Technical Instructions

TYPE 3 ENGINE

07-07-2011

Document Number **Description of Document** **Page Number**

Jenbacher Approved
Coolant Information

Ethylene Glycol

Chevron Dex-Cool - Extended Life Anti-Freeze Coolant
Product Number 221647
Prediluted 50/50

Propylene Glycol

Chevron Delo - Extended Life Coolant / Anti-Freeze PG
Product Number CPS-275109
Prediluted 50/50

Technical Instruction: TA 1000-0041
Requirements on the installation surface for GE Jenbacher plant

The target recipients of this document are:

Customer, Service Partner, Commissioning Partner, Subsidiaries/Branches, Location Jenbach

1 Purpose

This Technical Instruction describes the requirements for the arrangement surface of GE Jenbacher plants in terms of flatness, dimensions and load-bearing capacity

2 General

The particular advantages of our basic engine conception are the high speed and the special balance of the moved masses. Based on these characteristics, the requirements in terms of the static and dynamic load-bearing capacity of the arrangement surface are minimal.

However, because of the specially designed frame construction of our elastic module bearings (engine and generator), very strict requirements have been laid down in terms of the flatness of the arrangement surface.

3 Installation surface

3.1 Load-bearing capacity of the installation surface

The installation surface must be capable of withstanding the static and dynamic loads of GE Jenbacher plants.

Static load = Plant weight
Dynamic load = ≤ 3% of plant weight

3.2 Size of the installation surface

The arrangement surface can be either a pedestal, a paved surface or the engine-room floor.

3.2.1 Modules

The standard size of the installation surface is (frame length +200 mm [7,874 in]) x (frame width +200 mm [7,874 in]).

If an oil collection tray is used as an option, make sure that the dimensions of the installation surface at least match those of the oil collection tray.

3.2.2 Container trailer

The standard size of the installation surface is (trailer length +200 mm) x (trailer width +200 mm).

3.2.3 Container

The container installation surface can be either a strip or a slab foundation.

The surface dimensions are contained in the foundation plan or the a base-frame drawing.

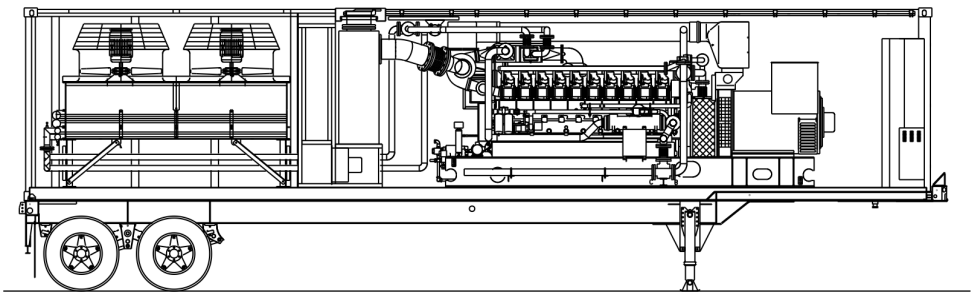
3.3 Flatness requirements for the installation surface:

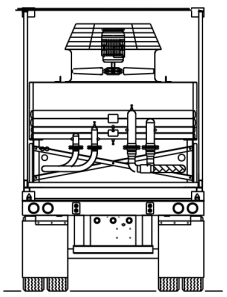
3.3.1 Modules

Contrary to the standards formulated and valid at this time, it has been agreed that the flatness requirement for the installation surface of the installation will be increased to ± 1.5 mm measured across the entire arrangement surface.

3.3.2 Container trailer

The trailer is installed horizontally (check using a spirit level). Use shims if necessary.





3.3.3 Container

The containers are normally supplied with support plates to enable the container to be installed horizontally.

3.3.4 If the contractor intends to use a grouting compound to meet the flatness criteria, the following minimum requirements should be met

1. Minimum amount of swelling 0.1%
2. Volume stability
3. Resistance to pressure

Pressure resistance must be at least 25 N/mm² after 24 hours. After 56 and 90 days respectively, there should be no noticeable reduction in the resistance to pressure.

Any remaining unevenness can be compensated by inserting plates between the module arrangement surface and the Sylomer strips.

The shim plate thickness must correspond to the deviation (between the plant arrangement surface and the sylomer strips) plus ~ 2 mm.

3.4 Surface treatment of the installation surface

It is advisable to make the arrangement surface oil- and water-resistant by applying a protective coating.

Many grout products are already water- and oil-resistant, in which case a protective coating is not required.

4 Revision code

Revision history

Index	Date	Description/Revision summary	Creator *Auditor*
1	26.05.2010	Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **f**	**Provin** *Giese*
2	15.10.2010	Pos.3.3.4 / Point 3.3.4	**Bilek** *Widner Martin / Maderböck / Messner Erich*

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Applies to GE Jenbacher modules with unsplit module frame (except for type 4 engine)

1000-0041
1000-0044

⚠ Please observe the safety and hazard signs in the safety instructions (TI 2300-0005) and wear the appropriate “personal protective equipment”.

1. Purpose:

This Technical Instruction describes how to lift, transport on appropriate transport vehicles and bring GE Jenbacher modules into engine rooms and how to use and maintain the load suspension device (hoisting gear, chains, cables, etc.).
(Not applicable to modules with split module frames and type 4 modules)

⚠ As the module’s centre of gravity is very high and cannot be determined, only the methods used in this TI must be applied.

2. Lifting:

⚠ Always check whether the load suspension device is in a ready-for-use condition (see 'Guidelines for use') prior to using it.

2.1 Load suspension device:

Normal operating conditions
This load suspension device is meant to lift GE Jenbacher modules in accordance with the relevant European and national standards, subject to the restrictions listed below.

Guidelines for use
Make sure that this load suspension device is only used by a trained hanger-on. When using the load suspension device always make sure that

- the device is not damaged to such an extent that its safety and functionality are affected (e. g.: fractures, notches, cracks, wear, deformation, damage due to heat, etc.),
- there are no knots or distortions,
- the device is not run across sharp edges without taking the necessary precautions,
- the device is not overloaded due to jolting,
- the device is not required to lift loads in excess of its lifting capacity as mentioned on the plate (lifting capacity plate, rating plate, label),
- the device is not non-symmetrically loaded without your taking the necessary precautions,
- the device is applied and loaded appropriately when using shortening devices.

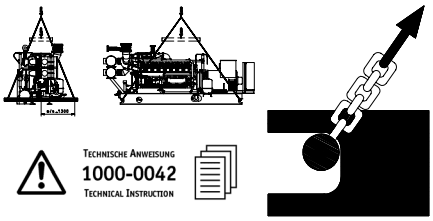
Disregarding the above instructions and improper use of the device can result in bodily injury and damage to property.

Maintenance
Make sure that this load suspension device is checked by an expert at least once a year for external damage, distortions, wear and corrosion, cracks and breaks. Reject the device if the defects found are intolerable. Do not make any modifications to the load suspension device which will affect the function and lifting capacity of the device.

Limitations to the use of the load suspension device
In case of high temperatures, the lifting capacity of the load suspension device must be reduced accordingly. Always check whether the load suspension device can be used in aggressive environments prior to actually using it.
Never use the load suspension device in circumstances in which the load can accidentally become unstrapped.

2.1.1 Transport bars:

The transport bars must be applied at the points on the unit frame provided for this purpose and expressly marked by adhesive labels (figure).



Eyebolts on engine and generator must never be used for lifting the unit.
These eyebolts must only be used for moving the components (engine or generator).

Transport bars for modules WITHOUT waste-heat boiler:

Type	Diameter range	Length (L)	Material / thickness
208 - 320	∅ 95 mm	2,270 mm	42 CrMo4V
612/616 (unsplit module frame)	∅ 120 mm	2,400 mm	42 CrMo4V

Transport bars for modules WITH waste-heat boiler:

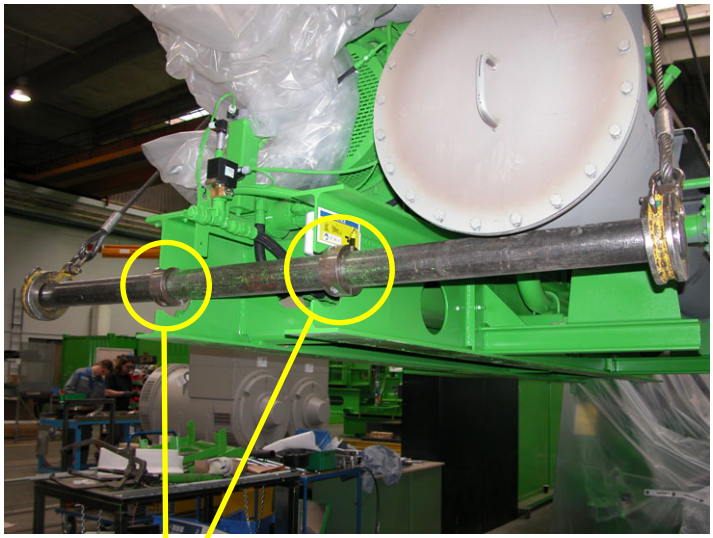
Type	Diameter range	Length (L)	Material / thickness
208 - 320	∅ 95 mm	2,400 mm	42 CrMo4V
612/616 (unsplit module frame)	∅ 120 mm	2,400 mm	42 CrMo4V

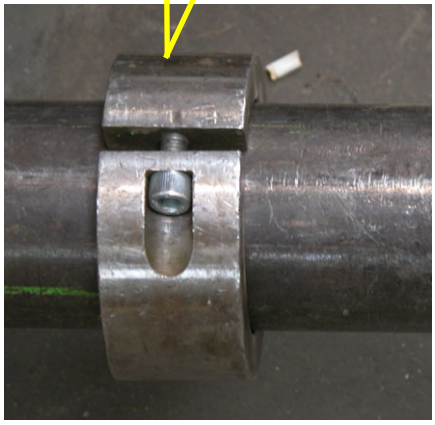
2.1.2 Lifting gear:

The lifting gear must consist of four individual lengths of cable or chain in order to ensure that the unit can be moved horizontally in a stable manner.

The ends of the cable or chain lengths must either be hooked into a crane hook or a cross beam.
The other ends are attached to the transport bars. This attachment must be safely maintained even when subjected to unexpected force application.
For this reason the cable or chain lengths must only be attached to the transport bars by means of clamping shoes (lifting clamps) or textile loops. When using textile loops, make sure to use clamping rings to prevent the loops slipping sideways. The lifting bars must also be secured against slipping sideways using clamping rings.

Clamping shoe

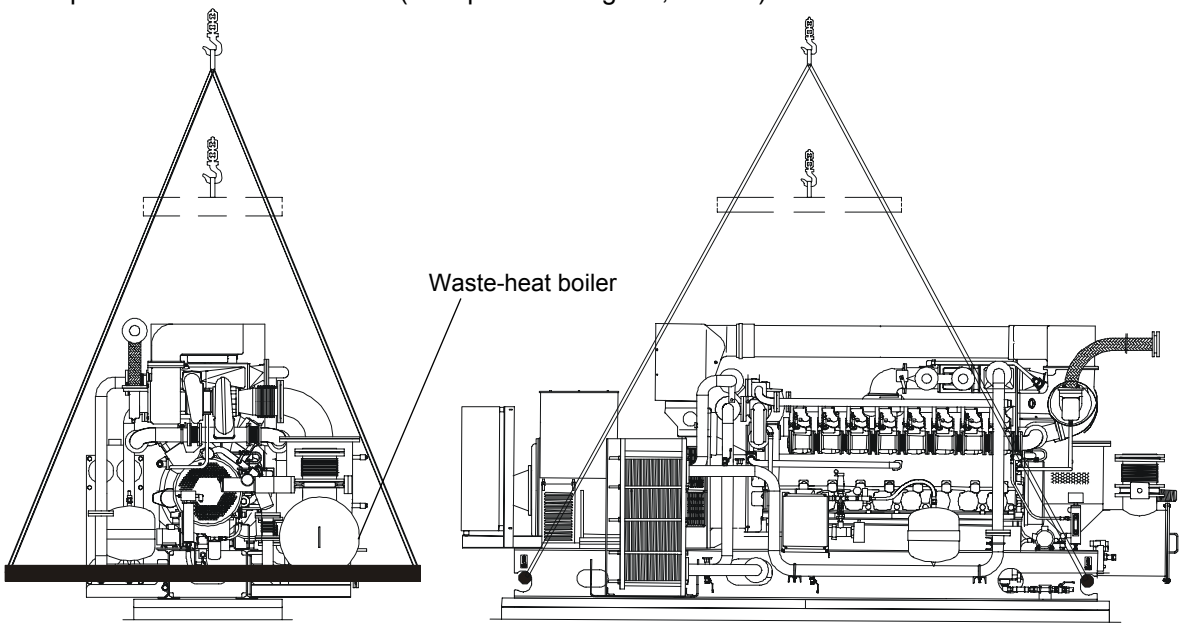




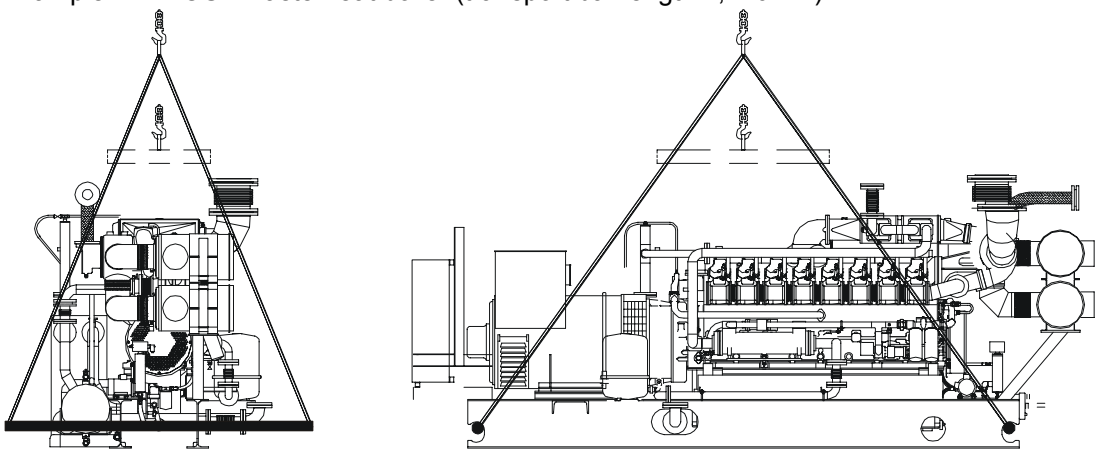
Clamping ring

⚠ The cable or chain lengths must never contact the unit.

Example WITH waste-heat boiler (transport bar length 2,400mm):



Example WITHOUT waste-heat boiler (transport bar length 2,270mm):



3. Transport on transport vehicles:

3.1 General tips:

When planning the module transport, and especially when installing the module on site, make sure to include both length and weight of the transport bars and the mass and dimensions of the module. In the case of transport bars with a length of 2,400 mm, the transport vehicle can normally only be unloaded from the back!

Transport safety devices must be installed according to TI 1000-0044.
This applies to the lifting, transporting on transport vehicles and positioning in engine rooms.

When transporting on transport vehicles it must be ensured that a suitable backing consisting of timber, rubber or similar is used between unit frame and platform.

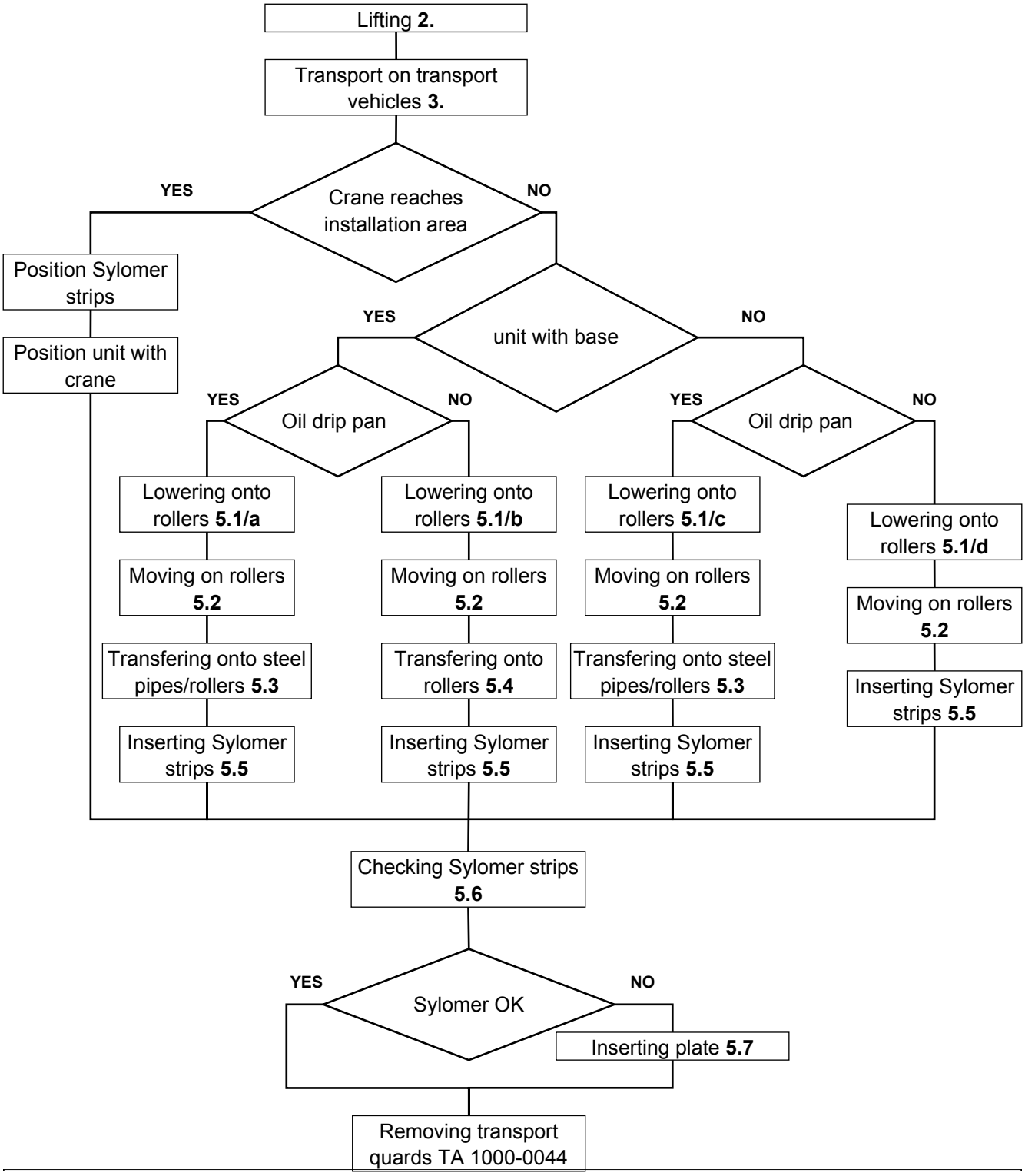
Risk of skidding and tipping must be excluded by the proper attachment of strapping.

3.2 Rail transport:

If possible, railway trucks must not be used for transport purposes as rail transport often involves frequent and hard bumping. Bumping can result in damage to the generator's roller bearings, also called false brinelling. There is also the risk during shunting of railway trucks being pushed away, possibly damaging the engine sliding bearings, and especially the main bearings. Cold welding has been known to be caused by railway trucks being pushed away resulting in very high axial accelerations.

If, due to local conditions rail transport cannot be avoided, silomer strips or other damping elements must be placed under the module frame (this does not apply to container versions as these are automatically provided with damping elements). The shipping company must also guarantee that the railway truck carrying the engine/module will NOT be pushed away during shunting.

4. Positioning in the engine room:



5. Unit installation is not directly possible by crane:

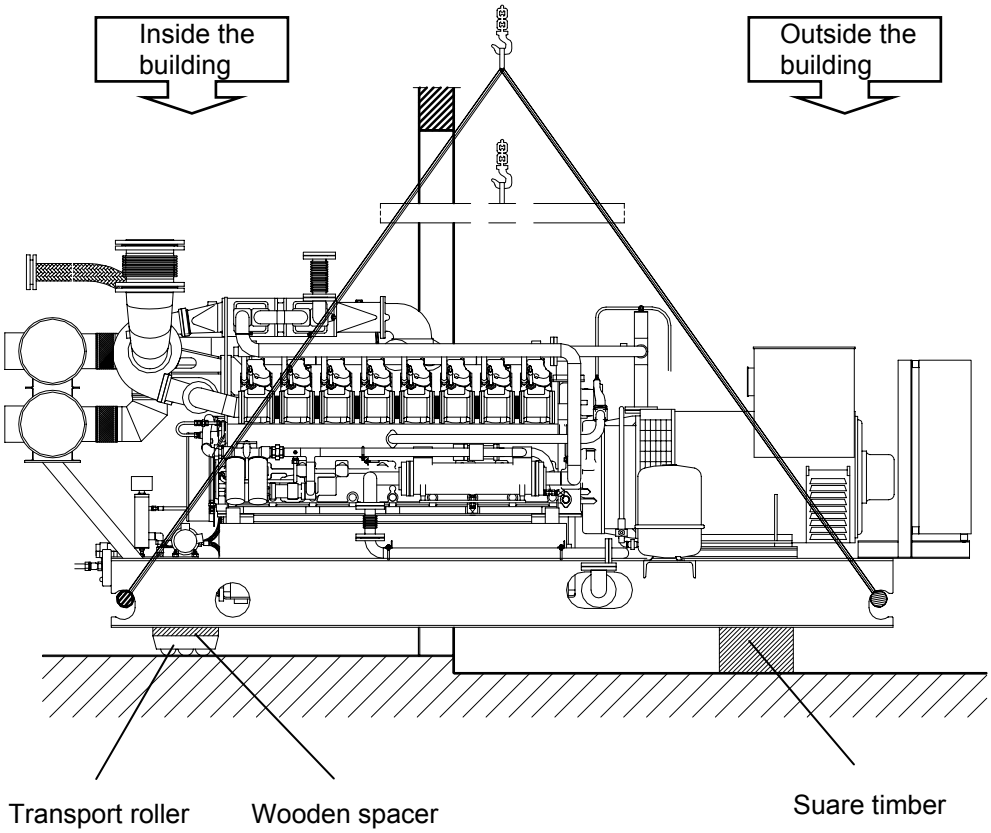
5.1 Lowering onto rollers:

Position transport rollers at the distance of the frame I-sections and position spacing timber onto the transport rollers if required.

5.1/**a** Height of spacing timber h = base height + height of oil collection tray
5.1/**b** Height of spacing timber h = base height
5.1/**c** Height of spacing timber h = height of oil collection tray
5.1/**d** No spacing timber is necessary! (Frame can be directly lowered onto the transport rollers.)

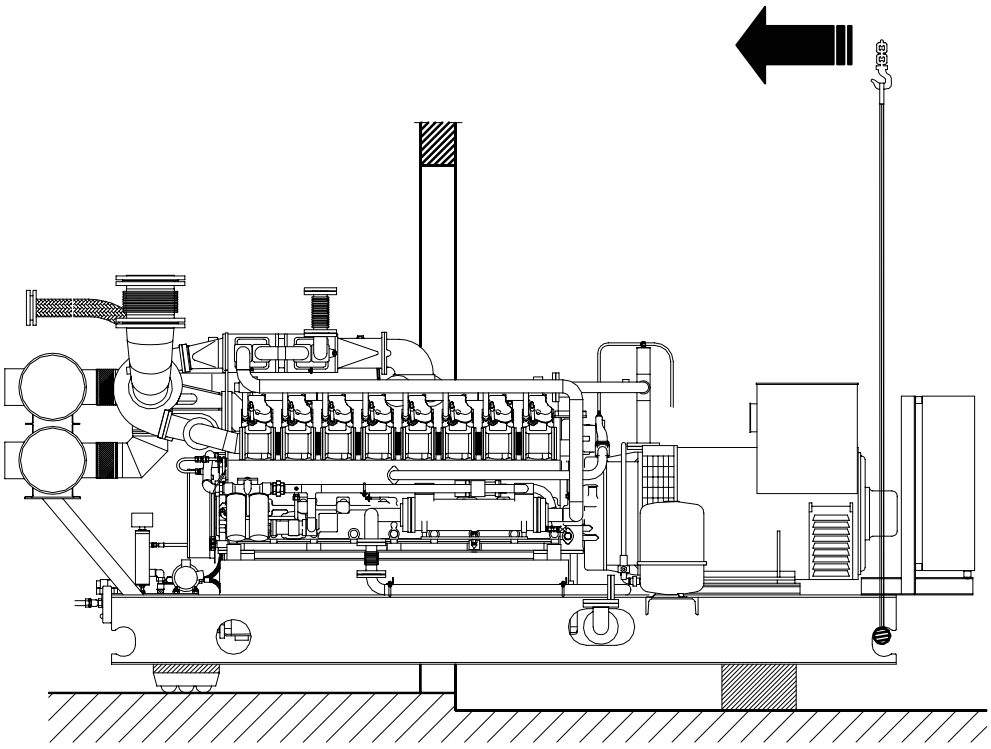
Lift unit with crane into the building as far as possible.

Lower frame side member onto transport rollers (in building) with spacing timber in position.

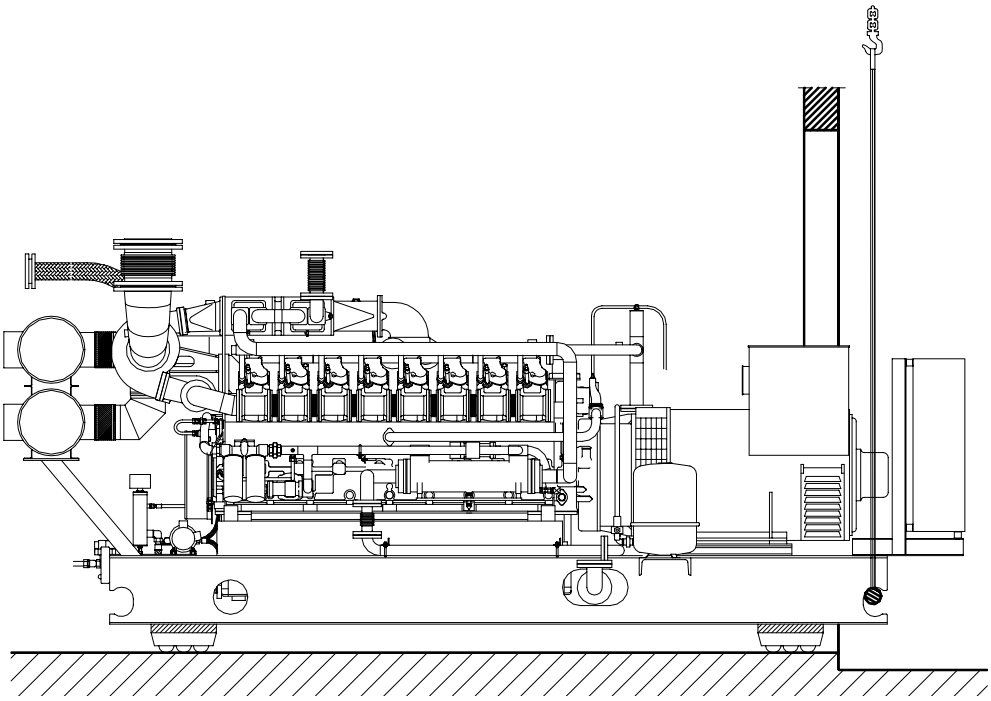


Lift transport bar (in the building) from the frame support recess.

Lift transport bar (outside) with crane and push unit into the building as far as possible.



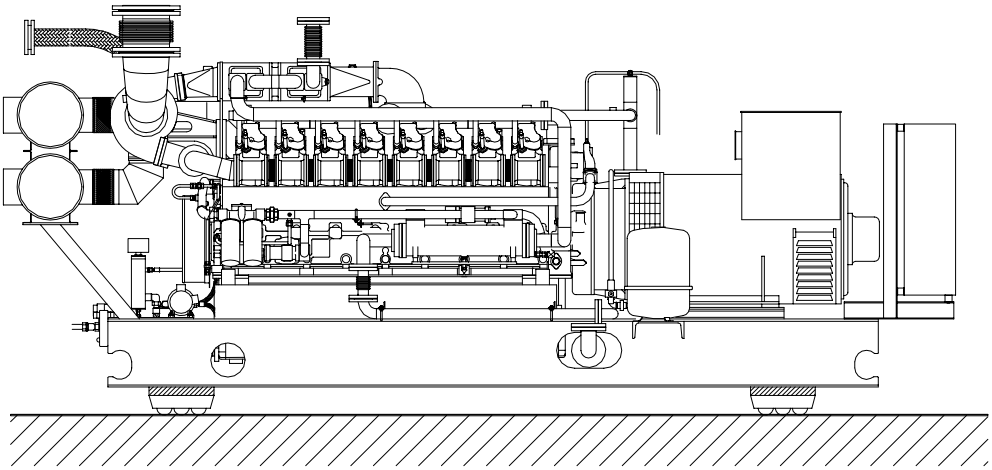
Position second transport roller pair with spacing timber. Lower unit onto second transport roller pair and lift transport bar from frame support recess.



The unit should now be positioned almost horizontally on the transport rollers.

5.2 Moving on rollers:

There are various options for moving the unit by means of transport rollers.



5.2.1 Pulling with a forklift or a cable winch:

Attach a chain, bar or cable to the unit frame cross member with a textile loop.

5.2.2 Pushing with a forklift or manpower:

For moving the unit with a forklift a square piece of timber must be fitted into the transport bar support recess. The unit can now be moved by positioning the forklift forks against this square timber.

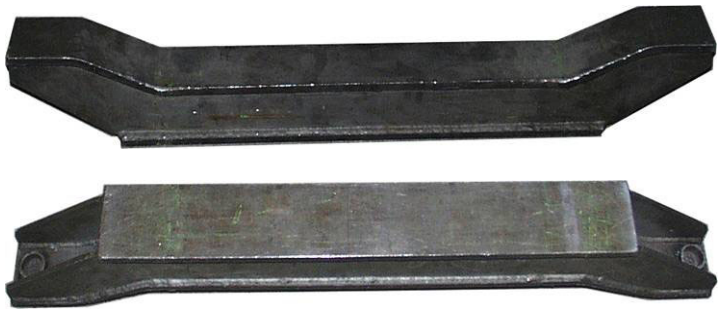
Experience has shown that even three to four strong persons will be able to move a unit. However, the following must be observed in order to prevent damage. The prerequisite for this is a level footing. Otherwise, the footing must be made level using sheet steel.

⚠ Under no circumstances must force be applied to unit components such as module interfaces, ignition box, etc.

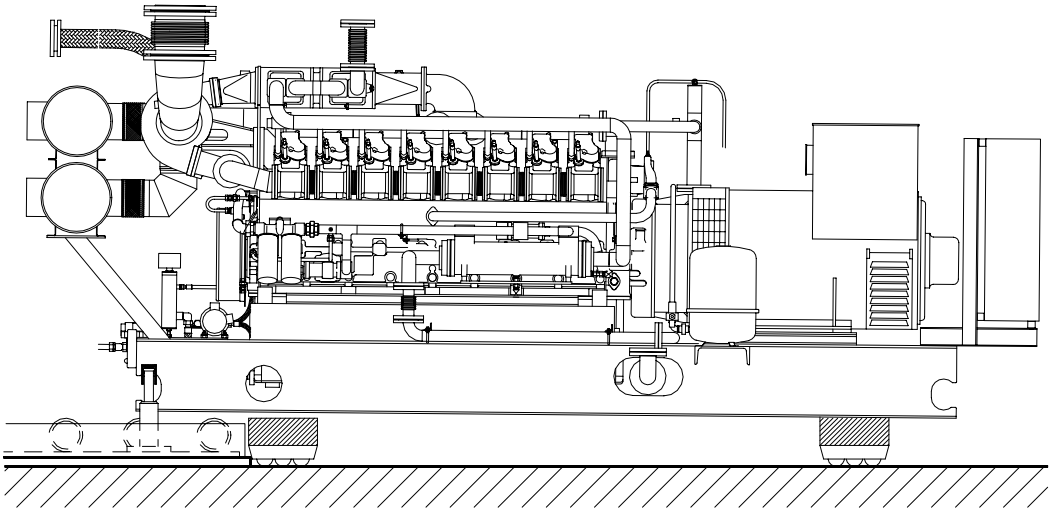
5.3 Transferring onto steel rollers/pipes:

In this case steel pipes/rollers must be used which are not wider than the oil collection tray and protrude over the upper edge so that the unit frame need only be lifted very little.
Move the unit directly to the oil collection tray.
Insert a cross beam with two hydraulic jacks into the transport bar support recess and lift the unit frame.

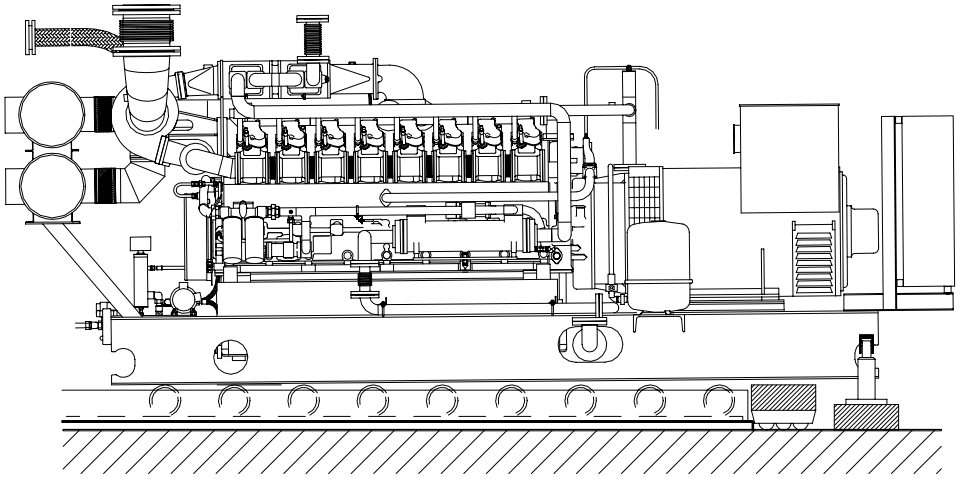
Crosshead:	
Part number	296408
Drawing number	JW 5364 100 00



Roll suitable steel pipes/rollers in the oil collection tray under the frame and remove the front transport roller pair.
Lower the unit onto the steel pipes/rollers.

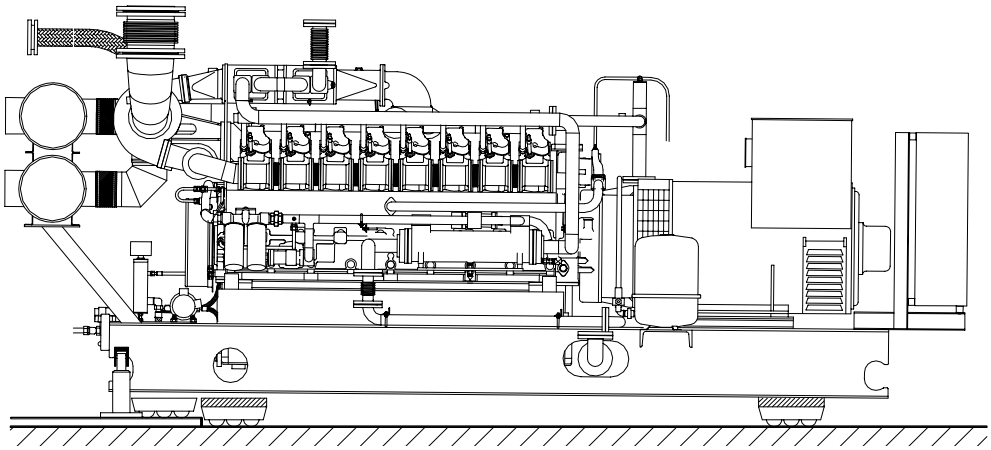


Transfer of the second transport roller pair is done in like manner.

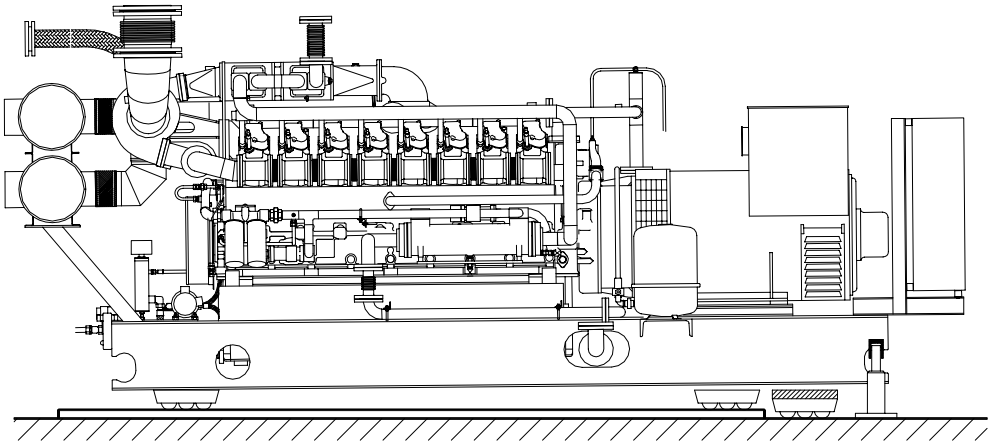


5.4 Transferring onto rollers:

Move the unit directly to the base.
Insert a cross beam with two hydraulic jacks in the transport bar support recess and lift the transport frame.
Remove spacing timber, lift transport roller onto the base and lower unit frame onto the base.



Transfer of the second transport roller pair takes place in like manner.

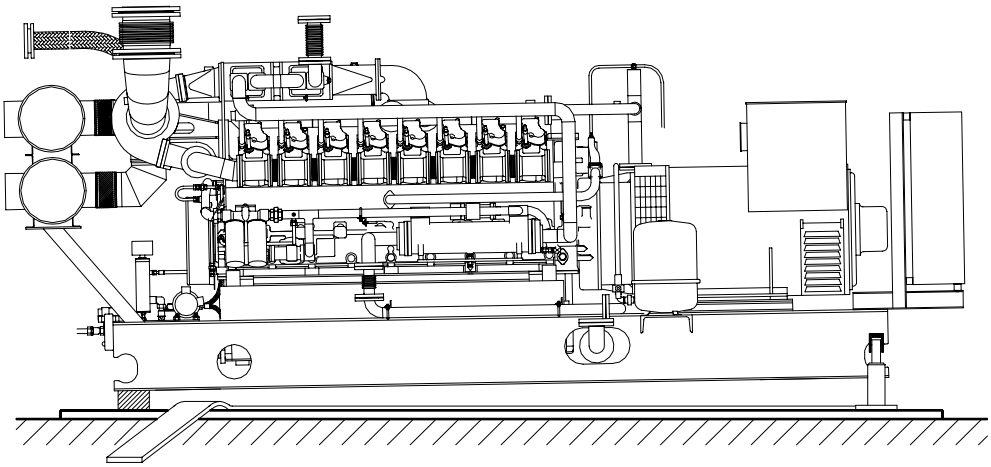


5.5 Inserting Sylomer strips:

Position a square timber under one end of the frame. Insert a cross beam with two hydraulic jacks in the transport bar support recess on the other end and lift the unit frame.

⚠ For reasons of safety, place the unit chassis on squared timber to prevent it from sinking.

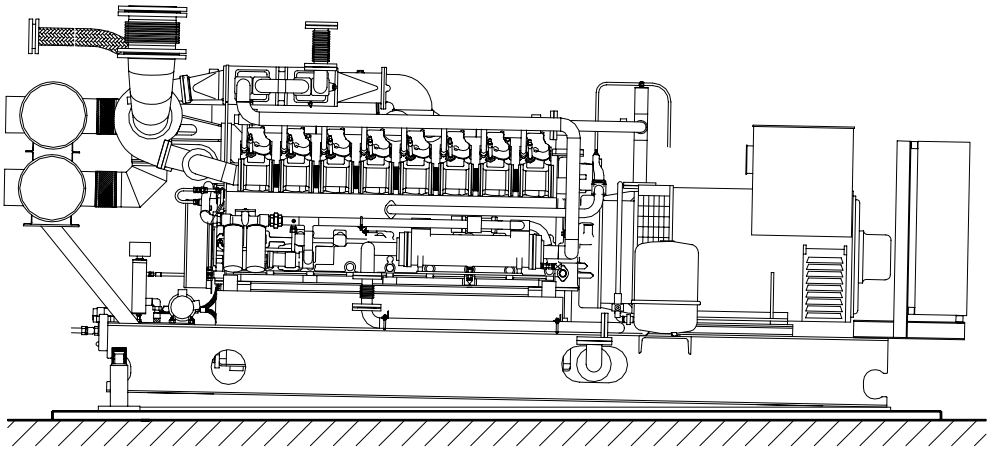
Remove transport roller and install Sylomer trips up to the square timber.



Lift unit frame on the other end and remove square timber.

Install Sylomer strips over the entire length and arrange so that the Sylomer strip protrusion under the frame side members is the same all round.

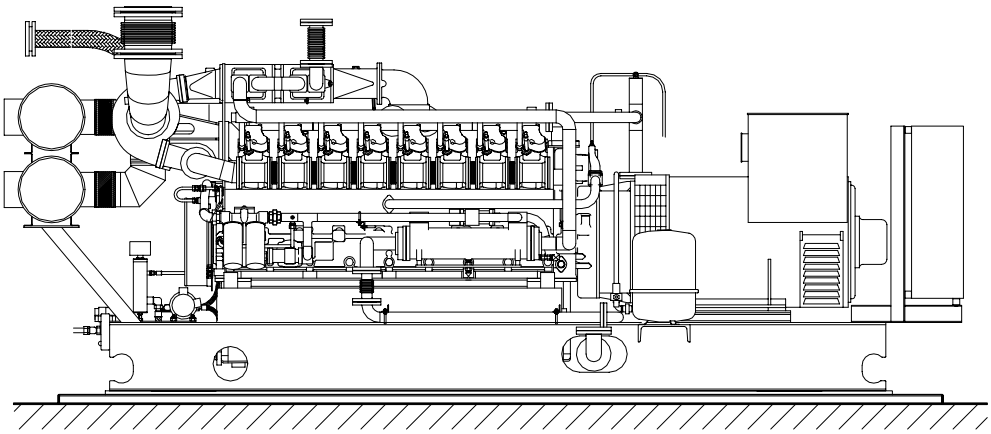
Trim Sylomer strips to the same length as the longitudinal chassis bearers.



5.6 Checking the Sylomer strips:

The load resulting from the unit frame must be evenly distributed on the Sylomer strips along the entire length.

⚠ At no point must it be possible to shift the Sylomer strip under the frame side member.



5.7 Inserting plate:

If the Sylomer strips are unevenly loaded, shim plate must be inserted (under Sylomer strips) at those points where the Sylomer strips can be moved.

The thickness of the inserted plate must correspond to the deviation (between unit installation surface and Sylomer strips) plus ~ 2 mm [0.079 in].

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1. Purpose:

These technical instructions describe the transport or movement of GE Jenbacher switch cabinets.

2. Transport:

Electrical control cabinets are transported in upright position and wrapped in foil:

on one-way pallets:
inside the control cabinet the base of the
cabinet is fixed to the pallet (see illustration).

on Euro-type pallets:
the control cabinet is strapped to the pallet using straps (see illustration).

in a container:
the control cabinet is strapped down without using pallets (see illustration).

3. Setting up of switch cabinets:

Always use the lifting lugs mounted on top of the control cabinet (see illustration) when setting up or transporting the control cabinet. Make sure that you always use two opposite lifting lugs when transporting the control cabinet using a crane.

Alternatively, the erected switch cabinet can be moved on a transport pallet by means of a suitable fork-lift device. The risk of slipping and tipping must be prevented by the correct application of retaining straps.

1. Tips:

Essential program for used-oil analyses on GE Jenbacher gas engines; limit and alarm levels.

Parameters and limit levels are for mineral-oil-based lubricants.

Parameters and alarm levels apply to wear and corrosion products.

These alarm levels are not applicable when bypass filters are used.

The measured value provides information on oil, gas and the engine.

To set the analysis intervals, refer to TI 1000-0099C.

2. Limit/alarm levels:

2.1 Oil condition:

Program point	Limit level	Guideline	Oil	Engine	Gas	Explanation
Viscosity 100°	≥ 12 ≥ 18 mm²/s and < fresh oil +3 mm²/s **≥ 16,9 mm²/s *)**	DIN 51562	x			
Base number BN	> 50% fresh oil and > 2 mg KOH/g **> 2,5 mg KOH/g *)**	DIN ISO 3771	x			
Acid number AN	Fresh oil value +2.5 mg KOH/g **Fresh oil value +3 mg KOH/g *)**	EN 12634	x			1)
ipH value	Min. 4.0 GE by Jenbacher method Min. 4.5 by Mobil method	TI 1000-0099D	x			2)
	Min. 4.5 GE by Jenbacher method Min. 5 by Mobil method					2) 3)
IR ageing	λ 5.8 µ max. 20 A/cm **max. 30 A/cm *)**	IR spectroscopy	x			
IR nitration	λ 6.1 µ max. 20 A/cm **max. 30 A/cm *)**	IR spectroscopy	x			

***) for Mobil Pegasus 1005 only.**

1) **AN (Acid Number)**
Each lubricating oil has a characteristic fresh oil AN, caused by the product-specific reaction mechanism. It is therefore necessary to determine the fresh oil AN in order to establish the AN limit

level. This must be done at regular intervals by the laboratory contracted by the customer to perform routine used-oil analyses.

2) **ipH value**
It is essential to determine the ipH value in all cases when biogas, landfill gas and special gases are used as the fuel gas, even if the BN value is well within the limit. With these fuel gases, we cannot rule out the possibility that acids are already present before the gas is burned.

3) **Only for biomass fermentation and NAWARO plants (not for MBA plants and 1800min^{-1}), in accordance with the requirements below:**

Gas quality:

- **biogas must be of natural gas quality**.
- **The limit levels for "operation with catalytic converter" as specified in TI 1000-0300 must be adhered to, irrespective of whether a catalytic converter is provided**.

2.2 Contaminants:

Program point	Limit level	Guideline	Oil	Engine	Gas	Explanation
Na	See explanations		x	x		1)
Foreign matter	Max. 1 m	EN 12662	x			
Chlorine content	See explanation	DIN 51577			x	2)
Glycol	max. 0.02 %			x		
Water	max. 0.2 %			x		
Si	See explanation			x	x	3)

1) **Na (Sodium)**
Sodium is an engine coolant additive. The Na content is determined in order to identify any water content which is or was present in the lubricating oil.

2) **Chlorine content**
The chlorine content of the oil has no limit. Chlorine can be present in lubricating oil in a wide variety of compounds. Particular attention must be paid in all cases to the AN, ipH and BN values to establish whether the chlorine found causes corrosion.

In the case of landfill gas, the chlorine content must be continuously monitored as standard procedure. In the case of biogas or special gas, the chlorine content must be determined until it has been proved that the biogas or special gas is chlorine-free for all practical purposes.

3) **Si (Silicon)**
The silicon content of used oil has no limit. Silicon can be present in lubricating oil in a variety of forms.

- as siloxanes in the form of trace and accompanying elements in landfill and biogas installations
- in crystalline form as dust
- in the form of silicone oil as an anti-foam agent

Siloxanes
It is possible to establish whether the silicon found will cause damage in a particular case by

estimating the operational value, SiB, as described in TI 1000-0300. Any increase in wear metals such as iron, chromium and aluminium must be carefully noted.

Any rise in the silicon content of the fuel gas may produce an increase in deposits in the combustion chamber and increased wear as a result. That is why a regular check of the combustion chamber with an endoscope is recommended.

As increased silicon content can also cause additional wear on the exhaust side, greater attention must be paid to correct valve play adjustment.

Dust
If the silicon found in the oil is due to inadequate filtration of the intake air, the air filters must be checked or replaced immediately and the oil changed. If there is an increased ratio of dust in the ambient air, an additional filter must be installed.

2.3 Metallic elements:

Program point	Alarm levels ppm/1000 Oh	Guideline DIN 51396/3	Oil	Engine	Gas	Explanation
Fe	Max. 20 ppm			x		1)
Pb	Max. 20 ppm			x		
Al	Max. 15 ppm			x		
Sn	Max. 5 ppm			x		
Cr	Max. 5 ppm			x		
Cu	Max. 15 ppm			x		

1) **Metallic elements**
A key factor for analysing the wear metals is the engine-specific trend analysis. If there are any deviations from this trend or the alarm levels are reached, follow-up actions will be required in every case.

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1. Range of application:

GE Jenbacher gas engines.

2. Oil-change interval:

2.1 The service life of a single filling of lubricating oil depends on many different factors. Next to the oil consumption of the engine, the thermal and mechanical load of the oil, the quantity of oil circulating, the firing-gas quality and composition, the wear of the engine, the quality of the oil used, etc. all have an important influence on the service life of the oil.

2.2 When landfillgas is used, it should be taken into account that depending on the fuel-gas quality, the oil-change intervals which are to be determined analytically are only half as long as the oil-change intervals for sweet-gas operation.

2.3 Make sure that when changing oil, the residual oil quantity in the engine is kept to a minimum (change oil filters, drain oil cooler, etc).

3. Judging the analysis results:

An oil filling should be changed when the measured value of one single item of the analysis has reached the limiting values mentioned in TI No. 1000-0099B, or if it can be expected that these limiting values will be reached in the short term, at which point in time an oil change would not be possible due to certain operational conditions.

The oil analysis should be kept for documentation purposes.

4. Instructions:

4.1 **First of all approximate values are fixed for a specific oil change interval, which depends on**

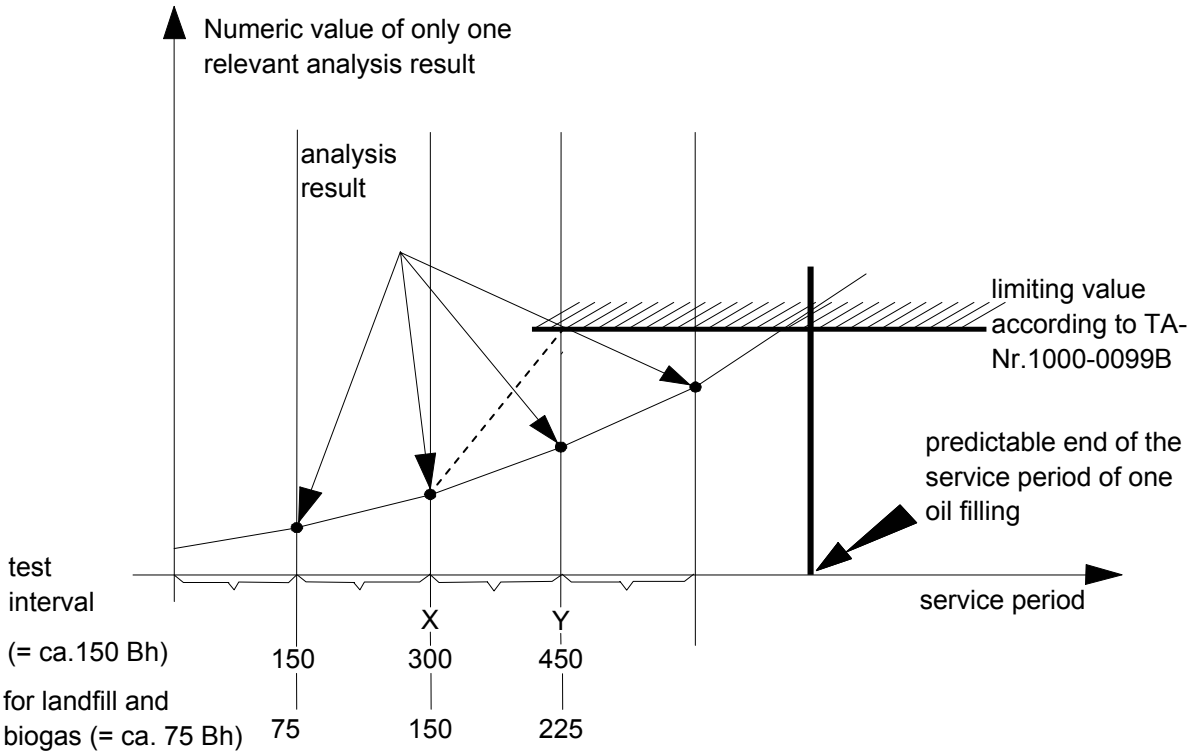
- the operation mode
- the fuel type
- the environment conditions
- the (lubricating oil) product

Oil lifetime. Generally this has to be done soon after the opening. However, if a basic change should arise some time during the service life of the engine, the above mentioned procedure has to be repeated in any case !

Before commissioning: replace any running-in oil remaining in the engine by the operating oil! As from this point in time used-oil samples are to be taken within a period of 150 operating hours (for landfill and biogas - after 75 o.h.) (see TI no. 1000-0112, DIN 51574).
When you send send the first oil sample to the laboratory which is going to carry out the oil analysis, a copy of TI 1000-0099B (Limiting values for used oil for GE Jenbacher gas engines) should be enclosed. The laboratory and/or the supplier should immediately process every oil sample and should comment the analysis results in relation to the GE Jenbacher limiting values, e.g. within the limits, outside the limits, almost at the limits, etc.

Renowned lubricant suppliers are ready to carry our analysis of used oil samples.

In order to give a clear idea of what is goint on during the service period of one oil filling every single analysis result can be charted (see the following diagram).



In case that - as e.g. example “X” - sudden change trends are being found in comparison with precedent analysis, this has to be considered as an allarm signal, even if the limit has not yet been reached as shown in example “Y” (curve _ _ _ _ _ _ _ _ _ _).

This presentation allows the operator to relatively easily form a picture of what is happening to his oil and/or engine and to estimate the length of oil lifetime he can expect.

4.2 If the duration of the oil lifetime is not fully satisfactory it can be prolonged by increasing the engine oil capacity by means of a supplementary tank.

4.3 After tests have established the plant-specific oil lifetime, an analysis must be carried out for each engine in the plant at every further oil filling.

It is recommended that used oil is analyzed:
- At approximately 60%;
- At approximately 90%; and
- At approximately 100%

of the thoroughly tested oil service life or at these percentages of the service life which could be expected on the basis of statistics for continuous analytical monitoring of operation in the future and risk-free maximization of the oil service life.

In any case, the "unmonitored" oil service life should not exceed 500 hours of operation after the first thorough test (250 hours of operation for landfill and biogas).

This certainty is obtained that:
- The oil change interval determined during the first 2 oil fillings has not been accidental
- The conditions of the plant have not changed
- The engine is in good condition (e.g. as far as the adjustment or wear is concerned).

4.4 If you wish to receive a comment on any analysis results, please contact:

GE JENBACHER
Fax: +43 / 5244 / 600 Ext. 2977

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1. Note:

For limiting values of lubricating oils, refer to TI-No. 1000-0099 B, TI-No. 1000-0099 C and TI-No. 1000-0099 D.

It is a normal process that lubricating oil is changing its properties (by ageing or depletion) in the course of operation. In case the ageing continues at a certain steadiness, but extraordinarily quickly, this often means that the “Pack of additives is not sufficient to suit the operational requirements (e. g. fuel , mode of running etc.) or that engine is disturbed e. g. by misadjustment.

In case the lubricating oil becomes depleted in form of collapse, this often indicates a sudden change in the engine operating mode (e. g. engine trouble, change of fuel type/quality, harmful substances in environment.

Very often there is an interaction between excessive oil ageing and disregarded change of engine condition. I. e. over-aged oil leads to engine troubles and engine troubles lead to increased stress of the oil.

2. Used oil test result:

2.1 Water present in oil:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Condensation	Low temperature operation	Stop-and-go driving. Low coolant temperature. Excessive engine idling.
	Flow-back of condensate from crankcase breather	Inadequate crankcase ventilation. Weather-dependent condensation in the crankcase ventilation pipe combined with an unfavourable pipe layout which allows condensation to run back into the engine.
Coolant leakage	Cylinder head gasket leaky (water passage)	Gasket defective or burned, or gasket incorrectly installed.
	Leaky O-rings on wet cylinder liners	Incorrect installation. Defective O-ring. Seating surface corroded.
	Engine block, cylinder head or watercooled exhaust manifold sometimes leaky wast heat boiler	Coolant frozen. Overheating during operation, or lack of coolant in cooling system.
High blowby	Ring belt area	Worn rings or liners. Stuck or broken rings.
	Exhaust system restrictions	Plugged exhaust manifold, exhaust pipe, silencer, turbocharger or waste heat boiler.
Faulty cleaning	Improper macine cleaning	e. g. water washing can introduce water into lube oil system.
Improper oil storage	Replenished with water-containing oil	Oil drums (even originally sealed ones) are standing in the rain.
Ingress of rain	Ingress via exhaust pipe end at standstill	Extreme weather conditions, water unfavourable layout of exhaust system.
Ingress of water via fuel supply	Not only atomized condensate in fuel gas supply	Insufficient drying of biologically or pyrolitically produced gases.

2.2 High insolubles:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Fuel soot or fuel additives	Rich operation	Overfueling. Restricted air intake.
	Worn piston rings or cylinderliners	Poor mechanical condition of engine or of shaft sealing ring on turbocharger.
Fuel soot	Defective injectors	Poor spray pattern. Dribbling nozzles. Start of delivery overadvanced (i. e. so-called “spraying beyond the piston edge” at simultaneously noticeably soot-free exhaust gas).
Oil breakdown	High temperature operation	Excessive peak power operation. Engine maladjusted or in poor mechanical condition, or exhaust gas enters the lubricating system via turbocharger. Oil cooler obstructed with oil sludge.
	Inadmissibly extended oil drain periods	Improper preventive maintenance practives.
	Oil pumping	High crankcase oil level. Worn bearings, guides and rings.
Dirt and dust	Inadequate air filter maintenance	Improper or poor preventive maintenance practice.
	Air leaks in intake system	Poor mechanical condition of intake system.
Engine metals	Wear, corrosion or failed or damaged parts	Refer to notes in section 2.6.
Lack of air in diesel engine	Choking on intake side	Intake air filter contaminated, turbocharger defective, charge air cooler contaminated. Leaks in intake or exhaust system between engine and turbocharger.
Disturbed combustion in diesel engines	Poor combustion	Insufficient charge air cooling, disturb. in injection system (e. g. concerning start of fuel delivery or equalization/coordination of pumps).

2.3 Viscosity increase:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Contamination	Fuel soot	Refer to notes in sections 2.2 fuel soot and fuel additives.
	Water	Refer to notes in section 2.1.
Oxidation and/or nitration	High temperature operation	All engines: Overextended oil drains. Inadequate cooling. Excessive peak power operation. Fuel gas engines: Fuel mixture setting too lean. Ignition point (spark) overadvanced
Use of higher viscosity oil	Misapplication	Initial fill or make-up with wrong product. Disregarding of lube-oil instructions. Use of “viscosity improver” supplement.

2.4 Viscosity decrease/General:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Use of lower viscosity oil	Misapplication	Initial fill or make-up with wrong product. Lube oil instructions disregarded.

2.5 Viscosity decrease diesel engines and analogously in hydraulically controlled two-stroke engines:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Fuel dilution	Rich fuel injection	Oversize injectors. Dribbling nozzles. Pressure in fuel return line or leakage oil line.
	Poor combustion	Piston rings broken or stuck. Dribbling injection nozzles. Poor spray pattern. Worn piston rings or cylinder liners. Restriction in air supply or in exhaust line.
	Cracked or broken connections in fuel line	Refers to machines (engines) with fuel lines routed on inside. Lines kinked inadvertently.
	Unsuccessful starting attempts	All reasons which can lead to unsuccessful engine starting.
	Internal leakage in injection or feed pumps	Plunger wear or defective sealing elements allow fuel entering the pump or engine oil space.

2.6 Higher than normal trace metals by spectro analysis atomic absorption analysis:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Outside contaminants. Coolants. Engine metals from wear and corrosion.	Metals found in used engine oils	Source of metal in used engine oil.
	Aluminium *)	Piston, bearings and cylinders: dirt and dust contamination.
	Barium	Oil additives, diesel fuel additives.
	Boron *)	Cooling water conditioners
	Calcium	Oil additives (major). Contamination by dirt and dust (minor).
	Chromium *)	Piston rings, cylinder liners, plated rocker arms, inlet valves, exhaust valve, crankshaft. Cooling water conditioners.
	Chlorine *) (or all the four halides)	Unauthorized addition to fuel or to combustion air. Important: As it deteriorates the alkalinity extremely, but it cannot always be recognized in full extent when applying section 2.7.
	Copper *)	Bearings, bushings, seal rings, air filter mesh, oil cooling tubes.
	Iron *)	Engine parts.
	Lead *)	Abrasives from bearing running-in layers.
	Magnesium	Oil additive (major). Sea water contamination (major).
	Phosphorus	Oil additive.
	Silicon *)	Pollution caused by sand and dust or as a result of organic silicon compounds in landfill and sewage gasses. Wear and tear of engine parts made from aluminium (secondary) or due to previous machine maintenance work which included abrading or honing.
	Sodium *)	Contamination due to water not previously distilled (or not condensed), cooling water conditioner, contamination due to dust.
	Tin *)	Tin-plated bearings.
	Zinc	Oil additive (major). Bearings (minor).

*) refers to those metals, which must be particularly supervised with oil samples and/or oil changes.

2.7 Low alkaline reserve:

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Contamination from combustion acids	High sulfur fuel	Oil not high enough TBN. Over-extended drain periods.
	Excessive blowby (nitrate development)	Poor combustion caused by misadjustm. or by defective parts. Poor mechanical conditions of engine.
	Intake of acidforming vapors together with intake air	Refrigerating agents like Freon or NH_3.
Oil oxidation	Excessive operating temperatures	Excessive peak power operation. Poor mechanical condition of engine. Poor engine setting (adjustment).
Faulty oil purification	Excessive oil remainders in oil filters, oil pan, oil cooler etc. when changing oil	Strong acids not removed. Cleaning intervals disregarded.

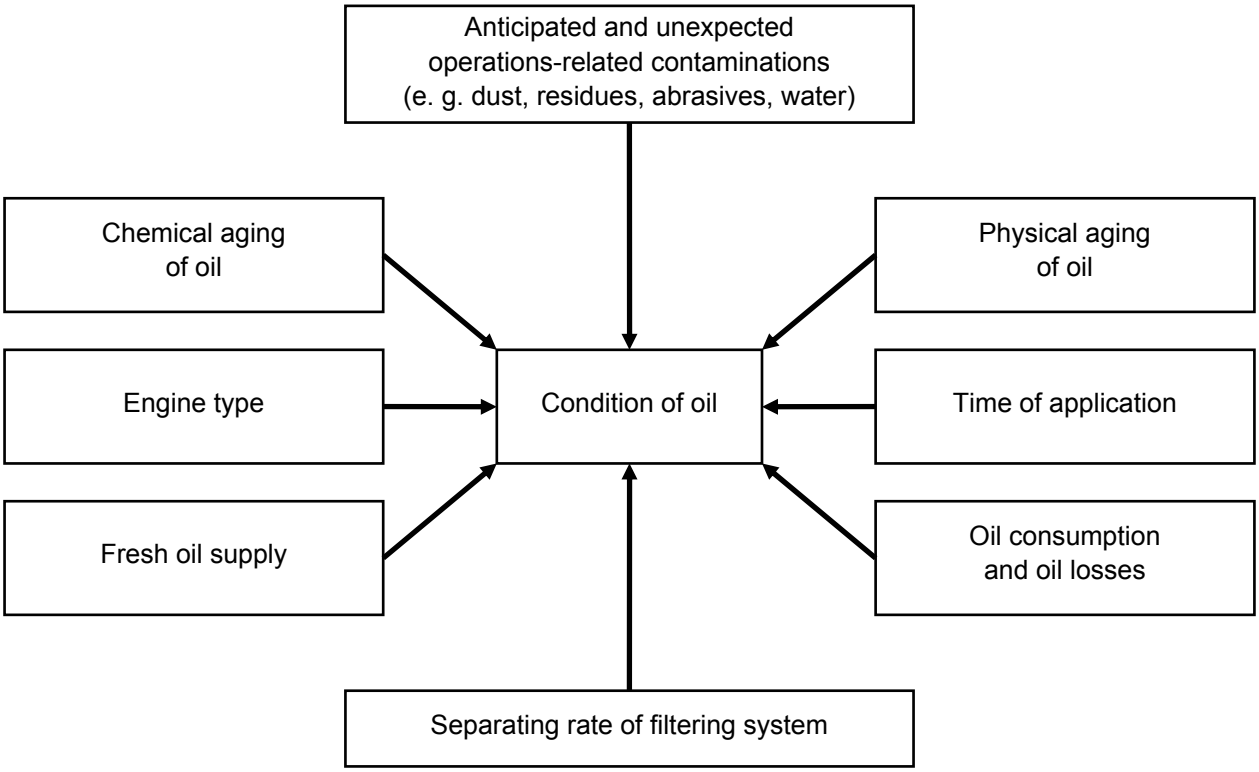
2.8 Infrared analysis (gas engines) increased absorption at 5.8 µm (1710 Hz):

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Oil oxidation	Excessive operating temperatures	High piston and cylinder temperatures. High fuel oil temperatures. Engine hot spots. Refer also to remarks in section 2.7 Oil oxidation.

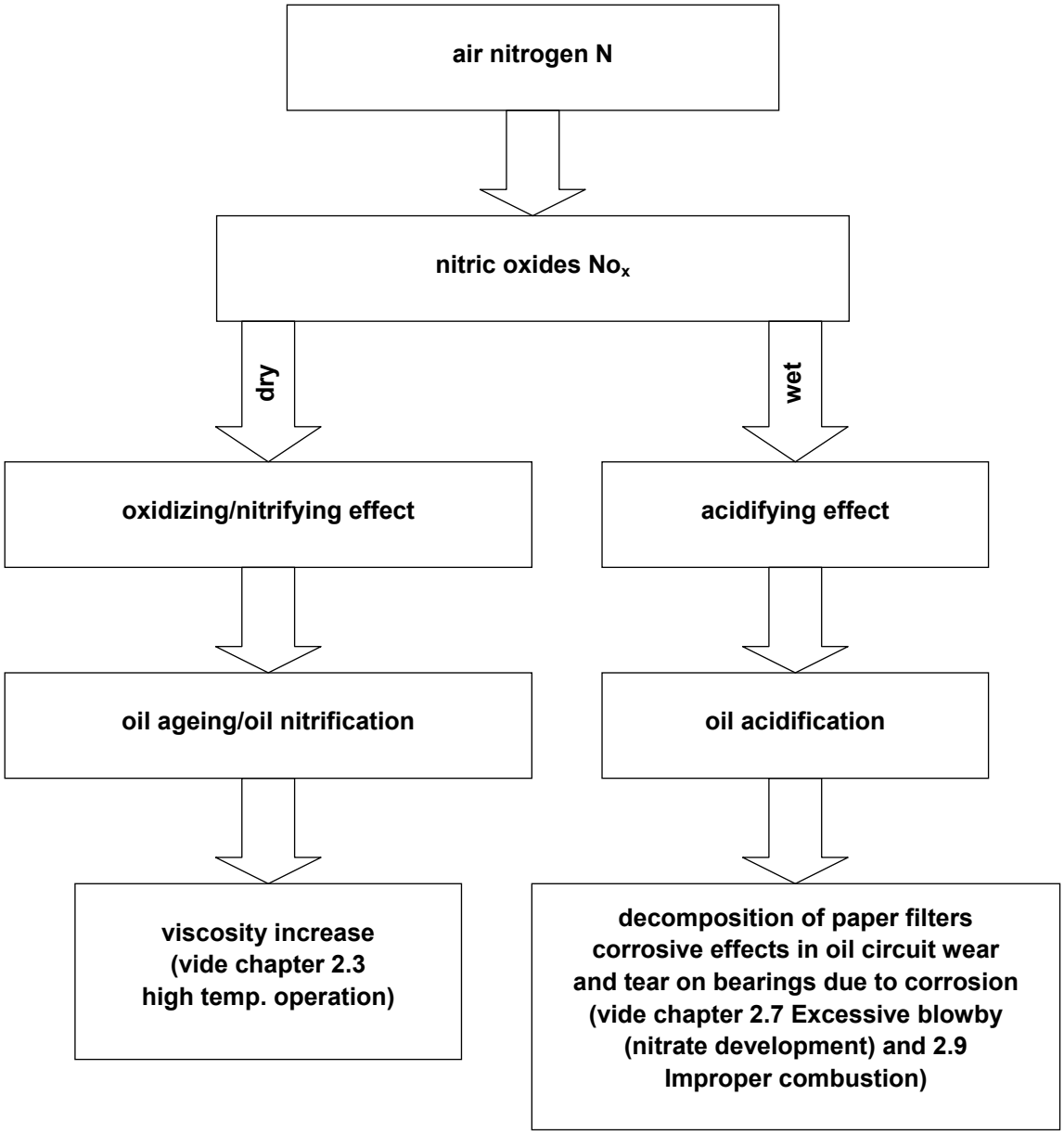
2.9 Infrared analysis (gas einges) increased absorption at 6.1 µm (1630 Hz):

Primary Causes	Specific Factors	Engine/Oil/Coolant Conditions Responsible
Nitrogen fixation (Nitration)	Improper combustion	Improper and/or poor operating practices such as: poor combustion, engine overload, faulty crankcase ventilation, improper spark timing, excessive blowby (piston, cylinder liner). Refer also to remarks in section 2.7 Excessive blowby (nitrate development).

3. Overview on factors influencing condition of the engine oil:



4. Overview on natural oil ageing, which proceeds occasionally too fast due to overstress:

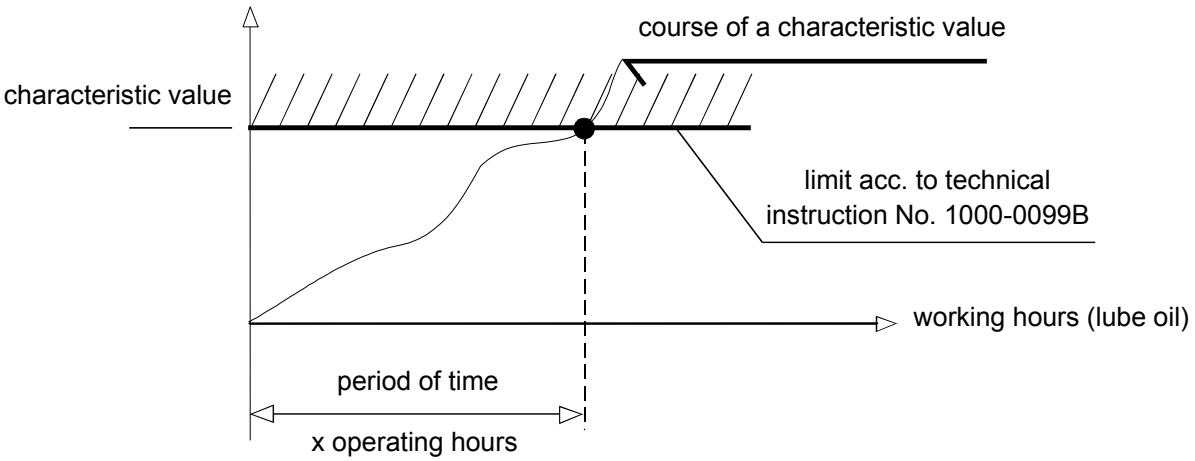


5. Additional valuation of the concentration of harmful substances in fuel gas by means of regular lube oil analyses:

5.1 Presupposition:

- Use of appropriate lube oil (acc. to the respective technical instruction)
- Observance of all characteristic values and limits which indicate the chemical aging of used oil (ipH, TBN, IR 5,8 my, IR 6,1 my, etc.)

5.2 Procedure:



5.3 Judgement:

shortest period given

> 300 operating hours...	Oil change is still effective; there is not much risk that the engine will be damaged by harmful substances	C a u t i o n
200 to 300 operating hours...	The harmful substances are still (at least to a certain extent) neutralized by an oil change	S t a t e o f a l a r m
< 200 operating hours...	The harmful substances can no longer be neutralized by an oil change	M a x i m u m s t a t e of a l a r m

1. Valid for:

This instruction is valid for all water-cooled engines, compressors and plants in closed circuits, in primary and secondary circuits.
Does not apply to heating circuits! (See TI-no. 1000-0206 Composition of circuit water in hot water and warm water heating system)

2. Composition of cooling water:

Appearance		**clear and odourless free of sediment and suspendend material**
pH - value at 25°C [77°F]		7,5 til 9
Elec. conductance (at 25°C [77°F])	µS/cm µS/in	< 600 <1524
Total hardness(German deg.)	°dH	6 til 12
Alkaline earths Ca^{2+} , Mg^{2+}	mmol/l	1,1 til 2,2
Sulfade SO_4^{2-}	mg/lgrains/gallon	<50 <2,92
Chloride Cl^-	mg/lgrains/gallon	<50 <2,92

3. For consideration:

3.1 Soft water (as e.g. rain water, distilled water, condensates) as well as brackish and sea water are not suitable for use as cooling water.

3.2 In case of frost danger an anti-freezing agent in accordance with the technical instruction TI-no. 1000-0201 has to be used. An eventually installed cooling water preheating device does not substitute the anti-freezing agent.
If no antifreeze is necessary a corrosion prevention material must be added in accordance with TI-no. 1000-0204.

3.3 A water analysis for checking the conditions of the cooling water must be carried out after every topping up with large amounts of water, however at least annually.

3.4 If water conforming to the specifications in the cable (Section 2) is not available, the customer must arrange appropriate water treatment through a specialist firm. In this case the customer and his sub-contractor shall take over the responsibility for the operation of the cooling water circuit.

4. Water analysis:

When carrying out water analyses attention is to be paid in general to the following:

4.1 Taking of samples is to be made in an expert manner as otherwise the results of the analysis may be distored. This requires the use of clean vessels of glass or plastic material.
Prior to taking the samples the vessels are to be flushed thoroughly (3 to 5 times) with the water to be examined. For water temperatures in excess of 25°C [77°F]the sample must be taken over a cooler which cools the water to be tested to 25°C [77°F].

4.2 The temperature, the pH value, the contents of oxygen and carbon dioxide are to be determined immediately following the taking of the samples at site.

4.3 The analytical examinations are to be performed in accordance with apropriate analysis instructions, adapted to the rescpective water quality.

4.4 Due to the mostly very minor concentration of substances contained in the water - in the dimension of below 0,1% or in some instances below 0,01% - a water analysis is comparable to a chemical trace analysis so that delicate procedures of evidence are required.

4.5 Application of uniform dimensions for the indication of concentration of substances contained in the water. The most usual units are ”mg/l” or ”g/l” or ”µg/1”.
Sometimes also ”mol/m³” or ”val/kg” are being used.

4.6 A one time analysis does not constitute an assurance of the actual water quality in the systems over an extended period of time. Therefore, for estimating the water quality, only average analyses are to be used.

1. General:

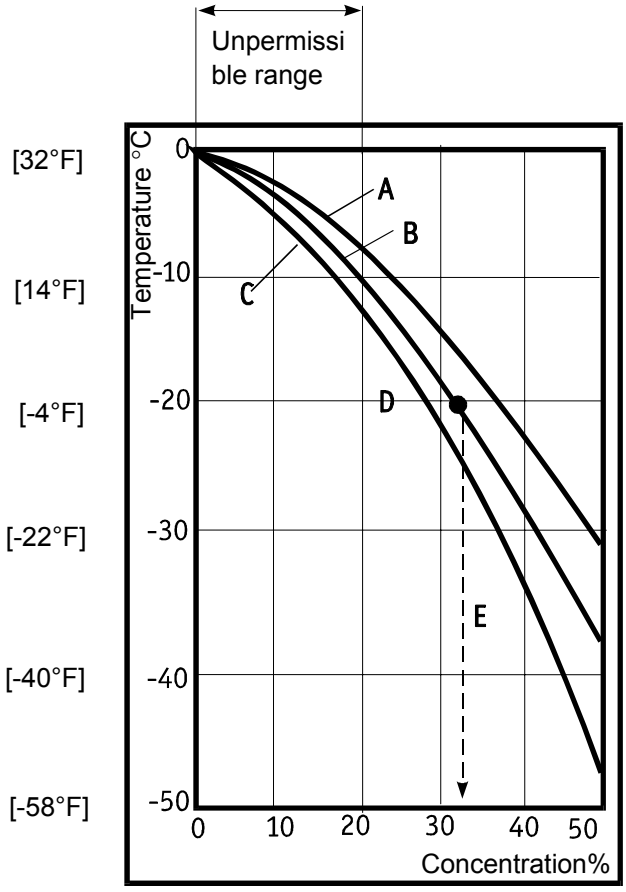
In order avoid that the cooling water freezes, antifreezing compound is added. These are water-soluble liquids, in most cases on glycol basis (e.g. ethylene glycol), with additives in order to avoid corrosion and foam formation. The congealing point depends on the mixing ratio with water - see schematic representation.
Products which are not explicitly given, can only be used if these are high-quality branded products; the manufacturer must also be liable for possible secondary effects.
This product liability is also required for explicitly given products.

2. Remarks:

Before filling in the antifreezing compound, clean the entire cooling system by rinsing with water and check for tightness.
Pour the necessary quantity of antifreeze into the cooling system and top up with clean, fresh water in accordance with TI-no. 1000-0200.
Let engine run for 30 minutes after filling.
The cooling system must be vented, otherwise corrosion will occur in the air area.
Too low concentration cannot only cause unsufficient frost protection, but the (for example ”weakened below 20 volume-%”) cooling liquid is possibly more corrosive than the cooling water itself!

Company	Product
ARTECO	Havoline XLC 40/60
BASF	Glysantin Protect Plus
Chemische Werke Hüls. AG.	Hüls 80
BP	BP - Anti Frost
ESSO	ESSO KÜHLERFROSTSCHUTZ
Hoechst	Genantin
MOBIL	Frostschutz 600
Shell	Glycoshell 400
OMV	Kühlerfrostschutz
IP	IP Antifreeze

SUBJECT TO WASTER DISPOSAL !



A = first ice crystals
B = thin-bodied crystal mash
C = no longer flowing (so-called solidification point)
D = protection against freezing up to -20°C [-4°F]
E = abt. 34 % by volume antifreezing compound

SUBJECT TO WASTER DISPOSAL !

1. Range of application:

For all water-cooled GE Jenbacher gas engines with engine and/or charge air cooling water circuit.

2. Application:

As per specific description of product on original container.

3. .Concentration:

Determination of concentration:

TI-No.1000-0201	by means of prisma-refractometer (available from authorized dealers) *)
DREW	ba means of maxigard standard ampule **)

*) least 20% in water
**) 1,6% in water

4. Effect:

Equally suitable for iron, aluminium and nonferrous heavy metals.

5. Compatibility:

Compatible with all sealing and elastomer materials used in a GE Jenbacher gas engines.

6. Selection of brands on the market:

Products from TI 1000-0201	Antifreeze with anticorrosive additive *)
DREW AMEROID	Maxigard**)

*) Is simultaneously a high-value anti freeze.
**) May be mixed with anti-freeze on ethylene-glycol base.

SUBJECT TO SPECIAL WASTE DISPOSAL !

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1. Scope:

These instructions apply to the composition of circuit water in hot water (admissible flow temperature above 100°C [212°F]) and warm water heating systems.
They do not apply to the circulation of engine cooling water (See TI-no. 1000-0200 Composition of cooling water in closed primary circuits)!

2. Composition of the cooling water:

		saliferous water	low-salt water
Appearance		clear and odourless, free from deposits and suspended matter	clear and odourless, free from deposits and suspended matter
pH-value (25°C [77°F])		9 - 10,5	9 - 10,5
Conductivity (at 25°C [77°F])	µS/cm µS/in	100 - 1500 254-3810	< 100
Oxygen content O_2	mg/l grain/gallon	< 0,02 <0,00117	< 0,05 0,0029
Alkaline earths Ca^{2+},Mg^{2+}	mmol/l	< 0,02	< 0,02
Total hardness	°dH	< 0,1	< 0,1
Chloride Cl^-	mg/l grain/gallon	< 20 <1,168	< 20 <1,168
Phosphate PO_4	mg/l grain/gallon	5 - 15 0,292 - 0,876	5 - 10 0,292 - 0,584

3. Please note:

3.1 If there is a risk of below-zero temperatures (freezing), make sure to contact a specialist firm to determine the type of cooling agent required. Always comply with the specifications of the waste-heat boiler .

3.2 The condition of the water is to be checked when adding larger quantities of supplementary water; in any case it needs to be checked at least once a year by means of a water analysis.

3.3 In the event that the values given in the table (section 2) cannot be observed, entrust a specialized company with the water treatment.

3.4 The basis alkalinization of the filling and supplementary water must be carried out with trisodium phosphate.

3.5 Minimum filling pressure:
In case of installations exploiting exhaust gas heat which are operating on a water/glycol mixture, please take into account the following minimum filling pressure values depending on the inlet temperature.

Inlet temperature		required Minimum filling pressure	
°C	°F	bar	psi
90	194	2,0	29
95	203	2,5	36
100	212	3,0	44
105	221	3,5	51
110	230	4,0	58

4. Water analysis:

When carrying out water analyses attention is to be paid in general to the following:

4.1 Taking of samples is to be made in an expert manner as otherwise the results of the analysis may be distored. This requires the use of clean vessels of glass or plastic material.
Prior to taking the samples the vessels are to be flushed thoroughly (3 to 5 times) with the water to be examined. For water temperatures in excess of 25°C [77°F] the sample must be taken over a cooler which cools the water to be tested to 25°C [77°F].

4.2 The temperature, the pH value, the contents of oxygen and carbon dioxide are to be determined immediately following the taking of the samples at site.

4.3 The analytical examinations are to be performed in accordance with apropriate analysis instructions, adapted to the rescpective water quality.

4.4 Due to the mostly very minor concentration of substances contained in the water - in the dimension of below 0,1% or in some instances below 0,01% - a water analysis is comparable to a chemical trace analysis so that delicate procedures of evidence are required.

4.5 Application of uniform dimensions for the indication of concentration of substances contained in the water. The most usual units are ”mg/l” or ”g/l” or ”µg/1”. Sometimes also ”mol/m³” or ”val/kg” are being used.

4.6 A one time analysis does not constitute an assurance of the actual water quality in the systems over an extended period of time. Therefore, for estimating the water quality, only average analyses are to be used.

1. Validity:

This technical instruction applies to all water-cooled engines and installations with open cooling circuits.
In principle, titanium platen-type heat exchangers should be used for open circuits. Stainless steel 1.4401 platen-type heat exchangers may only be used in combination with appropriate water treatment.
Compliance with the limit values is customer's responsibility.
Complying with the limit values for oxicat.

2. Cooling-water quality:

The following reference values for the circulation water are to be regarded as advice only and no claims whatsoever may be derived from them, as local water conditions may vary and the water may contain numerous, unknown combinations (of substances). The responsibility for the operation of the open cooling-water circuit is therefore borne by the customer and his supplier.

Circulation water guidance values for wall temperatures of < 60°C

Appearance of cooling water	clear, no deposits
Smell	odourless
pH value at 25 °C	7.5 – 8.5
Carbonate hardness	< 4 °KH
Carbonate hardness when adding inhibitors	< 20 °KH
Salinity	< 3,000 mg/l
Electrical conductivity (at 25 °C)	< 2,500 µS/cm
Sulphate content SO_4^{-2}	< 500 mg/l
Chloride content Cl^-	< 200 mg/l
Iron content	< 0.3 mg/l
Biological contamination (germ value)	< 10,000
Suspended solids	< 50 mg/l
Free of nitrates and ammonia	

3. Attention:

In the case of cooling-tower operation, the cooling-water composition is especially important as, to a large extent, the capacity, service life and profitability of the heat exchangers are affected by it.
That is why we recommend having a water analyses carried out and to consult a specialised company during the planning stage or before commissioning the system.

In cooling-tower systems, water aftertreatment is an important and indispensable activity to ensure trouble-free service of the system. The aftertreatment should be carried with the utmost care. At the very least, the water quality in the cooling-water circuit should be checked to prevent undesirable deposits at the heat-exchanger surfaces and in the entire system.

In every day practice, the use of (industrial) water as a cooling agent causes three technical problems:
1. corrosive effect of the water on metals,
2. forming of lime scale/salt deposit on the heat-exchanger surfaces,
3. microbial growth on installations and walls.

Because of these negative characteristics, the following measures must be taken to guarantee an optimal cooling-water quality and, therefore, a trouble-free service of the installation, i.e.:
- adding hardness stabilisers and corrosion inhibitors (HC products).
- The corrosion protection measures depend on the substances active in the system, the operating conditions and the characteristics of the thickened circulation water.
- checking biological growth at regular intervals using appropriate disposable test kits.

4. Required inspections:

- 1-2 times every month, check the electrical conductivity of the circulation water,
- 1-2 times every month, measure the water hardness of the circulation water,
- 1-2 times every month, check the cooling tower basin for algae growth, if required give biocide shock treatment.

5. Water analysis:

To determine the required measures for trouble-free operation of the installation, the analysis of the actual water quality should preferably be carried out by an outside firm specialising in water treatment.

When carrying out water analyses attention is to be paid in general to the following:

5.1 Taking of samples is to be made in an expert manner as otherwise the results of the analysis may be distored.

This requires the use of clean vessels of glass or plastic material.

Prior to taking the samples the vessels are to be flushed thoroughly (3 to 5 times) with the water to be examined. For water temperatures in excess of 25°C [77°F] the sample must be taken over a cooler which cools the water to be tested to 25°C [77°F].

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Sometimes also ”mol/m³” or ”val/kg” are being used.

5.6 A one time analysis does not constitute an assurance of the actual water quality in the systems over an extended period of time. Therefore, for estimating the water quality, only average analyses are to be used.

Specialist firms with water-aftertreatment systems:

Aqua Concept
Gesellschaft für Wasserbehandlung mbH
http://aqua-concept-planegg.de

ASC Wassertechnik GmbH
http://tmbnet.de/asc

GEA Wärme- und Anlagentechnik GmbH
http://www.gea-gwa.de

Rehsler Kühlsysteme GmbH
http://www.rehsler.de

Sulzer Cooling Towers
http://www.sulzercoolingtowers.com

UWD
Unternehmensverbund Wassertechnik Deutschland
http://www.uwd.de

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1. General:

Unlike petrol and diesel fuels, gaseous fuels generally do not have to comply with strict specifications or classifications.

GE Jenbacher engine systems are optimally designed to accommodate a contractually defined fuel-gas composition. Any deviation from this fuel-gas composition and/or any exceeding of the fuel gas limit levels will usually have a negative effect on engine operation.

Lubricating oil can lose its corrosion protection characteristics due to impurities in the fuel gas. The results of regular lubricating oil analyses are indicative of fuel gas impurities. In this respect, please refer to the following Technical Instructions:
TI 1000-0112
TI 1000-1109
TI 1000-0099B
TI 1000-0099C.

2. Gas types:

This TI applies to Natural, Associated Petroleum, bio- and landfill gas.

Please refer to the following Technical Instructions for other qualities of fuel gas:
TI No.: 1000-0301: Mine gas
TI No.: 1000-0302: Special gas (wood, coke and converter gas)

3. Limit levels:

Fuel gases are composed of various individual components, i.e. main components and trace and accompanying elements. In order to determine the relevant fuel characteristics for physical engine operation, the main components must be known and must be specified in the form of a comprehensive gas analysis.

Trace and accompanying elements are usually impurities found in the ppm range. Unlike the effects of main components, the effects of trace or accompanying elements do not become noticeable until the engine has been operational for a certain period of time.

General limiting conditions *)

Fuel gas must not be potentially explosive (no ATEX rating)		
Gas pressure	-	In accordance with project specification
Gas pressure, max. fluctuation speed	10 mbar/sec.	
Gas temperature	0°C < T < 40°C	Other temperatures should be checked in all cases.
Gas-moisture content	< 80% relative	We advise against using an active carbon filter. However, there must be no condensate in the controlled gas system up to the gas mixer.
	< 50% relative	A requirement when using a Jenbacher active carbon filter at the intake of the active carbon filter. Applies to any gas temperature.
	Dew point < 18°C	Requirement for ClAir pad gas (approx. 2% of total gas volume required), higher dew points on request.
	< 0.2 %Vol	For precombustion chamber gas in type 6 engines
Condensate, sublimate	0	No condensate or sublimate in the components that come into contact with gas and/or mixture.
Lower heating value fluctuation speed	1% / 30 sec.	
Methane Number fluctuation speed	10 MN/30 sec.	
Oxygen content	< 3 %Vol	When using a TSA gas cleaning system

*) Condition at the interface with the GE Jenbacher scope of supply

Dust

Particle size	> 3 µm	The filter in the gas pressure control system is not used as a work filter **)
Particle volume	50 mg/10kWh	

Trace and accompanying elements

Si: total silicon as Si_{BG} **)	0.02	Without catalytic converter
	0.0005	With catalytic converter

**) When using a fuel gas with traces of volatile oxidisable silicon compounds, a clear correlation can be established between the Si compound content of the fuel gas and that of the used engine oil. The operational value Si_B is the determining value for the amount of silicon fed to the engine.

This value is determined using two oil analyses:
Δ *Si content of engine oil*: the increase in the Si content of the engine oil in ppm between two analyses, and
Δ *Operational oil life*: the operating time in hours between the two oil analyses.

$$Si_{\text{operational value}}\ Si_B) = \frac{\Delta Si_{\text{content of engine oil}}\ [ppm] \times \text{Ölfüllmenge (l)}}{\text{average engine power [kW]} \times \Delta\ \text{operational oil life (h)}} \times 1.1$$

Sample calculation:

Increase in the Si content of the engine oil between two analyses	40 ppm
Oil capacity	500 l
Engine output	2000 kW
Operational oil life between the analyses	600 h

$$Si_B = \frac{40\ .\ ppm \times 500\ .\ l}{2000\ .\ kW \times 600\ .\ h} \times 1.1$$

$Si_B = 0.018$ actual value

$Si_{BG} = 0.02$ $Si_B < Si_{BG}$ → is OK

In the preparatory phase of the project, GE Jenbacher can use its own sampling and analysis technology to make an estimate of the expected operational value Si_B based on a fuel gas flow which is characteristic of the engine operation. Depending on the outcome, GE Jenbacher is able to offer its clients maintenance contracts and/or make recommendations for improvements. During operation, adherence to the limit levels found in the oil analysis will ensure the validity of the contractual maintenance plan. The sampling requirements and procedure are described in more detail in Section 5, Appendix II.

Trace and accompanying elements

Total sulphur ****)	< 700 mg/10kWh ***)	Without catalytic converter
	< 1,200 mg/10kWh ***)	Without catalytic converter, limited warranty *****)
	< 200 mg/10kWh ***)	With catalytic converter for CO ******)
	< 20 mg/10kWh ***)	With catalytic converter for formaldehyde *******)
	< 500 mg/10kWh ***)	When using an active carbon filter, limit does not relate to downstream components (see above)
	< 700 mg/10kWh ***)	When using a ClAir system, limit does not relate to upstream components (see above)
Halogen compounds ****) Total Cl + 2 * total F	< 100 mg/10kWh ***)	Without catalytic converter
	< 400 mg/10kWh ***)	Without catalytic converter, limited warranty *****)
	< 200 mg/10kWh ***)	When using an active carbon filter, limit does not relate to downstream components (see above)
	< 200 mg/10kWh ***)	When using a ClAir system, limit does not relate to upstream components (see above)

	< 20 mg/10kWh ***)	With catalytic converter
Ammonia	< 50 mg/10kWh ***)	NH3 has a direct effect on the nitrogen oxide emissions in the engine exhaust gas. Higher NH3 values in the fuel gas may result in the NOx values for the engine exhaust gas stated in the specification being exceeded.
Total – oil content	< 5 mg/10kWh ***)	
Total trace elements when catalytic converter is used	The metals and heavy metals listed below as examples have the effect of deactivating the catalytic converter. This reduces its service life accordingly. ➢ Sulphur, phosphorus, lead, mercury, arsenic, antimony, zinc, copper, tin, iron, nickel and chromium. ➢ The warranty will cease to apply if the cumulative volume of these elements exceed 350 g/m^3 of catalytic converter. The evidence will be provided by quantitative analysis of a used sample. The exhaust gas must in all cases be free of silicon compounds, such as siloxanes.	

**) The micro filter used as standard by GE Jenbacher boasts a filtration efficiency of approx. 99% for particles > 3 µm and is not designed to be a work filter.
The permissible dust or particle content specified for > 3 µm is only indicative of the filter service life if it has not been additionally reduced by moisture.
If the filter service life as stated in the maintenance plan is not achieved or the filter service life is found to be unacceptable or the operation of the gas pressure control system is compromised, measures must be taken by the customer to improve the situation.

***) The absolute quantity of elements which have entered the engine is decisive when analysing the trace element content. In order to compare different gases, the trace element concentration is compared to a certain level of fuel gas energy and to natural gas (methane, Lower heating value approx. 10 kWh/Nm³).

$$S = \frac{\textit{measured concentration [mg / Nm}^3\textit{]}}{\textit{Calorific value [kWh/Nm}^3\textit{]}} \; x\ 10$$

Concentrations are frequently indicated in volume-related quantities e.g. ppm (parts per million), which must be converted in an intermediate step to mg/Nm3 using the density under normal conditions: i.e.

S' [mg/Nm^3] = measured concentration [ppm] x density of the element [kg/Nm^3]

Comment: the ppm (=10^{-6}) indication and conversion from kg to mg (10^{+6}) cancel each other out.

Sample calculation:

CO_2	40%
CH_4	60%
H_2S	260 ppm (at normal density condition = 1.52kg/Nm^3)
Lower calorific value	6 kWh/Nm^3 (= 60% of 100% CH4 = 10kWh/Nm^3)

Step 1: conversion of measured value in ppm to mg/Nm3, in relation to H_2S

$$S'_1\ [mg/Nm^3] = 260\ [ppm] \times 1{,}52\ [kg/Nm^3] \qquad S'_1 = 395\ mg/Nm^3$$

Step 2: conversion of the value in relation to H_2S to the limited sulphur value in mg/Nm³

$$S'\ [mg/Nm^3] = \frac{Molar\ mass\ of\ sulphur}{Molar\ mass\ H2S} \times S'_1 \qquad S'\ [mg/Nm^3] = \frac{32}{34} \times 395\ [mg/Nm^3]$$

$$S'_1 = 372\ mg/Nm^3$$

Step 3: conversion of measured value in mg/Nm^3 to comparable value (mg/10kWh).

$$S = \frac{372\ [mg/Nm^3]}{6\ [kWh/Nm^3]} \times 10 \rightarrow S = 620\ mg/10\ kWh \quad actual\ value$$

$$Without\ catalytic\ converter \rightarrow S_G = 700\ mg/10\ kWh \qquad S < S_G \rightarrow \text{is OK}$$

In principle, this sample calculation also applies to all limit levels indicated in mg/10kWh.

****) The oil service life is reduced noticeably as soon as a total sulphur content of approx. 50 mg/10 kWh and a total halogen content of approx. 20 mg/10 kWh are reached (refer to TI 1000-0099 B and C). When using desulphurisation systems, it should be remembered that if these systems fail very high sulphur concentrations may enter the engine and damage it within a very short period of time.

*****) Assuming a service life reduction of all engine and system components that come into contact with the fuel gas, engine oil or exhaust gas and an increase in maintenance activities, the limits can be increased to the values mentioned in the table. In order to achieve a satisfactory minimum oil service life (approx. 500 Oh) a suitably large lubricating oil reservoir, as designed by GE Jenbacher, must be fitted. For plants using heat recovery, care must be taken to ensure that the acid dew point in the waste heat boiler - taking partial load operation into account - is exceeded.

******) The catalytic converter converts SO_2 into SO_3. Sulphurous acid is formed at the same time as condensate. Consequently, heat recovery boilers, catalytic converters and exhaust gas systems for exhaust gas temperatures < 180°C are covered by a limited warranty.

*******) Precondition for using formaldehyde cats with biogas: fuel gas except CO_2, N_2, O_2 equivalent to natural gas quality, i.e. for sulphur < 20 mg/10kWh. Natural gas lubricant must be used and the gas quality must be monitored.

3.1 Checklist for fuel gas quality information:

General information

Name of the project or the plant:	
Name of the contact person:	
Telephone number:	
Type and origin of the gas:	

Physical fuel gas characteristics

Gas pressure (from – to)	-	mbar(o)
Gas temperature (from – to)	-	°C
Rel. gas moisture content (from – to)	-	%
Atmospheric pressure (from – to)		mbar

Chemical fuel gas characteristics

Main components:	**%Vol:**	**Measurement method:**
Methane CH_4:		
Ethane C_2H_6:		
Propane C_3H_8:		
Butane C_4H_{10}:		
Pentane C_5H_{12}:		
Hexane C_6H_{14}:		
Carbon monoxide CO:		
Hydrogen H_2:		
Carbon dioxide CO_2:		
Nitrogen N_2:		
Oxygen O_2:		
Miscellaneous:		

Additional information

Trace elements:		**Quantity:**	**mg/10kWh:**	**Measurement method:**
Ammonia NH_3:				
Total chlorine:				
Total fluorine:				
Hydrogen sulphide H_2S:				
Total silicon-organic compounds:				
Total sulphur:				
Dust volume	< 3 µm			
	> 3 µm			

Other information:

GE Jenbacher recommends that you only use analysis institutes with which it is familiar.

4. Appendix I / Explanatory notes:

4.1 Remarks:

Unlike petrol and diesel fuels, gaseous fuels generally do not have to comply with strict specifications or classifications. In principle, all gaseous fuels which can be used in combustion engines can be classified as “fuel gases”.

The physical and chemical characteristics of gaseous fuels can vary enormously. However, from the point of view of construction and operating processes, the engines are designed to function within a very strict range of characteristics and are often very sensitive to changes to these characteristics.

The engine system is optimally designed to accommodate the contractually defined fuel-gas composition for which it was sold. If significant changes occur, particularly where fuel gas limit levels are exceeded, this can have an adverse effect on engine operation.

If it becomes clear or if the possibility exists that changes will occur in the fuel gas characteristics in the course of time, the customer should notify GE Jenbacher accordingly.
The limit levels specified in this TI are based on GE Jenbacher's extensive experience and offer a basis for uninterrupted operation.

GE Jenbacher offers its customers comprehensive information and advice.

4.2 Fuel gas composition and characteristics:

Fuel gases are normally made up of several components which can be divided into two classes, i.e. main components and trace elements.

The main components determine the relevant fuel characteristics for the physical engine operation (e.g. calorific value, combustion air ratio, combustion temperature, laminary flame propagation speed, ignition limits, knock resistance). These are usually expressed as % Vol.

Trace and accompanying elements usually enter the gas during the gas formation process. They are usually impurities in the ppm range. Unlike the effects of main components, the effects of trace or accompanying elements do not become noticeable until the engine has been operational for a certain time (cumulative effect).

As these effects are usually negative, fuel gases should be free of trace and/or accompanying elements. Where very substantial amounts of accompanying elements are present, a suitable fuel gas cleaning system is the best method for guaranteeing efficient use of the fuel gas.

To determine the suitability of a fuel gas for use in combustion engines, comprehensive knowledge of the gas analysis is required.

Practical experience shows that even results which were obtained in the same operating conditions can vary substantially. The effect of trace elements can therefore only be predicted to a certain extent, as very complex interrelationships and cause/effect relationships are often involved.

GE Jenbacher cannot honour warranty claims relating to problems caused by exceeding one or more of the limit levels specified in this TI.

4.2.1 Main components:

Apart from a number of limiting conditions relating to the data sheet, the technical specifications also contain the fuel gas type.
In cases where the available fuel gas does not conform to what is stated in the standard product range, a special - client-specific - solution can be arranged, taking into account all technical and efficiency-related options.
The composition of some gas types (e.g. landfill gases, pyrolysis gas, mine gas, etc.) can vary substantially. In Leanox-controlled engine operation (under load) these variations can largely be compensated for by the engine management. In order to guarantee a satisfactory starting behaviour, however, for certain ranges the engine management must have available suitable/usable information (e.g.: calorific value, CH4 content) on the current gas quality.

4.2.2 Trace and accompanying elements:

In principle, the effects of trace elements are proportional to the total amount of elements that were fed into the engine during the operating time. When using a fuel gas with a high calorific value, the gas flow to the engine is smaller compared to a gas with a lower calorific value. As a result, the amount of trace elements fed into the engine - and therefore their effect - differs in the event of identical concentrations of trace elements in the fuel gas. In order to be able to compare various gases, the trace element concentration values must be compared to a certain fuel gas energy amount (the fuel gas output required to generate a certain engine output is very similar for all gas types).
GE Jenbacher has therefore set the energy content of 1 standard cubic metre of methane to 10 kWh (rounded off).

5. Appendix II / Determining silicon-organic compounds in landfill gas, sludge gas and biogas:

5.1 Remarks:

Silicon-organic compounds are found in fuel gases from landfills, water purification plants and biogas installations (depending on the source of the biomass). When using these fuel gases in combustion engines, silicon oxide is produced (quartz particles), which may result in increased maintenance of the machinery and, in certain cases, in the deactivation of an exhaust gas catalytic converter.

While the tried and tested GE Jenbacher interchangeable active carbon system effectively removes these compounds from sludge gas and biogas, any decision to use this cleaning technique for landfill gas should be taken on a case-by-case basis.

The silicon load is monitored during operation of the plant using the silicon limit level referred to in section 2. Strict adherence to this limit level forms the basis for the validity of a service contract. This limit level is, however, not the actual value of the silicon load, but represents the cumulative silicon input for the operating period.

Particularly in the case of fuel gases from landfill sites, GE Jenbacher's advice is to analyse the silicon-organic compounds in the preparatory project phase in order to estimate the expected level of maintenance operations. The analysis results also provide GE Jenbacher with a framework on which to base its advice for the best gas-cleaning method, taking into account feasibility and efficiency aspects.

The sampling and analysis of silicon-organic compounds in the usual concentrations found cannot be regarded as being a readily available state-of-the-art technique. GE Jenbacher offers its customers a tried and tested analysis technique which the company has developed itself. The sampling should only be performed by trained specialist GE Jenbacher staff.

Section 5.1.1 explains the limiting conditions required for sampling and analysis to yield practical results. Section 5.1.2 contains general information regarding silicon-organic compounds that are relevant to the operation of engines using the above-mentioned gases.

5.1.1 Requirements for sampling and the selection of the sample location:

Any determination of silicon-organic compounds is always a random indication. Sampling can only yield suitable results if the fuel gas source to be sampled meets the following criteria:

1. The sampling location must be in a part of the gas line with a constant gas flow and must be **free of condensate**. Up or downward pipe sections are well suited for this purpose. In the case of horizontal pipe sections, the sampling location must branch off upwards, otherwise condensate will collect in the branches. This would distort the sampling result even if the condensate had been drained and the gas appeared dry to the naked eye.

2. The fuel gas supply must have been up and running without interruption for at least three (3) hours. The gas volume flow must be at least 75% of the operational gas flow that would be needed when the planned gas engine system was operating at full load. With gas lines having a reduced flow during sampling, there is a risk of measurement errors when trace elements condense on cold surfaces and/or when silicon-organic compounds are absorbed into other condensed trace elements.

3. The sampling location should preferably be in the pressurised part of the fuel gas line before the planned engine. However, sampling in negative pressure lines is also possible.

4. During this period, landfill gas plants require the suction pressure to be approximately the same as the suction pressure during the planned full-load operation. Landfill sites which produce no gas flows in the volumes required for the planned engine operation cannot be sampled satisfactorily. In the case of landfill sites, suitable samples can only be taken in a gas collecting line. Sampling from individual sources will not yield results that can be used as described in this Technical Instruction.

5. In order to ensure that the trace element load in the fuel gas is as consistent as possible, none of the settings of the operational gas plant should be altered during sampling.

5.1.2 Silicon-organic compounds:

Siloxanes, silanes and silanoles all belong to the silicon-organic compound group. Siloxanes are increasingly used in cosmetics, detergents and as anti-foaming agents in industry. The other substances enter the fuel gas as siloxane decomposition products. These are combustible and very volatile substances that originate from watery systems (sludge, fermenters, waste-dump leach water). The following eight individual components have proven to be the main components when estimating the silicon-compound content in fuel gas originating from

- landfill sites for domestic waste,
- waste treatment plants, mainly processing domestic waste water,
- biogas plants, depending on the origin of the biomass.

In the case of gases originating from landfills where intermediate products from silicon chemical processes are dumped, or originating from waste treatment plants into which silicon-containing waste water is discharged, a laboratory analysis is used to check these for other silicon-organic compounds. The list below describes the minimum scope of the analysis.

Description:	Abbreviation:	Molecule formula:	CAS No.:	Proportion of Si atoms in the molecule [g/g]:
Tetramethysilane	TMS	$Si\text{-}(CH_3)_4$	75-76-3	0.319
Trimethylsilanole	MOH	$Si\text{-}(CH_3)_3\text{–}OH$	1066-40-6	0.312
Hexamethyldisiloxane	L2	$Si_2\text{-}O\text{-}(CH_3)_6$	107-46-0	0.347
Hexamethylcyclotrisiloxane	D3	$Si_3\text{-}O_3\text{-}(CH_3)_6$	541-05-9	0.380
Octamethyltrisiloxane	L3	$Si_3\text{-}O_2\text{-}(CH_3)_8$	107-51-7	0.357
Octamethylcyclotetrasiloxane	D4	$Si_4\text{-}O_4\text{-}(CH_3)_8$	556-67-2	0.380
Decamethyltetrasiloxane	L4	$Si_4\text{-}O_3\text{-}(CH_3)_{10}$	141-62-8	0.362
Decamethylcyclopentasiloxane	D5	$Si_5\text{-}O_5\text{-}(CH_3)_{10}$	541-02-6	0.380

The total of the silicon-organic compounds contained in the fuel gas is used to calculate the total silicon atoms contained in the fuel gas in [mg/Nm³].
Together with the methane value, this value can be converted into the content of silicon atoms from silicon-organic compounds in [mg/10 kWh] (as stated on page 3). This value is the relevant value for estimating the maintenance level required by a gas engine.

Example:

Description	Analysis result [mg/Nm³]	Proportion of Si atoms in the molecule [g/g]	Silicon atoms [mg/Nm³]
Tetramethysilane	<0.1	0.319	0.0
Trimethylsilanole	3.3	0.312	1.0
Hexamethyldisiloxane	6.1	0.347	2.1
Hexamethylcyclotrisiloxane	0.3	0.380	0.1
Octamethyltrisiloxane	0.8	0.357	0.3
Octamethylcyclotetrasiloxane	2.2	0.380	0.84
Decamethyltetrasiloxane	0.4	0.362	0.145
Decamethylcyclopentasiloxane	1.6	0.380	0.6
Total silicon atoms [mg/Nm³]			**5.1**

Given a methane content of 55 % Vol in the fuel gas, this would result in:

$$\frac{(5.1 \text{ mg silicon atoms / Nm}^3 \times 100\%)}{(55\% \text{ methane content})} = 9.2 \text{ mg silicon atoms / 10kWh.}$$

This value is the relevant value for estimating the maintenance level required by a gas engine.

1. Importance of Measures for Electromagnetic Compatibility (EMC):

Cabling and grounding concept are the elements in a system that are mainly responsible for a sufficient decoupling between the present interference source and the potentially susceptible devices.

For this reason, any measures taken to eliminate defects must principally involve the wiring and the grounding concept.

2. Interference Measures:

2.1 Grounding of the Inactive Metal Parts:

An important factor for the interference-free structure is a well installed grounding.
Grounding refers to the conductive connection of all inactive metal parts (VDE0160).
Basically, the principle of surface grounding is to be applied.
All conductive inactive metal parts must be grounded!

The following must be observed when grounding:

All ground connections must be effected low-impedance.

All metal parts are to be connected in large-surface form.
Always use for the connection extremely broad grounding strips. Not only the cross-section is of primordial importance, also the surface of the ground connection
(As a rule, do not use aluminum, danger of oxidation!)

Screwed connections must always be executed with lock washer or serrated lock washer.

2.2 Shielding of Devices:

Cabinets and housings are included for the shielding of the controls. Please observe the following notes:

Cabinet covers, as side walls, rear walls, roof and ground sheets must be contacted in a sufficient distance in overlapping arrangement.

Doors must be connected additionally with the cabinet grounding by way of contacting measures. To do so, use several grounding strips.

Lines exiting from the shielding housing must be shielded or laid through a filter.

If there are sources of strong interference influence in the cabinet, these must be isolated from sensitive electronic parts with sheets. These sheets must be screwed in a low-impedance manner several times with the cabinet grounding.

The interference voltages which are coupled into the automation device via signal and supply lines are deflected to the central grounding point (standard mounting rail).

The central grounding point must be connected with the PE bus (grounding rail) with low-resistance and with a short Cu-conductor ≥ 10 mm² [0,0155 square inch].

2.3 Shielding of Lines:

Cables with braided shields must be used!
As a rule shielded lines must always be connected with the cabinet potential in a well conductive manner on both sides. A proper interference suppression of all coupled frequencies can only be achieved with a shielding on both sides. Place the shielding on the shielding bus over a large area and then lead it to the components.

The interference currents on cable shieldings will be deflected to the ground at SPC's via the shield bus and then via the equipotential bonding conductors. To make sure that these deflected currents do not turn into sources for interference themselves, note the following for a low resistance and low impedance path of the interference currents.

Tighten tightening screws from cable plugs, components and equipotential bonding conductors.

Protect resting surfaces of equipotential bonding conductors from corroding.

Lay equipotential bonding conductors as short and as directly as possible.

2.4 Wiring Arrangement:

2.4.1 Wiring Arrangement Within Cabinets:

When cabling a cabinet the arrangement of the lines is very important for the interference immunity (electromagnetic compatibility) of the system.
The lines are divided into three wiring groups:

Wiring Groups:

Wiring Group 1:
shielded data lines (bus lines, etc.)
shielded analog lines
unshielded lines for direct and alternating voltages ≤ 60 V
unshielded lines for direct and alternating voltages ≤ 230 V

Wiring Group 2:
unshielded lines for direct and alternating voltages > 60 V and ≤ 230 V

Wiring Group 3:
unshielded lines for direct and alternating voltages > 230 V, and ≤1 kV (generator power cable, lines for three-phase current drives, etc.)

Wiring Arrangement:
All wiring groups must be laid **separately** in the cabinet. This means that the cable routing meets the following precautions:
separate cable canals
separate cable bundling

Note:
Between the signal lines and power cables with ≥ 115/230 VAC a minimum distance of 10 cm [3,94 in] must be maintained.

When laying shielded lines, the shield must rest on the shield reception bus on the cabinet entrance.

2.4.2 Wiring Arrangement Exterior of Cabinets:

Outside of the cabinets (however inside of buildings) place the lines on metallic cable trays. The ends of the cable trays must be connected galvanically with each other and should be connected with the station grounding at a distance of 20 m [65,6 ft] to 30 m [98,4 ft].

As a rule shielded cables must be used for analog signal lines!

Wiring Groups
Wiring Group 1 (WG1): shielded analog lines
unshielded lines for direct and alternating currents ≤ 60 V
shielded lines for direct and alternating voltages ≤230 V
Wiring Group 2 (WG2): unshielded lines for direct and alternating voltages > 60 V and ≤ 230 V
Wiring Group 3 (WG3): unshielded lines for direct and alternating voltages > 230 V and ≤ 1 kV
(generator power line, lines for three-phase current drives, etc.)

Wiring Arrangements:
Each wiring group must be laid on separate cable carriers (cable routes, cable trays, cable channels, cable ducts).

Cables of different wiring groups must be laid with a minimum distance to each other of 10 cm [3,94 in] (when placing AEG-MODICON SPC's the WG1 cable must be laid at a minimum distance of 50 cm [19,69 in] to the WG3 cables), provided that the are not laid in separate conduits or ducts or separated by extremely rigidly attached separating webs.
The minimum distances must also be observed at crossings and places of approximation.

Interference prone cables must be laid at a distance of > 1 m [3,28 ft] from interference sources (contactors, transformers, engine, electric welding devices, electric starters).
Interference prone cables are:

- bus lines
- video lines
- keyboard lines
- printer cable
- analog signalling lines

If two control components are connected by several signal cables, make sure that the distance between the cables is as short as possible.

Lay the signalling cables and pertaining equipotential bonding conductors as closely together as possible. Keep signal cable and equipotential bonding conductor **as short as possible.**

Lay, and if necessary twist, single cables pertaining to same signal (feed and return line, power supply cable) as closely together as possible.

Lay all cables as close to grounding surfaces as possible.

Avoid cable and line extensions over clamps or similar devices.

Additional instructions for laying data transfer cables. Additional Requirements for the Laying of Cables for Videos, Keyboards and Printers (Laying of Cables is Effected by GE Jenbacher):

ET100 - Bus Line:
a) separate laying from all other lines
b) distance to WG3 lines ≥ 10 cm [3,94 in]
c) grounding as close to cabinet entrance (grounding clamp) as possible; lead shield up to interference plug without grounding again. (c) will be effected by GE Jenbacher!)

Sinec L1 - Bus Line:
a) separate laying from all other lines
b) distance to WG3 lines ≥ 10 cm [3,94 in]

REMOTE I/O for dia.ne:
a) Lay all other lines separately.
b) Distance from LG2 and LG3 lines: ≥ 10cm [3,94 in].
c) Ground as close to the cabinet lead-in (ground shield) as possible. Shield must be laid to immediately before interface plug. GE Jenbacher will perform c).

Video, Keyboard and Printer Cables:
a) separate laying from all other cables
b) distance from WG3 lines ≥ 10 cm [3,94 in] (> 50 cm [19,69 in] at AEG-MOIDICON SPC's)
c) strain relief in the switch cabinet with the provided clamps. (c) will be effected by GE Jenbacher)

General Shielded Lines:
a) distance to WG3 lines ≥ 10 cm [3,94 in] (> 50 cm [19,69 in] at AEG-MODICON SPC's)
b) strain relief in the switch cabinet at the provided spots
c) shield grounding as close to cabinet entry (shield rail) as possible using the provided shield clamps (b) and c) will be effected by GE Jenbacher)

2.4.3 General wiring guidelines:

Generator power cable:
The diameter for power cables must be stipulated (or tested) by the company carrying out the work, according to VDE 298 Part 1-4 (laying method, grouping ...) or OeVE L-20 or IEC 364-5-523. Nominal generator current: I_N = ... A, at cos phi = 0.8.

All cables used must be **flexible.**

The cables used must conform to the harmonized and national standards currently in force. The cables to be laid must be appropriate to the intended use and the laying method; they must be capable of withstanding the particular local conditions.

All cable supports must be of metal (also in on-site concreted cable conduits). All the materials used for mounting (including screws) must be reliably protected against corrosion.

The cables must be numbered according to the cable list.

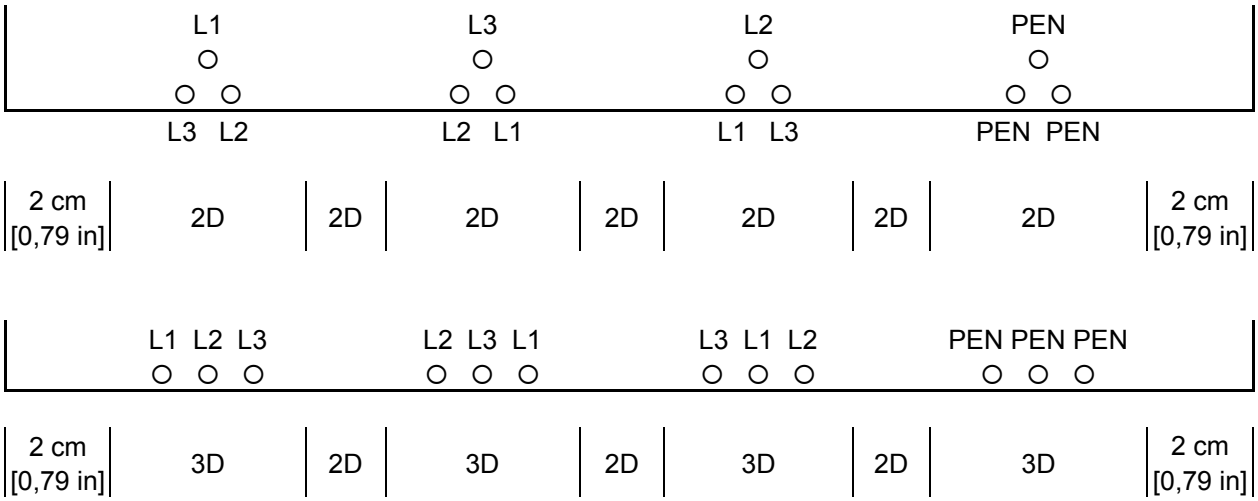
Bend radii of the cables must be taken into account.

Cable inlets must be strain-relieving. Additional strain relief must be provided if twist nipples are used.
Only one cable per bolting.
A method of protection must be chosen which is appropriate for the equipment to be connected.
Boltings at the generator must be carried out in a way suitable for the power cable being used.

Cables laid on cable boards or troughs must be laid out, fastened, made free of tension and covered with protective metal sheet where necessary. High voltage cables laid as single wires (NYY-E-YY) must be fastened so as to prevent short circuits.

Instructions for installing the cabling of the GE Jenbacher switch gear system by third-party companies.

Generator power cable:
The installation company should maintain and/or check the cable diameter for power cables in accordance with VDE 298 Part 1-4 (method of installation, number of cables ...) and/or ÖVE L-20 resp. IEC 364-5-523. Nominal generator current: I_N = ... A, at cos phi = 0.8.
(Recommended cable type for medium-voltage generators: SIEMENS PROTOLON, Type: NTMCGCWÖU).



D = cable diameter

In cable conduits and when there is an accumulation of cables in buildings the danger of fire breaking out and spreading, and the severity of the consequences if this happens, must be reduced by an appropriate choice of laying method and also by additional fire prevention measures.

An insulation check must be carried out after the work has been finished.
Insulation resistance tests in acc. with EN / IEC 60204-1 (section 18.3) and HD 60364-6 / IEC 60364-6, and local rules and regulations.
A report on the completed tests must be prepared which must contain all required test results, including information on the test equipment used.
This test report must be handed over to the customer.

⚠ **To enable insulation resistance tests at generator cables, these must be disconnected from the generator.**
This also applies to frequency converters.

The work must be carried out in such a way that all relevant regulations and standards are fully met.

The company carrying out the work must be present during the testing and commissioning of the plant in order to correct immediately any faults which may appear.

The company must take over the responsibility that their work is completely and properly carried out, i. e. any faults which appear must be put right free of charge.

All electrical plant components delivered by GE Jenbacher must be properly installed and fastened according to the installation plan, e. g. position and bolt together switching cupboards, set up batteries, mount charging equipment.

3. Grounding/Shielding Treatment on the Shield Bus:

Grounding
Grounding connection conductive with lock washer or serrated lock washer (corrosion protected) (1).

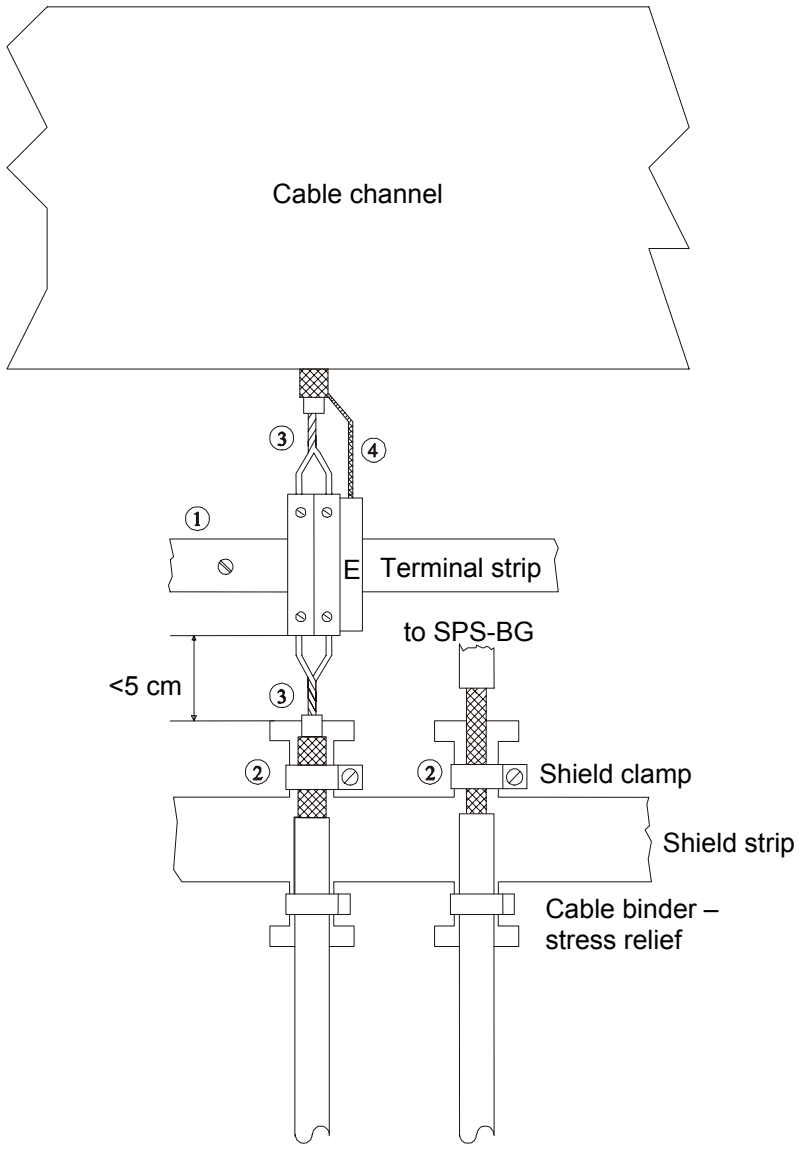
Grounding lines must be laid as directly as possible.

Partitioning with separating plates is necessary for the part of the cabinet in which the inductivities (especially transformers, valves and connectors) are mounted. Partition plates must be connected with the cabinet (ground) in a good conducting manner.

If powerful interference sources (EMC) are mounted in the cabinet (e. g. frequency converter, etc.), the shield housings of these must be connected separately with the central grounding point (> = 10 qmm) [≥AWG 7].

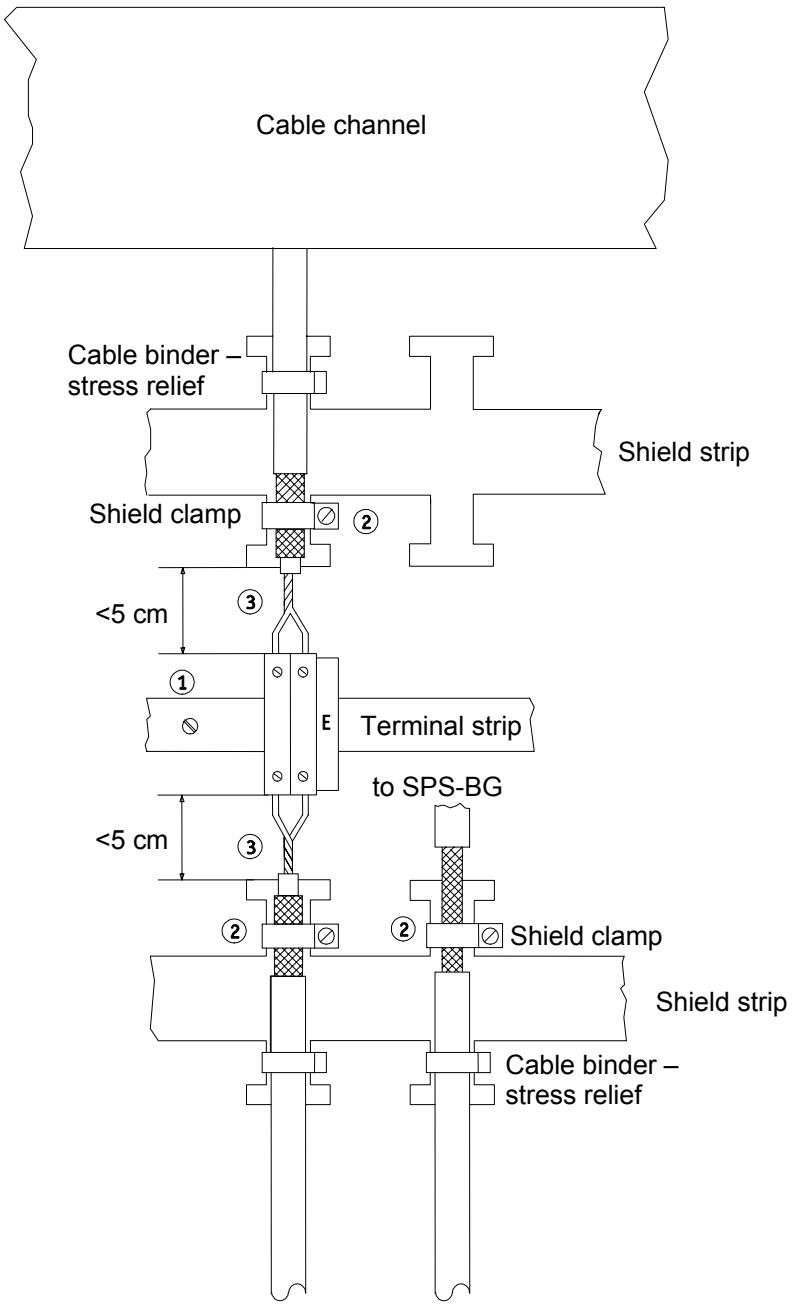
Shield Treatment on the Shield Bus
Lay shields so that they are spread out as far as possible and use suitable shield clamps.
Place shields with an as great a surface as possible with the corresponding shielding spots.
Connect shield bus in well conductive manner with assembly plate, or cabinet housing!
Braided screen or foil screen drawn back over cable insulation (2).
Twist pertaining signal feed and return lines (3).
Keep shield connection as short as possible (4).

Module Interface



Cable with shielding braid

Module control



Cable with shielding braid

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1. General:

The very low powered electronic components are especially endangered by external influences, e. g. electrostatic charges, magnetic fields, mechanical stresses etc.

2. Replacement of components:

Fundamentally, electrical connections to components must not be separated nor connected when they are current-carrying: Components may only be mounted in or dismounted when the distribution voltage for the central unit and the signal transmitteres has been disconnected.

When components are replaced, the following must be checked at any rate:

- right component type (stock number/distribution voltage)
- right connection (documentation)
- right assembly of the component (e. g. EPROMS)
- right adjustment of bridges and coding circuits (documentation)
- corresponding and valid software version

3. Operation:

If an electronic component is brought into the service room from a cooler surrounding, you must wait, according to the difference in temperature, until the moisture has dried away.

4. Handling of electrostatic sensitive devices (ESD):

4.1 Definition:

Electrostatic sensitive devices (ESD) are all electronic semiconductors and devices and components consisting of semiconductors which are not protected against charging by means of suitable housings.

4.2 Basic rules for protecting against electrostatics

a) All electrostatic sensitive devices must only be treated at a working place which is protected against electrostatics!

b) Storage and transport must only be carried out in protected packing and transportation materials!

c) Suppliers must observe these rules also, i. e. ESDs from suppliers in packings insufficiently protected against electrostatic charging must immediately be returned to the supplier.

4.3 Marking:

For the purpose of transportation, ESDs can be packed in electrostatically conductive protective coverings and marked as ESDs by means of clearly visible stickers e. g.:

Attention: Electrostatic sensitive devices (ESD)

Parts which are packed and marked in such a way must only be opened and treated by qualified personnel at

a working place which is protected against electrostatics.

4.4 Safety measures against electrostatic charging:

In order to protect a working place against electrostatics, you should prevent electrostatic charging at this place, and deviate already existing charges in a quick and safe way.

This is achieved by special conductive protection mats (connected to earth) at the working place (table/switch cupboard bottom) and by wristlets worn by the personnel (1 MOhm-safety resistance connected to earth).

1. Scope:

Testing the protection against shock currents (protective arrangements) when installing electrical equipment with nominal voltages of up to ~ 1000 V.

2. General:

All equipment, during installation and/or at completion of installation must be inspected and tested before it is commissioned by the user and measurements must be carried out.
The protective arrangements must be checked before the installation is first commissioned (original inspection) and before re-commissioning.

It is stressed that all regulations for the protective arrangements (hitherto nationally controlled) must be adhered to.

All those companies or operatives engaged in the setting up or installation of the aforesaid systems, who are subject to legislation apart from that of Austria, must of course, act strictly according to the regulations by which they are bound.
Furthermore, it is emphasised that the first electrical commissioning, especially the protective arrangements check, may only be carried out by appropriately trained technicians.

3. Protective arrangements - classification and use:

The protective arrangements are classified as those which offer protection against direct contact (basic protection) and those which offer protection against indirect contact (fault protection) and additional protection.

3.1 Protection against direct contact:

In the case of normal electrical equipment, protection against live parts is achieved by combining protection by insulation and protection by covering. It must only be possible to open or remove covers using a tool or key, unless either the equipment is shut down before the covers are opened or removed, or there are additional suitable barriers inside.

3.2 Protection in the case of indirect contact:

This form of protection, which should prevent dangerous voltages from coming into contact with parts which should not normally carry operational voltages but which have been made live through damage to the basic insulation, may be classified as follows:

Protective arrangements without earth-protection conductor:
- Protective insulation
- Safety extra-low voltage (Functional extra-low voltage)
- Protective isolation of one piece of equipment or of several pieces of equipment with equipment bonding conductors

Protective arrangements with earth-protection conductor:
- Protective earth
- Protective multiple earthing, neutralisation
- Current-operated earth-leakage circuit-breaker system
- Protective conductor system

Systems supplied by GE Jenbacher are always prepared with protective arrangements in the form of protective conductors. The choice of fault protection is determined by the local conditions. The on-site power supply in particular is a decisive factor in the choice of protective arrangements which may be used in the case of indirect contact. In relation to neutralisation, this situation must be emphasised, especially, because the neutralisation conditions in the distribution network and the consumer unit also have to conform to the regulations. Whether this is the case in the distribution network and neutralisation may be used, can only be decided by the electricity supply company responsible.

If, in the case of special types of electrical equipment or electrical operating areas, there are additional or more stringent stipulations or exceptions contained in the applicable regulations at any time, then these take precedence over the general regulations in this situation.

4. Reference sources:

- ÖVE-EN 1 Teil1/1989, Teil 1a/1992, Teil 1b/10.95 (ÖVE-EN 1 Part 1/1989, Part 1a/1992, Part 1b/10.95)
- VDE 0100 Teil 410/01.97 (VDE 0100 Part 410/01.97)
- VDE 0100 Teil 610/04.94 (VDE 0100 Part 610/04.94)
- EN 60 439 Teil 1(EN 60 439 Part 1)
- Fachbuch "Schutz gegen gefährliche Körperströme und gegen Überspannungen" - Bieglmeier/Mörx - siebente Auflage (Reference book: "Protection against shock currents and overvoltages" - Bieglmeier/Mörx -seventh edition)

The target recipients of this document are:

Customer, Service Partner, Commissioning Partner, Subsidiaries/Branches, Location Jenbach

1 General

When selecting a lubricating oil suitable for use in GE Jenbacher gas engines, account must be taken of the engine's requirements and the requirements related to the fuel gas and - possibly - the exhaust gas treatment unit.

2 Effects on the lubricating oil and the oil service life

Fuel gases contain trace and accompanying elements which can cause deposits in the combustion chamber, acid attack of components and wear.

Experience shows that the following harmful substances have the greatest effects on the lubricating oil and the oil service life:

Chlorine, fluoride, sulphur cause the lubricating oil to acidify, and
Organic silicon compounds cause wear.

Accordingly, fuel gases can be divided in the following classes:

- **Class A: Class A: natural gas and gases that permanently fulfil the limitations regarding trace and accompanying elements in acc. with TI 1000-0300, TI 1000-0301 and TI 1000-0302**
  Natural, Associated Petroleum, mine gas, biogas (sulphur < 200 mg/10 kWh), special gases (thermoselect and steel plant gases).
- **Class B: gases containing acid-forming trace elements or trace elements that primarily affect the oil condition**
  Biogas, sludge gas, wood gas and/or pyrolysis gases.
- **Class C: gases containing acid-forming trace elements and additional trace elements causing wear**
  Landfill gas

Lubricating oil can lose its corrosion protection characteristics due to impurities in the fuel gas. The results of regular lubricating oil analyses are indicative of fuel gas impurities. In this respect, please refer to the following Technical Instructions:

TI no. 1000-0112

TI no. 1000-0099 A, B, C, D and K.

3 Lubricating oil requirements for GE Jenbacher type 2 and 3 engines

SAE 40

additives suitable for spark-ignition gas operation.

Release procedure successfully completed in acc. with TI 1000-0099A.

Selection overview

A, B, C:	Class fuel gas
[CAT]:	with catalytic converter for formaldehyde conversion included in GE Jenbacher scope of supply

	A	B	C	[CAT]
Mobil	Pegasus 705 Pegasus 805 **Pegasus 1005****	Pegasus 710	Pegasus 610	Pegasus 705
bp	Energas NGL	Energas NGL Energas LFM	Energas LFM	
Castrol	Duratec L	Duratec L Duratec MX	Duratec MX	
Shell	Mysella LA 40 **Shell Mysella XL 40***	Mysella MA 40	Mysella MA 40	Mysella LA 40 Mysella XL
PETRO-CANADA	**Sentron LD 5000***			
Chevron	Geotex LA SAE 40 HDAX Low Ash Gas Engine Oil SAE 40	HDAX LFG Gas Engine Oil SAE 40	HDAX LFG Gas Engine Oil SAE 40	HDAX Low Ash Gas Engine Oil SAE 40
Texaco	Texaco Geotex LA SAE 40 Texaco HDAX Low Ash Gas Engine Oil SAE 40	Texaco Geotex LF SAE 40 Texaco HDAX LFG SAE 40	Texaco HDAX LFG SAE 40	Texaco HDAX Low Ash Gas Engine Oil SAE 40
CALTEX	Geotex LA SAE 40 HDAX Low Ash Gas Engine Oil SAE 40	Geotex LF SAE 40 HDAX LFG Gas Engine Oil SAE 40	HDAX LFG Gas Engine Oil SAE 40	HDAX Low Ash Gas Engine Oil SAE 40

	A	B	C	[CAT]
TOTAL	Nateria MH 40	Nateria ML 406		
FUCHS	Titan Ganymet LA Titan Ganymet Ultra	Titan Ganymet plus Titan Ganymet Ultra	Titan Ganymet	
CEPSA	Troncoil Gas 40			
OMV	LEG 40	Gas HD 40		
Agip		AUTOL BGJ 40		
Q8 Oils	Mahler G4	Mahler HA	Mahler HA	
REPSOL	**Long Life Gas 4005*** Super Motor Gas 4005			
ROLOIL	Mogas G4	Mogas AC-40	Mogas AC-40	
Roloil	Mahler G4	Mahler HA	Mahler HA	
ADDINOL	MG 40 extra LA	MG 40 extra plus		

	A	B	C	[CAT]
NILS		Burian SAE 40		
ENEOS	NOC ENEOS M40(M)			
TECTROL	Methaflexx NG Methaflexx HC Premium	Methaflexx HC plus Methaflexx HC Premi-um	Methaflexx D	
SRS SCHMIERSTOFF VERTRIEB GMBH		Mihagrun 40		
Valvoline.	GEO LA 40			
CENEX		NGEO 2500 MA		
Zeller+Gmelin Printing Inks	Divinol Spezial Typ 4 SAE 40	Divinol Spezial HA SAE 40	Divinol Spezial HA SAE 40	
AVIA		Gasmotorenöl HA SAE 40		
EUROLUB OIL · CHEMIE · CARCARE	Gasmotorenöl HGM SAE 40			

** **Mobil Pegasus 1005** is suitable for prolonged oil-change intervals. Can be assessed following increased oil-limit values (see TI 1000-0099B).

* **Shell Mysella XL SAE 40** is suitable for prolonged oil-change intervals.

* **Petro Canada Sentron LD 5000** is suitable for prolonged oil-change intervals.

* **Repsol Long Life Gas 4005** s suitable for prolonged oil-change intervals.

4 Lubricating oil requirements for GE Jenbacher type 4 engines:

SAE 40

additives suitable for spark-ignition gas operation.

Release procedure successfully completed in acc. with TI 1000-0099A.

Selection overview

A, B, C:	Class fuel gas
[CAT]:	with catalytic converter for formaldehyde conversion included in GE Jenbacher scope of supply

	A	B	C	[CAT]
Mobil	Pegasus 705 Pegasus 805 Pegasus 1005	Pegasus 705 Pegasus 805	Pegasus SR Pegasus 605	Pegasus 705
bp	Energas NGL	Energas NGL		
Castrol	Duratec L	Duratec L		
FUCHS	Titan Ganymet Ultra			
	Mysella LA 40			Mysella LA 40
ENEOS	NOC Eneos M40(M)			
Q8 Oils	Mahler G4	Mahler G4		
REPSOL	Long Life Gas 4005 Super Motor Gas 4005			

	A	B	C	[CAT]
ROLOIL	Mogas G4	Mogas G4		
Roloil	Mahler G4	Mahler G4		
TECTROL	Methaflexx HC Premium			
TOTAL	Nateria MH 40	Nateria MH 40	Nateria MH 40	
Valvoline.	GEO LA 40			
OMV	Gas LEG 40			
Zeller+Gmelin	Divinol Spezial Typ 4 SAE 40	Divinol Spezial Typ 4 SAE 40		

5 Lubricating oil requirements for GE Jenbacher type 6 engines:

SAE 40

additives suitable for spark-ignition gas operation.

Release procedure successfully completed in acc. with TI 1000-0099A.

Selection overview

A, B, C:	Class fuel gas
[CAT]:	with catalytic converter for formaldehyde conversion included in GE Jenbacher scope of supply

	A	B	C	[CAT]
Mobil	Pegasus 705 Pegasus 805 Pegasus 1005	Pegasus 705 Pegasus 805	Pegasus SR Pegasus 605	Pegasus 705
bp	Energas NGL	Energas NGL	Energas NGL	
Castrol	Duratec L	Duratec L	Duratec L	
	Mysella LA 40 Mysella XL			Mysella LA 40
PETRO-CANADA	Sentron LD 5000			
Chevron	HDAX Low Ash SAE 40			HDAX Low Ash SAE 40
	HDAX Low Ash Gas Engine Oil SAE 40			HDAX Low Ash Gas Engine Oil SAE 40
TECTROL	Methaflexx HC Premium			
TOTAL	Nateria MH 40	Nateria MH 40	Nateria MH 40	
FUCHS	Titan Ganymet Ultra			

	A	B	C	[CAT]
CALTEX	HDAX Low Ash Gas Engine Oil SAE 40			HDAX Low Ash Gas Engine Oil SAE 40
Q8 Oils	Mahler G4	Mahler G4		
REPSOL	Long Life Gas 4005 Super Motor Gas 4005			
ROLOIL	Mogas G4	Mogas G4		
Roloil	Mahler G4	Mahler G4		
ENEOS	NOC ENEOS M40(M)			
OMV	Gas LEG 40			
Zeller+Gmelin	Divinol Spezial Typ 4 SAE 40	Divinol Spezial Typ 4 SAE 40		

6 Revision code

Revision history

Index	Date	Description/Revision summary	Creator *Auditor*
7	30.05.2011	Pos. 3 Treibgas Klasse A / Point 3 Class A fuel gas Produkt / Product "Fuchs, Repsol, Tectrol, Total und/and Adinol". Treibgas Klasse B / Class B fuel Produkt / Product "Fuchs und/and Tectrol". Pos. 4, 5 Treibgas Klasse A / Class A fuel gas. Produkt / Product "Fuchs, Repsol, Tectrol, Total und/and Adinol". Treibgas Klasse B, C / Class B, C fuel Produkt / Product "Total".	**Bilek** *Chvatal Susanne*
6	21.02.2011	Pos. 3 Treibgas Klasse B / Point 3 Class B fuel gas. Produkt / Product Fuchs	**Bilek** *Chvatal Susanne*
5	30.10.2010	BR 2,3 Produkt "Fuchs" Treibgasklasse B / BR 4,6 Produkt "Mobil" Treibgasklasse C / type 2, 3 Product "Fuchs" Class B fuel gas / type 4, 6 Product "Mobil" Class C fuel gas	**Bilek** *Chvatal Susanne*
4	15.10.2010	Entwicklungsfreigaben/Development release: 071_2010-NOC ENEOS M40(M) BR/type 6	**Bilek** *Chvatal Susanne*
3		Treibgasklasse A/Class A fuel gas. 059_2010-Cenex, NGEO 2500 MA BR/ type 2,3 Treibgasklasse B/Class B fuel gas.	
2		087_2010 - OMV Gas LEG 40 BR/type 2,3,4,6 Treibgasklasse A/Class A fuel gas.	
		Freigabe - Mittlg / release No. 035/2010 Neu/new: Zeller/Gmelin, AVIA, Eurolub	
1	26.05.2010	Change to **C**ontent **M**anagement **S**ystem /replaced Index: **c**	**Schartner** *Giese*

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1 Tips

Anlagenspezifische technische Bedingungen: siehe jeweilige techn. Spezifikation.

The limit levels for harmful emissions guaranteed in the technical specification can be met only at a load of between 50% and 100%.

The values in the Technical Instruction applicable to the device must be observed and maintenance must be carried out regularly and expertly.

2 Potentially explosive atmospheres

GE Jenbacher Jenbacher products are generally **not** intended or suited to be used in surroundings in which there is a risk of explosion.

3 EMERGENCY STOP

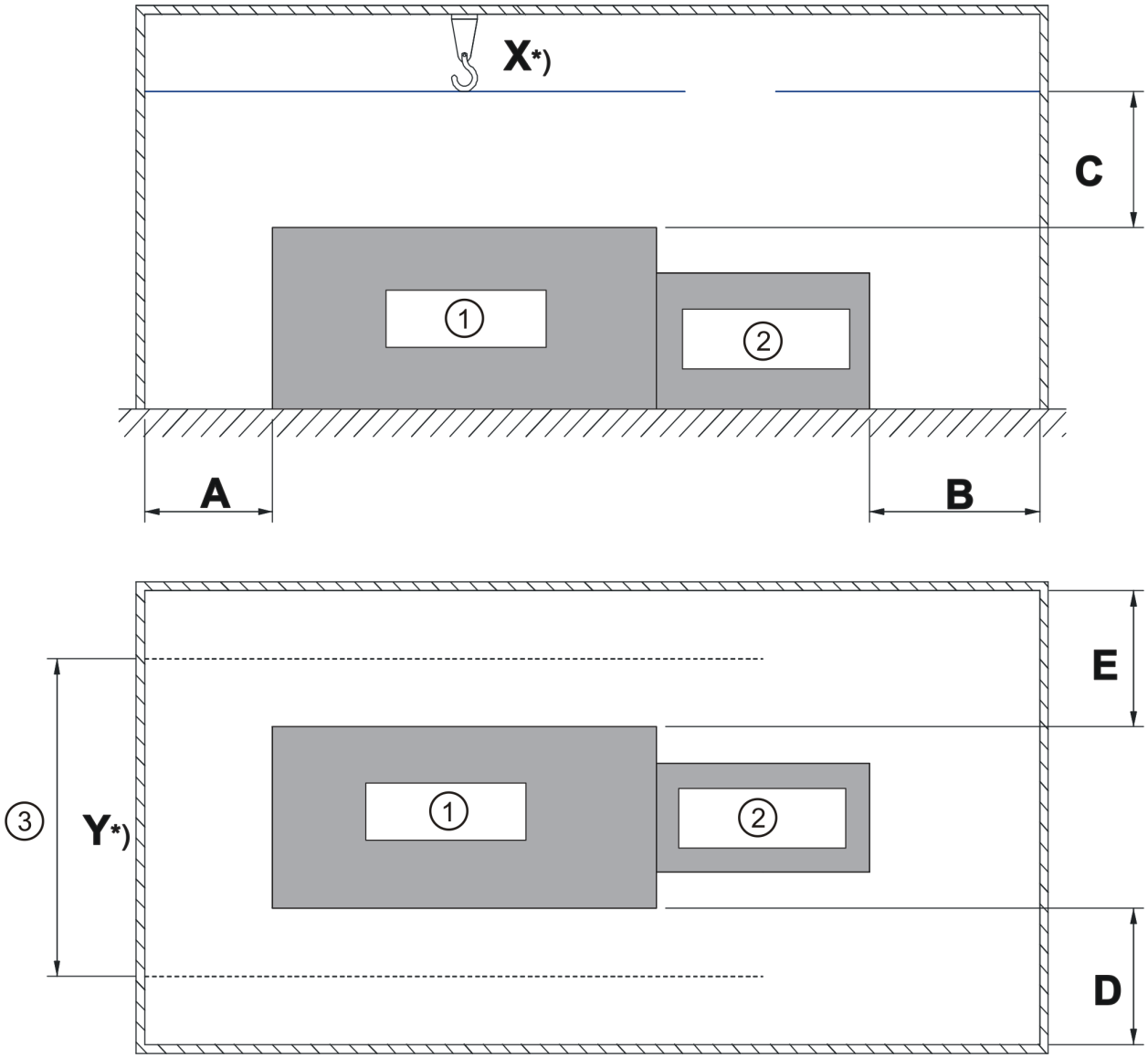
When installing Jenbacher modules, a manually-operated emergency stop facility (EMERGENCY STOP button) must be fitted on the **customer side** - on the inside and outside of the engine room - **and integrated into the Jenbacher control system.**

When installing Jenbacher container modules, a manually operated emergency stop facility (EMERGENCY STOP button) must be fitted on the customer side - on the outside of the container - and integrated into the Jenbacher control system.

The EMERGENCY STOP buttons must comply with the requirements of ISO 13850 and IEC 60947-5-5.

4 Minimum clearance to be left around the module for maintenance work

The lifting capacity of the crane, minimum travel for the crane and minimum clearance around the module as detailed below must be taken into account in the planning of the engine room. It must be possible to remove the generator from the engine room. When installing equipment in the engine room, you must allow space for the crane to operate and ensure there are freely accessible areas. If necessary, contact GE Jenbacher for advice.



①	Engine	**X*)**	Crane - max load.
②	Generator	③	Min. travel distance for crane*)

	A*)	B*)	C	D*)	E*)	X*)	Y´*)
J 208	1000 mm	1000 mm	1500 mm	1000 mm	1000 mm	100 kg	-
Engine type 3,4	1000 mm	1000 mm	1500 mm	1000 mm	1000 mm	500 kg	1600 mm
Engine type 6	1500 mm	1000 mm	1500 mm	1000 mm	1000 mm	1000 kg	1600 mm
J 624 TSTC	1500 mm	1000 mm	1500 mm	1000 mm	1000 mm	1000 kg	25000 mm

Y*) type 3, 4 and 6 engines: Crane on 2 overhead rails running above the cylinder heads. The overhead rails must be designed such that heavy machine parts can be moved at least up to the footboards and/or to the rear into the direction of the generator. The dimension specified is the ideal dimension for the rail distance.

X*) The stated weight is the minimum crane load capacity (not including the generator).

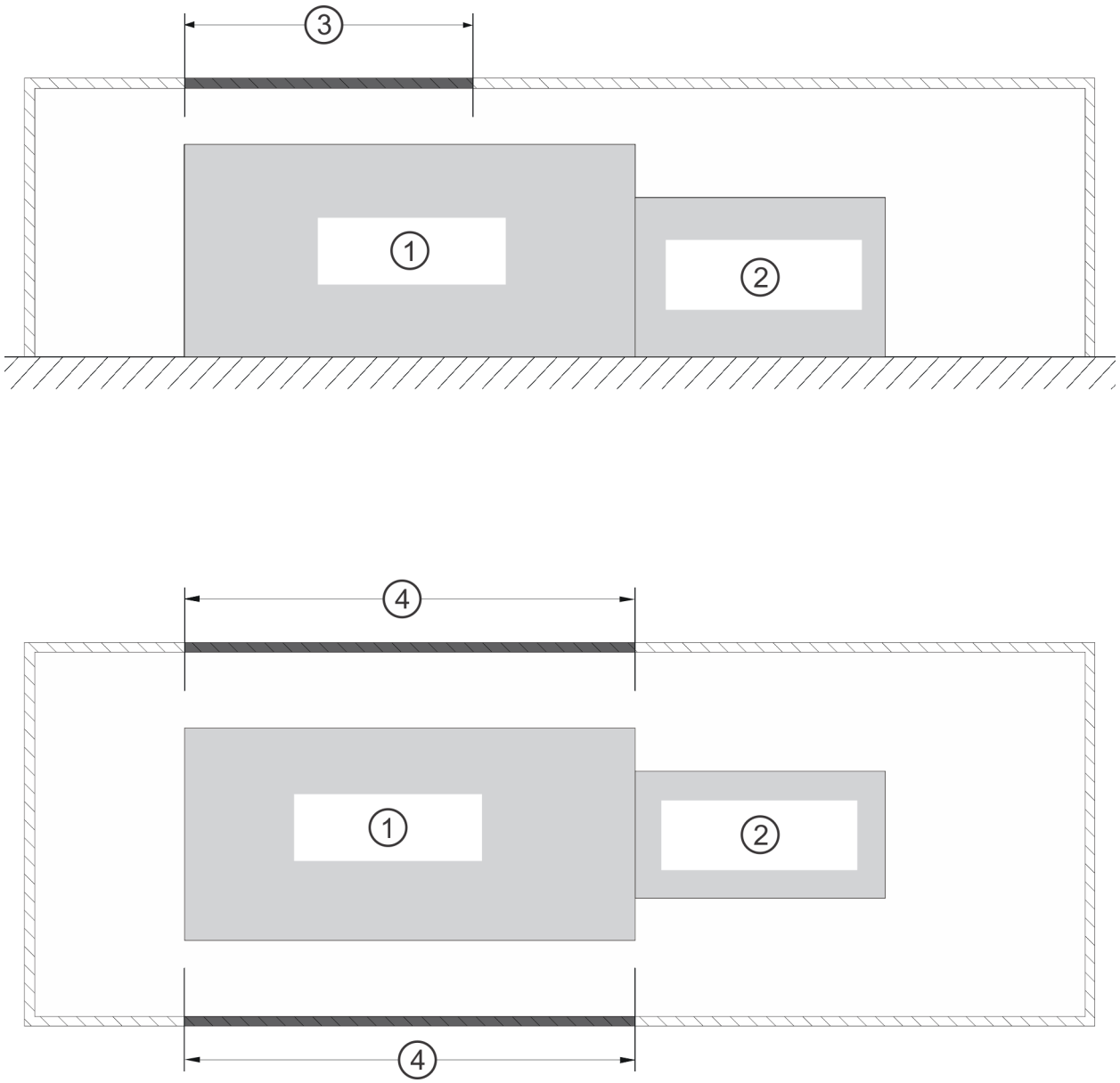
J 208: An overhead crane (trolley) with a rails above the cylinder heads would be helpful, but is not necessary.

A, B, D, E*): The dimensions specified are the minimum dimensions. Make sure that not on all sides of the engine only the minimum dimensions are maintained. Enough room must remain on one side to be able to store any disassembled parts during a revision.

It must be possible to position the engine type 6 cylinder heads and/or turbochargers and mixture coolers (for all engine types) which are disassembled at their temporary storage location or on pallets!

Not possible to maintain the minimum clearances?

If the minimum clearances around the module cannot be maintained in the engine room, openings must be provided in the engine room as shown in areas ③ and ④ in the illustration below to permit maintenance work to be carried out on the engine, and removed parts to be brought out.



①	Engine
②	Generator
③	Place for an opening for heavy engine parts
④	Place for an opening to the side of the engine

5 Gas and smoke alarm installation

GE Jenbacher requires a gas and smoke alarm with an acoustic alarm (alarm horn) to be installed.

It is the operator's responsibility to install a gas and smoke alarm system in the engine room in accordance with official regulations.

The number of sensors used must satisfy at least the minimum requirements laid down in this TI.

- Natural gas: at least 1 sensor per engine
- Non natural gas: at least 2 sensors per engine
- CO in fuel gas: The number of CO sensors must be specified specifically for each plant (at least 2 sensors per engine)

The sensors must be suitable for the gas components (taking toxicity into account!). Note the results of the gas analyses!

Take into account the following fundamental principles when determining the installation location for the gas-alarm sensors:

- If the engine is run on natural gas, a sensor must be placed above the gas train.
- If the engine is run on a gas other than natural gas (non-natural gas), at least 2 sensors must be installed. 1 sensor at ground level and 1 sensor above the gas train.
- If the fuel gas contains CO, CO sensors must be installed if:
  - the gas is odourless and the **CO content** of the fuel gas is **> 0%**.
  - the gas contains **odorants** and the **CO content** of the fuel gas is **> 0.5%**.

  CO sensor(s) in areas where people work, especially hazardous areas (next to components containing gas) and CO sensor(s) in areas without air flow (insufficient ventilation).
  The sensors must be installed at breathing height.

5.1 Exhaust, breather and air-bleed lines in the fuel-gas system

Gas can flow out around the outlet area of the pipes!

Breathing lines from the controller, air-bleed lines from the leak tester and exhaust lines should not be routed together and must be terminated outside the engine room to the open air. The diameter of the lines must be selected in accordance with local conditions (because of pressure loss over length, angulations, etc.).

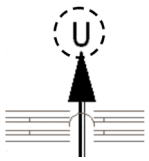
The gas exhaust line is not supplied by GE Jenbacher. The design of a permanently technically leakproof, well-made gas exhaust line (e.g. to TRBS2152/Part 2) is the responsibility of the plant planner/builder.

Gas leaks at the outlet of air-bleed lines must be taken into account.

The outlet area of the lines must be evaluated and designed in accordance with current local regulations (e.g. 94/9/EG, IEC 60079, EN 1127-1).

Example of a high-pressure gas train (inlet gas pressure exceeding 499 mbar):

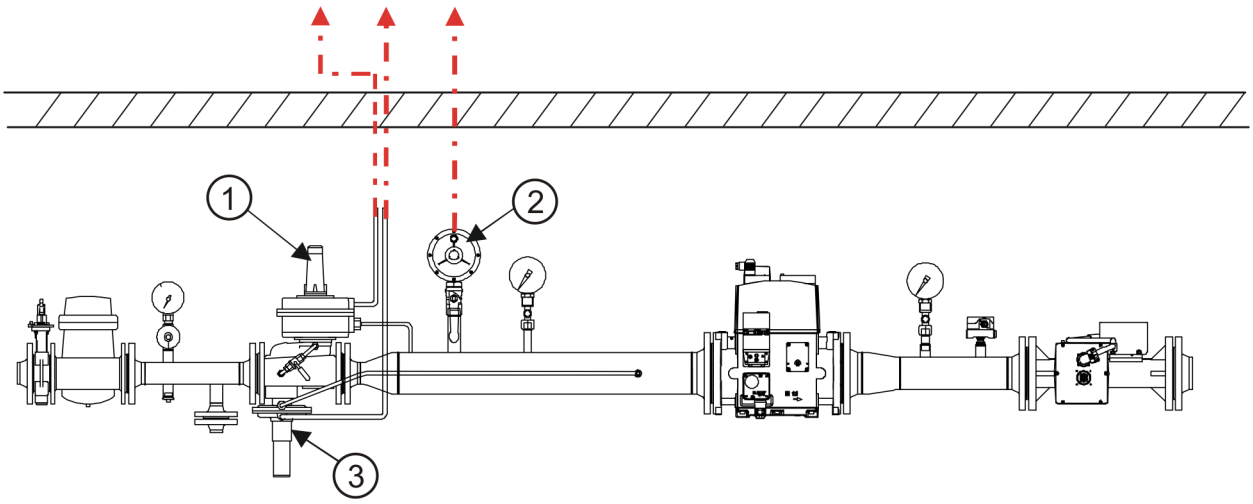
Details of the exact points at which gas should be exhausted can be found in the plant-specific technical diagram.



Symbol used in the technical diagram

Terminate exhaust, breather and air-bleed lines outside the engine room!

Gas can flow out around the outlet area of the pipes!



Symbolic drawing of a high-pressure gas train

①	High-pressure controller
②	Safety blow-off valve
③	Safety shut-off valve

6 Fuel gas

Make sure that the fuel gas quality is in accordance with TI 1400-0091 and TI 1000-0300.

The gas train is normally designed for a project-specific pressure. Design precautions must therefore be taken to prevent the gas pressure from exceeding the admissible maximum pressure. In addition, certified safety valves (SOV2) must be installed to prevent excessive pressure at all times.

GE Jenbacher When supplying fuel gas to products, make sure to only use gases that will not ignite under the conditions that prevail outside the engine (mixer connection interface). Where required, you must take additional measures in the plant (e.g. monitoring/controlling the oxygen concentration in the gas -> emergency shutdown), in order to comply with any specific national regulations.

A **manual stop valve** must be provided outside the engine room so that the plant can be shut down for repair and maintenance operations and in emergencies, preferably at the point where the gas pipes enter the engine room.

The manual stop valve must be designed to ensure that no unauthorised person can actuate it, i.e. open it when in locked position.

If there is CO in the fuel gas: if the CO content of the fuel gas is **>5%**, a **nitrogen flushing system** must be installed.

It is the operator's responsibility to ensure that the fuel gas system is equipped with the necessary devices, does not leak and satisfies official requirements.

6.1 Condensate removal in the fuel-gas system

Cooling of gases in the fuel-gas system can cause the water in the gases to condense. The condensate must be drained from the gas system and disposed of taking account of its composition and local regulations (e.g. surface-water protection regulations, explosion protection).

Condensate discharge, drainage and disposal is not part of the GE Jenbacher cope of supply. The design and construction of a gas-tight proper condensate drain line is the responsibility of the plant designer/builder and must comply with all local regulations regarding explosion protection and industrial safety.

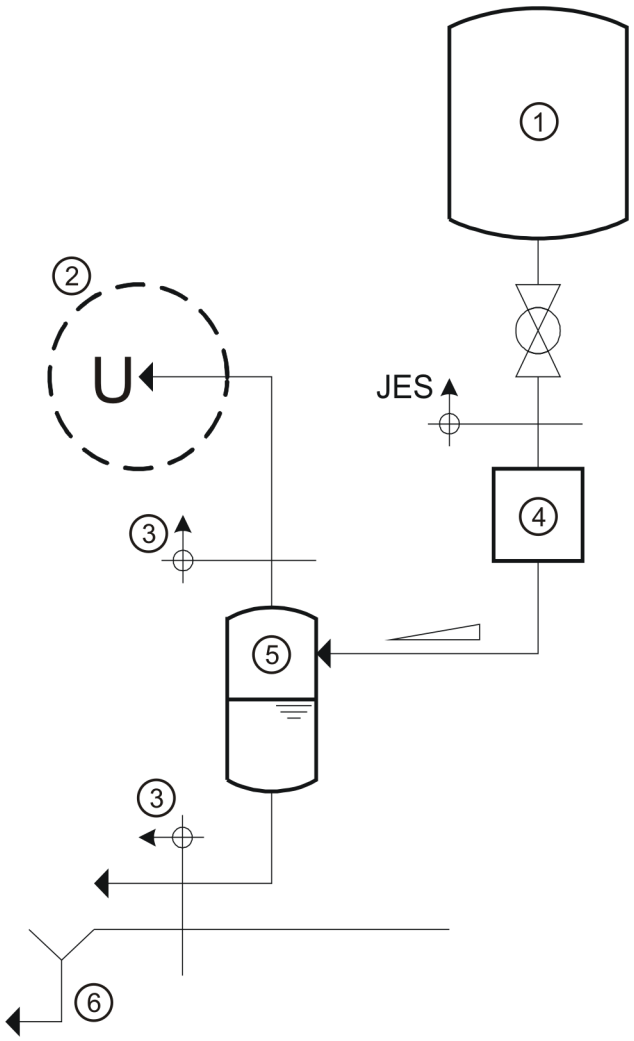
Notes on condensate drain lines:

- Not all commercially-available condensate drain lines are gas-tight, and some line can leak in the course of operation. The suitability for use as a gas-tight condensate drain line for fuel gases and the conditions for securing permanent gas-tightness must be expressly confirmed by the manufacturer/supplier.
- Gases dissolved in the condensate can come out of solution in the condensate drain line (pressure drop), which can lead to the formation of an explosive atmosphere in the condensate drain line.

  The condensate drain line should therefore be fitted with a vent to atmosphere.

  Depending on the maximum gas quantity released, the interior of the condensate drain line and the area around the venting point must be evaluated and designed in accordance with current local industerial safety regulations (e.g. the DIN 1127 standard).

  The adjacent illustration shows the layout in principle, with a vent point to atmosphere and a possible gas outlet location.
- The danger of frost in the condensate drain line to atmosphere should always be taken into account.
- The design of the condensate drain line must be approved by the site safety officer and taken into account when drawing up the plant safety plan.



Fuel gas system condensate drain system

①	Fuel gas + condensate	④	Gas-tight condensate discharge
②	Possible gas escape area	⑤	Water trap
③	Environment	⑦	Condensate disposal

6.2 Underrunning the minimum methane value

If the contractually agreed minimum methane value (see technical specification) is not reached, the engine control will automatically take the following steps to achieve knock-free operation and/or to prevent knock damage:

1. reduce the mixture temperature (if a controller has been installed and the ambient conditions so allow);
2. set the ignition point to a later time, but still within the permissible range (followed by a decrease in the degree of efficiency);
3. reduce the engine output to 50%.
4. If these anti-knock measures prove to be insufficient, the knock-control system will shut down the engine.

7 Intake air

7.1 Engine room

Use forced-draught fans for engine-room ventilation.

To prevent false starts and deflagrations when starting (the engine-side air/gas mixer functions just like a carburettor and is very sensitive to temperature fluctuations and pressure differences), the engine-room ventilation system must also be activated when requested by the module via the output contact "Auxiliary Equipment ON". In this way, a controlled set of boundary conditions is created when starting and accelerating. That is why you must not switch off the engine-room ventilation system until approx. 5 minutes after synchronisation when the preset engine-room temperature is reached (engine-room thermostat), nor should you switch from the mains to the generator within this period.

This means that during the starting and accelerating procedure (including synchronisation), no switching of the engine-room ventilation system should occur until conditions have stabilised.

Intake (of combustion air) from the engine room:

When taking in combustion air from the engine room, the engine room cladding should be free from dust and fibres.

The required filter mesh rate should be strictly adhered to.

If refrigeration compressors are installed in the engine room, the intake air should be drawn in from the outside atmosphere.

Intake air:

Dust-free air of purity class G3 to EN 779 and/or a filter degree of 85% to ASHRAE standards.

If required, install a coarse-dust filter of the relevant filter class!

Max. engine-room temperature:

40°C (to be reached at a maximum outside temperature of 35°C).

If higher engine-room temperatures are expected, have GE Jenbacher supply a special module version!

Maximum air intake temperature (at the engine air filter):

Take appropriate measures to keep the combustion air temperature down (+10°C to +25°C). The temperature should remain as constant as possible and vary only within the smallest possible bandwidth.

Measures this purpose: e.g. separate air guide systems up to the air-filter intake, circulation-air control facilities at the engine-room air intake, speed-controlled fans to keep the temperature constant, etc.

Warning:

As for the air pressure, air intake temperature and atmospheric humidity, the limit levels specified in ISO 3046 apply: i.e. 1,000 mbar, +25°C, 30% humidity. If local conditions differ, the specific engine performance will be reduced.

This corresponds to the standard boundary conditions as applied by all engine manufacturers.

However, other conditions may have been agreed upon before the order was placed! For example, full load at an intake temperature of 40°C. In this case, the booster system would have to be modified and the technical data corrected. Such arrangements should be stated in writing in the specification.

Min. air intake temperature and/or engine room temperature:

The starting behaviour of the engine and the power of the starter motor and the starter batteries are designed for a minimum ambient temperature of +10°C.

To prevent starting problems, every engine is fitted with an electric cooling water preheating system. During operation of the electric cooling-water pre-heating system, the intake and exhaust sound dampers, doors, gates etc. must be closed and the fans must be switched off.

Engine-room air:

Maximum sulphur concentrations in the engine-room air < 1.5 mg/m³.

Engine room ventilation:

The engine-room ventilation must be designed so as to:

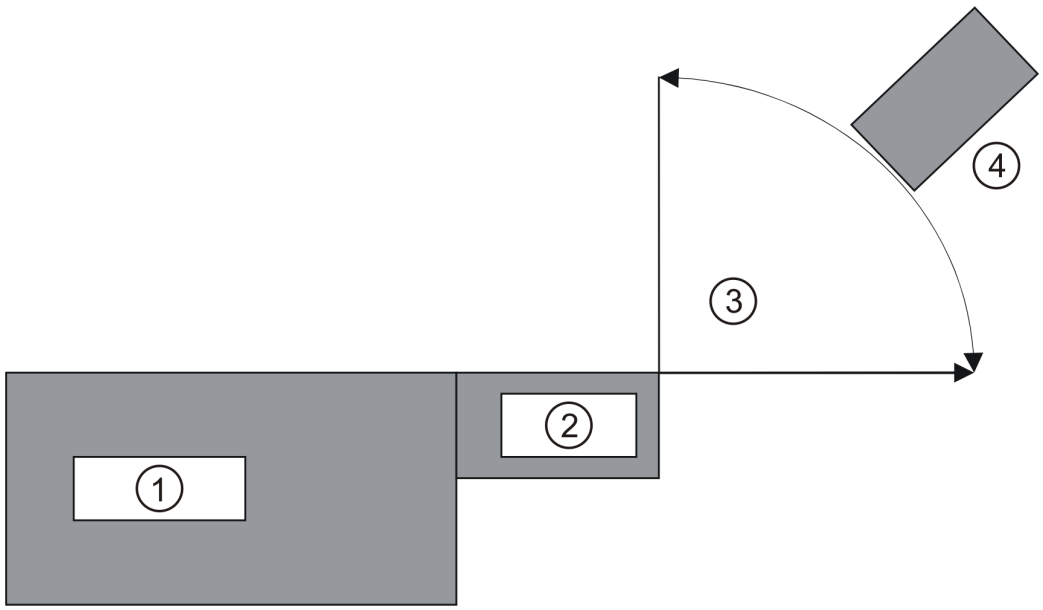
- make sure that the entire engine room is properly ventilated (to prevent an undesirable accumulation of gases),
- guarantee a directed airflow across the engine to make sure that the surface temperatures of the electrical components installed on top of the engine (ignition coils, ignition cables, knock-control and charge-pressure sensors, throttle-valve actuator, etc.) do not exceed a temperature of +70°C!
  If this is not guaranteed and the surface temperatures exceed this temperature, the service life of these components will be considerably reduced and the failure frequency may increase sharply. Any resulting damage and downtime are not covered by the warranty.
- guarantee that outside air is forced into the engine room by the frequency-controlled fans and the engine room is slightly overpressurised.

Engine-room overpressure: > 0.1 mbar, < 0.5 mbar.

If the engine is at standstill - especially if multiple-engine systems are in use - this overpressure causes a defined ventilation flow through the engine towards the exhaust stack.

In the event of a false start (which can never be fully prevented), this will prevent the unburned mixture from flowing back to the engine.

To ensure that the very cold outside air flow (<10°C) is thoroughly mixed with the hotter engine-room air (circulation-air control), never guide the fresh intake air flow directly to the air-filter intake.



Positioning the fresh air flow for the air filter intake

①	Engine	③	R = 3 - 4 m 90° if possible
②	Filter	④	Fan

This is to guarantee that even when outside temperatures are as low as e.g. –10°C, the air temperature at the air-filter intake will not fall below +10°C. Extreme temperature fluctuations will cause control problems, e.g. 'pumping" of the turbocharger.

Also make sure that the fresh intake air flow is not directed straight at the air-filter intake, as the dynamic effect of the air flow will affect the mixture composition and can cause false starts and deflagrations!

7.2 Cooling air generator

Air intake temperature max. 40°C

Relative atmospheric humidity max. 80%

Dust content ≤ 1 mg/m³

SO2 content ≤ 1.5 mg/m³

The Pt100 temperature-control sensor must be positioned in the engine room at the following location:

engine room side, before the centre of the exhaust sound damper.

8 Cooling water for the engine

Must comply with TI1000-0200.

Anti-freeze agent as specified in TI1000-0201.

Anti-corrosion agent as described in TI1000-0204.

Maximum permissible cooling water outlet temperature at the engine: refer to technical specification and/or technical diagram.

Maximum operating overpressure in the engine: 2.5 bar

In the case of multi-engine systems: make sure that the various engine cooling water circuits are separated.

9 Cooling water for the mixture and oil

Dirt collector (mesh size ≤ 0.1): refer to technical diagram.

Water quality: refer to sections 7 and 9.

Maximum intake temperature: refer to the technical diagram and/or the relevant technical specification

(permissible temperature change as stated in section 9).

Maximum permissible overpressure at intake: 6 bar (10 bar for special versions).

10 Raw water, warm water, hot water

Dirt collector (mesh size ≤ 0.1): refer to technical diagram.

Water quality: must comply with TI 1000-0206.

The specified warm-water return temperature should not be exceeded (install emergency cooling, otherwise the module will be shut down).

Permissible return-temperature change:	70°C +3/-20°C
	50°C +3/-10°C

Intermediate values should be determined by interpolation.

Permissible return-temperature change speeds: maximum 10°C per minute.

We advise you to install a thermostatic control to achieve a constant return temperature at the module intake.

In that case, the control must be integrated into the heating system and the operating conditions in accordance with GE Jenbacher Drawing No. E 9684 and/or in consultation with GE Jenbacher.

Water volume flow and minimum pressure in the high-temperature circuit (HT) of type 6 engines:

The minimum values are to prevent steam bubbles from forming in the HT stage of the mixture cooler. The HT stage of type 6 engine mixture cooler is subject to the relation between minimum pressure and water flow as shown in Diagram 1 (boundary conditions: average pressure 20 bar, cooling water inlet temperature at first cooler stage 70°C).

Minimum fill pressure in hot water circuits in plants using exhaust gas heat:

When an exhaust gas heat exchanger is fitted, the minimum-pressure requirements for the heating circuit must be as stated in TI 1000-0206.

When heat recovery is used, the relevant highest value from diagram 1 must be selected, as stated in TI 1000-0206!

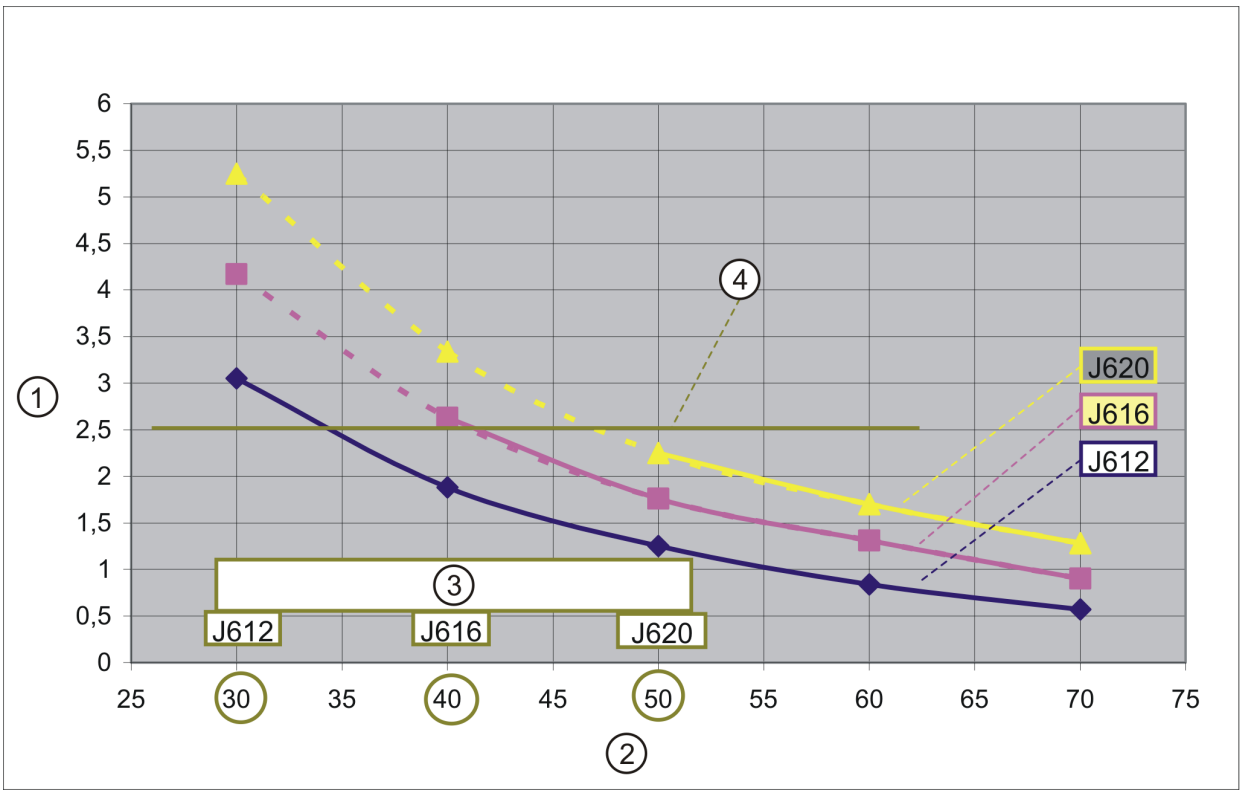


Diagram 1: Water volume flow and minimum pressure to prevent steam bubbles from forming in the HT stage of the type 6 engine mixture cooler at an average pressure of 20 bar and a cooling water temperature of 70°C.

①	Minimum fill pressure (bar gauge)	③	1st stage minimum volume flows
②	1st stage water volume flow [m3/h]	④	When integrating engine casing and mixture cooler into the same water circuit, the max. water pressure must not exceed 2.5 bar.

Additional design guidelines for the HT cooling circuit:

- Irrespective of the integration variant of the mixture cooler (in parallel, serial, etc.), the flow and pressure values from diagram 1 must be complied with.
- If the engine casing and mixture cooler are integrated into the same water circuit, the max. water pressure must not exceed 2.5 bar.
- A constant volume flow over the engine casing and mixture cooler must be guaranteed by using a hydraulic temperature control system. In principal, mixing-in return water is preferred over using a pump-speed control!

Water volume flow and minimum pressure in the low-temperature circuit (LT) of type 6 engines:

The following minimum flow values must apply in the LT circuit as otherwise the temperature gradient could increase across the cooler surface, possibly affecting the cooling operation of the LT stage .

- J624: 50 m³/h
- J620: 40m³/h
- J616: 30m³/h
- J612: 25m³/h

Demand by circulation pump – pump after-run:

In general, the circulation pump's demand for the hot water circuit (high temperature circuit) and other separate circuits is controlled by GE Jenbacher.

Customers must allow at least 5 minutes' after-run, especially for plants using exhaust gas heat in which the pumps are not controlled by GE Jenbacher.

Because of the arrangement of valves in the exhaust gas system, the exhaust gas heat exchanger must also be flushed with coolant when in bypass operation.

11 When operating with a steam boiler

Water quality must be in accordance with boiler manufacturer's specifications.

Refer to the technical specifications and technical diagram for the maximum permissible temperature and pressures.

12 Lubricating oil

Must comply with TI 1000-1109.

Oil changes should be carried out in accordance with TI 1000-0099 A/B/C/D or in accordance with the results of the oil analyses.

Warning:

The oil lines to the engine, fixtures, vessels, etc. should not be made from pure copper. Copper has a strong oxidising effect on lubricating oil, especially at increased temperatures (accelerates ageing), which will result in an increased Cu content in the oil, giving rise to incorrect diagnoses.

Similar Cu-Ni alloys (Ni content ≥ 10%) do not have these characteristics and can therefore, if so desired, be used instead of normal steel tubes.

13 Exhaust gas

Engine malfunctions can cause backfiring in the exhaust gas system. The exhaust gas system as a whole must therefore be capable of absorbing short-term pressure surges of up to 6 bar. The underpressure following a pressure surge can be in the order of approx. 200 mbar. This must be taken into account in the engineering of the exhaust gas system. The internal pipe must be resistant to buckling, especially when long double-wall funnels are used (DIN 4133).

See the technical specification and/or technical diagram for maximum permissible exhaust gas backpressure.

In the case of multi-engine systems, exhaust gas systems must not be combined.

Exception:

- double shut-off valves with intermediate ventilation for each module
- if a continuous underpressure exists at the point where the systems are combined (e.g. a continuous flow in the smoke stack).

The condensate from the heat-recovery boilers, silencers and the exhaust manifold, etc. should be collected and disposed of in an environmentally sound way.

Condensate lines should not be interconnected.

14 Electrical conditions

Nominal mains voltage change:	+/-10%*) of nominal voltage
Max. permissible transient mains voltage changes:	+/19% of nominal voltage*)
Nominal mains frequency deviation:	max. +/- 2%
Minimum duration of a short interruption:	min. 200 ms
Make time of the synchronising switch:	70 ms
Break time of the circuit-breaking switch:	60 ms

*) Note: The ranges relate to default voltages in accordance with IEC 60038/ EN 50160. In the case of countries with 415/240V, a maximum voltage tolerance of +6% applies because the related default voltage is 400/230V +/-10%.

Apart from the normal connecting and disconnecting coils, the generator switch must also be fitted with a DC low-voltage disconnecting coil. This coils disconnects the generator from the mains in the case of loss of control voltage or wire breakage.

To prevent external overvoltages from reaching the installation, overvoltage deflectors should be installed onsite at the mains supply voltage location. To protect the generator, overvoltage deflectors must be fitted onsite on the generator, if required, in combination with capacitors.

To mains supply locations with nominal voltages ≤ 1000V applies: The Up protective peak must be selected in accordance with the measurement surge voltage for IEC 60364-4-44 overvoltage category II, Table 44.B.

For example, the protective Up peak must not exceed 2.5 kV for 230/400V installations.

To mains supply locations with nominal voltages > 1000V applies: Select and apply overvoltage deflectors in accordance with EN / IEC 60099-5.

See TI No. 1100 -0112 for the overvoltage deflectors on the generator.

15 Operation and maintenance

Minimum operation time: 12 hours per engine start, except when commissioning, carrying out maintenance work and during emergency power operation.

This minimum operating time is **not** an essential condition, but a reference value for the maintenance intervals specified in the maintenance documentation. This reference value should help the operator to decide when, contrary to what has been stated in the maintenance manual, various wearing parts will have to be replaced (if, for example, a starter motor is used three times more frequently than expected, it will also have to be overhauled sooner).

The maintenance intervals as stated in the maintenance manual are **averages for normal operation based on experience**!

Preventive inspections of components can help the operator to determine the exact point in time when the wearing parts need to be replaced (see also TI 1100-0111).

Failure to adhere to the minimum operating time can have a serious effect on the service life of various parts.

Idling mode

Idling duration limited through the module control unit (except for maintenance and initial setting work: keep idling period as short as possible).

Partial load operation

Partial load operation without limitations up to > 40% of the nominal load for type 2, type 3 and type 4 engines and/or > 40% at pme = 18 bar for type 6 engines. Emission values referred to in the technical specifications only apply where a load exceeds 50%.

Continuous operation

You must always aim for full load operation. Partial load operation without limitations up to > 40% of the nominal load for type 2, type 3 and type 4 engines and/or > 40% at pme = 18 bar for type 6 engines. Emission values referred to in the technical specifications only apply where a load exceeds 50%.

isolated operation

During isolated operation, the module may be operated 6 times per year for 4 out of 24 hours at > 20% and < 40% of the rated module load.

Daily inspection

Maintain an engine log.

Maintenance as per GE Jenbacher maintenance plan.

All conditions as described in the TIs should be complied with.

For oil changes, oil analyses and oil quality assessments, refer to TI 1000-0099 A/B/C/D.

16 Pipelines (pickling and cleaning)

The inside of all piping, especially welded piping, must be cleaned before assembly;

e.g. gas lines, oil lines, cooling water lines, control lines, etc.

Note: pickling should only be carried out by companies that have sufficient experience in carrying out galvanizing work!

17 Connections (GE Jenbacher's limits of supply)

Connections (at GE Jenbacher limits of supply) should be equipped with compensators and/or flexible hoses.

The plant piping should be arranged in such a way that the compensators at GE Jenbacher limits of supply are not subjected to mechanical force.

18 Refer to the TIs listed below

The revision applicable when the contract was signed is valid:

General conditions

TI 1100-0111	General conditions - Operation and maintenance
TI no. 1100-0112	TI no. 1100-0112 Installation of GE Jenbacher modules

Warning signs

TI 1000-0330	Signage on the engine room door

Fuel gas

TI 1000-0300	Fuel gas quality - natural, associated petroleum, bio- and landfill gas
TI 1000-0301	Fuel gas quality: mine gas
TI 1000-0302	Fuel-gas quality - special gases
TI 1400-0091	Fuel gases, freedom from condensate

Lubricating oil

TI 1000-0099A	General instructions for lubricating oils
TI 1000-0099B	Limit levels for used oil on GE Jenbacher engines
TI 1000-0099C	Procedure for testing plant-specific oil service life
TI 1000-0099D	Determining the initial Ph value (iPh) for waste lube oil as defined in TI 1000-0099B
TI 1000-1109	Lub. oil for GE Jenbacher engine types 2, 3, 4 and 6

Cooling Water

TI 1000-0200	Quality of cooling water in closed circuits
TI 1000-0201	Anti-freeze agent
TI 1000-0204	Cooling water anti-corrosion additive
TI 1000-0206	Quality of circuit water in hot water and warm water heating systems
TI 1000-0208	Quality of cooling water in open circuits

Cabling

TI 1000-0505	Electromagnetically compatible (EMC) cabling and earth connections on and between engine modules and control cabinets

19 Revision code

Revision history

Index	Date	Description/Revision summary	Creator *Auditor*
4	14.01.2011	4. Einhaltung Mindestfreiräume nicht möglich / 4. Compliance with minimum clearance not possible	**Pichler** *Verbanck / Widner M.*
3	08.11.2010	4. Mindestfreiraum/Minimum clearance J 620- Version „H“	**Bilek** *TEK-Becker*
2		Pos.6.1 neu, 6.2 Schema -„Möglicher Gasaustrittsbereich“ / Point 6.1 new, 6.2 Diagram - “Possible gas escape area	*6.1, 6.2 TET-Fürhapter/ 6.1 TSD-Hochrainer*
		14. Elektrische Bedingungen / Electrical conditions - update	*TCG- Krucken-hauser*

Revision history

		15. Inselbetrieb/Isolated operation	*TCC- Hirzinger*
1	31.05.2010	Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **as**	**Provin** *Provin*

1. General Conditions - Operating and Maintenance:

1.1 Marginal conditions:

The boundary conditions for GE Jenbacher gas engines as specified in Technical Instruction No. 1100-0110 must be observed. The work specified in the operational-data sheet must be carried out and this sheet must be filled in correctly. All specified maintenance work must be performed regularly, expertly and on schedule. Knock-free operation must be guaranteed.

1.2 Cooler/heat exchanger(GE Jenbacher supply quantity):

When incorporated into the heating water system these components must be protected at the upstream side against deposits/soiling by taking adequate measures.

1.3 Supply limits Interfaces:

The conditions and devices pre-determined in the technical scheme, the wiring diagram, the interface list and the technical specification of the control at the supply limits/interfaces must be fulfilled or available respectively. Deviations from these can affect guaranteed characteristics of the product and safe operation and finally lead to a restriction or extinction of warranty claims.

1.4 Maintenance Maintenance personnel:

Work at the plant must only be carried out by specially trained, electric and mechanic specialists. It is possible to conclude service contracts with GE Jenbacher, GE Jenbacher subsidiaries or authorized and specialized companies. The intervals stated in the maintenance plan are average empirical values. Where there is a lack of proper operation and maintenance (such as defective oil care, large accumulations of dust or other problematic circumstances), maintenance operations have to be carried out before the specified intervals.

The above can only be judged by the operator. If irregularities are found during the daily inspection, especially during the warranty period (abnormal sounds or noises, etc.), the operator must take action to minimise any damage (e.g. by immediately switching off the engine, investigating the cause of the irregularity and rectifying it, and/or notifying the GE Jenbacher customer service department).
The service intervals may not be extended to avoid downtime during the heating season. All parts that contact exhaust are correspondingly not bound to fixed, predetermined useful lives.

1.5 Safety regulations:

The safety regulations contained in the user's manual must be observed The safety regulations and regulations for the prevention of accidents set out by the law must be observed. Prior to the commencement of any work the party ordering must make sure that the applying safety regulations are observed for the work to be carried out. In the event of work that may only be carried out with the engine standing still, the engine must be turned off and secured against unauthorized re-starting according to the technical instruction no. 1100-0105.

1.6 Risk assessment:

The plant operator (employer) is required to undertake a risk assessment to determine the measures necessary to effect the safe availability and use of the plant and equipment and to comply with all official and quasi-official safety rules and laws governing the operation of the plant. The employer must take the necessary measures to ensure that employees are only provided with equipment which is suitable for the conditions pertaining at the workplace and guarantees their health and safety if used properly.
The risk assessment will cover approval, planning, assembly, commissioning, operation, maintenance, servicing and shutting down.
The risk assessment to be performed by the plant operator and the official and quasi-official safety rules and laws may give rise to acceptance tests, inspections and maintenance operations which are not included in the Maintenance Plan. It is the operator’s responsibility to implement and enforce these additional measures.

1.7 Start conditions:

All GE Jenbacher engines are equipped with a preheating system for the engine cooling water. Only preheated engines with a engine cooling water temperature of >55°C may be started, loaded and run to full-load, otherwise the engine may be damaged.

1.8 Malfunctions:

When a failure results in the installation automatically being switched off by the engine control, the cause of the failure should be remedied first before the installation is started again! It is forbidden simply to reset a failure and then re-start the engine, as critical or wear-induced damage could possibly result in premature wear-induced replacement of various components.
Remote resetting: Based on the risk category selected by the customer (0-4), failures resulting in the installation being switched off can be reset using remote access to the visualisation system (Not more than 5 times per 6 hours of engine operation under load).

Failures:	Diane No.:	National restrictions	Risk category
MISFIRING FAILURE	1047, 3005-3024		0
JACKET WATER TEMPERATURE HIGH	1021	*	0
ROOM TEMPERATURE HIGH	1135	*	0
FAILURE WITH AUXILIARIES	1129		0
SYNCHRONIZING FAILURE	1039		0
HEATING WATER SUPPLY TEMPERATURE HIGH	1063		0
MISSING ENGINE RUNNING CONDITIONS	1025		1
STARTING FAILURE	1023	*	1
GAS PRESSURE MINIMUM CONTROLLED GAS SYSTEM 1	1028	*	1
GAS PRESSURE MINIMUM CONTROLLED GAS SYSTEM 2	1030	*	1
MIXTURE TEMPERATURE MAXIMUM	1040		
OIL TEMPERATURE MAXIMUM	1043		1
ADMISSABLE CONTROL DEVIATION OF LEANOX CONTROLLER EXCEEDED	1080		1
ENGINE COOLING WATER PUMP FAILURE	1090		1
GENERATOR FREQUENCY TOO LOW	1110		1
ACTUAL VALUE MEASURING SIGNAL FAILURE	1113		1
ENGINE SPEED MEASUREMENT SIGNAL FAILURE	1120		1
TECJET GAS QUANTITY JUMP	3099		1
ENGINE OIL LEVEL MINIMUM	1018		2
GENERATOR REVERSE POWER	1038		2
CYLINDER EXHAUST GAS TEMPERATURE DEVIATION FROM MAXIMUM AVERAGE VALUE	1044		2
CYLINDER EXHAUST GAS TEMPERATURE MAXIMUM EXCESS OVER ABSOLUTE VALUE	1049		2
COOLING WATER PRESSURE MAXIMUM	1050		2
MIXTURE TEMPERATURE FLUCTUATION SPEED MAXIMUM	1105		2
GENERATOR EXCITER FAILURE	1109		2
NEUTRAL CURRENT MAXIMUM	1112		2
ENGINE OIL LEVEL MINIMUM	1018		2
GENERATOR REVERSE POWER	1038		2
CYLINDER EXHAUST GAS TEMPERATURE DEVIATION FROM MAXIMUM AVERAGE VALUE	1044		2
CYLINDER EXHAUST GAS TEMPERATURE MAXIMUM EXCESS OVER ABSOLUTE VALUE	1049, 2001 – 2020		2
COOLING WATER PRESSURE MAXIMUM	1050		2
MIXTURE TEMPERATURE FLUCTUATION SPEED MAXIMUM	1105		2
GENERATOR EXCITER FAILURE	1109		2
NEUTRAL CURRENT MAXIMUM	1112		2
CYLINDER 1 MAXIMUM EXCESS OVER ABSOLUTE VALUE	2001		2

CYLINDER X DEVIATION FROM AVERAGE VALUE, MAXIMUM POSITIVE DEVIATION	2021 – 2040		2
CYLINDER X DEVIATION FROM AVERAGE VALUE, MAXIMUM NEGATIVE DEVIATION	2041 – 2060		2
GAS PROPORTIONING VALVE CAN LINK FAILED	3093		2
OIL PRESSURE MINIMUM	1017		3
MISSING POWER SIGNAL	1041		3
OIL FILTER DIFFERENTIAL PRESSURE MAXIMUM	1059		3
GAS MIXER CONTROL FAULTY	1083		3
BACKFIRE PROTECTION	1128		3
All other risk categories not listed in risk categories 0 – 3.			4

Due to national restrictions, risks listed in category 0 and 1 may be promoted to category 4 risks.

Resetting (single or multiple resetting) all other failures that have resulted in the installation being switched off without remedying the cause first will result in a considerable potential risk, endangering human life and possibly damaging the installation. The client (or the party responsible for the remote resetting) will be entirely responsible for such damage.

1.9 Registering operational data, Maintenance protocol:

It is compulsory that all operational data are registered and that all special events are described.

Attention:

Just registering the facts in writing is insufficient. The data should be compared with the commissioning data and be checked for plausibility. In case of deviations, abnormal noises etc. the cause should be tracked and remedied. If you cannot find the cause, the GE Jenbacher customer-service department should be notified immediately.

Maintaining and filling in operational data (maintenance protocol, operational data journal, data registration in the “Maintenance directory”) is in the best interest of the operator. Correctly filled-in operations journals and data registration sheets are important documents, enabling analysis and support in case of failures. Moreover, these documents are also important when deciding on warranty claims.

1.10 Spare parts:

Only use original GE Jenbacher spare parts (attention: e.g. oil filter!). Defects and damage caused by the use of non-original parts are not covered by the warranty.

Important: In order to avoid unexpected standstills due to maintenance work, you are strongly advised to keep the respective spare parts in store.

1.11 Lubricating oil:

No specific maintenance interval is determined for lubricating oil. It lies within the responsibility of the operator to take measures necessary for the protection and the safe operation of the plant and which guarantee the plant's availability.

The oil's service life (depending on gas quality, middle pressure, engine type, oil consumption, oil temperature and oil type) can be prolonged by an additional oil container. The results of the lubricating oil analysis with the observation of the limits according to the technical instruction no. 1000-0099B must be presented in a complete manner also after the warranty period has expired, if premature wear is claimed.

1.12 Ignition plug:

No specific maintenance interval is determined for ignition plugs. It lies within the responsibility of the operator to take measures necessary for the protection and the safe operation of the plant and which

guarantee the plant's availability. The ignition plugs' service life depends on the marginal conditions of the plant (e. g. type of ignition plugs, gas type, middle pressure, gas mixing temperature, ignition system, emission limits).

1.13 Elastomer components:

Elastomer components age and become brittle, even when the engines are not operational.That is why the service life of these components does not depend on the on-stream service time of the module, the cooling-water temperature and pressure etc. At normal annual on-stream service times of 5000-6000 operating hours and a cooling-water temperature of 90°C, all elastomer components are exchanged at the normal intervals as described in the maintenance schedule. If this number of operating hours is not reached, the elastomer components (e.g. O-rings at cylinder liners, elastic couplings etc.) should still be replaced as a precautionary measure after a maximum of 5 years.

1.14 Decommissioning the installation:

For long planned or unplanned downtimes such as after the heating season for power plants, the engine systems need to be prepared for downtime (preservation measures, change old lubricating oil, separate the chimney connection, etc.) depending on the geographic location (climate, proximity to ocean, type of gas, etc.).
Since situations can differ greatly, it is recommendable that an appropriate professional company be consulted or be entrusted with implementing the necessary measures.
Of course, it must be ensured that the system is made ready for use when it is started up again.

1.15 Welding work on the module:

Always make sure to attach the negative pole as close as possible to the weld location when carrying out welding work on the module – not on the mass connection (earth cable) though.

1.16 Components coming into contact with exhaust gas:

Due to the different operating situations and different contents (including traces of pollutants) in the fuel gas, no binding guarantee can be made on the life of the components such as the exhaust manifold, etc. In the case of silencers arranged in the open without external heat insulation, even installations without heat exchanger (hot exhaust gasses) can produce condensate (acid, water) which can shorten the service life. This also applies to silencers insulated internally where the dew point temperature may be underrun in the rock wool insulation.

1.17 Operating supplies:

Service life and safe operation of the plant strongly depend on the operating supplies that are used. Only use operating supplies such as propellants, engine cooling water, warm water, frost protection agent, anticorrosive agent, lubricating oil etc. corresponding to the respective technical instructions of GE Jenbacher.

1.18 Quality of propellant:

The operator is obliged to regularly check the quality of the propellant as for its thermal value, methane number and contents of harmful substances. If these values differ from the values stipulated in the contract, immediate measures must be taken in agreement with the GE Jenbacher customers service. If the contents of harmful substances increase (e. g. sewage gas, waste dump gas) the lubricating oil can be heavily acidified within a fraction of the normal oil change interval and acute or irreparable damage and increased wear occur all of a sudden e. g. on cylinder liners and bearings and/or the oil consumption increases. In the event of variations of the methane number downwards (within the range stipulated in the contract) the engine is protected against harmful knock operation by the control (automatic ignition control, efficiency decrease).

Note:
During the start-up the engine is optimally set according to the methane number given at that time.
If the methane number increases after the start-up (for a longer or decisive period of the operation time of the plant) the engine setting should be changed in the sense of an operation type optimizing the efficiency. This task is to be carried out by specialized personnel.

1. Remarks:

Before performing any work on the installation, the maintenance staff must ensure that the relevant safety precautions have been observed regarding the activities to be carried out.
For safety precautions, please refer to the operation or maintenance description (TI No.: 2300-0005).

Always make sure to attach the negative pole as close as possible to the weld location when carrying out welding work on the module – not on the mass connection (earth cable) though.

2. Transport and erection:

Deals with the lifting, transporting, unloading and erection of GE Jenbacher units and switch cabinets.

2.1 Lifting and transporting:

TA 1000-0042
TA 1000-0043
TA 1000-0044

2.2 Erecting (requirements as to foundation):

TA 1000-0041

3. Propellant gas:

Describes requirements as to the propellant gas (relating to its mechanical and chemical characteristics) and gas piping.

3.1 Quality of propellant gas:

TA 1000-0300
TA 1000-0301
TA 1000-0302
TA 1400-0091
TA 1100-0110

3.1.1 Gas filter:

A work filter (3µm) has been integrated into the gas control system of **type 2, 3, 4 and 6 engines.**

3.1.2 Gas piping and gas-pressure regulating section:

TA 1100-0110

Execute gas piping in such dimensions that the requisite gas admission pressure (at the entry to the gas-pressure regulation section) is attained.
Only specially qualified technical personnel may make welds in gas piping (regional regulations must be complied with).
A check (with test report) must be made on the impermeability of the gas piping.
The interface between the module (engine gas intake) and the gas line (gas pressure control system) must be a flexible connection. The distance between the zero pressure controller and the engine

connection must not exceed a maximum of 2 m [78,74 in] and, where TecJet is used, a maximum of 1.3 m [51,18 in] (length including hose in each case).
In other words, from a control point of view, the zero pressure controller and/or the TecJet must be positioned with the flexible connection as close as possible to the engine gas intake on the gas mixer.
The gas pressure control system must be viewed as a single unit; lines between the solenoid valve and the zero pressure controller are not allowed. The same holds true for the precombustion chamber pressure regulator (only for type 6 engines).

4. Lubricating oil:

Describes the requirements as to the engine lubricating oil.
Execution of the lubricating-oil piping.
Dimensioning of tanks for additional fresh oil and used oil.

4.1 Requirements as to the lubricating oil:

TA 1000-0099
A/B/C/D/K

4.2 Oil piping:

TA 1400-0131

Make oil piping from seamless steel (not copper) pipes.
Connect pipe ends with screwed pipe joints. Do not weld, as contamination may enter the engine and cause damage to it.
Check pipe system for impermeability (test report required).

4.3 Oil system:

Make fresh-oil tank of sufficient dimension to achieve the planned oil-change period (e. g. four changes annually).
Make used-oil tank of dimension corresponding to the total volume (of oil pan and fresh-oil tank).
Bottom edge of fresh-oil tank to be positioned a minimum of 1 metre [3.28 ft] and a maximum of 10 metres [32.80 ft] above the oil connection on the module in order to ensure gravity filling.
Separate pump for fresh oil and waste oil.

5. Exhaust gas:

TA 1100-0110

Dimensioning and constructional execution of the exhaust-gas system.

Execute the locating bearing for the exhaust-gas piping so that the exhaust-gas turbocharger is not subjected to any mechanical stress (provide a compensator at the interface between turbocharger outlet and inlet to exhaust-gas piping).
The exhaust-gas piping must be designed for brief pressure shocks of up to 6 bar [87 psi] (operating pressure: 0.05 bar [0,725 psi]).
Dimension exhaust-gas piping so that its resistance (= total of pipe resistance of all components starting from the turbocharger outlet) does not exceed the maximum permissible exhaust-gas counterpressure starting from the turbocharger outlet.
Provide a condensate drain at the lowest point of the exhaust-gas piping, exhaust-gas heat exchanger and noise insulation; lead drains individually into the water reservoir.

In the case of multi-engine installations, the exhaust-gas systems must not be combined.
Exception:

- double shut-off valves with intermediate ventilation for every module.
- if at the point where the systems are combined a continuous underpressure exists (e.g. a flow in the smokestack).

Important: Provide room for exhaust-gas piping insulation.
Make sure to leave enough room in front of and behind the boiler to clean the exhaust gas heat exchangers of type 6 engines.

6. Engine-cooling, warm and hot water:

Describes the requirements as to hot and warm water in closed heating systems.
Requirements as to engine cooling water (protection against freezing and corrosion).
Execution of piping (commissioning strainer).

6.1 Hot water and warm water in heating plant:

TA 1000-0206

6.2 Requirements as to engine cooling water:

TA 1000-0200
TA 1000-0201
TA 1000-0204

6.2.1 Quality of cooling water in open circuits:

TA 1000-0208

6.3 Piping:

TA 1400-0131

For the dimensioning of pipes, a water speed of 2 m/sec[6,56 ft/sec] should be assumed.
Flexible connections must be provided for at the interfaces between the unit and the water systems on the premises.
The warm-water system must be kept clean by means of suitable filters.
Important: Provide room for water-pipe insulation.
Monitoring systems (e. g. maximum pressure and temperature) must be provided in accordance with country-specific regulations. (i. e. max. pressure; max. temperature; max.flow).
Before commissioning, the piping system must be cleaned.
A check (with test certificate) must be made on impermeability.
It is recommended that a suitable, experienced firm be entrusted with the provision of the water system.

7. Ventilation:

TA 1100-0110

Describes the requirements as to the technical fittings for the ventilation of machine space, generator and engine.

8. Electrical:

TA 1100-0110

General protective measures for the installation of electrical power plants.
Requirements on the customer‘s control power supply.
Cabling; cable dimensions; installation.
Handling electronic components.

8.1 Protective measures for the installation of electrical power plants:

TA 1000-0515

8.2 Customer’s control power supply:

Voltage: 24VDC (at GE Jenbacher terminals: min. 22 V ⇔ max. 30 V, including ripple)
Ripple: max.U_{SS} 2,4 V

8.3 Starting system (Batteries):

TA 1000-0050

8.4 EMC cabling and cable dimensions:

TA 1000-0505

8.5 Handling electrical components:

TA 1000-0510

8.6 Energy output cable at the generator:

Generator power cable:
Rated generator current: I_N = ... A, where cos phi = 0.8.
The generator manufacturer’s connection instructions must be observed.

When connecting the cables, make sure that no force is exerted on the generator connection terminals. The same holds true for during installation.

Sufficient free cable length must be provided between the cable fastening on the generator and the foundation / junction box to compensate for the relative movement between the generator and foundation / junction box.

8.6.1 Low-voltage generators:

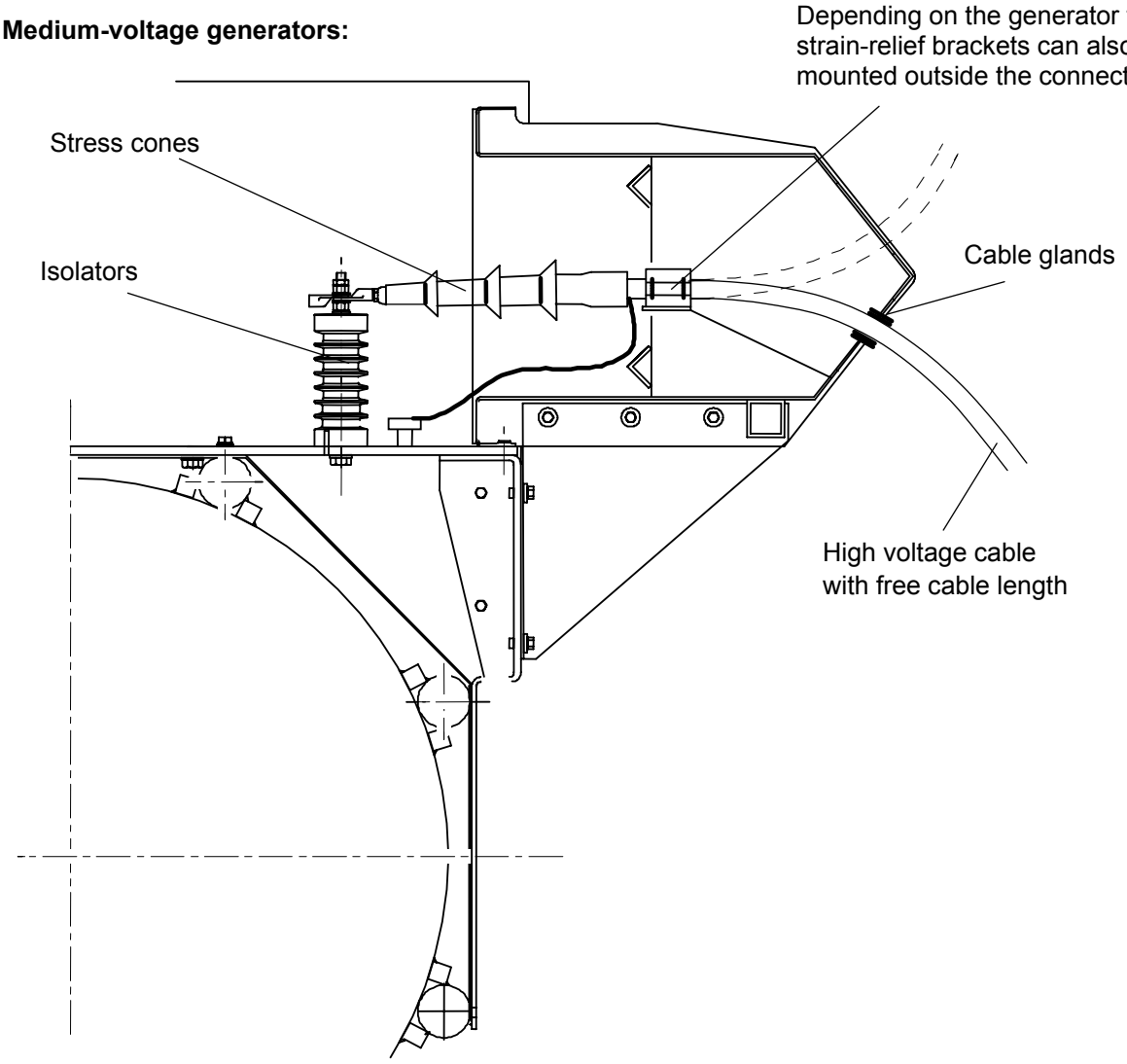
The output cable must be assembled horizontally and be located on the specified side.

⚠ Under no circumstances should the output cable be run vertically upward through the terminal-box cover.

Output using cable:
Use flexible finely stranded copper conductors (no aluminium conductors).
The individual conductors must at least comply with Class 2 (Class 5 recommended) of IEC 60228/ CENELEC HD 383/ VDE 0295.
Cable sockets: max. 45 mm wide (because of distance between connection bar holes).
Screwed cable glands: nickel-plated brass (no threaded plastic connections).

Output using bus bar:
To ensure that vibrations are not passed on and to compensate for any movements of the module, you must assemble highly flexible short cable joints between the generator connection bars and the current bars.
Note: Experience shows that compensators (e.g.mesh wire compensators) are not able to withstand long-term vibration loads.

8.6.2 Medium-voltage generators:



Principle sketch: Energy output with cable sealing ends and strain-relief brackets

In the case of elastically positioned modules (see drawing), sufficient "free cable length" must be provided to compensate for the movement of the module during start, stop and module switch-off at full load. In order to ensure that no load is placed on the terminal clamps as a result of this movement, a cable fastening must be introduced using the strain-relief brackets intended for that purpose. This cable fastening must be rigid and should be linked to the moving generator set to prevent cable fastening movements with respect to the terminal clamps (isolator).

Medium-voltage cable:
Flexible, finely stranded, copper single conductors must be used!
Conductor stranding: in accordance with IEC 60228/ CENELEC HD 383/ VDE 0295 Class 5.

Recommended cable for medium-voltage generators:
e.g.: - FELTOFLEX Typ. NTMCWOEU (Single-core conductor),
Fa. Draka Industrial Cable GmbH http://www.draka.dk/cableteq/pdf/7_11.pdf
- PROTOLON Typ. NTMCGCWÖU (Single-core conductor),
http://www.prysmian.com/en_42/cables_systems/technergy/cutsheet/mining/05PROTOLON1core.pdf

Stress cones ends for generator connection >4,2kV:
The available space between the terminal clamps (isolator) and the strain relief brackets is approx. 320 mm. Consequently, only "short" stress cones can be used..

Recommended stress cones:
e.g.: - 3M QUICK TERM III (24kV)
Set 93-EP630-1 for 95 -240mm² Cu at 6 – 13.8 kV
(For more information: www.3M-elektro.de)
- Raychem (17.5 kV)
Set TFTI 4131 for 95 – 240 mm² Cu at 6 – 13.8 kV
(For more information: http://energy.tycoelectronics.com/countryselector.asp)

Generator connection without cable sealing ends for voltages <= 4.2 kV:
For voltages < 4.2 kV no shielded medium-voltage cables are required. Instead of cable sealing ends suitable shrink tubing can be used.

Connectable power cables:
The generator terminal box with a rated apperant power of up to 6MVA is designed for cable/phase and cable/starpoint.

Cable lugs:
These should be dimensioned in such a way that they are suitable for the powers (vibrations) occurring in the generator.

Recommended (short) press cable lugs:
Nexans Company: Typ KU-F-V (for more information: www.nexans.com or www.gph.net)

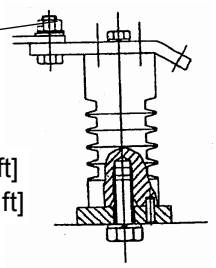
Screwed cable glands:
nickel-plated brass (no threaded plastic connections) or the built-in rubber glands.

Cable connection as per DIN 46200
Elastic components such as spring washers, dished washers, or aneroid diaphragms may be installed, but only on one side of the clamped conductor. Washers may also need to be used. The other side is reserved for conducting power, so only washers or safety plates made of a copper/zinc alloy (brass) can be used. Electrically and mechanically, at least equivalent materials are to be used.
When connecting eyelets, the eyelets must be protected on both sides from bending with washers.

Tightening Torque:
Insulated supports for indoor installations

Tightening torque M12
Tightening torque M16
Hex head screw: Steel 8.8

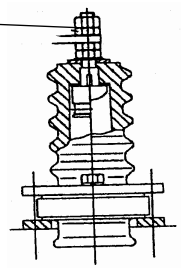
50 - 70 Nm [36,85 - 51,6 lb ft]
90 – 110 Nm [66,3 - 81,1 lb ft]



Capacitor type terminal DIN 46265

Tightening torque M12
Tightening torque M16
Terminal stud: Ms
Terminal nut: Ms

20 Nm [14,74 lb ft]
40 Nm [29,5 lb ft]



8.7 Generator transient over voltage surge protection:

High voltage transient surges caused by switching devices, lightning strikes on overhead cables etc., could damage the generator windings and measuring equipment. Therefore surge suppression devices must be installed.

Rating: It must ensure that the impulse level as seen at the generator terminals is reduced to less than:
Crest value kV = 1,25 × √2 × (2Vline+1).
e.g. for a 10 kV generator: 1,25 × 1,414 × (2×10 + 1) ≅ 37,1 kV
The maximum 'front rise time' of the calculated value above is 5 micro seconds.

This can be achieved using a combination of capacitors/resistors and varistors:
e.g.: High frequency transient surge suppressors ZORC from STRIKE technologies ltd.
http://www.strike.co.za/Products_zorc.html

Place of installation: The best practice for protection from switching transients and lightning strikes calls for the fitting of surge suppression devices as close as practicable to the generator output terminals.
It is possible to install the surge protection within the generator switchgear if the cable length between generator and switchgear is less than 25m. In this case a separate ground wire has to be run between the surge protection device and the generator housing. (Resistance less than 0,5Ohm)
If the cable length between generator and switchgear is more than 25m the device needs to be installed beside the generator.

The degree of protection from lightning strikes depends on the site installation requirements.
The engineer responsible for the protection system must ensure that the level of protection meets the requirement of all relevant regulations pertaining to the site.

9. Employee protection:

TA 2300-0001

Duties of the employer in regard to the safety and health of employees.

10. Technical instructions; norms; guidelines:

TA 1100-0110

On the topic of the installation of Jenbach units.

TA 1000-0041
TA 1000-0042
TA 1000-0043
TA 1000-0044
TA 1000-0046
TA 1000-0050
TA 1000-0099A
TA 1000-0099B
TA 1000-0099C
TA 1000-0099D
TA 1000-0099K
TA 1000-0200
TA 1000-0201
TA 1000-0204
TA 1000-0206
TA 1000-0208
TA 1000-0300
TA 1000-0301
TA 1000-0302
TA 1000-0330
TA 1000-0505
TA 1000-0510
TA 1000-1109
TA 1100-0110
TA 1100-0111
TA 1100-0112
TA 1400-0091
TA 1400-0131
TA 2300-0001
GE Jenbacher-ZNR E 9684 BI1 & BI2

The guidelines shown in ***italics*** are referred to in **TA 1100-0110.**

11. Plant documentation:

Technical documentation for the project, such as
- Technical diagram
- Installation plan/terminal diagram
- View of unit
- Wiring diagram
- Cable list
- Interface list
- Technical specification of the control system
- Description, operation
- Maintenance
- Catalogue of replacement parts

These technical documents are binding in every case.

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1. Lack of condensate concerning fuel gases for GE Jenbacher fuel gas engines:

1.1 Principle:

1.1.1 Operational troubles or breakdowns resulting from insufficient lack of condensate of the fuel gases available are excluded from any warranty. The only exception is given if the contracted scope of supply of the GE Jenbacher expressly includes a specific fuel gas drier.

1.1.2 Evaporated gas accompanying substances (which occure as liquids under certain conditions only) do in general not harm the engines (this is of course not applicable for the wellknown harmful gas components such as halogen compounds etc.).

2. Most frequent types of condensates found:

Gas type	Composition of condensate	Most common consequ. to the engines
Sewer- bio- and landfilgas	Acid water (already or not yet) in form of an emulsion with the cylinder oil of the gas compressor	Corrosion (—> wear)
		TAN-concentration or ipH reduction in lube oil
		Carbon deposits on: Valves Piston ring grooves Piston ring slots
Gas accompanying petroleum	Liquid forms of higher hydrocarbon compounds	Washing off lube oil film (seizing)
		Knocking combustion
		Edges burning off
	Liquid forms of higher hydrocarbon compounds and/or naphta	Carbon deposits on: Valves Piston ring grooves Piston ring slots
Propane/Butane gas (evaporated LPG)	Liquid forms of propane/ butane	Washing off lube oil film (seizing)
		Knocking combustion
		Edges burning off
Carbonization gas (e.g. woodgas)	In the same for of subst. as mentioned above	All the troubles as mentioned above

2.1 Notes:

2.1.1. According to our experience, operational troubles caused by insufficiently dried gas will in most of the cases first occure outside of the real engine, that is in instruments, controls and pipelines.
Such troubles should be recognized as a first sign of disorderly operating, as otherwise operational breakdown might follow at any time earlier or later.

3. Principle to be followed to prevent troubles due to condensat in the fuel gas:

3.1 Lack of steam by cooling and/or expansion.

3.2 Mechanical separation (e.g. cyclon or separation filter) and discharge of condensate.

3.3 The fuel gas line leading further to the engine should be designed to allow the gas not to further cool down, that means it is practically no more expanded by resistances or succeeding pressure reducers. (If necessary, insulate the fuel gas line or provide with an associating heating system).

3.4 Since in spite of the freedom from condensate found on the test taps, a certain quantity of condensate will still find its way into the engine, it is very important to ensure that the condensate is free from acid-forming components as far as possible. The ageous extract coming from the condensate separators should be tested for its pH-value for verification.
The higher the acid concentration, the higher the harmful effect even in case of quantities of condensate which are very small but still getting into the engine with the gas.

1. Aim:

These technical instructions describe the pickling and conservation of steel pipes.

2. General:

Pipes that are subjected to welding or that undergo scaling due to other effects of heat must be cleaned by pickling.
Secure all piping against vibration. Connections to the motor must be made via flexible connecting pieces.
A test certificate complying with DIN 8560 test group RII is required before welding work can be carried out on gas pipes.
Pressure and impermeability checks shall be carried out in accordance with country-specific or local regulations.
Seal gas-carrying threaded pipe connections with DIN-DVGW registered screw thread sealing tape or registered “Wevoplast F“ (DIN-DVGW Reg. No. 74.01 e 130) in conjunction with hemp (flax).

3. Pickling of pipes:

Use a mixture of sodium bisulphate and water or hydrochloric acid and water as the pickling agent.

Mixing ratio of water to acid:

Hydrochloric acid	1:1	
Sodium bisulphate	1:20	**Use the mixing ratios specified by the manufacturer of the pickling agent.**

Close pipe at one end and fill with pickling agent or, if possible, lay it in a pickling bath.
Comply with the temperature information given by the manufacturer of the pickling agent.

Pickling agent exposure time:

Hydrochloric acid/water	approximately 1 hour
Sodium bisulphate/water	approximately 10 hours

After expiry of exposure time, empty pipe or remove it from the pickling bath and rinse thoroughly with a cold cleansing agent.
Ensure that the pipe is adequately cleaned.

Dispose of pickling agent correctly.

4. Conservation of pickled pipes:

After pickling, conserve pipes with suitable media.
e. g. oil pipe - engine oil; cooling-water pipes - coolant.

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1. General:

1.1 Employer's duties:

Employers are required to assume responsibility for the safety and health of employees in all aspects of their work. Employers have to take any measures required to protect life, health and standards, including measures to prevent work-related dangers, to provide information and instruction and to provide a suitable organisation and the required resources.
First and foremost, companies contracted to carry out work must comply with all applicable country-specific regulations.

1.2 Employee's duties:

Employees are legally required to apply the measures to protect life, health and standards as laid down in statutory legislation and official regulations and in accordance with their training and their employer's instructions. They have to behave in such a way that avoids causing danger wherever possible.

1.3 Safety of machines and associated electrical equipment:

After proper assembly/installation and completion of commissioning, GE Jenbacher machines and the associated electrical equipment comply with all applicable EU directives and therefore European safety and health requirements (Machinery, Electro-Magnetic Compatibility and Low-Voltage Directives).

2. Specialist field - electrical engineering:

2.1 Definition of terms:

Electrically skilled person ⇨ The electrical specialist must (and can) recognise potential dangers and take responsibility for assessing the work given to him/her.

Technical qualification achieved by successful completion of a specialist training course (e.g. electrical engineer, master electrician, qualified electrician).

Similarly, several years of work experience – on-the-job-training - in a particular field of electrical engineering can impart the required knowledge and skills, and form the basis for qualification as a skilled electrician for limited ranges of tasks (e.g. staff who repair plants and carry out minor modifications).

Special knowledge in the field of "electrical plants based on block heating/power station technology using gas combustion engines".
Knowledge of the relevant electrical engineering requirements and employee protection regulations
(e.g. EN 50110-1 + EN 50110-2-x, BGV A3, ÖVE/ÖNORM E 8001-1, VDE 0100-410, HD 60364-4-41, IEC 60364-4-41, ÖVE/ÖNORM E 8001-6-61, VDE 0100-600, HD 60364-6, IEC 60364-6).

A **Electrically instructed person** is someone who has been instructed and if necessary trained by an electrical specialist for the tasks allotted to him/her and on the potential dangers arising from incorrect behaviour, as well as in terms of the protective measures required.
A person instructed in electrical engineering **is not allowed** to assemble, alter or maintain electrical plant and equipment on his/her own. This may only be done under the direction and supervision of an electrical specialist.

Operation of electrical installations
Covers all activities (**operating and working**) on and in electrical plants, as well as on and with electrical equipment.

Working on electrical installations
This includes the **manufacture, assembly**, modification, maintenance and repair of electrical plants and equipment (also, for example, clearing faults).

Operating electrical plants and equipment
In principle this can be any work performed on setting, switching and controlling devices (e.g. switching a power switch, replacing a plug fuse).

EN 50110-1 + EN 50110-2-x Operation of electrical installations:
This standard is applicable to all operation of and work activity on, with, or near electrical installations. These are electrical installations operating at voltage levels from and including extra-low voltage up to and including high voltage.

Initial start-up
An electrical plant may only be started up for the first time when a test has proved that the equipment conforms, electrically and mechanically, to the safety requirements specified in

- accident prevention regulations, and
- electrical engineering rules.

The same applies to restarting after a repair (in particular, testing the measures to protect against accidental contact).

Employee protection regulations

As the terms are generally understood, **national provisions** (laws and orders) and **accident prevention regulations** issued, for example, by professional associations, are deemed to be employee protection regulations.

The legal status of an accident prevention regulation must be inferred from the law or from the individual regulations (e.g. BGV A3 is legally binding in Germany).

Electrical engineering rules/provisions

These are "generally" recognised rules of the trade which are contained, for example, in the IEC, CENELEC EN-, CENELEC HD-, VDE, and ÖVE provisions (recognised = the majority of the experts are convinced of their correctness). Legislators and regulators refer to the "(**Generally**) **recognised rules of the trade**" and their legal status therefore follows from this.

ÖVE	Austrian Electrotechnical Association
VDE	German Association for Electrical, Electronic & Information Technologies
CENELEC	European Committee for Electrotechnical Standardisation
IEC	International Electrotechnical Commission

2.2 Spheres of activity and required qualifications:

Work on electrical plants

Exclusively by **electrical specialists**
or carried out under their **direction** and **supervision**

Limited in space and time, direction and supervision relate to a clear-cut task or a defined job (it must not mean in every case that the electrical specialist is required to be permanently "on site"). The electrical specialist's "responsibility for direction and supervision" covers, in particular:

- Induction (introduction, training)
- Instructing about possible dangers and safe behaviour (as well as regular or continuous supervision)
- Introduction and employment of some supervisory staff to whom, after relevant instruction by the electrical specialist, supervisory duties can be assigned to assist the electrical specialist.
- Monitoring to ensure that the work is carried out properly.

Operating electrical plants and equipment

These duties must be carried out by a person who is at least **instructed in electrical engineering**.

For the following examples, an employee must be at least qualified as an instructed person:

- Cleaning electrical plants
- Working close to electrically live parts
- Determining zero voltage
- Activating actuators which are required for the safety or functioning of an electrical plant or electrical equipment.

Initial start-up

Must be carried out by an **electrical specialist**

2.3 Complying and dealing with necessary technical informational materials:

2.3.1 Informational materials In our case, the general term "informational materials" includes

General provisions for employee protection

- Laws and statutory regulations

Accident prevention regulations, such as

- Electrical plant and equipment (**BGV A3**) - Germany
- Operation of electrical installations, basic regulations **EN 50110-1 + EN 50110-2-x**

Electrical engineering provisions

The "Generally recognised rules of the trade" (e.g. IEC, CENELEC EN-, CENELEC HD-, VDE regulations or standards) cover, for example, the following subjects:

- Assembly of electrical high-power plant with nominal voltage up to ≈ 1000V and = 1500V
  - Definition of terms and protection against shock currents, ÖVE/ÖNORM E 8001-1
  - Electrical equipment, ÖVE EN 1 Teil 2, ÖVE/ÖNORM E 8001-2-x
  - Quality and use of wiring and cables, ÖVE EN 1 Teil 3, ÖVE/ÖNORM E 8001-3-41
- Electrical high-power plant and safety current supply in structural works for communal facilities, ÖVE/ÖNORM E 8002-x, VDE 0100-718
- Electrical high-power plant in hospitals and in premises used for medical purposes outside hospitals, ÖVE EN 7, VDE 0100-710
- Assembly of electrical high-power plant with nominal voltages up to 1000 V - DIN-VDE 0100
  - Protective measures - Group 400 (part 410, 470)
  - Selection and assembly of electrical equipment - Group 500
  - Tests - Group 600 (part 600 - initial tests)
- Low-voltage switchgear and controlgear assemblies – Type-tested and partially type-tested assemblies, EN / IEC 60439-1
- Safety of machinery – Electrical equipment of machines – General requirements, EN / IEC 60204-1

2.3.2 Hand-over and handling (duty to instruct):

Information materials:

To be handed over to foremen and other **supervisors** as well as other people who work under their own responsibility.

Other employees who work on electrical equipment or electrical plants must be given the opportunity to **read** these materials (e.g. by creating a reading area or posting them on notice boards).

The workforce must be informed of the rules and operating regulations applicable to their work and have them explained, and make it their duty to follow them. This must be repeated at suitable intervals as dictated by the operational conditions.

People who only work temporarily in and on plants, or are only involved in specific jobs, must be informed of the dangers and the protective measures associated with these jobs and warned to be careful.

⇨For all work as defined in the provision on the "Operation of electrical high-power plant", a suitable person who is familiar with the necessary safety measures must be appointed as the person immediately responsible.

If you adhere to the "Generally recognised rules of the trade" it is unlikely that you will give the appearance of having acted negligently. You are therefore strongly urged to follow the "Generally recognised rules of the trade".

2.3.3 Sources of information:

- Laws or electrical engineering laws and statutory regulations arising from them
- Professional organisations ⇨ Accident prevention regulation VBG 4
- Trade associations (or committees) ⇨ ÖVE or VDE rules
- Standards institutes, e.g. DIN and ÖNORM
- European Committee for Electrotechnical Standardisation (CENELEC) EN Standards, HD (Harmonization Documents)
- International Electrotechnical Commission (IEC) ⇨ IEC publications (international standard).

2.4 Concluding explanatory note:

The contents of the above sections are based on current Austrian and German regulations. Basically, this section provides a path which, if converted into appropriate action, achieves a sufficiently high level of safety in terms of protecting human life and equipment. All those companies or operatives engaged in the setting up or installation of the above systems, who are subject to legislation other than that of Austria, must of course act strictly in accordance with the regulations by which they are bound. The above guidelines are intended, above all, to focus attention on the basic issues and call on those in executive positions to take considered action.
The subject of "commissioning" is only dealt with at a basic level because the commissioning of GE Jenbacher combined power/heat systems or electrical power generation systems demands more extensive and specialised training. GE Jenbacher does not consider technical training in electrical engineering alone to be sufficient for this task.

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1. General:

The operating and maintenance instructions contain basic safety signs, requirements and directions which must be observed during the delivery, setting-up, commissioning, operation and maintenance of GE Jenbacher machinery. These documents must be read and understood by the user before starting the machinery. The most recent edition of the operating instructions must always be available at the machine.

The information contained in the safety instructions below is intended to provide you with an overview of danger zones and possible causes of accidents.

While the instructions below are intended for your safety, they cannot cover in detail the scope of all accident risks posed by industrial machinery.

When operating this machinery it is your duty to comply with all current official and quasi-official safety rules and codes applicable to your sector. You should also use your own powers of judgement to avoid hazards and dangerous situations.
Most accidents are caused when people disregard simple, basic safety rules.

Any manipulation of the machine or its control cabinets which causes the machinery to operate outside its specified operating range (control range), is prohibited and could result in serious indirect damage.

Any modifications of the item supplied, including changes to the program and software, which are carried out by the customer or third parties without GE Jenbacher's prior consent will result in the lapse of any right to damages or the exercise of a warranty claim against GE Jenbacher.

2. Safety signs – hazard classification system:

The pictograms with hazard classification used in this document are also used on GE Jenbacher products. They refer to each of the hazards as described in this document.

DANGER (ISO DIS 3864-2)
denotes a high-risk hazard. If this hazard sign is ignored, death or severe injury will follow as a direct consequence.

WARNING (ISO DIS 3864-2)
denotes a medium-risk hazard. If this hazard sign is ignored, death or severe injury may result.

CAUTION (ISO DIS 3864-2)
denotes a low-risk hazard. If this hazard sign is ignored, minor or moderate injury may result.

NOTICE (similar to ANSI Z535.2)
denotes information directly or indirectly relating to the safety of employees or measures to protect the machinery. If this hazard sign is ignored, breakdowns or material damage may result.

3. Health and safety during operation and maintenance:

The customer will take all necessary precautions to ensure the safety of the contractor‘s personnel at the site. This includes provisions for review by the contractor of and safety instruction by the customer on the customer‘s safety practices, proper safe handling and disposal of hazardous substances and the protection of the contractor‘s personnel from exposure to such substances, activation and deactivation of all power systems (electrical, mechanical and hydraulic) using a safe and effective lock-out tag procedure, and conducting periodic safety meetings.

The contractor will comply with reasonable health and safety requirements imposed from time to time by the customer at the facility.

The contractor may conduct occasional safety audits to ensure that safe conditions exist and make recommendations to the customer concerning such conditions. Neither the performance or non-performance of safety audits nor the making of any recommendation by the contractor will relieve the customer of the responsibility to provide a safe place to work. If the contractor‘s staff require medical attention, the customer’s local facilities will be made available to the contractor‘s staff for as long as necessary.

If, in the contractor‘s opinion, the safe performance of work at the site is or may be endangered by local conditions, the contractor may remove some or all of its staff from the site and/or supervise performance of all or any part of its work and/or evacuate its staff. The customer will assist with any such evacuation.

The operation of equipment at the site will be the responsibility of the customer. If the customer requires or permits the contractor‘s staff to operate equipment at the site, the customer will indemnify the contractor, its employees and agents for all costs and liability (including any reasonable attorney‘s fees) incurred by or imposed upon the contractor, its employees and agents, based upon injury to persons (including death) or damage to property resulting from the operation of equipment at the site by the contractor‘s staff.

If the customer provides the contractor‘s staff with any tools and equipment to perform work at the site, these tools and equipment must be in a safe working condition (i.e. subject to inspections and preventive maintenance).

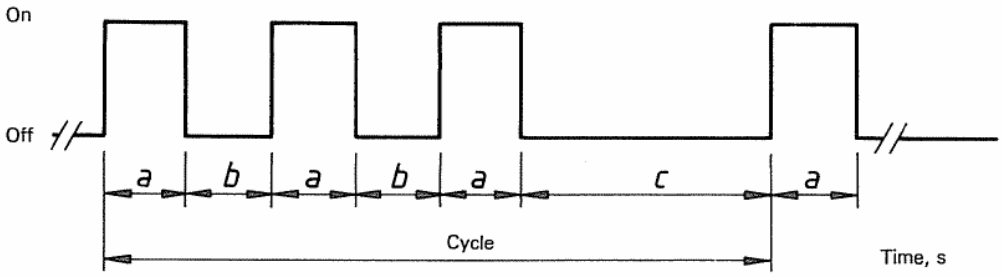
If the contractor encounters any hazardous material at the site which requires special handling and/or disposal, the customer will immediately take whatever precautions are required to legally eliminate such hazardous conditions so that the work under contract may proceed safely. The customer must ensure that all hazardous materials produced or generated in the course of the contractor’s work at the site are removed.

All decontamination necessary for the contractor‘s work (including any repair work) will be performed by the customer.

4. What to do in the event of an alarm:

4.1 Evacuation alarm (gas alarm, fire alarm, CO alarm, gas pre-alarm):

Evacuation alarm as specified in ISO 8201/minimum duration 180 seconds.



Key: Phase *a* signal is "on" for 0.5 s ± 10%
Phase *b* signal is "off" for 0.5 s ± 10%
Phase *c* signal is "off" for 1.5 s ± 10% (*c* = *a* + 2*b*)
Length of cycle: 4 s ± 10%

- **Leave the affected area immediately. Go out into the fresh air, outdoors, right away.**
- **Close the gas safety shut-off valve outside the engine room and outside the danger zone and make sure that it cannot be opened unintentionally.**
- **Call the fire brigade.**
- **Do not re-enter the affected area.**
- **Wait for the fire brigade to arrive.**
- **Warn other people about the danger.**
- **Do not re-enter the affected area until the danger has been eliminated with the professional assistance of the fire brigade, the fault or damage professionally rectified, all enclosed spaces thoroughly ventilated and the area has been declared safe to re-enter.**

Bear in mind that ambient and operating conditions differ from plant to plant and the general rule is that, **before work starts in plants using poisonous gases, the operator of the plant should draw up an EMERGENCY PLAN** which takes these specific conditions into account. The relevant statutory regulations must also be taken into account. This emergency plan must be brought to the attention of all persons employed at the plant, evidence of which must be available.

An emergency plan will generally consist of at least the following information:

- Emergency regulations (what to do, evacuation, escape routes, assembly point, etc.)
- Local emergency telephone numbers (rescue, emergency doctor, fire brigade)
- People to be notified in the event of an emergency
- Location of breathing apparatus independent of ambient air
- Other necessary safety information as laid down in statutory regulations, etc.

4.2 CO pre-alarm:

Close the gas safety shut-off valve outside the engine room and make sure that it cannot be opened unintentionally. Leave the engine to run until it stops of its own accord due to lack of gas. The ventilation is set to maximum by the engine control system. Call in professionals to look for the gas leak and initiate damage repair.

5. Personal protection:

TI 2300-0001 – Employee protection

The operation of the machinery or work on the machinery may only be carried out by specialist staff who have received relevant electrical and mechanical training.

Access to the machine room is restricted to persons (specialist staff) who have read, understood and will observe the safety instructions.

Prohibition, hazard, mandatory and warning signs must be obeyed at all times. Any failure to do so may result in injury and death or damage the machinery.

Wear personal protective equipment (PPE)!
Wear the personal protective equipment approved by the health and safety organisations for body, head, eyes, ears and breathing. Never be in the vicinity of an engine when wearing loose clothing, jewellery or long hair.

The standard equipment required for entering the engine room or approaching and working on plant components, even outside the engine room, consists of eye protection, protective clothing, hand protection and safety footwear.

Depending on the operational condition of the plant, the ambient conditions, the type or location of the operation, use hearing protection, safety helmet, fall prevention equipment, gas sensors, breathing mask or other personal protective equipment, as appropriate.

You should also use your own powers of judgement to avoid hazards and dangerous situations and wear the appropriate personal protective equipment.

It is your duty to comply with all current official and quasi-official safety rules and codes applicable to your sector.

Depending on the operating condition of the machinery or the operation, hazards may arise which cause injury, so wear the appropriate personal protective equipment. The examples below are not exhaustive.

Working when machinery is running:
- Hearing protection, eye protection, protective clothing, safety footwear, hand protection

Assembly operations during maintenance and repair:
Caution: many plant and engine components are heavy. This gives rise to a risk of severe crushing and impact injuries due to the heavy weight of the components.
- Safety footwear, protective clothing, hand protection!

Installation, construction site, difficult access:
Danger of falling, tipping or flying objects, swinging loads and bumping into obstacles, which can cause severe head injuries.
- Safety helmet, safety footwear!

Hot surfaces and liquids (oil, cooling water):
The engine, pipework, etc. can reach a surface temperature of up to 150°C.
- Thermal insulation gloves, protective clothing!

Pressurised pipes and containers:
Liquids such as engine cooling water and lubricating oil are hot and under pressure.
- Eye protection, protective clothing, thermal insulation gloves!

Working in dusty conditions:
Changing the air filter, cleaning operations, changing the active carbon, etc.
- Wear a breathing mask, eye protection, protective clothing and safety footwear!

Handling acids, starter battery, cleaning products, oil, anti-freeze and anti-corrosion products, chemicals:
- Acid- or chemical-resistant gloves and clothing, eye protection, safety footwear. Follow the manufacturer's instructions!

Working at height (above 1.2 m):
Even falls from low heights can result in serious injury. When working at height (above 1.2 m), where the provision of technical safeguards (e.g. handrails, work platforms, etc.) is either impossible or impractical, you should use:
- personal fall arrest equipment consisting of harness and associated equipment (safety rope, karabiner hook, shock absorber, lanyard or height safety device)!

Using fuel gas containing CO (read the results of the gas analyses):
- CO sensors as personal protective equipment! Ensure personal protective equipment is regularly maintained/calibrated.

People who are under the influence of alcohol and/or drugs represent a danger to themselves and other people.
They must not be allowed to enter the engine room under any circumstances.

6. Transporting-lifting-installing:

Familiarise yourself with the technical instructions concerning the requirements for the installation surface, lifting, transport safety pegs, transporting and positioning and installing GE Jenbacher modules, containers and switch cabinets, and the corresponding constraints.

Never use transport security shackles to lift components or modules. They are only used to secure components or modules to the transport vehicle.

7. Shutdown procedure and securing:

Automatic machinery: liable to start without warning!

If the operating mode selector switch is in "Aut" position, the module may start without warning at any time.

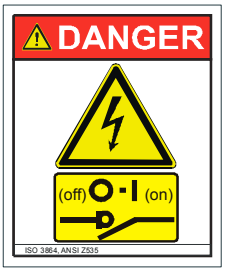
Before commencing maintenance work, repairs, etc., shut down machinery as described below and secure to prevent unauthorised start-up!

Shut down and secure!

To shut down the engine:
Switch off the engine in accordance with **Technical Instruction No. 1100-0105** and ensure that unauthorised persons cannot start the engine.

Isolate from power supply before starting work!

Before starting work, isolate the machinery from the relevant circuits to prevent it from being restarted and check to ensure that the system is dead.



Dangerous voltage!

If you see this warning near the mains isolating device, this means that the mains isolating device does not switch off all electrical circuits. The 'except for' electrical circuits - i.e. the circuits that are not switched off - are shown in the circuit diagram.

Despite having isolated the machinery, you should regard all components as live. Check that all components are disconnected!

High-voltage ignition system – 40kV!
Improper use may be fatal!

The ignition system may cause electric shock.
Ignition systems may also produce **extremely dangerous voltages** when the equipment is **not operating**. This applies to all ignition system components, such as the cable, coil, connector, etc!

Hot surfaces!

Risk of burns

Let engine cool down, wear personal protective equipment!
Wear thermal insulation gloves and protective clothing!

Risk of escaping liquids (hot and under pressure)!

Liquids such as engine cooling water and lubricating oil are hot and under pressure. Escaping liquids may cause serious injury.

Wear personal protective equipment!
Wear eye protection, thermal insulation gloves and protective clothing!

Allow the engine and cooling water to cool down before removing pipes, gaskets and covers or opening components that contain liquids. The pressure must first be reduced to zero. Only then, drain the cooling water if necessary. Liquids must be drained completely.

Risk of explosion!

When charging, batteries produce hydrogen and oxygen which under certain conditions may form an explosive mixture.
The battery is charged with 24 V DC even when the control system is switched off. Sparks generated at the battery poles can ignite an explosive atmosphere.

Check that the battery poles are firmly secured. No smoking, no naked flames, no sparks!

Poisonous gases!

The air in the engine room may be severely polluted with evaporating oil, cooling water, fuel gases or exhaust gases.

Ventilate the engine room thoroughly before starting work!
Ensure there is a fresh air supply when working in the engine room!
Wear personal protective equipment (gas sensors)!

8. Engine room:

No admittance for unauthorised persons!
Room contains electrical equipment!
Admittance for authorised and trained personnel only (specialist staff)!

In principle, the engine room is an enclosed, protected room for the unmanned operation of machinery.

Read the personal protection guidelines in these safety instructions and wear the personal protective equipment appropriate to the dangers concerned!

Noise!

The noise produced when the machinery is operating or being started may damage your hearing.

Wear hearing protection!

No pacemakers!

Because of the possibility of electromagnetic effects on pacemakers or similar devices, people with such devices are prohibited from entering the engine room.

No fire, naked flames or smoking!

Install fire extinguishers!

Fire extinguishers must be installed in places where they can be easily reached in the event of a fire. Comply with official regulations and establish the types, size and number of extinguishers required with your supplier and insurance agent.

Risk of slipping!

Wipe up any spilt oil and coolant immediately and keep the machinery clean!

Highly flammable materials!

Keep oily rags in fire-proof containers. Never leave them lying on the engine.

Do not store flammable liquids near engines.
Keep the machinery clean!

Mark escape routes!

Mark escape routes from the engine room and keep them clear of obstructions.

Risk of escaping liquids (hot and under pressure)**!**

Avoid danger zones around safety valve and explosion protection valve openings.
There are also danger zones around air filters.

Hot surfaces!

Risk of burns

Let engine cool down, wear personal protective equipment!
Wear thermal insulation gloves and protective clothing!

Poisonous gases!

Enclosed spaces must be well ventilated to ensure a constant supply of fresh air.
Rooms in which gas-consuming devices are operated must be ventilated.

If you become aware of **unusual machine noise and unusual smells** in the engine room, carry out a check. If you detect a gas concentration in a building, you should always observe the following instructions:

If you fear that a hazard exists, actuate the **emergency stop button** outside the engine room, close the gas safety shut-off valve outside the engine room and make sure that it cannot be opened unintentionally. Prevent any possibility of ignition and, if possible, break all the electrical circuits from outside the danger zone.
Evacuate all staff from the danger zone.
Allow air into the affected parts of the building by opening windows and doors.
Call in professionals to look for the gas leak and its cause and initiate damage repair.

Poisonous gases (e.g.: CO, H_2S, etc.)!
Read the results of the fuel gas analyses!

Fuel gases may be poisonous and may result in death or damage to health if inhaled.

Wear **gas sensors** as personal **protective equipment (appropriate to the poisonous gas components)** and ensure proper ventilation!

If the fuel gas contains carbon monoxide CO:
Carbon monoxide is a poisonous, **odourless, colourless, highly flammable** gas, which is about as heavy as air.

Read the results of the fuel gas analyses!

Wear CO sensors as personal protective equipment when:

- the gas is odourless and the **CO content** of the fuel gas is **>0%**.
- the gas contains **odours** and the **CO content** of the fuel gas is **>0.5%**.

Observe these guide values if no other safety guidelines are available or they are less stringent than the guide values. Country-specific thresholds/guidelines ALWAYS have priority. Also ensure that personal protective equipment is regularly maintained/calibrated.

CO concentration in the air and its effect if inhaled:

- 0.003 Vol% = 30 ppm — no/minimal risk to health
- 0.010 Vol% = 100 ppm — slight headache after several hours
- 0.050 Vol% = 500 ppm — severe headache after several hours, accompanied by dizziness, fainting
- 0.1 Vol%-0.2 Vol% = 1000-2000 ppm — **death after 30 minutes**
- 0.3 Vol%-0.5 Vol% = 3000-5000 ppm — **death after a few minutes**

Other symptoms: vomiting and nausea, buzzing in the ears, light-headedness, convulsions, hyperventilation, etc.

Risk of explosion

The air-gas mixture used as engine fuel is easily ignited and may explode.

Close and make secure the manual stop valve, ensure there are no sparks or naked flames, impose a strict ban on smoking and provide adequate ventilation!

9. Components:

Protective devices should not be removed while the machinery is in operation. Repair or replace damaged protective devices immediately.
Before removing any protective device, secure the machinery to prevent unauthorised start-up.

Shut down and secure!

Shutdown procedure and securing → Refer to section on "Shutdown procedure and securing" in these safety instructions!

9.1 Exhaust-gas system:

Engine exhaust gases are poisonous and may result in death or damage to health if inhaled.
Exhaust gases must always be discharged into the atmosphere.
The exhaust-gas system must be inspected regularly to ensure that it is gas-tight:

Visually	-	Cracks, corrosion, faulty gaskets
Odour	-	Exhaust smell

Locations at risk: Flange connections, gaskets, compensators, welded joints.
It is the operator's responsibility to ensure that there are no leaks in the exhaust system.

Poisonous gases!

Inhalation will result in damage to health or death.

Discharge exhaust gases into the atmosphere, check for leaks, provide adequate ventilation.

Hot surfaces!

Components which are not insulated and through which exhaust gas passes are very hot and can cause severe burns.

Let engine cool down, wear personal protective equipment!
Wear thermal insulation gloves and protective clothing!

9.2 Turbocharger:

As the turbocharger operates at high temperatures, flammable material must be kept at a distance.
Work on the turbocharger must only be carried out once the engine has been shut down and room temperature has been reached, otherwise there is a risk of injury and fire.

Hot surfaces!

Risk of burns

Let engine cool down, wear personal protective equipment!
Wear thermal insulation gloves and protective clothing!

Fire risk!

Fire

Avoid contact with flammable material and keep the machinery clean!

9.3 Fuel gas system:

The engine is equipped for the fuel gas quality specified by the customer when the engine was ordered, and is adjusted for this gas when it is first put into operation.

Notify GE Jenbacher Customer Service before you convert the system to another type of fuel gas and each time the fuel gas quality is changed!

Caution: The air-gas mixture used as engine fuel is easily ignited and may explode.
As soon as fuel gas is present in the pipes **no welding work** must be carried out in the engine room concerned.
No naked flames may be used and a **strict ban on smoking** must be observed.

The guidelines below must be read in conjunction with other mandatory requirements (arrangement plan, Technical Instructions, statutory regulations, official directives, etc.) when assembling and operating the machinery:

The engine room ventilation must be designed so that gas concentrations are prevented and a slight overpressure exists in the engine room. Refer to TI 1100-0110.

Ensure that the pipes and components through which the fuel gas passes are fully leakproof.

A leak test as described in IW 8049 0 is required if a leak is detected or after repairs to pipes or components carrying fuel gas and mixtures.

Install a flame trap (depending on the legal requirements of the country where the equipment is located) in the gas supply line.

Plant-side safety valves must always be directed downwards.

A **manual stop valve** must be provided outside the engine room for intentional shutdown of the machinery (e.g. for repair and maintenance and in emergencies), preferably at the point where the gas pipes enter the engine room.
The manual stop valve must be designed to ensure that no unauthorised person can actuate it, i.e. open it when in locked position.

It is the operator's responsibility to ensure that the fuel gas system is equipped with the necessary devices, does not leak and satisfies official requirements.

Risk of explosion

The air-gas mixture used as engine fuel is easily ignited and may explode. Gas being discharged could create a potentially explosive atmosphere.

No welding, no naked flames, strict ban on smoking, efficient maintenance/inspection, leak tests, adequate ventilation gas alarm system, manual stop valve closed and made safe!

Poisonous gases (e.g.: CO, H_2S, etc.)!
Note the results of the gas analyses!

Fuel gases may be poisonous and may result in death or damage to health if inhaled.

Wear **gas sensors** as personal **protective equipment (appropriate to the poisonous gas components)** and ensure proper ventilation!

You must also read the engine room guidelines in these safety instructions!

Extreme care is required when carrying out maintenance or repair work on the gas pressure control system and the gas pipes. These components contain quantities of residual gas which will escape when the gas filter for example is changed or during draining condensate from the fuel-gas system!

9.4 Cooling system:

The engine coolant is hot and under pressure at operating temperature.

Damaged or weathered pipes, gaskets, hoses and hose clips and other components must be replaced immediately. If these components fracture, hot coolant could injure people and cause a fire.

Keep away from pressure relief valves when operating the machinery.

Risk of escaping liquids (hot and under pressure)

The fracturing of components causes hot coolant to escape, thereby posing a risk of injury.

Regular maintenance/inspection of components. Wear personal protective equipment (protective spectacles, protective clothing and thermal insulation gloves). Keep away from pressure relief valves!

Hot surfaces!

Risk of burns

Let engine cool down, wear personal protective equipment!
Wear thermal insulation gloves and protective clothing!

To replace pipes and components:

Shut down and secure!

Shutdown procedure and securing → Refer to section on "Shutdown procedure and securing" in these safety instructions!

Coolants are treated with anti-corrosive and anti-freeze products.
Anti-freeze and anti-corrosion products are usually classified as harmful to health. Follow the manufacturer's instructions!

Wear personal protective equipment when handling anti-corrosion products, anti-freeze products and coolant! Follow the manufacturer's safety instructions!
Note disposal requirements!

9.5 Heat exchangers:

Heat exchangers are pressure vessels which are designed for specific pressure and temperature limits.

Operators must be made familiar with the specific design pressure and temperature.

Heat exchangers must be pressure-tested on a regular basis.
A visual inspection of the following points of risk must be carried out: Flange connections, gaskets, locks and covers.

Any liquids escaping as the result of a leak may cause serious injury.

Keep away from pressure relief valves when operating the machinery.

Risk of escaping liquids (hot and under pressure)

The fracturing of components causes hot liquids to escape, thereby posing a risk of injury.

Regular maintenance/inspection, regular pressure-testing. Wear personal protective equipment (protective spectacles, protective clothing and thermal insulation gloves). Keep away from pressure relief valves! Reduce pressure!

Hot surfaces!

Risk of burns

Let heat exchangers and pipes cool down, wear personal protective equipment! Wear thermal insulation gloves and protective clothing!

Do not remove pipes, seals and covers from the cooling system until the components have cooled down, the pressure has been reduced and all liquids have been fully drained off.

To replace pipes and components:

Shut down and secure!

Shutdown procedure and securing → Refer to section on "Shutdown procedure and securing" in these safety instructions!

9.6 Safety valve:

Avoid the danger zones around the valves as they could open at any time during operation. There is a risk of injury due to hot operating materials under pressure.

Risk of escaping liquids (hot and under pressure)

The actuation of safety valves causes hot liquids to escape, thereby posing a risk of injury.

Wear personal protective equipment (protective spectacles, protective clothing and thermal insulation gloves). Keep away from pressure relief valves!

9.7 Lubrication system:

The lubricant is hot and under pressure at operating temperature.

Hot oil or hot components may cause injury when you are carrying out an oil change or replacing the filter.

Oil leaks must be scrupulously avoided as oil spray or splashes may ignite on contact with hot engine components.

Risk of escaping liquids (hot and under pressure)

The actuation of safety valves causes hot liquids to escape, thereby posing a risk of injury.

Wear personal protective equipment (protective spectacles, protective clothing and thermal insulation gloves). Keep away from pressure relief valves!

Hot surfaces!

Components of the lubrication system (oil lines and filters, valves, etc.) are hot and can cause severe burns.

Let components cool down, wear personal protective equipment! Wear thermal insulation gloves and protective clothing!

Fire risk!

Oil leaks must be scrupulously avoided as oil spray or splashes may ignite on contact with hot engine components.

Keep the machinery clean and carry out maintenance/inspection as instructed!

Lubricating oils and oily rags must be disposed of as special waste.

9.8 Control system:

The control rod assembly must not be obstructed while the machinery is operating. Any unauthorised adjustment or bending of the control rod assembly could cause the engine to race.

9.9 Ignition system:

High-voltage ignition system – 40kV!
Improper use may be fatal!

The ignition system may cause electric shock.
Ignition systems may also produce extremely dangerous voltages when the equipment is not operating.
Do not touch ignition system components such as the cable, coil, connector, etc. while the engine is running. Do not pull ignition cables off of coils! Ignition cables must not come into contact with other parts!

The spark plug ignites an air-gas mixture in the combustion chamber. As a result, any air-gas mixture which has accumulated in the induction port, exhaust system or turbocharger may ignite. Failures must not simply be reset. Before restarting the module, you must first remedy the cause of the failure! Please read the rules on this subject in **Technical Instruction 1100-0111**.

Risk of explosion
Failures or incorrect operation (e.g. frequent unsuccessful attempts to start, resetting the fault contrary to instructions, cause of the failure not remedied, etc.) may cause an air-gas mixture to accumulate outside the combustion chamber and explode, thereby causing serious injury, death and severe damage.

Remedy failures, operate machinery and carry out maintenance and inspections in accordance with instructions!

9.10 Cables and insulated wiring:

Dangerous electrical voltage

To protect you from the hazards posed by electrical energy, we would point out that the use of cables and insulated wiring must comply with the technical specifications issued by VDE, IEC, etc., in accordance with local regulations and such work may only be performed by authorised technicians (officially licensed electricians).
GE Jenbacher accepts no liability for injury, loss or damage due to improper installation.

9.11 Throttle valve:

- Do not obstruct or block the control rod assembly.
- Do not attach objects to or suspend them from the control rod assembly.
- Do not misuse the control rod assembly as a fixing point for fall prevention equipment.

9.12 Electrical connections:

Dangerous electrical voltage

All electrical connections involve a risk of making a direct or indirect electrical contact. Contact could result in a serious, and possibly fatal, electric shock.

Connected components must be installed only by authorised experts (officially licensed electricians) in accordance with local regulations.

9.13 Generator:

Dangerous electrical voltage

The voltage produced by the generator is **deadly**.

Contact could result in a serious, and possibly fatal, electric shock.

Connected components must be installed only by authorised experts (officially licensed electricians) in accordance with local regulations.

Make sure that the generator is earthed before it is operated for the first time.

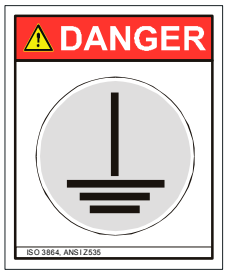
Extreme caution is required if the generator or the area around it is damp or wet.

In the event of an accident caused by electric shock, shut the module down immediately by pressing the emergency stop button.

If the victim is injured or unconscious, summon a first-aider or medical assistance immediately.

If the generator is shut down by a safety device, do not restart it until the cause of the accident has been remedied.

During commissioning, the manufacturer of the power supply cubicle must implement the protective measures required under local regulations.



Ensure machine is properly earthed!

The machine must be **properly earthed** to prevent contact voltages and electrostatic charging contrary to regulations.
Make sure that the engine is resting **on non-conductive rubber bearings.**

9.14 Electrical cabinets:

Dangerous electrical voltage

The voltage inside electrical cabinets is **deadly.**

Contact could result in a serious, and possibly fatal, electric shock.

Connected components must be installed only by authorised experts (officially licensed electricians) in accordance with local regulations.

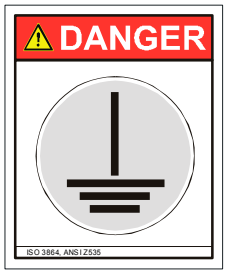
Make sure that the control cabinet is earthed before the plant is operated for the first time.

Extreme caution is required if the electrical cabinet or the area around it is damp or wet.

In the event of an accident caused by electric shock, shut the module down immediately by pressing the emergency stop button.

If the victim is injured or unconscious, summon a first-aider or medical assistance immediately.

During commissioning, the manufacturer of the power supply cubicle must implement the protective measures required under local regulations.



Ensure machine is properly earthed!

The electrical cabinet must be **properly earthed** to prevent contact voltages and electrostatic charging contrary to regulations.

Keep door closed!

Proper operating conditions for electrical devices can only be achieved with the cabinet door closed (e.g. weather exposure, heat, cold, dust, air-conditioning in the cabinet, etc.)
This relates to all types of electrical cabinets, e.g. interface, control cabinet, power cubicle, thermal reactor cabinet, etc.

Isolate from power supply before starting work!
Caution: electrical cabinets can be supplied from a number of energy sources!

Before starting work in electrical cabinets, isolate them from all energy sources to prevent them from being reactivated and check to ensure that the system is dead.

9.15 Acoustic insulation (container; sound absorber hood):

Fire risk!

There is a risk of fire if loose lagging material comes into contact with hot engine parts.

Check acoustic insulation for damage,
Keep the machinery clean and carry out maintenance/inspection as instructed!

9.16 Battery:

Corrosive substances!

The batteries used by GE Jenbacher are filled with dilute sulphuric acid, which may cause serious corrosion.

Avoid contact with eyes and skin!

Wear personal protective equipment!
Wear acid-resistant gloves, protective clothing, protective spectacles and safety footwear when handling battery acid!
Battery acid may leak if batteries are damaged (e.g. during repair work), its corrosive action causing damage to health as well as damage to the environment and property. Acid can also cause a chemical reaction with the lime in the concrete and damage the floor.

Risk of explosion!

When charging, batteries produce hydrogen and oxygen which under certain conditions may form an explosive mixture.
The battery is charged with 24 V DC even when the control system is switched off. Sparks generated at the battery poles can ignite an explosive atmosphere.

Check that the battery poles are firmly secured. No smoking, no naked flames, no sparks!

Batteries, battery acid and rags contaminated with acid must be disposed of as special waste.

9.17 Container/enclosure:

Extreme caution is required when carrying out maintenance and installation work on the roof. **Ensure workers are always safely harnessed to prevent a fall!**

Wear safety harness / Risk of falling!

Climbing on to the roof without a safety harness is extremely dangerous.

Secure the safety harness to suitable points provided on the roof!

Use personal fall arrest equipment consisting of harness and associated equipment (safety rope, karabiner hook, shock absorber, lanyard or height safety device)!

The container or enclosure housing the plant must be designed so that the plant does not pose any risks in the accessible area.

No ladders should be permanently attached to freely accessible containers or enclosures, so as to prevent unauthorised persons from climbing on to the roof.

Where pipework, ducts, system components, etc. have to be laid or installed in the accessible area, they must be positioned at such a height that they cannot be used for climbing or the system components installed within the danger zone will also have to be enclosed.

If this is not possible, or if other dangers exist, the operator must secure the plant so as not to allow unauthorised persons access to the danger zones.

Doors left open (e.g. during maintenance work) on the container, the enclosure, the air intake, etc. can be slammed shut by a gust of wind. This may result in hand or head injuries caused by crushing and impact.

Secure open doors with storm hooks (if available) or by other suitable measures!

Keep door closed!

All doors must be closed **while the plant is operating**! Proper operating conditions can only be achieved with doors closed.

10. Maintenance and servicing:

Caution: Automatic machinery: liable to start without warning!

The customer must make sure that before performing any maintenance work on the machinery, the relevant safety precautions are taken.

Refer to the section on "Health and safety during operation and maintenance" in these safety instructions.

Before commencing maintenance work, shut down the engine as described below and make sure that it cannot be started unintentionally!

Shut down and secure!

Shutdown procedure and securing → Refer to section on "Shutdown procedure and securing" in these safety instructions!

Work on the machinery may only be carried out by specialist staff who have received relevant electrical and mechanical training. There may also be a service or maintenance contract, under which all servicing is carried out by GE Jenbacher personnel.

Suitable safe lifting gear must be used **when assembling or disassembling heavy components**. Handling heavy components gives rise to a risk of severe crushing and impact injuries due to the heavy weight of the components. Wear personal protective equipment such as safety footwear, protective clothing, hand protection and safety helmet.

Working at height (above 1.2 m):
When working at height (above 1.2 m), where the provision of technical safeguards (e.g. handrails, work platforms, etc.) is either impossible or impractical, you should use personal fall arrest equipment consisting of harness and associated equipment (safety rope, karabiner hook, shock absorber, lanyard or height safety device)!

Poisonous gases in vessels below ground level, or in basins and pits!

Poisonous gases can accumulate in basins and pits, as well as in vessels below ground level (e.g. in condensate vessels).

Ensure proper ventilation or extraction to remove gas concentrations!
Check the maximum permissible workplace values (gas concentration).

Wear **gas sensors** as personal protective equipment **(appropriate to the poisonous gas components).**

If the maximum admissible workplace values cannot be guaranteed, a suitable breathing apparatus must be worn.

Before carrying out any work on the machinery, the customer has a duty to ensure that safety will not be compromised.
Maintenance and repair work must be carried out with care. Temporary measures are not permitted:

- never repair fuses
- never deliberately ignore or re-use defective parts
- never place drip catchers under leaks
- never tighten screws, which have a specified tightening torque, contrary to the specification
- never make temporary repairs
- never implement unsystematic and unsuitable fault-finding procedures

Temporary repairs and makeshift arrangements may result in serious injury or damage the machinery.

Only repair methods specified in the engine documentation are allowed and are to be used.

11. Cleaning:

Fire risk!

Cleaning agents are usually highly flammable.

When carrying out cleaning operations, only use approved cleaning agents in well ventilated areas. Under no circumstances use petrol, paint thinners and other easily vaporising agents!
Keep cleaning agents and solvents away from flames and flying sparks!

Poisonous gases!

Avoid inhaling any gases as they may be fatal.

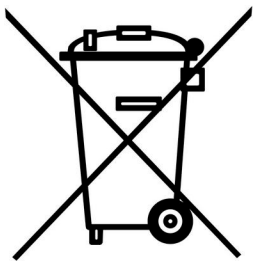
When carrying out cleaning operations, only use approved cleaning agents in well ventilated areas!

Read the labels on all cleaning agent containers and follow the instructions.

Never use unlabelled products.

Note disposal requirements.

12. Disposal requirements for waste electrical and electronic equipment:



Electrical and electronic equipment can contain harmful substances which can affect the environment and human health.

WEEE symbol (Waste of Electrical and Electronic Equipment):
the symbol for the separated disposal of electrical and electronic equipment is a crossed-out waste bin on wheels (Directive 2002/96/EC Waste Electrical and Electronic Equipment).

You must not dispose any electrical and electronic equipment marked with this symbol (battery-operated electrical appliances, measurement equipment, light-bulbs .....) in the domestic waste but dispose of these separately.

Always use the waste return and collection systems locally available and contribute to the reuse, recycling and all other forms of use for waste electrical and electronic equipment.