A TOGNUM GROUP BRAND

FLUIDS AND LUBRICANTS SPECIFICATION
BR4000

For Type Series 4000

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Subject to technical alterations in the interest of further development.

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1 Foreword

INFORMATION		
	Approved operating media must not be mixed.	SH-H-018

The service life, operational reliability and function of the plant are very much dependent on the fluids and lubricants used. That is why the correct selection and care of the fluids and lubricants is of the utmost importance and is fixed in these fluids and lubricants specifications.

The supplier of the fluids and lubricants is responsible for the internationally consistent quality of the products mentioned.

The Fluids and Lubricants Specification will be modified or supplemented where necessary.

Test standards for fluids and lubricants:

DIN	German institute for standardization
EN	European standardization
ISO	International standards
ASTM	American Society for Testing and Materials
IP	Institute of Petroleum

These rules are derived from the specifications of manufacturers, statutory provisions and regulations in the respective country. Since there can be major differences from country to country, it is not possible to provide a universally applicable statement on the rules to be observed within the framework of these fluids and lubricants specifications.

The user of the product mentioned herein is obligated to inform him-/herself about the provisions applicable in his/her country. MTU Onsite Energy does not accept any liability whatsoever for improper or unlawful use of the fluids and lubricants it has approved.

The use of the approved fluids and lubricants, either by name or in accordance with the stipulated specification, is an integral part of the terms of warranty.

Fluids and lubricants for plants can be hazardous substances. Certain rules must be observed when handling, storing and disposing of these substances.

When handling fluids and lubricants the "Rules for the protection of the environment (see Safety Regulations, Disassembly and Disposal)" are to be adhered to, 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.

The customer / operator bears the responsibility for adhering to the fuel values.

2 Fuel

⚠ CAUTION		
	**Moisture in the fuel / air mixture** Damage / destruction of the catalytic converter / destruction of the gas control unit It must be ensured that the limit values of the moisture in the fuel as well as the intake air are not exceeded at any time!	SH-V-103

⚠ CAUTION		
	**Harmful substances / contamination in the fuel** Long-term damage due to corrosion It must be ensured that no corrosive compounds (e.g. siloxane, phosphor, arsenic, heavy metal, sulfur, ammonia, chlorine, fluorine, bromine, iodine compounds) enter the fuel lines. Or their limit values must not be exceeded. Exceeding the limit values voids the warranty.	SH-V-104

⚠ CAUTION		
	**Harmful substances / contamination in the intake air** Long-term damage due to corrosion It must be ensured that no corrosive compounds (e.g. siloxane, phosphor, arsenic, heavy metal, sulfur, ammonia, chlorine, fluorine, bromine, iodine compounds) enter the intake air. Or their limit values must not be exceeded. Exceeding the limit values voids the warranty.	SH-V-102

2.1 Natural Gas

2.1.1 General

It is essential to make sure - at the latest prior to commissioning - by consulting the relevant gas supply company that the minimum methane number specified in the respective data sheet and the calorific value range are observed. It is also necessary here to inquire about the occasional admixture of butane- or propane-air mixtures.

The fuel must be technically free of vapor, dust and liquid.

The gas engines are to be operated exclusively with the gas approved for this model. The options for use of the approved types of gas are to be checked at half-yearly intervals by means of gas analysis to detect changes in the composition of the gas, as well as changes in the hazardous constituents in the gas and to introduce rectifying measures. The use of fuels in the entire area of application and operation of the engine is limited to purely gaseous fuels. Liquid fuels are not admissible nor are they provided for.

The components applicable for gas engines are listed in the following table. The components listed apply to gas engines. Components other than those listed are not admissible for gas engines. They provide an approximate value for the commonly used gas compositions. Limit values for the individual components, unless they are explicitly specified, result from the general requirements of the freedom of liquid constituents, the exclusion of condensation of hydrocarbons and the global parameters of the gas mixture.

2.1.2 Main Components

Natural gas

Components	Unit	Value range
CO	% by volume	<2
CO_2	% by volume	<10
CH_4	% by volume	80 - 100
C_2H_6	% by volume	<12
C_3H_8	% by volume	<9
C_4H_{10}	% by volume	<1
N_2	% by volume	<20
O_2	% by volume	<3

2.1.3 Composition of Natural Gas

Natural gas H

(according to DVGW Worksheet G260)

		Russia	North Sea I	North Sea II	Composite gas
CO	% by volume	0,0000	0,0000	0,0000	0,0000
CO_2	% by volume	0,1000	0,0000	0,3000	1,4000
CH_4	% by volume	98,3000	88,6000	83,000	88,6000
C_2H_4	% by volume	0,0000	0,0000	0,0000	0,0000
C_2H_6	% by volume	0,5000	8,4000	11,6000	5,3000
C_3H6	% by volume	0,0000	0,0000	0,0000	0,0000
C_3H_8	% by volume	0,2000	1,7000	3,1000	1,4000
C_4H_6	% by volume	0,0000	0,0000	0,0000	0,0000
C_4H_8	% by volume	0,0000	0,0000	0,0000	0,0000
C_4H_{10}	% by volume	0,1000	0,7000	0,5000	0,6000
C_5H_{12}	% by volume	0,0000	0,0000	0,0000	0,0000
C_XC_Y	% by volume	0,0000	0,0000	0,0000	0,0000
N_2	% by volume	0,8000	0,6000	1,5000	2,7000
O_2	% by volume	0,0000	0,0000	0,0000	0,0000
H_2	% by volume	0,0000	0,0000	0,0000	0,0000
H_2O	% by volume	0,0000	0,0000	0,0000	0,0000
H_2S	% by volume	0,0000	0,0000	0,0000	0,0000
SO_2	% by volume	0,0000	0,0000	0,0000	0,0000
AR	% by volume	0,0000	0,0000	0,0000	0,0000
$\sum$	% by volume	100,000	100,000	100,000	100,000
Ho	kWh/m^3_N	11,1	12,2	12,5	11,5
Hu	kWh/m^3_N	10,0	11,0	11,3	10,3
Density	kg/m^3_N	0,731	0,810	0,853	0,814
Rel. density	---	0,56	0,62	0,66	0,63
Ws, n	kWh/m^3_N	14,7	15,4	15,4	14,5
Methane number	MN (± 2)	89	72	68	78

Natural gas L

(according to DVGW Worksheet G260)

		Holland I	Holland II	East Hanover
CO	% by volume	0,0000	0,0000	0,0000
CO_2	% by volume	1,0000	1,3000	0,7000
CH_4	% by volume	81,3000	82,900	79,5000
C_2H_4	% by volume	0,0000	0,0000	0,0000
C_2H_6	% by volume	2,8000	3,7000	1,1000
C_3H_6	% by volume	0,0000	0,0000	0,0000
C_3H_8	% by volume	0,4000	0,7000	0,1000
C_4H_6	% by volume	0,0000	0,0000	0,0000
C_4H_8	% by volume	0,0000	0,0000	0,0000
C_4H_{10}	% by volume	0,3000	0,3000	0,0000
C_5H_{12}	% by volume	0,0000	0,0000	0,0000
C_XC_Y	% by volume	0,0000	0,0000	0,0000
N_2	% by volume	14,2000	11,1000	18,6000
O_2	% by volume	0,0000	0,0000	0,0000
H_2	% by volume	0,0000	0,0000	0,0000
H_2O	% by volume	0,0000	0,0000	0,0000
H_2S	% by volume	0,0000	0,0000	0,0000
SO_2	% by volume	0,0000	0,0000	0,0000
AR	% by volume	0,0000	0,0000	0,0000
$\sum$	% by volume	100,000	100,000	100,000
Ho	kWh/m^3_N	9,76	10,20	9,04
Hu	kWh/m^3_N	8,81	9,21	8,15
Density	kg/m^3_N	0,836	0,832	0,835
Rel. density	---	0,64	0,64	0,64
Ws, n	kWh/m^3_N	12,2	12,7	11,3
Methane number	MN (± 2)	90	86	101

2.1.4 Requirements of Fuel Gas

Requirements and peripheral conditions for fuel gas and fuel supply

Designation	Unit	Limit value	Remark
Gas type	---	Natural gas	Applies to natural gas H and L, other gases are currently not approved
Methane number MN	---	See Technical Description	Depending on the model
Calorific value Hu	kWh/m^3_N	8.0 < Hu < 11.5	For lower values consult the factory
Fluctuations in calorific value to the setting value	%	± 5	For higher values consult the factory
Admissible rate of change in calorific value	$kWh/m^3_N/h$	0,5	Constant linear change necessary
Gas density	kWh	0,73 - 0,84	The density of the gas can fluctuate depending on the composition, it is constant for a specific type of gas. Gases from different sources of supply could result in changes in density. When changing to a different gas supplier it may be necessary to adjust the mixture control.
Maximum setting value of gas pressure entry into gas control unit	mbar	300	Specification of the gas control unit relative to the project is to be observed.
Minimum gas flow pressure (overpressure) V8 V12	mbar	120	
Minimum gas flow pressure (overpressure) V16 V20	mbar	180	
Gas pressure fluctuations to the setting value	%	± 5	

Admissible rate of change in gas pressure	mbar/min.	0,08	Constant change required
Gas temperature	°C	10 < T < 40	Condensation of steam at T <10°C, thermal aging of NBR materials (seals, diaphragms) and the effects of changes in elasticity at higher temperatures
Fluctuations of gas temperature to setting value	°C	± 9	
Admissible rate of change in gas temperature	K/min.	0,3	
Relative moisture in gas at 20°C	%	< 30	No condensation of steam in pressure and temperature area; gas drying is to be provided at higher values
Oil vapors (HC with carbon number > 5)	mg/m^3_N	< 0,4	No condensation in lines carrying fuel gas and fuel gas air mixture, no formation of condensable oil vapors
HC solvent vapors	mg/m^3_N	0	Factory consultation and analysis is required
Organically bound silicon (e.g. silanes, siloxenes, silicones)	mg/m^3_N	< 0,1	Factory consultation and analysis is required
Inorganically bound silicon	$mg/m^3_N CH_4$	< 5	At Si < 5 mg/m^3_N relative to 100% CH_4 fuel gas content, wearing products are to be taken note of in the oil analysis

Total sulfur	mg/m^3_N	30	DVGW Worksheet G260
Mercaptan sulfur	mg/m^3_N	6	DVGW Worksheet G260
Hydrogen sulfide H_2S	mg/m^3_N	5	DVGW Worksheet G260
Chlorine	mg/m^3_N	10	Consultation with the factory and analysis are necessary at higher values
Fluorine	mg/m^3_N	5*	Consultation with the factory and analysis are necessary at higher values
Chlorine + fluorine	mg/m^3_N	10*	Consultation with the factory and analysis are necessary at higher values
NH_3	ppm	70*	Consultation with the factory and analysis are necessary at higher values

* = This is a recommended value when using oxidizing catalytic converters; analysis and consultation with factory are necessary.

The limit values refer to a calorific value of 10 kWh/m^3_N. This corresponds to fuels with 100% volume of 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_N is used. This means that the admissible value for the total sulfur in the gas corresponds precisely to the specified limit value.

When using a gas with the example of East Hanover with Hu = 8.15 kWh/m^3_N the admissible maximum value for the total sulfur is calculated as:

admissible total sulfur content = 30 mg/m^3_N (8.15 kWh/m^3_N: 10.0 kWh/m^3_N) = 24.5 mg/m^3_N

2.2 Biogas, Sewer Gas

⚠ CAUTION		
	**Harmful substances / contamination in the exhaust gas** Long-term damage due to corrosion It must be ensured that no metal such as iron, nickel, chromium, copper, zinc and tin enters the exhaust gas system / catalytic converter. If the cumulative quantity of these metals together with the heavy metals exceeds the total limit value of 350 g/m^3 of the catalytic converter space volume, this voids the warranty of the catalytic converter.	SH-V-106

⚠ CAUTION		
	**Exceeding the temperature in the exhaust gas system** Damage / destruction of the catalytic converter It is to be ensured that the maximum operating temperature of 600°C is not exceeded. Exceeding the limit values voids the warranty.	SH-V-107

2.2.1 General

Fluctuations in the gas quality of biogas cannot be avoided.

However, to facilitate trouble-free operation and to avoid damage, it is necessary to adhere to specific limit values.

If it transpires during commissioning that the required quality of the fuel is not met, we reserve the right to bill the cancelled commissioning.

Adherence to the emission and consumption figures specified in the data sheet applies only to the specified reference gas compositions for biogas. The CO_2 / CH_4 volume ratio is of importance here.

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

Silicone 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.

Experience shows that damage of this kind occurs at silicon concentrations in excess of 5 mg / m_n^3 CH_4.

It is necessary to use an oxidation catalytic converter in order to ensure that the formaldehyde limit value of H_2CO <= 40 mg/ m_n^3, is not exceeded.

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

When the plant is operating with exhaust heat utilization (180°C) and the limit values for sulfur in the fuel have been exceeded, early cleaning of the exhaust gas heat exchanger is necessary.

Since in practice the sulfur content varies greatly, MTU cannot provide guarantees with regard to the cleaning intervals.

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

Fuels for gas engines of the biogas series

The gas engines of the biogas series are to be operated exclusively with gas approved for this model. The use of fuels in the entire area of application and operation of the engine is limited to purely gaseous fuels. Liquid fuels are not admissible nor are they provided for.

The gas used by the customer is to be checked prior to commissioning and at six-monthly intervals after commissioning. This ensures that the gas composition used by the customer corresponds to the approved gas specifications for biogas engines. If the gas specification is not adhered to due to changes in the composition of the gas, as well as changes of hazardous additives, appropriate shutdown measures are to be initiated. The effectiveness of this measure is to be verified by means of a renewed gas analysis.

Generally valid limits are listed in the Table under item main components.

INFORMATION		
i	The components / limit values listed apply to biogas engines. Other components / limit values are inadmissible.	SH-H-261

2.2.2 Main Components

Biogas, Sewage Gas

Components	Unit	Value range
CO	% by volume	n.a.
CO_2	% by volume	15 - 55
CH_4	% by volume	45 - 85
C_2H_6	% by volume	n.a.
C_3H_8	% by volume	n.a.
C_4H_{10}	% by volume	n.a.
N_2	% by volume	Rest
O_2	% by volume	Rest

2.2.3 Compositions of Bio/Sewage Gas

Components	Unit	Biogas systems	Sewer gas plant
CO	% by volume	0,0000	0,0000
CO_2	% by volume	55 - 15 (50*)	35 - 20 (35*)
CH_4	% by volume	45 - 85 (50*)	65 - 70 (65*)
C_2H_4	% by volume	0,0000	0,0000
C_2H_6	% by volume	0,0000	0,0000
C_3H_6	% by volume	0,0000	0,0000
C_3H_8	% by volume	0,0000	0,0000
C_4H_8	% by volume	0,0000	0,0000
C_4H_{10}	% by volume	0,0000	0,0000
C_5H_{12}	% by volume	0,0000	0,0000
C_XH_Y	% by volume	0,0000	0,0000
N_2	% by volume	5 - 10 (0*)	5 - 10 (0*)
O_2	% by volume	0 – 2,0 (0*)	0 – 0,6 (0*)
H_2	% by volume	0,0000	0,0000
H_2O	% by volume	**	*
H_2S	% by volume	</ = 66 (0*)	</ = 66 (0*)
SO_2	% by volume	0,0000	0,0000
AR	% by volume	0,0000	0,0000
Σ	% by volume	100,000	100,000
Ho	kWh/m^3_N	5,53	7,19
Hu	kWh/m^3_N	4,98	6,48
Density	kg/m^3_N	1,347	1,158
Rel. density	---	1,042	0,896
Ws, n	kWh/m^3_N	5,42	7,60
Methane number	MN (± 2)	>140	133,8

* Calculated values for gas properties, ** H_2O dew point 35°C

2.2.4 Requirements of Fuel Gas

Requirements and peripheral conditions for fuel gas and fuel supply

The following fuel values must be adhered to at the inlet into the gas control unit (supplied by MTU Onsite Energy):

Designation	Unit	Limit value	Remark
Gas type		Biogas	Biogenic gases from fermentation processes
Methane number MN		≥ 115	Dropping below this value there is the danger of knocking combustion, gas analysis and consultation with factors necessary
Calorific value Hu	kWh/m^3_N	4.5 < Hu < 8.0	For lower and higher values consult the factory
Fluctuations in calorific value to the setting value	%	± 20	For higher values consult the factory
Frequency of calorific value fluctuations	1/h	5	Related to a full hour
Admissible rate of change in calorific value	$kWh/m^3_N/h$	1,0	Constant linear change at otherwise constant operating factors such as gas pressure, gas temperature, engine load
Maximum rate of change in the calorific value to the setting value	% / min	10,0	Fast change in calorific value, e.g. during starts and start-up processes with a frequency of 1/h
Gas density	Kg/m^3_N	0,93 - 1,40	The density of the gas could fluctuate due to its composition. During changes of the main substrate and / or significant changes in the ratio of the mixture of the substrates, a gas analysis, and, if necessary, an adjustment of the mixture control is required.
Maximum gas pressure for gas control unit	mbar	250	Specification of the gas control unit relative to the project is to be observed.
Minimum gas flow pressure before the gas control unit (overpressure) V8 / V12	mbar	100	
Minimum gas flow pressure before the gas control unit (overpressure) V16 / V20	mbar	130	

Gas pressure fluctuations to the setting value	%	± 5	
Admissible rate of change in gas pressure entry	mbar/s	1	
Gas temperature	°C	0 < T < 50	Phase transitions in the fuel gas and air mixture are inadmissible during engine operation. Thermal aging of NBR materials (seals, diaphragms) and the effects of changes in elasticity at higher temperatures. Applies to the entry of gas at the metering valve (TecJet).
Admissible rate of change in gas temperature	K/min.	0,3	Applies to the entry of gas at the metering valve (TecJet)
Relative moisture in the gas at 35 °C and 1.013 bar	%	< 80	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
Gas cooling at least to dewpoint temperatures	°C	< 25	
Oil vapors (HC with carbon number > 5)	mg/m^3_N	< 0,4	No condensation in lines carrying fuel gas and fuel gas mixture, no formation of condensed oil vapors
HC solvent vapors	mg/m^3_N	0	
Organically bound silicon (e.g. silanes, siloxenes, silicones)	mg/m^3_N	< 10 *	
Inorganically bound silicon	mg/m^3_N	< 6 *	At Si > 5 mg/m^3_N relative to 100 % CH_4 fuel gas content, wearing products are to be taken note of in the oil analysis
Mercaptan sulfur	mg/m^3_N	10 *	
Total of all chlorine and fluorine compounds	mg/m^3_N	< / = 100 *	

* = These values are recommended values for engines of model BR4000L62FB.

The limit values refer to a calorific value of 10 kWh/m³$_N$. This corresponds to fuels with 100% volume of methane, or the existence of other combustible components in the fuel with the same energy equivalent and the same input of hazardous materials.

Example:

When using a gas with the example of northern Germany with Hu = 5.18 kWh/m³$_N$ the admissible maximum value for the total sulfur is calculated as:

admissible total sulfur content = 800 mg/m³$_N$ (5.18 kWh/m³$_N$: 10.0 kWh/m³$_N$) = 414.4 mg/m³$_N$

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.

Depending on the application, the following maximum permissible pollutant concentrations in the fuel are to be adhered to:

Oxidizing catalytic converter		Without	With	With
Exhaust heat utilization		180 °C / without	120 °C	180 °C
Total of all sulfur compounds (calculated as S) corresponds to	mg/ m_n^3 CH_4	800	20	200
Hydrogen sulfide (H_2S)	ppm at 50 % CH_4	280	7	70
Total of all chlorine compounds (calculated as Cl)	mg/ m_n^3 CH_4	100	0,5	0,5
Total of all fluorine compounds (calculated as F)	mg/ m_n^3 CH_4	50	0,5	0,5
Total of all silicone compounds (calculated as Si)	mg/ m_n^3 CH_4	5	0	0
Ammonia (NH_3)	ppm at 50 % CH_4	30	30	30
Heavy metals (Pb, Hg, As, Sb, Cd)	µg/ m_n^3 CH_4	-	10	10

⚠ CAUTION

Harmful substances / contamination in the fuel

Long-term damage due to corrosion

It must be ensured that no corrosive compounds (e.g. siloxane, phosphor, arsenic, heavy metal, sulfur, ammonia, chlorine, fluorine, bromine, iodine compounds) enter the fuel lines. Or their limit values must not be exceeded. Exceeding the limit values voids the warranty.

SH-V-104

3 Inlet Air and Combustion Air

⚠ CAUTION		
	**Harmful substances / contamination in the intake air** Long-term damage due to corrosion It must be ensured that no corrosive compounds (e.g. siloxane, phosphor, arsenic, heavy metal, sulfur, ammonia, chlorine, fluorine, bromine, iodine compounds) enter the intake air. Or their limit values must not be exceeded. Exceeding the limit values voids the warranty.	SH-V-102

When operating the plant in swimming pool facilities or in the vicinity of refrigerating installations, it is important to bear in mind that even small traces of halogen compounds (chlorine, fluorine) in the combustion air and in the intake air may cause corrosion in the engine and on peripheral components (e.g. on electric motors). It must likewise be noted that even cleaning agents may contain aggressive substances that encourage corrosion.
The entry to the motor in total (fuel and air) must not exceed the limit values specified under fuels.

NOTICE		
	In case of doubt, MTU Onsite Energy, Augsburg, is to be consulted.	SH-H-264

4 Coolant

⚠ CAUTION		
	**Liquids hazardous to the environment** Environmentally hazardous Avoid release into the environment. Do not dispose of into the sewerage system; dispose of correctly by observing the local regulations of the authorities. Adequate barriers are to be provided.	SH-V-101

4.1 Requirements for Engine Coolant Quality

INFORMATION		
	Requirements for the quality of heating water above 100 °C apply when an exhaust heat exchanger has be installed in the engine cooling circuit or the heating circuit.	SH-H244

For the engine coolant system, it is imperative to use filling and top-up water which complies with the following stipulations and which has been premixed with approved corrosion inhibitor/antifreeze in accordance with Chapter 4.6:

General requirements	**Clear, colorless and free from undissolved substances**	
pH-value (25 °C)	8,2 – 9,0	
Electric conductivity (25 °C)	< 300	mS/m
Sum total, alkaline earths	1,0 – 1,5 5,6 – 8,4	mmol/l °dH
Chlorides	< 80	mg/l
Sulfates	< 70	mg/l
Iron	< 0,2	mg/l

4.2 Requirements for the Quality of Mixture Coolant

For the engine coolant system, it is imperative to use filling and top-up water which complies with the following stipulations and which has been premixed with approved corrosion inhibitor/antifreeze in accordance with Chapter 4.6:

General requirements	**Clear, colorless and free from undissolved substances**	
pH-value (25 °C)	8,2 – 9,0	
Electric conductivity (25 °C)	< 300	mS/m
Sum total, alkaline earths	1,0 – 1,5 5,6 – 8,4	mmol/l °dH
Chlorides	< 100	mg/l
Sulfates	< 70	mg/l
Iron	< 0,2	mg/l

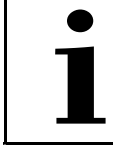
4.3 Requirements for the Quality of Water for the Gas Sequential Heater

INFORMATION		
	The requirements of the quality of the water for the gas sequential heater with temperatures up to 60 °C are to be observed.	SH-H-242

For the sequential heater system, it is imperative to use filling and top-up water which complies with the following stipulations and which has been premixed with approved corrosion inhibitor/antifreeze in accordance with Chapter 4.6:

General requirements	**Clear, colorless and free from undissolved substances**	
pH-value (25 °C)	8,2 – 9,0	
Electric conductivity (25 °C)	< 300	mS/m
Sum total, alkaline earths	1,0 – 1,5 5,6 – 8,4	mmol/l °dH
Chlorides	< 100	mg/l
Sulfates	< 70	mg/l
Iron	< 0,2	mg/l

4.4 Requirements for the Quality of Water for the Gas Cooler and Gas Sequential Heater

INFORMATION		
	The requirements for the quality of the water of the water source for gas coolers and gas sequential heaters with temperatures of up to 60 °C are to be observed.	SH-H-243

The operator must specially prepare and monitor the initial water and the filling and top-up water. As filling and top-up water, low-salt water or desalinated water (e.g. permeate) or perfect condensate is to be used.

The cold-water system and the reheater circuit may only be filled with the antifreeze Antifrogen N from the company Hoechst AG.

We recommend (bearing in mind the VdTÜV instructions TCh 1466) adherence to the following requirements for a low-salt operating mode:

General requirements	**Clear, colorless and free from undissolved substances**	
pH-value (25 °C)	9,0 – 10,5	
Electric conductivity (25 °C)	< 100	µS/cm
Oxygen	< 0,05	mg/l
Chlorides	< 20	mg/l
Sum total, alkaline earths	< 0,02 (< 0,1)	mmol/l °dH
Phosphate	5 – 10	mg/l

4.5 Treatment with Corrosion Inhibitor / Antifreeze

Add corrosion inhibitor/antifreeze to the water with a concentration of at least 35 % by volume when antifreeze protection to minus 21 °C is sufficient. If lower ambient temperatures are expected, increase the concentration accordingly, but do not under any circumstances increase to values in excess of 50 % by volume. 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.

Check the concentration at regular intervals in accordance with the maintenance schedule. Due to antifreeze aging, change the coolant after 10,000 operating hours or at the latest after 2 years.

4.6 Approved Corrosion Inhibitors and Antifreeze Agents

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

Corrosion inhibitor/antifreeze concentrate

Manufacturer	Brand name	Operating hours hour / year	Comments
Arteco	Freecor SPC (EU Code 503347)	9000 / 3	
Avia	Antifreeze APN	9000 / 5	
BASF	Glysantin G05 Glysantin Protect G05 Glysantin G48 Glysantin Protect Plus / G48 Glysantin G30 Glysantin Alu Protect / G30	9000 / 5 9000 / 5 9000 / 5 9000 / 5 9000 / 3 9000 / 3	
Bucher	Motorex Antifreeze G05 Motorex Antifreeze Protect G48 Motorex Antifreeze Protect Plus G30	9000 / 5 9000 / 5 9000 / 3	
CCI Corporation	L415	9000 / 3	
CCI Manufacturing IL Corporation	C521	9000 / 3	
Clariant	Genatin Super	9000 / 3	
Detroit Diesel	Power Cool Antifreeze Power Cool Off-Highway	9000 / 3 9000 / 5	
Deutsche BP	ARAL Antifreeze Extra Castrol Antifreeze NF	9000 / 5 9000 / 5	
Fuchs	Maintain Fricofin Maintain Fricofin G12 Plus	9000 / 5 9000 / 3	
Ginouves	York 716	9000 / 5	
Krafft	Refrigerante ACU 2300	9000 / 3	
Maziva	INA Antifritz AI Super	9000 / 5	
Mol-Lub	EVOX Extra G48 Antifreeze concentrate	9000 / 5	
Mobil	Mobil Antireeze Extra	9000 / 5	
MTU Detroit Diesel Australia	Power Cool - HB500	9000 / 3	
Nalco	Nalcool 5990	9000 / 3	
Nalco Australien	Nalcool NF 48	9000 / 5	
Old World	Fleetcharge SCA Precharged Heavy Dutoy Coolant / Antifreeze Final Charge Global Extended Life Coolant Antifreeze	9000 / 3 9000 / 3	
OMV	OMV Coolant Plus	9000 / 5	Angabe prüfen

	OMV Coolant SF	9000 / 3	
Ravensburger Schmier-stoffvertrieb GmbH	RAVENOL Kühlerfrostschutz silikatfrei	9000 / 3	
Recochem	R542	9000 / 3	
Shell	Glyco Shell Glyco Shell longlife Shell HD Premium	9000 / 5 9000 / 3 9000 / 3	
Sotragal - Mont Blanc	Antigel Power Cooling Concentrate	9000 / 5	
Total	Glacelf MDX	9000 / 5	
Valvoline	Zerex G-05 Zerex G-48 Zerex G-30	9000 / 5 9000 / 3 9000 / 3	

Corrosion inhibitor/antifreeze ready-mixed

Manufacturer	Brand name	Operating hours hour / year	Comments
Bantleon	Avilub Antifreeeze Mix (50 %)	9000 / 5	
BASF	Kühlstoff G05-23</50 (50 %)	9000 / 5	
Castrol Ltd.	Castrol Antifreeze Premix (45 %)	9000 / 5	
CCI Corporation	L415 (50 %)	9000 / 3	
CCI Manufacturing IL Corporation	C521 (50 %)	9000 / 3	
Detroit Diesel	Power Cool Plus Marine (30/70) Power Cool Off-Highway (50 %)	9000 / 5 9000 / 5	
MTU Detroit Diesel Australia	Power Cool - HB500 Premix 50/50	9000 / 3	
Sotragal - Monit Blanc	L.R.-30 Power Cooling (44 %) L.R.-38 Power Cooling (52 %)	9000 / 5 9000 / 5	
Old World	Final Charge Global 50/50 Predilluted Extended Life Coolant Antifreeze	9000 / 3	
Total	Coolelf MDX (40 %)	9000 / 5	
Valvoline	Zerex G-05 50/50 Mix	9000 / 5	

Corrosion inhibitor/antifreeze concentrate for special applications

Manufacturer	Brand name	Operating hours hour / year	Comments
BASF	G206	9000 / 3	Für Einsätze in arktischen Regionen (> -40 °C)

Water-soluble corrosion inhibitor concentrate

Manufacturer	Brand name	Operating hours hour / year	Comments
Arteco	Freeco NBI	6000 / 2	
BASF	Glysacorr G93-94	6000 / 2	
CCI Corporation	A216	6000 / 2	
CCI Manufacturing IL Corporation	A216	6000 / 2	
Chevron	Texcool A - 200	6000 / 2	
Detroit Diesel	Power Cool Plus 6000	6000 / 2	
Ginouves	York 719	6000 / 2	
Old World	A216	6000 / 2	
Valvoline	Zerex G-93	6000 / 2	

Additional concentrations of water-soluble corrosion inhibitors

Manufacturer	Min. % by volume	Max. % by volume
• Arteco Freecor NBI • BASF Glysacorr G93 - 94 • CCI Manufacturing IL Corp. A216 • Chevron Texcool A-200 • Detroit Diesel Power Cool Plus 6000 • Ginouves Youk 719 • Valvoline Zerex G-93	9	11
• Detroit Diesel Power Cool Plus 2000 • Nalco Alfloc 2000 • Nalco Nalco 2000 • Nalco Nalcool 2000 • Pentray Pencool 2000	3	4
• Arteco Havoline Extended Life Corrosion Inhibitor XLI (EU 032765) • Chevron Texaco Extended Life Corrosion Inhibitor Nitrite Free (US 236514) • Nalco Alfloc (Maxitreat) 3477 • Total WT Supra	7	11
• Fleetguard DCA-4L	5	6

5 Heating Water

⚠ CAUTION		
	**Inadequate preparation / ventilation of water circuits** Long-term damage to water conveying components It must be ensured that the specifications of MTU Onsite Energy for the preparation / ventilation of the water are observed. Failure to observe these voids the warranty.	SH-V-108

5.1 Heating Water Quality Requirements up to 100 °C

INFORMATION		
	Requirements for the quality of heating water above 100 °C apply when an exhaust heat exchanger has be installed in the engine cooling circuit or the heating circuit.	SH-H244

Filling and top-up water, permissible supply temperatures 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)	8,2 – 9,0	
Electric conductivity (25 °C)	10 – < 500	µS/cm
Sum total, alkaline earths	1,0 – 1,5 5,6 – 8,4	mmol/l °dH
Chlorides	< 80	mg/l
Sulfates	< 70	mg/l
Oxygen content when using oxygen binding agents	< 0,1	mg/l
Iron	< 0,2	mg/l
If the above limit values are not adhered to, it will be necessary to introduce measures against scale formation, either through water treatment (softening, demineralization, reverse osmosis) or hardness stabilization (ST-DOS-H products), and against corrosion processes through inhibiting or oxygen binding (ST-DOS-H products).		

5.2 Heating Water Quality Requirements above 100 °C

INFORMATION		
	Requirements for the quality of heating water above 100 °C apply when an exhaust heat exchanger has be installed in the engine cooling circuit or the heating circuit.	SH-H244

Filling and top-up water, admissible supply temperatures above 100 °C and for large heating systems or long-distance heating systems.

The base alkalization must occur with trisodium phosphate.

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)	8,2 – 9,0	
Electric conductivity (25 °C)	10 – < 250	µS/cm
Sum total, alkaline earths	< 0,02 < 0,10	mmol/l °dH
Chlorides	< 20	mg/l
Sulfates	< 5 – 10	mg/l
Oxygen content	< 0,05	mg/l
Phosphate	5 – 10	mg/l
Iron	< 0,2	mg/l
Measures against scale formation are necessary, either through water treatment (softening, demineralization, reverse osmosis) or hardness stabilization (ST-DOS-H products), and against corrosion processes through inhibiting or oxygen binding (ST-DOS-H products).		

5.3 Additional Information

It is pointed out as a precaution that generally costs for foreseeable damage, e.g. through unsuitable water quality, are not absorbed by machine breakdown insurance.

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.

6 Lubricating Oil

INFORMATION		
	The changeover to a different lube oil is only permitted after consultation with the MTU Onsite Energy "After-sales" service center.	SH-H-019

6.1 General

INFORMATION		
	**When using biogas, sewer gas or landfill gas** The quantity of oil in the engine oil sump is not adequate here. A larger quantity of oil is required!	SH-H-047

6.1.1 Operation with Natural Gas

When operating with natural gas (without corrosive contaminants), the gas engine can be operated with synthetic or mineral lube oil.

The use of mineral lube oil is recommended for plants in which there is a risk of the engine drawing in pollutants with the intake air, e.g. air containing chlorine in swimming pools, refrigerants from neighboring plants, solvents.

6.1.2 Operation with Biogas

When operating biogas (with corrosive contaminants), the lube oil is subjected to 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 in the lube oil. Corrosion damage to the oil-lubricated engine components can only be avoided by more frequent oil changes. The greater aging stability of synthetic lube oils can therefore not be exploited. For this reason, the use of synthetic lube oils is not economical.

To be able to buffer concentration peaks better when lube oil is subjected to corrosive contaminants, an increased lube oil volume of at least 200 l is prescribed.

In the event of low pollutant contamination, it is possible to extend the oil change intervals after consultation with the Service Center of MTU Onsite Energy.

6.2 Approved Lube Oils

Manufacturer / Supplier	Designation			
BP Energas	Energas NGL	SAE 40 [1)]	M	E
ChevronTexaco	Geotex LA 40	SAE 40 [1)]	M	E
ExxonMobil	Pegasus 705	SAE 40 [1)]	M	E
ExxonMobil	Pegasus 805	SAE 40 [1)]	M	E
Fuchs Europe Schmierstoffe GmbH	Titan Ganymet LA	SAE 40 [1)]	M	E
Shell Global Solutions	Mysella LA 40	SAE 40 [1)]	M	E
SRS Schmierstoff Vertrieb GmbH	SRS Mihagrun LA40	SAE 40 [1)]		
Total	Nateria MH 40	SAE 40 [1)]	S	E

Manufacturer / Supplier	Base number in mgKOH/g			Designation			
	4 - 7	8 - 10	> 12				
Addinol *	6,5			MG 40 Extra LA	SAE 40 [1)]	M	B
Addinol		9,8		MG 40 ExtraPlus	SAE 40 [1)]		B
Total *	4,6			Nateria MP 40	SAE 40 [1)]		B
Total		8,8		Nateria MJ 40	SAE 40 [1)]		B

* Low Ash Performance

[1)] Approval limited to engine ambient temperature > + 10 °C
S = Synthetic lube oil
M = Mineral lube oil
E = Natural gas
P = Propane
B = Biogas

INFORMATION

The use of multi-purpose oils is not admissible.

SH-H-262

6.3 Lube Oil Intervals

6.3.1 Natural Gas

Oil operating periods for gas engines

The operating period for the oil depends on the quality of the engine oil, its maintenance as well as the operating conditions and the fuel used.

The fluctuating qualities of the gas make oil analyses at regular interval necessary. At the start of the life cycle of the product oil samples must be taken and tested every 500 operating hours.

At a consistent quality of the gas an oil change interval of a maximum of 1,500 operating hours is recommended.

In individual cases the oil change interval can also be optimized:

- Here oil samples are analyzed after every 200 - 250 operating hours.
- The oil samples are always to be taken under the same conditions and at the point provided.

Used oil analysis

The test methods and limit values listed in the Table (analytical limit values for gas engine oils) show when the result of a single analysis of an oil sample is to be considered as being 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).

Analytical limit values for used gas engine oils SAE 40

	Testing method	**Limit values**
Viscosity at 100°C (mm²/s)	ASTM D 445 DIN 51562	max. 17.5 min. 11.5
Total base number (mgKOH/g)	ASTM D 2896 ISO 3771	min. 3
Acid value (mgKOH/g)	ASTM D664	New oil value + 2.5
pH-value		min. 4.5
Water (% by volume)	ASTM D 6304 EN 12937 ISO 6296	max. 0.2
Oxidation (A/cm)	DIN 51453	max. 20
Nitration (A/cm)	IR process	max. 20
Wear elements (mg/kg) Iron (Fe) Lead (Pb) Aluminum (Al) Copper (Cu) Tin (Sn) Silicone (Si)	RFA, ICP	 max. 30 max. 20 max. 10 max. 20 max. 5 max. 15

6.3.2 Biogas

Oil operating periods for gas engines

The operating period for the oil depends on the quality of the engine oil, its maintenance as well as the operating conditions and the fuel used.

The fluctuating qualities of the gas make oil analyses at regular interval necessary. At the start of the life cycle of the product oil samples must be taken and tested every 500 operating hours.

At a consistent quality of the gas an oil change interval of a maximum of 1,500 operating hours is recommended.

In individual cases the oil change interval can also be optimized:

- Here oil samples are analyzed after every 200 - 250 operating hours.
- The oil samples are always to be taken under the same conditions and at the point provided.

Oil operating period for gas engines of model BR4000L62FB

The operating period for the oil depends on the quality of the engine oil, its maintenance as well as the operating conditions and the fuel used.

Due to the fluctuations in gas qualities and the resultant wide variation of engine-related additives the oil samples are to be taken and analyzed at fixed intervals of 250 operating hours.

Fixed oil change intervals without oil analysis are inadmissible.

Used oil analysis

The oil samples are always to be taken under the same conditions and at the point provided.

The test methods and limit values listed in the Table (analytical limit values for gas engine oils) show when the result of a single analysis of an oil sample is to be considered as being 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 the individual oil samples. When these limit values have been reached or exceeded an immediate oil change is indicated. 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 also the condition, operating condition and possible malfunctions of the engine and the periphery of the system are of equal importance.

Analytical limit values for gas engine oils (biogas application)

	Testing method	**Limit values**
Viscosity at 100°C	ASTM D 445 DIN 51562	(New oil value + 20%) max. mm²/s 18.0 min. mm²/s 11.5
Total base number (mgKOH/g)	ASTM D 2896 ISO 3771	min. 3 (BN > AN)
Acid value AN (mgKOH/g)	ASTM D664	New oil value + 2.5
Strong acids SAN (mgKOH/g)		< 0,00
pH-value		min. 4.0
Water	ASTM D 6304 EN 12937 ISO 6296	max. 0.2% by volume
Oxidation at 5.8 µm	DIN 51453	max. 20 A/cm
Nitration at 6.1 µm	IR	max. 20 A/cm
Wear elements (mg/kg) Iron (Fe) Lead (Pb) Aluminum (Al) Copper (Cu) Tin (Sn) Silicone (Si) Chromium (Cr) Nickel (Ni)	RFA, ICP	 max. 30 max. 20 max. 10 max. 20 max. 5 max. 15 max. 10 max. 8

6.3.3 Mineral Oil

Designation	Lube oil system with oil spray and additional volume	
Gensets with engine model	Oil change after operating hours	Min. quantity of the additional volume
8V4000L62	Approx. 3300	1,000 l
8V4000L62FB	Data not yet available	Data not yet available
8V4000L63	Approx. 3300	1,000 l
12V4000L62	Approx. 2200	1,000 l
12V4000L62FB	Data not yet available	Data not yet available
12V4000L63	Approx. 2200	1,000 l
16V4000L62	Approx. 3600	2,000 l
16V4000L62FB	Data not yet available	Data not yet available
16V4000L63	Approx. 3600	2,000 l
20V4000L62	Approx. 2700	2,000 l
20V4000L62FB	Data not yet available	Data not yet available
20V4000L63	Approx. 2700	2,000 l

Designation	Lube oil system only with fresh oil replenishment (without oil spray)	
Gensets with engine model	Oil change after operating hours	Recommended size Fresh oil tank
8V4000L62	Approx. 1300	1,000 l
8V4000L62FB	Data not yet available	Data not yet available
8V4000L63	Approx. 1300	1,000 l
12V4000L62	Approx. 1300	1,000 l
12V4000L62FB	Data not yet available	Data not yet available
12V4000L63	Approx. 1300	1,000 l
16V4000L62	Approx. 1300	1,500 l
16V4000L62FB	Data not yet available	Data not yet available
16V4000L63	Approx. 1300	1,500 l
20V4000L62	Approx. 1300	1,500 l
20V4000L62FB	Data not yet available	Data not yet available
20V4000L63	Approx. 1300	1,500 l

6.3.4 Synthetic Oil

INFORMATION		
	The use of synthetic oil is not economical.	SH-H-257

What basically applies to all plants is that oil change intervals (apart from oil quality parameters, operating conditions, fuel, etc., as previously stated in the stipulations) depends on the consumption of oil.

Regular oil analyses are also required in these cases.

7 Exhaust Condensate

⚠ DANGER		
	**Liquids hazardous to the environment** Environmentally hazardous Avoid release into the environment. Do not dispose of into the sewerage system; dispose of correctly by observing the local regulations of the authorities. Adequate barriers are to be provided.	SH-G-120

When fuel is burned in the engine, nitrogen oxides NO_x 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 = 2 ... 4.

Condensate starts to form, depending on the acid-forming constituent, at exhaust temperatures below approx. 160 °C.

Theoretically, 1.5 kg condensate can be created from 1 m_n^3 natural gas.

In the case of modules with exhaust cooling in a heat exchanger, at exhaust temperatures not below 110°C, with properly insulated exhaust lines and with a normal number of start/stop procedures (ratio of operating hours to starts at least 2: 1), the accumulation of condensate in the heat exchanger and in the downstream silencer is reduced to a few kilograms per day.

A free discharge via a siphon at a height of approx. 300 mm[1] must be provided for the condensate to prevent exhaust gas from escaping 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.

Exhaust condensate may only be discharged into the sewerage 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.

[1)] At least 50 mm above the corresponding max. exhaust backpressure according to the module.

8 Confirmation for Fluids and Lubricants Specification

NOTICE		
	The plant must not be commissioned without this confirmation.	SH-H-035

Plant reference:

Plant consists of:

Factory / SAP no.:

Customer:

Operator:

MTU Project Manager:

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

MTU Onsite Energy shall not furnish warranty for damage incurred as a result of deviating fluid and lubricant quality.

Place

Date

Legally binding signature (customer)

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