Fluids and Lubricants Specifications

Gas engines and gas engine-generator sets
Series 4000 gas engine – marine application
Series 4000 gas engine – generator application and engine-generator set
Series 400 gas engine – engine-generator set
Series 500 gas engine – engine-generator set

A001072/03E

A Rolls-Royce solution

© Copyright MTU

This publication is protected by copyright and may not be used in any way, whether in whole or in part, without the prior written consent of MTU. This particularly applies to its reproduction, distribution, editing, translation, microfilming and storage and/or its processing in electronic systems including databases and online services.

All information in this publication was the latest information available at the time of going to print. MTU reserves the right to change, delete or supplement the information or data provided as and when required.

Table of Contents

DCL-ID: 0000047995 - 006

DCL-ID: 0000047995 - 006

1 Preface

1.1 General information

These Fluids and Lubricants Specifications contain general instructions for the proper and safe operation of your product from the manufacturer MTU.

Definition of MTU

MTU refers to Rolls-Royce Power Systems AG and MTU Friedrichshafen GmbH or an affiliated company pursuant to Section §15 AktG (German Stock Corporation Act) or a controlled company (joint venture).

Used symbols and means of representation

The following instructions are highlighted in the text and must be observed:

Important
This field contains product information which is important or useful for the user. It refers to instructions, work and activities that have to be observed to prevent damage or destruction to the material.

Note:

A note provides special instructions that must be observed when performing a task.

Fluids and lubricants

The service life, operational reliability and function of the drive systems are largely dependent on the fluids and lubricants employed. The correct selection and treatment of these fluids and lubricants are therefore extremely important. This publication specifies which fluids and lubricants are to be used.

Test standard	Designation
DIN	Federal German Standards Institute
EN	European Standards
ISO	International Standards Organization
ASTM	American Society for Testing and Materials
IP	Institute of Petroleum
DVGW	German Gas and Water Industry Association

Table 1: Test standards for fluids and lubricants

Important
Approved fluids and lubricants may not be mixed.

Important
The customer must comply with the instructions specified in the safety data sheets of the respective manufacturers.

Applicability of this publication

The Fluids and Lubricants Specifications will be amended or supplemented as necessary. Prior to use, ensure that the most recent version is available. The most recent version can be consulted under:

http://www.mtu-solutions.com

If you have any questions, your contact person will be happy to help you.

TIM-ID: 0000051765 - 005

Warranty

Use of the approved fluids and lubricants, either under the brand name or in accordance with the specifications given in this publication, constitutes part of the warranty conditions.

The supplier of the fluids and lubricants is responsible for the worldwide standard quality of the named products.

Important

Fluids and lubricants for drive systems may be hazardous materials. Certain regulations must be obeyed when handling, storing and disposing of these substances.

These regulations are contained in the manufacturers' instructions, legal requirements and technical guidelines valid in the individual countries. Great differences can apply from country to country and a generally valid guide to applicable regulations for fluids and lubricants is therefore not possible within this publication.

Users of the products named in these specifications are therefore obliged to inform themselves of the locally valid regulations. MTU accepts no responsibility whatsoever for improper or illegal use of the fluids and lubricants which it has approved.

When handling fluids and lubricants the "Rules for the protection of the environment" (see Operating Instructions, Safety Regulations, Disassembly and Disposal) must be observed since they are hazardous to health and flammable.

Incorrect use of fluids and lubricants causes environmental pollution:

- Fluids and lubricants must not enter the ground or the sewerage system.
- Used fluids and lubricants must be disposed of through used oil recycling or hazardous waste disposal.
- Used filter elements and cartridges must be disposed of with hazardous waste.

Important

The customer / operator bears the responsibility for observing the fuel values.

Preservation

All information on preservation, represervation and depreservation including the approved preservatives is available in the Preservation and Represervation Specifications (publication number A001070/...). The most recent version can be consulted under:

http://www.mtu-solutions.com

TIM-ID: 0000051765 - 005

2 Lubricants

2.1 General Information

2.1.1 Engine oil

The selection of a suitable engine oil for gas engines depends primarily on the type of gas used to power the engine. The gas engine must only be operated with approved engine oil.

Approved engine oils are specified in the following chapters:
- For Series 4000 (→ Page 15)
- For Series 400 (→ Page 19)
- For Series 500 (→ Page 25)

An essential factor is the share of interfering contamination in the fuel gas. This requires that the operator regularly carries out gas checks. The gas engine oils to be used are characterized by the lowest possible ash content. This prevents increased ash deposits which can lead to reduced catalytic converter performance or combustion knocking.

During operation with biogas, in certain circumstances the engine oil contains corrosive contaminants which are created when the pollutants contained in the gas (chlorine, fluorine and sulfur compounds) are burned. These corrosive constituents can only be neutralized to a limited extent even by special additives engine oil.

Corrosion damage to the oil-lubricated engine components can only be avoided by more frequent oil changes. To improve buffering of concentration peaks when oil is subjected to corrosive contaminants, an increased engine oil volume is urgently recommended.

Important

Dispose of used fluids and lubricants in accordance with local regulations.

Important

Viscosity grade SAE 40 is stipulated for gas engines.
Multigrade oils are not permitted.

Important

Mixing different engine oils is strictly prohibited.

Important

Changing to another oil grade can be accomplished in the course of an oil change provided certain conditions are met. Contact MTU Service for this purpose.

Important

For applications with biogas, sewage gas or landfill gas, the quantity of oil in the engine oil pan is not adequate. A larger volume of oil is required.

TIM-ID: 0000051962 - 006

2.1.2 Engine oil limit values for Series 4000, 400

Oil change intervals for gas engines

Engine oil change intervals depend on the engine-oil quality, its conditioning, the operating conditions and the fuel used.

An oil sample must therefore be extracted on a regular basis depending on the engine oil volume, type of gas and series and the oil analysis must be compared with the limit values from (→ Table 2). The oil samples must always be taken under the same site conditions (engine at operation temperature) and at the designated point (extraction nozzle on oil filter housing).

If the limit values in accordance with (→ Table 2) are reached or exceeded, an oil change must be carried out immediately.

When using an extended volume of oil, the limit values for wear elements must be reduced inversely proportional to the volume enlargement. The maximum permissible reduction of limit values for the wear elements is 50% of the limit value (→ Table 2).

Fixed oil change intervals without oil analysis are permitted following consultation with MTU.

Limit values for used gas engine oils SAE 40

	Test method	Limit values for Series 4000	Limit values for Series 400
Viscosity at 100 °C (mm^2/s)	ASTM D445 DIN 51562	Max. 17.5 Min. 11.5	New oil value +30 % **
Total base number TBN (mgKOH/g)	ASTM D2896 ISO 3771	Min. 2.5 and TBN > TAN	New oil value -60 % **
Total acid number, TAN (mgKOH/g)	ASTM D664	max. new oil value +2.5	On request from factory
iph value	ASTM D7946	Min. 4	Min. 4
Water (% by vol.)	ASTM D6304 EN 12937 ISO 6296	Max. 0.2	Max. 0.2
Glycol (mg/kg)	ASTM D2982	Max. 100	On request from factory
Oxidation (A/cm)	DIN 51453	Max. 20	Max. 30
Nitration (A/cm)	DIN 51453	Max. 20	Max. 30
Wear elements (mg/kg):	DIN 51399-1/-2		
Iron (Fe)		Max. 30	Max. 50
Lead (Pb)		Max. 20	Max. 30
Aluminum (Al)		Max. 10	Max. 20
Copper (Cu)		Max. 20 ***	Max. 50
Tin (Sn)		Max. 5	Max. 15
Silicon (Si)		Max. 15 *	Max. 10 *

* The limit value for the wear element Si only refers to natural gas operation.
** New oil value can be requested from the factory
*** During the 1st oil change (max. 3000 op. hrs.), the limit value is 50 ppm.

Table 2: Limit values for used gas engine oils SAE 40

Used-oil analysis

The results of the oil analyses must be archived.

TIM-ID: 0000051978 - 006

From the indicated test methods and limit values, (→ Table 2) you can derive when the result of a single oil sample analysis is to be viewed as abnormal. An abnormal result (e.g. increased wear of the oil) requires an immediate investigation and rectification of the irregular operating condition (e.g. check of the gas preparation or analysis of the gas samples).

The limit values relate to individual oil samples. If the limit values are reached or exceeded, an oil change must be carried out immediately. The results of the oil analysis do not necessarily indicate the wear taking place on specific elements and components.

Aside from the analytical limit values, the condition, operating condition and possible malfunctions of the engine and the periphery of the system are also of equal importance.

TIM-ID: 0000051978 - 006

2.1.3 Engine oil limit values Series 500

Limit values for used gas engine oils

The following limit values must be observed when determining the oil change intervals for the corresponding series and modules.

Important

With an installed lube oil volume extension, the following limit values for iron, lead, aluminum, tin, chromium, copper and silicon must be halved in each case.
The reason for the limit value adaptation is the greater mixing of particles in the total oil filling volume. Without an adaptation of the limit values the measures for damage prevention can not be introduced.

Characteristics	Test method	Limit values Series 500
Viscosity at 100 °C (mm2/s)	ASTM D445 DIN 51562	Max. 17.5
Total base number TBN (mgKOH/ g	ASTM D2896 ISO 3771	Min. 2.5
Total acid number TAN (mgKOH/ g	ASTM D664	Fresh oil valve +2.5
iph value	ASTM D7946	Min. 4
Water (% by vol.)	ASTM D6304 EN 12937 ISO 6296	Max. 0.2
Glycol (vol. %)	ASTM D2982 DIN 51375	Max. 0.02
Oxidation (A/cm)	DIN 51453	Max. 20
Nitration (A/cm)	DIN 51453	Max. 20
Wear elements	DIN 51399-1/-2 DIN 51396	
Iron (Fe), ppm per 1000h		Max. 20
Lead (Pb), ppm per 1000h		Max. 35
Aluminum (Al), ppm per 1000h		Max. 15
Copper (Cu), ppm per 1000h		Max. 15
Tin (Sn), ppm per 1000h		Max. 10
Silicon (Si), ppm		Max. 15*
Chromium (Cr), ppm per 1000h		Max. 5
Sodium (Na), ppm		Max. 20
* For sewage gas applications, the limit value is increased to 100 mg/kg		

Table 3: Limit values for used gas engine oils

TIM-ID: 0000092047 - 001

2.1.4 Silicon compounds in the fuel gas

Silicon compounds in the gas lead to deposits and promote wear. Even catalytic converters are deactivated by these compounds. Damage caused by silicon compounds is not covered by the warranty.

Silicon operational value Si_B

During operation with gases containing silicon, take particular note of the increased silicon content in the oil. For this purpose, the silicon operational value Si_B must be calculated with the help of the formula below.

$$Si_B = \text{Delta Si oil analysis B - A [ppm]} \times \frac{\text{(Oil fill quantity + top-up quantity) [liters]}}{\text{generated electrical work [kWh]}}$$

Compliance with the Si_B must be seamlessly verified by the operator's analyses.

Silicon operational value Si_{BG}

With regard to the silicon operational limit values Si_{BG}, a distinction is made between operating with a catalytic converter and operating without one.

Operation	Si_{BG}
With catalytic exhaust gas cleaning	0
Without catalytic exhaust gas cleaning	< 0.01 (Series 4000)
Without catalytic exhaust gas cleaning	< 0.02 (Series 400)

Experience has shown that for the required use of oxidation catalytic converters, the impossibility of verification must be requested ($Si_B = 0$).

Nevertheless, due to the high sensitivity of the catalytic converter, premature activity loss can occur, particularly at formaldehyde conversion.

Important
MTU excludes damage caused by silicon to the engine and catalytic converter from the warranty.

Example for calculating the silicon operating value Si_B

Example data for calculating the silicon operating value Si_B		
Delta Si between oil analysis A and B	20	ppm (mg/kg)
Oil fill quantity in circulation	800	dm^3
Topped up oil quantity	200	dm^3
Generated electrical work between oil analysis A and B	2000000	kWh

$$SI_B = 20 \text{ [ppm]} \times \frac{(800 + 200) \text{ [dm}^3\text{]}}{2000000 \text{ [kWh]}} = 0.01$$

TIM-ID: 0000079056 - 003

2.1.5 Fluorescent dyestuffs for detecting leaks in the lube oil circuit

The fluorescent dyestuffs listed below are approved for detection of leaks in the lube oil circuit.

Manufacturer	Product name	Working concentration	Material number	Container size	Storage stability[1)]
Chromatech Europe B.V.	D51000A Chromatint Fluorescent Yellow 175	0.04 % - 0.07 %	X00067084	16 kg	2 years
Cimcool, Cincinnati	Producto YFD-100	0,5 % - 1,0 %		5 gallons (canister) 55 gallons (barrel)	6 months

Table 4:

[1)] = ex works delivery, based on original and hermetically sealed containers in frost-free storage (> 5 °C).

The fluorescence (light-yellow color tone) of both dyestuffs is made visible with a UV lamp (365 nm).

TIM-ID: 0000055616 - 003

2.1.6 Lubricating greases

Requirements

The conditions of MTU for the approval of lubricating greases are specified in the delivery standard MTL 5050, which can be ordered under this reference number.

Grease manufacturers are notified in writing if their product is approved.

Lubricating greases for general applications

Use lithium-saponified grease for all grease lubrication points.

Exceptions are:
- Compressor bypass, fitted between turbocharger and intercooler
- Coupling internal centering

Lubricating greases for applications at high temperatures

High-temperature grease (up to 250 °C) must be used for the compressor bypass installed between turbocharger and intercooler:
- Aero Shell Grease 15
- Optimol Inertox Medium

General purpose greases suffice for the compressor bypass located before the turbocharger or after the intercooler.

Greases for internal centerings of couplings

Greases for internal centerings:
- Esso Unirex N 3 (temperature-stable up to approx. 160 °C)

Lubricants for special applications (only Series 4000)

Oil for turbochargers

Exhaust turbochargers with integrated oil supply are generally connected to the engine lube oil system.

For ABB turbochargers which are not connected to the engine lube oil system, mineral-based turbine oils with viscosity grade ISO-VG 68 must be used.

Lubricating greases for curved tooth couplings

Depending on the application, the following lubricants have been approved for curved tooth couplings:
- Make: Klüber: Structovis BHD MF (highly-viscous lube oil)
- Make: Klüber: Klüberplex GE11–680 (adhesive gearbox/transmission lubricant)

Guidelines on use and service life are contained in the relevant Operating Instructions and Maintenance Schedules.

TIM-ID: 0000079205 - 003

2.1.7 Lubricating greases for general applications

For details and special features, see chapter "Lubricating greases"(→ Page 7)

Manufacturer	Brand name	Notes
Aral AG	Mehrzweckfett Arallub HL2	
BP p.l.c.	Energrease LS2	
Castrol Ltd.	Spheerol AP2	
Chevron	Multifak EP2	
SRS Schmierstoff Vertrieb GmbH	SRS Wiolub LFK2	
Shell Deutschland GmbH	Shell Gadus S2 V220 2	
Total	Total Multis EP2	
Veedol International	Multipurpose	

Table 5:

TIM-ID: 0000019094 - 004

2.2 Series 4000 gas engine – Generator application and engine-generator set - marine application

2.2.1 Approved engine oils

For details and special features, see chapter "General" (→ Page 7).

Engine oils for Series 4000 gas engines

Manufacturer	Brand name	SAE viscosity class	Model type						Comments / material number
			4000L61 / L62 / L63	4000L64 / L64FNER	4000L32 / L33 / L32FNER	4000L32FB	4000L62FB*	4000Mx5xN	
MTU Friedrichshafen	GEO BG Power B2L	40				X	X		20 l container: X00072870 205 l container: X00072871 IBC: X00072872
	GEO NG Power X2L	40	X						20 l container: X00072874 205 l container: X00072875 IBC: X00072876
	GEO NG Power X3L	40	X	X	X			X	20 l container: X00072877 205 l container: X00072878 IBC: X00072879
X = Approval for model type * = With this model type, the additional information in the Technical Description under the item Lube oil system must be observed when selecting the approved engine oil.									

Table 6: Engine oils for Series 4000 gas engines

Important
To determine the engine oil change intervals, oil samples must be taken every 250 op. hrs. and analyzed. The limit values must be observed (→ Page 8).

TIM-ID: 0000077948 - 005

Alternative engine oils for Series 4000 gas engines

Manufacturer	Brand name	SAE viscosity class	Model type					
			4000L61 / L62 / L63	4000L64 / L64FNER	4000L32 / L33 / L32FNER	4000L32FB	4000L62FB**	4000Mx5xN
Addinol	MG 40 Extra LA	40				X	X	
	MG 40 Extra Plus	40					X	
BayWa AG	Tectrol MethaFlexx HC Premium	40				X	X	
Castrol Ltd.	Castrol Duratec L	40	X		X *			
Exxon Mobil Corporation	Mobil Pegasus 705	40	X		X *			
	Mobil Pegasus 805 (55 gallons: 23538056)	40	X		X *			
	Mobil Pegasus 1005 (55 gallon drum: 800019)	40	X	X				X
Fuchs Europe Schmierstoffe GmbH	Titan Ganymet Ultra	40				X	X	
	Titan Ganymet LA	40	X					
NILS S.p.A.	Burian	40					X	
Schnell Motoren GmbH	Schnell Protect Oil	40				X	X	
Shell International Petroleum Company	Shell Mysella S3 N 40	40	X		X *			
	Shell Mysella S5 N 40	40	X	X	X			
SRS Schmierstoff Vertrieb GmbH	SRS Mihagrun LA 40	40	X		X *			
Total Deutschland	Nateria MH40	40	X		X *			
	Nateria MJ40	40					X	
	Nateria MP40	40	X	X	X	X	X	X
Petro-Canada Europe Lubricants Ltd.	Sentron CG 40 (205 l drum: 800262)	40				X	X	
	Sentron LD 5000	40	X					
	Sentron LD 8000 (205 l drum: 800315)	40	X	X	X			X

X = Approval for model type
* The use of these engine oils shortens the service life.
** = With this model type, the additional information in the Technical Description under the item Lube oil system must be observed when selecting the approved engine oil.

Table 7: Alternative engine oils for Series 4000 gas engines

TIM-ID: 0000077948 - 005

Important

To determine the engine oil change intervals, oil samples must be taken every 250 op. hrs. and analyzed. The limit values must be observed (→ Page 8).

2.2.2 Lubricating greases for generators

The generator manufacturers lubricate the bearings before shipment.

Lubricant must be added when the unit is out into operation.

Important information
The specifications on the generator plate are always applicable. Observe the manufacturer's specifications on the generator nameplate.

The manufacturers provide the following information on the generator:
- Lubricating grease to be used
- Amount of grease to be added
- Lubricating interval

The applicable Maintenance Schedule must be complied with.

Further information is available in the manufacturer's documentation.

Important information
The temperature of the generator bearings should be monitored during the first operating hours.

Important information
Poor lubrication can lead to excessive temperatures and damage to the bearings.

Lubricating greases for generators in Series 4000 gas

Generator manufacturer	Lubricating grease (MTU material number)
Leroy-Somer	Shell Gadus S3 V220C2 (X00067217) *
	Mobil Polyrex™ EM: grade NLGI 2 (X00071899) *
Cummins	KLUEBER ASONIC GHY72 (09110145007)
Hitzinger	LUKOIL SIGNUM EPX2 (X00071900)
* According to the manufacturer, operation with a mixture of the two lubricating greases is not permitted. Observe the manufacturer's specifications on the generator nameplate.	

TIM-ID: 0000072708 - 003

2.2.3 Gear oils

Approved lubricating oils

Only applies for 60 Hz applications.

Manufacturer / supplier	Designation	SAE Viscosity class	Note
Mobil	Mobilgear SHC XMP320 (5 gallons: 800233 / (55 gallons: 800232)	40	S
Mobil	SHC 632 (5 gallons: 800235 / (55 gallons: 800234)	40	S
Klüber	GEM4-320N	40	S
Total	Carter SH320	40	S
S = synthetic lube oil			

Table 8: Approved lubricating oils

Important
Only synthetic gear oil types are permitted.

Capacity

Type of gearbox/transmission	Engine	liter
GU 320	8V4000Lx 12V4000Lx	65
GU 395	16V4000Lx 20V4000Lx	92

Table 9: Capacity

The test run is carried out at MTU with Mobil SHC 632.

MTU material number:
- 09110149525 – gear oil MOBIL SHC 632 (barrel)
- 09110149555 – gear oil MOBIL SHC 632 (canister)

Oil change intervals:
- Also refer to the Maintenance Schedule from MTU and the operating instructions of the gearbox manufacturer
- First oil change after 500 operating hours, then every 6000 operating hours
- Regular oil analysis in accordance with the Maintenance Schedule

Fill cold gear oil exactly up to the middle of the sight glass. During operation, the oil level at the sight glass initially sinks but can subsequently rise above it due to temperature expansion. Ventilation takes place via the labyrinth seal at the shafts.

TIM-ID: 0000051979 - 005

2.3 Series 400 gas engine – Engine-generator set

2.3.1 Approved engine oils

Engine oils for naturally-aspirated Series 400 engines

Manufacturer / supplier	Brand name	SAE viscosity class	Note	
MTU Friedrichshafen	GEO NG POWER X2L [2)]	40[1)]	M	E, P

Table 10: Engine oils for naturally-aspirated Series 400 engines

1) Approval conditional on ambient temperature at engine being > +10 °C
2) 20 l container: X00072874 / 205 l container: X00072875 / IBC: X00072876
M Mineral engine oil
E Natural gas
P Propane

Alternative engine oils for naturally-aspirated Series 400 engines

Manufacturer / supplier	Brand name	SAE viscosity class	Note	
Addinol Lube Oil GmbH	ECO GAS 4000 XD	40[1)]	M	E, P
	MG 40 Extra LA	40[1)]	M	E, P
AUTOL	ELA 40	40[1)]	M	E, P
AVIA AG	LA 40	40[1)]	M	E, P
	LA Plus 40	40[1)]	M	E, P
Castrol	Duratec HPL	40[1)]	M	E, P
	Duratec XPL	40[1)]	S	E, P
BayWa AG	TECTROL Methaflexx HC Premium	40[1)]	M	E, P
	TECTROL Methaflexx NG	40[1)]	M	E, P
Eni Schmiertechnik GmbH	Eni Geum 40	40[1)]	M	E, P
ExxonMobil	SHC Pegasus 40	40[1)]	S	E, P
	Pegasus 605	40[1)]	M	E, P
	Pegasus 705	40[1)]	M	E, P
	Pegasus 805	40[1)]	M	E, P
	Pegasus 1005	40[1)]	M	E, P
	Pegasus 1107	40[1)]	M	E, P
Fuchs Europe Schmierstoffe GmbH	Titan Ganymet LA	40[1)]	M	E, P
	Titan Ganymet Ultra	40[1)]	M	E, P
Kuwait Petroleum	Q8 Mahler MA	40[1)]	M	E, P
Petro-Canada Europe Lubricants Ltd.	Sentron LD 5000	40[1)]	M	E, P
	Sentron LD 8000	40[1)]	M	E, P
Shell International Petroleum Company	Shell Mysella S5 N 40	40[1)]	M	E, P

TIM-ID: 0000053541 - 007

Manufacturer / supplier	Brand name	SAE viscosity class	Note	
Shell International Petroleum Company	Shell Mysella S5 S 40	40 [1)]	M	E, P
Total Deutschland	Total Nateria MP40	40 [1)]	M	E, P

Table 11: Alternative engine oils for naturally-aspirated Series 400 engines

1) Approval conditional on ambient temperature at engine being > +10 °C
S Synthetic engine oil
M Mineral engine oil
E Natural gas
P Propane

Engine oils for Series 400 turbo engines

Manufacturer / supplier	Brand name	SAE viscosity class	Note		
MTU Friedrichshafen	GEO NG POWER X2L [2)]	40 [1)]	M	E, P	K
	GEO BG POWER B2L [3)]	40 [1)]	M	B	K

Table 12: Engine oils for Series 400 turbo engines

1) Approval conditional on ambient temperature at engine being > +10 °C
2) 20 l container: X00072874 / 205 l container: X00072876 / IBC: X00072875
3) 20 l container: X00072870 / 205 l container: X00072872 / IBC: X00072871
M Mineral engine oil
E Natural gas
P Propane
B Biogas
K suitable for catalytic converter

Alternative engine oils for Series 400 turbo engines

Manufacturer / supplier	Brand name	SAE viscosity class	Note		
AUTOL	BGJ 40	40 [1)]	M	B	K
	ELA 40	40 [1)]	M	E, P	K
AVIA AG	HA 40	40 [1)]	M	B	K
	LA 40	40 [1)]	M	E, P	K
	LA Plus 40	40 [1)]	M	E, P	K
Addinol Lube Oil GmbH	ECO GAS 4000 XD	40 [1)]	M	E, P	K
	MG 40 Extra Plus	40 [1)]	M	B	K
	MG 40 Extra LA	40 [1)]	M	E, P	K
NILS	Burian	40 [1)]	M	B	K
BayWA AG	TECTROL Methaflexx D	40 [1)]	M	B	K
	TECTROL Methaflexx HC Plus	40 [1)]	M	B	K
	TECTROL Methaflexx HC Premium	40 [1)]	M	E, P	K
	TECTROL Methaflexx HC Premium	40	M	B	SRK
	TECTROL Methaflexx NG	40 [1)]	M	E, P	K

TIM-ID: 0000053541 - 007

Manufacturer / supplier	Brand name	SAE viscosity class	Note		
Castrol	Duratec HPL	40 [1)]	M	E, P	K
	Duratec XPL	40 [1)]	S	E, P	K
Chevron Texaco	Geotex LF 40	40 [1)]	M	B	K
Eni Schmiertechnik GmbH	Eni Geum 40	40[1)]	M	E, P	K
ExxonMobil	SHC Pegasus 40	40 [1)]	S	E, P	K
	Pegasus 605	40 [1)]	M	E, P	K
	Pegasus 610	40 [1)]	M	B	K
	Pegasus 705	40 [1)]	M	E, P	K
	Pegasus 710	40 [1)]	M	B	K
	Pegasus 805	40 [1)]	M	E, P	K
	Pegasus 1107	40 [1)]	M	E, P	K;
Fuchs Europe Schmierstoffe GmbH	Titan Ganymet	40 [1)]	M	B	K
	Titan Ganymet LA	40 [1)]	M	E, P	K
	Titan Ganymet Plus	40 [1)]	M	B	K
	Titan Ganymet Ultra	40 [1)]	M	E, P	K
	Titan Ganymet Ultra	40 [1)]	M	B	SRK
Hessol Lubrication GmbH	Hessol Gasmotorenöl	40 [1)]	M	B	K
Kuwait Petroleum	Q8 Mahler HA	40 [1)]	M	B	K
	Q8 Mahler MA	40 [1)]	M	E, P	K
Petro-Canada Europe Lubricants Ltd.	Sentron CG 40	40 [1)]	M	B	K
	Sentron LD 5000	40 [1)]	M	E, P	K
	Sentron LD 8000	40 [1)]	M	E, P	K
Shell International Petroleum Company	Shell Mysella S5 N 40	40 [1)]	M	E, P	K
Shell International Petroleum Company	Shell Mysella S5 S 40	40 [1)]	M	E, P, B	K
Total Deutschland	Total Nateria MJ40	40[1)]	M	B	K
Total Deutschland	Total Nateria MP40	40 [1)]	M	E, P	K

Table 13: Alternative engine oils for Series 400 turbo engines

1) Approval conditional on ambient temperature at engine being > +10 °C
S Synthetic engine oil
M Mineral engine oil
E Natural gas
P Propane
B Biogas
K suitable for catalytic converter
SRK Sulfur-resistant catalytic converter

TIM-ID: 0000053541 - 007

2.3.2 Engine oil change intervals

Mineral oil, engine oil system with oil spray-off system and additional capacity

If the additional capacity is increased, e.g. to 800 l for the E3066Dx, the oil change interval will also increase 4-fold in comparison to the case where the additional capacity is 200 l.

Oil analyses need to be carried out at regular intervals in such cases.

Designation	Engine oil system with oil spray-off system and additional capacity	
Module / engine-generator set with engine model	Oil change based on operating hours	Min. additional capacity
E3066D1-D3	2500	200 l
E3066D4	3000	200 l
E3066Lx/Zx	1000	120 l
E3042D1-D3	1250	200 l
E3042D4	1500	200 l
E3042Lx/Zx	1000	200 l
E3042Lx/Zx	5000 (or oil analysis)	1000 l
B3066Lx/Zx	1000	200 l
B3042Lx/Zx	1000	300 l

Table 14: Mineral oil, engine oil system with oil spray-off system and additional capacity

Mineral oil, engine oil system with fresh-oil replenishment function only (no oil spray-off system)

Designation	Engine oil system with fresh-oil replenishment function only (no oil spray-off system)	
Module / engine-generator set with engine model	Oil change based on operating hours	Recommended capacity of fresh-oil tank
E3066D1-D3	600	60 l
E3066Lx/Zx	300	60 l
E3042D1-D3	600	60 l
E3042Lx/Zx	300	60 l

Table 15: Mineral oil, engine oil system with fresh-oil replenishment function only (no oil spray-off system)

Synthetic oil, engine oil system with oil spray-off system and additional capacity

If the additional capacity is increased, e.g. to 800 l for the E3066Dx, the oil change interval will also increase 4-fold in comparison to the case where the additional capacity is 200 l.

Oil analyses need to be carried out at regular intervals in such cases.

Designation	Engine oil system with oil spray-off system and additional capacity	
Module / engine-generator set with engine model	Oil change based on operating hours	Min. additional capacity
E3066Lx/Zx	2000	200 l
E3042Lx/Zx	1000	160 l
E3042Lx/Zx	8000 (or oil analysis)	1000 l

Table 16: Synthetic oil, engine oil system with oil spray-off system and additional capacity

TIM-ID: 0000053502 - 002

Synthetic oil, engine oil system with fresh-oil replenishment function only (no oil spray-off system)

Designation	Engine oil system with fresh-oil replenishment function only (no oil spray-off system)	
Module / engine-generator set with engine model	Oil change based on operating hours	Recommended capacity of fresh-oil tank
E3066D1-D3	1250	50 l
E3066D4	1500	50 l
E3066Lx/Zx	600	50 l
E3042D1-D3	1250	100 l
E3042D4	1500	100 l
E3042Lx/Zx	600	100 l

Table 17: Synthetic oil, engine oil system with fresh-oil replenishment function only (no oil spray-off system)

TIM-ID: 0000053502 - 002

2.3.3 Lubricating greases for generators

Lubricating greases for generators in Series 400

Generator manufacturer	Lubricating grease
Leroy-Somer	Lubricated for life

Important information
Observe the manufacturer's specifications on the generator nameplate.

TIM-ID: 0000072692 - 002

2.4 Series 500 gas engine – Engine-generator set

2.4.1 Approved engine oils

Special gas engine oils must be used for the gas engines and be evaluated according to described criteria.

Approved products for all series including the corresponding sample sets can be obtained directly from MTU.

Important
The use of oil additives is prohibited.

If pollutant values that negatively influence the oil level are exceeded (in particular, hydrogen sulfide (H_2S)), the oil change intervals must be shortened following consultation with MTU.

Manufacturer / supplier	Brand name
Shell	Mysella S5 S40
Mobil	Pegasus 1005
Addinol	Eco Gas 4000 XD

Table 18: Approved oils for natural gas/lean gas (biogas, sewage gas, syngas,...)

The oil volume is composed as follows:

Engine	Engine oil pan	Auxiliary tank in the base frame (option)	Total
12V500	90 l	190 l	280 l
8V500	60 l	140 l	200 l
6R500	40 l	100 l	140 l

Table 19: Composition of the oil volume

TIM-ID: 0000091952 - 001

2.4.2 Engine oil change intervals

The engine oil service lives must be determined based on regular oil analyses depending on the operating conditions.

The oil change must always be carried out depending on the engine oil condition.

Oil sample intervals

During the first oil interval, sample intervals of 250 op. hrs. starting after 250 op. hrs. must be observed. After the third sample extraction, i.e. after 750 op. hrs., an oil change must be carried out in all circumstances.

Based on the last sample, a service life forecast can be made for the next oil interval. With the first three oil fillings of an engine, MTU recommends to always start sampling at the latest at 500 op. hrs. with sampling in a 250 op. hrs. cycle because considerable changes in the oil load are still possible in the running-in phase of an engine.

Important

MTU recommends continuous monitoring of the gas quality. The sampling intervals can only be guaranteed if the required gas quality is observed and fluctuations are low. Insufficient monitoring of the gas quality makes shorter oil sampling intervals necessary.
The oil change must be carried out based on the condition. The operating company must ensure that the trend resulting from the analyses does not result in the named limit values being exceeded (→ Page 10).
With the use of lean gas in particular, it is recommended to observe a buffer between the maximum oil limit values. MTU recommends an oil change when 80% of the wear values have been reached.
After major repair measures (e.g. after an inspection) or after changing the oil grade, the procedure for determining the oil change intervals in accordance with the above instructions must be carried out again.

For each engine of a plant, after testing the plant-specific oil service life every additional oil filling must also be analyzed again. For the further analytical operational monitoring or low-risk maximization of the oil usage time,

- at approx. 60%,
- at approx. 80% and
- at approx. 100%

of the tested or statistically evaluated oil service life, used oil analyses are prescribed.

Independently of the oil change interval, you must always ensure that the oil analysis interval does not exceed 500 op. hrs. With a lean gas application with seriously fluctuating fuel gas quality, a considerably reduced maximum oil analysis interval of 100 operating hours can be expected.

Before carrying out an oil change, a sample must be taken and sent for analysis.

Lean gas operation

In lean gas operation, it can be anticipated that a reduction in the oil service life is necessary depending on the given fuel gas quality.

A reduction in the oil change intervals is necessary if a constant gas quality can not be guaranteed or if the gas quality is subject to major fluctuations (e.g. with the use of syngases).

Oil filter

The oil filter(s) must be replaced during every oil change.

In the case of long oil service lives (> 1000 h) or with a low annual utilization of the engine, the oil filter must be replaced at least once a year independently of the oil change or be replaced during all scheduled maintenance.

TIM-ID: 0000091954 - 001

2.4.3 Oil volume

Oil volume extension and line systems

If the resultant oil service life is not fully satisfactory, by increasing the engine oil capacity with the option "Oil volume extension" the oil service life can be extended.

Oil changeover procedure

To keep the described influences to a minimum, MTU recommends the following oil changeover procedure:

1. Drain the oil of the original brand as completely as possible.
2. Fill the new oil grade up to the minimum marking of the engine.
3. Run the engine for 2 hours at full load.
4. Carry out an oil and filter change.

The achievable oil service life must be checked again using the described procedure, see (→ Page 26).

Important
The oil supply tank and all lines must be flushed accordingly with the new oil in order to keep the influences here also to a minimum.

TIM-ID: 0000091955 - 001

2.4.4 Lubricating greases for generators

Lubricating greases for generators in Series 500

Generator	Lubricating grease
LSAH 44.3 LSA 49.1 / 49.3 optional LSA 46.3 / 46.1 / 47.2	Esso Unirex N3

Important
Observe the manufacturer's specifications on the generator nameplate.

TIM-ID: 0000094907 - 001

3 Coolants

3.1 General Information

3.1.1 Coolant - Definition

Important

Ensure that used fluids and lubricants are collected in sufficiently large collecting containers. Observe safety data sheets and dispose of used fluids and lubricants in accordance with country-specific regulations.

Coolant =	coolant additive (concentrate) + fresh water to predefined mixing ratio • Ready for use in engine
Antifreeze =	Corrosion inhibitor + glycol + additives + water • The predecessor version of the Fluids and Lubricants Specifications used the term "corrosion inhibiting antifreeze". For clarity purposes, this publication uses the term "Antifreeze".

Antifreeze is necessary for engine operation in areas where below-freezing temperatures may occur.

The relevant concentration range for use is listed in the section on operational monitoring.

Coolant without antifreeze =	Corrosion inhibitor + additives + water • The predecessor version of the Fluids and Lubricants Specifications used the term "water-soluble corrosion inhibitors". This designation will be replaced with immediate effect with "coolant without antifreeze".

The coolants approved by MTU ensure adequate corrosion protection provided the correct concentrations are used. The relevant concentration range for use is listed in the section on operational monitoring.

Approved coolant additives are specified in the following chapters:
- For Series 4000 gas engine – marine application (→ Page 43)
- For Series 4000 gas engine – generator application and engine-generator set (→ Page 53)
- For Series 4000 gas engine – engine-generator set (→ Page 62)
- For Series 500 gas engine – engine-generator set (→ Page 65)

.

Special arrangements presently in effect remain valid.

Important

Coolant additives containing nitrite must not be used in conjunction with coolers that contain brass.

Important

Flushing with water is required at every change to a different coolant product. For flushing and cleaning specifications for engine coolant circuits, see (→ Page 100).

TIM-ID: 0000051961 - 006

Note

- Propylene glycol-based antifreezes are stipulated for use in some types of applications. These products have a lower thermal conductivity than the usual ethylene glycol products. This results in a higher temperature level in the engine.
- The product BASF G206 is available for use at extremely low temperatures (-65 °C/arctic regions). This product will no longer be available in the future. Stock inventory of this product may be used up as long as the shelf life has not expired. Please contact your MTU partner.

The corrosion-inhibiting effect of coolant is only ensured with the coolant circuit fully filled.

Only corrosion inhibitors approved for internal preservation of the coolant circuit also provide proper corrosion protection when the medium is drained. This means that, after draining of the coolant, the cooling circuit must be preserved if the coolant is not refilled. The procedure is described in the Preservation and Represervation Specifications A001070/...

Coolants must be prepared from suitable fresh water and a coolant additive approved by MTU. Conditioning of the coolant must take place outside the engine.

Important

Mixtures of different coolant additives and supplementary additives (also in coolant filters and filters downstream of plant components) are not permitted.

Important

For ready mixtures, the proportion of coolant additive (concentrate) is always named first.
Example: Coolant AH 40/60 Antifreeze Premix = 40% by volume coolant additive / 60% by volume Fresh water

TIM-ID: 0000051961 - 006

3.1.2 Operational monitoring / coolant conditioning for Series 4000 and 400 engines

Inspection of the freshwater and continuous monitoring of the coolant are essential for trouble-free engine operation. Fresh water and coolant should be checked at least once per year and with each fill-up. Inspections can be carried out using the MTU Test Kit, or by an authorized laboratory. The MTU test Kit contains the necessary equipment, chemicals and instructions for use.

Analysis	Method for on-site checks (MTU Test Kit)	Method for lab analysis
Determination of the water hardness	Titration	Determination of the Ca and Mg content by means of ICP and calculation of the hardness in °dH or mmol/l
Determination of the pH value	Litmus paper strips for an appropriate measuring range	ASTM D 1287
Determination of the chloride content	Titration	IC
Determination of the sulfate content	-	IC
Determination of the silicon content	-	ICP
Determination of additive concentration in aqueous coolant solutions	Brix refractometer, compare degree(s) Brix against table (→ Table 22) and read off concentration in % by volume	Refractometer method DIN 51423, compare Brix degree against table (→ Table 22) and read off concentration in % by volume
Determination of antifreeze concentration	Glycol refractometer, concentration in % by volume can be read off directly	Refractometer method DIN 51423, calculation through refraction index or product-specific factor
Determination of germ total for aqueous media	-	Dip slides (tube with culture medium, e.g. by VWR Prolabo No. 535112D or equivalent) incubation time: 4 days at 30 °C

Table 20: Minimum requirements and methodology for coolant monitoring

Orders for fresh water and coolant analysis may be placed with MTU. In particular cases, operational monitoring can cover more checks that those listed in table (→ Table 20). Please contact your MTU partner if necessary.

Permissible concentrations of antifreezes

	Minimum			Maximum
Antifreeze on ethylene glycol basis	35% by volume	40% by volume	45% by volume	50% by volume
With antifreeze protection up to*	-20 °C	-25 °C	-31 °C	-37 °C
BASF G206	65% by volume for application at outside temperatures of up to -65 °C in arctic regions			
* = antifreeze specifications determined as per ASTM D 1177				

Table 21: Permissible concentrations of antifreezes

Important
After flushing the engine coolant circuit, the concentration of antifreeze must not exceed 35 % by volume.

TIM-ID: 0000078628 - 004

Add antifreeze to the fresh water with a concentration of at least 35 % by volume when antifreeze protection to minus - 20 °C is sufficient. If lower ambient temperatures are expected, the concentration must be increased accordingly. A concentration of above 50 % by volume is impermissible.

Mixtures containing a proportion of antifreeze below 35 % by volume do not guarantee adequate corrosion protection.

Use the treated water in both summer and winter operation. Compensate for coolant losses in such a way as to maintain the antifreeze concentration.

Permissible concentrations, coolant without antifreeze for all applications

Permissible concentration range	Manufacturer	Brand name	Reading on hand refractometer[1] at 20 °C (= degrees Brix) vol%					
			7	8	9	10	11	12
9 to 11% by volume	MTU Friedrichshafen	Coolant CS 100 Corrosion Inhibitor Concentrate	3.5	4.0	4.5	5.0	5.5	6.0
		Coolant CS 10/90 Corrosion Inhibitor Premix	3.5	4.0	4.5	5.0	5.5	6.0
	MTU America	Power Cool® Plus 6000	3.5	4.0	4.5	5.0	5.5	6.0
	Arteco	Freecor NBI	Please use test kit of manufacturer					
	BASF SE	Glysacorr G93 green	3.5	4.0	4.5	5.0	5.5	6.0
	CCI Corporation	A 216	4.9	5.6	6.3	7.0	7.7	8.4
	CCI Manufacturing IL Corporation	A 216	4.9	5.6	6.3	7.0	7.7	8.4
	Chevron	Texcool A -200	Please use test kit of manufacturer					
	Detroit Diesel Corporation	Power Cool Plus 6000	4.9	5.6	6.3	7.0	7.7	8.4
	Drew Marine	Drewgard XTA	3.5	4.0	4.5	5.0	5.5	6.0
	ExxonMobil	Mobil Delvac Extended Life Corrosion Inhibitor	4.9	5.6	6.3	7.0	7.7	8.4
	Ginouves	York 719	3.5	4.0	4.5	5.0	5.5	6.0
	Old World Industries Inc.	Final Charge Extended Life Corrosion Inhibitor (A 216)	4.9	5.6	6.3	7.0	7.7	8.4
	Valvoline	Zerex G-93	3.5	4.0	4.5	5.0	5.5	6.0

[1] = concentration determination by means of suitable hand refractometer

Table 22: Permissible concentrations, coolant without antifreeze for all applications

Calibrate the hand refractometer with clean water at coolant temperature. The coolant temperature should be 20 °C. Observe the specifications of the manufacturer.

Important

After flushing the engine coolant circuit, the concentration of corrosion inhibitor must not exceed 9 % by volume.

TIM-ID: 0000078628 - 004

Permissible concentrations, additional coolant without antifreeze exclusively for marine (free of light metals)

Permissible concentration range	Manufacturer	Brand name	Reading on hand refractometer[1] at 20 °C (= degrees Brix) vol%					
			7	8	9	10	11	12
7 to 11% by volume	Arteco	Havoline Extended Life Corrosion Inhibitor XLI [EU 32765]	2.6	3.0	3.4	3.7	4.1	4.4
	Chevron Lubricants	Delo XLI Corrosion Inhibitor - Concentrate	2.6	3.0	3.4	3.7	4.1	4.4
	Nalco Water An Ecolab Company	Alfloc™ 3443	1.75	2.0	2.25	2.5	2.75	3.0
		Alfloc™ 3477	1.75	2.0	2.25	2.5	2.75	3.0
	PrixMax Australia Pty. Ltd.	PrixMax RCP	2.6	3.0	3.4	3.7	4.1	4.4
	Total	WT Supra	2.6	3.0	3.4	3.7	4.1	4.4
5 to 6% by volume	Fleetguard	DCA-4L	Please use test kit of manufacturer					
3 to 4% by volume	Detroit Diesel Corporation	Power Cool 2000	Please use test kit of manufacturer					
	Nalco Water An Ecolab Company	Nalcool® 2000						
	Penray	Pencool 2000						
[1] = concentration determination by means of suitable hand refractometer								

Table 23: Permissible concentrations, additional coolant without antifreeze exclusively for marine (free of light metals)

Calibrate the hand refractometer with clean water at coolant temperature. The coolant temperature should be 20 °C. Observe the specifications of the manufacturer.

Permissible concentrations, antifreeze on ethylene glycol basis

The concentration is determined using a suitable glycol refractometer and direct reading of the scale value in % by vol.

Calibration table for antifreeze for special applications

Reading on hand refractometer at 20 °C (= degrees Brix)		Corresponds to a concentration of
I. Propylene glycol antifreeze	II. BASF G206	
26.3	24.8	35% by volume
26.9	25.5	36% by volume
27.5	26.1	37% by volume
28.2	26.7	38% by volume
28.8	27.4	39% by volume
29.5	28.0	40% by volume
30.1	28.6	41% by volume

TIM-ID: 0000078628 - 004

Reading on hand refractometer at 20 °C (= degrees Brix)		Corresponds to a concentration of
I. Propylene glycol antifreeze	II. BASF G206	
30.8	29.2	42% by volume
31.3	29.8	43% by volume
31.9	30.4	44% by volume
32.5	30.9	45% by volume
33.1	31.5	46% by volume
33.7	32.1	47% by volume
34.2	32.6	48% by volume
34.8	33.2	49% by volume
35.3	33.8	50% by volume
	34.4	51% by volume
	34.9	52% by volume
	35.5	53% by volume
	36.1	54% by volume
	36.7	55% by volume
	37.2	56% by volume
	37.8	57% by volume
	38.3	58% by volume
	38.9	59% by volume
	39.4	60% by volume
	39.9	61% by volume
	40.5	62% by volume
	41.0	63% by volume
	41.5	64% by volume
	42.0	65% by volume

Table 24: Calibration table for antifreeze for special applications

Limit values for coolants

pH value when using:		
– Antifreeze	Min. 7.5	Max. 9.0
– Coolant without antifreeze for engines containing light metal	Min. 7.5	Max. 9.0
– Coolant without antifreeze for engines free of light metal	Min. 7.5	Max. 11.0
– Silicon (valid for coolants containing Si)	Min. 25 mg/l	

Important

For a holistic appraisal of a coolant function, apart from the above-mentioned limit values the respective coolant-specific characteristic data and the fresh water quality used must be taken into consideration.

TIM-ID: 0000078628 - 004

3.1.3 Coolant concentrates – Storage capability

The storage capability specifications refer to coolant concentrates in original, hermetically sealed packing with storage temperatures up to max. 30 °C.

Follow manufacturer's instructions.

Coolant concentrate	Limit value	Brand name / Comments
Antifreeze	Approx. 3 years	Observe manufacturer's specifications
Products containing propylene glycol	3 years	BASF G206
Coolant without antifreeze	2 years	Arteco Freecor NBI Chevron Texcool A-200 Detroit Diesel Corp. Power Cool 2000 ImproChem Cool-C18 Nalco Nalcool® 2000 Penray Pencool 2000 PrixMax RCP
	3 years	BASF Glysacorr G93 green Drew Marine Drewgard XTA Ginouves York 719 MTU Friedrichshafen Coolant C150 MTU America Power Cool® Plus 6000 Nalco Alfloc™ 3477 Valvoline ZEREX G-93
	5 years	Arteco Havoline Extended Life Corrosion Inhibitor XLI [EU 032765] CCI Corporation A216 CCI Manufacturing IL A216 Chevron Delo XLI Corrosion Inhibitor Concentrate Detroit Diesel Corp. Power Cool Plus 6000 ExxonMobil Mobil Delvac Extended Life Corrosion Inhibitor Fleetguard DCA-4L Old World Industries Final Charge Extended Life Corrosion Inhibitor (A216) Total WT Supra

Table 25: Coolant concentrates – Storage capability

Note

- This product BASF G206 will no longer be available in the future. Stock inventory of this product may be used up as long as the shelf life has not expired. Please contact your MTU partner.
- For reasons of corrosion protection, do not store in galvanized containers. Take this requirement into account when coolant must be transferred.
- Containers must be hermetically sealed and stored in a cool, dry place. Frost protection must be provided in winter.
- Further information can be obtained from the product and safety data sheets for the individual coolants.

TIM-ID: 0000078631 - 003

3.1.4 Color additives for detection of leaks in the coolant circuit

The following listed fluorescent dyes are approved as additives for coolant without antifreeze for the detection of leaks.

Manufacturer	Product name	Part No.	Container size	Storage stability[1)]
Chromatech Inc. Chromatech Europe B.V.	D11014 Chromatint Uranine Conc	X00066947	20 kg	2 years

Table 26: Approved dye additives

[1)] = based on original and hermetically sealed containers in frost-free storage (> 5 °C)

Application:

Approx. 40 g dye must be added to 180 l coolant.

This dye quantity is already very generous and must not be exceeded.

The fluorescence (yellow color tone) is easily recognizable in daylight. In dark rooms, UV light can be used with a wave length of 365 nm.

TIM-ID: 0000053354 - 004

3.1.5 Cooling system damage – Prevention

- When topping up (following loss of coolant) it must be ensured that not only water but also concentrate is added. The specified antifreeze and/or corrosion inhibitor concentration must be maintained.
- The corrosion inhibitor concentration must not exceed 50 % by volume Use antifreeze. Concentrations in excess of this reduce antifreeze protection and heat dissipation. Only exception: BASF G206 (special application)
- The coolant must not contain any oil or copper residue (in solid or dissolved form).
- The majority of corrosion inhibitors currently approved for internal coolant circuit preservation are water-soluble and do not provide antifreeze protection. Make sure that the engine is stored safe from frost, because a certain amount of coolant remains in the engine after draining.
- A coolant circuit can not usually be drained completely, i.e. residual quantities of used coolant or fresh water from a flushing procedure remain in the engine. These residual quantities can result in the dilution of a coolant to be filled (mixed from a concentrate or use of a ready mixture). This dilution effect is higher the more add-on components there are on the engine. Check the coolant concentration in the coolant circuit and adapt it if necessary.

Important information

All coolants approved in these Fluids and Lubricants Specifications generally relate only to the coolant circuits of MTU engines. In the case of complete propulsion plants, the fluids and lubricants approvals of the component manufacturer must be observed.

Important information

For corrosion-related reasons, it is not permissible to operate an engine with pure water without the addition of an approved corrosion inhibitor.

TIM-ID: 0000078599 - 001

3.1.6 Unsuitable materials in the coolant circuit

Components made of copper, zinc and brass materials

Unless various preconditions are observed, components made of copper, zinc and brass materials or with galvanized surfaces in the coolant circuit (incl. supply and drain lines) can cause an electrochemical reaction with base metals (e.g. with aluminum). As a result, components made of base metals are subject to corrosion or even corrosive pitting. The coolant circuit becomes leaky at these points.

Non-metallic materials

- Do not use EPDM or silicon elastomers if emulsifiable corrosion inhibitor oils are used or other oils are introduced to the coolant circuit.

Coolant filter / filter downstream of plant components

- If such filters are used, only products that do not contain additives may be used.
  Supplementary additives such as silicates, nitrites etc. can diminish the protective effect or service life of a coolant and, possibly, attack the materials installed in the coolant circuit.

Information:

In case of doubt about the use of materials on the engine / add-on components in coolant circuits, consultation with the respective MTU specialist department must be held.

TIM-ID: 0000080979 - 003

3.1.7 Fresh water requirements - Series 4000

Only clean, clear water with values in accordance with those in the following table must be used for conditioning the coolant with and without antifreeze. If the limit values for the water are exceeded, de-mineralized water can be added to reduce the hardness or mineral content.

Parameter	Minimum	Maximum
Sum of alkaline earth metals *) (Water hardness)	0 mmol/l 0°d	2.7 mmol/l 15°d
pH value at 20 °C	5.5	8.0
Chloride ions		100 mg/l
Sulphate ions		100 mg/l
Anions total		200 mg/l
Bacteria		10^3CFU (colony forming unit)/ml
Fungi, yeasts	are not permitted	

Table 27: Fresh water requirements, Series 4000

*) Common designations for water hardness in various countries:

1 mmol/l = 5.6°d = 100 mg/kg $CaCO_3$

- 1°d = 17.9 mg/kg $CaCO_3$, USA hardness
- 1°d = 1.79° French hardness
- 1°d = 1.25° English hardness

TIM-ID: 0000078621 - 001

3.1.8 Fresh water requirements – Series 400

Only clean, clear water with values in accordance with those in the following table must be used for preparing the coolant. If the limit values for the water are exceeded, de-mineralized water can be added to reduce the hardness or mineral content.

General requirements	Clear, colorless and free from undissolved substances	
pH value (25 °C)	7.4 to 8.5	
Electric conductivity (25 °C)	< 300	µS/cm
Sum total, alkaline earths	0.9 to 1.3 5 to 7	mmol/l °dH
Chlorides	< 80	mg/l
Sulfates	< 70	mg/l
Iron	< 0.2	mg/l
Bacteria	< 10^3	CFU (colony forming unit)/ml
Fungi, yeasts	are not permitted	

Table 28: Fresh water requirements, Series 400

TIM-ID: 0000078708 - 001

3.1.9 Fresh water requirements Series 500

Potable tap water with the limiting analysis values in the following table is suitable for producing the mixture.

Characteristic	Unit	Limit value
Appearance	-	Colorless, clear, free of mechanical contaminants
pH value at 25 °C	-	8.2 to 8.5
Odor	-	Neutral
Alkaline earth metals (hardness)	mmol/l	Max. 0.02
	°dH	Max. 0.1
Conductivity at 25 °C	µS/cm	Max. 250
Chlorides	mg/l	Max. 10
Sulfates	ppm	Max. 150
Phosphate (PO_4)	mg/l	5 to 10

Table 29: Mixture water limit values

Important

The named limit values for the mixture water serve for technical orientation from which no legal claims can be asserted because the water ratios are too different depending on the location.
The water can thus have numerous unknown combinations of secondary substances. The customer is responsible for safe operation.
MTU recommends the use of a ready-mixed water-antifreeze mixture.

TIM-ID: 0000092000 - 001

3.2 Series 4000 gas engine – Marine application

3.2.1 Coolant – General information

Important

The coolant change depends on the operating time (hours/years) of the engine and on which operating time is reached first.

Operating hours = preheating time + engine operating time

Important

All details are based on the coolant circuit on the engine side, no allowance is made for external add-on components.

Important

In the case of an engine coolant circuit with no light metal elements but with add-on components containing light metal (e.g. external cooling system), the coolant approvals for cooling systems containing light metal shall apply. If you have any doubts about a coolant application, consult your contact person.

Important

The use of products other than those listed will invalidate the warranty.

For details and special features, see “General” (→ Page 29) and “Unsuitable materials in the coolant circuit” (→ Page 38).

Any deviant special agreements between the customer and MTU remain valid.

TIM-ID: 0000078605 - 003

3.2.2 Coolants without antifreeze – Concentrates for cooling systems free of light metal

For details and special features, see chapter on “Coolants” (→ Page 29)

Coolants without antifreeze – concentrates

Manufacturer	Brand name	Inhibitors					Operating time Hour / Year	Comments / Material number
		Organic	Silicon	Nitrite	Phosphatized	Molybdate		
MTU Friedrichshafen GmbH	Coolant CS100 Corrosion Inhibitor Concentrate		X				6000 / 2	X00057233 (20 l) X00057232 (210 l) X00070455 (1000 l) Also available through MTU Asia
MTU America Inc.	Power Cool®Plus 6000 Concentrate		X				6000 / 2	colored green 23533526 (1 gallon) 23533527 (5 gallons) Available through MTU America Inc.
Arteco NV	Freecor NBI		X				6000 / 2	
	Havoline Extended Life Corrosion Inhibitor [EU Code 32765] (XLI)	X					6000 / 2	
BASF SE	Glysacorr G93 green		X				6000 / 2	X00054105 (barrel) X00058062 (canister)
CCI Corporation	A 216	X				X	6000 / 2	
CCI Manufacturing IL Corporation	A 216	X				X	6000 / 2	X00051509 (208 l)
Chevron Corp.	Texcool A – 200		X				6000 / 2	
Chevron Lubricants	Delo XLI Corrosion Inhibitor - Concentrate	X					6000 / 2	
Detroit Diesel Corp.	Power Cool Plus 2000		X	X			6000 / 2	
	Power Cool Plus 6000	X				X	6000 / 2	colored red
Drew Marine	Drewgard XTA		X				6000 / 2	
ExxonMobil	Mobil Delvac Extended Life Corrosion Inhibitor	X				X	6000 / 2	
Fleetguard	DCA-4L		X	X	X		2000 / 1	
ImproChem	COOL-18		X	X			6000 / 2	
Nalco Water An Ecolab Company	Alfloc™ 3477	X					6000 / 2	
	Nalcool® 2000		X	X			6000 / 2	
Old World Industries Inc.	Final Charge Extended Life Corrosion Inhibitor (A 216)	X				X	6000 / 2	
Penray	Pencool 2000		X	X			6000 / 2	
PrixMax Australia Pty. Ltd.	PrixMax RCP	X					6000 / 2	

TIM-ID: 0000019146 - 008

Manufacturer	Brand name	Inhibitors					Operating time Hour / Year	Comments / Material number
		Organic	Silicon	Nitrite	Phosphatized	Molybdate		
Total Lubrifiants	Total WT Supra	X					6000 / 2	
Valvoline	Zerex G-93		X				6000 / 2	
YORK SAS	York 719		X				6000 / 2	

Table 30:

TIM-ID: 0000019146 - 008

3.2.3 Coolant without antifreeze – Ready mixtures for cooling systems free of light metal

For details and special features, see chapter on “Coolants” (→ Page 29)

Coolant without antifreeze, ready mixtures

Manufacturer	Brand name	Inhibitors					Operating time Hour / Year	Comments / Material number
		Organic	Silicon	Nitrite	Phosphatized	Molybdate		
MTU-Friedrichshafen GmbH	Coolant CS 10/90 Corrosion Inhibitor Premix		X				6000 / 2	X00069385 (20 l) X00069386 (210 l) X00069387 (1000 l) (Sales region: Italy)
Nalco Water An Ecolab Company	Alfloc™ 3443 (7 %)	X					6000 / 2	
PrixMax Australia Pty Ltd	PrixMax RCP Premix	X					6000 / 2	

Table 31:

TIM-ID: 0000019147 - 008

3.2.4 Antifreeze – Concentrates for cooling systems free of light metal

For details and special features, see chapter "Coolants" (→ Page 29).

Antifreeze, concentrates

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MTU Friedrichshafen GmbH	Coolant AH100 Antifreeze Concentrate	X	X				9000 / 5	X00057231 (20 l) X00057230 (210 l) X00068202 (1000 l) also available through MTU Asia
AVIA AG	Antifreeze APN	X	X				9000 / 5	
	Antifreeze APN-S	X					9000 / 3	
BASF SE	Glysantin® G48® blue green	X	X				9000 / 5	X00058054 (25 l) X00058053 (210 l)
	Glysantin® G30® pink	X					9000 / 3	X00058072 (canister) X00058071 (barrel)
BayWa AG	Tectrol Coolprotect	X	X				9000 / 5	
BP Lubricants	ARAL Antifreeze Extra	X	X				9000 / 5	
Bucher AG Langenthal	Motorex Coolant G48	X	X				9000 / 5	
Castrol	Castrol Radicool NF	X	X				9000 / 5	
CCI Corporation	L415	X				X	9000 / 3	
Classic Schmierstoff GmbH + Co. KG	Classic Kolda UE G48	X	X				9000 / 5	
Comma Oil & Chemicals Ltd.	Comma Xstream ® G30® Antifreeze Coolant Concentrate	X					9000 / 3	
	Comma Xstream ® G48® Antifreeze Coolant Concentrate	X	X				9000 / 5	
COPARTS Autoteile GmbH	CAR1 Premium Longlife Kühlerschutz C48	X	X				9000 / 5	
Daimler Trucks North America	Alliance OAT Extended Life Coolant	X				X	9000 / 3	
Detroit Diesel Corp.	Power Cool Plus Coolant	X				X	9000 / 3	
ExxonMobil	Mobil Delvac Extended Life Coolant	X				X	9000 / 3	
	Mobil Antifreeze Advanced	X					9000 / 3	
	Mobil Antifreeze Extra	X	X				9000 / 5	
	Esso Antifreeze Advanced	X					9000 / 3	
	Esso Antifreeze Extra	X	X				9000 / 5	
Finke Mineralölwerk GmbH	AVIATICON Finkofreeze F30	X					9000 / 3	
	AVIATICON Finkofreeze F48	X	X				9000 / 5	

TIM-ID: 0000080984 - 005

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
Fuchs Petrolub SE	Maintain Fricofin	X	X				9000 / 5	
	Maintain Fricofin G12 Plus	X					9000 / 3	X00058074 (canister) X00058073 (barrel)
Gaszpromneft Lubricants Ltd.	BELAZ G-Profi Antifreeze Red	X					9000 / 3	X00058075 (barrel)
Kuttenkeuler	Kuttenkeuler Antifreeze ANF KK48	X	X				9000 / 5	
	Glyostar® ST48	X	X				9000 / 5	
INA Maziva Ltd.	INA Antifriz Al Super	X	X				9000 / 5	
LLK-International (Lukoil Lubricants Co	Lukoil Antifreeze HD G12 K	X					9000 / 3	
Lukoil Lubricants Europe GmbH	Lukoil Coolant Plus	X	X				9000 / 5	
	Lukoil Coolant SF	X					9000 / 3	
Mitan Mineralöl GmbH	Alpine C30	X					9000 / 3	
	Alpine C48	X	X				9000 / 5	
MOFIN Deutschland GmbH & Co KG	MOFIN Kühlerschutz M48 Premium Protect	X	X				9000 / 5	
MJL Bangladesh Limited Lube Oil Blending Plant East Patenga	Omera Premium Coolant	X					9000 / 3	
Nalco Water An Ecolab Company	Nalcool NF 48 C	X	X				9000 / 5	
Navistar Inc.	Fleetrite Nitrite-Free Extended Life Coolant	X				X	9000 / 3	
Old World Industries Inc.	Blue Mountain Heavy Duty Extended Life Coolant	X				X	9000 / 3	
	Final Charge Global Extended Life Coolant Antifreeze	X				X	9000 / 3	
Panolin AG	Panolin Anti-Frost MT-325	X	X				9000 / 5	
Raloy Lubricantes	Antifreeze Long Life NF-300 Concentrate	X	X				9000 / 5	
SMB - Sotragal / Mont Blanc	Antigel Power Cooling Concentrate	X	X				9000 / 5	
Total	Glacelf MDX	X	X				9000 / 5	
Valvoline	Zerex G-48	X	X				9000 / 3	
	Zerex G-30	X					9000 / 5	
	OEM Advanced G30	X					9000 / 3	
	OEM Advanced G48	X	X				9000 / 5	

TIM-ID: 0000080984 - 005

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
Volvo Trucks	Road Choice Nitrite-Free OAT Extended Life Coolant	X				X	9000 / 3	
YORK SAS	York 716	X	X				9000 / 5	

Table 32: Antifreeze, concentrates

TIM-ID: 0000080984 - 005

3.2.5 Antifreeze – Concentrates for special applications

For details and special features, see chapter on “Coolants” (→ Page 29)

Concentrates for special applications

Manufacturer	Brand name	Inhibitors					Operating time Hour / Year	Comments / Material number
		Organic	Silicon	Nitrite	Phosphatized	Molybdate		
BASF SE	G206	X	X				9000 / 3	For use in arctic regions (< -40 °C)

Table 33:

TIM-ID: 0000019151 - 006

3.2.6 Antifreeze – Ready mixtures for cooling systems free of light metals

Antifreeze, ready mixtures

For details and special features, see chapter "Coolants" (→ Page 29).

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MTU Friedrichshafen GmbH	Coolant AH 35/65 Anti-freeze Premix	X	X				9000 / 5	X00069382 (20 l) X00069383 (210 l) X00069384 (1000 l) (sales region: Italy)
	Coolant AH 40/60 Anti-freeze Premix	X	X				9000 / 5	X00070533 (20 l) X00070531 (210 l) X00070532 (1000 l) (sales region: England, Spain)
	Coolant AH 50/50 Anti-freeze Premix	X	X				9000 / 5	X00070528 (20 l) X00070530 (210 l) X00070527 (1000 l) (sales region: England)
	Coolant RM 30 (40 %)	X					9000 / 3	X00073922 (20 l) X00073916 (205 l) X00073923 (1000 l)
MTU America Inc.	Power Cool ® Universal 35/65 mix	X	X				9000 / 5	800085 (5 gallons) 800086 (55 gallons)
	Power Cool ® Universal 50/50 mix	X	X				9000 / 5	800071 (5 gallons) 800084 (55 gallons)
Bantleon	Avilub Antifreeze Mix (50 %)	X	X				9000 / 5	X00049213 (210 l)
BayWa AG	Tectrol Coolprotect Mix 3000	X					9000 / 3	Antifreeze protection up to -24 °C
Bucher AG Langenthal	Motorex Coolant G48 ready to use (50/50)	X	X				9000 / 5	
Castrol	Castrol Radicool NF Premix (45 %)	X	X				9000 / 5	
CCI Corporation	L 415 (50 %)	X				X	9000 / 3	
Cepsa Comercial Petróleo S.A.U	Xtar Super Coolant Hybrid NF 50 %	X	X				9000 / 5	
Daimler Trucks North America	Alliance 50/50 Prediluted OAT Extended Life Coolant	X				X	9000 / 3	
Detroit Diesel Corp.	Power Cool Plus Prediluted Coolant (50/50)	X				X	9000 / 3	
ExxonMobil	Mobil Delvac Extended Life Prediluted Coolant (50/50)	X				X	9000 / 3	
Finke Mineralölwerk GmbH	AVIATICON Finkofreeze F30 RM 40:60 +	X					9000 / 3	
	AVIATICON Finkofreeze F48 RM 50:50	X	X				9000 / 5	

TIM-ID: 0000080986 - 004

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
LLK-International (Lukoil Lubricabts Co)	Lukoil Antifreeze HD G12 (50%)	X					9000 / 3	
Navistar Inc.	Fleetrite 50/50 Prediluted Nitrite-Free Extended Life Coolant	X				X	9000 / 3	
Old World Industries Inc.	Blue Mountain Heavy Duty Extended Life Prediluted Coolant (50/50)	X				X	9000 / 3	
	Final Charge Global Extended Life Predilluted Coolant / Antifreeze (50/50)	X				X	9000 / 3	
Raloy Lubricantes	Antifreeze Long Life NF-300 Ready-to-Use (50/50)	X	X				9000 / 5	
SMB - Sotragal / Mont Blanc	L.R.-30 Power Cooling (44 %)	X	X				9000 / 5	
	L.R.-38 Power Cooling (52 %)	X	X				9000 / 5	
Total	Coolelf MDX (-26 °C)	X	X				9000 / 5	
Tosol-Sinzez	Glysantin Alu Protect/G30 Ready Mix	X					9000 / 3	
	Glysantin Protect Plus/G48 Ready Mix	X	X				9000 / 5	
Valentin Energie GmbH	Valentin Coolant Plus -25 °C Ready	X					9000 / 3	
Valvoline	Zerex G-48 premix 50%	X	X				9000 / 5	
	OEM Advanced 48 premix 50%	X	X				9000 / 5	
Volvo Trucks	Road Choice 50/50 Prediluted Nitrite-Free OAT Extended Life Coolant	X				X	9000 / 3	
YPF S.A. Argentina	Kriox MTL50	X				X	9000 / 3	

Table 34: Antifreeze, ready mixtures

TIM-ID: 0000080986 - 004

3.3 Series 4000 gas engine – Generator application and engine-generator set

3.3.1 Coolant - General information

Important

The coolant change depends on the operating time (hours/years) of the engine and on which operating time is reached first.

Operating hours = preheating time + engine operating time

Important

All details are based on the coolant circuit on the engine side, no allowance is made for external add-on components.

Important

In the case of an engine coolant circuit with no light metal elements but with add-on components containing light metal (e.g. external cooling system), the coolant approvals for cooling systems containing light metal shall apply. If you have any doubts about a coolant application, consult your contact person.

Important

The use of products other than those listed will invalidate the warranty.

For details and special features, see “General” (→ Page 29) and “Unsuitable materials in the coolant circuit” (→ Page 38).

Any deviant special agreements between the customer and MTU remain valid.

TIM-ID: 0000078605 - 003

3.3.2 Coolant without antifreeze – Concentrates for cooling systems containing light metal

For details and special features, see chapter "Coolants" (→ Page 29).

Coolants without antifreeze – concentrates

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MTU-Friedrichshafen GmbH	Coolant CS100 Corrosion Inhibitor Concentrate		X				6000 / 2	X00057233 (20 l) X00057232 (210 l) X00070455 (1000 l) also available through MTU Asia
MTU America Inc.	Power Cool ® Plus 6000 Concentrate		X				6000 / 2	colored green 23533526 (1 gallon) 23533527 (5 gallons) Available through MTU America Inc.
Arteco NV	Freecor NBI		X				6000 / 2	
BASF SE	Glysacorr G93 green		X				6000 / 2	X00054105 (barrel) X00058062 (canister)
CCI Corporation	A 216	X				X	6000 / 2	
CCI Manufacturing IL Corporation	A 216	X				X	6000 / 2	X00051509 (208 l)
Chevron Corp.	Texcool A - 200		X				6000 / 2	
Detroit Diesel Corp.	Power Cool Plus 6000	X				X	6000 / 2	colored red
Drew Marine	Drewgard XTA		X				6000 / 2	
ExxonMobil	Mobil Delvac Extended Life Corrosion Inhibitor	X				X	6000 / 2	
Old World Industries Inc.	Final Charge Extended Life Corrosion Inhibitor (A 216)	X				X	6000 / 2	
Valvoline	Zerex G-93		X				6000 / 2	
YORK SAS	York 719		X				6000 / 2	

Table 35:

TIM-ID: 0000080988 - 003

3.3.3 Coolant without antifreeze – Ready mixtures for cooling systems containing light metal

For details and special features, see chapter "Coolants" (→ Page 29).

Coolant without antifreeze, ready mixtures

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MTU Friedrichshafen GmbH	Coolant CS10/90 Corrosion Inhibitor Premix		X				6000 / 2	X00069385 (20 l) X00069386 (210 l) X00069387 (1000 l) (sales region: Italy)

Table 36:

TIM-ID: 0000078718 - 003

3.3.4 Antifreeze – Concentrates for cooling systems containing light metal

For details and special features, see chapter "Coolants" (→ Page 29).

Antifreeze, concentrates

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MTU Friedrichshafen GmbH	Coolant AH100 Antifreeze Concentrate	X	X				9000 / 5	X00057231 (20 l) X00057230 (210 l) X00068202 (1000 l) also available through MTU Asia
AVIA AG	Antifreeze APN	X	X				9000 / 5	
	Antifreeze APN-S	X					9000 / 3	
BASF SE	GLYSANTIN® G05®		X	X			9000 / 5	
	GLYSANTIN® G48® blue green	X	X				9000 / 5	X00058054 (25 l) X00058053 (210 l)
	GLYSANTIN® G30® pink	X					9000 / 3	X00058072 (canister) X00058071 (barrel)
	GLYSANTIN® G40® pink (concentrate)	X	X				9000 / 3	X00066724 (20 l) X00066725 (210 l) Concentration for use: 40 to 50% by volume
BayWa AG	Tectrol Coolprotect	X	X				9000 / 5	
BP Lubricants	ARAL Antifreeze Extra	X	X				9000 / 5	
Bucher AG Langenthal	Motorex Coolant G48	X	X				9000 / 5	
	Motorex Coolant M 4,0 Concentrate	X	X				9000 / 3	Concentration for use: 40 to 50% by volume
Castrol	Castrol Radicool NF	X	X				9000 / 5	
CCI Corporation	L415	X				X	9000 / 3	
Clariant	Genantin Super		X	X			9000 / 3	
Classic Schmierstoff GmbH + Co. KG	Classic Kolda UE G48	X	X				9000 / 5	
Comma Oil & Chemicals Ltd.	Comma Xstream ® G30® Antifreeze Coolant Concentrate	X					9000 / 3	
	Comma Xstream ® G48® Antifreeze Coolant Concentrate	X	X				9000 / 5	
COPARTS Autoteile GmbH	CAR 1 Premium Longlife Kühlerschutz C48	X	X				9000 / 5	
Daimler Trucks North America	Alliance OAT Extended Life Coolant	X				X	9000 / 3	

TIM-ID: 0000080987 - 004

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
Detroit Diesel Corp.	Power Cool Antifreeze		X	X			9000 / 3	
	Power Cool Plus Coolant	X				X	9000 / 3	
	Power Cool Diesel Engine Coolant		X	X			9000 / 3	
ExxonMobil	Mobil Delvac Extended Life Coolant	X				X	9000 / 3	
	Mobil Antifreeze Advanced	X					9000 / 3	
	Mobil Antifreeze Extra	X	X				9000 / 5	
	Mobil Antifreeze Special		X	X			9000 / 5	
	Mobil Heavy Duty Coolant		X	X			9000 / 3	
	Mobil Mining Coolant		X	X			9000 / 3	
	Esso Antifreeze Advanced	X					9000 / 3	
	Esso Antifreeze Extra	X	X				9000 / 5	
Finke Mineralölwerke GmbH	AVIATICON Finkofreeze F30	X					9000 / 3	
	AVIATICON Finkofreeze F40	X	X				9000 / 3	Application concentration: 40 to 50% by volume
	AVIATICON Finkofreeze F48	X	X				9000 / 5	
Fuchs Petrolub SE	Maintain Fricofin	X	X				9000 / 5	
	Maintain Fricofin G12 Plus	X					9000 / 3	X00058074 (canister) X00058073 (barrel)
Gazpromneft Lubricants Ltd.	Belaz G-Profi Antifreeze Red	X					9000 / 3	
Krafft S.L.U	Refrigerante ACU 2300		X	X			9000 / 3	X00058075 (barrel)
Kuttenkeuler	Kuttenkeuler Antifreeze ANF KK48	X	X				9000 / 5	
	Glyostar® ST48	X	X				9000 / 5	
INA Maziva Ltd.	INA Antifriz AI Super	X	X				9000 / 5	
LLK-International (Lukoil Lubricants Co)	Lukoil Antifreeze HD G 12 K	X					9000 / 3	
Lukoil Lubricants Europe GmbH	Lukoil Coolant Plus	X	X				9000 / 5	
	Lukoil Coolant SF	X					9000 / 3	
	Lukoil Coolant SOT	X	X				9000 / 3	Application concentration: 40 to 50% by volume
Mitan Mineralöl GmbH	Alpine C30	X					9000 / 3	
	Alpine C48	X	X				9000 / 5	
MJL Bangladesh Limited Lube Oil Blending Plant East Patenga	Omera Premium Coolant	X					9000 / 3	

TIM-ID: 0000080987 - 004

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MOFIN Deutschland GmbH & Co KG	MOFIN Kühlerschutz M48 Premium Protect	X	X				9000 / 5	
	MOFIN Kühlerschutz M40 Extra	X	X				9000 / 3	Application concentration: 40 to 50% by volume
Nalco Water An Ecolab Company	Nalcool NF 48 C	X	X				9000 / 5	
Navistar Inc.	Fleetrite Nitrite-Free Extended Life Coolant	X				X	9000 / 3	
Old World Industries Inc.	Blue Mountain Heavy Duty Extended Life Coolant	X				X	9000 / 3	
	Fleetcharge SCA Precharged Coolant/ Antifreeze		X	X			9000 / 3	
	Final Charge Global Extended Life Coolant Antifreeze	X				X	9000 / 3	
	Peak Heavy Duty Coolant		X	X			9000 / 3	
Panolin AG	Panolin Anti-Frost MT-325	X	X				9000 / 5	
Penske Power Systems	Power Cool - HB500 Coolant Concentrate	X	X				9000 / 3	
Raloy Lubricantes	Antifreeze Long Life NF-300 Concentrate	X	X				9000 / 3	
Recochem Inc.	R542	X	X				9000 / 3	
SMB - Sotragal / Mont Blanc	Antigel Power Cooling Concentrate	X	X				9000 / 5	
Total	Glacelf MDX	X	X				9000 / 5	
Valvoline	Zerex G-05		X	X			9000 / 5	
	Zerex G-48	X	X				9000 / 3	
	Zerex G-30	X					9000 / 5	
	ZEREX G40 (Konzentrat)	X	X				9000 / 3	Concentration for use: 40 to 50% by volume Material number (USA): 800180 (Drum)
	OEM Advanced 30	X					9000 / 3	
	OEM Advanced 48	X	X				9000 / 5	
	OEM Advanced 40	X	X				9000 / 3	Concentration for use: 40 to 50% by volume
Volvo Trucks	Road Choice Nitrite-Free OAT Extended Life Coolant	X				X	9000 / 3	
YORK SAS	York 716	X	X				9000 / 5	

Table 37: Antifreeze, concentrates

TIM-ID: 0000080987 - 004

3.3.5 Antifreeze – Concentrates for special applications

For details and special features, see chapter on “Coolants” (→ Page 29)

Concentrates for special applications

Manufacturer	Brand name	Inhibitors					Operating time Hour / Year	Comments / Material number
		Organic	Silicon	Nitrite	Phosphatized	Molybdate		
BASF SE	G206	X	X				9000 / 3	For use in arctic regions (< -40 °C)

Table 38:

TIM-ID: 0000019151 - 006

3.3.6 Antifreeze – Ready mixtures for cooling systems containing light metals

For details and special features, see chapter "Coolants" (→ Page 29).

Antifreeze, ready mixtures

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
MTU Friedrichshafen GmbH	Coolant AH 35/65 Anti-freeze Premix	X	X				9000 / 5	X00069382 (20 l) X00069383 (210 l) X00069384 (1000 l) (sales region: Italy)
	Coolant AH 40/60 Anti-freeze Premix	X	X				9000 / 5	X00070533 (20 l) X00070531 (210 l) X00070532 (1000 l) (sales region: England, Spain)
	Coolant AH 50/50 Anti-freeze Premix	X	X				9000 / 5	X00070528 (20 l) X00070530 (210 l) X00070527 (1000 l) (sales region: England)
	Coolant RM30 (40%)	X					9000 / 3	X00073922 (20 l) X00073916 (205 l) X00073923 (1000 l)
MTU America Inc.	Power Cool ® Universal 35/65 mix	X	X				9000 / 5	800085 (5 gallons) 800086 (55 gallons)
	Power Cool ® Universal 50/50 mix	X	X				9000 / 5	800071 (5 gallons) 800084 (55 gallons)
	Power Cool ® Off-Highway Coolant 50/50 Premix		X	X			9000 / 5	23533531 (5 gallons) 23533532 (55 gallons)
Bantleon	Avilub Antifreeze Mix (50 %)	X	X				9000 / 5	X00049213 (210 l)
BayWa AG	Tectrol Coolprotect Mix 3000	X					9000 / 3	Antifreeze protection up to -24 °C
Bucher AG Langenthal	Motorex Coolant G48 ready to use (50/50)	X	X				9000 / 5	
	Motorex Coolant M 4,0 ready to use	X	X				9000 / 3	Antifreeze protection up to -38 °C
Castrol	Castrol Radicool NF Premix (45 %)	X	X				9000 / 5	
CCI Corporation	L 415 (50 %)	X				X	9000 / 3	
Cespa Comercial Petróleo S.A.U.	Xtar Super Coolant Hybrid NF 50%	X	X				9000 / 5	
Detroit Diesel Corp.	Power Cool Plus Prediluted Coolant (50/50)	X				X	9000 / 3	
	Power Cool Prediluted (50/50) Diesel Engine Coolant		X	X			9000 / 3	

TIM-ID: 0000078607 - 005

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
ExxonMobil	Mobil Delvac Extended Life Prediluted Coolant (50/50)	X				X	9000 / 3	
	Mobile Heavy Duty 50/50 Prediluted Coolant		X	X			9000 / 3	
	Mobile Mining 50/50 Prediluted Coolant		X	X			9000 / 3	
Finke Mineralölwerk GmbH	AVIATICON Finkofreeze F30 RM 40:60 +	X					9000 / 3	
	AVIATICON Finkofreeze F48 RM 50:50	X	X				9000 / 5	
LLK-International (Lukoil Lubricants Co)	Lukoil Antifreeze HD G 12 (50%)	X					9000 / 3	
Navistar Inc.	Fleetrite 50/50 Prediluted Nitrite-Free Life Coolant	X				X	9000 / 3	
Old World Industries Inc.	Blue Mountain Heavy Duty Extended Life Prediluted Coolant (50/50)	X				X	9000 / 3	
	Final Charge Global Extended Life Predilluted Coolant / Antifreeze (50/50)	X				X	9000 / 3	
	Fleet Charge SCA Precharged 50/50 Prediluted Coolant		X	X			9000 / 3	
Penske Power Systems	Power Cool - HB500 Premix 50/50	X	X				9000 / 3	
Raloy Lubricantes	Antifreeze Long Life NF-300 Ready-to-Use (50/50)	X	X				9000 / 5	
SMB - Sotragal / Mont Blanc	L.R.-30 Power Cooling (44 %)	X	X				9000 / 5	
	L.R.-38 Power Cooling (52 %)	X	X				9000 / 5	
Tosol-Sintez	Glysantin Alu Protect/G30 Ready Mix	X					9000 / 3	
	Glysantin Protect Plus/G48 Ready Mix	X	X				9000 / 5	
Total	Coolelf MDX (-26 °C)	X	X				9000 / 5	
Valentin Energie GmbH	Valentin Coolant Plus -25 °C Ready	X					9000 / 3	
Valvoline	Zerex G-05 50/50 Mix		X	X			9000 / 5	
	Zerex G-48 premix 50%	X	X				9000 / 5	
	OEM Advanced 48 premix 50%	X	X				9000 / 5	

TIM-ID: 0000078607 - 005

Manufacturer	Brand name	Inhibitors					Runtime Hours / Years	Comments / Material number
		Organic	Silicon	Nitrite	Phosphate	Molybdate		
Volvo Trucks	Road Choice 50/50 Prediluted Nitrite-Free OAT Extended Life Coolant	X				X	9000 / 3	
YPF S.A. Argentina	Kriox MTL50	X				X	9000 / 3	

Table 39: Antifreeze – Ready mixtures for cooling systems containing light metals

TIM-ID: 0000078607 - 005

3.4 Series 400 gas engine – Engine-generator set

3.4.1 Approved coolants

Important
The use of products other than those listed will invalidate the warranty.

Antifreeze, ready mixtures (silicate-free)

Manufacturer / supplier	Designation
MTU Friedrichshafen GmbH	Coolant RM 30*
BayWa AG	Tectrol Coolprotect MIX3000*
Montana	Kühlerfrostschutz BHKW -25°*
Valentin Energie GmbH	Coolant Plus -25° Ready*
* Extended change interval possible	

Table 40:

Antifreeze, concentrates

Manufacturer / supplier	Designation
BASF	Glysantin G30
Aral	Antifreeze Silikatfrei

Table 41:

Information on warranty

It is strongly recommended to use ready mixed antifreezes for the engine cooling circuit.

If these ready mixtures are used, the following requirements will be met:
- The ratio of water to antifreeze is set correctly
- The used (fresh) water complies with the specifications set out in “Requirements of engine coolant”.

The service lives of components will be shortened if the water used does not comply with the specifications. In such a case, there is a risk of deposits forming for many components, which can lead to a reduction in heat transfer and hence a reduction in functionality (heat exchanger) or to overheating of the components.

Observe the following with "self-mixing" of coolant:
- Only use the approved silicate-free antifreezes with the specified ratio to water
- A form must be signed confirming that the water used fulfills the requirements set out in the Fluids and Lubricants Specifications.

Check the concentration at regular intervals in accordance with the maintenance schedule. The coolant should be checked once a year or each time it is added, whichever comes first. Due to aging, the coolant filling must be replaced after 25,000 operating hours or after 3 years at the latest.

TIM-ID: 0000053805 - 005

3.5 Series 500 gas engine – Engine-generator set

3.5.1 Coolants – General information

Antifreezes checked and approved by MTU guarantee sufficient protection against frost, corrosion and cavitation, do not attack gaskets and hoses and do not foam, see (→ Page 65).

To ensure continuous, trouble-free operation of engine-generator sets, the coolant used must always have a suitable composition all year round that guarantees protection against frost and corrosion.

TIM-ID: 0000091998 - 001

3.5.2 Coolant – Check and replacement

The coolants used by MTU are subject to natural aging and their condition must therefore be checked regularly.

Coolant losses must always be replaced with a mixture of water and antifreeze. The mixing volume ratio depends on the engine and selected antifreeze.

MTU expressly points out that the water quality must be checked when topping up supplementary water and that the values must be observed, see (→ Page 41).

For topping up, MTU recommends the use of a ready-mixed water-antifreeze mixture.

To maintain the cooling capacity of the engine, the coolant quality must be checked after 2,000 operating hours. The following must be observed in this case:
- Check the coolant concentration every three months using a hydrometer or refractometer
- Never allow the antifreeze concentration to fall below 40% by volume
- The coolant must be replaced completely at the latest after the interval predefined in the Maintenance Schedule of the respective plant.
- Observe the limit values (→ Table 41)
- Vent the cooling system, adjust coolant pressure if necessary

Important
Coolants must not be mixed. Otherwise there is a danger of engine damage. Cooling systems only work reliably if they are operated with sufficient upstream pressure and are correctly vented. On MTU plants, the respective minimum pressure is saved as a warning value in the control system. This may deviate, however, due to local conditions. It is recommended to always set the pressure to the upper limit.

When extracting a sample to checking the coolant, fill a clean vessel using a suitable hose. 100 ml are already sufficient. Select a suitable extraction point, the vent points of the coolant circuit. As the plants are under pressure, for safety reasons the sample must be extracted at low temperatures below 60 °C. Otherwise explosive evaporation of the coolant is possible. It is essential to observe the respective safety instructions!

Limit values for coolants

Characteristic	Unit	Limit value
Appearance	-	Change with brown discoloration
pH value at 25 °C	-	Min. 7.5
Odor	-	Change in case of odor of solvents
Antifreeze	°C	Min. -20

TIM-ID: 0000091999 - 001

3.5.3 Approved coolants

Only approved antifreezes provide the protection for the engine cooling system according to MTU requirements. The concentrates and the ready-mixed water-antifreeze mixtures also provide the necessary corrosion protection.

Approved coolants

Coolant manufacturer	Product	Mixing volume ratio	Operating hours hour / year	Note
BASF	Glysantin Protect Plus G48	Concentrate/water 50/50 or ready-mixed	16000/2	
Caltex, Chevron, Texaco	Havoline® ELC Dex-Cool®	Concentrate/water 50/50 or ready-mixed	16000/2	Alternative, only for America, ethylene-glycol-based
Caltex, Chevron, Texaco	Delo® ELC PG	Concentrate/water 50/50 or ready-mixed	16000/2	Alternative, only for America, propylene-glycol-based
Vavoline	Zerex G48	Concentrate/water 50/50 or ready-mixed	16000/2	Alternative, only for America, ethylene-glycol-based

Table 42: Approved coolants

Avoid coolant concentrations above 50%.

Important

The coolant change depends on the operating time (hours/years) of the engine and on which operating time is reached first.

Important

All details are based on the coolant circuit on the engine side, no allowance is made for external add-on components.

TIM-ID: 0000092001 - 001

4 Fuels

4.1 General Information

4.1.1 Fuels - Usage

Important information

The specified limit values for moisture in the fuel must be observed because otherwise the warranty shall become void.

Important information

The fuel must not contain any corrosive compounds (e.g. siloxanes, phosphor, arsenic, heavy metal, sulfur, ammonia, chlorine, fluorine, bromide and iodine compounds).
The specified limit values must be observed because otherwise the warranty shall become void.

Gas engines must only be operated with the gases approved for the respective gas engine type.

For operation with natural gas from the public grid, the following must be confirmed by the responsible gas utility company prior to commissioning of the engine at the latest:

- Whether the minimum methane number and calorific value range specified on the respective data sheet are observed
- Whether butane or a propane-air mixture are added at times
- Whether biogas feeding into the natural gas grid is also possible (coordinate through factory request). A gas analysis must be available.

The usage options of the approved gas types must be checked by gas analysis at least twice a year. The following changes can thus be detected and measures initiated:

- Gas composition
- Harmful elements in the gas

In the entire application and operating range of the engine, the use of fuels is restricted to purely gaseous fuels. Liquid fuels are not permitted.

The fuel must be technically free of mist, dust and liquid. Condensation in the gas system must be prevented by suitable measures (dehumidification, protection against cooling down, heating, etc.). Corrosive constituents may only be present in the concentrations set out below (→ Page 68).

If the quality of the raw gas exceeds the sulfur limit values, a gas desulferization system that is designed for the quality of the gas must be installed.

TIM-ID: 0000078925 - 001

4.1.2 Requirements for fuel gas

Requirements for MTU gas engines

Designation	Unit	Limit value	Note
Methane number	–	≥70: Engine configuration for standard water content in intake air ≥75: Engine configuration for high water content in intake air	Adjustments may prove necessary depending on model type, power and fuel consumption. Observe the Operating Instructions (Technical data). Consult with the manufacturer before operating with lower values as a gas analysis is required in such case. Knock monitoring reduces engine power. Methane number calculated in accordance with DIN EN 16726.

Table 43: Requirements for fuel gas for MTU gas engines

TIM-ID: 0000095894 - 001

4.1.3 Main constituents of natural gas and fuel gases of biogenic origin

Generally applicable limits for the main constituents of natural gas and fuel gases of biogenic origin

Components that may be used for gas engines are listed in the following tables:

- Generally applicable limits for the main constituents of natural gas (→ Table 44)
- Generally applicable limits for the main constituents of fuel gases of biogenic origin (→ Table 45)

Main constituents of natural gas

Component	Unit	Value range (maximum value)
CH_4	% by vol.	80 to 100
C_2H_6 (or sum of C_2H_x)	% by vol.	< 12
C_3H_8 (or sum of C_3H_x)	% by vol.	<9
C_4H_{10} (or sum of C_4H_x)	% by vol.	<2
C_5H_{12}	% by vol.	<0.3
Hydrocarbons C5+	% by vol.	< 0.1
CO_2	% by vol.	< 10
N_2	% by vol.	< 15
Sum of CO_2 + N_2	% by vol.	< 15
O_2	% by vol.	< 3
H_2	% by vol.	<2
CO	% by vol.	< 0.2

Table 44:

The above-listed components apply to natural gas compositions. Components other than those listed above (as well as trace elements) are not usual for natural gas compositions.

If the components of the natural gas exceed the listed maximum values, consultation must be made with MTU before using this natural gas.

Main components of fuel gases of biogenic origin, mainly from fermentation processes (values are specified air-free)

Component	Unit	Value range (maximum value)
CH_4	% by vol.	40 to 85
CO_2	% by vol.	20 to 55
N_2	% by vol.	< 10
O_2	% by vol.	< 3
H_2	% by vol.	<2
CO	% by vol.	< 0.2

Table 45:

The above-listed components apply to fuel gases of biogenic origin. Components other than those listed above (as well as trace elements) are not usual for such gas fuels.

If the components of the fuel gas exceed the listed maximum values, consultation must be made with MTU before using this biogas.

TIM-ID: 0000078928 - 003

4.1.4 Liquid Natural Gas (LNG)

Notes on Liquid Natural Gas (LNG)

Note that the LNG Bunker Delivery Note in the IGF Code specifies component fractions as mass percent. The representation deviates significantly from other common representations in Mol or volume percent.

LNG tanks may only be filled with LNG to 90% of their overall volume. Any additional heat in the tank causes small amounts of liquid gas to vaporize and accumulate as gas in the “boil-off” phase. The composition of this boil-off gas depends on the composition of the liquid phase. The N_2 component in the boil-off phase may by 20x greater than the nitrogen content in the liquid phase. In general, boil-off gas can contain 20 % by volume nitrogen and 80 % by volume methane as well as traces of ethane.

LNG as per EN1160 has a lower methane limit mass fraction of 75% and an upper nitrogen limit mass fraction of 5%.

The use of LNG with a nitrogen content of <1 m/m% is recommended to avoid rollover effects.

The term “rollover” is used to describe vaporization and the subsequent increase in pressure this entails as a result of stratification and the rapid mixing of superheated liquid from the lower layer with the upper layer under the hydrostatic head exerted by the latter.

LNG contains no significant, or only traces of CO_2, as CO_2 solidifies at temperatures below -56 °C and the pressures around 5.2 bar which generally prevail in such tanks. CO_2 sublimates at -78.5 °C under normal pressure conditions.

TIM-ID: 0000081014 - 001

4.1.5 Silicon and sulfur compounds in the fuel gas

Silicon compounds in the gas lead to deposits and promote wear. Even catalytic converters are deactivated by these compounds. Damage caused by silicon and sulfur compounds is not covered by the warranty.

For determination of the Si concentration in the lube oil and its limit value, refer to chapter Lubricants (→ Page 11).

Determination of silicon concentration and sulfur content in the fuel gas from gas analysis

To determine the silicon or sulfur concentration, the measured concentrations or the sulfur content of the individual compounds are multiplied by the Si or S mass fractions.

The result is based on the calorific value of the fuel gas and standardized at 10 kWh energy content (equals 1 m^3 NTP. CH_4).

Measured silicon share from the gas analysis (or sulfur concentration)

Concentration of silicon in sewage gas	K Si	5.1 mg/m^3 NTP
CH_4 content of the sewage gas	K CH_4	65% by volume
Calorific value – sewage gas	Hi_n	6.5 kWh/m^3 NTP

Example: Calculated concentration of silicon limited to Hi_n = 10 kWh/m^3NPT

$$K_{Si}\ 10\ (kW/m^3i.N) = K_{Si\ measured} \quad x \quad \frac{Hi_{n\ measured}}{10\ (kWh/m^3NTP)} =$$

$$5.1\ (mg\ Si/m^3\ NTP) \quad x \quad \frac{6.5}{10} = 3.3\ (mg\ Si/m^3\ NPT)$$

TIM-ID: 0000081015 - 001

4.2 Series 4000 gas engine – Marine application

4.2.1 General

Important information
There is no warranty in case of impairments and / or damages (corrosion, contamination, etc.) that are caused by gases or substances whose existence was not known or agreed upon at the time of signing the contract.

TIM-ID: 0000081018 - 001

4.2.2 Requirements of fuel gas for marine applications

Requirements and boundary conditions for MTU gas engines in marine applications

Designation	Unit	Limit value	Note
Type of gas		Natural gas	Applies to natural gas H, other gases are currently not approved.
Methane number	–	≥70: Engine configuration for standard water content in intake air ≥75: Engine configuration for high water content in intake air	Adjustments may prove necessary depending on model type, power and fuel consumption. Observe the Operating Instructions (Technical data). Consult with the manufacturer before operating with lower values as a gas analysis is required in such case. Knock monitoring reduces engine power. Methane number calculated in accordance with DIN EN 16726.
Calorific value Hi,n	kWh/m^3_n	9.2 <Hi,n < 11.5	Consult the manufacturer before operating with lower or higher limit values.
Wobbe index WI i,n[1), 2)]	kWh/m^3_n	11.77 <WI i,n < 14.18	The Wobbe index is related to the calorific value. The Wobbe index values must be observed.
Admissible rate of calorific value change[1)]	kWh/m^3_n/min	0.067	Constant linear change necessary with a frequency of 1/h
Gas density[2)]	kg/m3n	0.73 to 0.84	The gas density can vary according to the composition; for a specific gas type it is constant. When using gas from different gas supply areas, the density may vary.
Minimum gas pressure upstream of gas regulation unit	bar(g)	1	Relevant for idle and low-load operation. Consult the specifications for the gas train of the relevant project / engine type.
Permissible range for gas pressure before the gas train for full engine power and acceleration capacity.	bar(g)<supscrpt />	6.0...10.0	Consult the specifications for the gas train of the relevant project / engine type.
Gas pressure deviation from setpoint	bar	±0.5	The setting value for gas pressure upstream of the gas train must not be undershot.
Permissible change speed of gas pressure upstream of gas train	bar/s	0.3	Constant change rate for transient and steady state engine condition.

TIM-ID: 0000081017 - 006

Designation	Unit	Limit value	Note
Gas temperature	°C	10...40	Condensation of water vapor at < 10 °C, thermal aging of NBR materials (seals, diaphragms) and impact of higher temperatures on elasticity. Minimum temperatures also apply to the starting sequence. Consult the specifications for the gas train of the relevant project / engine type. Consult the manufacturer before operating with lower or higher temperatures.
Admissible rate of gas temperature change	K/min	10	
Water: dew point	°C	0	At operating pressure. No water vapor condensation in pressure and temperature range. Gas must be dried if values are higher. Value valid for whole gas temperature range.
Oil vapors (HC with carbon number >5)	mg/m^3_n	< 10	No condensation in lines carrying fuel gas and fuel gas-air mixture. No formation of condensable oil mists.
HC solvent vapors	mg/m^3_n	0	Analysis and consultation with manufacturer is required
Organically-bound silicon (e.g. hydrosilicons, siloxanes, silicons)	mg/m^3_n CH_4	< 1.0	Analysis and consultation with manufacturer is required
Inorganically-bound silicon	mg/m^3_n	< 5	With Si >5 mg/m^3N based on 100% CH_4 fuel gas content, wear products must be taken into consideration during the oil analysis.
Dust 3 – 10 µm	mg/m^3_n	< 5	DVGW worksheet G260
Dust < 3 µm	mg/m^3_n	Analysis	Analysis required
Hydrogen sulfide	mg/kg	7	DIN 51624
Total sulfur	mg/kg	10	DIN 51624
Chlorine	mg/m^3_n	10[3)]	Consult the manufacturer in case of higher values and an analysis is required
Fluorine	mg/m^3_n	5[3)]	Consult the manufacturer in case of higher values and an analysis is required

TIM-ID: 0000081017 - 006

Designation	Unit	Limit value	Note
Chlorine + fluorine	mg/m^3_n	10[3)]	Consult the manufacturer in case of higher values and an analysis is required
NH_3	ppm	70[3)]	Consult the manufacturer in case of higher values and an analysis is required

Table 46:

[1)] = Calorific value
The amount of heat which would be released by complete combustion of a given amount of gas in air, whereby the pressure p at which the reaction takes place remains constant and all combustion products return to the same temperature t as that of the reactants. All these combustion products are in gaseous form.
The standard enthalpy of calorific value and Wobbe index specified here are referenced to a temperature of 25 °C. Please note that reference temperatures of 15 °C are commonly used in US publications.
Base conversion to other reference temperatures on EN ISO 6976 or EN ISO 14912.

[2)] = Volumetric quantities are based on the standard state specified in DIN 1343. The standard state is the reference state defined by standard temperature T_n = 273.15 K or t_n = 0 °C and standard pressure p_n = 101325 or Pa = 1.01325 bar.
Please note that the standard enthalpy references for heating and calorific values and Wobbe index are based on 15 °C in US publications and more recent standards such as DIN EN 16726, and that volumetric quantities are defined by the standard temperature T_0 = 288.15 K or t_0 = 15 °C and standard pressure p_n = 101325 or Pa = 1.01325 bar.

[3)] = A non-binding guideline when using oxidation catalysts. Confer with the MTU as an analysis is required.
The limit values are based on a calorific value of 10 kWh/m3n . This corresponds to a reference to fuels with 100 % by vol. methane, or the existence of other combustible components in the fuel with the same energy equivalent and the same input of hazardous materials.

TIM-ID: 0000081017 - 006

4.2.3 Specifications for the medium in the gas piping leak chamber for marine applications

General

IGF 5.5.2 stipulates that all piping bearing fuel gas routed in engine rooms complying with the "safe machinery concept" shall feature a double-wall or jacketed design. This leak chamber surrounding the fuel piping shall facilitate the detection of leaking fuel gas by means of a suitable medium and appropriate measuring technology. The IGF code basically envisages two ways of accomplishing this:

1. Purging/ventilating the leak chamber with air
2. Pressurizing the chamber surrounding the fuel pipe with an inert gas at a higher pressure than that of the fuel gas.

The gas system of the MTU marine engine is designed for operation in either of these scenarios. The gas train itself can only be used in conjunction with the air purging concept. The media in the leak chamber surrounding the gas piping are specified as follows:

1. Air purging concept

Designation	Unit	Limit value	Note
Medium type		Air	Intake from outside the vessel via a separate air tract
Medium temperature at engine inlet	°C	0-50	
Humidity (abs)	$g_{water}/kg_{dry\ air}$	37.7	
Saline content in intake air	ppm	50	
Volumetric flow	m^3/h	11.5 - 30	The lower limit value is based on the max. volume including gas train and supply pipework. The lower limit value ensures the minimum air change rate per hour. The upper limit value should not be exceeded to avoid excessive pressure loss.

Table 47:

2. Pressurized inert gas concept

Designation	Unit	Limit value	Note
Medium type		Nitrogen	Nitrogen from a generator or cylinders
Medium temperature at engine inlet	°C	0-80	
Water content	vol.‰	≤ 50	Nitrogen value 2.8
Nitrogen purity	vol%	≥99.8	Nitrogen value 2.8
Oxygen content	vol.‰	≤100	Nitrogen value 2.8
Medium pressure range	bar (abs)	< 11	

TIM-ID: 0000076444 - 003

Designation	Unit	Limit value	Note
Chamber volume on engine (excl. gas train) (jacketing)	m^3_N	0.079 - 0.095	
Leakage	$g_{nitrogen}/h$	3 - 5	Facilitates specification of refilling volume/intervals

Table 48:

Detailed information on integration in the gas system and design concepts for monitoring and arranging the various components are provided in the Safety Concept, schematic drawings and installation specifications.

TIM-ID: 0000076444 - 003

4.3 Series 4000 gas engine – Generator application and engine-generator set

4.3.1 General

Important information

There is no warranty in case of impairments and / or damages (corrosion, contamination, etc.) that are caused by gases or substances whose existence was not known or agreed upon at the time of signing the contract.

TIM-ID: 0000081018 - 001

4.3.2 Natural gas - Requirements of the fuel gas

Requirements for fuel gas

Designation	Unit	Limit value	Note
Type of gas		Natural gas	Applies to natural gas H, L and pre-mining coal bed methane. Other gases are currently not approved.
Methane number change	-/min.	5	Linear constant change with a frequency of max. 1/h
Calorific value Hi,n	kWh/m³ NTP	8.0 < Hi,n < 11.0	Consultation with manufacturer required in case of lower and higher values
Calorific value deviation from the setting value	%	± 5**	Consultation with manufacturer required for higher values
Admissible change rate of calorific value in relation to set value	%/min.	1.0	Linear constant change necessary with a frequency of maximum 1/h
Density of gas	kg/m³ NTP	0.73 to 0.84	The density of the gas can fluctuate in accordance with the composition; it is constant for a certain type of gas. When using gas from different gas supply areas, the density may vary. When changing to a different gas supplier it may be necessary to adjust the mixture control.
Gas pressure deviation from the setting value	%	± 5	
Admissible gas pressure change rate	mbar/min.	1	Constant change required

*** = For engines with exhaust aftertreatment and/or exhaust gas heat recovery, lower limit values may apply. When using oxidizing catalytic converters; analysis and consultation with MTU are required.**
**** = For the optional operating mode "Energy balancing mode with quick-start feature 120 seconds*, a limit value of ± 3 % from the setting applies.**

TIM-ID: 0000051849 - 005

Designation	Unit	Limit value	Note
Gas temperature Natural gas from the public gas supply grid	°C	5 < T < 45	If there is a danger of undershooting the dew point, the gas temperature must be increased. In case of deviating temperatures, there is a danger of thermal aging of NBR materials (seals, diaphragms) and impact on elasticity. Certain pressure and calorific value combinations may restrict the temperature range. This can be compensated by pressure adjustment to guarantee operation at rated load over the complete temperature range. On plants with LNG operation, the permissible temperature range must be coordinated project-specifically. The gas evaporation system design must be analyzed on the part of MTU for this purpose.
Natural gas from LNG evaporator plants		15 < T < 45	
Gas temperature deviation from the setting value	°C	± 9	
Admissible rate of gas temperature change	K/min.	0.3	
Relative moisture in gas in the permissible temperature and pressure range	%	< 80	In the entire gas and mixture system no condensation is permitted. No water vapor condensation in pressure and temperature range. No condensation permitted in lines and containers carrying fuel gas and fuel gas-air mixtures.
Max. moisture in gas, absolute	g/kg	< 20	
Oils / oil fumes (HC with carbon number >8)	mg/m³ NTP	< 0.4	No condensation in lines carrying fuel gas and fuel gas-air mixture, nor formation of condensible oil mists
Long-chain hydrocarbons (C_6 - C_n)	mewl %	No information	Consultation with MTU necessary
HC solvent vapors	mg/m³ NTP	0	Consultation with manufacturer and analysis necessary
Organically bound silicon	mg/m³ NTP	< 1.0	
Inorganically bound silicon	mg/m³ NTP	< 6	At Si > 5 mg/m³ NTP relative to 100 % $CH_{4\ fuel}$ gas content, wear products are to be taken note of in the oil analysis

* = For engines with exhaust aftertreatment and/or exhaust gas heat recovery, lower limit values may apply. When using oxidizing catalytic converters; analysis and consultation with MTU are required.
** = For the optional operating mode "Energy balancing mode with quick-start feature 120 seconds*, a limit value of ± 3 % from the setting applies.

TIM-ID: 0000051849 - 005

Designation	Unit	Limit value	Note
Dust 3 to 10 µm	mg/m³ NTP	5	DVGW worksheet G260 Dust must be removed in such a manner that trouble-free operation of standard-conformant, or standard design gas devices and gas equipment, is ensured.
Dust< 3 µm	mg/m³ NTP	Technically free	Dust < 3 µm must be evaluated through a technical analysis, if necessary appropriate special filters must be used.
Total sulfur	mg/m³ NTP	30	DVGW worksheet G260
Mercaptan sulfur	mg/m³ NTP	6	DVGW worksheet G260
Hydrogen sulphide H_2S	mg/m³ NTP	5	DVGW worksheet G260
Chlorine	mg/m³ NTP	10*	Consult the manufacturer in case of higher values as analysis is necessary
Fluorine	mg/m³ NTP	5*	Consult the manufacturer in case of higher values as analysis is necessary
Chlorine + fluorine	mg/m³ NTP	10*	Consult the manufacturer in case of higher values as analysis is necessary
NH_3	ppm	70*	Consult the manufacturer in case of higher values as analysis is necessary
* = For engines with exhaust aftertreatment and/or exhaust gas heat recovery, lower limit values may apply. When using oxidizing catalytic converters; analysis and consultation with MTU are required. ** = For the optional operating mode "Energy balancing mode with quick-start feature 120 seconds*, a limit value of ± 3 % from the setting applies.			

Table 49: Requirements and site conditions for natural gas fuel and the corresponding fuel supply

All listed limit values for pollutants (in ppm and mg/m^3) are based on a calorific value of 10 kWh/m^3 NTP. This corresponds to a reference to fuels with 100 % by vol. methane, or the existence of other combustible components in the fuel with the same energy equivalent and the same input of hazardous materials.

Example:

- Russian natural gas with a calorific value of 10 kWh/m^3 NTP is used. The permissible value for total sulfur in the gas thus corresponds exactly to the limit value specified in the table.
- When using a gas (e.g. East Hanover) with Hi,n = 8.15 kWh/m^3 NPT, the permissible maximum value for the total sulfur is calculated as follows:
  Permissible total sulfur content = 30 mg/m³ NPT · (8.15 kWh/m^{3}NPT : 10.0 kWh/m^3 NPT) = 24.5 mg/m³ NPT

TIM-ID: 0000051849 - 005

4.3.3 Biogas – Requirements for fuel gas

Biogas fuel requirements

Designation	Unit	Limit value	Note
Type of gas		Biogenic gases from fermentation processes	
Methane number	–	≥ 115	If undershot, danger of combustion knock. Gas analysis and consultation with the factory required
Calorific value Hi,n	kWh/m³ NTP	4.5 < Hi,n < 8.0	Consultation with manufacturer required in case of lower and higher values
Calorific value deviation from the setting value	%	± 20	Consultation with manufacturer required for higher values
Maximum rate of change in the calorific value in relation to the setting value in operation	%/min.	1	<1/ h is permissible in normal operation
Fast change in calorific value during starting and start-up processes	%/min.	<10.0	with a frequency of <1/ h is permissible
Density of gas	kg/m³ NTP	0.93 to 1.40	The gas density can fluctuate according to the composition. If there are changes to the main substrate and/or significant changes in the mixing ratio of the substrates, a gas analysis or, if necessary, an adaptation of the mixture control is required.
Gas pressure fluctuation in relation to setting value	%	± 10	This applies to the gas inlet at the gas control valve on the engine side
Admissible gas pressure change rate	mbar/min.	1	This applies to the gas inlet at the gas control valve on the engine side
Gas temperature	°C	5 < t < 45	Phase transitions in the fuel gas-air mixture during engine operation are not permissible. If there is a danger of undershooting the dew point, the gas temperature must be increased. If there are deviating temperatures, there is danger of thermal aging of NBR materials (seals, diaphragms) and the effects of changes in elasticity at higher temperatures. The limit values apply to the gas inlet at the gas control valve on the engine side

*** = These values are recommended values for series 4000 engines, for gensets with exhaust aftertreatment, lower limit values can apply.**
**** = lower values apply to the 20V4000L32FB engine. Consultation with the factory is required.**

TIM-ID: 0000051850 - 004

Designation	Unit	Limit value	Note
Gas temperature deviation from the setting value	°C	± 15	This applies to the gas inlet at the gas control valve on the engine side
Permissible change speed of Gas temperature	K/min.	0.3	This applies to the gas inlet at the gas control valve on the engine side
Relative gas humidity in the permissible temperature and pressure range Max. moisture in gas, absolute	% g/kg	< 80 <28	In the entire gas and mixture system no condensation is permitted No water vapor condensation in pressure and temperature range. No condensation permitted in lines and containers carrying fuel gas and fuel gas-air mixtures. At higher values or if there is a danger of condensation in the operating range of pressure and temperature, gas drying must be provided. Phase transitions in the fuel gas and air mixture are inadmissible during engine operation in the pressure and temperature range; gas drying is to be provided in case of higher values.
Oils / oil fumes	mg/m³ NTP	< 0.4	No condensation in lines carrying fuel gas and fuel gas-air mixture, nor formation of condensable oil mists.
HC solvent vapors	mg/m³ NTP	0	
Silicon from organic compounds	mg/m³ NTP	< 4*	At Si > 2 mg/m³ NPT based on 100 % CH_4 fuel gas content, wear products must be noted in the oil analysis.
Inorganically-bound silicon	mg/³ NTP	< 2*	
Dust 3 to 10 µm	mg/m³ NTP	5	DVGW worksheet G260 Dust must be removed in such a manner that trouble-free operation of standard-conformant, or standard design gas devices and gas equipment, is ensured. Dust < 3 µm must be evaluated through a technical analysis, if necessary appropriate special filters must be used.
Dust< 3 µm	mg/m³ NTP	Technically free	
Silicon from organic and inorganic compounds	mg/m³ NTP	6*	
Total sulfur	mg/m³ NTP	800* / **	
Mercaptan sulfur	mg/m³ NTP	4*	
Hydrogen sulphide H_2S	mg/m³ NTP	850*	
Total of all chlorine and fluorine compounds	mg/m³ NTP	≤ 40*	

*** = These values are recommended values for series 4000 engines, for gensets with exhaust aftertreatment, lower limit values can apply.**
**** = lower values apply to the 20V4000L32FB engine. Consultation with the factory is required.**

TIM-ID: 0000051850 - 004

Designation	Unit	Limit value	Note
Chlorine	mg/m³ NTP	≤ 40*	Consult the manufacturer in case of higher values as analysis is necessary
Fluorine		≤ 20*	Consult the manufacturer in case of higher values as analysis is necessary
NH_3	ppm	70*	Consult the manufacturer in case of higher values as analysis is necessary
* = These values are recommended values for series 4000 engines, for gensets with exhaust aftertreatment, lower limit values can apply. ** = lower values apply to the 20V4000L32FB engine. Consultation with the factory is required.			

Table 50: Requirements and site conditions for biogas fuel and the corresponding fuel supply

When using the series 4000 in gensets, with and without exhaust heat coupling and/or exhaust aftertreatment systems, the respective instructions provided by the engine-generator set manufacturer must be complied with.

Requirements of the fuel "low-pollutant biogas"

The following limit values define "low-pollutant biogas". All other limit values for low-polluted biogas correspond to the general limit values for biogas (→ Table 50).

Designation	Unit	Limit value	Note
Silicon from organic compounds	mg/m³ NTP	< 1*	At Si > 2 mg/m³ NPT based on 100 % CH_4 fuel gas content, wear products must be noted in the oil analysis.
Inorganically-bound silicon	mg/³ NTP	< 0.5*	
Silicon from organic and inorganic compounds	mg/m³ NTP	1.5*	
Total sulfur	mg/m³ NTP	140*	
Mercaptan sulfur	mg/m³ NTP	1*	
Hydrogen sulphide H_2S	mg/m³ NTP	150*	
Total of all chlorine and fluorine compounds	mg/m³ NTP	≤ 8*	
Chlorine	mg/m³ NTP	≤ 8*	Consult the manufacturer in case of higher values as analysis is necessary
Fluorine		≤ 4*	Consult the manufacturer in case of higher values as analysis is necessary
NH_3	ppm	14*	Consult the manufacturer in case of higher values as analysis is necessary
* = These values are non-binding recommended values for Series 4000 engines, for gensets with exhaust aftertreatment, lower limit values can apply (→ Table 52).			

Table 51: Requirements and site conditions for low-pollutant biogas fuel and the corresponding fuel supply

All listed limit values for pollutants (in ppm and mg/m³) are based on a calorific value of 10 kWh/m³ NTP. This corresponds to a reference to fuels with 100 % by vol. methane, or the existence of other combustible components in the fuel with the same energy equivalent and the same input of hazardous materials.

TIM-ID: 0000051850 - 004

Example:

- Russian natural gas with a calorific value of 10 kWh/m³ NTP is used. The permissible value for total sulfur in the gas thus corresponds exactly to the limit value specified in the table.
- When using a gas (e.g. East Hanover) with Hi,n = 8.15 kWh/m³ NPT, the permissible maximum value for the total sulfur is calculated as follows:
  Permissible total sulfur content = 30 mg/m³ NPT · (8.15 kWh/m³NPT : 10.0 kWh/m³ NPT) = 24.5 mg/m³ NPT

Pollutant concentration in fuel (with exhaust aftertreatment / exhaust gas heat recovery)

Depending on the application, the following maximum permissible pollutant concentrations in the fuel must be observed:

Designation	Unit	Oxidation catalyst / exhaust gas heat recovery		
		Without* / Without	With / 120 °C to 180 °C	With / Without
Sum of all sulfur compounds (calculated as S)	mg/m³ NTP	800	20	200
Hydrogen sulfide (H_2S)	ppm	550	7	70
Sum total of all chlorine compounds (calculated as Cl)	mg /m³ NTP	40	0.5	0.5
Sum total of all fluorine compounds (calculated as F)	mg /m³ NTP	40	0.5	0.5
Total of all silicon compounds (calculated as Si)	mg /m³ NTP	5	0	0
Ammonia (NH_3)	ppm	30	30	30
Heavy metals (Pb, Hg, As, Sb, Cd)	µg/m³ NTP	Upon request	10	10
*= for "low-pollutant biogas", lower values apply accordingly (→ Table 51).				

Table 52: Pollutant concentration in the fuel

TIM-ID: 0000051850 - 004

4.4 Series 400 gas engine – Engine-generator set

4.4.1 Natural gas - Fuel values

Fuel specifications to be complied with

The following fuel values must be observed at the inlet to the gas train (scope of supply of MTU):

Designation	Unit	Limit value
Minimum methane number	See Technical Description	
Minimum calorific value		
Rate of change, calorific value	% per min	<1
Rate of change, methane number	Change in MN per min	< 5
Minimum gas flow pressure (overpressure)	mbar	< 20
Maximum gas flow pressure (overpressure)	mbar	< 50
Max. gas pressure variation (brief control fluctuation)	mbar	±5
Max. rate of change of gas pressure	mbar/s	<1
Gas temperature	°C	5 to 45
Max. water vapor content	% by vol.	< 0.5
Dust particle size > 3 µm	mg/m^{3}NPT	< 5
Oily constituents	mg/m^{3}NPT	< 0.4

Table 53: Fuel specifications to be complied with

A max. total of 30 mg/m^{3}NPT and, for brief periods, 150 mg/m^{3}NPT, are permissible, but otherwise no corrosive constituents may be present (analogous to DVGW Sheet G 260).

Important: The supplied gas filter (mesh size: 50 µm) fitted at the inlet of the gas train does not ensure compliance with the dust limit value specified above and is used solely to protect the gas fittings.

TIM-ID: 0000053740 - 004

4.4.2 Biogas – Fuel values

It is not possible to avoid variations in gas quality for biogas, sewage gas and landfill gas, the same applies to harmful impurities.

In order to allow trouble-free operation and avoid damage, however, certain limit values have to be complied with.

If it turns out during commissioning that the quality requirement for the fuel is not met, MTU reserves the right to charge for the aborted commissioning procedure.

Compliance with the emission and consumption values specified in the data sheet applies only to the specified reference gas compositions for biogas, sewage gas and landfill gas. The CO_2 / CH_4 volume ratio is of importance here.

Important
The listed constituents / limit values listed are relevant for biogas engines. Other constituents / limit values are not permitted.

Fuel specifications to be complied with

The following fuel values must be observed at the inlet to the gas train (scope of supply of MTU):

Designation	Unit	Limit value
Minimum methane number	See Technical Description	
Minimum calorific value		
Rate of change, calorific value	% per min	1
Rate of change, methane number	Change in MN per min	5
CO_2 / CH_4 volume ratio	–	≤ 0.65
Methane content, moist	% by vol.	See techn. data
Minimum gas flow pressure (overpressure)	mbar	30
Maximum gas flow pressure (overpressure)	mbar	50
Max. gas pressure variation (brief control fluctuation)	mbar	±5
Max. rate of change of gas pressure	mbar/s	1
Max. gas temperature (no derating)	°C	35
Max. oxygen content	% by vol.	2
Max. water vapor content	% by vol.	3.1
Maximum temperature of cooled gas	°C	< 25
Dust particle size > 3 µm	mg/m³NPT	5
Oily constituents	mg/m³NPT	0.4

Table 54: Fuel specifications to be complied with

CAUTION: The supplied gas filter (mesh size: 50 µm) fitted at the inlet of the gas train does not ensure compliance with the dust limit value specified above and is used solely to protect the gas fittings.

TIM-ID: 0000053741 - 006

4.4.3 Harmful impurities (pollutants)

The following application-dependent maximum limits for permissible pollutant concentrations in the fuel are to be complied with:

Designation	Unit	Oxidation catalyst / exhaust gas heat recovery					
		Without / 180 °C / Without		With EMK* / 120 °C / 180 °C	With EMK* / Without	With SRK** / 180 °C	With SRK** / Without
		Biogas	low-pollutant biogas	20 mg/m³ NTP HCHO		30 mg/m³ NTP HCHO	
Sum total of all sulfur compounds (S)	mg/m³ NPT	1200	140	20	200	70	140
Corresponding hydrogen sulphide (H_2S)	ppm	840	50	14	140	50	100
Sum total of all chlorine compounds (Cl)	mg/m³ NPT	100	8	0.5	0.5	0.5	0.5
Sum total of all fluorine compounds (F)	mg/m³ NPT	50	8	0.5	0.5	0.5	0.5
Sum total of all silicon compounds (Si)	mg/m³ NPT	5	4	0	0	0	0
Ammonia (NH_3)	ppm	60	14	60	60	60	60
Heavy metals (Pb, Hg, As, Sb, Cd)	µg/m³ NPT	upon request	upon request	10	10	10	10
* EMK = noble-metal catalytic converter ** SRK = sulfur-resistant catalytic converter							

Table 55: Pollutant concentration in the fuel

All listed limit values for pollutants (in ppm and mg/m³) are based on a calorific value of 10 kWh/m³ NTP. This corresponds to a reference to fuels with 100 % by vol. methane, or the existence of other combustible components in the fuel with the same energy equivalent and the same input of hazardous materials.

Example:

- Russian natural gas with a calorific value of 10 kWh/m³ NTP is used. The permissible value for total sulfur in the gas thus corresponds exactly to the limit value specified in the table.
- When using a gas (e.g. East Hanover) with Hi,n = 8.15 kWh/m³ NPT, the permissible maximum value for the total sulfur is calculated as follows:
  Permissible total sulfur content = 30 mg/m³ NPT · (8.15 kWh/m³NPT : 10.0 kWh/m³ NPT) = 24.5 mg/m³ NPT

If the quality of the raw gas exceeds the appropriate limit value for sulfur, a gas desulfurization system, designed according to the quality of gas in the system, has to be installed.

With the special sulfur-resistant MTU oxidizing catalytic converter, operation without fine desulfurization is permissible as long as the specified limit value for sulfur in the fuel is complied with.

In the case of active exhaust gas heat utilization, if limit values are exceeded during operation there will be an increased build-up of corrosive deposits. Damage caused by these deposits can result in total failure of the components. Earlier cleaning of the exhaust gas heat exchanger is therefore necessary.

Due to potential fluctuations in the sulfur content in practice, MTU is unable to offer any guarantees regarding the cleaning intervals.

TIM-ID: 0000075182 - 004

Concerning operation with the oxidizing catalytic converter without exhaust gas heat utilization, the exhaust gas temperature at the exhaust gas system opening must definitely be above 300 °C. If necessary, the exhaust pipe must be insulated.

TIM-ID: 0000075182 - 004

4.5 Series 500 gas engine – Engine-generator set

4.5.1 Gas types

As the elements of fuel gases, in part, vary considerably, a classification of the gases based on certain properties and gas composition is necessary. A classification is carried out here based on their calorific value.

Parameters	Symbol	Limit value	Unit	Comments
Calorific value	$H_{i,N}$	< 5	kWh / Nm³	Lean gas operation in consultation with MTU
		< 483.1	BTU/ft³	
		> 5	kWh / Nm³	Lean gas operation
		> 483.1	kWh / Nm³	
		> 10	kWh / Nm³	Natural gas operation
		> 966.2	kWh / Nm³	

Table 56: Subdivision of fuel gases

The classification based on the calorific value provides an initial insight into whether the fuel gas can potentially be used. The following (→ Table 57) provides an overview of which main elements are contained in the respective fuel gases independently of their quantitative share.

Element	Symbol	Natural gas	Biogas/sewage gas/landfill gas
Methane	CH_4	X	X
Ethane	C_2H_6	X	
Propane	C_3H_8	X	
Butane	C_4H_{10}	X	
Pentane	C_5H_{12}	X	
Hexane	C_6H_{14}	X	
Carbon monoxide	CO		X
Carbon dioxide	CO_2	X	X
Hydrogen	H_2	X	
Nitrogen	N_2	X	X
Oxygen	O_2		X

Table 57: Main elements of fuel gases

For gas secondary substances that are not named in this table nor in table (→ Page 90) consultation with MTU is required.

TIM-ID: 0000092005 - 001

4.5.2 Minimum requirements of gas composition

The following table provides information on the minimum requirements of the gas quality. The gas operating data must also be observed (→ Page 91).

In addition, special components, e.g. a catalytic converter, may require deviating limit values in certain circumstances (→ Page 93).

Important

Continuous observance of the minimum gas requirements must be guaranteed by the customer!

The large number of possible fuel gases and the different compositions necessitate a gas-dependent analysis of the gas quality limit values. For this purpose, MTU requires a conversion of the gas analysis values based on the calorific value, see (→ Page 92).

Parameters	Symbol	Limit value	Unit	Comments
Methane Number	MN	>135		Lean gas operation Low methane number after consultation with MTU
		>80		Natural gas operation Low methane number available after consultation with MTU
Chlorine	Cl	<8	mg / kWh	Chlorine is present as a volatile compound.
		< 5.169 x10^{-9}	lb / BTU	
Fluorine	F	< 4	mg / kWh	Fluorine is present as a volatile compound.
		< 2.584 x10^{-9}	lb / BTU	
Total chlorine + fluorine	Σ (Cl, F)	<8	mg / kWh	
		< 5.169 x10^{-9}	lb / BTU	
Dust content < 5 µm		< 1	mg / kWh	
		< 0.646 x10^{-9}	lb / BTU	
Oil vapor		< 0.02	mg / kWh	No condensation must form in the intake tract.
		< 12.9 x10^{-12}	lb / BTU	
Solvents in combustion air	VOC	< 2.5	mg / kWh	
		< 1.62 x10^{-9}	lb / BTU	
Total silicon	Σ Si	< 0.2	mg / kWh	High fluctuation in the gas. Oil analysis provides more exact information.
		< 0.129 x10^{-9}	lb / BTU	
Total sulfur	Σ S	< 40	mg / kWh	Sulfur share from hydrogen sulfide must be taken into consideration via the molar masses with total sulfur.
		< 25.83 x10^{-9}	lb / BTU	
Hydrogen sulfide	H_2S	< 42.4	mg / kWh	
		< 27.38 x10^{-9}	lb / BTU	
Ammonia	NH_3	< 3	mg / kWh	
		< 1.938 x10^{-9}	lb / BTU	
Tar	$C_xH_yR_z$	< 6.5	mg / kWh	Only with syngas Condensing must not take place in gas-carrying components. It may be necessary to install a gas reheating system.
		< 4.2 x10^{-9}	lb / BTU	

Table 58: Permissible limit values for gas components

Deviations from the limit values or the use of further elements not listed here only after consultation with MTU.

TIM-ID: 0000092006 - 001

4.5.3 Gas operating data

Parameters	Limit value	Unit	Comments
Rate of gas pressure change	< 1	mbar / 2 s	
	< 0.0145	psi / 2 s	
Calorific value rate of change H_i	< 1	% / 30 s	
Rate of change, methane number	< 10	MN / min	
Gas low pressure at rated load	30 – 70	mbar	At inlet to gas regulating unit
	0.4351 – 1.015	psi	
Max. assured gas pressure	350	mbar	
	5.076	psi	
Temperature of the gas mixture before gas mixer T_G	10 – 30	°C	
	50 – 86	°F	
Relative humidity φ	< 60	%	No condensation must form in the intake tract and the gas regulating unit.

Table 59: General boundary conditions for fuel gas

TIM-ID: 0000092018 - 001

4.5.4 Conversion of limit values from gas analysis

The large number of possible fuel gases and the associated, in part widely varying, compositions necessitate a dynamic analysis of the gas quality limit values.

For this purpose, MTU requires a conversion of the gas analysis values depending on the calorific value based on kWh / Nm³ (BTU / ft³).

The following is an example of the calculation.

Givens:	Calorific value from gas analysis	$Hi_{,N}$	1.5 kWh / m³
	Chlorine from gas analysis	Cl	10 mg/m³
	Fluorine from gas analysis	F	5 mg/m³
	Plant without catalytic converter		

First, the measured values (MV) are converted on the basis of the calorific value $Hi_{,N}$ to a comparative value (CV). This is then compared with the matching limit value (LV):

$$CV_{Cl} = \frac{MV_{Cl}}{Hi_N} = \frac{10\ mg/m^3}{1.5\ kWh / m^3} = 6.6\ mg/kWh \quad < \quad LV_{Cl} = 8\ mg/kWh$$

→ OK

$$CV_F = \frac{MV_F}{Hi_N} = \frac{5\ mg/m^3}{1.5\ kWh / m^3} = 3.3\ mg/kWh \quad < \quad LV_F = 4\ mg/kWh$$

→ OK

The simultaneous presence of chlorine and fluorine means that a further limit value must be taken into consideration:

$$CV_{Cl,\,F} = CV_{Cl} + CV_F = 6.6\ mg/kWh + 3.3\ mg/kWh = 9.9\ mg/kWh \quad > \quad LV_{Cl} = 8\ mg/kWh$$

→ not OK

Important

In part, the gas composition from the gas analysis is expressed in ppm (parts per million). To make a comparison with the limit values possible, an intermediate conversion step is required. For this purpose, the respective density under normal conditions is used in accordance with the following equation:
Measured value [mg/m^3_{norm}] = measured element volume [ppm] x $density_{norm}$ [kg/m^3_{norm}]

TIM-ID: 0000092020 - 001

4.5.5 Special limit values

Deviations from the specified limit values or the use of further elements not listed here only after consultation with MTU.

Permissible limit values for gas components with use of catalytic converter

With the use of a catalytic converter, the limit values become stricter as follows:

Parameter/catalytic converter toxin	Symbol	Limit value	Unit
		< 1.52	mg / kWh
Hydrogen sulfide	H_2S	< 0.982 x10^{-9}	lb / BTU
		< 1	mg / kWh
Sulfur	S		lb / BTU
		< 6	mg / kWh
Ammonia	NH_3	< 3.877 x10^{-9}	lb / BTU
		50	mg / kWh
Arsenic	As		lb / BTU
		< 0.2	mg / kWh
Mercury	Hg	< 0.129 x10^{-12}	lb / BTU
		< 0.4	mg / kWh
Lead	Pb	< 0.258 x10^{-12}	lb / BTU
		< 2	mg / kWh
Cadmium	Cd	1.292	lb / BTU
Zinc	Zn		mg / kWh
			lb / BTU
Phosphor compounds and halogens	P, F, Cl, Br, I, At, Ts		mg / kWh
			lb / BTU
Silicon		0	mg / kWh
		0	lb / BTU
Silicon	Si	0	mg / kWh
		0	lb / BTU
Sodium	Na	< 2	mg / kWh
		< 1.292 x10^{-12}	lb / BTU
Calcium	Ca	< 2	mg / kWh
		< 1.292 x10^{-12}	lb / BTU
Bismuth	Bi	< 0.2	mg / kWh
		< 0.129 x10^{-12}	lb / BTU
Manganese	Mn	< 2	mg / kWh
		< 1.29 x10^{-12}	lb / BTU
Potassium	K	< 2	mg / kWh
		< 1.29 x10-^{12}	lb / BTU
Antimony	Sb	< 0.2	mg / kWh
		< 0.129 x10^{-12}	lb / BTU
Chlorine	Cl	< 2	mg / kWh
		< 1.29 x10^{-12}	lb / BTU

TIM-ID: 0000092034 - 001

Parameter/catalytic converter toxin	Symbol	Limit value	Unit
Iron	Fe	< 2	mg / kWh
		< 1.29 x10-^{12}	lb / BTU

Table 60: Permissible limit values for gas components with use of catalytic converter

Details not listed in the table remain unchanged.

Permissible limit values for gas components with use of activated carbon

With the use of an activated carbon filter, the limit values become stricter as follows:

Parameters	Symbol	Limit value	Unit	Comments
Oxygen max.	O_2	< 3	%	The development of explosive mixtures must be prevented
Oxygen min.	O_2	> 0.5	%	Follow manufacturer's instructions

Table 61: Permissible limit values for gas components with use of activated carbon

Details not listed in the table remain unchanged.

TIM-ID: 0000092034 - 001

4.5.6 Operational malfunctions due to condensate in the fuel gas

Operational malfunctions caused by insufficient freedom from condensate in the provided fuel gases shall not be covered by the warranty.

Consequences of condensate in the fuel gas

Condensate contained in the power gas (e.g. with the lube oil of the gas compressor) can form an acidic compound/emulsion. Among other things, this can result in the following:

- Corrosion (wear)
- TAN increase or TBN/ipH decrease in lube oil
- Carbon deposits on: Valves, piston ring grooves and chases

Prevention of malfunctions due to condensate in the power gas

- No vaporization due to cooling and/or pressure release.
- Mechanical separation (e.g. cyclone or separation filters) and removal of the condensate must only take place with the engine no longer in operation. Following this, it is essential to seal the separation cock again gastight.
- The gas line leading to the engine must be designed such that the gas does not cool any further and is practically no longer depressurized through resistance or downstream pressure reducers. If necessary, insulate the fuel gas line or possibly provide trace heating.
- As a certain amount of condensate can still enter the engine in spite of freedom from condensate at the test valves, it is important that the condensate is largely free of acidifiers. To make sure of this, the pH value of the aqueous solution accumulating at the condensate separators must be checked. The stronger the acid the greater the harmful impact even with hardly detectable small amounts of condensate which can nevertheless enter the engine with the gas.
- With exhaust gas cooling below 170 °C in lean gas operation, in particular, continuous monitoring of the gas quality with connection to the CHP control system is absolutely necessary.

TIM-ID: 0000092042 - 001

5 Exhaust Gas Aftertreatment System

5.1 General

To reduce exhaust emissions on stoichiometric engines (lambda = 1, without excess air), 3-way catalytic converters are used.

To reduce exhaust emissions due to incompletely burned combustion products on engine with lean operation (operation with excess air), oxidation catalysts are used.

For additional reduction of NOx emissions with lean operation engines, SCR catalytic converters (selective catalytic reduction) can be used. The reducing agent (urea solution with an urea concentration of 32.5 %) in such catalysts reduces the nitrogen oxide emissions.

To guarantee the range of functions of the catalytic converters over a specific runtime, all specifications in the Fluids and Lubricants Specifications (with regard to fuels, intake air, lube oils) must be observed.

TIM-ID: 0000079041 - 001

5.2 NOx reducing agent AUS 32 for SCR exhaust gas aftertreatment systems

To ensure efficient operation of the exhaust gas aftertreatment system, compliance of the reducing agent with the quality requirements stipulated in DIN 70070 / ISO 222 41-1 is mandatory.

In Europe, this reducing agent is often offered under the brand name “AdBlue”.

The test methods for determining the quality and characteristics of the reducing agent are specified in the standards DIN 70071 / ISO 222 41-2. The following table (→ Table 62) shows the quality characteristics of the reducing agent together with the associated test methods (extract from ISO 222 41-1).

Important

SCR systems from MTU are usually designed for a concentration of 32.5 % urea. The use of NOx reducing agent with other urea concentrations (AUS 40, AUS 48) requires a different design of the dosing systems. Systems with the corresponding design must be run with the appropriately adapted concentration.
The purity requirements of the reducing agent then comply with the standards for AUS 32

Important

The use of antifreeze additives for AUS 32, or winter urea, is generally not approved.

Quality features and test procedures for the reducing agent

	Unit	Test method ISO	Limit values
Urea content	by weight %	22241–2 Annex B	31.8 to 33.2
Spec. grav. at 20 °C	kg/m^3	3675 12185	1087.0 to 1092.0
Refractive index at 20 °C		22241–2 Annex C	1.3817 to 1.3840
Alkalinity as NH_3	by weight %	22241–2 Annex D	Max. 0.2
Biuret content	by weight %	22241–2 Annex E	Max. 0.3
Aldehyde content	mg/kg	22241–2 Annex F	Max. 5
Non-soluble constituents	mg/kg	22241–2 Annex G	Max. 20
Phosphate content as $P0_4$	mg/kg	22241–2 Annex B	Max. 0.5
Metal contents		22241–2 Annex I	
Calcium	mg/kg		Max. 0.5
Iron	mg/kg		Max. 0.5
Copper	mg/kg		Max. 0.2
Zinc	mg/kg		Max. 0.2
Chrome	mg/kg		Max. 0.2
Nickel	mg/kg		Max. 0.2
Aluminum	mg/kg		Max. 0.5
Magnesium	mg/kg		Max. 0.5
Sodium	mg/kg		Max. 0.5
Potassium	mg/kg		Max. 0.5
Identity			Identical with the reference sample

Table 62: Quality features and test procedures for the reducing agent

TIM-ID: 0000079042 - 003

Storage of reducing agent

Information on storage/packaging/transport as well as suitable/unsuitable materials in the reducing agent circuit can be obtained in the standard ISO 222 41-3. Also observe the manufacturer's specifications in this regard.

Avoid direct sunlight because it promotes the occurrence of microorganisms and the decomposition of the reducing agent.

Where possible, store and transport the reducing agent AUS 32 between -5 and +25 °C to prevent loss in quality. Long storage periods at temperatures above 25 °C can lead to destruction of the reducing agent.

Max. constant storage temperature [°C]	Min. durability [months]
≤10	36
≤25	18
≤ 30	12
≤35	6
>35	Check each batch prior to use

Table 63: Storage temperature of reducing agent

Important
The reducing agent crystallizes at -11 °C.

TIM-ID: 0000079042 - 003

5.3 Exhaust condensate

Important information

Ensure that used fluids and lubricants are collected in sufficiently large collecting containers. Dispose of fluids and lubricants in accordance with the applicable national specifications. Do not burn used oil or dispose of in fuel tank.

When fuel is burned in the engine, nitrogen oxides NOx are created in addition to carbon dioxide and water vapor. These transform into nitric acid in the downstream components in the presence of condensed water. Other inorganic and organic acids, e.g. sulfuric acid or sulfurous acid, can likewise be created depending on the fuel composition. Condensate samples therefore display a lightly pungent smell and dissolved iron as a corrosion product. The hydrogen ion concentration, i.e. the pH value of such condensate samples, is usually in the strong to weak acid range of pH = approx. 0.5 to 4.

The water dew point of the exhaust gas depends on the composition of the fuel gas used as well as the air ratio at which the engine is operated. The water dew point is approx. 50 °C (lean engines) up to 80 °C (lambda = 1). Condensate starts to form, depending on the acid-forming constituent, at exhaust temperatures below approx. 170 °C (acid dew point).

Theoretically, 1.5 kg condensate can be created from 1 m^3 NTP of natural gas. When exhaust gas is cooled down to temperatures of approx. 100 °C, significant quantities of condensate only form during start-up procedures. When exhaust gas temperatures are further cooled (below T = approx. 80 °C), condensate starts to accumulate continuously.

To limit condensate formation as much as possible (in the exhaust gas heat exchanger or in the downstream exhaust silencer), you should guarantee the following with gensets with exhaust cooling:

- In the exhaust gas heat exchanger, never cool the exhaust gas temperatures below 110 °C
- Ensure exhaust lines are properly insulated
- Keep the ratio of the number of machine starts to operating hours as low as possible (average values lower than "one start" per four operating hours are recommended).

Where possible, do not merge condensate lines from different components before the siphon (or water seal) because otherwise condensate would escape continuously during operation due to circulation in the condensate line.

A free drain via a siphon (or water seal) must be provided for the condensate at a minimum height of 400 mm. In any case, however, the drain must have more than a 100 mm water column above the corresponding maximum permissible exhaust back pressure of the engine. This prevents exhaust gas emerging from the condensate line. The exhaust condensate should be neutralized in a neutralization plant before being discharged into the sewerage system. An oil separator is additionally required.

The condensate drain line must be checked regularly during operation and safeguarded against freezing in winter.

Exhaust condensate may only be discharged into the local sewage system without being treated after consultation with the local waste water authority, and must not under any circumstances be discharged to atmosphere. Municipalities in Germany, or the authorities instructed by them, are obliged to remove accumulated waste water which also contains condensate. Condensate can also be classified in the "Special waste" category.

TIM-ID: 0000079045 - 001

6 Flushing and Cleaning Specifications for Engine Coolant Circuits

6.1 Flushing and cleaning specifications for Series 400 and 4000 engines

6.1.1 General information

In the course of time, sludge deposits from aging coolant additives can accumulate in the coolant circuits. Reduced cooling capacity, clogged vent lines and drain points and dirty coolant level sight glasses can result.

Below-standard water quality or incorrect coolant preparation can also heavily contaminate the system.

If such conditions occur, the coolant circuit is to be flushed out with fresh water, repeatedly if necessary.

If these flushing sequences are insufficient or if the system is too heavily contaminated, the coolant circuit and all affected parts must be cleaned.

Only clean, fresh water (no river or sea water) must be used for flushing.

Only products approved by MTU or equivalent products at the specified concentrations may be used for cleaning, see (→ Page 101). The specified cleaning procedure is to be complied with.

Immediately after flushing or cleaning, fill the coolant circuits with prepared engine coolant as stipulated in the current Fluids and Lubricants Specifications. Otherwise there is a danger of corrosion!

Important

Fluids and lubricants (e.g. treated engine coolant), used flushing water, cleaning agents and cleaning solutions can be hazardous materials. Certain regulations must be obeyed when handling, storing and disposing of these substances.
These regulations are contained in the manufacturer's instructions, legal requirements and technical guidelines valid in the individual countries. Considerable differences can apply from country to country so that no generally valid statement on the applicable regulations for fluids and lubricants etc. can be made in this publication.
Users of the products named in these specifications are therefore obliged to inform themselves of the locally valid regulations. MTU accepts no liability whatsoever for improper or illegal use of the fluids and lubricants / cleaning agents which it has approved.

Important

Scrap oil heat exchangers from engines with bearing or piston seizures or friction damage.

Test equipment, auxiliary materials and fluids and lubricants

MTU test kit or electric pH-value measuring instrument

Required auxiliary materials:
- Compressed air
- Superheated steam

Required fluids and lubricants:
- Fresh water
- Prepared engine coolant

TIM-ID: 0000080702 - 003

6.1.2 Approved cleaning agents

Manufacturer	Product name	Working concentration		Order no.
For coolant systems:				
Kluthe	Hakutex 111 [1, 5]	2% by volume	Liquid	X00065751
	Decorrdal 20-1 [8]	10% by volume	Liquid	[7]
	Hakupur 50-706-3 [4]	2% by volume	Liquid	X00055629
For assemblies:				
Henkel	Bonderite C-AK FD [2]	1 to 10% by weight	Powder	[7]
	Bonderite C-MC 11120 [3]	2 to 10% by weight	Powder	[7]
Kluthe	Hakutex 60 MTU	100% by volume	Liquid	X00070585 (25 kg)
For coolant systems contaminated with bacteria, fungi or yeast (so-called system cleaners):				
Schülke & Mayr GmbH	Grotan WS Plus [5]	0.15% by volume	Liquid	X00065326 (10 kg)
	Grotanol SR2 [6]	0.5% by volume	Liquid	X00069827 (10 kg)

Table 64:

[1] For light lime deposits, light corrosion

[2] For lime deposits containing oil and grease

[3] Preferred for heavy lime deposits

[4] Not suitable for galvanized surfaces

[5] Bacteria contamination up to 10^4

[6] Bacteria contamination up to > 10^4, contamination with fungi and yeast

[7] Not stocked by MTU

[8] With serious corrosion; not permitted for aluminum materials

Important
The technical data sheets and safety data sheets of the product must be observed!

The cleaning agents are available world-wide through the branches of the manufacturers or their trading partners.

TIM-ID: 0000019197 - 016

6.1.3 Engine coolant circuits – Flushing

1. Drain engine coolant.
2. Measure pH-value of the fresh water using the MTU test kit or electric pH-value measuring device.
3. Fill coolant circuit with fresh water.

Important information
Never pour cold water into a hot engine!

4. Preheat, start and run engine until warm.
5. Run engine for approx. 30 minutes at increased speed.
6. Take flush-water sample at engine-coolant-sample extraction cock.
7. Shut down engine.
8. Drain flush water.
9. Measure pH value of flush-water sample using the MTU test kit or electric pH value measuring device and compare with the pH value of the fresh water.
   a) pH value difference < 1: Fill system with treated coolant and start engine.
   b) pH value difference > 1: Fill system with fresh flush water and repeat flushing process.
   c) If the pH value difference is still > 1 after 4 to 5 flushing operations: The coolant circuit must be cleaned, see (→ Page 103). The assemblies may also have to be cleaned, see (→ Page 104).

Important information
Refer to the engine operating instructions for additional information.

TIM-ID: 0000037747 - 006

6.1.4 Engine coolant circuits – Cleaning

1. Mix cleaner to the specified concentration with freshwater. Use warm freshwater (45 °C) if the engine is warm.
2. Cleaning agents for coolant circuits are prepared in warm freshwater as a concentrated solution, see (→ Page 101).
3. In the case of powdered products, stir until the cleaning agent is completely dissolved and without sediment.
4. Pour solution together with freshwater into coolant circuit.
5. Start engine and run until warm.
6. Select temperature and duration of residence time according to the specifications of the technical data sheets of the manufacturer.
7. Shut down engine.
8. Drain off cleaning agents and flush the engine coolant circuit with fresh water.
9. Take flush-water sample at engine-coolant-sample extraction cock.
10. Measure pH value of flush-water sample using the MTU test kit or electric pH value measuring device and compare with the pH value of the freshwater.
    a) pH value difference < 1: Fill system with treated coolant and start engine.
    b) pH value difference > 1: Clean assemblies, see (→ Page 104).

Important
Refer to the engine operating instructions for additional information.

TIM-ID: 0000037713 - 008

6.1.5 Cleaning engine coolant circuit assemblies

1. Remove, disassemble and clean assemblies in the engine coolant circuit that are exposed to heavy sludge deposits e.g. expansion tanks, preheating units, heat exchangers (coolant cooler, oil heat-exchanger, charge-air cooler, charge-air preheater, fuel preheater etc.) and lower sections of pipework.
2. Before cleaning, examine degree of contamination on water sides.
3. In case of lime deposits that contain oil and grease, degrease the water side first.
4. Deposits in charge-air coolers caused by oil mist can be removed using Kluthe Hakutex 60.
5. Remove hard lime deposits with a decalcifying product. In the event of stubborn lime deposits, if necessary a 10% inhibited hydrochloric acid solution may have to be used.
6. Dissolve deposits on and in heat-exchanger elements in a heated cleaning bath. Observe the manufacturer's specifications and use only approved detergents in the permissible concentration, see (→ Page 101)

Important

Deposits on the oil side can also be dissolved in a kerosene bath.
The dwell time in the cleaning bath depends on the type and degree of contamination, as well as the temperature and activity of the bath.

7. Clean individual components such as housings, covers, pipes, sight glasses, heat-exchanger elements with superheated steam, a nylon brush (soft) and a powerful water jet.

Important

In order to avoid damage:
Do not use hard or sharp-edged tools (steel brushes, scrapers, etc.) (oxide protective layer).
The pressure of the water jet must not be ≤ 60 bar (to avoid damage, e.g. of the cooler fins).

8. After cleaning, blow through the heat exchanger elements with low-pressure steam in the direction opposite to operational flow, rinse with clear water (until pH-value difference is < 1) and blow dry with compressed or hot air.
9. Check that all components are in perfect condition, repair or replace as necessary.
10. Flush oil and engine coolant sides of heat-exchanger elements with corrosion-inhibiting oil. This step may be omitted if the heat exchanger is installed and taken into service immediately after cleaning.
11. After installing all assemblies, flush engine coolant circuit once, see (→ Page 28).
12. Check coolant system for leaks during initial operation of engine.

Important

For further information, see the Maintenance Manual for the engine in question.

TIM-ID: 0000037714 - 007

6.1.6 Coolant circuits contaminated with bacteria, fungi or yeast

System cleaning

The system cleaner must flow a sufficiently long time through the complete cooling system to ensure effective cleaning and disinfection.

Therefore, the predefined amount of the approved system cleaner must be added to the contaminated coolant in the system, see (→ Page 101). Use a circulating pump to provide continuous mixture flow through the coolant system for at least 24 hours or max. 48 hours.

Flushing

When the coolant and system cleaner have been drained, the cooling circuit must be flushed with fresh water. Flushing must be carried out until no more contaminants are visible and the flushing liquid has the same pH-value as the fresh water used (max. pH-value difference < 1).

Refill

Before refilling the circuit, make sure the system is free of contaminants.

Refill must be performed directly after flushing to avoid the risk of corrosion!

TIM-ID: 0000019202 - 006

6.2 Flushing and cleaning specifications for Series 500 engines

6.2.1 General Information

Only clean, fresh water (no river or sea water) must be used for flushing.

Only the P3 Standard cleaning agents must be used for cleaning, see (→ Page 107). The specified cleaning procedure is to be complied with.

Immediately after flushing or cleaning, fill the coolant circuits with prepared engine coolant as stipulated in the current Fluids and Lubricants Specifications. Otherwise there is a danger of corrosion!

Important

Fluids and lubricants (e.g. treated engine coolant), used flushing water, cleaning agents and cleaning solutions can be hazardous materials. Certain regulations must be obeyed when handling, storing and disposing of these substances.
These regulations are contained in the manufacturer's instructions, legal requirements and technical guidelines valid in the individual countries. Considerable differences can apply from country to country so that no generally valid statement on the applicable regulations for fluids and lubricants etc. can be made in this publication.
Users of the products named in these specifications are therefore obliged to inform themselves of the locally valid regulations. MTU accepts no liability whatsoever for improper or illegal use of the fluids and lubricants / cleaning agents which it has approved.

Important

Scrap oil heat exchangers from engines with bearing or piston seizures or friction damage.

Test equipment, auxiliary materials and fluids and lubricants

MTU test kit or electric pH-value measuring instrument

Required auxiliary materials:
- 2 x 200 l steel barrel
- Hose for bypass as plate-core heat exchanger
- Spare flushing barrel
- 1-10 or 1-5 softening cartridge for water conditioning

Required fluids and lubricants:
- Fresh water

TIM-ID: 0000094905 - 001

6.2.2 Approved cleaning agents

Approved cleaning agents

Cooling system cleaning agents: P3 Standard, non-foaming powder.

25% phosphoric acid cartridge.

Important
The technical data sheets and safety data sheets of the product must be observed!

The cleaning agents are available through the branches of the manufacturers or their trading partners.

TIM-ID: 0000094906 - 001

6.2.3 Engine cooling system - Cleaning

Draining engine coolant

1. Connect fresh water hose on the thrust side of the engine coolant pump and connect to engine coolant pump.
2. Connect hose with waste water hose to intake side of engine coolant pump and place in a barrel.
3. Drain old water-glycol mixture and dispose of in accordance with the manufacturer's specifications.
4. Remove plate-core heat exchanger and replace with a bypass.
5. If the plate-core heat exchanger is seriously contaminated (pressure loss > 500 mbar), remove it (see step 4). Replace the old plate-core heat exchanger with a cleaned or new plate-core heat exchanger.

Preflushing engine coolant circuit

Note:
- Engine is not was started.
- Never pour cold water into a hot engine (> 60 °C)!

1. Preflush engine coolant circuit with fresh water.
2. Flush out coarse dirt particles.
3. Drain water.

Mixing in cleaning solution

Note:
- Plant is filled with demineralized water.
- The water must be softened. For softening, a water conditioning cartridge must be cut in through which the fresh water is directed.
- If hard water is used for flushing, there is a danger from a temperature of < 60 °C that limescale falls out and irreparably clogs the heat exchanger.

1. Fill the mixing barrel until half full.
2. Provide a flushing barrel.

Note:
- Do not allow the coolant pressure in the engine to exceed 1.5 bar.
- Regulate the pressure via the inlet and supply volume.

.

3. Allow the water from the plate-core heat exchanger in the engine circuit to drain via the hose into the barrel.
4. Extract water with electric pump out of barrel and add again to the engine circuit behind the plate-core heat exchanger.
5. Start engine and run at 60% power up to operating temperature.
6. Add the P3 solution in steps via the flushing barrel until a pH value of approx. 13 is reached.
7. Run the CHP at 60% power for approx. one hour.
8. Switch off engine.
9. Drain P3 solution and replace with fresh, demineralized water until a pH value of 10 is reached.
10. Start the CHP.
11. Close all valves that lead to the flushing barrel.
12. Run the CHP at 60% power over night.
13. Pump off P3 solution.
14. Neutralize in the flushing barrel with 25% phosphoric acid until a pH value of 7 is reached.

Flushing out cleaning solution

1. Flush out cleaning solution with the plant in operation.
2. Reflush with approx. 2 m^3 water.

Refill

Note: If necessary, install plate-core heat exchanger.

1. Fill fresh water-glycol mixture.
2. Document pressure losses in the plant folder.

TIM-ID: 0000094908 - 001

7 Inlet Air and Combustion Air

7.1 General Information

Important
No corrosive compounds must penetrate the intake air. The specified limit values must be observed because otherwise the warranty shall become void.

For operation in swimming pools or near refrigerating machines, note that even small traces of halogen compounds in the supply air (intake air) can lead to corrosion on the following components:

- In the engine
- On peripheral components, e.g. electric motors

Cleaning agents can also contain aggressive substances that can cause corrosion.

In case of doubt, consult MTU.

The intake air must not be supplied with desorption air or off-gases from thermochemical process without prior consultation with MTU.

The permissible temperature range with specification of the minimum and maximum temperature is stipulated in the technical data sheet of the engine / engine-generator set.

Limit values in the gas mixture

The gas mixture consists of air and fuel. The limit values in the gas mixture must not be exceeded (→ Page 66).

The limit values in the gas mixture (in ppm) are clearly lower than the values specified for the fuel (usually lower by approx. factor 20).

TIM-ID: 0000051960 - 006

7.2 Humidity

When operating gas engines in high air humidity conditions, there is a danger of condensation in the gas-air mixture. This condensation can lead to damage, e.g. corrosion on parts that make contact with the mixture. The dew point [°C] of the intake air is drawn on for assessing the permissible air humidity.

All gas engines from MTU can be operated with intake air below a dew point of 20 °C. Operation with intake air above a dew point of 17.5 °C should therefore be restricted to < 200 operating hours per year. A dew point temperature of the intake air above 21 °C is only permitted for specially designed products or with project-specific adaptations.

Damage caused by operation with excessive air humidity shall be excluded from the warranty.

TIM-ID: 0000096234 - 001

7.3 Dust load

Dust deposits reduce the heat dissipation of surfaces and can therefore lead to thermal overload and premature failure of components. This affects not only the engine and generator but also other electrical operating equipment.

To prevent harmful effects of dust, filters are used in various places and have to be replaced corresponding to defined maintenance intervals or based on their condition.

The service life of the combustion air filters can be drawn on as an indicator of increased dust load because the contaminated state of this filter is recorded via a measurement.

A shortened service life of these filters indicates an increased, impermissible dust load in the engine room and technical measures for conditioning the engine room air / combustion air must be introduced to prevent damage to the components and electrical operating equipment.

Damage caused by an increased dust load of the machine room air shall be excluded from the warranty.

Design of the combustion air filtration as a fine dust filter in accordance with ISO 16890 ePM_1 50% (formerly DIN EN 779 F7).

If filtration of the supply air to the engine room is necessary, with a general dust load we recommend pocket filters in accordance with ISO 16890 ePM_{10} 50% (formerly DIN EN 779 M5) where all particles of particle class PM_{10} are at least 50% separated. In case of special project-specific dust loads, e.g. through coarse fiber dust, sand load in desert areas or large amounts of fine-grained dust from mills, foundries or cement factories, the filtration must be designed for the prevailing particle load.

TIM-ID: 0000096196 - 001

8 Heating Water

8.1 General information

Important

The specifications of MTU with regard to conditioning / ventilation of the coolant circuits must be observed.
The specified limit values must be observed because otherwise the warranty shall become void.

Important

Requirements for the quality of heating water above 100 °C apply when an exhaust heat exchanger has been installed in the engine cooling circuit or the heating circuit.

Important

Adding sulfite is not allowed.
It is recommended to use WBcon 2347 as an alternative for the heating water circuit.
Please note that the product contains borates and sodium hydroxide, which are corrosive to materials such as aluminum and brass.

Supplementary information

It is pointed out as a precaution that, in general, costs for foreseeable damage, e.g. by unsuitable water quality, are not covered by machine breakdown insurance either.

The term "Sum total, alkaline earths" refers to the content of hardness-forming, dissolved calcium and magnesium salts. To convert to the former standard unit of measurement of "Total hardness", the following applies:

- 1 mol/m ^{3} = 5.6 dH
- The pH value is a measure of the acidity or alkalinity of a solution.
- pH = 7 neutral, < 7 acid, > 7 alkaline.

Important

Max. permissible fluctuation of the heating water inlet temperature: Max. 3 K / min.

TIM-ID: 0000051994 - 005

8.2 Information on heating water for Series 4000 and 400

Important
Adding sodium sulfite as binding agent for oxygen is not allowed.

Important
The base alkalization must be carried out with trisodium phosphate.

Requirements of heating water up to 100 °C

VDI Directive 2035 Sheet 1 (December 2005) and Sheet 2 (September 1998) is definitive. "Prevention of damage by corrosion and scale formation in water heating installations" with the following guide values (see also the corresponding explanations in the original):

General requirements	Clear, colorless and free from undissolved substances	
pH value (25 °C)	8.0 to 9.0	
Electric conductivity (25 °C)	< 250	µS/cm
Sum total, alkaline earths	Up to 1.5 Up to 8.4	mmol/l °dH
Chlorides	< 50	mg/l
Sulfates	< 50	mg/l
Phosphates	< 10	
Oxygen content when using oxygen binding agents	< 0.1	mg/l
Iron	< 0.2	mg/l

Table 65: Requirements of heating water up to 100 °C

If the upper limit values are not observed, the following measures are required:
- Against scale formation: Coolant conditioning (softening, complete demineralization, reverse osmosis) or hardness stabilization (ST-DOS-H products)
- Against corrosion processes: Inhibition or oxygen binding (ST-DOS-H products)

Requirements imposed on heating water above 100 °C

The definitive specification is the VdTÜV Directive TCh 1466 governing the quality of water in heating installations which are operated with a supply temperature above 100 °C. The following guide values subsequently apply for low-salt method of operation:

General requirements	Clear, colorless and free from undissolved substances	
pH value (25 °C)	8.0 to 9.0 *	
Electric conductivity (25 °C)	10 to < 250	µS/cm
Sum total, alkaline earths	< 0.02 < 0.10	mmol/l °dH
Chlorides	< 20	mg/l
Sulfates	< 5 to 10	mg/l
Oxygen content	< 0.05	mg/l
* Deviation from TCh 1466 (TÜV)		

TIM-ID: 0000051996 - 004

General requirements	Clear, colorless and free from undissolved substances	
Phosphate	5 to 10	mg/l
Iron	< 0.2	mg/l
* Deviation from TCh 1466 (TÜV)		

Table 66: Requirements imposed on heating water above 100 °C

Measures against scale formation and corrosion processes:

- Against scale formation: Coolant conditioning (softening, complete demineralization, reverse osmosis) or hardness stabilization (ST-DOS-H products)
- Against corrosion processes: Inhibition or oxygen binding (ST-DOS-H products)

TIM-ID: 0000051996 - 004

8.3 Information on heating water for Series 500 engines

8.3.1 Water quality for heating water circuit Series 500

When topping up large volumes of supplementary water, or at least once a year, the water quality must be checked by means of a water analysis. For water quality, see (→ Page 116).

If the specifications of these technical instructions are not observed, the operating company must commission a specialist company with the water conditioning.

Characteristic	Unit	Limit value
Appearance	-	Clear and of neutral odor, free of sediment and suspended particles
pH value at 25 °C	-	8.2 to 10.0
Electr. conductivity (at 25 °C)	µS/cm	< 250
Oxygen content O2	mg/l	< 0.05
Total hardness *	°dH	< 0.3 (=0.05 mmol/l)
Chlorides	mg/l	< 10
Phosphate (PO_4)	mg/l	5 to 10
*** If the total heating output of the heating system is less than 600 kW, higher values according to VDI 2035, Sheet 1 can be tolerated**		

Table 67: Limit values for heating water circuit

TIM-ID: 0000092049 - 001

8.3.2 Heating water – Water quality Series 500

Further information on observance of the water quality

- Operation with deionized water with a weak alkaline buffering is generally recommended. In particular, with a pH value that has to be closely observed this prevents the self-alkalization effect. Furthermore, this type of water conditioning removes further elements that have corrosive effects (e.g. chlorides).
- In general, corrosion effects are prevented by low conductivity of the heating water. A low-salt control mode according to VDI 2035 is with a value < 100 µS/cm. The limit values for the heating water circuit should be undershot (→ Page 115).

Important

Relevant rules and standards provide further information (DIN EN 12828, VDI 2035, VD-TÜV, Specification Sheet 1466,...).

TIM-ID: 0000092051 - 001

9 Confirmation for Fluids and Lubricants

9.1 Confirmation by the operator of engine-generator sets

Important
The plant must not be put into operation without this confirmation.

Plant description:

Plant consisting of:

Factory / SAP no.:

Customer:

Operator:

Project Manager from MTU:

We hereby confirm that the quality of the fluids and lubricants (coolant, gas, lubricating oil, heating water, etc., where applicable) conforms to the Fluids and Lubricants Specifications of MTU.

MTU does not provide any warranty for damage incurred as a result of deviating fluid and lubricant quality.

City / date

Legally binding signature (customer)

TIM-ID: 0000051982 - 004

10 Revision Overview

10.1 Revision overview from version A001072/02 to version A001072/03

Seq. No.	Chapter	Subject	Action
1	0	Gas engines and gas engine-generator sets	Series 500 added
2	2.1.1	Engine oil	Revised
3	2.1.2	Engine oil limit values for Series 4000, 400	Revised
4	2.1.3	Engine oil limit values Series 500	New
5	2.2.1	Series 4000 gas engine – Generator application and engine-generator set - marine application: Approved engine oils	Revised
6	2.3.1	Series 400 gas engine – Engine-generator set: Approved engine oils	Revised
7	2.4.1	Series 500 gas engine: Approved engine oils	New
8	2.4.2	Engine oil change intervals	New
9	2.4.3	Oil volume	New
10	2.4.4	Lubricating greases for generators	New
11	3.1.1	Coolant – Definition	Revised
12	3.1.2	Operational monitoring / coolant conditioning for Series 4000 and 400 engines	Revised
13	3.1.3	Coolant concentrates – Storage capability	Revised
14	3.1.9	Fresh water requirements Series 500	New
15	3.2.4	Series 4000 gas engine – Marine application: Antifreeze – Concentrates for cooling systems free of light metal	Revised
16	3.2.6	Series 4000 gas engine – Marine application: Antifreeze – Ready mixtures for cooling systems free of light metals	Revised
17	3.3.4	Series 4000 gas engine: Antifreeze – Concentrates for cooling systems containing light metal	Revised
18	3.3.6	Series 4000 gas engine: Antifreeze – Ready mixtures for cooling systems containing light metals	Revised
19	3.5.1	Series 500 gas engine – Engine-generator set: Coolants – General information	New
20	3.5.2	Series 500 gas engine: Coolant – Check and replacement	New
21	3.5.3	Series 500 gas engine: Approved coolants	New
22	4.1.2	Requirements for fuel gas	Revised
23	4.2.2	Requirements of fuel gas for marine applications	Revised
24	4.5.1	Series 500 gas engine: Gas types	New
25	4.5.2	Series 500 gas engine: Minimum requirements of gas composition	New
26	4.5.3	Series 500 gas engine: Gas operating data	New
27	4.5.4	Series 500 gas engine: Conversion of limit values from gas analysis	New
28	4.5.5	Series 500 gas engine: Special limit values	New

TIM-ID: 0000098552 - 001

Seq. No.	Chapter	Subject	Action
29	4.5.6	Series 500 gas engine: Operational malfunctions due to condensate in the fuel gas	New
30	6.2.1	Flushing and cleaning specifications for Series 500 engines: General Information	New
31	6.2.2	Series 500 gas engine: Approved cleaning agents	New
32	6.2.3	Series 500 gas engine: Engine cooling system – Cleaning	New
33	7.1	Supply air and combustion air: General Information	Revised
34	7.2	Humidity	New
35	7.3	Dust load	New
36	8.2	Information on heating water for Series 4000 and 400	Revised
37	8.3.1	Water quality for heating water circuit Series 500	New
38	8.3.2	Heating water – Water quality Series 500	New

TIM-ID: 0000098552 - 001

11 Appendix A

11.1 List of abbreviations

Abbreviation	Meaning	Explanation
ASTM	American Society for Testing and Materials	–
Bh	Betriebsstunden	Operating hours
BR	Baureihe	Series
BV	Betriebsstoffvorschrift	Fluids and Lubricants Specifications
DIN	Deutsches Institut für Normung e. V.	German national standards institute, at the same time identifier of German standards (DIN = "Deutsche Industrie-Norm")
DVGW	Deutsche Vereinigung des Gas- und Wasserfaches e.V.	German Federal Association for Gas and Water
EN	Europäische Norm	European standard
IP	Institute of Petroleum	–
ISO	International Organization for Standardization	International umbrella organization for all national standardization institutes
MZ	Methanzahl	Methane number
SAE	Society of Automotive Engineers	U.S. standardization organization
ST-DOS-H	Sicherheitsdatenblatt	Safety data sheet
VDI	Richtlinie, Normen Regeln und Standards	Guidelines, rules, and standards
VdTÜV	Technische Regeln	Technical rules
Vol.	Volumen	Volume

TIM-ID: 0000075707 - 003

11.2 Conversion table of SI units

SI unit	US unit	conversion
°C	°F	°F = °C*1.8+32
kWh	BTU	1 BTU = 0.0002930711 kWh
kWh/m³ NTP	BTU/ft³	1 BTU/ft³ = 00.010349707 kWh/m³
kW	kBTU/h	1 kBTU/h = 0.2928104 kW
kW	bhp	1 bhp = 0.7457 kW
l	gal	1 gal = 3.785412 liters
mm	inch	1 inch = 25.4 mm
m	ft	1 ft = 0.3048 m
m/s	ft/s	1 ft/s = 0.3048 m/s
m³ NTP	ft³ NTP	ft³ = 0.02831685 m³ NTP
bar	psi	1 psi = 0.06894757 bar
kg	lb	1 lb = 0.4535924 kg

Table 68: Conversion table

TIM-ID: 0000053888 - 001

11.3 Contact person/Service partner

Service

The worldwide network of the sales organization with subsidiaries, sales offices, representatives and customer service centers ensure fast and direct support on site and ensure the high availability of our products.

Local Support

Experienced and qualified specialists place their knowledge and expertise at your disposal.

For locally available support, go to the Internet site: http://www.mtu-solutions.com

24 h Hotline

With our 24 h hotline and high flexibility, we are your contact around the clock: during each operating phase, preventive maintenance and corrective operations in case of a malfunction, for information on changes in conditions of use and for supplying spare parts.

Your contact person in our Customer Assistance Center:

E-mail: service.de@ps.rolls-royce.com

Spare Parts Service

Quick, easy and correct identification of the spare part required for your system. The right spare part at the right time at the right place.

With this aim in mind, we can call on a globally networked parts logistics system.

Your contact at Headquarters:

Germany:
- Tel: +49 821 74800
- Fax: +49 821 74802289
- E-mail: spareparts-oeg@ps.rolls-royce.com

Worldwide:
- Tel: +49 7541 9077777
- Fax: +49 7541 9077778
- E-mail: spareparts-oeg@ps.rolls-royce.com

TIM-ID: 0000002624 - 009

12 Appendix B

12.1 Index

DCL-ID: 0000047995 - 006

D

E

F

G

H

DCL-ID: 0000047995 - 006

DCL-ID: 0000047995 - 006