1. Gas Genset

◆ Gas Genset data

CCETC- Genset data sheet

Technical data
989 kWel ; Natural gas, MN = 80

AntEnergy Ltd

Design conditions		
Inlet air temperature / rel. Humidity:	[°C] / [%]	25 / 60
Altitude:	[m]	100
Exhaust temp. after heat exchanger:	[°C]	120
NO_x Emission (tolerance - 8%):	[mg/Nm³ @5%O_2]	500

Fuel gas data: [2]		
Methane number:	[-]	80
Lower calorific value:	[kWh/Nm³]	10,17
Gas density:	[kg/Nm³]	0,79
Standard gas:	Natural gas, MN = 80	

Genset:		
Engine:	**MWM TCG 3016 V16**	
Configuration code:	[-]	S
Speed:	[1/min]	1500
Configuration / number of cylinders:	[-]	V / 16
Bore / Stroke / Displacement:	[mm]/[mm]/[dm³]	132 / 160 / 35
Compression ratio:	[-]	11
Mean piston speed:	[m/s]	8
Mean lube oil consumption at full load:	[g/kWh]	0,1
Generator:	**LEROY-SOMER LSA 52.2 ZL60**	
Voltage / voltage range / cos Phi:	[V] / [%] / [-]	10500 / ±5 / 1
Speed / frequency:	[1/min] / [Hz]	1500 / 50

Energy balance				
Load:	[%]	**100**	**75**	**50**
Electrical power COP acc. ISO 8528-1:	[kW]	**989**	**740**	**489**
Engine jacket water heat:	[kW ±8%]	557	423	307
Intercooler LT heat:	[kW ±8%]	77	50	27
Lube oil heat:	[kW ±8%]			
Exhaust heat with temp. after heat exchanger:	[kW ±8%]	603	490	359
Exhaust temperature:	[°C ±25°C]	469	498	524
Exhaust mass flow, wet:	[kg/h]	5633	4199	2870
Combustion mass air flow:	[kg/h]	5442	4052	2767
Radiation heat :	[kW ±8%]	33/39	25/31	21/25
Fuel consumption:	[kW+5%]	2455	1876	1313
Electrical / thermal efficiency:	[%]	40,3 / 47,3	39,4 / 48,6	37,2 / 50,7
Total efficiency:	[%]	87,5	88,1	88,0

System parameters [1]		
Ventilation air flow (comb. air incl.) with ΔT = 7K	[m³/h]	50000
Combustion air temperature minimum / design:	[°C]	15 / 25
Exhaust back pressure from / to:	[mbar]	30 / 50
Maximum pressure loss in front of air cleaner:	[mbar]	5
Zero-pressure gas control unit selectable from / to: [2]	[mbar]	20 / 200
Pre-pressure gas control unit selectable from / to: [2]	[bar]	0,5 / 10
Starter battery 24V, capacity required:	[Ah]	286
Starter motor:	[kWel.] / [VDC]	9 / 24
Lube oil content engine & extension / clean oil tank:	[dm³]	330 / 210
Dry weight engine / genset:	[kg]	3090 / 10300

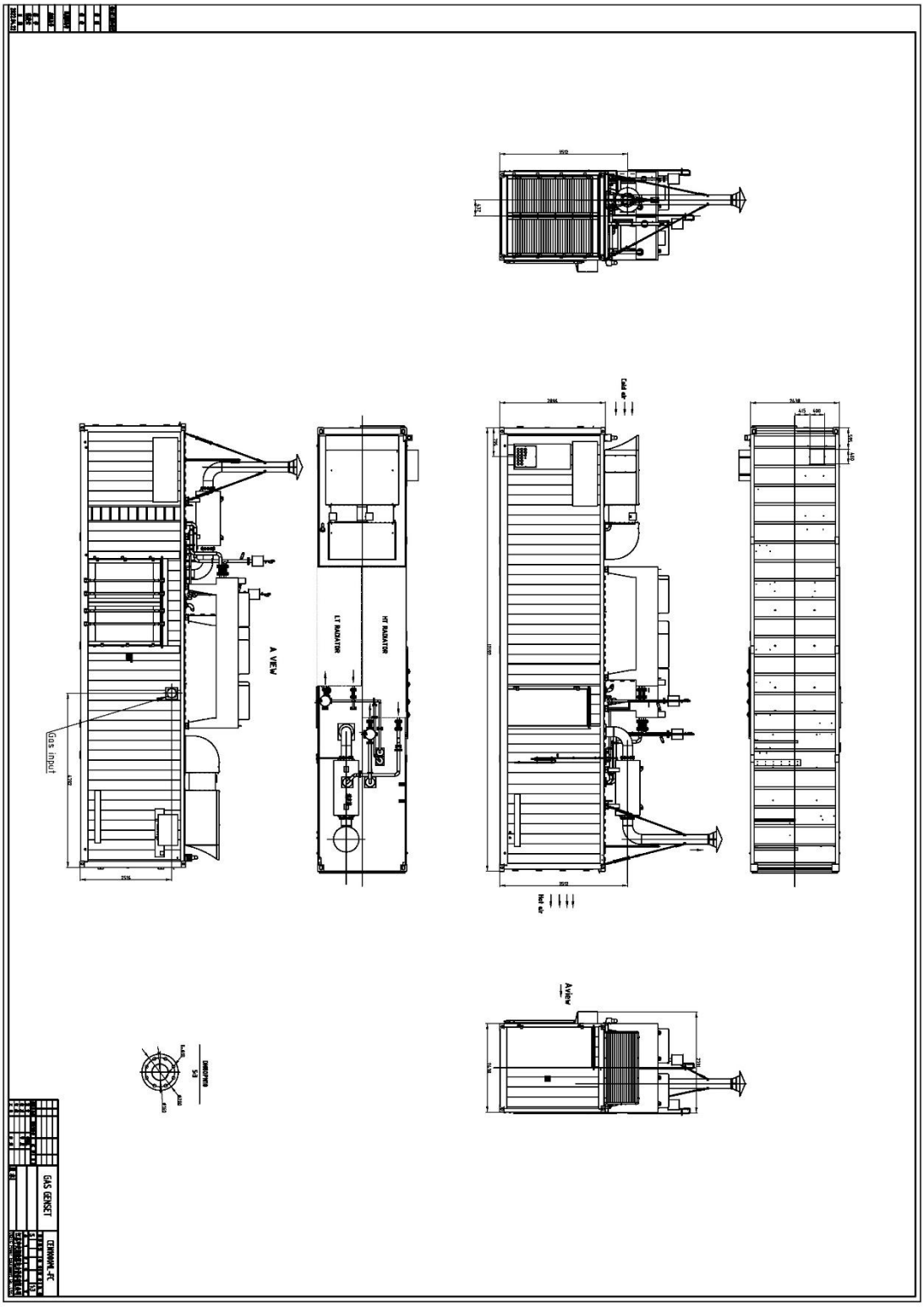
Cooling system		
Glycol content engine jacket water / intercooler:	[% Vol.]	35 / 35
Water volume engine jacket / intercooler:	[dm³]	56 / 5
KVS / Cv value engine jacket water / intercooler:	[m³/h]	29 / 14
Jacket water coolant temperature in / out:	[°C]	78 / 89
Intercooler coolant temperature in / out:	[°C]	45 / 51
Engine jacket water flow rate from / to:	[m³/h]	35 / 50
Water flow rate engine jacket water / intercooler:	[m³/h]	47 / 12
Water pressure loss engine jacket water / intercooler:	[bar]	2,6 / 0,8

1) See also "Layout of power parts" 2) See also Techn. Circular 0199 99 3011

Frequency band f [Hz]	25	31,5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1,25k	1,6k	2k	2,5k	3,15k	4k	5k	6,3k	8k	10k	12,5k	16k	L_{WA} [dB(A)]	S [m²]
Air-borne noise [3] $L_{W,1m}$ [dB(lin)]	87,8	85,6	87,1	96,3	108,1	108,2	115,2	107,4	112,1	104,6	103,9	107,4	102,5	102,1	100,7	102,4	102,1	101,1	101,3	100,2	100,0	101,3	103,4	109,2	111,2	115,5	99,1			118,4 ±4dB(A)	
Exhaust noise [4] $L_{W,1m}$ [dB(lin)]	113,0	114,7	129,4	123,0	122,1	133,4	141,1	132,3	127,7	123,5	124,6	122,6	121,6	122,0	123,0	123,8	122,1	119,2	118,6	120,3	118,0	118,0	116,1	121,0	116,2	113,4	112,8	112,2	110,7	132,4 ±3dB(A)	15,2 [5]

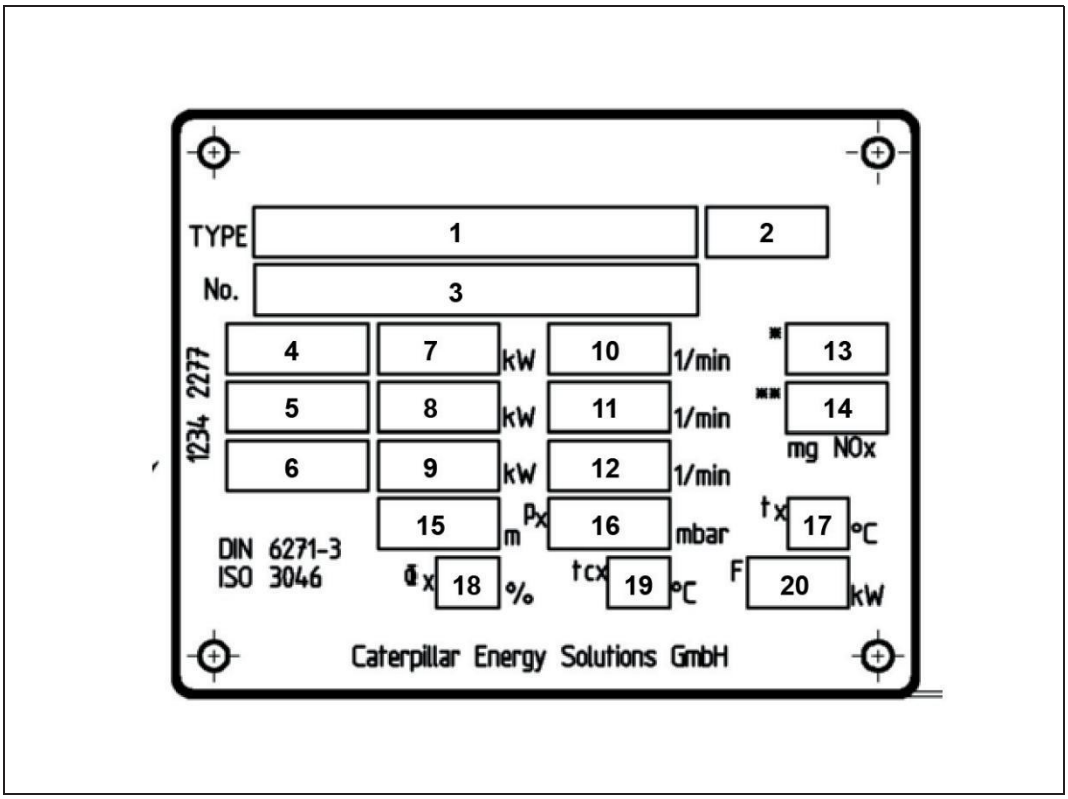
2) DIN EN ISO 9614-2 (grade: dB) 4) Measured in exhaust pipe (f < 250Hz: ±5dB; f > 250Hz: ±2dB; L_W: Sound power level S: Area of measurement surface (S_0=1m²) 5) DIN 45635-11 Appendix A

◆ Gas Genset Overview



2. TCG 3016 Engine

◆ Rating plates



1 Designation of engine design
2 Year of construction
3 Engine number
4 Power code according to DIN ISO 3046 Part 7 and power code for the gas type
⇒Section References to the power codes
5 Like position 4
6 Like position 4
7 Power (kilowatts)
8 Like position 7
9 Like position 7
10 Engine speed (revolutions per minute)
11 Like position 10
12 Like position 10
13 Nitrogen oxide emission (milligram)
14 Like position 13
15 Maximum installation height (meters)
16 Air pressure at the installation location (millibar)
17 Charge air coolant temperature at the installation location (degree Celsius)
18 Relative humidity at the installation location (percent)
19 Mixture coolant temperature at the installation location (degree

Celsius)

20 Lube oil pump power (kilowatts)

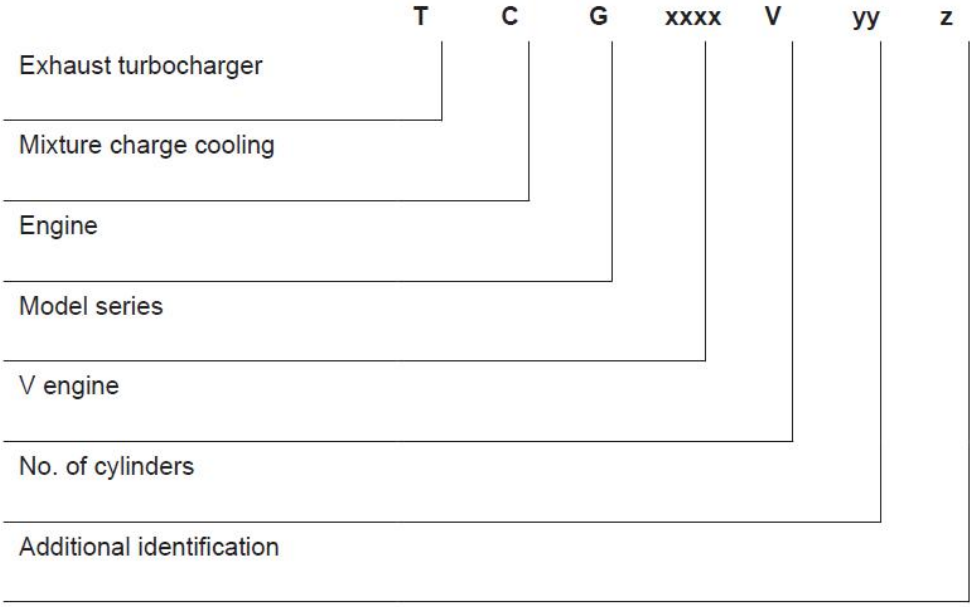
Information on power codes

The following power codes are valid:

b = Biogas
n = Natural gas
s = Sewage gas
l = Landfill gas
m = Mine gas
p = Propane gas

The symbols ∗ or ∗∗ before the power code refer to the corresponding nitrogen oxide emission; refer to positions 13 and 14.

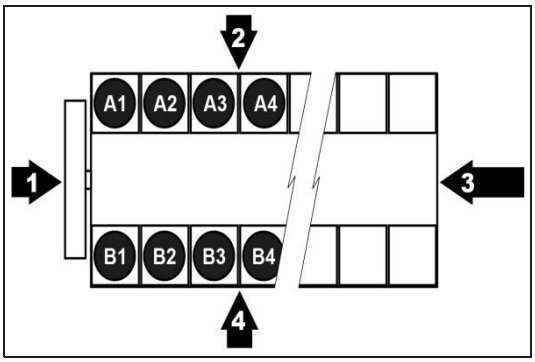
Engine type designation



◆ Engine

● Designations used

➢ Designation of engine sides



1 Drive-end (flywheel side or coupling side)
2 Left side (cylinder side A)
3 Free side (face side or opposite side of the coupling)
4 Right side (cylinder side B)

Binding terms are used for the engine sides in this document. The terms correspond to the defined designations from the guideline DIN ISO 1204.

● Designation for direction of engine rotation

Viewed from the drive end, the engine rotates counterclockwise.

● Cylinder designation

Every cylinder has an alphanumeric code. The cylinder counting starts from the drive-end on each engine side.

The first cylinder on the left engine side has the code A1. The first cylinder on the right engine side has the code B1. The cylinders are counted successively on each engine side.

● Engine Assembly overview

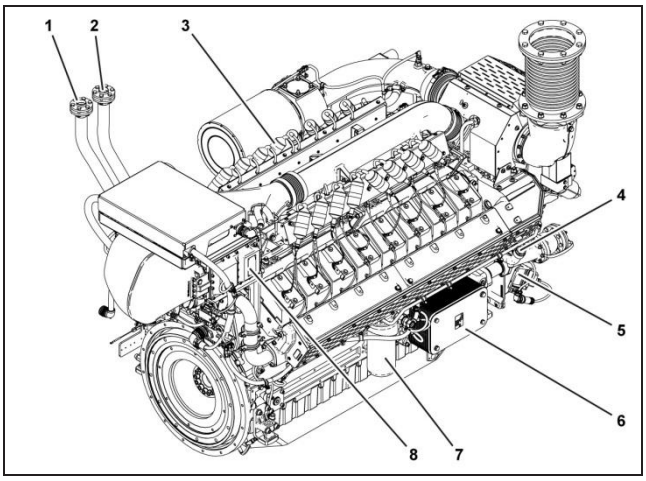


Figure V16 right side; V12 similar

1 Coolant inlet (mixture cooling circuit)
2 Coolant outlet (mixture cooling circuit)
3 Ignition coil
4 Filler nozzle lube oil
5 Actuator with wastegate
6 Lube oil cooler
7 Lube oil filter
8 Mixture cooler

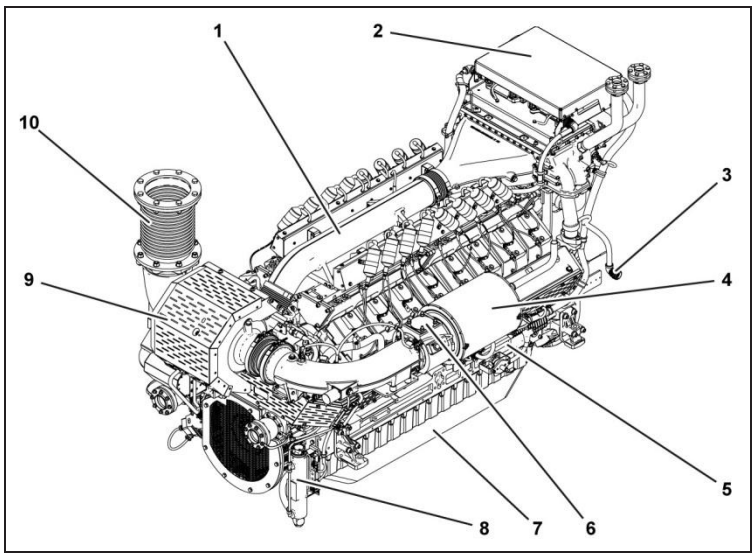


Figure V16 right side; V12 similar

1 Mixture pipe
2 Structure with control devices
3 Engine connector
4 Intake air filter
5 Starter
6 Gas-air mixer
7 Lube oil tray
8 Lube oil level sensor
9 Exhaust turbocharger
10 Exhaust expansion joint

- **Functional description**

  The engine is a liquid-cooled four-stroke gas engine. The gas type depends on the location and operational area of the engine. The permissible gas type is indicated on the rating plate of the engine.

◆ Engine components

● Crankcase

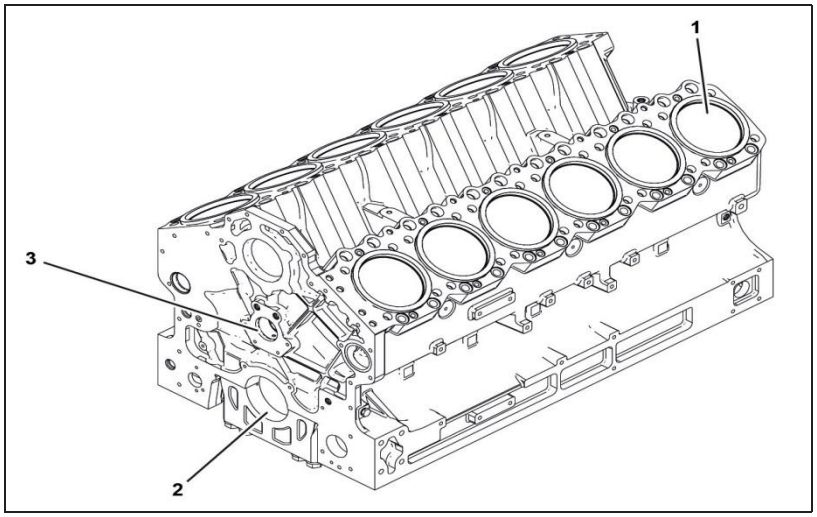


Figure V12; V8 and V16 similar

1 Bore for cylinder liner
2 Bore for crankshaft
3 Bore for camshaft

The crankcase is the central component of the engine. The crankcase is used to accommodate:

Cylinder liners
Camshafts
Mechanical engine control

● Crankshaft drive

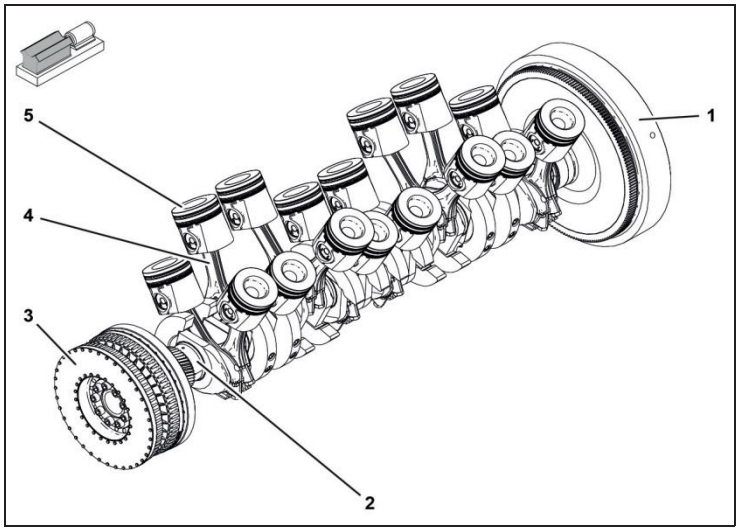


Figure V12; V16similar

1 Flywheel
2 Crankshaft
3 Torsional vibration damper

4 Con-rod
5 Piston

The crankshaft drive is installed in the crankcase. The crankshaft drive converts the linear motion of the pistons into a rotary motion of the crankshaft.

- **Mechanical engine control**

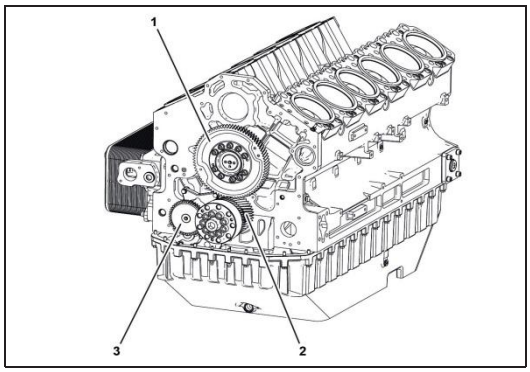


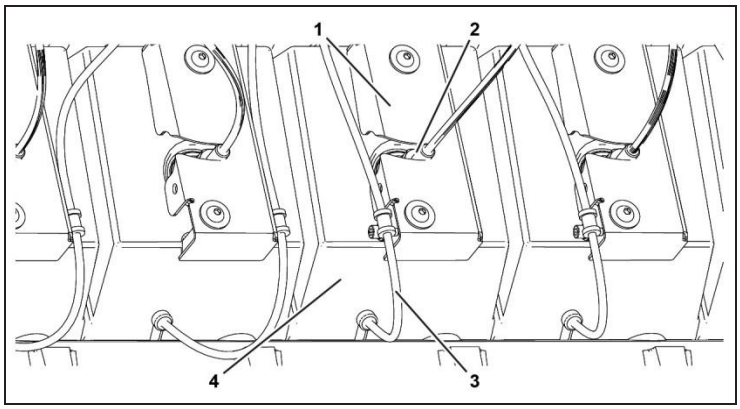
Figure V12; V8 and V16 similar

1 Camshaft gear wheel
2 Crankshaft
3 Lube oil pump gear wheel

The mechanical engine control consists of the gear train and valve control. The mechanical engine control is installed on the free side (opposite side of the clutch).

The camshaft is mounted in replaceable bearing liners in the crankcase. The camshaft controls the inlet valves and outlet valves in accordance with the ignition sequence. The inlet valves and outlet valves are activated via tappets, push rods and rocker arms ⇒ Chapter Valve control.

- **Cylinder head**



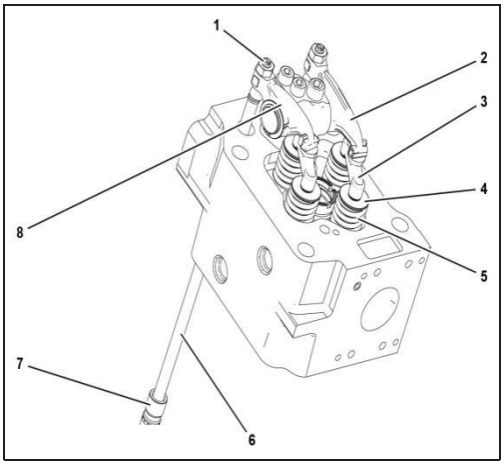
1 Spark plug cover

2 Spark plug
3 Combustion chamber temperature sensor cable
4 Cylinder head cowling

Every cylinder head is mounted as an individual cylinder head. The cylinder head closes the combustion chamber of the engine. The cylinder head contains the inlet ducts and outlet ducts for the fuel gas and valve control.

The spark plug is screwed into the cylinder head, which is connected to the ignition coil via an ignition cable. A spark plug cover is mounted over the spark plug. The cylinder heads are liquid-cooled.

- **Valve control**

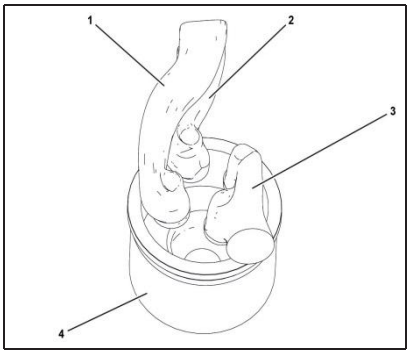


1 Setting screw for valve clearance
2 Outlet rocker arm
3 Valve crosshead
4 Spring plate
5 Valve spring
6 Push rod
7 Tappet
8 Inlet rocker arm

The cylinder heads are multi-valve heads. Two inlet valves ensure an optimum filling degree per cylinder. Two outlet valves enable a quick exhaust gas leak.

The camshaft moves the push rods linearly. The push rods route the linear movement to the rocker arm. The rocker arms press the valve crossheads. One valve crosshead activates both inlet valves and one valve crosshead activates both outlet valves.

- **Duct layout**



1 Swirl duct
2 Filling duct
3 Outlet duct
4 Cylinder liner

The cylinder heads are designed according to the cross flow principle. Here, the inlet and outlet ducts are arranged tangentially opposite each other. All the ducts are aligned perpendicularly on the piston top.

The gas-air mixture is supplied to the cylinder heads by two inlet ducts. The outlet ducts discharge the fuel gases from the cylinder head. The outlet ducts converge into one single duct and guide the fuel gases into the exhaust system.

- **Speed control and power control**
  - **Speed control**

Speed is regulated by the electronic control. A speed sensor detects the actual speed. The electronic control compares the actual speed with the preset target speed. The electronic control compensates for speed deviations by adjusting the actuator. The actuator adjusts the throttle valve. The throttle valve affects the engine.

Load changes of the consumers cause speed changes. As long as the load changes of the consumers are small enough, the speed changes caused by them are completely compensated for by the electronic control.

An external target speed specification can influence the engine speed in island mode and the power in mains parallel mode.

- **Throttle valve with actuator**

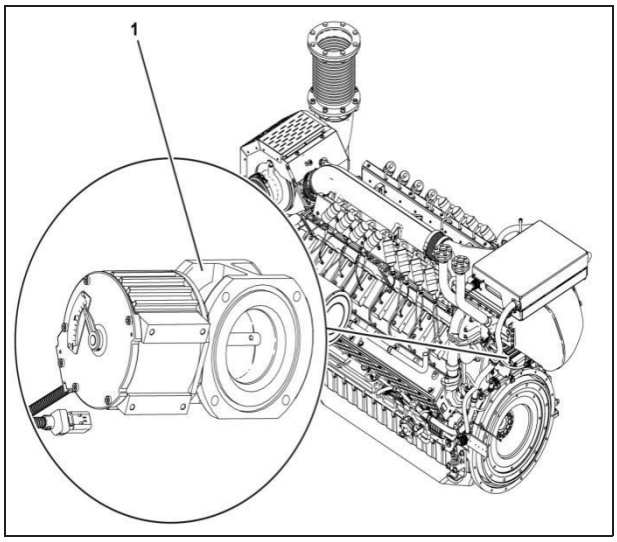


Figure V12; V8 and V16 similar

1 Throttle valve with actuator

The engine is equipped with a throttle valve. The actuator controls the throttle valve. The actuator has the following properties:

High adjusting forces which act in both directions
Low current consumption
Not sensitive to a slow change in voltage of the power supply

Sudden, abrupt voltage changes in quick succession can lead to controller malfunctions

A DC motor works in the actuator. The DC motor transmits the torque to the controller output shaft via an intermediate transmission. The position of the controller output shaft on the feedback cams is gauged without contact by a sensor and transmitted to the electronic control system.

- **Intake air system**

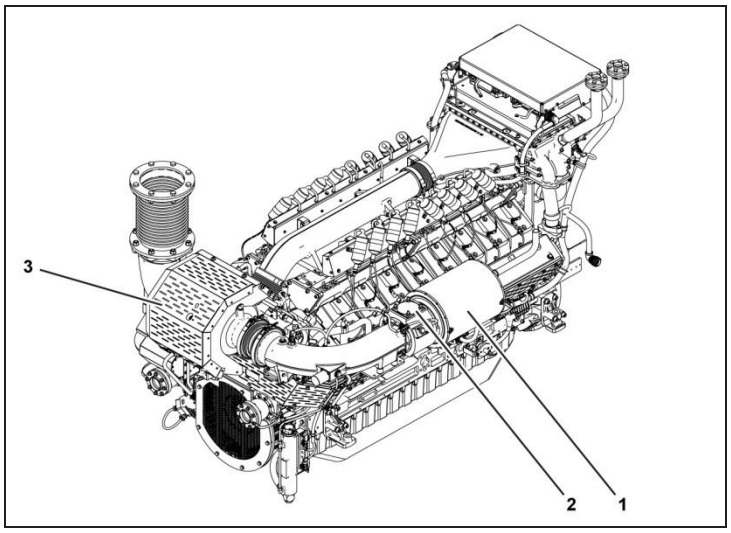


Figure V16; V12 similar

1 Intake air filter
2 Gas-air mixer
3 Exhaust turbocharger

Clean, filtered intake air enters the gas-air mixer via the intake air filter. The intake air is mixed with the fuel gas in the gas-air mixer. The exhaust turbocharger draws in the gas- air mixture.

- **Exhaust system**

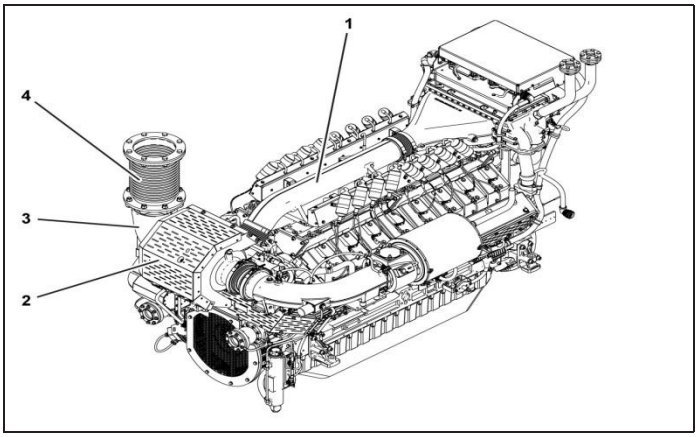


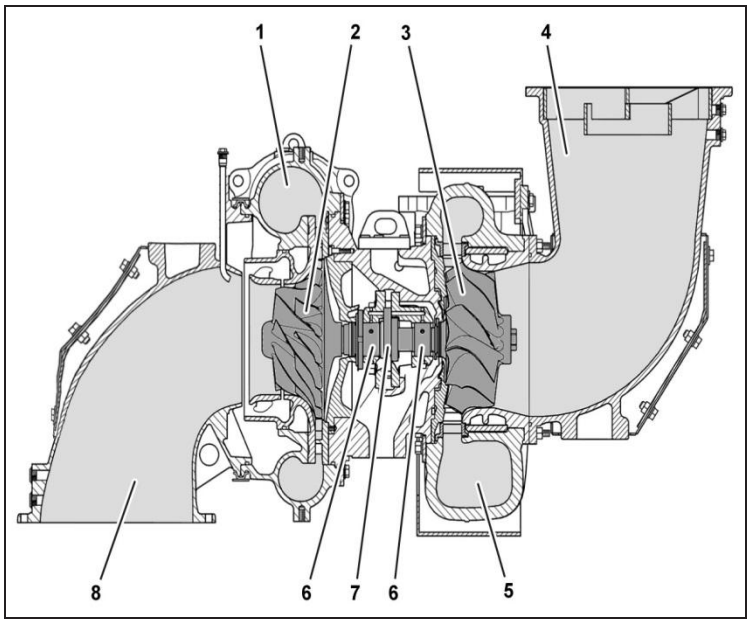
Figure V16; V12 similar

1 Mixture pipe from exhaust turbocharger to mixture cooler
2 Exhaust turbocharger
3 Exhaust manifold downstream of turbine
4 Exhaust expansion joint

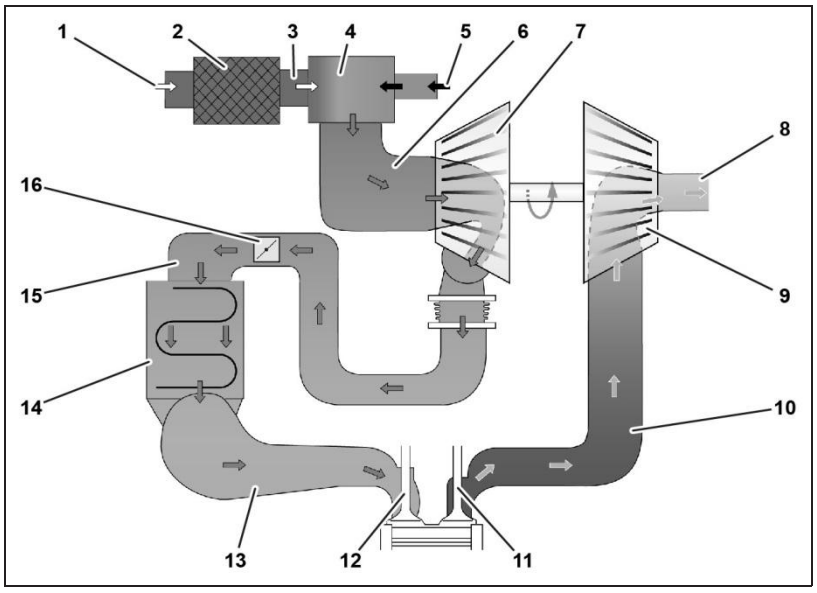
Exhaust gas is produced during the combustion of the gas-air mixture. The exhaust system guides the exhaust gas from the cylinders into the atmosphere via the exhaust line and exhaust turbocharger. The exhaust turbocharger is connected to the exhaust line via an exhaust

expansion joint.

- **Exhaust turbocharger**



1 Gas-air mixture outlet
2 Compressor wheel
3 Turbine wheel
4 Exhaust gas outlet
5 Exhaust gas inlet
6 Journal bearing
7 Thrust bearing
8 Gas-air mixture inlet



1 Intake air
2 Intake air filter
3 Filtered intake air

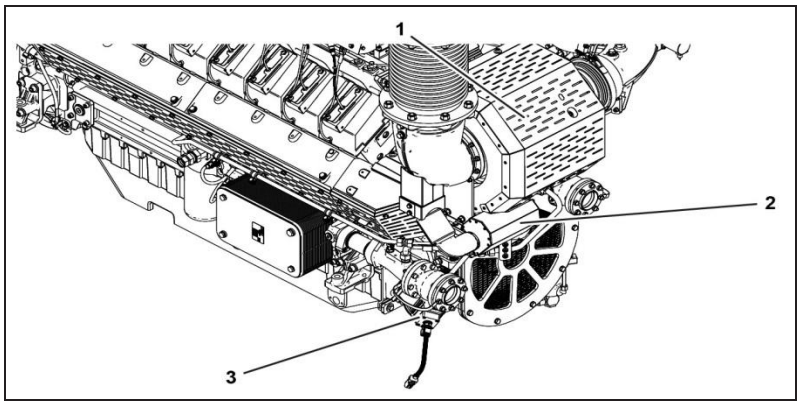
4 Gas-air mixer
5 Fuel gas
6 Gas-air mixture
7 Compressor wheel
8 Exhaust manifold
9 Turbine wheel
10 Exhaust gas
11 Outlet valve
12 Inlet valve
13 Cooled and compressed gas-air mixture
14 Mixture cooler
15 Compressed gas-air mixture
16 Throttle valve

From the cylinders, the exhaust gas flows through the nozzle ring to the turbine wheel. The turbine wheel uses the flow energy to drive the compressor wheel. At the same time, the gas-air mixture, which is required for operating the engine, flows through the intake manifold to the compressor wheel. The gas-air mixture is precompressed by the rotation of the compressor wheel and pressed into the mixture pipe of the engine. The exhaust gas flows into the atmosphere by the exhaust gas outlet via the exhaust line and the exhaust silencer.

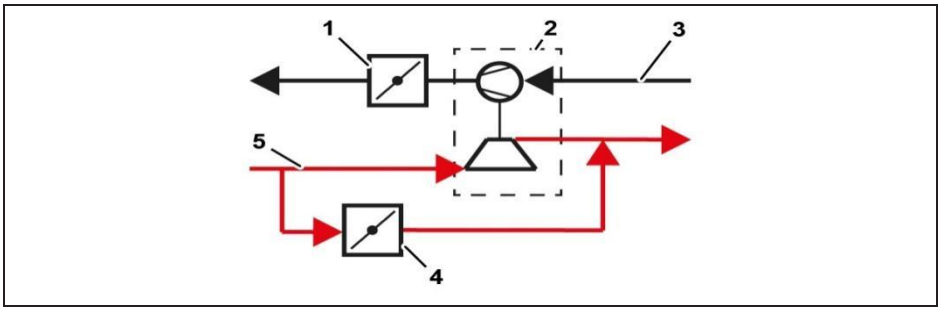
The exhaust turbocharger uses the exhaust energy and compresses the gas-air mixture (mixture turbocharging). The mixture turbocharging enables a higher level of performance of the engine, while at the same time reducing pollutant emissions.

The temperature of the gas-air mixture increases during the compression. Therefore, a mixture cooler is mounted upstream of the mixture pipe. The mixture cooler cools the gas-air mixture to the set temperature before the gas-air mixture is introduced into the cylinders via the inlet valves.

- **Wastegate**

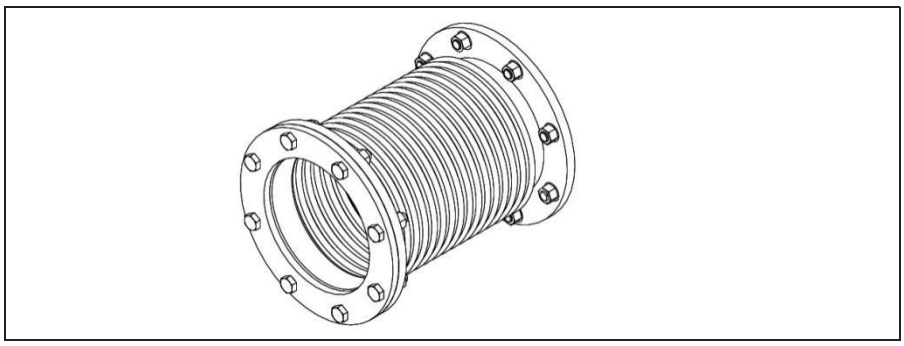


1 Exhaust turbocharger
2 Wastegate
3 Actuator



1 Throttle valve
2 Exhaust turbocharger
3 Gas-air mixture flow direction
4 Wastegate
5 Exhaust gas flow direction

➢ **Exhaust expansion joint**



The exhaust expansion joint is mounted between the exhaust turbocharger and exhaust line. The exhaust expansion joint offsets the fluctuations and vibrations of the elastically mounted engine against the securely installed exhaust line.

- **Fuel gas system**

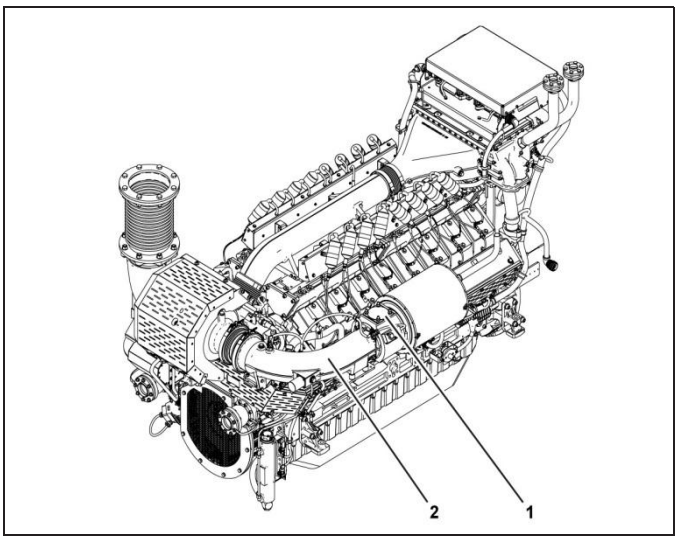
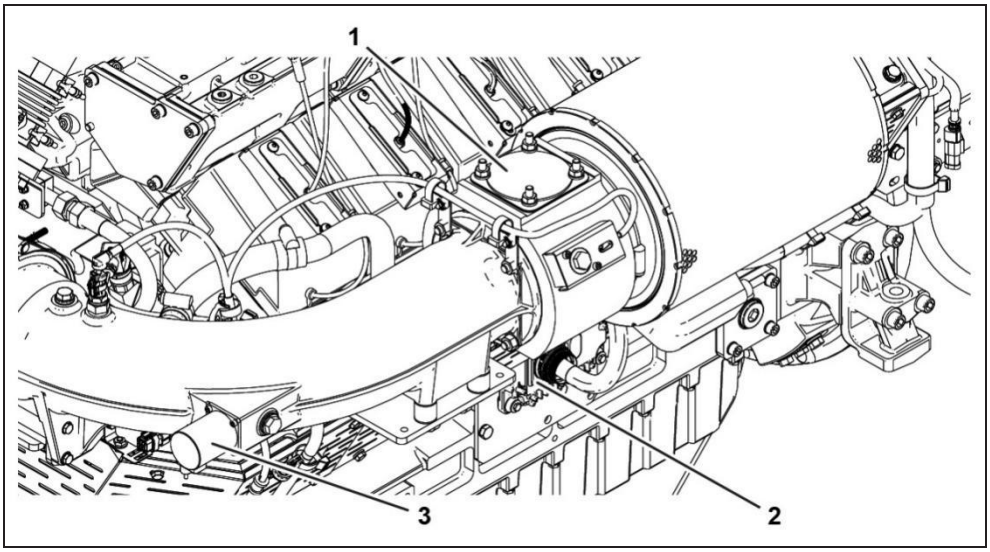


Figure V16; V12 similar

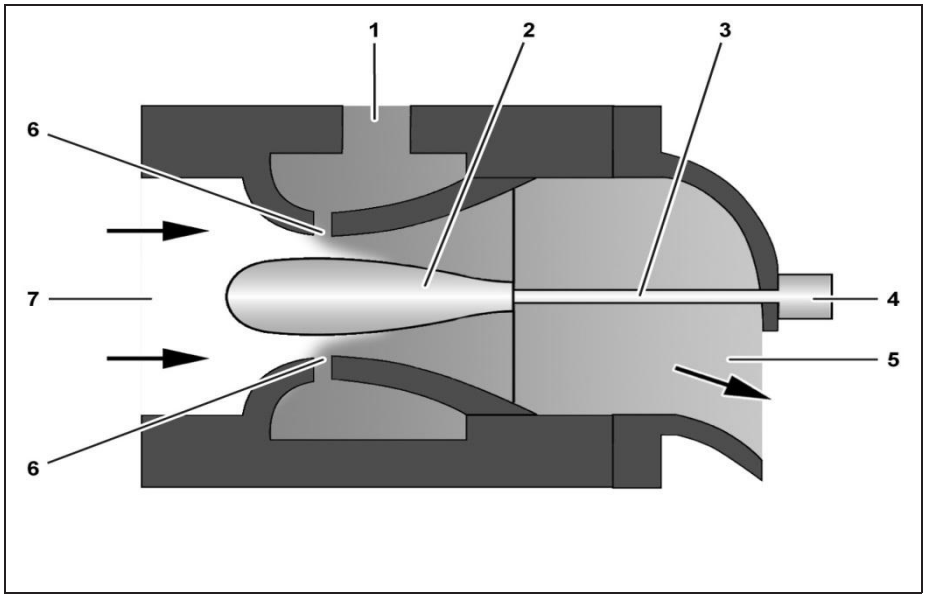
1 Gas-air mixer
2 Intake line for gas-air mixture

For the combustion process the gas-air mixer combines gas and air in an optimal ratio. The combustion gas system supplies the engine with the quantity of gas-air mixture required for operation.

- **Gas-air mixer**



1 Gas-air mixer
2 Control device
3 Stepper motor



Gas-air mixer sectional view

1 Gas inlet
2 Flow element
3 Connection piping to the stepper motor
4 Stepper motor
5 Gas-air mixture outlet
6 Ring gap
7 Air inlet

The gas-air mixer mixes the gas and air into a combustible mixture. The gas-air mixer is mounted upstream of the exhaust turbocharger.

The gas-air mixer works according to the Venturi principle. The flow has the highest speed at the narrowest point in the gas-air mixer. Underpressure is generated at this point. The underpressure sucks the gas via a ring gap into the core flow. The ring gap adjusts the mixing ratio of fuel gas and intake air. A stepper motor adjusts the ring gap for this.

- **Lube oil system**

The engine lubrication is designed as a wet sump lubricating system. The lube oil system consists of the following components:

Prelubrication pump
Lube oil coolers
Lube oil filters
Lube oil tray with lube oil pump

The lube oil pump is mounted in the lube oil tray. The lube oil pump is fitted with a pressure relief valve. Pressure control valves adjust the lube oil pressure. The prelubrication pump supplies the engine with

lube oil before it is started. In order to avoid an overpressure in the lube oil cooler when starting the engine with cold lube oil, the lube oil cooler is fitted with a bypass valve.

Prelubrication pump (optional)
The engine must be prelubricated before every start. To do this, activate the prelubrication pump via the superior control during the starting process ⇒ Installation directive, Chapter Lube oil system.

The prelubrication pump has the following functions:

- Prelubrication before every engine start
- Relubrication after shutting down engine
- Pumping out of the lube oil during the lube oil change
- Filling of lube oil cooler and lube oil filter after the lube oil change

- **Lube oil level sensor**

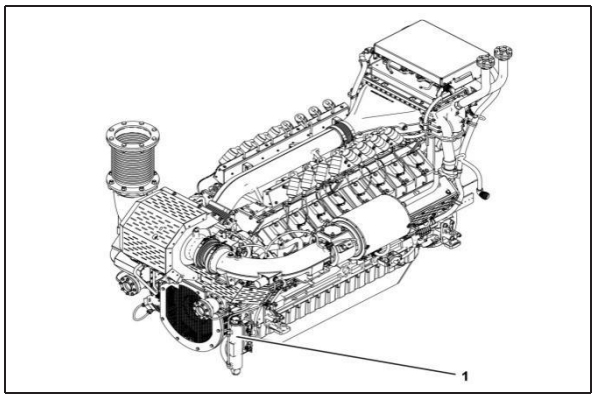


Figure V16; V12 similar

1 Lube oil level sensor

The lube oil level sensor transfers the current information about the lube oil level in the engine to the electronic control.

- **Lube oil filter**

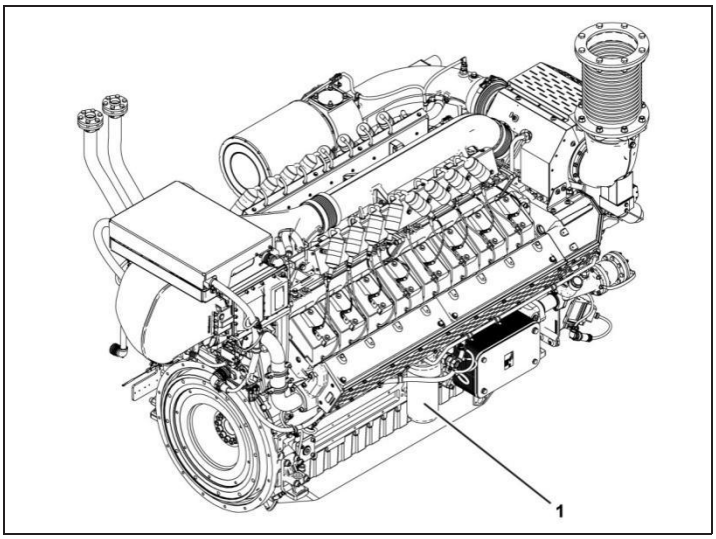


Figure V16; V12 similar

1 Lube oil filter

The lube oil filter is located in the flow direction downstream of the lube oil cooler.

The lube oil filter removes mechanical impurities from the lube oil. The lube oil pump transports the lube oil through the lube oil filter. The lube oil reaches the lube points in the engine only after filtering.

➢ **Lube oil cooler**

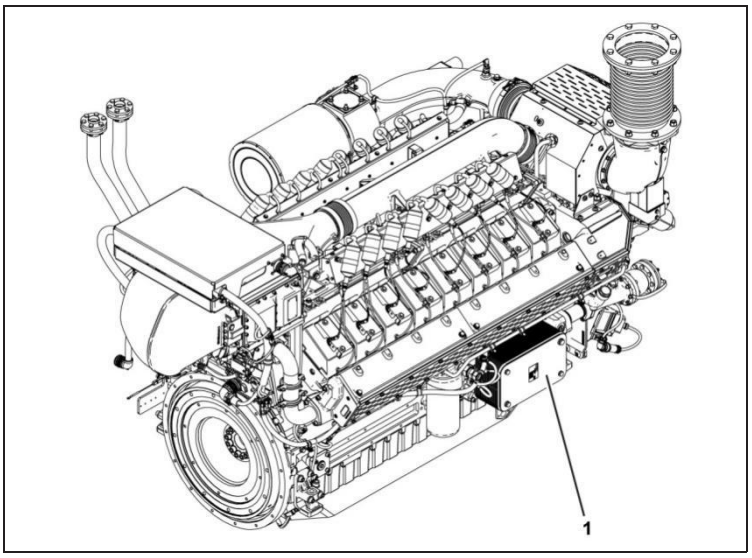


Figure V16; V12 similar

1 Lube oil cooler

The lube oil cooler is mounted in the flow direction upstream of the lube oil filter.
In the lube oil cooler, lube oil flows through the heat exchanger on one side and coolant on the other.
The temperature of both operating media is adjusted in the heat exchanger.

Lube oil, which is cooler than the coolant, heats up.
Lube oil, which is warmer than the coolant, cools down.

- **Cooling system**

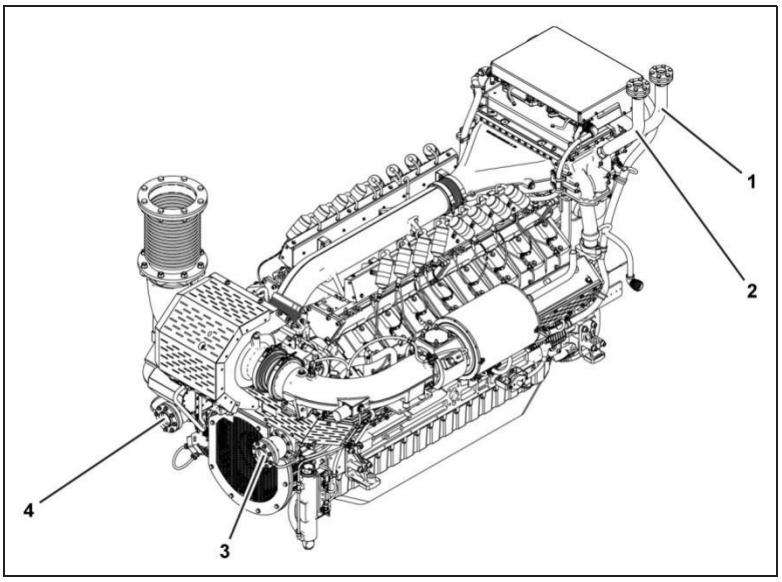


Figure V16; V12 similar

1 Coolant inlet (mixture cooling circuit)

2 Coolant outlet (mixture cooling circuit)
3 Coolant outlet (engine cooling circuit)
4 Coolant inlet (engine cooling circuit)

The cooling system has the following functions:
Dissipating combustion heat
Cooling the engine
Cooling the gas-air mixture

The cooling system consists of the engine cooling circuit and mixture cooling circuit.

Engine cooling circuit

- **Engine cooling circuit**

The engine cooling circuit is the high-temperature circuit (HT circuit). The engine cooling circuit contains the following assemblies:
Mixture cooler
Lube oil cooler
Engine

- **Mixture cooling circuit**

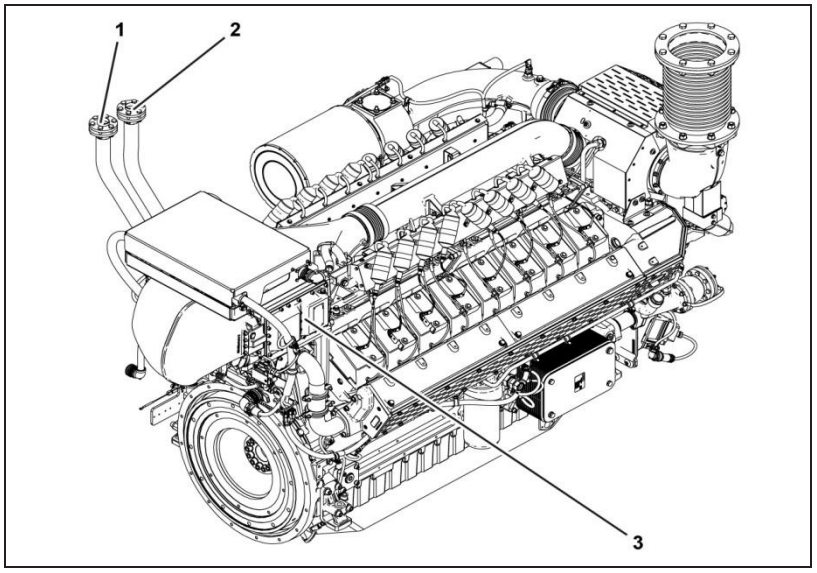


Figure V16; V12 similar

1 Coolant inlet (mixture cooling circuit)
2 Coolant outlet (mixture cooling circuit)
3 Mixture cooler

The mixture cooling circuit is the low-temperature circuit (LT circuit). The mixture cooling circuit contains the following assemblies:
Mixture cooler

The mixture cooling circuit lowers the mixture temperature and increases the engine power.

➢ Mixture cooler

The engine cooling circuit and mixture cooling circuit flow through the mixture cooler. The mixture cooler is the central component of the dual-circuit cooling.
The versions of the dual-circuit cooling are shown schematically in the cooling system variants section.

➢ Coolant

The coolant consists of water, which is mixed with cooling system protection agents. The cooling system protection agents prevent damage from corrosion, freezing or cavitation. Monitor the composition of the coolant. If necessary, prepare the coolant.

➢ Control and monitoring

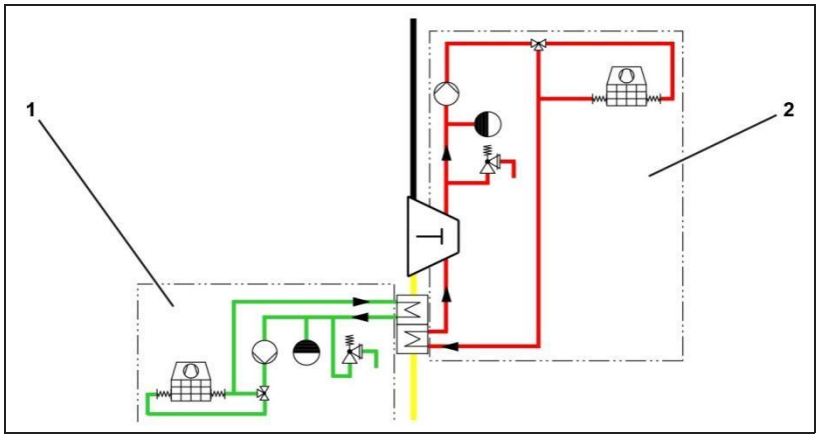
The electronic control monitors the following in the engine cooling system:

- Coolant temperature
- Coolant pressure

The monitoring is carried out with the aid of temperature sensors and pressure sensors.

If the coolant temperature exceeds the specified limit, the electronic control emits an alarm sound. If the coolant temperature increases up to a second limit, the electronic control shuts down the engine and indicates a fault.

➢ Cooling system variants

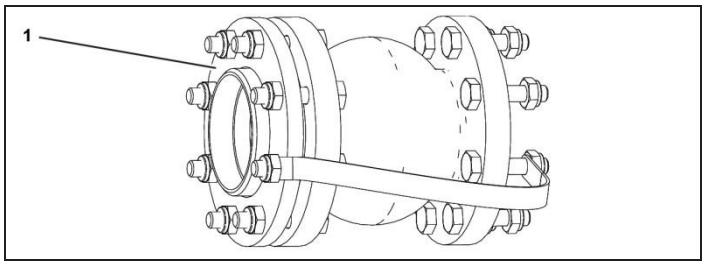


Example. Components not included in the scope of supply

1 Mixture cooling circuit

2 Engine cooling circuit

- **Rubber expansion joint**



1 Rubber expansion joint

The lines of the engine and plant are connected using rubber expansion joints. The rubber expansion joints prevent the transfer of vibrations from the elastically supported engine to the fixed plant components.

- **Electrical system of the engine**

The electrical system consists of the following components:

Starter
Ignition
Anti-knock control
Sensors
Electronic control system

➢ **Installation location of the electrical components in the engine**

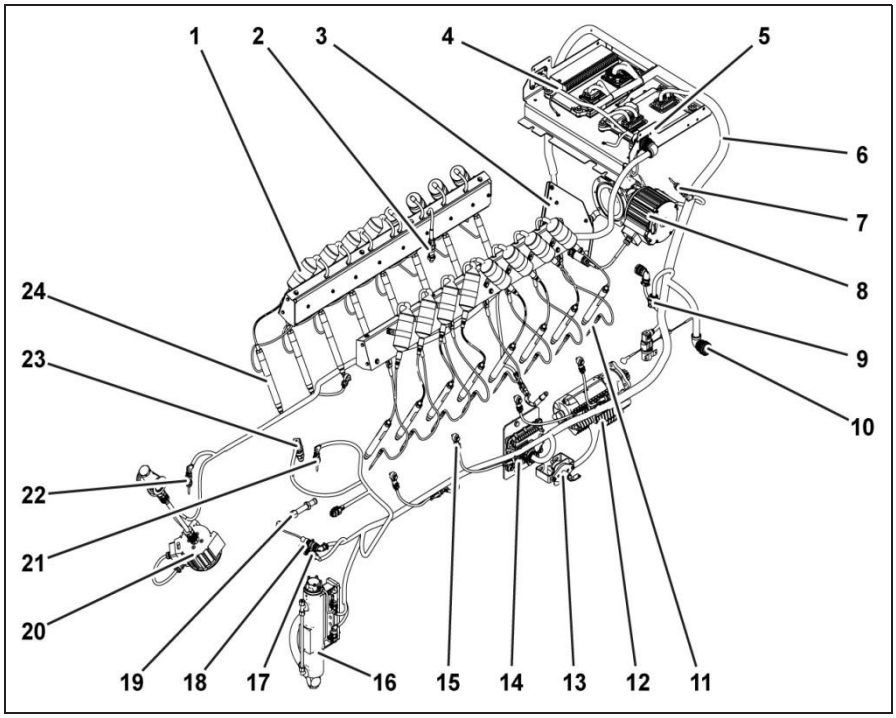
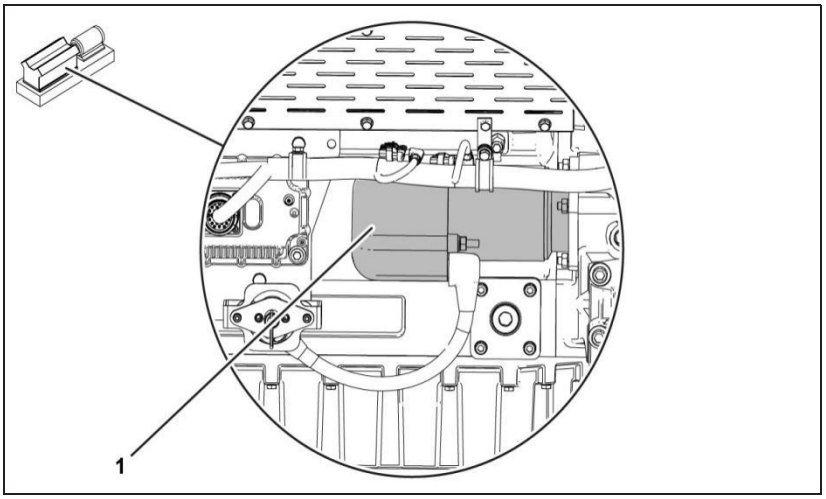


Figure V16; V12 similar

1 Ignition coil

2 Charge air mixture pressure sensor
3 Control device
4 Control device
5 Control device
6 Wiring harness
7 Charge air mixture temperature sensor
8 Actuator with throttle valve
9 Service connector
10 Engine connector
11 Combustion chamber temperature sensor
12 Electric starter
13 Starting system switch
14 Control device
15 Knock sensor
16 Lube oil level sensor
17 Coolant pressure sensor
18 Coolant temperature sensor
19 Camshaft sensor
20 Actuator with wastegate
21 Mixture temperature sensor
22 Temperature sensor
23 Crankcase pressure sensor
24 Spark plug

- **Electric starter**



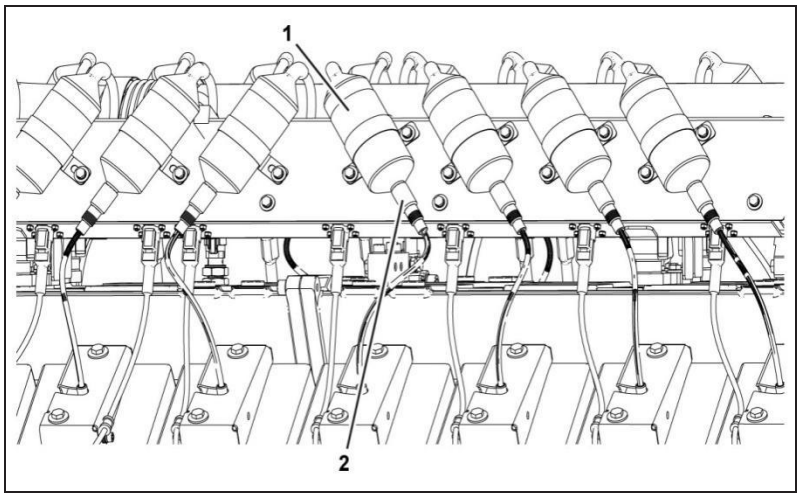
V16

1 Electric starter

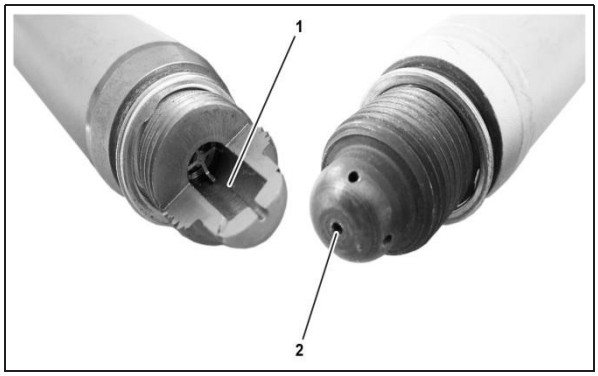
The engine is equipped with an electric starter. To start the engine, the electric motor presses the starter pinion into the flywheel gear ring. Then the electric starter brings the engine up to the starting speed.

The electric starter turns the engine until the combustion process starts. The electronic control then gives the command to decouple the starter pinion from the flywheel gear ring.

- **Ignition**



1 Ignition coil
2 Ignition cable



1 Chamber
2 Bore

The electronic control generates the ignition impulse and transmits the ignition impulse to the ignition coils as a voltage impulse. The ignition coil generates high voltage. The ignition cable transmits the high voltage to the spark plug and triggers the ignition spark in the spark plug.

The spark plug is a chamber spark plug. The chamber on the head of the spark plug must be fitted with bores. The ignition spark is generated in the chamber of the spark plug. The resulting flames pass through the bores in the combustion chamber of the cylinder. The flames ignite the gas-air mixture in the combustion chamber.

Advantages of the chamber spark plug:

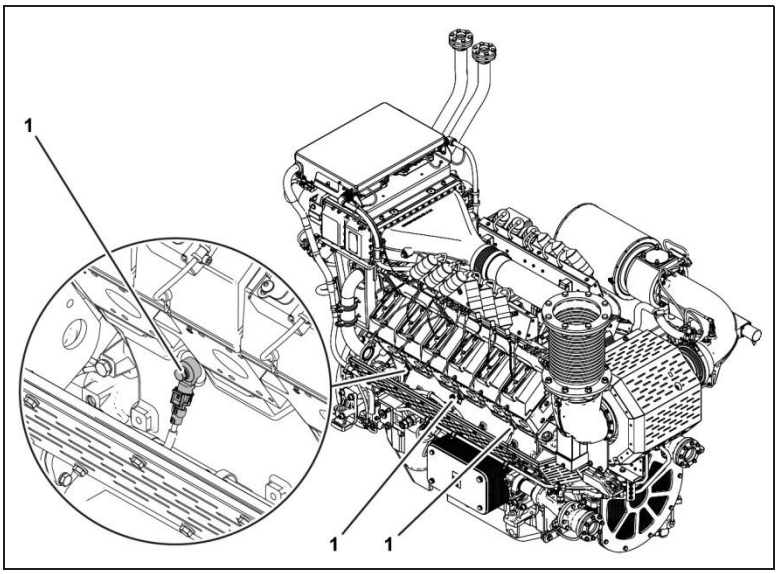
Consistent distribution of the flames across the entire combustion chamber

More effective combustion

Low electrode wear

Greater service life of the spark plug

- **Anti-knock control**



V16 right side

1 Position of the knock sensors

With respect to the following points, there is a danger of the combustion gas self-igniting (knocking combustion):

Combustion gases with a fluctuating methane number

Combustion gases with a low methane number

Change of the fuel gas composition

◆ Maintenance schedule

Maintenance schedule **Overview of intervals**

For information on the assignment and validity of the maintenance schedule:
see Technical Bulletin (TR) 2167

Operating hours	Maintenance level							
	E1	E10	E20	E30	E40	E50	E60	E70
as specified	x							
50		x						
2000				x				
4000					x			
6000				x				
8000					x			
10000				x				
12000					x			
14000				x				
16000						x		
18000				x				
20000					x			
22000				x				
24000					x			
26000				x				
28000					x			
30000				x				
32000							x	
32050		x						
34000				x				
36000					x			
38000				x				
40000					x			
42000				x				
44000					x			
46000				x				
48000						x		
50000				x				
52000					x			
54000				x				
56000					x			
58000				x				
60000					x			
62000				x				
64000								x

Technical Bulletin

MWM

3017/07 EN

This circular replaces:
3017/06

TR

Specification for fuel gas

Valid for: **TCG 2016, TCG 3016, TCG 2020, TCG 3020, TCG 2032, TCG 2032B**

The 7th replacement is made because of:

- Introduction of a new engine type
  - TCG 3020
- Update of value limit list for combustion properties
  - Humidity
  - Dust content
  - Higher hydrocarbon compounds and tars

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Date:
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Note:
There is no revision service for the parts numbers specified in this document. Only the spare parts documentation is binding for the identification of spare parts.

Copies to:
- TR
- According to SIT 7010

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General information

Combustion gas

Combustion gas refers to gas mixtures which are suitable for genset operation and which differ in their composition.

The most important main components are:

- Methane (CH_4)
  - as an essential heating value carrier of the usual combustion gases,
- chained hydrocarbons (C_nH_m with n greater than 1)
  - which have a strong tendency towards knocking combustion,
- inert gases (N_2 and CO_2)
  - which do not actively participate in the combustion. Inert gases increase the methane number in a combustion gas. This increases the methane number in CO_2 with the triple effect of N_2,
- Hydrogen (H_2)
  - which considerably reduces the methane number of the combustion gas.

Accompanying substances

The gas accompanying substances are also very important in the assessment of suitability as a combustion gas. They make no significant contribution to the combustion energetically. However, these gas accompanying substances must be taken into account with regard to the reliable operation of the overall system.

In addition to the gas accompanying substances which do not change the combustion process, there are also substances which lead to a change in the ignition properties (such as oil fumes).

Other gas accompanying substances are significant because of the combustion products such as ashes or deposits. These are elements and compounds which contain silicon, halogens, metals, etc.

Although the accompanying substances only occur in traces, the combustion products can cause wear.

Depending on the amount and damage effect, these gas accompanying substances must be eliminated from the combustion gas before entering the gas control line.

Examples:

- Hydrogen sulfide H_2S from e.g. biogas combusts to SO_2 and H_2O. These two intermediate products react to sulfurous acid H_2SO_3. A further reaction to sulfuric acid H_2SO_4 is possible in the oxidation catalyst. The acids formed in the combustion cause the lube oil to become acidified, which leads to the lube oil replacement intervals becoming shorter. Furthermore, sulfurous and sulfuric acid can condense in the exhaust heat exchanger and lead to deposits and corrosion occurring there.
- The silicon connection hexamethylcyclotrisiloxane D3 $(CH_3)_6Si_3O_3$ e.g. from landfill and sewage gas combusts to silicon dioxide SiO_2 (quartz sand), CO_2 and steam. Silicon dioxide forms deposits on all components surrounding the combustion chamber, which leads to abrasive wear. Furthermore, the deposits cover the exhaust catalyst and deactivate it.
- Chloroform $CHCl_3$ e.g. from landfill gas reacts to hydrochloric acid, carbon dioxide and steam. This hydrochloric acid pressurizes the lube oil and corrodes components.

General requirements

If the designated combustion gas does not satisfy the minimum requirements described in this bulletin or the combustion gas contains by-products which are not specified without the particular combustion gas analysis having been granted written release, all warranty claims against MWM will be voided.

Failure of a combustion gas to comply with the minimum requirements or its contamination by unspecified ingredients will lead to a reduction in the life of the genset and all components affected. The regular maintenance intervals for operation according to specifications listed in the regular maintenance schedule are sometimes much too early and lose all their reference value.

During commissioning, a gas analysis must always be submitted to the manufacturer (not older than 2 weeks) and documented in the commissioning report. After commissioning, a gas analysis must be made according to the maintenance schedule and compliance with the minimum requirements checked.

All gas analyses must be presented to the manufacturer in a warranty case.

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Classification of the gas qualities for the maintenance schedules

The combustion gases are classified into various gas quality groups by their accompanying substances and their effects on the wear.

The maintenance schedule must be assigned to the corresponding gas quality for maintenance of the genset.

Note

Because of the different composition of the combustion gases, not every engine in a series achieves the maximum possible power for the series with every approved combustion gas.

Delivered gensets may only be operated with the combustion gas prescribed according to the contract.

If the genset is to be operated with another combustion gas, the service partner must be contacted before changing the combustion gas.

Low gas quality

according to the limit values of this bulletin, such as:

Sewage gas

Landfill gas

Biogas

Associated gas (petroleum gas)

Coke oven gas

Medium gas quality

according to the limit values of this bulletin, such as:

Biogas after precision cleaning

Mine gas

High gas quality

according to the limit values of this bulletin, such as:

Natural gas

Liquefied gas such as propane, LNG (liquefied natural gas)

Mine gas after precision cleaning

3017/07 EN

Definitions of the combustion gas types

General

The gas types suitable for operation are explained below.

Restrictions on which genset is released for which gas type are specified in the sales literature.

For a better understanding, a typical combination of components is defined for every gas type in addition to the permissible spectrum range as far as this is useful and possible.

Note

The components listed in the following tables are to be seen respectively in combination and only give 100% in the **typical composition**. Totaling of the Min and Max values is not useful. These values only serve to limit the spectrum range.

All values refer to a totally dry gas. The real steam proportion must be taken into account in the design of gas systems.

Sewage gas

Sewage sludge collects during waste water purification in the sedimentation basins (sewage basins) of a sewage plant. The sewage gas is formed during the anaerobic (oxygen-free) sewage sludge fermentation in fermentation towers.

Composition			
Component	Min.	Typical	Max.
Methane (CH_4) in %	57	65	72
Carbon dioxide (CO_2) in %	28	34	43
Nitrogen (N_2) in %	0	1	20
Oxygen (O_2) in %	0	0.5	2
Silicon compounds in mg/10kWh	0	4	20
Hydrosulfide (H_2S) in ppm based on 10kWh	0	60	1500

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3017/07 EN

Landfill gas

Landfill gas is formed as a result of biochemical decomposition processes of organic compounds and materials in the refuse body. The processes are divided into aerobic and anaerobic (oxygen-free) decomposition processes which can be divided into chronological phases at the beginning and which run simultaneously towards the end of the process.

Composition			
Component	Min.	Typical	Max.
Methane (CH_4) in %	45	50	65
Nitrogen (N_2) in %	10	23	34
Carbon dioxide (CO_2) in %	20	27	45
Oxygen (O_2) in %	0	0	10
Silicon compounds in mg/10kWh	0	12	20
Hydrosulfide (H_2S) in ppm based on 10kWh	0	300	1000
Chlorine (Cl) in mg/10kWh	0	20	100
Fluorine (F) in mg/10kWh	0	10	50

Biogas

Biogases are gases with a plant or animal origin.

Biogas is produced in the anaerobic (oxygen-free) fermentation of organic material. The following are suitable as initial materials for the technical production of biogas:

- fermentable waste containing biomass such as biological waste or leftover food
- commercial fertilizers such as liquid manure or dung
- specially cultivated energy plants (regrowable raw materials)

Composition			
Component	Min.	Typical	Max.
Methane (CH_4) in %	45	55	70
Nitrogen (N_2) in %	0.01	4.5	10
Carbon dioxide (CO_2) in %	20	40	55
Oxygen (O_2) in %	0.01	0.5	2
Hydrosulfide (H_2S) in ppm based on 10kWh	0	60	1500

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Associated gas

Associated gas is a by-product of mineral oil production. Due to reductions in pressure, the solubility for gases in the liquid phase of the mineral oil drops and these gases pearl off. The concentration may vary considerably depending on the mineral oil source.

When using as a combustion gas, you must ensure that no increase in concentration of longer-chained hydrocarbons can take place.

Coke oven gas

Coke oven gas forms as a by-product when producing coke. The high dust, tar and contaminant concentrations make a laborious pre-connected gas processing necessary.

Composition			
Component	Min.	Typical	Max.
Hydrogen (H_2) in %	52	56	60
Methane (CH_4) in %	22	25	28
Ethane (C_2H_6) in %	0.5	1.5	3
Nitrogen (N_2) in %	8	10	12
Oxygen (O_2) in %	0	0.5	2
Carbon dioxide (CO_2) in %	1	2	4
Carbon monoxide (CO) in %	3	5	7

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Mine gas

Mine gas is discharged for underground mining. In coal mining, it is mainly methane (CH_4) which is used as a heating value carrier.

Composition			
Active mine			
Component	Min.	Typical	Max.
Methane (CH_4) in %	25	40	70
Nitrogen (N_2) in %	4	47	68
Carbon dioxide (CO_2) in %	0	3	20
Oxygen (O_2) in %	0	10	17
Dust in mg/10kWh	0	5	10

Composition			
Shut down shafts			
Component	Min.	Typical	Max.
Methane (CH_4) in %	40	65	80
Nitrogen (N_2) in %	4	28	68
Carbon dioxide (CO_2) in %	0	4	25
Oxygen (O_2) in %	0	3	15
Dust in mg/10kWh	0	1	10

Natural gas

Natural gas is a combustible gas found in underground deposits. It is often found together with mineral oil as it evolves in a similar way. Natural gas is a gas mixture whose composition varies considerably depending on where it is found. Natural gases consist mainly of methane but differ in their further chemical composition.

Composition			
Component	Min.	Typical	Max.
Methane (CH_4) in %	85	90.6	98
Ethane (C_2H_6) in %	0	3	10.3
Propane (C_3H_8) in %	0	1.6	2
Butane (C_4H_{10}) in %	0	0.5	0.7
Pentane (C_5H_{12}) in %	0	0.1	0.15
Nitrogen (N_2) in %	0	3.7	11
Carbon dioxide (CO_2) in %	0	0.5	2

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Liquefied Natural Gas (LNG)

LNG (Liquefied Natural Gas) is natural gas in a liquid form. The gas is liquefied by compression and cooling. The values depend on the natural gas base.

Through extraction from the liquid phase of the tank and complete evaporation, an increase in concentration of liquid components can be counteracted.

Liquefied gas (propane)

Propane is a colorless, odorless gas which belongs to the alkanes. Since propane liquefies at relatively low pressures even at normal temperatures, large amounts of energy can be stored in the liquid phase.

Because of the solubility of alkanes in one another, DIN 51622 defines the common technical propane on the market as a mixture of at least 95% propane and the rest a mixture of ethane, ethene, butane and butene.

Through extraction from the liquid phase of the tank and complete evaporation, an increase in concentration of liquid components can be counteracted.

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Methane number

The methane number (MN) describes the knocking resistance of the combustion gas. It is defined by the mixing ratio of a mixture of hydrogen and methane which has the same knocking tendency as the available combustion gas.

The MN 100 is knocking-resistant (for methane CH_4) and MN 0 high knocking (for hydrogen H_2).

The MN can increase to more than 100 in mixtures with CO_2.

The methane number MN depends on the content of various components. Even the smallest concentrations of long chained hydrocarbons lead to a drastic drop in the methane number MN.

Examples:

- Propane has the same knocking behavior as a mixture of 33% methane and 67% hydrogen. Therefore, propane gas is assigned the MN 33.
- A mixture of 10% butane (MN 10) and 90% methane (MN 100) leads to an MN 51 and not to MN 91 (no linear curve).

The basis for calculation and evaluation of the methane number is the computing program of MWM.

Note

For combustion gases with a fluctuating or low methane number, there is a danger of a knocking combustion. The consequences are extreme mechanical and thermal stresses which can cause damage.

Examples for the methane number (MN) of some gases:

Biogas	MN greater than 120
Mine gas (active mine)	MN approx. 100
Mine gas (shut down shafts)	MN approx. 120
Methane (CH_4)	MN 100 (definition)
Natural gas	MN 65 to 95
Propane (C_3H_8)	MN 33
Butane (C_4H_{10})	MN 10
Hydrogen (H_2)	MN 0 (definition)

3017/07 EN

Limit values of combustion gases

The limit values for operation of MWM gas gensets are specified in the following table.

If the values on site deviate from the limit values, contact your Service Partner.

Note

Condensation of water and hydrocarbons in the gas control line and the feeding lines is generally impermissible.

Standard reference conditions

For the conversion to standard reference conditions, a temperature t_n of 0 °C (corresponding to 273.15 K) and an absolute pressure p_n of 1013.25 mbar must be used.

Calculation examples

Standard cubic meters:

One thousand cubic meters of gas V_b at a temperature t_b of 35 °C, an overpressure $p_{b,ü}$ of 100 mbar and an ambient pressure $p_{barometer}$ of 970 mbar are converted to the standard condition according to the following formula.

$V_n = V_b \times ((p_{b,ü} + p_{Barometer}) / p_n) \times ((t_n + 273.15\ K) / (t_b + 273.15\ K))$

$936\ m^3{}_n = 1000\ m^3 \times ((100 + 970) / 1013.25) \times ((0 + 273.15) / (35 + 273.15))$

Calorific value reference:

At a measured CH_4 concentration of 50 vol% (corresponds to 5 kWh/m_n^3), a concentration of 500 ppm H_2S is measured.

This gives a concentration of 1000 ppm H_2S based on 10 kWh/m_n^3.

Note

For combustion gases, the calorific value carrier of which is methane, the methane concentrations can also be used alternatively for concentration references for pollutant gases.

e.g. 100 $mg/m^3{}_n$ CH_4 correspond to 100 mg/10 kWh.

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3017/07 EN

Value limit list for combustion properties

Methane number	
Methane number (MN)	33 to 150
Rate of change	less than 5 MN/min
Heat value	
lower heat value H_i	4.5 kWh/Nm^3 to 26 kWh/Nm^3
Rate of change	less than 5%/min

Value limit list for combustion properties

Gas quality	Low	Medium	High
Sulphur (total S)			
per 10 kWh	less than 2200 mg	less than 440 mg	less than 15 mg
Hydrosulfide (total H_2S)			
based on 10 kWh	less than 1500 ppm (corresponds to 0.15 Vol%)	less than 300 ppm (corresponds to 0.03 Vol%)	10 ppm (corresponds to 0.001 Vol%)
Chlorine (total Cl)			
per 10 kWh	less than 100 mg	less than 20 mg	less than 2 mg
Fluorine (total F)			
per 10 kWh	less than 50 mg	less than 10 mg	less than 1 mg
Chlorine and fluorine (Sum Cl and F)			
per 10 kWh	less than 100 mg	less than 20 mg	less than 2 mg
Ammonia (total NH_3)			
per 10 kWh	less than 150 mg	less than 30 mg	less than 2 mg
Humidity* (relative humidity φ)	less than 80 %	less than 80 %	less than 80 %
* at lowest temperature of the entire gas line system			
Silicon compounds (total VOSiC)			
per 10 kWh	less than 20 mg	less than 1 mg	0 mg
Dust content			
Total per Nm^3	less than 0.5 mg	less than 0.5 mg	less than 0.5 mg
Grain size	maximum 1.5 µm	maximum 1.5 µm	maximum 1.5 µm

3017/07 EN

Gas quality	Low	Medium	High
Higher hydrocarbon compounds and tars			
greater than C5 / less than C10			
per 10 kWh	less than 3000 mg	less than 600 mg	less than 100 mg
Sum of all hydrocarbons C5 to C11			
per Nm^3	less than/equal to 2 vol%	less than/equal to 2 vol%	less than/equal to 2 vol%
greater than/equal to C12			
per Nm^3	0 mg	0 mg	0 mg

Notes for system components

Note

Combustion gas components which have no significant effects on genset operation on compliance with the limit value specifications may still have a considerable effect on the other district heating power station components.

Exact specifications of permissible concentrations of traces and the warranty conditions are provided in the MWM documentation **Power plants layout (Planning and Installation Notes), chapter Exhaust System.**

3017/07 EN

Limit values for zero-pressure control lines

Note

The design of the gas control line is always project-related depending on the heating value.

At a pre-pressure of over 200 mbar, a project-related pre-pressure control system with safety shutoff valve and safety blow-off valve is necessary.

If the values on site deviate from the limit values, contact your Service Partner.

Limit value list	
Pre-pressure (inlet gas control line)	20 to 200 mbar
Gas pressure fluctuations	+/- 10 % of the setting value
Fluctuation frequency	less than 10/h
Gas temperature	10 to 50 °C
for liquefied propane gas (according to DIN 51622), LNG (liquefied natural gas), coke oven gas and associated gas, the following deviation applies.	
Gas temperature	greater than 35 °C

Sampling and gas analysis

Sampling and gas analysis must be performed according to the valid standards and regulations.

For further information, see job card B 7-18-1 Sampling fuel gas.

Note

A detailed gas analysis must ensure that the genset is operated with combustion gas according to the specification in this Technical Bulletin.

Gas analyses must be kept so that proof of the proper operation of the genset can be presented.

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Service Information

This document was created digitally and is valid without a signature.

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Technical Bulletin

MWM

2105/26 EN

This circular replaces:
2105/25

TR

Specification for lube oil

Valid for: **TCG 2016, TCG 3016, TCG 2020, TCG 3020, TCG 2032, TCG 2032B**

The 26th replacement is made due to:

- Update of the approved lube oils

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Servicedokumentation
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Note:
There is no revision service for the parts numbers specified in this document. Only the spare parts documentation is binding for the identification of spare parts.

Copies to:
- TR
- According to SIT 7010

2105/26 EN

Contents:

2105/26 EN

General information

Risk of destruction of components

From non-approved lube oils

- Only use approved lube oils

The owner is solely responsible for observing the lube oil specification described.

The operator must be able to demonstrate their maintenance obligation by analyzing the lube oils in accordance with this lube oil specification.

The engine manufacturer accepts no liability for damage caused by the use of non-approved lube oils or by improper operation.

Lube oils for combustion engines are exposed to extreme mechanical and thermal stress. The lube oil should not evaporate at the high temperatures of the cylinder liners but should form a sufficiently tenacious, pressure-stable, well adhesive lube film. It should be thin enough in the cold state to enable starting of the cold engine. The sliding surfaces of the engine components should remain wet for restarting the engine when the engine is shut down.

The lube oils must generally have the following properties:

- stable lube film at all operating temperatures
- optimal viscosity at all operating temperatures
- high thermal stability
- high resistance to aging
- wear-preventing properties
- neutralizing properties against corrosive materials
- balanced ratio of ash-forming active ingredients
- high safety reserves for long lube oil change intervals

Economic operation is achieved by as long a lube oil change interval of the lube oil filling as possible. The emphasis is always on the avoidance of damage and achievement of the expected service lives of important engine components.

TR

2105/26 EN

Lube oil selection

Lube oils (sulfate ash content up to 0.6 wt. %)

The lube oils listed in the section **Approved lube oils (sulfate ash content up to 0.6 wt. %)** must be used for operating gas engines.

Lube oils (sulfate ash content 0.6 - 1.0 wt. %)

Other lube oils are approved specially for operation with fuel gases with a higher pollution load (see also Technical Bulletin (TR) 3017). These are listed in the section **Approved lube oils (sulfate ash content 0.6 - 1.0 wt. %)**.

According to the manufacturer's data sheet, these lube oils are recognizable by their high TBN and sulfate ash values and have a higher neutralization reserve against acids which are produced by the burning of pollutants in the fuel gas. These acids are produced, for example, from chlorine (Cl), fluoride (F) and sulfur (S). The neutralization of the acids protects the engine from corrosion.

Larger amounts of lube oil additives are necessary to ensure neutralization. However, this means the higher the neutralization potential of a lube oil, the higher the tendency for deposits to form during combustion.

If such lube oils are used in fuel gases which exhibit no continuously high pollutant loads (in accordance with the values permitted in Technical Bulletin (TR) 3017), the additives are not consumed because no, or only small amounts, of acids are produced which have to be neutralized.

Here, the advantages of these special lube oils become clear disadvantages.

- The unused additives form deposits in the combustion chamber and in the following system parts such as exhaust gas heat exchanger, silencer etc.
- These deposits can bond with elements in the fuel gas, e.g. silicon (Si), in the combustion chamber. These compounds are very hard and lead to abrasive wear on pistons, piston rings, cylinder liners, valves and valve seat rings.

We therefore recommend operating all engines with lube oils according to section **Approved lube oils (sulfate ash content up to 0.6%)** until a stable fuel gas generation has been achieved. During this time, the boundary conditions and effects of the used fuel gas on economical and reliable operation of the engine must be determined by lube oil and gas analyses.

If, at the end of the system start-up process, the concentration of pollutants in the fuel gas remains continuously high and no economical lube oil change intervals are reached as a result, it is possible to convert to lube oils in accordance with section **Approved lube oils (sulfate ash content 0.6 - 1.0 wt. %)** in agreement with the service partner responsible.

2105/26 EN

TR

Lube oil sampling

Careful preparation and execution of the lube oil sampling is a prerequisite for useful analysis values.

Ensure that the lube oil sample is not falsified by dirt or lube oil residue in the additives.

About 100 ml of lube oil is sufficient for a routine analysis.

The lube oil sample must be taken from the lube oil circuit whilst the engine is running and warm.

For further information on lube oil sampling, see

- Genset Operating Manual ⇒ Job cards
  - B 8-1-1 Sampling the lube oil

At least 100 ml of lube oil must be drained and properly disposed of before taking the sample. Then the necessary amount of lube oil for the lube oil sample must be taken.

Changes in the lube oil due to sampling and transport are to be avoided.

The samples must be clearly identified and the following minimum information contained:

- Operator
- Engine type
- Engine serial number
- Lube oil manufacturer
- Lube oil designation
- Sampling date
- Engine operating hours
- Lube oil operating hours
- Filling amount / lube oil consumption
- Total lube oil volume

TR

2105/26 EN

Lube oil analysis

The operator must guarantee that the analysis values necessary for choosing the lube oil change intervals are available on schedule.

The analysis lube must be presented to the operator as quickly as possible (maximum half of the lube oil analysis interval).

Perform the first lube oil analysis independently of the fuel gas type after 100 operating hours.

A detailed lube oil analysis must ensure that the engine is operated with lube oil according to the specification in this technical bulletin. Lube oil analysis reports must be kept to provide proof of this proper operation of the engine.

In case of abnormal wear values within an analysis series, the analysis must be submitted to the service partner responsible for engines still under guarantee.

The trend analysis is most suitable for monitoring the analysis values over a longer period of time. The individual analysis values are recorded in tables or graphs in this case. This allows an assessment of the condition of the lube oil and engine (trend detection).

If you need any help in your search for an accredited lube oil laboratory, contact your service partner.

2105/26 EN

Lube oil change

Lube oil change

The entire amount of lube oil must be replaced when performing a lube oil change. The remaining lube oil volume in the engine and add-on parts should be kept as low as possible.

The lube oil change is necessary when one of the following criteria is satisfied:

- when nearing the permissible limit value
- after coolant has entered the lube oil system
- after maintenance work according to the maintenance and service schedule E60 and E70
- after E60 or E70 service work
- at least once a year
  - This does not include gensets with a lube oil change interval as per lube oil analysis greater than 10000 oh.

Lube oil change intervals

In addition to the lube oil quality, the lube oil change intervals are dependent on:

- the fuel gas quality
- the ambient conditions
- the operating principle of the engine

As a rule, these influences lead to a change in the lube oil parameters.

It is therefore necessary to determine the lube oil change intervals by lube oil analyses for every system.

By selecting suitable time intervals for the lube oil analyses, the lube oil can be used until the limit values have been reached.

The lube oil change intervals must always be re-determined:

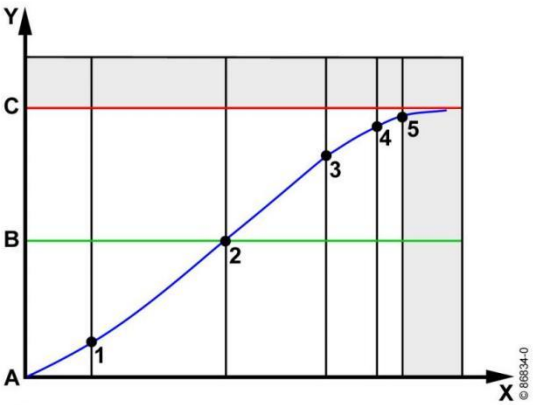
- when commissioning the system
- when changing the type of operation
- after maintenance work according to the maintenance and service schedule E60 and E70
- after E60 or E70 service work

Under unchanged operating conditions, the further lube oil analysis intervals and the necessary lube oil change must be agreed between the operator and the responsible service partner on the basis of this technical bulletin.

2105/26 EN

The lube oil change intervals must be determined as follows:

Example 1:



A 1

X axis:	Time interval
Y axis:	Numeric value of analysis result
A:	Initial value
B:	Half of limit value
C:	Limit value
Positions 1-5:	Time of lube oil analysis
Position 5:	Time of next lube oil change

- First lube oil filling
  - If the analysis values (position 1) are well below half the permissible limit values (B), the time interval before the next lube oil analysis (position 2) can be doubled.
  - If individual analysis values reach half the permissible limit value (B), the time interval before the next analysis (position 3) must be reduced.

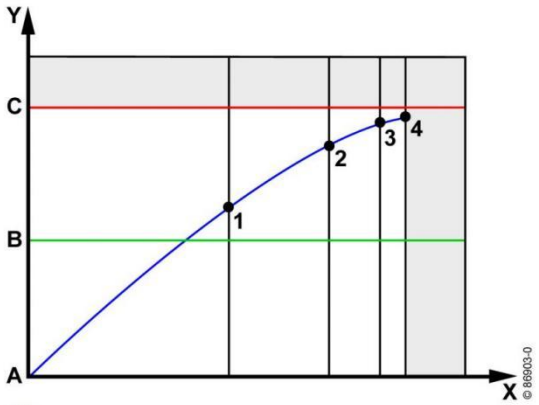
On approaching the permitted limit value (C), the time intervals from analysis to analysis (positions 4 and 5) must be halved respectively.

- Second and further lube oil fillings
  - After the initial determination of the lube oil change interval, the first lube oil analysis can be taken after a longer interval (position 3) for the second lube oil filling.

- Another lube oil analysis (position 4) is taken if comparable analysis results with the first lube oil filling are obtained.
- If, on the other hand, the same analysis values are reached, the same lube oil change interval as in the first lube oil filling can be determined.
- In case of unchanged operating conditions, the lube oil analyses for the following lube oil fillings can be taken at the same interval (position 4).

If the analysis results deviate from the previous results, the lube oil change intervals must be re-determined until repeatable results are achieved.

Example 2:



A 2

X axis:	Time interval
Y axis:	Numeric value of analysis result
A:	Initial value
B:	Half of limit value
C:	Limit value
Positions 1-4:	Time of lube oil analysis
Position 4:	Time of next lube oil change

- If the analysis values of the first lube oil sample are already close to the permitted limit values (position 1), the operating time until the next lube oil analysis must be reduced (position 2).
- If it is confirmed that the limit values are almost being reached, the last analysis period (position 3 to 4) must be halved.

TR

2105/26 EN

Lube oil change intervals for TCG 2016 without increased lube oil volume

Due to the time delay between taking the lube oil sample and the availability of the analysis results (due to mailing and processing times), the procedure that has already been described can only be applied to a limited extent for TCG 2016 without increased lube oil volume.

To prevent limit values from being exceeded in all cases during the analysis period, the following procedure must be applied:

- After 100 oh
  - First lube oil sample
- At 250 oh
  - Second lube oil sample, then renew lube oil

Depending on the results of the lube oil sampling, the change time can now be gradually increased by 50 operating hours for future intervals, if the limit values have not yet been exceeded at the point of the respective change time.

Analogous to this, the change interval must be shortened if the limit values are exceeded.

2105/26 EN

Lube oil filter change

All lube oil filters must always be replaced when performing a lube oil filter change.

The lube oil filter change is necessary:

- after 4000 operating hours at the latest - unless otherwise indicated in the maintenance plan
- at the first lube oil change after commissioning
- at the first lube oil change after maintenance work according to maintenance and service schedule E60 and E70, or after E60 or E70 repair work
- at least once a year
- if a SAN has been detected in the lube oil - see limit values
- after coolant has entered the lube oil system

After coolant has entered the lube oil system, all filter elements in the crankcase breather and the sub-stream lube oil filter (TCG 2032, TCG 2032B) must be replaced.

TR

2105/26 EN

Limit values

Risk of destruction of components

Due to failure to comply with the limit values

- If one of the following limit values is not complied with, the lube oil must be changed immediately.

During operation

Properties	Limit	Test method
Increase in viscosity in comparison with the new condition at 100 °C	max. 3 mm^2/s (cSt)	
Viscosity at 100 °C	min. 12 mm^2/s (cSt) max. 18 mm^2/s (cSt)	DIN 51366, ASTM D445, DIN EN ISO 3104
Water content	max. 0.2 %	DIN 51777, ASTM D1744, DIN ISO 12937
Glycol content	max. 500 ppm	DIN 51375, ASTM D4291
Total base number TBN	min. 2.0 mg KOH/g	ISO 3771, ASTM D4739
AN	not greater than the TBN	DIN EN 12634, ASTM 664
SAN[1)]	max. 0.2 mg KOH/g	ASTM 664
i pH value[2)]	Min. 4.5	ASTM D7946
Oxidation[2)]	max. 20 A/cm	DIN 51453
Nitration	max. 20 A/cm	DIN 51453
Silicon	max. 300 mg/kg	DIN 51396, ASTM D5185

[1)] The SAN must only be determined for Low gas quality fuel gases.

[2)] Cannot be consulted for used oil assessment with fully synthetic ester-based lube oil.

If a wear metal exceeds its permissible limit, then the limit for silicon decreases to max. 15 mg/kg (DIN 51396, ASTM D5185)

2105/26 EN

When decommissioning

When decommissioning, the acidity of the lube oil can cause damage to parts carrying lube oil when not in use. The acidity is characterized by the alkaline reserve (TBN, Total Base Number) and the pH value.

To avoid damage when not in use, the values must not fall below the following limit values.

Properties	Limit value	Test method
Total base number TBN	min. 3.5 mg KOH/g	ISO 3771, ASTM D4739
i pH value	min. 5.0	ASTM D7946

If the analysis values are above the values indicated, the lube oil can remain in the genset during the shutdown phase and be used when recommissioning.

If measured values from the lube oil analysis fall below the limit values indicated above, the lube oil must be replaced.

Afterwards, the genset must be operated for at least 12 hours.

TR

2105/26 EN

Wear metals

The wear metals data provides an aid for engine assessment. In this way, changes in the engine conditions can be detected at an early stage.

For analysis, the temporal concentration progression of every individual wear metal must be monitored over several lube oil analyses (trend analyses).

The wear rate of every individual value, rather than its absolute value, is the decisive factor in this case.

If a wear metal exceeds 50 % of the analysis value listed below, the sampling time intervals must be halved.

If the increased wear values are confirmed, the responsible service partner must be consulted.

All measurements must be performed according to DIN 51396 (ICP OES / RFA).

Example:

Wear rates calculation

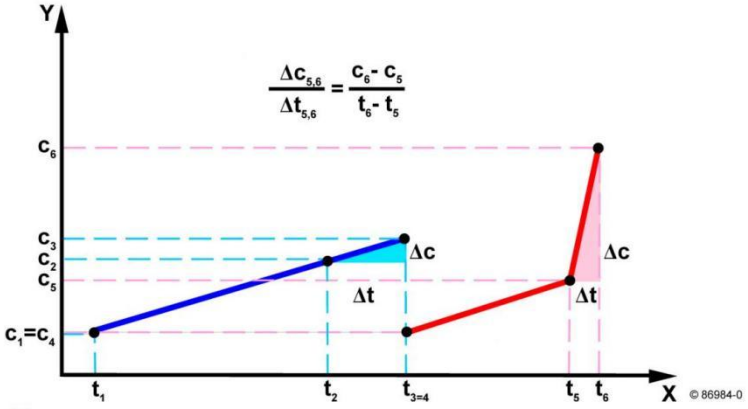
$$v_v = (c_1-c_2) / (t_1-t_2)$$

v_v = wear rate
c_1 = new concentration
c_2 = old concentration
t_1 = new operating hours
t_2 = old operating hours

2105/26 EN

Six lube oil samples were analyzed for an engine. The lube oil was changed after the 3rd lube oil analysis $t_{3=4}$. From the penultimate lube oil analysis t_5 to the last t_6, the wear metal concentration c_6 increases considerably faster than expected from earlier lube oil analyses.

Since the last rate of increase (delta $c_{5,6}$ / delta $t_{5,6}$) is above 50 % of the limit value, the time interval up to the next lube oil analysis must be halved.



A 3

X axis:	Time interval
Y axis:	Numeric value of analysis result
$t_{3=4}$	Time of lube oil change
$c_1=c_4$	Concentration in the new lube oil

2105/26 EN

Limit values for wear rate

TCG 2016	
Aluminum	max. 1.0 mg/kg per 100 oh
Chrome	max. 0.5 mg/kg per 100 oh
Copper	max. 2.5 mg/kg per 100 oh
Iron	max. 3.0 mg/kg per 100 oh
Lead	max. 2.0 mg/kg per 100 oh
Tin	max. 1.0 mg/kg per 100 oh
TCG 3016	
Aluminum	max. 0.5 mg/kg per 100 oh
Chrome	max. 0.3 mg/kg per 100 oh
Copper	max. 1.0 mg/kg per 100 oh
Iron	max. 1.0 mg/kg per 100 oh
Lead	max. 1.0 mg/kg per 100 oh
Tin	max. 0.5 mg/kg per 100 oh
TCG 2020	
Aluminum	max. 1.0 mg/kg per 100 oh
Chrome	max. 0.5 mg/kg per 100 oh
Copper	max. 1.5 mg/kg per 100 oh
Iron	max. 2.0 mg/kg per 100 oh
Lead	max. 2.0 mg/kg per 100 oh
Tin	max. 0.5 mg/kg per 100 oh
TCG 3020	
Aluminum	max. 0.5 mg/kg per 100 oh
Chrome	max. 0.3 mg/kg per 100 oh
Copper	max. 1.0 mg/kg per 100 oh
Iron	max. 1.0 mg/kg per 100 oh
Lead	max. 1.0 mg/kg per 100 oh
Tin	max. 0.3 mg/kg per 100 oh
TCG 2032 / TCG 2032B	
Aluminum	max. 0.5 mg/kg per 100 oh
Chrome	max. 0.5 mg/kg per 100 oh
Copper	max. 1.0 mg/kg per 100 oh
Iron	max. 2.0 mg/kg per 100 oh
Lead	max. 1.0 mg/kg per 100 oh
Tin	max. 0.5 mg/kg per 100 oh

2105/26 EN

Conversion table		
1 mg/kg	1 ppm	0.0001 %
10 mg/kg	10 ppm	0.001 %
100 mg/kg	100 ppm	0.01 %
1000 mg/kg	1000 ppm	0.1 %
10000 mg/kg	10000 ppm	1.0 %

TR

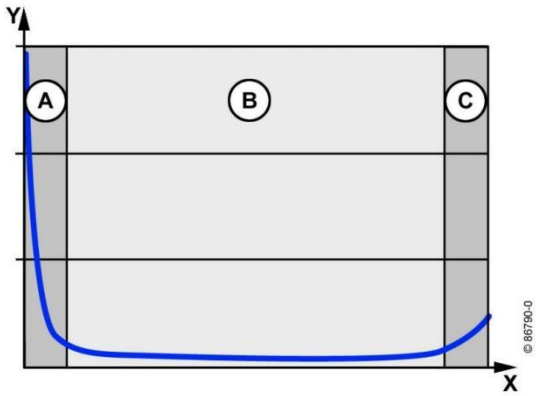
2105/26 EN

Lube oil consumption

The specific lube oil consumption is to be understood as the lube oil volume which is consumed per unit of time at a definite power.

The lube oil consumption is determined over a longer period in the same type of operation during continuous operation.

The lube oil consumption drops after the first operating hours (run-in time). Then it should remain constantly low for a longer period. The wear in the engine increases with a very long runtime and with it the lube oil consumption.



A 4

X axis:	Runtime
Y axis:	Lube oil consumption
Range A:	Run-in time
Range B:	Operating period
Range C:	Period of rising lube oil consumption due to increasing material wear

2105/26 EN

Interpretation of parameters of the lube oil analysis

Viscosity

Unit: mm^2/s

The viscosity indicates the flow capacity of the lube oil (resistance to shift of two adjacent layers, inner friction). The viscosity is temperature-dependent.

The viscosity is increased by:

- Ageing/oxidation
- Soot/solid foreign bodies
- Evaporation of components with a low boiling point

Total Base Number (TBN)

Unit: mgKOH/g

The TBN indicates the alkaline reserve of the lube oil and characterizes the chemical neutralization capacity.

This is a necessary property of the lube oil to check the corrosive wear.

With the use of the lube oil, the alkaline reserve is reduced due to a reaction with acids. The acids are ultimately products of the reaction caused by the combustion process as well as ageing/oil oxidation and nitration.

During operation with acid-forming fuel gases (especially landfill, sewage and biogases), a fast reduction of the TBN is to be expected.

Acid Number (AN, formerly TAN) or Neutralization Number (Nz)

Unit: mgKOH/g

The method covers the strong and weak acids. The strong acids are recorded separately as Strong Acid Number (SAN). Lube oil ingredients influence the value of the AN which may be between 0.5 and 2 mgKOH/g in new lube oils.

Oxidation and nitration processes can produce weak organic acids. These are only partially neutralized by the alkaline properties of the lube oil. If the lube oil has a sufficient alkaline reserve, the AN only records the weak organic acids.

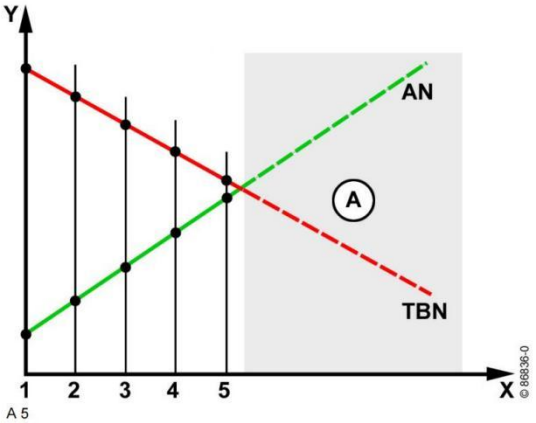
There is a rough correlation between AN rise, lube oil ageing and lube oil nitration.

TR

2105/26 EN

Explanation of the relation between TBN and AN

The TBN falls whilst the AN rises. Since, according to the limit value list, the AN must always be smaller than the TBN, no engine operation is permitted in range A.



A 5

X axis:	Runtime
Y axis:	Numeric value of analysis result
Range A:	Impermissible operating period
Positions 1-5:	Time of lube oil analysis
Position 5:	Time of next lube oil change

Strong Acid Number (SAN)

Unit: mgKOH/g

The method only covers strong acids (e.g. sulfuric acid). If a SAN is proven, there is a risk of corrosion. The determination of the SAN is only necessary for fuel gases of the Low gas quality.

Ageing/oxidation

Unit: A/cm

Ageing/oxidation is caused by a reaction of the basic oil and ingredient molecules with oxygen which leads to an increase in the viscosity and the Acid Number. Component smearing and sludge deposits can occur. The oxidation products can form organic acids which lead to corrosion even when the lube oil still has alkaline reserves.

The extinction at wave number 1710 cm^{-1} in the infrared light spectrum is measured whereby the carbonyl compounds formed in the oxidation are recorded.

2105/26 EN

Nitration

Unit: A/cm

Nitration is caused by reactions of the basic oil and ingredient molecules with nitrogen oxides. The influences are comparable with those of ageing/oxidation. They lead to changes in the lube oil parameters. However, the risk of corrosive products caused by reactions is higher in comparison. In the case of strong nitration, the alkaline reserve usually also decreases significantly.

The extinction at the wave factor cm^{-1} in the infrared light spectrum is measured.

i pH

Unit: none

The method serves to determine the pH value of the lube oil. The measurement result is specified in dimensionless pH value units. Over-acidification of the lube oil leads to corrosive wear.

Water

Unit: wt.%

Water in the lube oil generally leads to an emulsion which leads on the whole to increased wear and corrosion risk.

Water increases the viscosity of the lube oil.

Possible causes:

- Leaks in the coolant system
- Condensation processes in the lube oil system due to frequent starts and emergency stops
- Improper storage of the lube oil
- Insufficient ventilation of the crankcase or lube oil tank
- Penetration of rain water into the exhaust system

Glycol

Unit: ppm

Glycol leads to formation of sludge and filter blockage due to a reaction with the lube oil ingredients.

Glycol is incompatible with mineral oil.

Possible causes:

- Leaks in the coolant system
- Contamination with a lube oil based on polyglycol

TR

2105/26 EN

Interpretation of elements of the lube oil analysis

Silicon

Unit: mg/kg

Possible origin:

- Component in antifoaming ingredients
- Dust from suction intake air
  - Leads to abrasive wear even in the smallest of amounts.
- Compounds of fuel gases (e.g. landfill, sewage and biogases)
  - The silicon load in the lube oil also gives an indirect indication of the silicon load of the fuel gas.

Sodium

Unit: mg/kg

Typical element of ingredients for corrosion protection in the coolant. Strong increase in the sodium content is a sign of contaminated coolant. The engine must be checked continuously for possible coolant leaks in the course of further operation.

In many cases no water can be found in the lube oil despite high sodium values and the associated contamination because it evaporates due to the lube oil temperature during engine operation.

Aluminum

Unit: mg/kg

Typical wear element of pistons and slide bearings, for example.

Aluminum may also be a part of contaminated suction intake air under certain circumstances.

Iron

Unit: mg/kg

Typical wear element of cylinder liners, cams/tappets, shaft journals, piston rings and toothed wheels.

Chrome

Unit: mg/kg

Typical wear element of piston rings, valve stems, cams/tappets and other high alloyed engine components.

Copper

Unit: mg/kg

Typical wear element of bearings and corrosion product of lube oil coolers and lube oil lines.

Copper is also part of different mounting compounds.

Lead

Unit: mg/kg

Typical wear element of slide bearings and solder from lube oil coolers and lube oil lines.

The cause of a rapid change in the wear rate for lead and copper is frequently chemically corrosive wear (note limit value for i pH value).

Tin

Unit: mg/kg

Typical wear element of slide bearings.

Molybdenum

Unit: mg/kg

May be part of lube oil ingredients as well as different mounting compounds.

Also used as a running surface coating for sliding bearings.

Interpretation of optionally analyzed elements of the lube oil analysis

Potassium and boron

Unit: mg/kg

Typical elements of ingredients for corrosion protection in the coolant. An increase in the lube oil is a sign of a contamination by coolant.

However, boron is a typical element of frequently used ingredients in the lube oil.

Calcium, zinc, phosphorus, sulfur

Unit: mg/kg

Typical elements of ingredients in the lube oil.

Sulfur is also a part of the lube oil and fuel gases.

2105/26 EN

Service Information

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Approved lube oils

Valid for: TCG 3016

Recommended lube oils with a sulfate ash content of up to 0.6 wt. %

Manufacturer / Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	Viscosity in mm²/s at 100 °C
MWM						
Premium GMO 240[1)]	Mineral	0,55	5,2	40	122,0	13,3
Premium GMO 440[1)]	Synthetic	0,42	5,4	40	127,0	13,5

[1)] Not available in all countries, please contact your MWM service partner

Lube oils with a sulfate ash content up to 0.6 wt. %

Manufacturer / Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	Viscosity in mm²/s at 100 °C
ADDINOL						
NG 40	Mineral	0,54	5,6	40	122,5	13,8
Eco Gas 4000 XD	Mineral	0,62	7,3	40	116,5	13,3
AVIA						
Gasmotorenöl LA-XT 40	Mineral	0,54	5,6	40	123,0	13,8
Gasmotorenöl LA-Plus 40	Mineral	0,62	7,3	40	116,5	13,3
BAYWA						
Tectrol MethaFlexx NG Plus	Mineral	0,50	5,9	40	141,5	14,9
Tectrol MethaFlexx NG Pro	Mineral	0,50	5,5	40	120,7	13,7
Tectrol MethaFlexx SG Pro	Mineral	0,50	4,9	40	116,0	13,2
CASTROL						
Duratec HPL	Mineral	0,45	5,1	40	121,0	13,0
Caterpillar						
NGEO Ultra 40	Mineral	0,54	6,0	40	125,0	13,0
NGEO Special Application[1)]	Mineral	0,60	5,3	40	137,5	15,0

[1)] Recommended for use with sewage gas, landfill gas and other biogases

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Appendix for Technical Bulletin 2105/26

TCG 3016

Manufacturer / Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	Viscosity in mm²/s at 100 °C
CEPSA						
Troncoil Gas LD40	Mineral	0,50	4,6	40	133,1	14,0
Troncoil Biogas Low Ash[1)]	Mineral	0,55	4,5	40	120,0	13,4
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
CHEVRON / CALTEX / TEXACO						
HDAX 5200 Low Ash	Mineral	0,50	4,2	40	124,0	13,5
HDAX 6500 LFG[1)]	Mineral	0,55	4,5	40	121,0	13,5
HDAX 9200 Low Ash	Mineral	0,50	4,2	40	124,0	13,5
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
DeOliebron						
Tor Geo GB/LF 40	Mineral	0,57	4,5	40	124,4	13,6
ENGEN						
GEO N-40	Mineral	0,50	5,5	40	125,8	14,0
ENI						
GEUM NG	Mineral	0,50	5,5	40	124,0	13,6
ENOC						
Khaura LA 40	Mineral	0,50	5,4	40	119,3	13,6
EXOL						
Taurus GEO G240	Mineral	0,49	5,5	40	126,0	13,8
FUCHS						
Titan Ganymet Plus LA	Mineral	0,50	6,6	40	142,1	15,1
Titan Ganymet Pro LA	Mineral	0,50	5,5	40	120,7	13,7
Titan Ganymet Pro MA[1)]	Mineral	0,56	4,7	40	117,2	13,4
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
GALP						
Power Gas NGB 40	Mineral	0,50	5,5	40	122,0	13,5
Power Gas SG 40[1)]	Mineral	0,56	4,7	40	125,0	13,5
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
GAZPROMNEFT						
G-Profi PSN 40	Mineral	0,49	5,5	40	125,8	14,0
GULF OIL						
Gulfco LA Supreme	Mineral	0,50	5,4	40	124,0	14,4
HESSOL						
Gasmotorenöl SAE 40 LA Pro	Mineral	0,54	5,6	40	122,5	13,8
HILL Corporation LLC						
Fastroil Gas Engine Oil SAE40	Mineral	0,50	5,3	40	128,5	13,5

Manufacturer / Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	at 100 °C
I.G.A.T.						
Platin Cogeneration Oil SAE 40	Mineral	0,50	5,4	40	124,0	13,6
INDIAN OIL CORPORATION						
Servo NGE 40	Mineral	0,50	5,3	40	125,0	13,5
JX Nippon						
Gas Engine Oil M40 (M)	Mineral	0,50	4,7	40	101,9	13,8
KUWAIT PETROLEUM - Q8						
Mahler G5	Mineral	0,50	6,0	40	120,0	13,3
Mahler GR5	Mineral	0,50	6,0	40	88,7	13,2
LUBES SCHMIERSTOFFE						
TIGROL GEO EXTRA 40	Mineral	0,57	4,5	40	124,4	13,3
LUKOIL						
Efforse XDI 4004	Mineral	0,48	5,1	40	121,0	13,6
MABANOL						
Neon LAX 40	Mineral	0,50	5,0	40	123,0	13,6
MOBIL						
Pegesus 605 Ultra[1)]	Mineral	0,60	5,3	40	137,5	15,0
Pegasus 805 Ultra	Mineral	0,50	6,2	40	129,0	13,8
Pegasus 1005	Mineral	0,50	5,0	40	125,0	13,0
Pegasus 1107	Mineral	0,65	6,7	40	106,0	13,1
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
MOL						
GMO Energy 40	Mineral	0,50	5,4	40	123,4	13,6
MORRIS LUBRICANTS						
GEO Ultra 40	Mineral	0,50	5,5	40	121,1	13,7
GEO Ultra LZ 40[1)]	Mineral	0,50	6,9	40	113,8	13,6
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
MOTOREX						
Evolube NG SAE40	Mineral	0,50	5,5	40	125,0	13,9
MOTUL						
GASMA	Mineral	0,50	5,5	40	126,0	13,6
CRESSIDA[1)]	Mineral	0,50	4,5	40	126,0	13,6
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
NIS						
Nisotec GEO NBG	Mineral	0,50	5,4	40	120,5	13,5

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Appendix for Technical Bulletin 2105/26

TCG 3016

Manufacturer / Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	at 100 °C
NORTH SEA LUBRICANTS						
Tidal Power LA 40	Mineral	0,49	6,0	40	144,0	14,5
OILFINO						
Linogas LA 40	Mineral	0,49	5,2	40	123,0	13,6
ORI-TECH						
Gas Engine Oil 40 C	Mineral	0,49	5,5	40	119,8	14,0
ORLEN OIL						
Delgas L 40	Mineral	0,50	5,4	40	126,0	13,9
PAZ Lubricants & Chemicals						
PAZ NG 40	Mineral	0,50	5,5	40	120,0	13,9
PETRO CANADA						
Sentron LD 5000	Mineral	0,57	4,8	40	124,0	13,4
Sentron LD 8000	Mineral	0,52	4,6	40	120,6	13,3
Sentron CG40 Plus[1)]	Mineral	0,52	4,5	40	119,0	13,4
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
PETRONAS						
GEO NG	Mineral	0,48	5,4	40	121,8	13,5
GEO BLG[1)]	Mineral	0,50	4,5	40	119,3	13,3
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
PT. PERTAMINA LUBRICANTS						
NG Lube SAE40	Mineral	0,53	5,1	40	120,0	13,6
NG Lube HSG SAE40[1)]	Mineral	0,50	4,7	40	118,9	13,6
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
REPSOL						
Long Life Gas 4005	Mineral	0,50	5,1	40	118,0	13,2
ROLOIL						
Mogas G5	Mineral	0,50	6,0	40	120,0	13,3
Mogas XNG	Mineral	0,50	5,5	40	122,2	13,5
ROWE						
Hightec Powerplant SAE40	Mineral	0,50	5,4	40	124,0	13,6
SASOL						
Gas Engine Oil LA 40	Mineral	0,50	5,5	40	127,0	14,0
SHELL						
Mysella S5 N	Mineral	0,48	4,5	40	125,0	13,7
Mysella S5 S[1)]	Mineral	0,57	5,3	40	135,0	13,5
[1)] Recommended for use with sewage gas, landfill gas and other biogases						

Manufacturer Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	 at 100 °C
SINOPEC						
GS200-L	Mineral	0,50	5,5	40	116,8	13,1
SRS						
Mihagrun LAX 40	Mineral	0,50	5,0	40	123,0	13,6
Mihagrun X 40[1)]	Mineral	0,55	4,8	40	120,0	13,4
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
SYNLUBE						
GEO LD40	Mineral	0,50	5,5	40	135,5	14,0
TOTAL						
Nateria MP 40	Mineral	0,50	4,6	40	133,1	14,0
Nateria MX 40	Mineral	0,51	7,2	40	122,5	13,9
VALVOLINE						
GEO SNG-4	Mineral	0,50	4,7	40	121,0	13,6
GEO SLF 40[1)]	Mineral	0,50	6,2	40	112,8	12,9
[1)] Recommended for use with sewage gas, landfill gas and other biogases						
WIPA CHEMICALS INTERNATIONAL						
Ecosyn GE 4004	Synthetic	0,40	5,5	40	135,0	13,7
77 LUBRICANTS						
Gas Engine Oil LA 40	Mineral	0,49	6,0	40	144,0	14,5

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Appendix for Technical Bulletin 2105/26

TCG 3016

Lube oils with a sulfate ash content of 0.6 to 1.0 wt. %

Manufacturer Product	Basic oils	Sulfate ash wt. %	TBN mgKOH/g	Class SAE	Viscosity in mm²/s at 40 °C	 at 100 °C
ADDINOL						
MG 40 Extra Plus	Mineral	0,85	9,8	40	133,0	14,2
AVIA						
Gasmotorenöl HA 40	Mineral	0,85	9,8	40	133,0	14,2
BAYWA						
Tectrol Methaflexx HC Premium	Mineral	0,70	8,2	40	105,0	14,4
CASTROL						
Duratec M	Mineral	0,72	7,5	40	125,0	13,0
FUCHS						
Titan Ganymet Ultra	Mineral	0,70	8,2	40	105,0	13,4
HESSOL						
Gasmotorenöl SAE40	Mineral	0,85	9,8	40	133,0	14,2
KUWAIT PETROLEUM - Q8						
Mahler G8	Mineral	0,80	8,0	40	120,0	13,3
Mahler GR8	Mineral	0,80	8,0	40	88,2	13,1
MOBIL						
Pegasus 610 Ultra	Mineral	1,00	11,3	40	113,8	12,9
NILS						
Burian SAE 40	Mineral	0,85	9,8	40	133,0	14,2
PHI OIL						
Gas Engine Oil MA 40	Mineral	0,91	9,8	40	133,0	14,2
ROLOIL						
Mogas G8	Mineral	0,80	8,0	40	120,0	13,3
Mogas GR8	Mineral	0,90	8,5	40	88,2	13,1

Specification for coolant

Technical Bulletin

2091/17 EN

This circular replaces:
2091/16

Specification for coolant

Valid for: **TCG 2016, TCG 3016, TCG 2020, TCG 3020, TCG 2032, TCG 2032B, gensets, and plants**

The 17th replacement is made on account of:

- Updating the approved cooling system protection agents

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Note:
There is no revision service for the parts numbers specified in this document. Only the spare parts documentation is binding for the identification of spare parts.

Copies to:
- TR
- According to SIT 7010

TR

2091/17 EN

Contents:

2091/17 EN

General information

Risk of destruction of components

Due to non-approved cooling system protection agents

- The engine or plant may only be operated with the approved cooling system protection agents

The owner is solely responsible for observing the coolant specification described.

The manufacturer assumes no liability for damage arising from the use of non-approved cooling system protection agents or through improper operation.

The owner is responsible for observing the respective national legal provisions.

All the data in this Technical Bulletin corresponds to the latest state of knowledge. Please contact the manufacturer or your authorized service partner if you have any queries.

The cooling water referred to in this bulletin is water with suitable properties for preparing the coolant ⇒ see chapter Cooling water properties.

The coolant consists of cooling water with the admixture of cooling system protection agents ⇒ see chapter Preparing the coolant.

The coolant must be suitable for all the components in the engine (different metals, elastomers) and meet the different requirements in the engine cooling circuit, heating circuit, and mixture cooling circuit or charge air cooling circuit. Appropriate properties of the coolant are necessary to avoid damage especially to the exhaust heat exchanger due to poor quality of the coolant ⇒ see chapter Limit values of the coolant.

The products that are approved as cooling system protection agents are listed in the chapter Cooling system protection agents.

TR

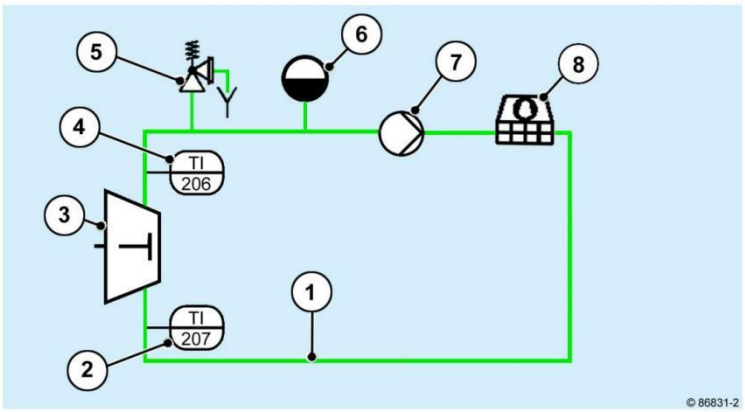
2091/17 EN

Cooling systems

Cooling systems are designed differently depending on the requirements.

The designs of cooling circuits are shown in simplified form below:

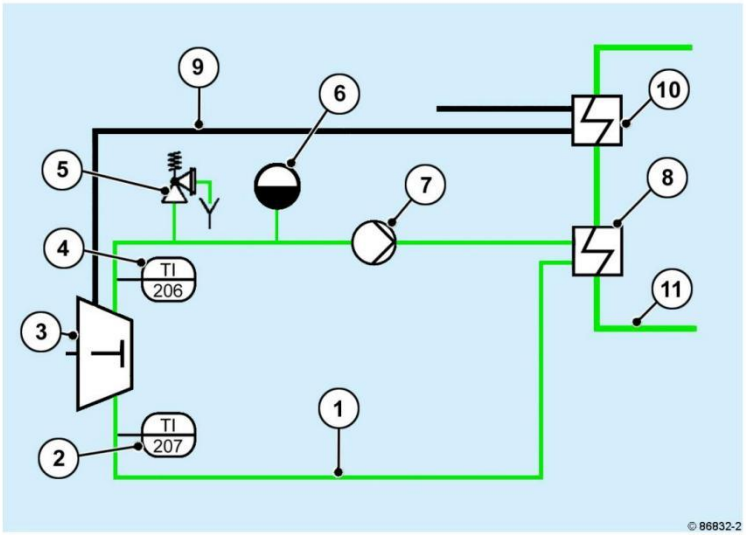
A) Cooling system without heat utilization:



A 1

1 Engine cooling circuit
2 Temperature sensor at engine inlet
3 Engine
4 Temperature sensor at engine outlet
5 Safety valve
6 Diaphragm expansion vessel
7 Coolant pump
8 Coolers

B) Cooling system with exhaust heat exchanger in the heating circuit:



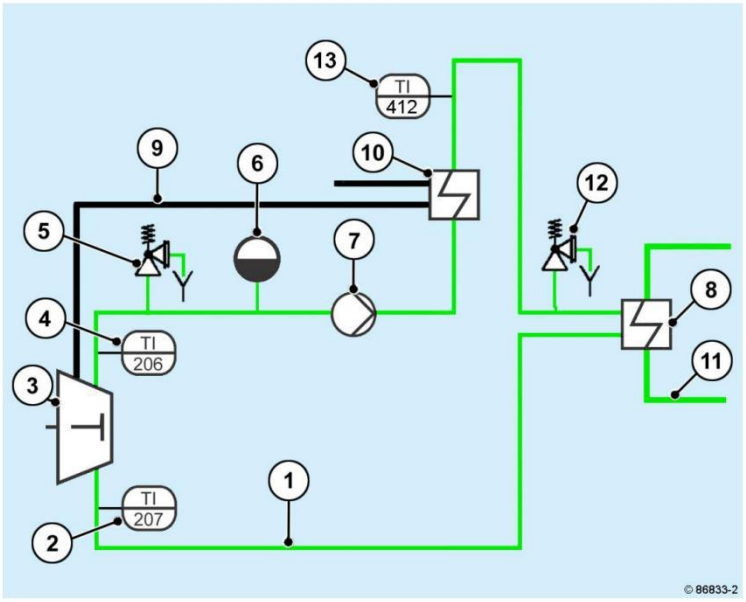
A 2

1 Engine cooling circuit
2 Temperature sensor at engine inlet
3 Engine
4 Temperature sensor at engine outlet
5 Safety valve
6 Diaphragm expansion vessel
7 Coolant pump
8 Heat exchanger
9 Exhaust gas
10 Exhaust heat exchanger
11 Heating circuit

TR

2091/17 EN

C) Cooling system with exhaust heat exchanger in the engine cooling circuit:



A 3

1 Engine cooling circuit
2 Temperature sensor at engine inlet
3 Engine
4 Temperature sensor at engine outlet
5 Safety valve
6 Diaphragm expansion vessel
7 Coolant pump
8 Heat exchanger
9 Exhaust gas
10 Exhaust heat exchanger
11 Heating circuit
12 Safety valve
13 Temperature sensor at exhaust heat exchanger outlet

2091/17 EN

Cooling system protection agents

Risk of destruction of components

Cooling system protection agents that are made from different raw materials may not be mixed.

- When converting the cooling circuit to a different product, the compatibility of the products must be ensured. If necessary, the cooling system must be purged before conversion

WARNING

Danger of poisoning

Due to the mixing of agents containing amine and nitrite

This can lead to severe injuries or even death.

- Do not mix agents containing amine and nitrite, as this produces carcinogenic nitrosamines

With regard to system protection agents a distinction is made between:

- Chemical corrosion protection agents that form a protective film on metal surfaces through chemical reactions and therefore prevent damage such as corrosion and cavitation on the cooling system, but do not offer frost protection
- Antifreezes with corrosion inhibitors that prevent the coolant from freezing while also providing corrosion protection

Chemical corrosion protection agents

Chemical corrosion protection agents have the following properties:

Properties	
Corrosion protection	good
Cavitation protection	satisfactory
Freezing protection	none
Maintenance	low
Operational safety	good

Chemical corrosion protection agents that contain silicates can damage the mechanical seals of the coolant pumps. These agents are therefore not listed under the approved products.

TR

2091/17 EN

Antifreezes with corrosion inhibitors

When using antifreezes the heat transition value (heat capacity and heat conductance) of the coolant is reduced.

Make sure that the cooling system is designed for this.

Antifreezes with corrosion inhibitors have the following properties:

Properties	
Corrosion protection	good
Cavitation protection	satisfactory
Freezing protection	depending on the mixing ratio
Maintenance	low
Operational safety	good

Antifreezes with corrosion protection are used when sub-zero ambient temperatures can occur.

2091/17 EN

Preparing the coolant

The coolant is prepared by adding a chemical corrosion protection agent or an antifreeze with corrosion inhibitors to the cooling water.

Cooling water properties

Risk of destruction of components

- Sea water, river water, brackish water, or industrial waste water are not suitable as cooling water for engines and plants
- Depending on the structure of the cooling circuit, the following limit values must be observed when preparing the cooling water

Information about the properties of the water can be obtained from the local waterworks or can be determined with the test set for cooling water or in a suitable chemical laboratory.

Sampling and water analysis must be carried out with the greatest care and accuracy.

Only clean and odorless water with the following properties may be used as cooling water for engines and plants:

Limit values of the cooling water for cooling systems A and B without exhaust heat exchanger	
pH value at 25 °C	6.5 ... 8.5
Chloride ion content	≤ 100 mg/l
Sulfate ion content	≤ 100 mg/l
Total hardness	≤ 12 °dH
Carbonate hardness proportion of the total hardness	≤ 12 °dH

Limit values of the cooling water for cooling system C with exhaust heat exchanger	
pH value at 25 °C	6.5 ... 8.5
Chloride ion content	< 20 mg/l
Sulfate ion content	≤ 100 mg/l
Total hardness	< 1 °dH
Carbonate hardness proportion of the total hardness	< 1 °dH

2091/17 EN

The water hardness is specified in moles per liter or, for low concentrations, in millimoles per liter (mmol/L).

The unit of measurement degree of German hardness (°dH) is still most common in Germany.

The degree of German hardness (°dH) is converted into mmol/L as follows:

1 °dH = 0.178 mmol/l, 1 mmol/l = 5.6 °dH

In case of deviation from the limit values listed, the cooling water is prepared as follows:

- pH value too low:

  Addition of diluted sodium hydroxide or potassium hydroxide.

  It is advisable to make small sample mixtures before adding.

- Total hardness and/or carbonate hardness too low:

  Mixing with harder water

  Harder water is usually available in the form of drinking water (city mains water).

- Total hardness, chloride, and/or sulfates too high:

  Mixing with softened water

  Softened water is distilled water or water treated with an ion exchanger.

Another water analysis must be carried out after preparing the cooling water.

2091/17 EN

Addition of chemical corrosion protection agents

Risk of destruction of components

- An insufficient concentration of the chemical corrosion protection agent has a damaging effect on the cooling system, especially aluminum components
- Observe the correct dosing of the chemical corrosion protection agent

The corrosion protection agent is first mixed with the cooling water and then filled into the cooling system as described in job card **B 9-0-4 Emptying and filling the cooling system** in the relevant operating manual.

The required concentrations of the chemical corrosion protection agent in cooling circuits are determined according to the specifications of the manufacturer or supplier.

Addition of antifreezes with corrosion inhibitors

The antifreeze is first mixed with the cooling water and then filled into the cooling system as described in job card **B 9-0-4 Emptying and filling the cooling system** in the relevant operating manual.

The coolant must be inspected for the necessary freezing protection after preparation.

The freezing protection of the antifreeze depends on the mixing ratio with the cooling water:

Antifreeze	Cooling water	Freezing protection to
33 %	67 %	-21°C
40 %	60 %	-29°C
45 %	55 %	-35°C
50 %	50 %	-40°C

The concentration of the antifreeze must be at least 33 % to ensure an adequate corrosion protection.

When using an antifreeze with corrosion inhibitors for corrosion protection the antifreeze must stay in the cooling system even at temperatures above freezing point.

Risk of destruction of components

- Pure antifreeze may not be filled into the cooling system
- Please contact your service partner if freezing protection below -40 °C is required
- The limit values listed for the coolant must be observed

TR

2091/17 EN

Limit values of the coolant

Engine cooling circuit

Limit values of the coolant for cooling systems A and B without exhaust heat exchanger in the engine cooling circuit	
If the specifications for cooling water quality and dosing of the cooling system protection agent are complied with, the quality of the coolant is sufficient.	
Limit values of the coolant for cooling system C with exhaust heat exchanger in the engine cooling circuit	
pH value at 25 °C	7.5 ... 8.5
Chloride ion content	< 20 mg/l
Total hardness	< 1 °dH
Filling volume	≤ 3,5 m^3
Temperature at exhaust heat exchanger outlet	≤ 110 °C

The filling volume is limited to 3.5 m^3 to avoid heat build-up deposits due to escaping carbonate at the limit surfaces of the exhaust heat exchanger.

Heating circuit

Risk of destruction of components

- The coolant, which can only be used in heating circuits made of iron materials, is not suitable for the engine cooling circuit
- The manufacturer shall not be liable for damage caused by using this coolant in the engine cooling circuit

Limit values of the coolant for the heating circuit	
pH value at 25 °C	9 ... 10.5
Electrical conductivity	< 0,1 mS/cm
Oxygen (O_2)	< 0.05 mg/l
Chloride	< 20 mg/l
Copper (Cu)	< 0.05 mg/l
Total iron (Fe)	< 0.05 mg/l
Phosphate (PO_4)	5 ... 10 mg/l
Earth alkalis	< 0,02 mmol/l
Total hardness	< 0.1 °dH

2091/17 EN

Checking and changing the coolant

The cooling system must be inspected and serviced at the specified intervals. This also includes inspecting the properties of the coolant and the concentrations of the cooling system protection agents in cooling systems as well as refilling and changing the coolant.

The cooling system protection agent in the coolant must be checked according to job card **B 9-1-1 Checking the percentage of corrosion protection agent or antifreeze in the coolant** in the relevant operating manual.

When determining the application concentration of corrosion protection and antifreeze agents in the coolant, the plant specifications must be followed. Alternatively, the application concentration of antifreeze agents can be measured by using the gravimetric analysis method.

The specifications of the manufacturer of the cooling system protection agent must be observed when checking the coolant.

All inspections must be carried out according to the maintenance schedule and documented in the operation log.

The coolant's period of use is specified in the maintenance schedule.

The coolant must also be changed in the following circumstances:

- After 36 months at the latest – unless otherwise indicated in the maintenance schedule
- Penetration of water from outside
- Lube oil penetration
- Conspicuous turbidity due to corrosion residues or other suspended particles

Risk of destruction of components

Due to non-observance of the information and specifications for the production and use of coolants.

- The same product must be used again when refilling the coolant
- The compatibility of the products must be checked if a product needs to be changed
- In the event of incompatibility, the entire cooling system must be cleaned thoroughly before changing the product
- The engine or plant may only be operated with the approved cooling system protection agents

TR

2091/17 EN

Cleaning the cooling system

The entire cooling system must be cleaned in the following circumstances:

- Contamination with dirt
- Lube oil penetration
- Penetration of water from outside
- Product change (incompatible products)
- Maintenance work

The coolant must be completely drained and the cooling system purged with an approved cleaning agent.

For more information on the cleaning agents, see

- Operating Manual ⇒ General ⇒ Operating media regulations
  - Technical Bulletin (TR) 2147 Specification for auxiliary media

Disposing of the coolant

Coolant and cooling system protection agents must be disposed of properly by a licensed disposal company in accordance with the respective country-specific legal regulations and specifications of the manufacturer or supplier.

Service Information

This document was created digitally and is valid without a signature.

This is a translation of the German original. All translations are based on the German original.

Approved cooling system protection agents

Valid for: TCG 3016

Risk of destruction of components

Due to non-observance of the information and specifications for the production and use of coolants.

- Owing to different compositions of antifreezes with corrosion inhibitors, these are divided into product group 1 and 2 (silicate-based / silicate-free)
- Products of group 1 may not be mixed with products of group 2

Mono-ethylene glycol (MEG) or propylene glycol (PG) are used to lower the freezing point.

Some manufacturers provide ready-to-use mixtures for cooling systems.
If these mixtures are based on approved products and meet the requirements specific to the cooling system with regard to water quality, these can also be used.

Recommended ready-mix with freezing protection

Manufacturer Product	Product basis	Product group	Glycol content / Antifreeze	Color
MWM				
Premium Antifreeze -20 [1)]	MEG	1 (silicate-based)	35 vol.% / -23 °C	blue/green
Antifreeze Advanced - Silicate Free [1)]	MEG	2 (silicate-free)	35 vol.% / -23 °C	orange/red

Recommended ready-mix without freezing protection

Manufacturer Product	Inhibitor concentration	Color
MWM		
Premium Protect [1)]	6 vol.%	colorless

[1)] Not available in all countries, please contact your MWM service partner

Appendix for Technical Bulletin 2091/17
TCG 3016

Antifreezes with corrosion inhibitors

Product group 1 (silicate-based)

Manufacturer Product	Product basis	Application concentration	Determining concentration with a refractometer	Color
ARAL				
Antifreeze Extra	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue/green
AVIAFLUID				
MAXCool Hybrid	MEG	33 - 50 vol.%	22,5 - 32,5%Brix	blue/green
BASF				
Glysantin G48	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	colorless
Glysantin G64	MEG	40 - 50 vol.%	27,0 - 32,5%Brix	green
BayWa				
Tectrol Coolprotect	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue/green
Classic				
Kolda UE G48	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue
Fuchs				
Maintain Fricofin	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	pink/violet
INEOS				
C2230	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	colorless
Mobil				
Antifreeze Extra	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue/green
OMV				
Coolant Plus	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue/green
Shell				
Shell Premium Antifreeze G	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue
TOTAL				
Glacelf MDX	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	green
Valvoline				
Zerex G48	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	blue

Product group 2 (silicate-free)

Manufacturer Product	Product basis	Application concentration	Determining concentration with a refractometer	Color
Addinol				
Antifreeze Extra	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	red/violet
Aqua Concept				
Coracon BF6	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	green
Arteco				
Havoline XLC	MEG	33 - 50 vol.%	25,5 - 32,5 %Brix	orange
Havoline XLC-PG	PG	33 - 50 vol.%	25,5 - 35,5 %Brix	colorless
AVIAFLUID				
MAXCool Energy	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	yellow
Caltex / Chevron / Texaco				
Delo XLC Antifreeze/Coolant	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	orange/red
Delo ELC Antifreeze/Coolant	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	red
Delo XLC-PG Antifreeze/Coolant	PG	33 - 50 vol.%	25,5 - 35,5 %Brix	colorless
Delo ELC-PG Antifreeze/Coolant	PG	33 - 50 vol.%	25,5 - 35,5 %Brix	pink
Castrol				
Radicool SF	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	pink
Caterpillar				
ELC	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	red
Chevron				
Havoline Xtended Life Coolant	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	orange
Fuchs				
Maintain Fricofin LL	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	orange
Gazprom Neft				
G-Energy Antifreeze SNF	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	red
Kemetyl				
GlycoCool Longlife Premium Antifreeze	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	orange
PEAK Chemicals				
Thermal Charge GX	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	colorless
Q8				
Antifreeze Long Life	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	orange
ROWE				
Hightec Antifreeze AN-SF 12+	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	violet
Shell				
Premium Antifreeze Longlife	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	orange

MWM

Appendix for Technical Bulletin 2091/17

TCG 3016

Manufacturer Product	Product basis	Application concentration	Determining concentration with a refractometer	Color
SWD Rheinol				
Antifreeze GW-12 Konzentrat	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	violet
TOTAL				
Glacelf Supra	MEG	33 - 50 vol.%	22,5 - 32,5 %Brix	yellow
Glacelf CHP Supra[1)]	MEG	20 - 30 vol.%	13,0 - 19,0 %Brix	yellow

[1)] Freezing protection only possible to -15 °C

Chemical corrosion protection agents without freezing protection

Manufacturer Product	Application concentration	Determining concentration with a refractometer	Color
Addinol			
Protect Extra	5,0 -7,5 vol.%	1,9 - 2,7 %Brix	colorless
Aqua Concept			
Coracon BL6	4,0 - 5,0 vol.%	1,6 - 2,0 %Brix	yellow
Arteco			
Havoline XLI	5,0 - 7,5 vol.%	1,9 - 2,7 %Brix	colorless
Caltex / Chevron / Texaco			
Delo XLI Corrosion Inhibitor	5,0 - 7,5 vol.%	1,9 - 2,7 %Brix	green
Delo ELI Corrosion Inhibitor	5,0 - 7,5 vol.%	1,9 - 2,7 %Brix	red
Caterpillar			
ELI	5,0 - 7,5 vol.%	1,9 - 2,7 %Brix	red
Total			
WT Supra	5,0 - 7,5 vol.%	1,9 - 2,7 %Brix	colorless