – as pipe helix (which can at the same time serve as cooler for the compressed air) or via pressure hose.

If pressure hoses are directly connected to the compressor outlet, their compressive strength must be ensured even at a compressed air temperature of 250°C.

The max. admissible permanent temperature of the air flow in the pressure socket of the compressor is 220°C; this temperature is permitted to be exceeded only for a very short time during the filling phase (arrangement of measuring points as directed by the manufacturer). The temperature of the pressure socket is strongly influenced by the counter-pressure, the kind of cooling of the compressor, the intake air temperature and, in particular, the connection time (ED) of the compressor.

Table 2:
Sizes pressure pipe

Pipe length between compressor and following system (pressure governor)	Diameter [mm]	Compressor size / kind of cooling [cm³]
Recommendation: maximally up to 4 [m] however see note below	≥ 15 (pipe 18x1,5)	225 + 360 + 720 water cooled
NOTE: Pipe joint with all compressors M26x1,5 Pipe lengths exceeding 4m are admissible, but require the assessment of the compressor manufacturer regarding the observation of temperature limits at the following systems as regards their functioning during summer/winter operation. For compressors with ESS, the pressure pipe can be reduced to NW 8 mm, if the admissible air intake temperature at the following system is observed. See the specifications of the appropriate devices.		

A suitable pipe routing must make sure that no condensed water can flow to the compressor or remains in the pipe – therefore, lay pipes with an inclination.

9.4 Pressure regulation

When laying out the pressure regulating system, it must be made sure that the pressure governor with its regulating system is matched to the compressor. Pressure governor and the air drier always connected behind are mostly forming one unit. The use of air driers is always recommended to keep the water off the overall compressed air system.

Observe the installation instructions of the manufacturer.

To keep the thermal load on the cylinder heads small, the impact pressure in the pressure line between compressor and pressure governor must not exceed 0.7 bar during the shutting down phase of the compressor.

The following regulating systems are used:

9.4.1 System with Unloader (pressure governor)

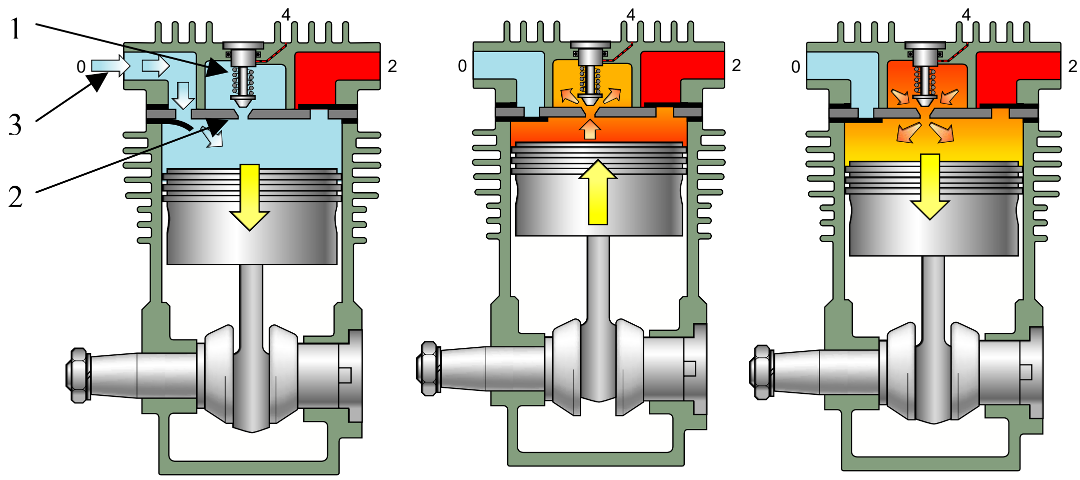
This regulating system is frequently used in nearly all of the Central European countries including Eastern Europe. As this system relates to compressors without intake valve control (ESS), no further details are given here.

9.4.2 System with Governor

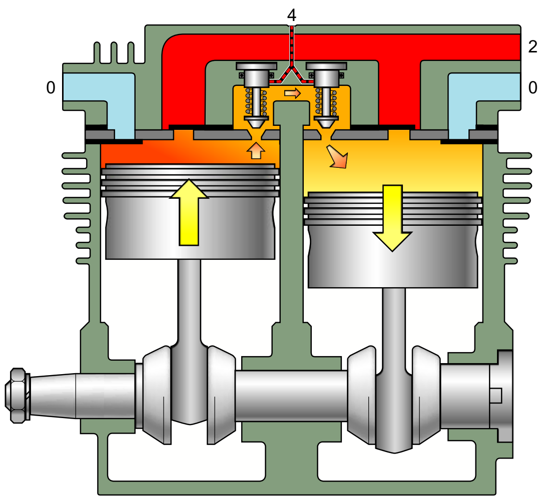
This regulating system is predominantly used in the USA, in Sweden, Norway, partly also in England and South-Africa. In the case of this governor regulating system, in the idling phase of the compressor (compressor shutdown), the intake valve of the compressor is opened so that the power consumption of the compressor in the idling phase is distinctly lower than with blowing via pressure regulating valve.

9.4.3 Energy saving system (ESS) – not in the 225cm³ compressor

During the pumping phase the valve piston (1) closes the valve seat (2). The compressor cylinder sucks the air to be compressed through the suction holes (3).
The compressor then operates like a compressor of the earlier type without ESS.



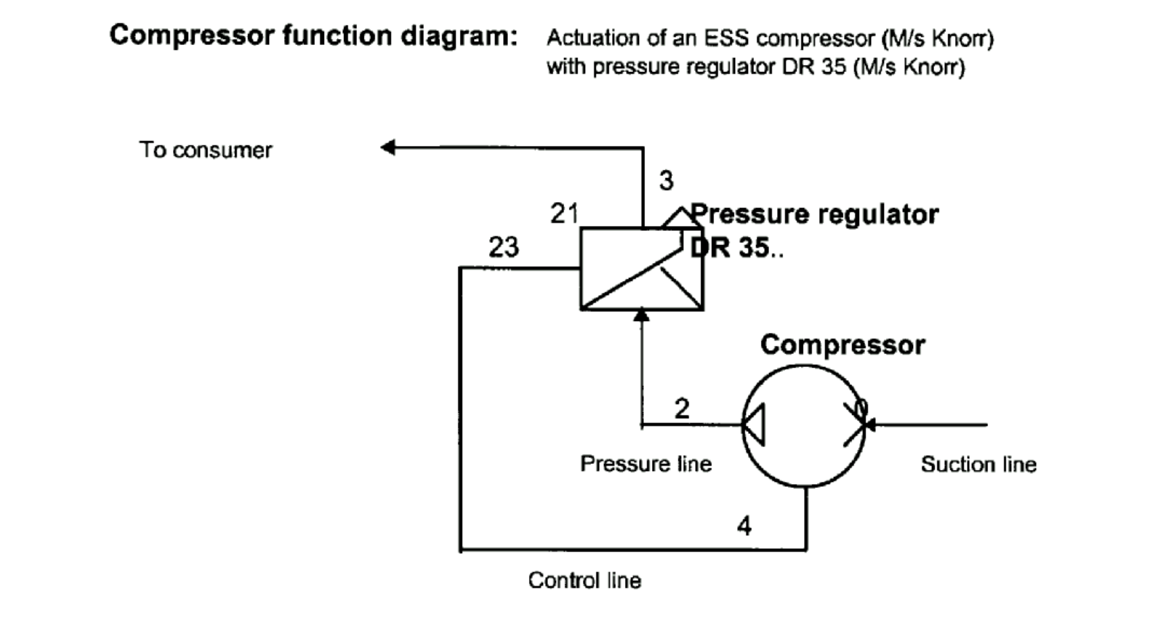
In the ESS phase the valve piston (1) is lifted against the spring force of the valve seat (2) by the control pressure. The control pressure comes from the governor or the air drier. This establishes a connection between the compression chamber and a so-called "closed room". In the first cycle in the ESS phase the compressor piston sucks the air to be compressed through the suction holes (3). The air is then compressed and flows into the "closed room". The compressed air in the "closed room" then expands again in the compression chamber in the next cycle …
In this condition the compressor operates in a closed circuit process – only friction, leakage current and heat loss demand minimum drive energy.



For a two-cylinder with "linkwall" the valve pistons are lifted from the valve seat by the control pressure (from the governor or air drier). This establishes a connection between the two compression chambers. The sucked in air flows from one chamber to the other during compression.

Compressors with ESS and pressure governor must be matched to each other so that the compressor manufacturer must assess the selection of the pressure governor.

FIGURE 9-3



Control line (connection 4 at cylinder head – see circuit diagram compressor)
The control line for the compressor with **ESS** (energy saving system) must laid by the customer with a continuous inclination between the cylinder of the compressor and the pressure governor or the air drier (connection 4).

Dimensioning of the control line:

Line length:	≤ 6 [m]
Line diameter:	NW 4 [mm]

If the line length or the nominal width of the control line is increased, trouble-free functioning of the ESS is not ensured.

If the customer renounces the ESS, the connection of the control line at the compressor must be closed with a bore of 2mm using a locking screw M 10 x 1.
This breathing bore ensures that the control piston clearly remains in its position and the full compressor delivery is always guaranteed.

The maximally admissible counter-pressure of the compressors depends on its type and is mostly defined by the OEM via the disconnection pressure in the system. Normally, the disconnection pressure is 8 bar, the compressed air being blown into the open air (compressor without ESS) via separate exhaust air silencers. Such silencers are part of the scope of supply of the compressor manufacturer and are carefully matched.
With ESS-compressors, the air is circularly delivered (recirculation), when the disconnection pressure is reached.
For ESS compressors, a minimal disconnection pressure of 8 bar must be considered.

9.5 Cooling/lubrication of the compressor

The water-cooled compressors integrally attached to the engine are connected to the engine cooling system for performing their cooling function.
The connection to the engine lubrication circuit ensures the lubrication of the compressor.
Coolant pipes and pressure oil pipes are laid at the engine.

9.6 Compressor design

An air requirement calculation must clarify the required compressor size. Here, it must be clarified, which air requirement is existing for which period of time.

The compressor connection time (ED) – i.e. the delivery of compressed air – shall be 40% at a maximum of the entire compressor operation time.

Connections time values exceeding 60% are too high and can lead to premature compressor failures. If necessary, values for permanent connection times must be determined by measurements of the delivery- and idling times or extended operating periods (days).

9.7 Compressor power take-off for auxiliary steering pump

Optionally, individual compressors are equipped with a power take-off for connecting e.g. auxiliary steering pumps to the compressor crankshaft. Generally, the power take-off is suitable for a take-off of 82Nm.

Auxiliary steering pump as per DEUTZ scope of supply (Presently available only for the 225cm³ variant):

Vane cell pumps of ZF
21 cm³/min (max 16.l/min delivery, controlled) up to 150 [bar] pressure
(without pressure limiting valve)

with intake pipe connection M26x1.5 (12 mm deep) for pipe 19x22
pressure pipe connection M18x1.5 (16 mm deep) for pipe 12x15

10. COLD CLIMATE APPLICATIONS

Cold start means starting of the engine without starting aid down to a specific ambient temperature.

Cold start at lower temperatures (down to –30°C) is possible for the engine with an adequate battery, starter and engine-integrated starting aids (pin-type heater plug, heating flange). To the engine coolant, always an appropriate percentage of antifreeze must be admixed (see instruction manual or chapter "Annex").

Consult the acquisition staff or the head office for the cold start limit temperatures and the engine equipment required here – also see "Technical Pocket Book".

Extreme cold start conditions (colder than –30°C), require further measures, among others:

complete engine enclosure (to avoid heat losses upon preheating) and
internal engine or component preheating.

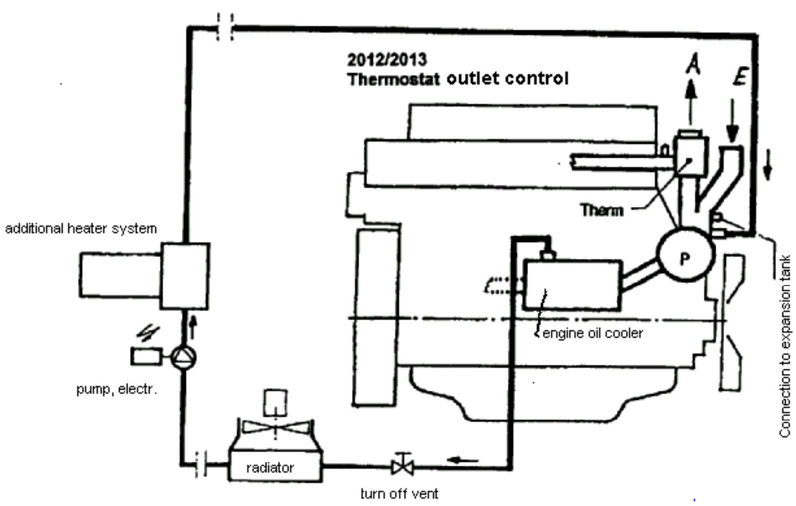
The details for a certain application are to be clarified with the technical support DEUTZ

10.1 Coolant preheating

The liquid-cooled DEUTZ diesel engines BF M 1012/1013 and BF M 2012/2013 are equipped for the subsequent installation of a coolant heating system via heating rod (socket heating), PN 0419 8898 KZ 0130-63, having a heating capacity of abt. 820W at 230V.

For units having a fuel-operated auxiliary heating system directly integrated in the heating circuit of the engine, beyond the cab heating, at the same time, the engine can be preheated by the heated up coolant – also see chapter 1 "Heating system".

BILD 10-1 Schaltschema bei TD/TCD 2012/2013



Note: the heating circuit and the additional heating system must be vented

10.2 Radiator cover (winter cover)

When liquid-cooled engines are operated in winter, relevant functions of thermostat and/or viscous fan clutches keep the coolant temperature at optimal level.

As a result of installation conditions and equipment applications, additional measures may be required to keep the engine and the engine compartment "warm".

Normally, in the case of engines with external cooling system, the air inlet cross section of the engine radiator is covered ("winter covers").

When using such radiator covers, attention should be paid that this cover can be opened simultaneously at the upper and lower radiator end to ensure a uniform supply to the fan. This is especially important for fans which involve the risk of overheating of the clutch.

11. VIBRATION DAMPER

11.1 Cooling system

The torsional vibration damper fitted to the free crankshaft end of the engine must emit vibration energy to the environment in the form of heat.

To prevent damage to the vibration damper, it must be made sure that the heat energy generated in the vibration damper is dissipated by cooling.

Therefore, make sure that air – as cool as possible – circulates at the crankshaft end.

For engines with external cooling system and engine-mounted fan drive, a sufficient air circulation near the vibration damper is always ensured.

For engines with external cooling system and external fan drive, the circulating air temperature level around the vibration damper must be more intensely investigated depending on the installation position of the fan/cooler unit.

The ambient temperature should not exceed 85°C.
The permissible damper unit temperature based on the upper ring amounts to115°C.

12. SOUND INSULATION / SOUND ABSORPTION

12.1 General

The nose of a diesel engine originates from many individual noise sources, e.g. intake and exhaust noise, injection-, combustion- noise, noise generated by the operation of valves, gears, bearings and the blower. Consequently, the entire surface of a diesel engine radiates air-borne noise and transmits structure-borne noise via all connecting elements and its mounting. The noise level increases, the higher the engine speed.

To reduce the noise of a diesel engine installation, special sound insulation and absorption measures will have to be taken so as to meet the – partly equipment-specific – legal regulations in the different countries.

12.2 Sound insulation

This is the most important acoustic measure and provides comprehensive acoustic insulation of the noise source from the environment. According to the type of installation concerned, partition walls can achieve this, enclosure of the engine and structure-borne sound insulation.

Partition walls or enclosures should be insulated against structure-borne sound at engine end. This is realised in the simplest way by a flexible engine mount. Sound-absorbing materials must be mounted towards the engine. Enclosures must be sealed as much as possible; the respective passages for operating elements or supply lines to the engine must also be sealed.

To increase the insulating effect of enclosures, we recommend to have them made of sandwich plates or plastic material or to mount heavy-duty laminated mats on steel plates.

In front of the engine cooling air blower or at the inlet of a cooler/fan unit, the ducting should be deflected to avoid direct noise radiation. It should be made sure that the intake duct is adequately dimensioned to keep the cooling air volume losses within permissible limits. Such ducts must be cladded with sound-absorbing materials.

Analogous measures must be taken for the discharge air and scavenging ducts of enclosed engine installations.

An initial structure-borne sound insulation is obtained when using flexible engine mounting elements. The insulation effect increases the softer the flexible mounting elements. To increase the damping effect f

12.2 Sound absorption

In spaces or enclosures, the effective noise level can increase, if freely reflected from the walls or side panels; thus, an additional expenditure for the insulating measures may be involved.

To reduce the vibrations and thus the sound emitted from the walls or body components, these must be covered with appropriate sound absorbing material.

Sound absorption includes, above all, lining of the enclosure with foamed or fibrous materials, the surface of which may be covered with a perforated sheeting (hole portion 50%).

When lining the enclosure of the air intake and discharge ducts, it must be made sure that the used material and adhesive are temperature-resistant (up to + 130°C). It is recommended to secure the lining mechanically to prevent loosening and obstruction of flow cross sections.

In rooms or capsules the active noise level can be increased by unhindered reflections from the walls which could cause additional efforts for insulation measures.

To suppress vibrations and thus the noise emissions from walls or body parts, these must be subjected to appropriate damping measures.

12.3 Sound insulation and absorption materials

Beyond sound absorption, the material examples listed below have, at the same time, an insulating effect because of material structure and weight and vice versa.

Sound insulation:
Sound-deadener sprayed on, thickness of the sound-deadener max. 3x plate thickness
Heavy twin-layer matting, bonded
Sandwich sheeting
Plastic plates
Double-walled construction of enclosures

Sound absorption:
Foamed material, at least 20 mm thick or more for air ducts, permanently bonded or mechanically fastened.

Fibrous or foamed materials, treated against trickling or soaking by a thin foil covered with perforated sheeting with a large hole portion exceeding 50%.

Sound insulation:
Uncoupling via flexible mountings or coupling of enclosure walls via flexible elements.

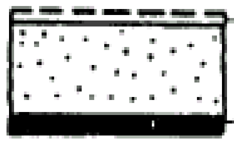
Material examples: see Fig. 12 - 1

FIGURE 12 – 1 Material examples

Sound-deadening material large-size sheeting and cowlings

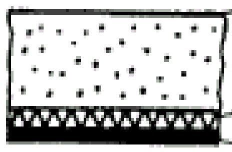
Foamed material

Intake air and discharge ducts



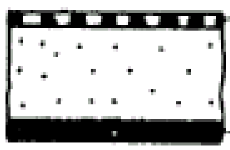
Foamed material

(skin-type coating)
e.g. lining of engine compartment



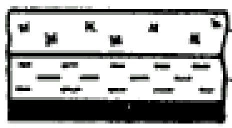
Fibrous material

e.g. rock wool or
softer fibrous material
engine compartment



Floor covering

driver's cabs



Insulation matting

partition walls

12.4 Additional measures required for engine enclosures

The sound insulation features a high thermal insulation which must be considered for the heat dissipation.

The temperatures inside an engine enclosure can considerably increased; therefore, attention must be paid to the temperature resistance of the engine components and used construction elements.

To reduce the thermal load in an engine compartment, it is recommended to provide a forced ventilation via an auxiliary fan or by suitable installation measures at the air intake and discharge ducts of an engine installation.

12.5 Notes

Detailed enclosure measure to reduce the noise generated by the diesel engine are not described here, as all silencing measures have to be matched to the overall arrangement of the driven equipment and the engine and its power take-off units.

In view of the complexity of this subject, please contact application engineering for individual applications or the Technical Support of the head office.

13. HEATING OF ENGINE COMPARTMENT

13.1. Radiation heat

The air in the engine compartment is heated up by the radiation heat of the engine, the exhaust gas system, the power take-off units at the engine (e.g. generators, transmissions, hydraulic pumps, compressors etc.) as well as of possible auxiliary systems (heating, hot water boiler etc.).

At no point in the engine compartment, the air temperature should exceed 80°C. Therefore, the engine compartment must always be ventilated.

Considering the withdrawal of cold air for the generators from the engine compartment, in the case of generator systems, the compartment temperature must be limited to lower values – observe instructions of the generator manufacturer as regards the maximal cooling air temperature at the generator inlet.

The overall air volume passing the engine compartment is made up of:

- Combustion air - if, for thermal reasons, the combustion air may be taken from the compartment
- Cooling air for the engine cooler
- Cooling air for the generator
- Cooling air for the hydrostatic cooler
- Air for auxiliary consumers (compressor, heating system...)
- Additional air for dissipating radiation heat

1. Engine radiation heat Q_{Eng} :

The average radiation heat of a diesel engine (4-stroke) is assumed with 3...6% of the heat introduced via the fuel:

$Q_{Eng} = (0{,}03...0{,}06) \times P \times b_e \times H_U$ [kJ/h]	P = Engine power in [kW] b_e = spec. fuel consumption in [kg/kWh] H_U = Calorific value fuel with 43000 [kJ/kg] 3600 [kJ] = 1 [kWh]

2. Generator radiant heat Q_{Gen} :

The generators are normally cooled via installed fans. The cooling air is withdrawn from the compartment and returned to it again. When designing the engine compartment ventilation, this heat must be considered. This heat (lost heat) is calculated as follows:

$Q_{Gen} = P_{Gen} \times [1-(\eta/100)] \times \cos\varphi \times 3600$ [kJ/h]	P_{Gen} = Generator power [kVA] $\cos\varphi$ = Power factor [-] η = mech. efficieny Generator [%] 3600 [kJ] = 1 [kWh]

3. Auxiliary systems Q_{aux}:

The determination of the volumes of radiation heat originating from exhaust gas pipes, silencers, water pipes, cooling systems, pump units, compressors, boilers and similar is quite difficult. From experience, it is known that these radiation portions are considered sufficiently precise with abt. 10% of the engine radiation heat.

$Q_{aux} = 0{,}1 \times Q_{engine}$ [kJ/h]

4. Overall radiation heat Q_{gesamt}:

$Q_{total} = Q_{Engine} + Q_{gen} + Q_{z\ total}$ [kJ/h]

13.2 Air volume for ventilating the engine compartment:

The air volume required for ventilating the engine compartment results from

$M_{air} = Q_{total} / (\Delta T \times c_p)$ [kg/h]	with c_p = specif. heat of air = 1 [kJ/kg°C] ΔT = admiss. temperature rise in engine compartment [°C] normal abt. 12°C at 35°C ambient temperature at outside

or the required air volume according to the following relation

$V_{air} = M_{air} / \rho$ [m³/h]	with ρ = 1,29 [kg/m³] as spec. air weight at 0°C, 1bar

For many engine installations, the airflow of the axial fans of the cooling system is simultaneously used for ventilating the engine compartment. Here, it must be checked, in how far the related pre-heating of the airflow and, consequently, the reduced cooling capacity of the cooler can still be tolerated.

The usual preheating rate of the cooling air with cooling systems with pusher-type fans is between 10 and 15°C. However, the combustion air must always be directed to the engine via pipes from the free, not heated up environment.

The influence of the cold engine compartment walls as well as floors and ceilings on the heat dissipation must be individually assessed for the respective case.

NOTE: Crankcase breathing

In the case of engines without re-circulating crankcase breathing, the crankcase gases flow into the engine compartment so that particular precautionary measures may become necessary.

The DEUTZ engines TC/TCD 2012/2013 are provided without re-circulating crankcase breathing systems.

If installation assistance is required, please ask the technical support DEUTZ

14. INSTALLATION SURVEY BY MEASUREMENT

For a final assessment of an engine installation, the following examinations must be made by measurement.

14.1 Temperature test:

In installed condition (in the equipment), an engine must operate at its full power- without restrictions.

Therefore, the temperature test is performed under full engine power (nominal power of the engine at nominal speed) over a period of at least 45 minutes or until all temperature values are steady.

If, in view of a specific application, continuous operation of the engine at its maximal speed must be expected, an additional test run must be made also at that operating point.

If engine full load cannot be represented in this test, as the equipment is not suitable regarding its operating capacity (equipment utilisation under 100% engine full load), the test must be run with the maximally possible equipment utilisation and this condition must be remarked in the log of results as "practical utilisation".

Prior to starting the tests, the coolant thermostat must be converted to a forced-opened thermostat with 8 mm stroke. The coolant must have a mixing ratio glycol-water of 35:65 to 50:50.

The following temperatures must be measured – **also see measuring diagram:**

1	Ambient temperature of the free environment (in shadow). **This temperature value is important for assessing the cooling system (application limit).**
2	Air temperature at the cooling air inlet in front of the equipment
3	Cooling air temperature in front of radiator core (for C-engines in front of charge air cooler). In case of forced cooling, this temperature is measured between fan and engine at the fan circumference.
4	Combustion air at filter inlet
5	Combustion air temperature in front of turbo charger inlet
6	Charge air temperature in front of charge air cooler (combustion air behind turbocharger)
7	Charge air temperature behind charge air cooler
8	Exhaust gas temperature behind turbocharger
9	Water temperature behind engine outlet This temperature value is important for assessing the cooling system (application limit)
10	Water temperature in front of engine inlet
11	Engine compartment temperature left-hand/right-hand above engine at a distance of abt. 0.2 to 0.4 m from engine surface in order to collect ambient temperatures of sensors-, wiring harness-, wiring plug- temperatures. Various admissible temperatures see table – "Temperature limit values"
12	Cooling air intake temperature - alternator

13	Temperature at the starter motor / starter solenoid (ambient, housing)
14	Fuel temperature (in tank, if necessary, in front of delivery pump inlet and in the return line)
15	Temperature at the vibration damper (ambient / housing)

To complete the temperature examinations, the „Hot-Shut-Down“ test must be performed:
By covering the radiator, at engine load, the water outlet temperature is run up, until the disconnection temperature is reached – then, at once stop engine (corresponding to emergency engine stop). The test is considered as stood, if no coolant (water) emerges via the breather valve of the expansion tank and the coolant system remains tight.

14.2 Pressure measurements:

P0	Pressure in the free atmosphere at the time of temperature measurement. The sufficient supply of the cooling system with cooling air is assessed by determining the actual cooler application limit related to the ambient temperature compared with the design values. To that end, it is required to record the air pressure PO prevailing in the free atmosphere at the time of the temperature measurement. Then, via a calculation programme (can be obtained from application engineering), the actual application limit of the ambient temperature for the equipment must be determined.
P1	Coolant pressure in front of water pump inlet (Wapu) Measurement at nominal speed and open blocked thermostats. The test is considered stood, if in front of the pump inlet, at least 0.3 bar at max. 100°C coolant temperature and minimum coolant level are reached in the expansion tank.
P2	Coolant pressure behind engine outlet. From the difference P2-P1, the system resistance is resulting. The test is considered stood, if the pressure difference ≤ 0,.35 bar* related to engine speed is 2400rpm for 2012 or 2300rpm for 2013. Observe data in Technical Pocket Book.
P3	Exhaust gas counter-pressure behind turbocharger outlet. Measurement always under full engine load. The test is considered stood, if the pressure value is below 100 mbar (10 kPa) .
P4	Combustion air vacuum pressure at filter outlet (connection servicing switch). For new filter cartridges, the vacuum pressure should not exceed 20mbar (2kPa).
P5	Charge air pressure behind turbocharger or in front of charge air cooler. Measurement always at engine full load.
P6	Charge air pressure behind charge air cooler or in front of engine inlet. Measurement always at engine full load. The test has been passed if the pressure difference between P5 - P6 at TCD 2012/2013 engines is ≤ 150mbar.
P7	Fuel vacuum in front of inlet of fuel delivery pump. The test is considered stood, if the pressure value is between –0..5bar and 0 bar at low idle speed and clean pre-filters (=highest flow rate). In case of doubt, the fuel volume flow rate must be measured, the volume flow rate being abt. 4 - 5 l/min at low idle speed (=highest flow rate).
P8	Fuel pressure in the return pipe behind FCU Permitted max. 0,5 bar (rel.). Pressure is to measure at low idle speed (=highest flow rate).

Measuring point connections:

for pressures:	Threaded nipple M12x1,5 or threaded bore M10x1 Threaded nipple M10x1	(P1,P2,P3,P5,P6) (P4)
for temperature:	Threaded bore M8x1 or M14x1,5	(6,7,8,9,10)

14.3. Temperature limit values

The engine installation must be such that, during continuous operation of the engine under nominal load (or at max. torque) and the respective application limit temperatures of the equipment, the following temperatures are not exceeded:

Component, measuring site, medium	**Permanent temperature °C**	**Brief temp. °C** *1
Coolant temperature: all except TCD 2013L06 2V, TCD 2013L06 2V, Pgr. I, 2300 u. 2200rpm, Pgr. II –IV TCD 2013L06 2V, Pgr. I, < 2200 rpm	110 105 110	118 113 118
Engine oil in sump	125	133
Fuel in tank before supply pump in return pipe fuel pipes	70 70 -40 / 100	90 90 130** 130
Exhaust gas temperature after turbocharger outlet	710	
Combustion air in front of turbocharger	Ambient temperature plus 10	
Combustion air after charge air cooler at full load and nominal speed, related to 25°C ambient temperature: TIER III Agripower TCD 2013 L06 4V, High performance variant (G261/S253kW/2200 rpm)	50 46	
Cooling air (suction fan) Cooling air (pusher fan)	T_U plus < 5 T_U plus < 15	
Generator (cooling air) (housing)	100	110
Starter: (ambient temperature) (housing temperature) (environment magnetic switch)	100	120
Starter relay: Bosch Kissling	100 120	120
AGR actuator	110	120
Combi sensor charging pressure / temperature	130	
Sensors: (coolant, camshaft speed crankshaft speed. (cable) oil pressure, rail pressure fuel pressure sensor)	130 120 125 130 140	

Plug, central plug, cable harness Cable harness corrugated tube Pipes	130 135 150	
Relays (heating plug, heating flange) Kissling Tyco Bosch	120 125 100	 120
FCU (fuel control unit)	120	140
Ambient temperature rail, injection system	120	140
Ambient temperature fuel supply pump	120	140
Ambient temperature: Fuel main filter: Fuel pre-filter (Racor):	 100 90	 120
Ambient temperature – crankcase bleeding valve	135	
Ambient temperature – compressor water-cooled, not a Deutz part	85	95
Vibration damper Ambient temperature: measured, 100mm axially from damper Component temperature: measured on upper ring	 85 115	
Engine mounting (DEUTZ BS)	120	
Ambient temperature – poly V-belt	120	140
Ambient temperature – battery not a Deutz part	50...60	
Ambient temperature – electronic control unit EDC 7, EDC 16 Plug for control unit	 80 approx. 135	
Ambient temperature – ignition starter switch not a Deutz part	90	
Ambient temperature – brake flap adjustment cylinder	145	

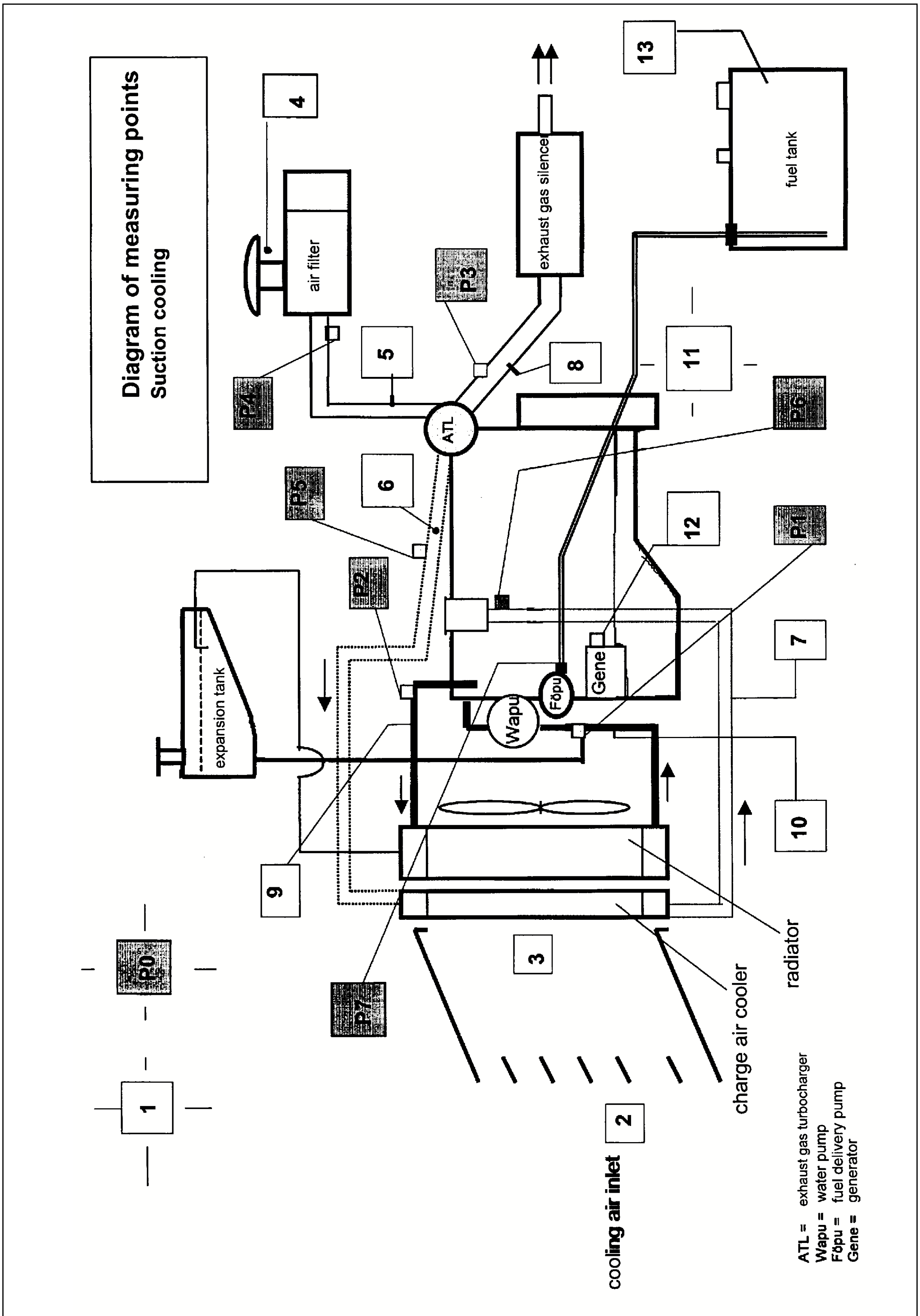
Remarks:
*1 Brief temperature is defined differently by our suppliers, (from 3min..30min) the appropriate drawings and specifications must be consulted for this.

** In case of malfunctioning of the FCU (fuel control unit) this temperature may be reached briefly in the return. The inlet area to the fuel tank must also withstand this temperature. The fuel temperature in the lead may not exceed 90°C.

The various engine components are usually suitable for subzero operating temperatures of –30°C, and storage temperatures of –40°C.

14.4 Diagram of measuring points

FIGURE 14-1



15 ELECTRICS

15.1 Starter and battery capacities, Battery switch / master controller / starter switch

In view of its short-term high current consumption, the starter is decisive for dimensioning the battery. The starter converts the electrical energy stored in the battery into mechanical energy. It can develop its capacity only, if a battery of sufficient capacity is available.

Maximally admissible maximum cold-start test currents are assigned to the starters; therefore, when assigning starters and batteries, make sure that the data given in table "Assignments starters/batteries" are observed

Ideally the starter selection should be made according to the turnover torque of the engine and drive required when starting whereby the design should be such that no more than the nominal power of the starter is taken off even at +20°C.

Starters can be executed with and without insulated return cable.

The starters must be protected against splash water, road dirt, fuel, oil and excessively high temperatures. If necessary, install a screening plate.

+100°C as admissible permanent temperature of the starter housing (pole housing) must not be exceeded.

Short-term temperature peaks of up to +120°C are admissible at the two pick-up points "pole housing" and "housing starter solenoid", short-term being defined with a time of 15 min. at a max. and the sum of the events can be abt. 5% of the entire operating time.

The maximally admissible housing temperature of the starter solenoid is also +100°C.

Notes:

- During welding works, it is best, if the battery remains connected with both poles and also the generator remains connected wit the battery.

  This only refers to generators without Zener diodes. Generators of today are normally equipped with Zener diodes; therefore, during welding works, both poles of the battery must be isolated to protect further electronic components.

- The so-called external starting (via an additional, external battery) is dangerous without connected battery. When withdrawing the cables from the poles, high inductive phenomenon can occur (electric arcs, voltage peaks) and destroy the installed electronic components – unless these are protected against voltage peaks by suitable protection circuits (e.g. recovery diodes).

- Starters are permitted to turn without interruption for a maximum of 1 minute. Then, a waiting time of 30 minutes (cooling down) is necessary prior to the next turning operation.

- By suitable software in the control unit or a start lock relay (see TPI 0199-99-0217), the starter is protected against reeling in in the running or slowing down engine. A locking time of at least 6 seconds is recommended.

- Starters must not be cleaned with high-pressure steam cleaners.

- The contacts of the starter terminals 30, 45, 50, must be protected against unintended short-circuiting (jump protection)

- The admissible tightening torques for nuts and screws at terminals 30, 50 may be taken form the starter drawings.
- No additional consumer may be connected at terminal 50, these must be connected to terminal 45.
- The cables must be fixed after about 30 cm.
- When replacing a starter, check the girth gear on the engine flywheel for damage and check the number of teeth – if necessary replace the girth gear.
- The strength of the cable insulation must stand the max. current at an ambient temperature of +100°C without being damaged.
- Prior to performing assembly works at the engine in the starter area or at the starter proper, the battery must be isolated.
- Unless otherwise expressly indicated in the individual case, starters are not suitable for being used in an environment with an explosion risk.

Battery switch, starter switch, master controller

The switches must be protected against dust and water.

The switches must stand currents (inductive loads) as indicated in the following table:

	12 Volt system		24 Volt system	
	short-term	permanently	short-term	permanently
BOSCH EV / IF Starter	60 A	12 A	24 A	7 A
MELCO 9CP 47 / 55				

- For electrical systems in busses, tramcars, fuelling vehicles etc., battery main switches are specified, with which the board mains can be isolated from the battery.
- If no electric start lock relay with a time lock of min. 6 s is used, the start switch must have a mechanical lock so that the key has to be turned back to the stop position before repeating the start-up.
- In the case of systems with three-phase alternator, an electro-magnetic battery main switch is required. It avoids that the alternator can be isolated from the battery with running engine.

Batteries

Electrically started engines draw heavy currents from the battery upon starting. The batteries must be capable of supplying these currents.

In addition to an adequate capacity of the battery, the cold starting behaviour of the engine is essentially determined by the cold-start test current (for further details, see DIN 43539, Part 2). You will find the respective values on the battery nameplates.

- If a battery with a larger cold-start test current than recommended is used, the starter can become mechanically and thermally overloaded.
- If the cold-start test currents are too small, the cold starting behaviour deteriorates; the starting function is no more ensured.

Observe the following when installing the battery:

- The ambient temperature of the batteries must not exceed 60°C at a max.
- The acceptability of the battery installation in the engine compartment must be confirmed by temperature measurements.
- Install batteries in an easily accessible position considering possible servicing works, unless "maintenance free" batteries are used.
- Batteries must be fastened such that no natural movements are possible.
- The battery installation space must be well ventilated. Do not install electric switches near the battery in view of the generation of sparks and the risk of explosions.
- In devices with a high vibration load, special “shake-proof” batteries must be installed.

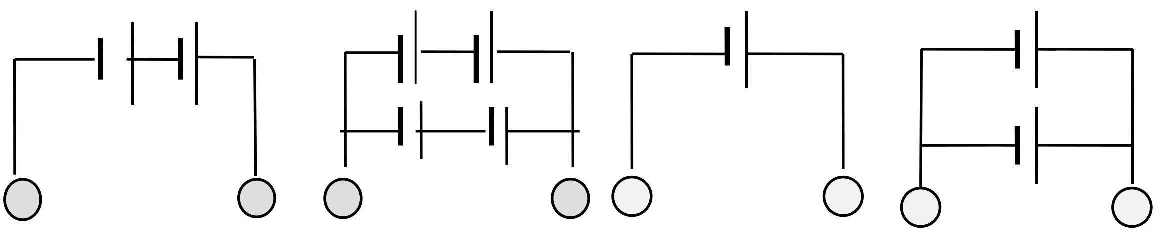
Servicing instructions and further references may be taken from the documentation of the battery manufacturers.

Note:
Standard lead batteries for motor vehicles are not allowed to be used as starter batteries for generating sets within the scope of application of VDE 0108. Nickel-cadmium accumulators or similar batteries are required here for example.

Table: Assignment starter / batteries

Battery cold-start test current and starter motor short-circuit current as a function of the battery and starter motor size at the following temperatures and at 0% battery discharge.

Circuit diagram A | Circuit diagram B with 4 x 88 Ah batteries | Circuit diagram C | Circuit diagram D



24 Volt | 24 Volt | 12 Volt | 12 Volt

Starter-capacity [kW]	**Rated voltage** [Volt]	**Admiss. battery capacity**[Ah] (27°C)**	**Battery cold-start test current** DIN I_{kp} [A](-18°C)	**Starter short-circuit current** I_k [A] (+20°C)* at supply cable resistance 1 [mΩ]	**Circuit diagram of the batteries**	**Min. / max. admissible total resistance** R_{Batt} + $R_{supply\ cable}$ + $R_{return\ cable}$ + $R_{transition}$ [mΩ]
3,0 Bosch EV	12	88 110 143 210 176***= 2x88 225	395 450 570 700 790 680	1420 1420 1560 --- 1750 ---	C C C C D C	3,1 / 4,7 3,1 / 4,7 3,1 / 4,7 3,1 / 4,7 3,1 / 4,7 3,1 / 4,7
4,0 Bosch EV	24	66 88 110*** 170 210 225	300 395 450 600 700 680	1200 1300 1400 1400 1400 1400	A A A A A A	8,4 / 12,0 8,4 / 12,0 8,4 / 12,0 8,4 / 12,0 8,4 / 12,0 8,4 / 12,0
4,8 Bosch IF	24	66 88 110*** 170 210 225	300 395 450 600 700 680	1090 1170 1270 1270 1270 1270	A A A A A A	8,2 / 12,0 8,2 / 12,0 8,2 / 12,0 8,2 / 12,0 8,2 / 12,0 8,2 / 12,0
4,7 MELCO 9CP 47	12	180***	950	1860	D	???
5,5 MELCO 9CP 55	24	180***	950	1900	B	6,6 / 7,2

Note: Missing values were not available at the time of going to print, these will be updated successively.

The highest cold-start test current given in each cable indicates the maximally permissible battery for the corresponding starter motor.

The short-circuit current at a temperature of the battery acid of +20° is taken as a basis for the maximal starter current; this results in the largest cable cross sections.

* The short-circuit current of a starter is a function of the size (cold-start test current), the temperature and the charging condition of the used battery.

** Larger battery capacities should not be used in connection with the individual starter sizes as, otherwise, the starter can become thermally and mechanically overloaded. To avoid this, the supply cable resistance must be selected so that at least the permissible minimum total resistance is reached.

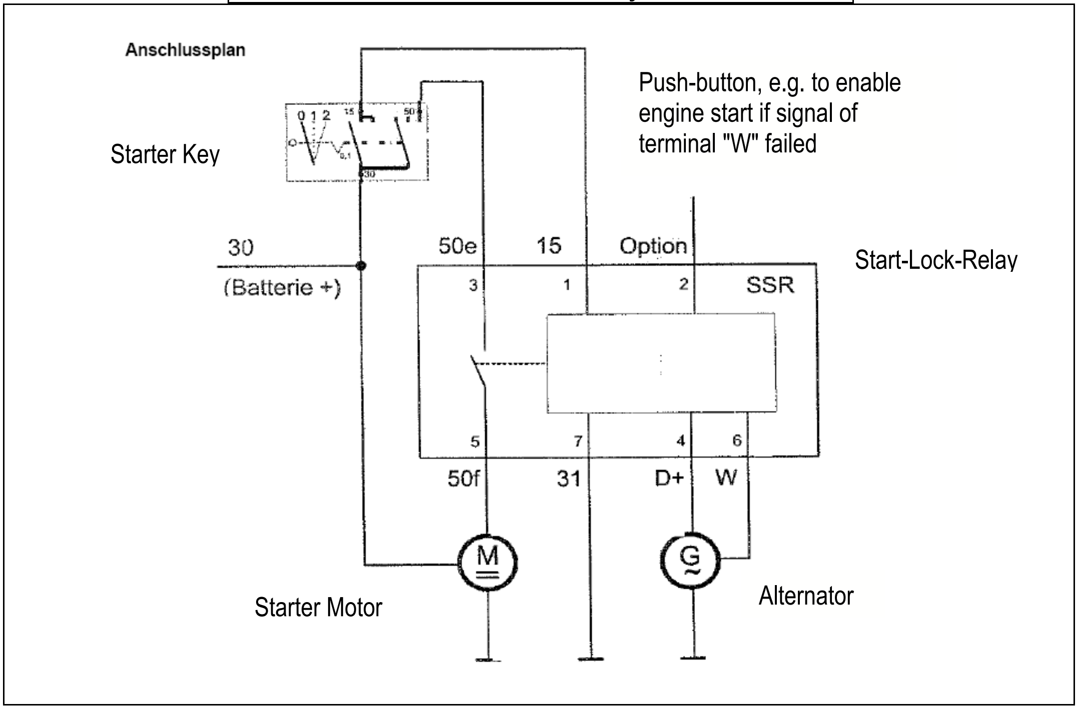
Largest available and common individual battery capacity is 210 Ah/700A.

Note:
If nevertheless larger battery capacities with larger cold-start test current are used than indicated here, larger supply cable resistances are required observing the minimal admissible total resistance from internal resistance of battery and supply cable resistance. If necessary, contact application engineering or the starter manufacturer (Messrs. Bosch, MELCO).

*** This battery capacity is absolutely required, if the max. cold-start limit temperature of the engine (assignment starter – engine type as per pocket book) must be reached. The minimal supply cable resistance of the starter main cable (advance/reverse) with 1 Milliohm (MELCO starter 2mOhm) must be observed.

15.2 Dimensioning of the starter main cable (cable between terminals 30,31 of starter and battery)

Circuit of a starter system with electronic start lock relay



Required rated cross section considering heating up of the cable (minimum cross section)

We recommend determining the required minimum cross section of the starter main cable (between starter and battery) with the maximal short circuit current I_K occurring at the starter to exclude restrictions when selecting the battery.

For classified on-board systems, the following calculation is not admissible. Here, only the specifications of the respective classification society must be observed.

The determination of the minimum cross section by calculation is made considering heating up of the cable at a short-term admissible cable charge of 30 A/mm² taking the following relation as a basis.

$$\mathbf{q} = \frac{I_K}{I_L} = \frac{\mathbf{I_K}}{\mathbf{30}} \ (mm^2) \quad \text{mit}$$

I_K = short circuit current of the starter at +20 °C [A]

I_L = Admissible cable load [A/mm^2]

This minimum cross section **q** must not be fallen below.

Required rated cross section of the starter main cable

For laying out the starter main cable, the total resistance of the system – comprising the line resistances of the supply and return line, transition resistances and the internal battery resistance - must be considered

$$R_{total} = R_{admissible\ line\ supply} + R_{admissible\ line\ return} + R_{transition} + R_{intern.\ battery}$$

Depending on the starter size, a total resistance R_{total} must be observed which is within the specified limits (see quotation drawing to the starter and basic specification of Bosch). Thus, the individual resistances and, consequently, cross sections, batteries and cable lengths can be selected such that the admissible range is observed.

If the minimal total resistance is fallen below, there is the risk of mechanical and thermal damage to the starter.
If the maximally admissible total resistance is exceeded, functional failures and power losses of the starter must be expected (caution in case of busses and ships in view of the long cables).

Among others, power losses of the starter lead to a bad cold starting behaviour of the diesel engine (e.g. not reaching the cold starting limit due to excessively low cranking speed). The starter reaches its highest power at minimally admissible total resistance.

Calculation of the line resistance:

With the minimum cross section (considering the line heating up) calculated before, the line resistances can be determined on the basis of table "copper line cross sections".

Frequently, parts of the body or the frame are used as return line. Here, the same resistance value must be assumed as for the supply line from battery to starter.

If ground return line is selected, it must be particularly made sure that the bridging resistances by ground leads are avoided. The cross section of the ground leads should at least maintain the cross section of the plus line.

Make sure that the ground cable "from battery to ground at diesel engine" is clamped in the close vicinity of the starter (potential restriction).

Calculation transition resistance:

The transition resistances are strongly differing and cannot be calculated on a common basis. Especially in applications with many transitions or when using a battery isolating switch, it is recommended to repeat the measurement.
Approximately, an internal resistance of 0.05 mOhm per interface can be applied.

Calculation battery resistance:

The battery resistance at +20°C is not known, but can be calculated from the cold-start test current I_{KP} indicated on the battery as per DIN 43539 (30sec discharge time, 9V minimal voltage).

For 12V-systems:	$R_{iBatt\ +20°C}$	=	$2400 \times 0{,}687 / I_{KP}$
For 24V-systems:	$R_{iBatt\ +20°C}$	=	$4800 \times 0{,}687 / I_{KP}$

Attention: The formula only applies in connection with a BOSCH starter system!

For MELCO starter systems it is necessary to consult DEUTZ Technical Support at the moment.

Beyond DIN standard, the cold-start test current is often also indicated as per SAE, BCI or DIN EN (10sec discharge time, 7.5V minimum voltage).
According to SAE, BCI and DIN EN 60095-1 (will become DIN EN 50342), the value for the battery resistance is larger by the factor 1.66 than according to DIN 43539. This must be considered in the above equation.

In rare cases, IEC (60 sec. discharge time, 8.4 V minimum voltage) is applied. Here, the conversion factor to DIN 43539 is 1.15.

These data only apply to lead acid batteries.

15.3 Dimensioning of the control line to the starter (from battery via starter switch to terminal 50 at starter)

To secure starter functioning at maximally admissible ambient temperature, the effective supply line resistance R_{max} – determined between battery plus pole and terminal 50 at starter – is permitted to be only within the range given by the manufacturer in his quotation drawing.

The data apply to any operation of the starter.

Dimensioning of the cables is made via recording of individual electrical resistances, contact resistances and individual currents of additional consumers.

The effective control cable resistance determined such must be checked by current and voltage measurements with specified resistances (instead of the picking up relay).

Required rated cross section of the control cable for engines without cable harness as per DEUTZ scope of supply

The rated cross section of the control cable is determined by determining the supply line resistance of the control cable between battery plus pole via starter switch up to terminal 50 (switch relay starter).

The limit values to be observed for the line resistances R_{max} of the control cables are a function of size and type of the starter and may be taken from the respective quotation drawing of the starter manufacturer.

The following values apply to the supply line resistances of the control cable between terminal 50 and the battery plus pole:

Type	Starter motor Power [kW] / Nominal voltage [V]		max. admissible control cable resistance R_{max} in [mOhm] at 100°C	at 120°C
Bosch EV	3,0	12		32
Bosch EV	4,0	24		115
Bosch IF	4,8	24	10*	
MELCO 9CP47	4,7	12	Required minimum cross section of the control cable = 1,5mm², Relay-holding current = 2A	
MELCO 9CP55	5,5	24		

(*) To maintain the temperature-depending functioning limit of 100°C, in the case of the IF-starters the supply line resistances must be limited to 10 mΩ.

Missing values of the MELCO starters were not at present printing available and are gradually completed.

On the basis of the relation

$$R = q_R \times L$$ with L = line length [m]
q_R = spec. line resistance [mΩ/m]

via the resolution according to $q_R = R / L$

the pertaining **rated cross section A[mm²] of the control line** can be determined from the table copper line cross sections:

Required cross section of the control cable for
engines with cable harness as per DEUTZ scope of supply

The portion of the control cable in the cable harness has a line resistance, which must be considered when determining the cross section of the residual length of the control cable.

That means that, from the specified resistance values for the entire control cable, the resistance value R_{Part} of the control cable integrated in the engine cable harness must be deducted.

The result is the line resistance $R_{max,\ residue}$ for determining the cross section of the residual length of the control cable, which the OEM intends to lay.

The line resistances of the control cables in the engine cable harness $R_{part\ control\ line}$ must be obtained from DEUTZ Technical Support.

The theoretical determination of the effective supply cable resistance (control cable):

The effective supply cable resistance between the battery plus pole and terminal 50 on the starter contains:

- All effective line resistances – see table "copper wire cross sections"
- All effective contact resistances through terminal points
- All effective contact resistances through switching elements
- All effective volume resistances through fuses

Currents of consumers which flow through partial sections of the whole line during the starting process must be taken into consideration additionally.

In case of several consumers, if allowed, the individual voltage drops $\Delta U_{1,2,3}$ from the partial currents –added to the individually connected consumers- $I_{1,2,3}$ and the individual line resistances $R_{L1,2,3}$ must be calculated.

It applies: $\Delta U_{1,2,3} = I_{kl50}, I_2, I_3 \times R_{L1,2,3}$ $\Delta U_{tot} = \sum \Delta U_{1+2+3}$

The effective supply cable resistance $R_{+/50}$ is given by the quotient:

$$R_{+/50} = \Delta U_{tot} / I_{kl50}$$

Measuring the effective supply cable resistance in existing cable harnesses

The supply cable resistance of the starter main cable and the control cable can only be measured with sufficient accuracy during the starting process with the actual installation. All additional consumers which may be switched on during the starting process must be switched on. Measurements by means of equivalent resistors have proven too inaccurate.
If required and at a cost, Bosch will carry out such measurements with suitable measuring equipment. Further information about this can be requested from DEUTZ.

15.4 Triggering protection terminal 50

When triggering terminal 50, make sure that the reel-in relay of the starter represents an electro-magnetic component. Therefore, triggering must be protected against inductive disconnection voltage peaks by a suitable protective circuit.
This also applies to starters with additional pilot relay.

This means that between terminal 50 of the starter solenoid switch and the output of the starter key (terminal 50) no additional consumers are permitted to be connected as this can lead to starter defects due to a hindered reeling out – unless a start lock relay e.g. DEUTZ No. 0421 3663 is connected.

For more information see TR 0199-44-1153, 1. supplement or TPI 0138-44-0289.

15.5 Power relay for activating the starter

The control cable to the starter solenoid switch can be connected via a power relay (e.g. Bosch article no. 0332 002 150 / 12Volt and 24Volt).This power relay is then triggered via the starter switch. In this way, the voltage losses of the control cable do no more influence the solenoid switch of the starter and safe reeling in of the starter is made sure.

The relay should be installed near the starter, but not mounted to the engine.

Technical data of a suitable relay:

• Response voltage less than or equal 8Volt	• Switching current about 10% above starting current specification in the starter drawing
• Brief load less or equal 1 sec. about 250A	• Drop voltage between 1.5....4.0Volt

15.6 Start lock relay - see TPI 0199-99-0217c

The start lock relay avoids reeling in of the starter pinion with running engine and, in this way, protects the starter pinion and the girth gear against destruction.

The start lock function can be represented by a separate start lock relay or integrated in the electronic engine control (EMR III).

A start lock relay is always necessary, if upon starting the engine cannot be directly heard or watched or in case of twin engine systems. The relay should be installed in the close vicinity of the starter – but not fastened to the engines – to keep the voltage losses low with a normal cable expenditure.

Install the relay always such that the connections show downwards.

When selecting the time-lag relay, make sure that the start can only be repeated, when the engine is absolutely standing still.

The start lock function must meet the following requirements:

- Locking time after voltage drop at terminal 50 of 6 sec.
- Locking time at the end of the speed signal (W, D, n-pick-up) of 6 sec.
- Locking time after automatic switch-off of the starter by the speed signal of 6 sec.
- Lock start function as long as a speed signal is available.

Admissible ambient temperature for the start lock relay:	-30°C / +70°C

15.7 Dimensioning of various line cross sections

15.7.1 Minimum cross section

For reasons of strength, the cross section of control cables, light cables or supply lines must be at least 1.5 mm².

15.7.2 Dimensionig

When determining line cross sections, the voltage drop and heating up must be considered.

a) Determining the current size I [A] :

From the power requirement of the electrical consumer and the rated voltage, the current size results with:

$$I\,[A] = P\,[Watt] \,/\, U\,[Volt]$$

b) Determining the theoretical line cross section A [mm²] :

With the admissible voltage drop U_{VL} [V] -see table "admissible voltage drops"and the current size I [A] as well as the specific electrical resistance $\rho = 0.0185\ [\Omega\ mm^2/m]$ and the line length L [m], the line cross section is determined as follows:

$$A\,[mm^2] = I \times \rho \times L \,/\, U_{VL}$$

c) Actual line cross section A_w [mm²] :

The line cross section A determined by calculation must be rounded to the next higher value Aw according to table "copper line cross sections".
Cross sections below 1.5 mm² are not admissible!

d) Actual voltage drop U_{VList} [V] :

The following results from the relation under b) together with the actual line cross section:

$$U_{VList} \text{ [V]} = I \times \rho \times L \; / \; A_w$$

e) Checking the current density S [A/mm²] :

To avoid inadmissible heating up of the line, the current density S must be observed.

S < 30 [A/mm²]	Short-term consumers	(e.g. main starter-cable)
S < 10 [A/mm²]	Permanent consumers	(e.g. B+ charge line alternator)

Values for rated cross sections and admissible permanent current upon continuous operation may be taken from table "copper line cross sections".

15.7.3 Line cross-sections for selected consumers

The following line cross sections are only rough reference values; a re-calculation is obligatory. The indicated line lengths comprise plus and minus line.

			Rated cross section mm²
Heater plugs∗	12 V / 4 cyl. engines	Fuse 50 A	up to 5 m: 6
	12 V / 6 cyl. engines	Fuse 70 A	up to 5 m: 10
	24 V / 4 cyl. engines	Fuse 30 A	up to 5 m: 4
	24 V / 6 cyl. engines	Fuse 40 A	up to 5 m: 6
Heating flange	12 V – system	Fuse 125 A	up to 5 m: 25
	24 V – system	Fuse 100 A	up to 7 m: 16
Monitoring systems			1,5
Lifting solenoids / solenoid valves			2,5
Start lock relay	12 V		up to 5 m: 4,0
	24 V		up to 5 m: 2,5
Glow plug (direct injection) Connecting cable from starter switch (or power relay for glow plug.	12 V 24 V		up to 5 m: 6,0 up to 5 m: 4,0
Remote voltage regulator for alternator		D -, D +, DF	up to 5 m: 1,5 up to 5 m: 2,5

∗ Individually, short circuits may occur at individual heater plugs as a consequence of which the electrical line burns through, if it is not fused. As, for engines installed in vehicles or equipment, these lines are combined with lines for the monitoring systems, e.g. in a cable harness, in the most unfavourable case, a cable fire can result. Therefore, we urgently recommend to fuse the electrical lines to the heater plugs.

15.8 Admissible voltage drops:

Type of line	Admiss. voltage drop in plus line		Admiss. voltage drop in total circuit		Remarks
Rated voltage	24 V	12V	24 V	24 V	
Charge line from three-phase generator Terminal B + to battery	0.65V	0.3V	0.8V	0.65V	Current upon rated voltage and rated power
Control cable from three-phase generator to regulator (Terminals D+, D-, DF)	0.2V	0.1V	--	0.2V	At max. exciting current - **see remark 1**
Other control cables from switch to relay, horn etc.	1.0 V	0.5V	2.0 V	1.0 V	Current upon rated voltage

Remark 1: All of the three control cables, if possible, of the same length and resistance.

15.9 Copper line cross sections: (as per DIN ISO 6722, part 3, Insulation of PVC)

Rated cross section [mm²]	**Resistance per meter of line length** [mΩ/m] at + 20 °C	**Diameter** [mm]	**Diameter with isolation** (see remark 5) [mm]	**Admissible permanent current** (see remark 4) **at ambient temperature** **+ 30°C** [A]	**+ 50°C** [A]
0,75	24,7	1,3	2,5 (-)	-	-
1,0	18,5	1,5	2,7 (2,1)	19	13,5
1,5	12,7	1,8	3,0 (2,4)	24	17
2,5	7,6	2,2	3,6 (3,0)	32	22,7
4	4,71	2,8	4,4 (3,7)	42	29,8
6	3,14	3,4	5,0 (5,0)	54	38,3
10	1,82	4,5	6,5 (6,4)	73	51,8
16	1,16	6,3	8,3 (8,0)	98	69,6
25	0,743	7,8	10,4	129	91,6
35	0,527	9,0	11,6	158	112
50	0,368	10,5	13,5	198	140
70	0,259	12,5	15,5	245	174
95	0,196	14,8	18	292	207
120	0,153	16,5	19,7	344	244

Remark 4: as per DIN VDE 0298, Part 4.
Remark 5: smaller outer diameters can be represented with other insulation material (values in brackets for material TPE-E, line 13Y as per DEUTZ works standard 823 600-2, temp.-resistant from -40°C...+150°C, e.g. for engine cable harness).

15.10 Generators and Regulators

- Generators and regulators must be protected against heat radiation and splash water.
- The admissible max. temperature of the generators depends on their design. Generally, for the generators offered within our scopes of supply, the following maximum values apply:

	Housing	**Cooling air temperature**
	BOSCH	BOSCH / ISKRA
Three-phase AC generator	max. + 90 °C	100°C, for short time 110°C
Regulator attached to three-phase AC generator (integrated)	max. + 130 °C*	100°C, for short time 110°C
Overvoltage protection systems	max. + 60 °C	-

* Pick-up point at regulator letter "A" of the word GERMANY (for Bosch systems).

- In case of a high dust development or when the above-mentioned temperatures are exceeded, the cooling air can be sucked from a dust-free and cooler space via air intake sockets of the generators using a hose. However, this room must not be under vacuum pressure.
  The availability is to be inquired over the technical support DEUTZ

Internal width of the hose line:			
Upon sucking from free space:	60 mm ∅	for 55, 80 Amp. Gen.	(Typ K,N)
	70 mm ∅	for 120, 140, 180 Amp. Gen.	(Typ T)

- The attached regulator and the connection terminal can be provided with a protective cap (e.g. against falling rocks).
- We recommend to attach dust-proof generators to avoid the premature wear of the carbon brushes.
- When installing the generator, ensure a good accessibility for resetting the belt tension and possibly required servicing works.
- **Self-exciting of the generator:**
  To ensure self-exciting of the generator, a 3 Watt lamp is required in 14 V and 28 V generators or when using diodes, for example, an appropriate resistor at terminal D+ as a series resistance.
- In the case of **parallel connection of generators**, make sure that regulator types and regulator levels (V) - with temperature compensation – are identical. In case of differing generators or regulator temperatures, the intersection of the characteristic lines can lead to a differing utilisation (service life) of the generators. Sucking in of fresh air avoids this and, moreover, entails a clear increase of the service life of the generator.
  The parallel connection of generators with additional diodes must be avoided.
- When cleaning the generator with water vapour or a high-pressure water cleaner, make sure that the vapour- or water jet is not directed onto or into the generator opening or ball bearing. After the cleaning procedure, the generator should be operated for 1-2 minutes to remove water residues, if any, from the generator.

15.10.1 Three-phase generators (charging balance)

The selection of the generator size depends on the energy requirement of all consumers permanently connected or intermittently connected consumers. Consider that, despite all consumers, always a reserve for charging the battery must be available.

For a 24 Volt system, the current requirement results from the determination of the total electrical power Pelec [kW] required for all consumers.

$$I = P_{elek} / 24 \qquad [A]$$

On the basis of this current value, with the aid of generator characteristic lines, it must be decided, which minimum speed a selected generator must have to cover the current requirement – for characteristic line, see pocket book.

It must be aimed at covering the current requirement of all systems connected permanently or over an extended period of time already upon engine idling operation. This must be made sure by determining the transmission ratio of n-engine / n-generator. It must also be made sure that, upon maximum engine speed, the limit speed value of the generator is not exceeded.

Notes:

The 28V generators are resistant to voltage peaks up to 300V for max. 20 msec.

Voltage peaks from the generator are limited to max. 56V by Zener diodes.

In the case of the voltage-resistant versions or those protected by Zener diodes, voltage peaks can occur in the mains without jeopardising the generator or the governor, e.g. upon emergency operation without battery.
All generators with attached governors included in the DEUTZ scope of supply are protected against overvoltage from the on-board mains.

Increasingly, however, electronic components are connected to the mains. These electronic components are very sensitive to voltage peaks generated by the generator or during switching operations in the mains. Therefore, it is necessary to protect inductive components such as coils, relays or solenoids with a recovery diode or a parallel resistor.

When connecting e.g. the battery cables to the terminal of the three-phase generators, absolutely make sure that the polarities are correctly assigned (alternator B+ to the plus-pole of the battery). Exchanging the polarity by mistakes means short-circuit and destruction of the rectifier elements – the generator is out of function.

In the case of 2-pole generators, generator B- is connected with the minus-pole of the battery.

15.10.2 Dimensioning of the B+ line from the generator (charging line)

Dimensioning of the B+ line (from generator B to battery plus-pole) depends on the maximally admissible voltage loss.

Max. admiss. voltage loss	$\Delta U_{total.}$	= 0,65 V	for 24V-systems with ground connection
		= 0,80 V	for 24V-systems, 2-pole version for supply and return (e.g. for marine-applications)
		= 0,40 V	for 12V-systems with ground connection

With the determined max. current of the generator (see charging balance), with the aid of the specific line resistance $q_{R,}$

$$q_R = R_{charging\ line} / L_{line} = \Delta U_{total} / (I_{charging\ current} \times L_{line}) \quad [m\Omega / m\text{-}line]$$

the required rated cross section can be determined from table "copper line cross sections"

Or the following calculation is directly made:

$$A[mm^2] = \{ I_{charging\ current} [A] \times L_{line}[m] \times \rho[mm^2\Omega/m] \} / \Delta U[V]$$

with ρ = 0,0185

Then, the pertaining line diameter is searched for in table "copper line cross sections".

References:

- The admissible voltage drop of the line (e.g. additional ground line for a flexibly supported generator) from generator B- to ground connection of battery is permitted to be 0.1 V at a maximum.
- In the case of 2-pole insulated generators, the cables from battery plus-pole to B+ at the generator and from B- at the generator to battery minus-pole are permitted to have a maximal voltage drop of 0.8V.
- Maximally admissible length of the charging line at 12 Volt: $\leq$ 5 m; 24 Volt: $\leq$ 15 m

15.10.3 Application and operating conditions for BOSCH compact generators

Bosch issues technical customer documents for using the generators which concern the equipment manufacturer in addition to the engine manufacturer who usually installs the generator.

DEUTZ is unable to test all the requirements according to the BOSCH customer document in the course of an engine installation inspection. The equipment manufacturer is therefore jointly responsible for meeting the requirements of this customer document.

Below you will find the notes on (chapter 2) of the Bosch document, area of application and operating conditions.

(2.1) Area of application, restricted use
All applications (vehicle-engine combinations) for which the generator is released by BOSCH are listed in the appropriate application data sheet.

If the generator is used for other application purposes / in other applications, the customer assumes the responsibility for a correct application.

Therefore the following limited liability conditions apply in this case :

> **We provide a guarantee for the freedom from faults of the products in accordance with the latest state-of-the-art. The guarantee is limited at our discretion either to the acceptance of the material costs for faulty products or the free repair of the faulty product by us.**
> **No further guarantee and liability, especially a liability for direct or indirect consequential damages will be provided or accepted.**
> **In case of product liability claims above and beyond the amount of the material costs for the product causing the damage, the customer will refrain from claiming against us or release us from such claims.**

(2.2) Storage
The generators must be handled properly in every case. They must be stored in a dry, tempered place if necessary.
The product may not fall or be exposed to extraordinary shocks.

(2.3) Mounting and post-assembly position
The mounting conditions and the post-assembly position are part of the release. Changing them later can reduce the function and life of the generator (changed vibration stress, changed position of the water drain holes, etc.). The post-assembly position is documented in the offer drawing or the application data sheet.

(2.4) Electrical connections
The assembly of the cable shoe for connecting the on-board power supply at the B+bolt must be carried out so that a minimum clamping force of 4KN is guaranteed for the whole life of the generator.

The LIC-B and LIE generators have been tested and released with the controller plug K 80224 from Grote & Hartmann. When using other plugs, no guarantee can be provided for consequential damages. Make sure that the cable is suitably supported to absorb any vibrations. See the plug drawing for hints.

Attention:
Switching the battery connections destroys the generator and is therefore not permissible!

Attention:
Disassembly of the battery cable can loosen the generator-side B+nut below it. It is essential to re-tighten the nut in this case. The equipper must ensure that third persons concerned (car repair shops, end customers...) are informed of this in an appropriate manner.

(2.5) Generator drive
The generator is driven by a V-belt or poly V-belt.
The generator is delivered with or without the belt pulley by agreement.

Attention:
If the belt pulley is assembled by the customer, make sure that the tightening torque of the belt pulley nut is kept within the prescribed tolerances. Otherwise there is a danger that the belt pulley fastening will come loose or the rotor be damaged.

The belt should be tightened by a separate tensioning pulley in the interest of a permanently constant belt tension.
The belt can also be tightened by swinging the generator. In this case, the equipper must ensure that third parties (car repair shops, end customers...) are informed of the correct procedure for tightening the belt. On exceeding the maximum permissible belt tension, a sufficient service life of the ball bearings cannot be guaranteed.
The description and calculation of the released belt drive and the pre-tension to be used are documented in the application data sheet.

(2.6) Cooling
The generator is cooled by two internal fans. The cooling medium is air with a low dust content.
The air enters the generator axially from both sides and exits radially.

Attention:
The cool air supply and exhaust of the generator in the vehicle may not be impermissibly obstructed.

Attention:
Adequate cooling of the generator is only guaranteed when the prescribed direction of rotation is observed. The direction of rotation is marked by a direction arrow on the drive bearing plate.

(2.7) Operating conditions
The generator may only be operated with the battery connected. In special cases, emergency operation without the battery is permissible, in which case the life of the generator is specially limited.

(2.8) Foreign body and splash water protection
Foreign body and splash water protection of the generator comply with degree of protection IP54K (9K) in accordance with DIN 40050, part 9, Edition May 1993; touch protection cannot be used because the belt drive and the connection terminals are not protected on the generator side.

Attention:
When using high pressure cleaners, make sure that the maximum permissible loads (see test "High pressure/steam jet cleaning at generator standstill") are not exceeded. Stressing of the generator above and beyond this can considerably reduce the life of the ball bearing. The equipper must ensure that car repair shops and end customers are reasonably informed.

(2.9) Maintenance
The generator is maintenance-free. Function testing and repairs must be carried out exclusively by authorised departments.

15.11 Electronic engine equipment

15.11.1 General

The functional capability, reliability and endurance of electronic / electrical components or systems depends to a very large extent on their installation and their handling and care.

The life endurance of electronic / electrical components depends among other things on the ambient temperature which is why the permissible application temperature range is always defined. It should be noted here that continuous operation of the component at the upper limit of a given temperature range is permissible but will ultimately lead to a reduction in the service life.

The electromagnetic compatibility (EMC) of the electronic components is guaranteed by their design in accordance with ISO 7637, ISO 11451, ISO 11453 or DIN 40839 (part 1 to 4) or VDE 0879 (part 1 to 3).

The design of the electrical wiring, the quality of the cables and their electrical connections are significantly important for the function of the electronic devices because they are the main source of interference.

The wiring of the electronic devices is not part of the installation regulation but part of the drawing documents in the technical pocket book. Such drawings with the detailed specifications, e.g. pin assignments of the plugs must be taken from the documentation literature of the individual electronic systems which can be requested from DEUTZ Technical Support if required.

Note:
The FCU must be supplied constantly with power by the engine control unit when the engine is turning over. Special attention must be paid to this especially during starting and during engine stop, i.e. the power supply must also exist during run-out of the engine.

This functionality is implemented accordingly in the BOSCH control units EDC 16 and EDC 7 because the switch-off procedure is only initiated there when the engine speed is virtually zero.

In the EMS control unit, a fixed lag time of 6-7sec. is used. In applications with large inertia masses, it should be checked here whether the lag time is sufficient.

You should generally make sure that any existing vehicle or equipment control units which are superior to the engine control unit supply power to the engine control unit for a sufficiently long time.

15.11.2 Installation and handling instructions

The specifications for installation and handling of the electronic engine control are contained in the installation regulation named below, 5th edition of October 2005:

Installation regulations for installing electronic systems in DEUTZ diesel engines
Order no. 0399 1990/5 (German) or 0399 1991/5 (English)

15.11.3 Engine monitoring

The engine is monitored by the electronic engine control. Sensors and cable harness up to the engine control unit are delivered by DEUTZ. See the aforementioned installation regulation for installation instructions.

15.11.4 Cold start aid

The engines are equipped with **heating plugs** as a standard cold start aid.
By pre-heating of the heating plugs in the combustion chamber of the diesel engine, these guarantee a reliable cold start on the one hand and, on the other hand, the emissions of the still “cold running” diesel engine are positively influenced by the post-heating of the heating plugs (e.g. avoidance of white smoke, noise reduction). The appropriate circuit diagrams must be observed as regards the wiring.

Depending on the engine version, a **heating flange**, mounted in front of the engine charge air pipe, can be used as a cold start aid. For information about the wiring and the heating flange application, see the circuit layout and the technical product information 0199-63-0206.

Both devices are controlled by the electronic engine control unit.

16. ACCESSIBILITY FOR SERVICING AND MAINTENANCE JOBS, START-UP PROCEDURE

16.1 General

A correct installation must not only meet the technical requirements but also ensure an easy access to parts requiring maintenance work.

If this accessibility is not given, there is always the risk that the necessary maintenance jobs are not carried out at all or not at the specified intervals. This will necessarily lead to increased wear and premature failure of the engine.

The self-adhering servicing pictures (also see operating manuals) with the references to the engine servicing works or filter changing works must be stuck at a well-visible place within the working area of the operating staff.

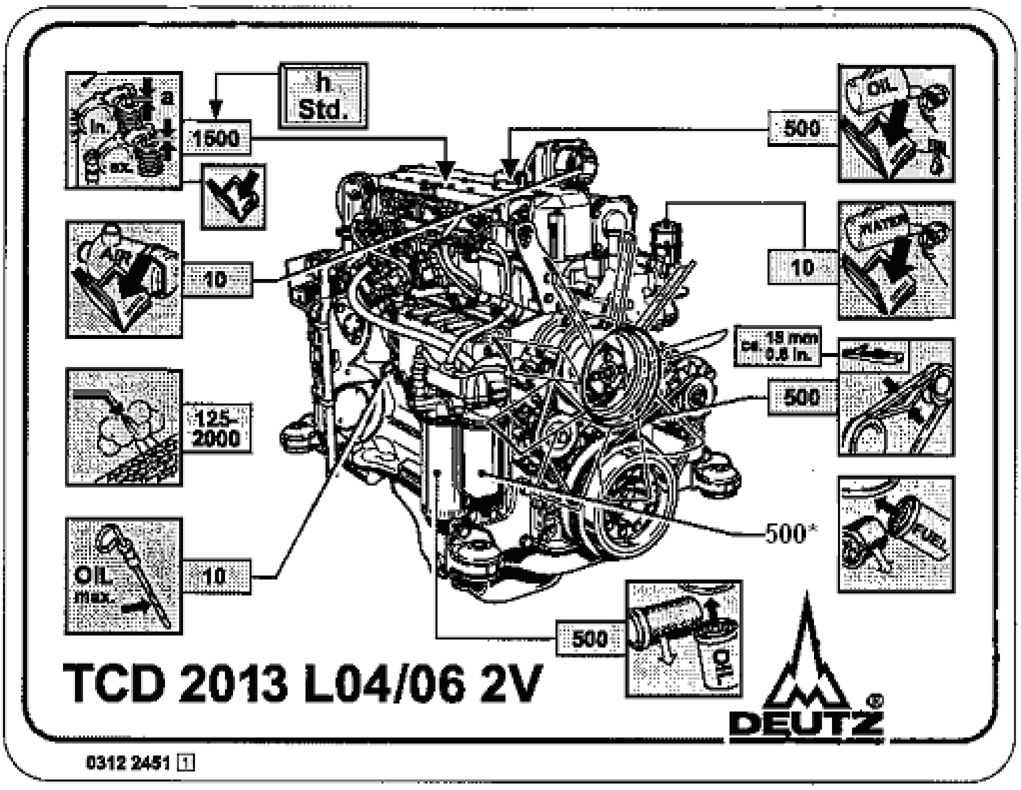
16.2 Maintenance jobs requiring easy and convenient access

Maintenance jobs which should be carried out with direct access wherever practicable, i.e. without having to remove parts or plates and without having to overcome other kinds of access problems:

- Checking oil level in engine
- Engine oil change
- Cleaning fuel pre filter (draining water)
- Renewing lube oil filter and fuel filter cartridges
- Checking and cleaning air filter
- Cleaning cooling system
- Checking V-belt tension
- Battery servicing works
- Breathing fuel pipes
- Checking cooling water level.

Example of a maintenance sticker

FIGURE 16 - 1



* Maintenance interval dependent on the filter size, with double-filter according to standard   2 x 1,4ltr. = 1000Bh

16.3 Maintenance jobs not requiring easy access

Maintenance jobs which should be carried out with direct access wherever practicable, i.e. without having to remove parts or plates and without having to overcome other kinds of access problems:

- Checking alternators and regulators
- Checking starter
- Checking injection pump
- Setting valves
- Checking and renewing injectors
- Cleaning exhaust gas turbocharger
- Coolant change.

16.4 Engine commissioning:

Venting the fuel system:

On long fuel suction pipe, wet the inner parts of the fuel hand supply pump with fuel to guarantee an immediate suction effect of the manual supply pump.

Unlock the bayonet connection of the hand supply pump by turning to the left.

In pre-filter with thermostat valve, turn the shutoff lever clockwise until it snaps in.

Pump until you feel a strong resistance, then pump a few more times.

Turn the actuating lever of the thermostat valve back anticlockwise until it is standing vertical again.

Lock the bayonet catch of the hand supply pump by turning clockwise.

Start engine, maximum starter running time 30 sec. Note recovery times, see chapter 15, Electrics.

After the engine has been started, higher load applications should be avoided for the first 5 minutes, the engine may only be operated at idle speed or with low load. Reason: Possible air in the high pressure system leads to impermissible pressure fluctuations.

Note:

The low pressure system should be filled up to behind the FCU for fast starting. The return pipe can be released from the FCU slightly to check the return pipe.

The fuel main filter may never be pre-filled with unfiltered fuel.

Fuel pipes after the main filter (except return) may not be opened.
The high pressure pipes especially may not be opened because here permanent pressure from the rail is applied, danger of injury!

When venting with an electric fuel supply pump, the pressure on the fuel system may not exceed 6 bar. About 5 sec. filling time are usually sufficient.

Note on the fuel control unit (FCU):

The FCU must be supplied constantly with power by the engine control unit when the engine is turning over. Pay attention to this especially during starting and during engine stop, i.e. the power supply must also exist during the runout time.

It should generally be ensured that any existing vehicle or equipment control units which are superior to the engine control unit supply the engine control unit with power for a sufficiently long time.

17. ANNEX

17.1 Calculation formulae for internal combustion engines

Exhaust gas volume flow rate:

In the pocket book, the exhaust gas volume flow rate M [kg/h] is indicated related to 25 °C. To determine the actual volume flow rate V_W, the first "cold" volume flow rate V_K is ascertained:

$V_K = M / \rho$ [m³/h] with M [kg-exhaust/h] from pocket book
ρ [kg-exhaust/m³] = 1.18

The actual volume flow rate V_W is calculated with the aid of the exhaust gas temperature "t" at the respective power – see engine map – neglecting the influence of pressure:

$$V_W = V_K \times (273 + t) / 298 \quad [m^3/h]$$

Swept volume:

$$V_H = (\pi \times D^2 \times s \times z) / 4 \times 10^6 \quad [ltr]$$

V_H	=	Swept volume	[ltr]
D	=	Bore diameter	[mm]
s	=	Stroke	[mm]
z	=	Number of cylinders	
π	=	3.12 for German swept volume	

Piston speed:

$$c_m = s \times n / 30000 \quad [m/s]$$

c_m	=	Mean piston speed	[m/s]
s	=	Stroke	[mm]
n	=	Engine speed	[1/min]

Circumferential speed

$$c_U = r \times (\pi \times n) / 30 \quad [m/s]$$

c_U	=	Circumferential speed	[m/s]
r	=	Radius	[m]
n	=	Speed	[1/min]

Power/torque

Old units

$$N = V_H \times p_e \times n / 900 \quad [PS]$$

$$T_d = 716{,}2 \times N / n \quad [kpm]$$

SI-units

$$P = V_H \times p_{me} \times n / 1200 \quad [kW]$$

$$T = 9550 \times P / n \quad [Nm]$$

N	=	Power	[PS]	P	=	Power	[kW]
V_H	=	Swept volume	[ltr]	V_H	=	Swept volume	[ltr]
P_e	=	Mean effect. pressure	[kp/cm^2]	p_{me}	=	Mean effec. pressure	[bar]
n	=	Engine speed	[1/min]	n	=	Engine speed	[1/min]
T_d	=	Torque	[kpm]	T	=	Torque	[Nm]

18.2 Formal connections concerning fans and coolant pumps

The centrifugal pumps used as coolant pumps on DEUTZ diesel engines and the fans are fluid flow engines and, as such, are subject to the same physical laws.

For the calculation of the volume flow rates, pressures and the power requirement at different speeds, the following equations apply.

Volume flow rate:	$V_1 = n_1 \times V / n$	[m³/min]

Delivery head:	$\Delta p_1 = (n_1 / n)^2 \times \Delta p$	[mbar]

Power requirement:	$P_1 = (n_1 / n)^3 \times P$	[kW]

Torque:	$T_1 = (n_1 / n)^2 \times T$	[Nm]

Where:

n = Speed of coolant pump or of fan [1/min]

Δp = Pressure difference between suction- and delivery side [mbar]

P = Power requirement in [kW] at speed n

T = Torque requirement in [Nm] at speed n

$_1$ = Index 1 (condition 1)

17.3 Checklist for inspection of starter motor system

Cable laying, cable dimensioning, cable connection:

Main cable (to terminal 30) and control cable (to terminal 50) have to be routed in that way that they do not come into contact (prevent short circuit)
The cables have to be fixed approx. 200 - 300mm after starter motor connection for the first time.
At terminal 50 only the control line to starter motor coming from a relay or from starter switch is allowed. Additional electrical consumer e.g. relays have to be connected at terminal 45.

The permitted resistance of control cable (terminal 50) and battery main cable (terminal 30) can be rough calculated with cross section, cable length (incl. ground cable, if available) number of transitions (add per transition 0,05mOhm).
For the starter motor the permitted total resistance is cable resistance plus battery internal resistance. Admissible values see starter drawing or installation guide line.

Power relay for activating starter:

This relay should be similar to Bosch relay 0 332 002 150, the following data should be checked:

- Switch-on voltage lower than 8Volt
- admissible electrical power 10% over value on starter motor drawing, e.g. HE starter 60Amps, relay min 66Amps.
- for short time (under 1 sec.) 250Amps must be permitted
- relay should be switched off when voltage is between 1,5 to 4,0V.

Start blocking relay:

A minimum waiting time of 5 (6) sec. must be observed

- after the drop of signal of terminal 50
- after drop of signals of "W", "D", "n"
- after starter has been switched off by speed signal

Start function must be blocked as long a speed signal occurs.

17.4 Engine coolant

Technical Circular 0199-99-1115

Delivery specification coolants H-LV 0161 0188 US 8039-40

17.5 Engine lube oil

Technical circular 0199 – 99 – 1119

Technical circular 0199 – 99 – 3002

17.6 Fuel

Technical circular 0199 – 3005