# Technical Instructions

## TYPE 3 ENGINE

**ISOLATED OPERATION**

07-30-2012

## Blank Page for Notes

**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.

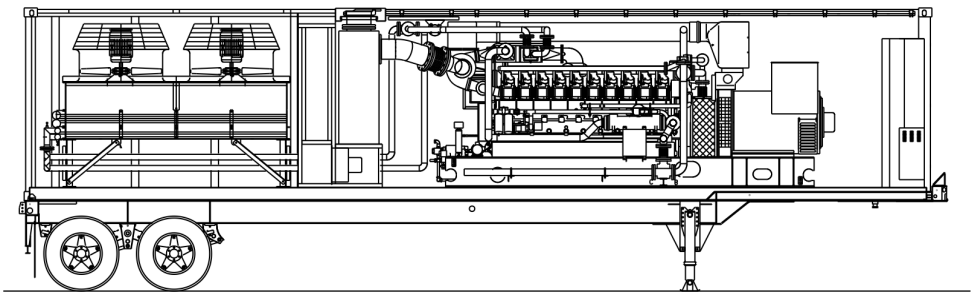
### 3.3 Flatness requirements for the installation surface:

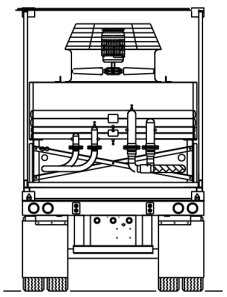
#### 3.3.1 Modules

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<br>*Auditor* |
|---|---|---|---|
| 1 | 26.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **f** | **Provin**<br>*Giese* |
| 2 | 15.10.2010 | Pos.3.3.4 / Point 3.3.4 | **Bilek**<br>*Widner Martin / Maderböck / Messner Erich* |

## Blank Page for Notes

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.

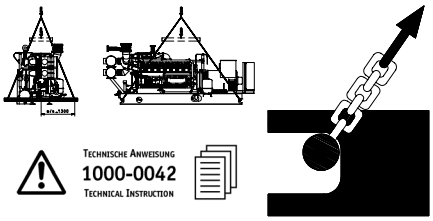
Disregarding the above instructions and improper use of the device can result in bodily injury and damage to property.

**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:**

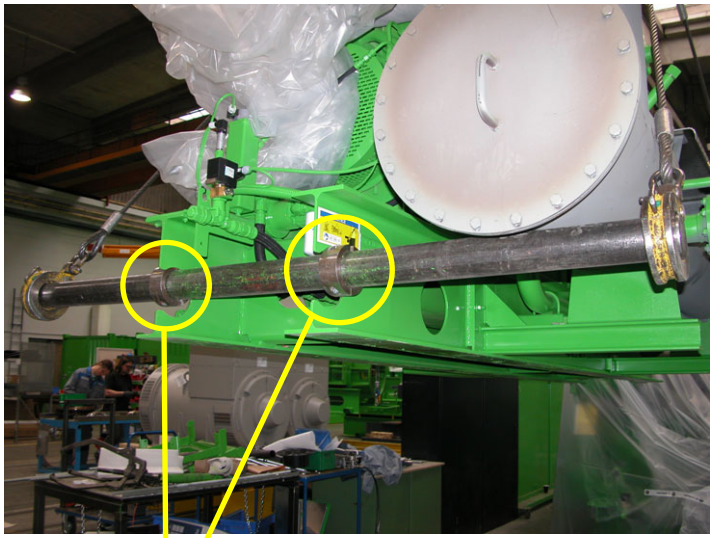
| Type | Diameter range | Length (L) | Material / thickness |
|---|---|---|---|
| 208 - 320 | ∅ 95 mm | 2,400 mm | 42 CrMo4V |
| 612/616 (unsplit module frame) | ∅ 120 mm | 2,400 mm | 42 CrMo4V |

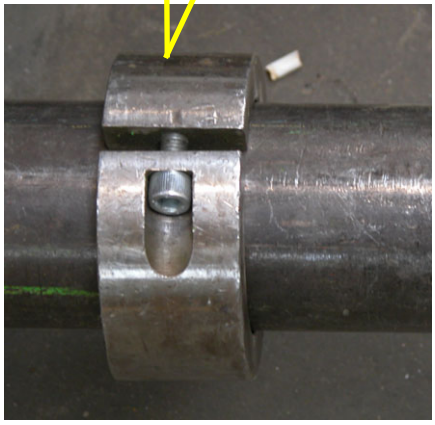
### 2.1.2 Lifting gear:

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

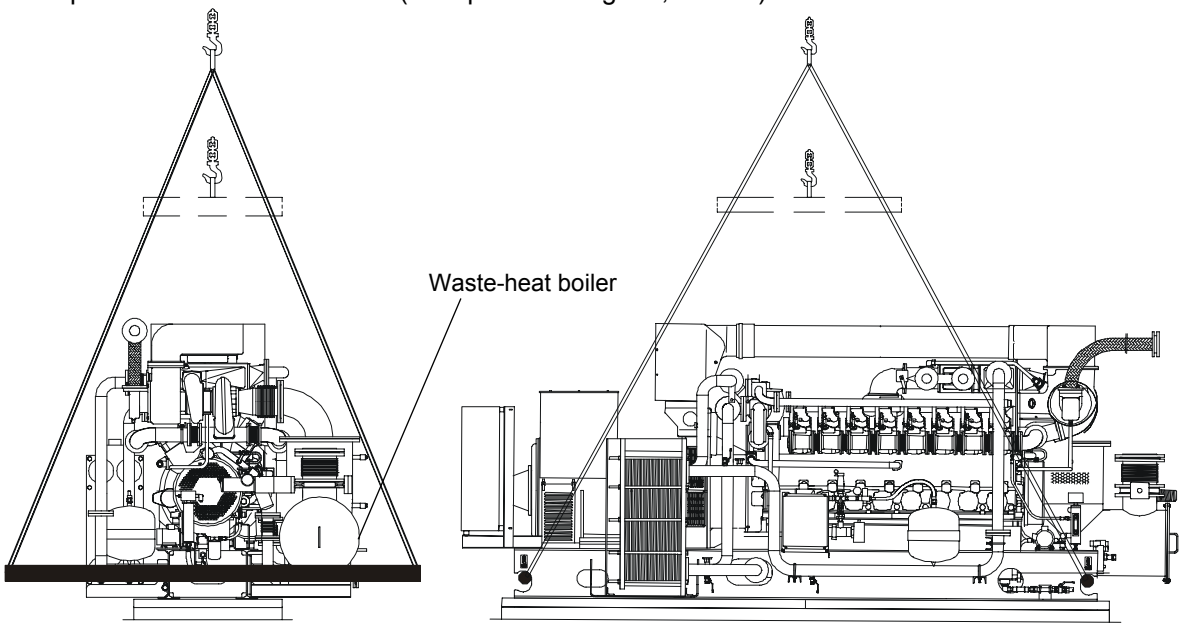




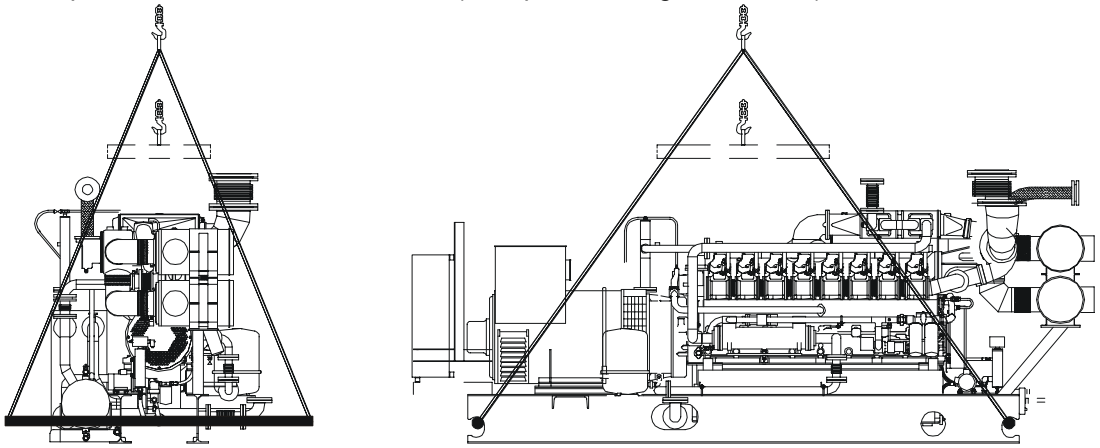
Clamping ring

⚠ 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.

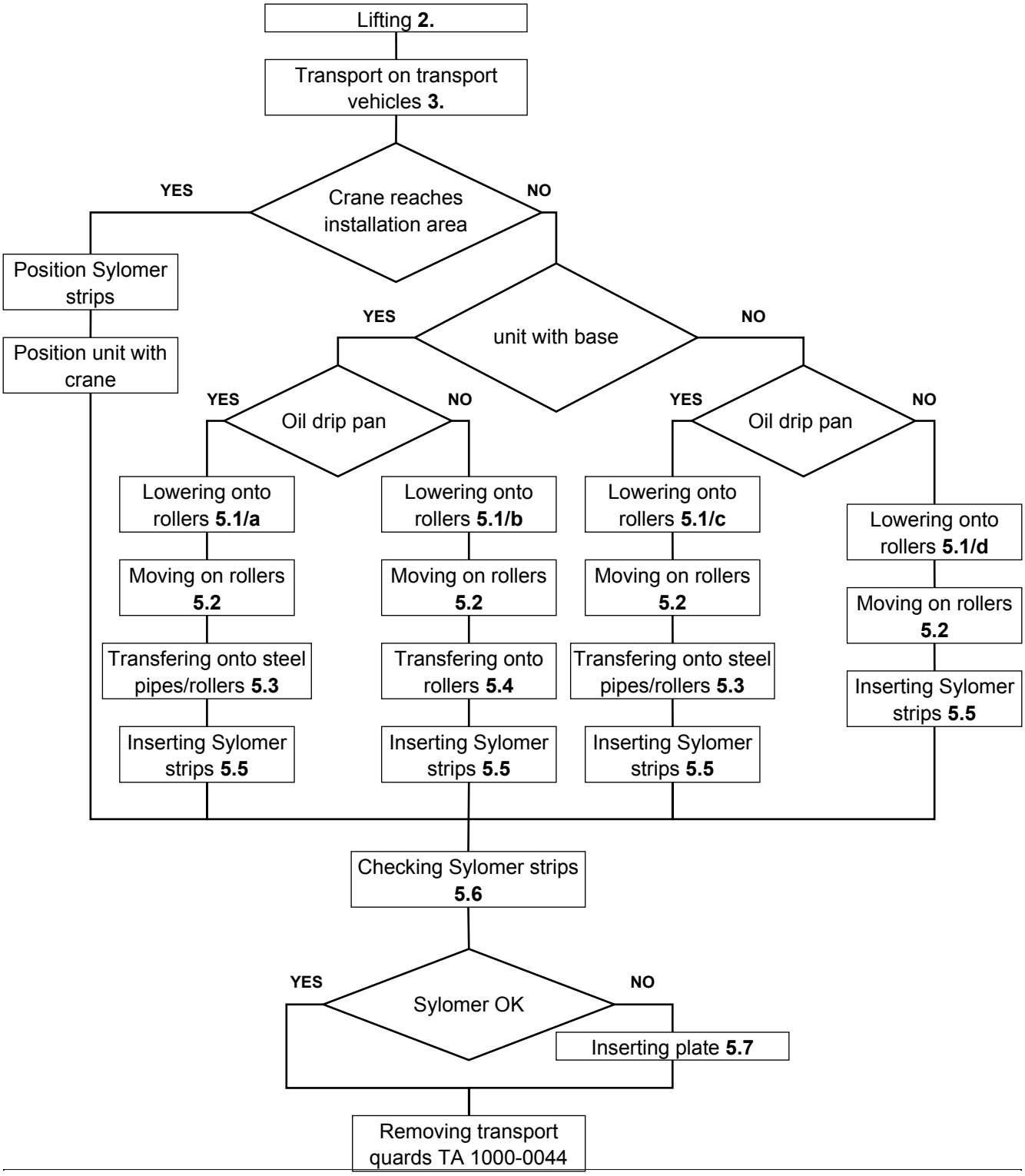
Risk of skidding and tipping must be excluded by the proper attachment of strapping.

### 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:

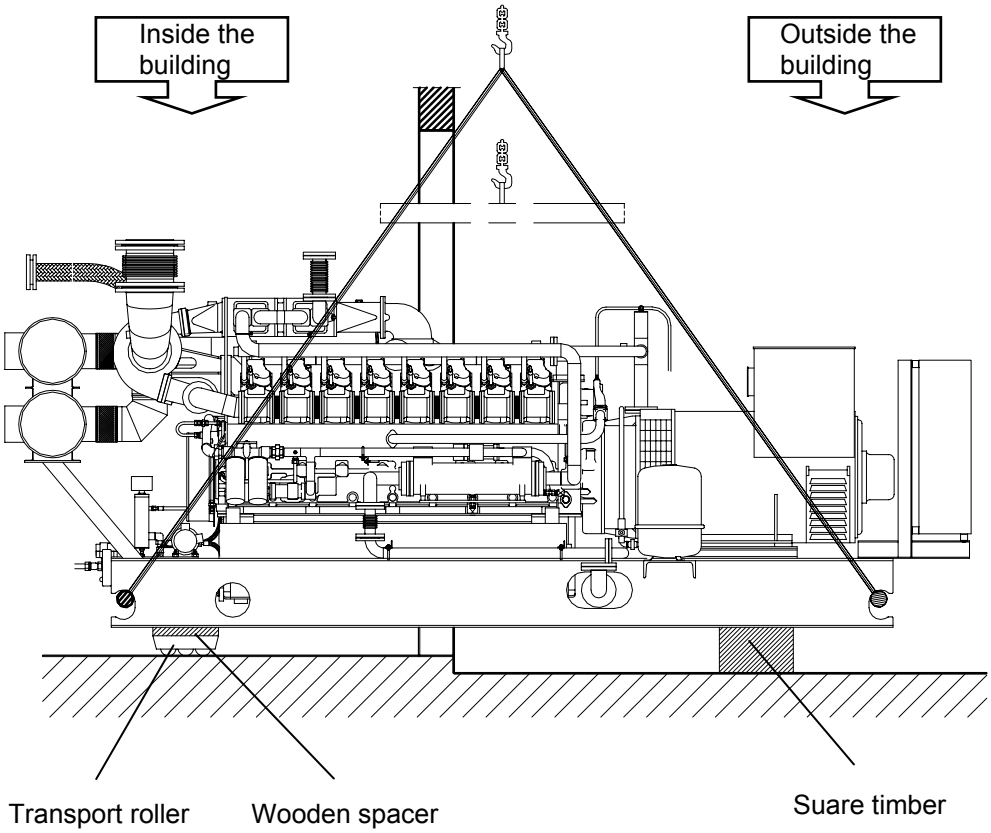
### 5.1 Lowering onto rollers:

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.)

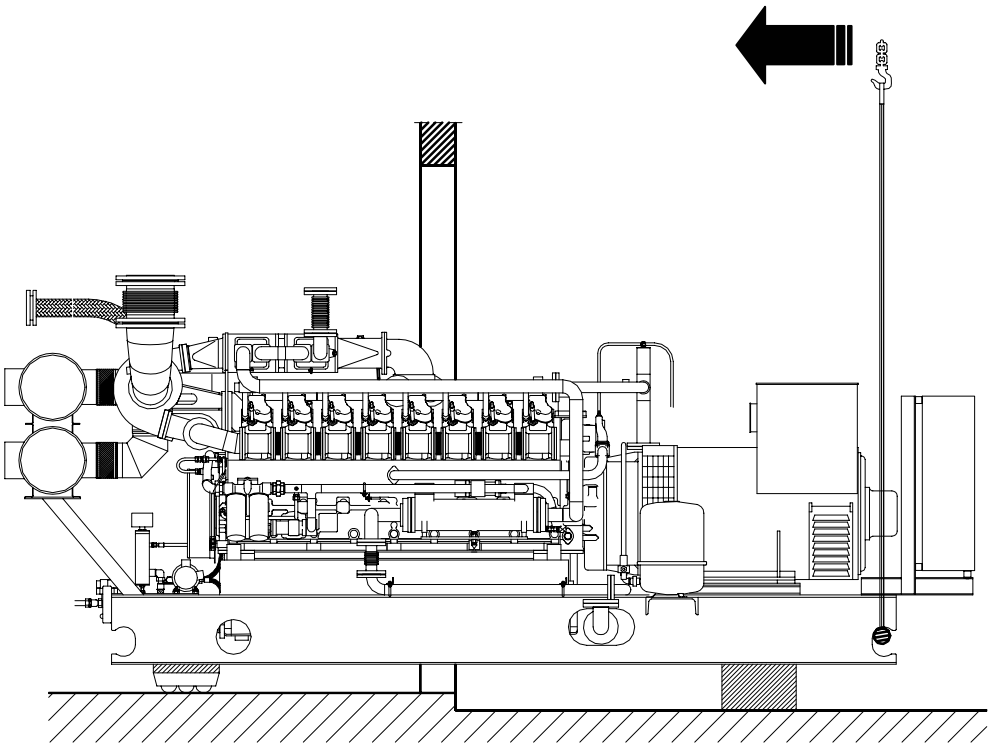
Lift unit with crane into the building as far as possible.

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

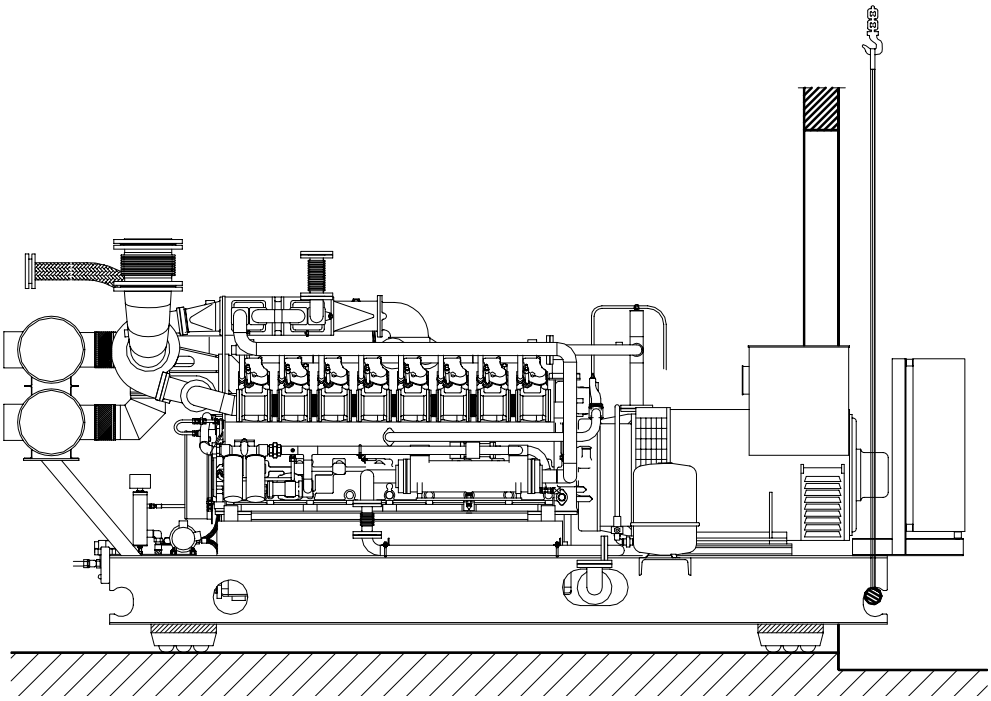



Lift transport bar (in the building) from the frame support recess.

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



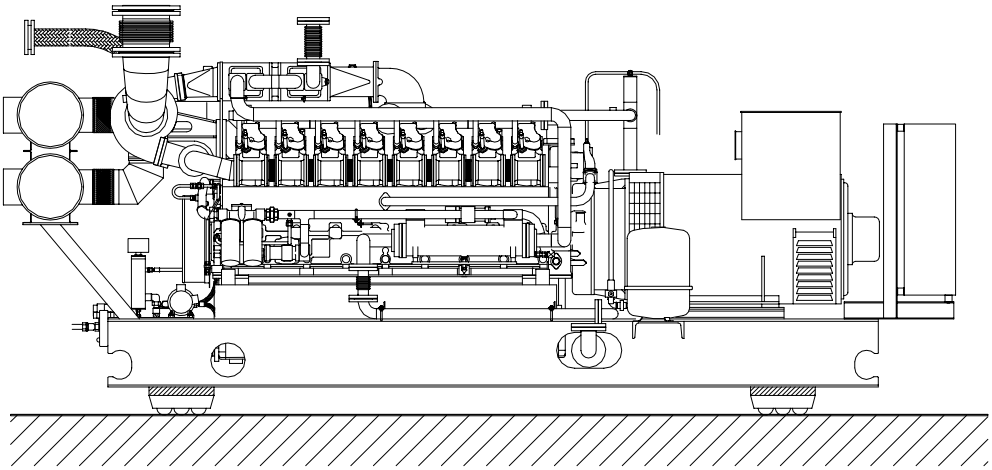
Position second transport roller pair with spacing timber. Lower unit onto second transport roller pair and lift transport bar from frame support recess.



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.

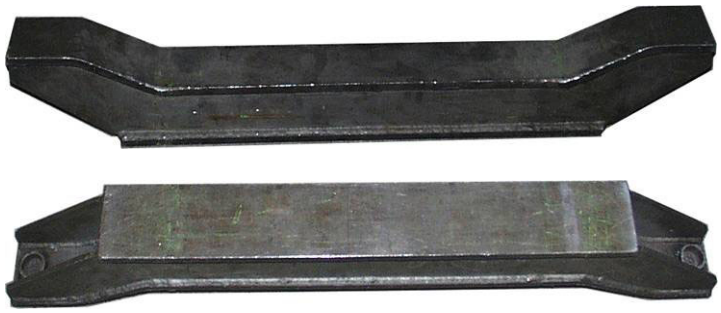
Experience has shown that even three to four strong persons will be able to move a unit. However, the following must be observed in order to prevent damage. The prerequisite for this is a level footing. Otherwise, the footing must be made level using sheet steel.

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

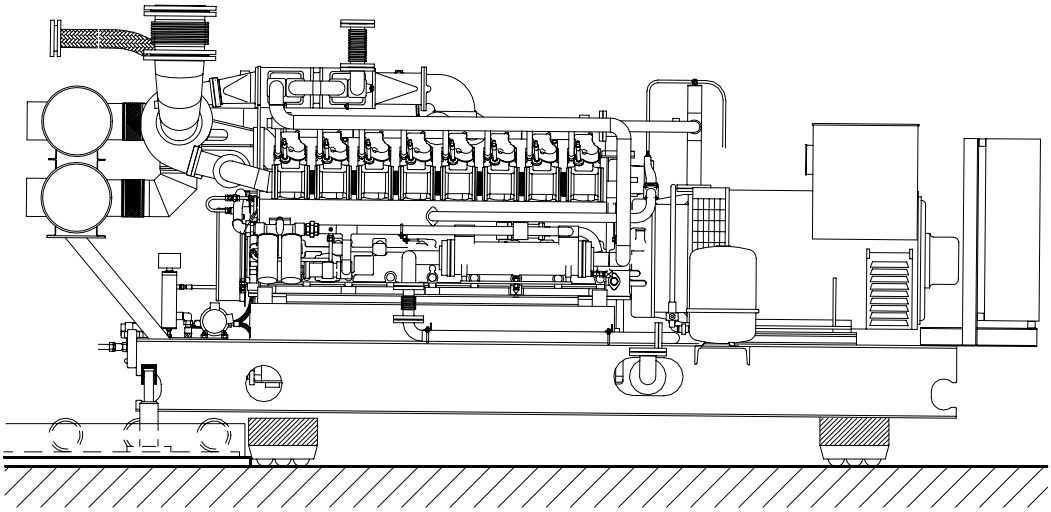
## 5.3 Transferring onto steel rollers/pipes:

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.

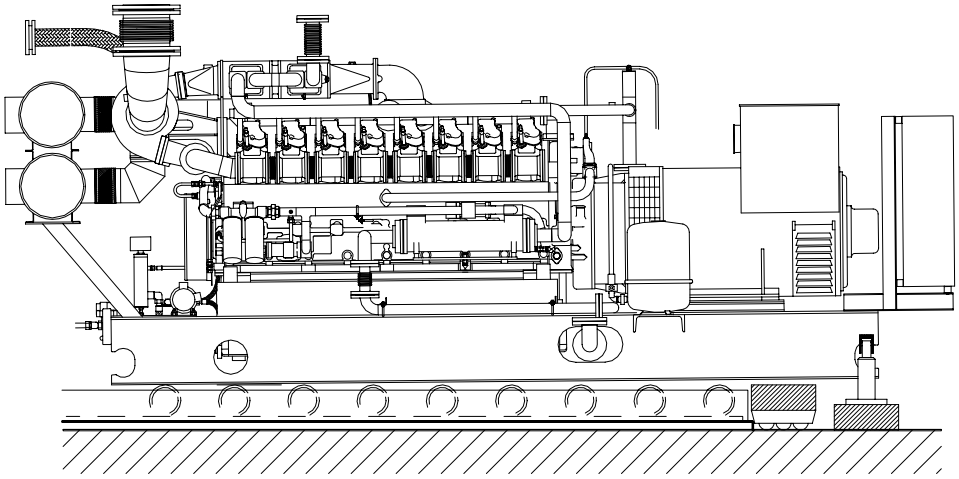
| **Crosshead:** | |
|---|---|
| **Part number** | 296408 |
| **Drawing number** | JW 5364 100 00 |



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.

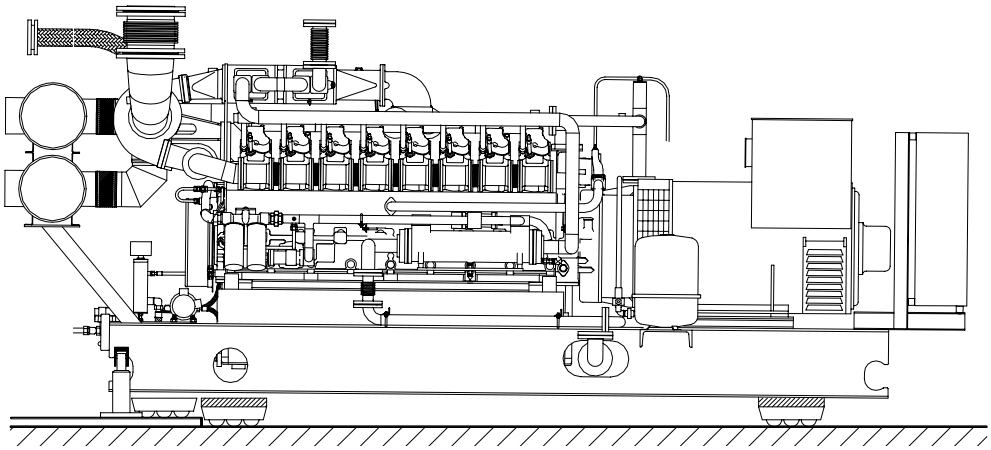


Transfer of the second transport roller pair is done in like manner.

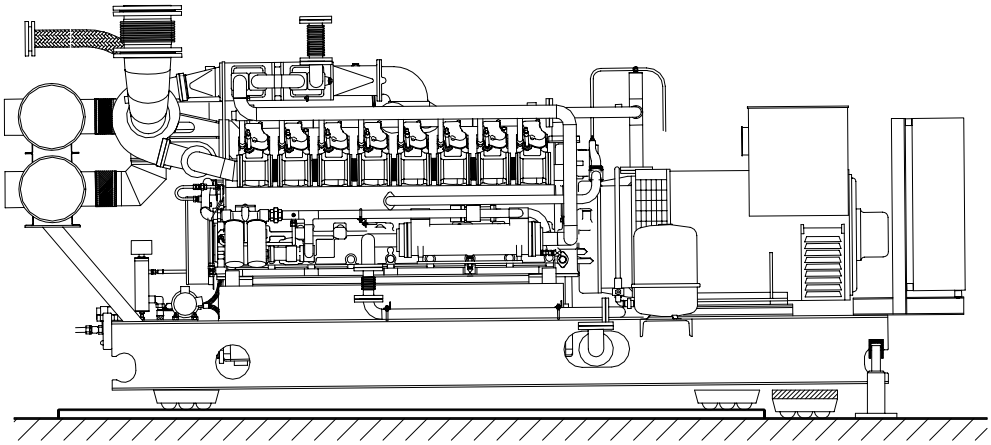


**5.4 Transferring onto rollers:**

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.

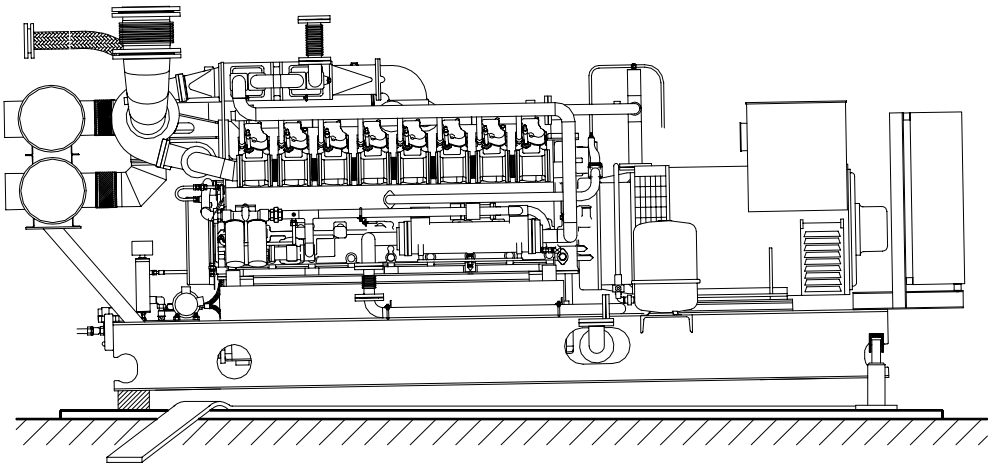


## 5.5 Inserting Sylomer strips:

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.

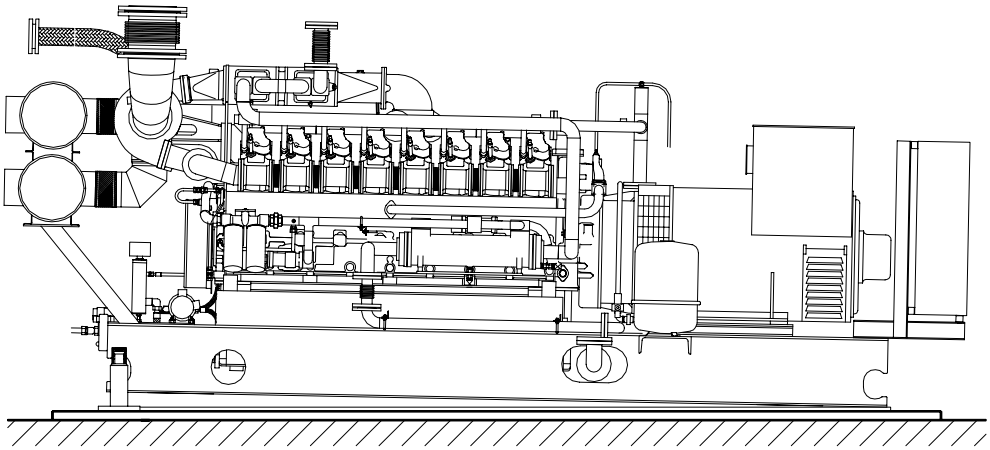
Remove transport roller and install Sylomer trips up to the square timber.



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.

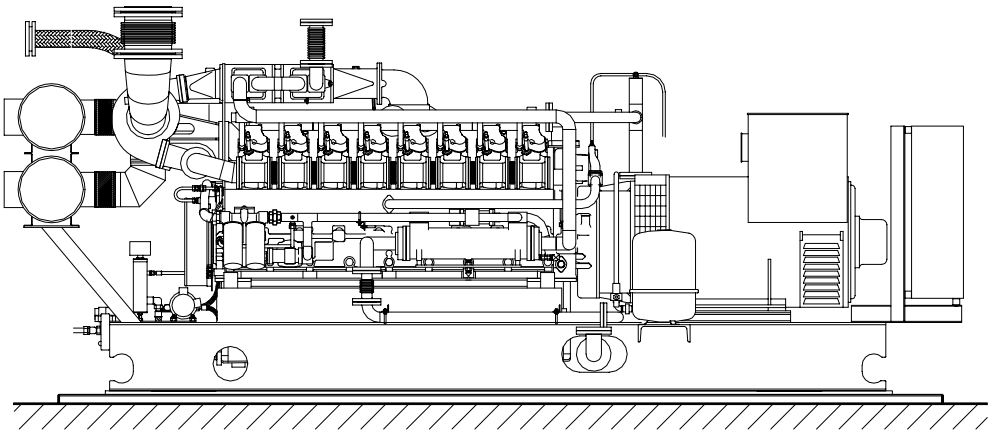
Trim Sylomer strips to the same length as the longitudinal chassis bearers.



**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].

## Blank Page for Notes

## 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.

GE Energy

# TA 1000-0099B

## Limit levels for used oil in GE Jenbacher gas engines

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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



# 1 Application

This Technical Instruction gives directions on the oil care for GE Jenbacher gas engines.

| | |
|---|---|
| Other applicable Technical Instructions: | 1000-0099C (analysis intervals) |
| | 1000-0099D (determination of the ipH value) |
| | 1000-0112 (sampling) |

**GE Jenbacher oil monitoring programme**

The scope of the analysis and the assessment and evaluation of the used oil analyses can only be guaranteed to have been carried out in accordance with GE Jenbacher guidelines if the GE Jenbacher analysis system is used (TI 510132).

The special GE Jenbacher colour code allows simple decisions to be taken about necessary measures (Caution: only applicable to GE Jenbacher partner laboratories)

| | |
|---|---|
| Green | No action necessary before the next sample |
| Yellow | Change the oil before the next sample |
| Red | Contact your Technical Service Hotline |

**Caution**

The GE Jenbacher colour code and the actions derived from it only apply to the GE Jenbacher oil monitoring programme. Third-party laboratories may possibly use the same traffic light colours but not the same derived necessary actions. The use of third-party laboratories is allowed. However, the scope of the analysis, evaluation of the data and the measures based on these recommended by third party laboratories do not necessarily comply with the GE Jenbacherguidelines.

Evaluation of the used oil analysis data and measures based on it must be done by the responsible person in accordance with the GE Jenbacher guidelines (see Sections 2 and 3)>

### 1.1 Brief Instruction

- Lubricating oil in internal combustion engines changes and ages as a function of the operating conditions.
- The lubricating oil in GE Jenbacher gas engines must be changed depending on its condition. GE Jenbacher does not issue any guaranteed fixed oil change intervals.
- Lubricating oil must be tested for serviceability on a regular basis. (See TI 1000-0099C) for the analysis interval).
- The analysis programme must be carried out in its entirety (see Section 2).
- The limit and alarm values must be observed (see Section 2).
- The analysis reports must be documented and kept by the customer, and submitted to GE Jenbacher in a suitable form on request.
- The analysis reports must show a trend. At least 5 analysis reports (see Section 5 for an example).
- See Section 3 for the interpretation of the analysis data, and for measures to be taken.
- The customer is responsible for ensuring that samples are sent to the laboratory immediately after they are taken. The time between a sample being taken and its arrival at the laboratory must not exceed 5 days.
- If a change is made to another brand of lubricating oil, the products must not be mixed in the storage tank or oil pan. The amount of residual oil held in the engine and storage tank must be kept as low as possible. If oils are mixed, the various oil characteristics can no longer be correctly interpreted.

## 2 Analysis programme - limit / alarm values

Parameters and limit values only apply for lubricants approved for GE Jenbacher engines in accordance with TI 1000-1109.

Parameters and alarm levels apply to wear and corrosion products. These alarm levels are not applicable when bypass filters are used.

### 2.1 Oil condition

| | | | | Information | | |
|---|---|---|---|---|---|---|
| **Programme point** | **Unit** | **Limit level** | **Guideline** | **Oil** | **Engine** | **Gas** |
| Viscosity at 100°C | mm²/sec, cSt | **≥** fresh oil +3 and **≥** 17**≥16.9 *)** | DIN 51562 | x | | |
| Viscosity at 40°C | mm²/sec, cSt | **≥** fresh oil +25% | DIN 51562 | x | | |
| Base number BN (TBN) | mg KOH/g | **≤** 50% of the fresh oil **≤ 2.5 *)** | DIN ISO 3771 | x | | |

| Programme point | Unit | Limit level | Guideline | Information Oil | Engine | Gas |
|---|---|---|---|---|---|---|
| Acid number AN (TAN) | mg KOH/g | ≥ fresh oil value +2.5<br>**≥ fresh oil value +3 *)** | DIN ISO 3771 | x | | |
| ipH value | - | ≤ 4.0 GE Jenbacher method<br>≤ 4.5 Mobil method | TA 1000-099D | x | | |
| Ageing (oxidation) | ABS/cm | ≥ 20<br>**≥ 30 *)** | IR spectroscopy | x | | |
| IR nitration | ABS/cm | ≥ 20<br>**≥ 30 *)** | IR spectroscopy | x | | |
| Soot | % | ≥ 2 | IR spectroscopy | x | | |

***) for Mobil Pegasus 1005 only**

### 2.2 Contaminants

| Programme point | Unit | Limit level | Guideline | Information Oil | Engine | Gas |
|---|---|---|---|---|---|---|
| Sodium (Na) | ppm, mg/kg | 20 | DIN 51396/3 | | x | |
| Potassium (Ka) | ppm, mg/kg | 5 | DIN 51396/3 | | x | |
| Chlorine (Cl) | ppm, mg/kg | - | DIN 51396/3 | | | x |
| Glycol | % | 0.02 | | | x | |
| Water | % | 0.2 | | | x | x |
| Silicon (Si) | ppm, mg/kg | 20<br>(Class A) | DIN 51396/3 | | | x |
| Silicon (Si) | ppm, mg/kg | 200<br>(Class B, C) | DIN 51396/3 | | | x |
| Sulphur (S) | ppm, mg/kg | - | DIN 51396/3 | x | | x |

### 2.3 Metallic elements

| Programme point | Unit | Alarm levels | Guideline | Information Oil | Engine | Gas |
|---|---|---|---|---|---|---|
| Iron (Fe) | ppm, mg/kg | 20 | DIN 51396/3 | | x | |
| Aluminium (Al) | ppm, mg/kg | 15 | DIN 51396/3 | | x | |
| Chromium (Cr) | ppm, mg/kg | 5 | DIN 51396/3 | | x | |
| Copper (Cu) | ppm, mg/kg | 15 | DIN 51396/3 | | x | |
| Tin (Sn) | ppm, mg/kg | 5 | DIN 51396/3 | | x | |
| Lead (Pb) | ppm, mg/kg | 20 | DIN 51396/3 | | x | |

### 2.4 Oil additive elements

| Programme point | Unit | Limit values | Guideline | Information Oil | Engine | Gas |
|---|---|---|---|---|---|---|
| Calcium (Ca) | ppm, mg/kg | - | DIN 51396/3 | x | | |
| Zinc (Zn) | ppm, mg/kg | - | DIN 51396/3 | x | | |
| Phosphorus (Ph) | ppm, mg/kg | - | DIN 51396/3 | x | | |
| Boron (B) | ppm, mg/kg | - | DIN 51396/3 | x | | |
| Molybdenum (Mb) | ppm, mg/kg | - | DIN 51396/3 | x | | |

## 3 Interpretation of used oil values and measures based on them

It is quite normal for the properties of lubricating oil to change (through ageing) in the course of operation. The lubricating oil must therefore be changed in good time, in other words before it becomes unserviceable. The lubricating oil can be prevented from becoming unserviceable if it is changed when the limit values of an analysis variable are reached.

### 3.1 Oil condition characteristics

**Viscosity ➢ If the limit value has been reached, the oil must be changed.**

Viscosity is a measure of the fluidity of lubricating oil and is temperature-dependent. Viscosity increases as a result of thermal loading and ageing of the oil.

**Oxidation ➢ If the limit value has been reached, the oil must be changed.**

Ageing

Oil oxidation is due to the lubricating oil reacting with oxidised combustion products. Oxidation increases during usage. Oxidation products can contribute to the formation of organic acids, so that corrosion cannot be ruled out.

**Nitration ➢ If the limit value has been reached, the oil must be changed.**

Oil nitration is due to the lubricating oil reacting with oxides of nitrogen. Nitration increases during usage. There is a danger of the formation of corrosive reaction products.

**Base number ➢ If the limit value has been reached, the oil must be changed.**

The base number (BN, TBN) denotes the alkaline reserve of the lubricating oil, and characterises its chemical neutralising capacity. The alkaline reserve of the lubricating oil is constantly reduced with continued usage due to its reaction with acids. A rapid reduction in the total base number is to be expected when operating with contaminated fuel gases (biogases, sludge gases or landfill gases).

**Acid number ➢ If the limit value has been reached, the oil must be changed.**

TAN, AN

Oxidation and nitration processes can lead to the formation of weak organic acids which are only partially neutralised by the basic reserve of the lubricating oil. The TAN increases during usage. A sharp increase in the acid number is to be expected when operating with contaminated fuel gases (biogases, sludge gases or landfill gases).

**ipH value ➢ If the limit value has been reached, the oil must be changed.**

Determination of the ipH value is absolutely essential when using non-natural gas fuels. The presence of acids in these fuel gases before combustion cannot be ruled out, even if the BN value has not yet reached its limit. The ipH value decreases steadily during usage.

**Soot ➢ If the limit value has been reached, the oil must be changed.**

Experience has shown that gas engines do not form soot. However, soot formation cannot be ruled out on more recent engine versions. The soot content of the oil must therefore be routinely checked.

### 3.2 Impurities

**Sodium ➢ If the limit value has been reached, the oil must be changed and the cooling system checked for leaks.**

Sodium is a typical element in cooling water corrosion protection additives. An increase in the sodium content of used oil indicates contamination with cooling water. In many instances no water can be proved in the oil despite a high sodium content.

**Potassium ➢ If the limit value has been reached, the oil must be changed and the cooling system checked for leaks.**

Potassium is a typical element in cooling water corrosion protection additives. An increase in the potassium content of used oil indicates contamination with cooling water.

Potassium is a possible impurity in wood gas, which is sometimes used as a fuel. If potassium is suspected in the fuel gas, no limit value applies.

**Chlorine ➢ Pay particular attention to the BN, AN and ipH values**

Chlorine in small quantities in oil may be an additive element. Chlorine is known as an impurity in biogas, special gas or landfill gas if these used as fuel. Chlorine can exist in lubricating oil in a various compounds, some of which can cause severe corrosion. The chlorine content itself has no limit.

**Glycol ➢ If the limit value has been reached, the oil must be changed and the cooling system checked for leaks.**

If coolants with antifreeze products are used, glycol is an indicator of cooling water leaks. Glycol is incompatible with mineral oil and reacts with the additives in lubricating oil to form sludge. This severely impairs the lubricity of the oil.

**Water ➢ If the limit value has been reached, the oil must be changed and the cooling system checked for leaks.**

Check for leaks. It is essential to check whether uncontrolled condensation processes are occurring in the lubricating oil system or whether the oil is being incorrectly stored.

Water contained in the oil of a gas engine generally leads to the formation of an emulsion, which reduces the overall usefulness of the oil. Water in the oil leads in particular to increased wear and corrosion.

**Silicon (fuel gas classes A, B and C) ➢ If the limit value has been reached, the oil must be changed and the air filters inspected or replaced.**

- Fuel gas classes A and B ➢ dust:

If class A or B fuel gas B is used, silicon in the oil is due to dust in the combustion air. Dust consists of relatively large silicon particles and causes severe wear.

- Fuel gas class C ➢ siloxanes:

Siloxanes are organic compounds produced when Class C fuel gases are used. The increased silicon content in the gas results in heavier deposits in the combustion chamber which in turn can cause increased wear to pistons, rings and liners. Increase exhaust gas wear is also known as a consequence of the silicon content of the fuel gas. It is possible to establish whether the silicon found in the oil will cause damage in a particular case by determining the operational value, SiB, as described in TI 1000-0300.

The SiB value must be regularly calculated and documented. A regular inspection of the combustion chamber with an endoscope is recommended. Any increase in abrasive metals such as iron, chromium and aluminium must be carefully noted. Increased attention must also be paid to the correct valve play adjustment.

- Anti-foaming agents

The silicon content for steady-state gas engines is generally between 4 and 7 ppm and is not critical for engine operation.

An analytical determination of the origin of the silicon in the used oil is not possible.

**Sulphur ➢ Pay particular attention to the BN, AN and ipH values**

Sulphur is a major component of the lubricating oil. The sulphur in the lubricating oil is not a problem for engine operation, but gives information about the quality of the lubricating oil. Sulphur is known as an impurity in class B and C fuel gases. Sulphur from the fuel gas produces acidic compounds in the lubrication oil, thereby increasing the danger of corrosion. The sulphur content itself has no limit.

### 3.3 Metallic elements

**➢ If the alarm level is reached, contact your Technical Service Hotline.**

### 3.4 Additive elements

No limits are in operation. Most additive elements remain relatively stable over the service life of the oil. Determination of the additive elements supports the product control.

## 4 Used oil reports

Used oil reports must include the following data:

- Customer:
- Engine type:
- Fuel gas:
- Lubricating oil product:
- GEJ ZU number:
- Sample date:
- Engine operating hours:
- Oil operating hours:

## 5 Documentation for used oil analyses

Example of suitable documentation for used oil analyses:

| Customer: | | Plant data: | |
|---|---|---|---|
| Name: | BioPower | Engine type: | JMS 420 GS-B.L |
| Address: | Grünwalden | Fuel gas: | Biogas |

| Contact: | | Mr. A.N. Other | | Lubricating oil: | | Product name: ---------- | |
|---|---|---|---|---|---|---|---|
| | | | | Engine number: | | XXXXXXX | |
| | | | | GE J ID number: | | J XXXX | |
| Sample number | | 29 | 30 | 31 | 32 | 33 | 34 |
| Sample date | | 12/10/2010 | 20/10/2010 | 29/10/2010 | 16/11/10 | 23/11/2010 | 03/12/2010 |
| Analysis date | | 17/10/2010 | 27/10/2010 | 05/11/2010 | 24/11/2010 | 30/11/2010 | 08/12/2010 |
| Oil operating hours | | 602 | 803 | 1004 | 202 | 417 | 613 |
| Engine operating hours | | 11615 | 11816 | 12017 | 12351 | 12566 | 12762 |
| | Unit | | | | | | |
| Viscosity at 40°C | cSt | 158 | 165 | 172 | 149 | 157 | 162 |
| Viscosity at 100°C | cSt | 15.4 | 15.9 | 16.3 | 14.9 | 15.5 | 15.8 |
| Oxidation/Ageing | ABS/cm | 13 | 15 | 18 | 7 | 12 | 15 |
| Nitration | ABS/cm | >1 | >1 | >1 | 2 | >1 | >1 |
| TAN | mgKOH/g | 2.14 | 2.56 | 3.08 | 2.02 | 2.17 | 2.56 |
| TBN | mgKOH/g | 3.6 | 3 | 2.8 | 4.1 | 3.6 | 3.1 |
| IPH | --- | 6.83 | 5.96 | 5.48 | 7.29 | 6.71 | 5.74 |
| Silicon | ppm | 1 | 2 | 2 | 2 | 2 | 2 |
| Sodium | ppm | 2 | 2 | 2 | 2 | 2 | 2 |
| Boron | ppm | 1 | 1 | 1 | 1 | 1 | 1 |
| Sulphur | ppm | 7800 | 7700 | 7700 | 8500 | 8500 | 8400 |
| Chlorine | ppm | <50 | <50 | <50 | <50 | <50 | <50 |
| Glycol | % by weight | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Water | % by weight | <0.05 | <0.05 | <0.05 | <0.016 | <0.05 | <0.01 |
| Potassium | ppm | <1 | <1 | <1 | <1 | <1 | <1 |
| Iron | ppm | 4 | 4 | 5 | 2 | 2 | 5 |
| Chromium | ppm | <1 | <1 | <1 | 1 | <1 | <1 |
| Molybdenum | ppm | <1 | <1 | <1 | <1 | <1 | <1 |
| Aluminium | ppm | 1 | 2 | 1 | 1 | 1 | 2 |
| Copper | ppm | <1 | <1 | <1 | <1 | <1 | <1 |
| Lead | ppm | <1 | <1 | <1 | <1 | <1 | <1 |
| Tin | ppm | <1 | <1 | <1 | <1 | <1 | <1 |
| Nickel | ppm | <1 | <1 | <1 | <1 | <1 | <1 |
| Magnesium | % by weight | 0.0004 | 0.0004 | 0.0005 | 0.0005 | 0.0005 | 0.0006 |
| Calcium | % by weight | 0.1290 | 0.1373 | 0.1459 | 0.1252 | 0.1325 | 0.1214 |
| Phosphorus | % by weight | 0.0273 | 0.0287 | 0.0317 | 0.0287 | 0.0305 | 0.0360 |
| Zinc | % by weight | 0.0293 | 0.0336 | 0.0359 | 0.0309 | 0.0350 | 0.0399 |

## 6 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 3 | 29.02.2012 | Punkt 1 und 5 / Point 1 and 5 | **Bilek**<br>*Chvatal Susanne* |
| 2 | 23.01.2012 | Neues / new update | **Bilek**<br>*Chvatal Susanne* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: w | **Ersteller**<br>*Prüfer* |

GE Energy

# TA 1000-0099C

## Procedure for testing plant-specific oil service life

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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



# 1 Scope

GE Jenbacher -Gas engines:

Other applicable Technical Instructions:

- TI 1000-0099B: Limit values for used oil in GE Jenbacher gas engines
- TI 1000-0112 Taking lubricating oil samples / lubricating oil sampling protocol

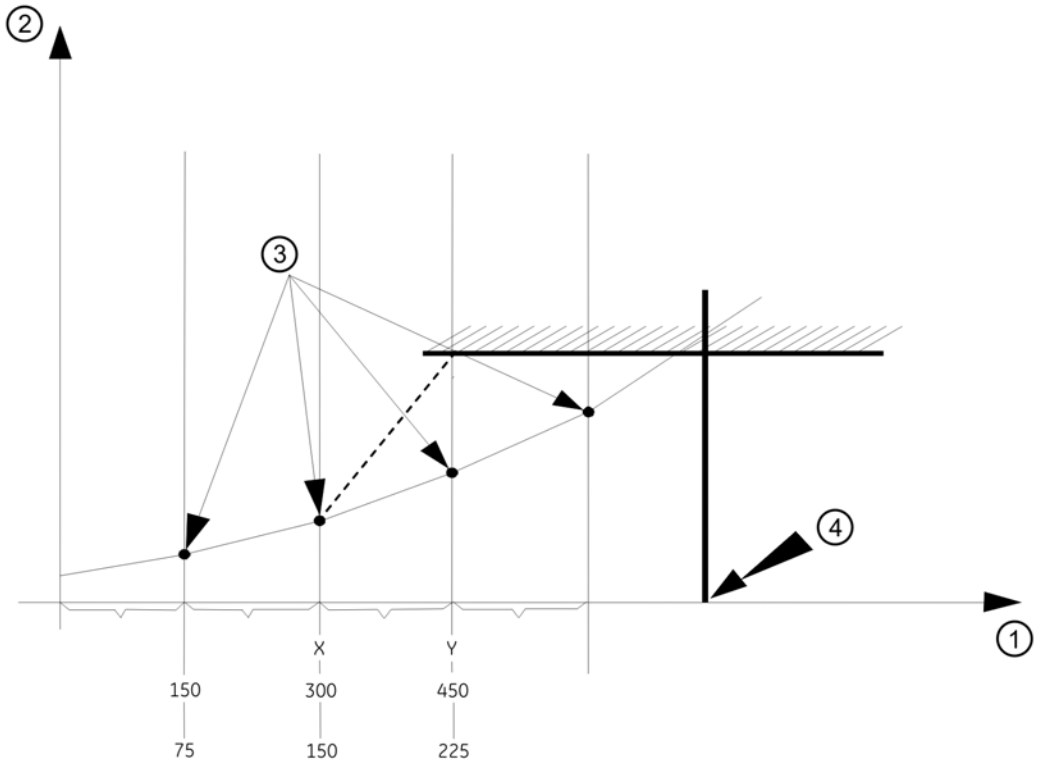
# 2 Brief Instruction

**GE Jenbach does not guarantee any guaranteed fixed oil change intervals. The lubricating oil in** GE Jenbacher **gas engines must be changed depending on its condition.**

## 2.1 Oil interval (after commissioning or major overhaul of the engine, and engine upgrades)

| | |
|---|---|
| Fuel gas class A: | Oil samples every 150 operating hours |
| Fuel gas classes B and C: | Oil samples every 75 operating hours |

The oil must be changed if any measured value has reached its limits under Section 2.1 of TI 1000-0099B.




| | | | |
|---|---|---|---|
| ① | Service life | ③ | Analysis results in each case |
| ② | Numerical value of relevant analysis results - here, only one | ④ | forecastable end of the service life of an oil filling |
| | test interval (approx.150 Oh with natural gas, 75 Oh with landfill gas and biogas) | | |
| | Limit value as per TI 1000-0099B | | |

### 2.2 Oil intervals and all other

oil samples must be taken at approx. 20%
approx. 70%
approx. 100% of the expected oil service life.

BUT:

No unmonitored period of use of the oil may exceed:

| | |
|---|---|
| fuel gas class A: | 500 operating hours |
| fuel gas classes B and C: | 250 operating hours |

**ATTENTION**

After commissioning or carrying out maintenance work on the engine, particular attention must be paid to impurities and abrasives in the lubricating oil. If a warning value is reached, contact the technical service hotline.

- See TI 1000-0110, section 2.2 for impurities.
- See TI 1000-0110, section 2.3 for abrasives.

## 3 Notes

**Oil service life**

Lubricating oil in internal combustion engines changes and ages as a function of the operating conditions. The lubricating oil must be changed before it becomes unserviceable.

The service life of a single filling of lubricating oil depends on different factors. The following have a major influence on the oil service life:

- oil consumption
- thermal load on the oil
- mechanical load on the oil
- oil circulation quantity
- composition of the fuel gas
- brand of lubricant

In non-natural gas operation (fuel gas classes Band C) the oil service life can be expected to be considerably shorter for a given fuel gas quality compared to natural gas operation (fuel gas class A).

**Oil change**

When changing oil, make sure that the oil residues in the engine are kept to a minimum, i.e. by changing the oil filters, draining the oil cooler, etc.

If a change is made to a different brand of lubricating oil, the amount of residual oil held in the engine and storage tank must be kept as low as possible. If oils are mixed, the various oil characteristics can no longer be correctly interpreted.

**Oil analyses**

The analysis reports must be documented and kept by the customer, and made available to GE Jenbacher on request.

**Auxiliary tank**

If the oil service life is unsatisfactory, it can be prolonged by increasing the engine oil capacity by adding an auxiliary tank

**Changes in the analysis results trend**

If a value (e.g. "X" in Fig. 1) suddenly exhibits change trends compared to previous analyses, this must be considered an alarm signal, even if the limit has not yet been reached as shown in example "Y" (curve ).

**If you have any questions or require assistance in evaluating the analysis results, call the technical service hotline.**

## 4 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 3 | 05.03.2012 | Grundlegende Überarbeitung / Fundamental revision | **Provin**<br>*Chvatal S.* |
| 2 | 07.12.2010 | Punkt 4.4 / Point 4.4 | **Bilek**<br>*Chvatal S.* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to Content Management System ersetzt / replaced Index: I | **Schartner**<br>*Giese* |

## Blank Page for Notes

## 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.<br>Low coolant temperature.<br>Excessive engine idling. |
| | Flow-back of condensate from crankcase breather | Inadequate crankcase ventilation.<br>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.<br>Seating surface corroded. |
| | Engine block, cylinder head or watercooled exhaust manifold sometimes leaky wast heat boiler | Coolant frozen.<br>Overheating during operation, or lack of coolant in cooling system. |
| High blowby | Ring belt area | Worn rings or liners.<br>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.<br>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.<br>Oil cooler obstructed with oil sludge. |
| | Inadmissibly extended oil drain periods | Improper preventive maintenance practives. |
| | Oil pumping | High crankcase oil level.<br>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.<br>Fuel gas engines: Fuel mixture setting too lean.<br>Ignition point (spark) overadvanced |
| Use of higher viscosity oil | Misapplication | Initial fill or make-up with wrong product. Disregarding of lube-oil instructions.<br>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).<br>Contamination by dirt and dust (minor). |
| | Chromium *) | Piston rings, cylinder liners, plated rocker arms, inlet valves, exhaust valve, crankshaft. Cooling water conditioners. |
| | Chlorine *)<br>(or all the four halides) | Unauthorized addition to fuel or to combustion air.<br>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).<br>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.<br>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.<br>Over-extended drain periods. |
| | Excessive blowby (nitrate development) | Poor combustion caused by misadjustm. or by defective parts.<br>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.<br>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.<br>Cleaning intervals disregarded. |

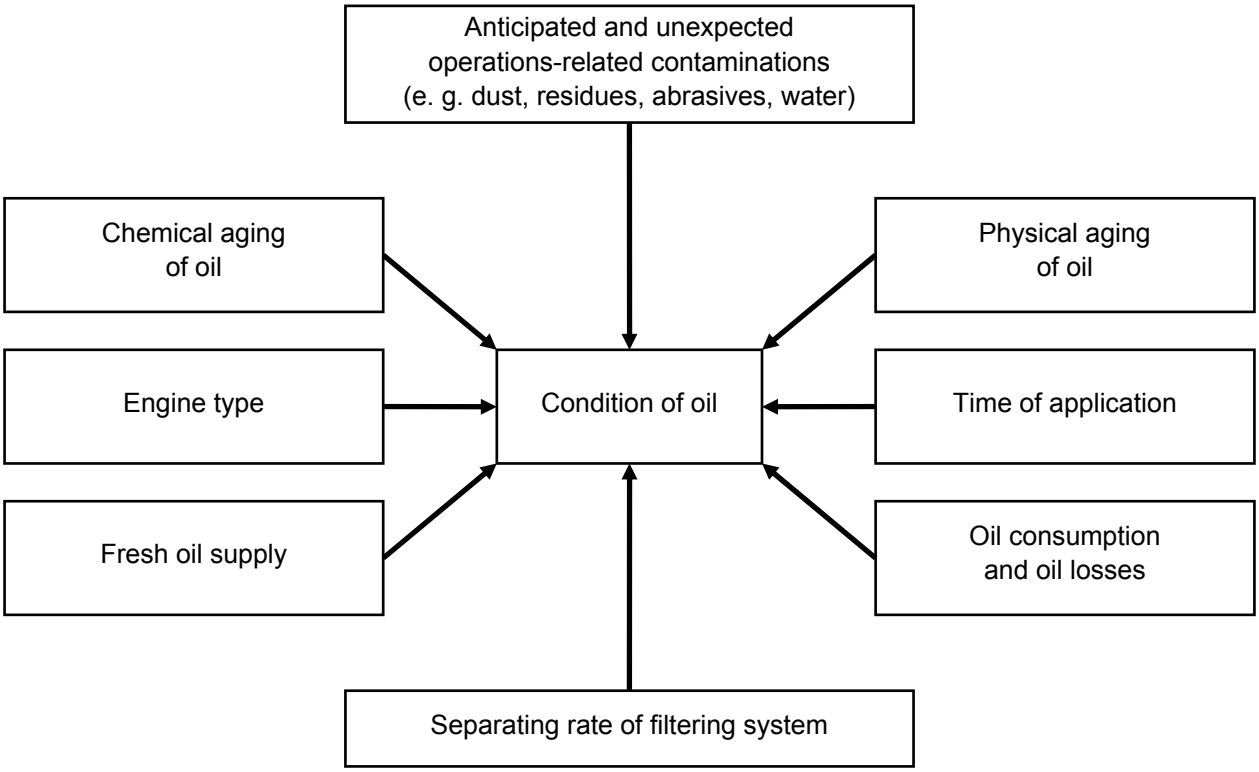
### 2.8 Infrared analysis (gas engines) increased absorption at 5.8 µm (1710 Hz):

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

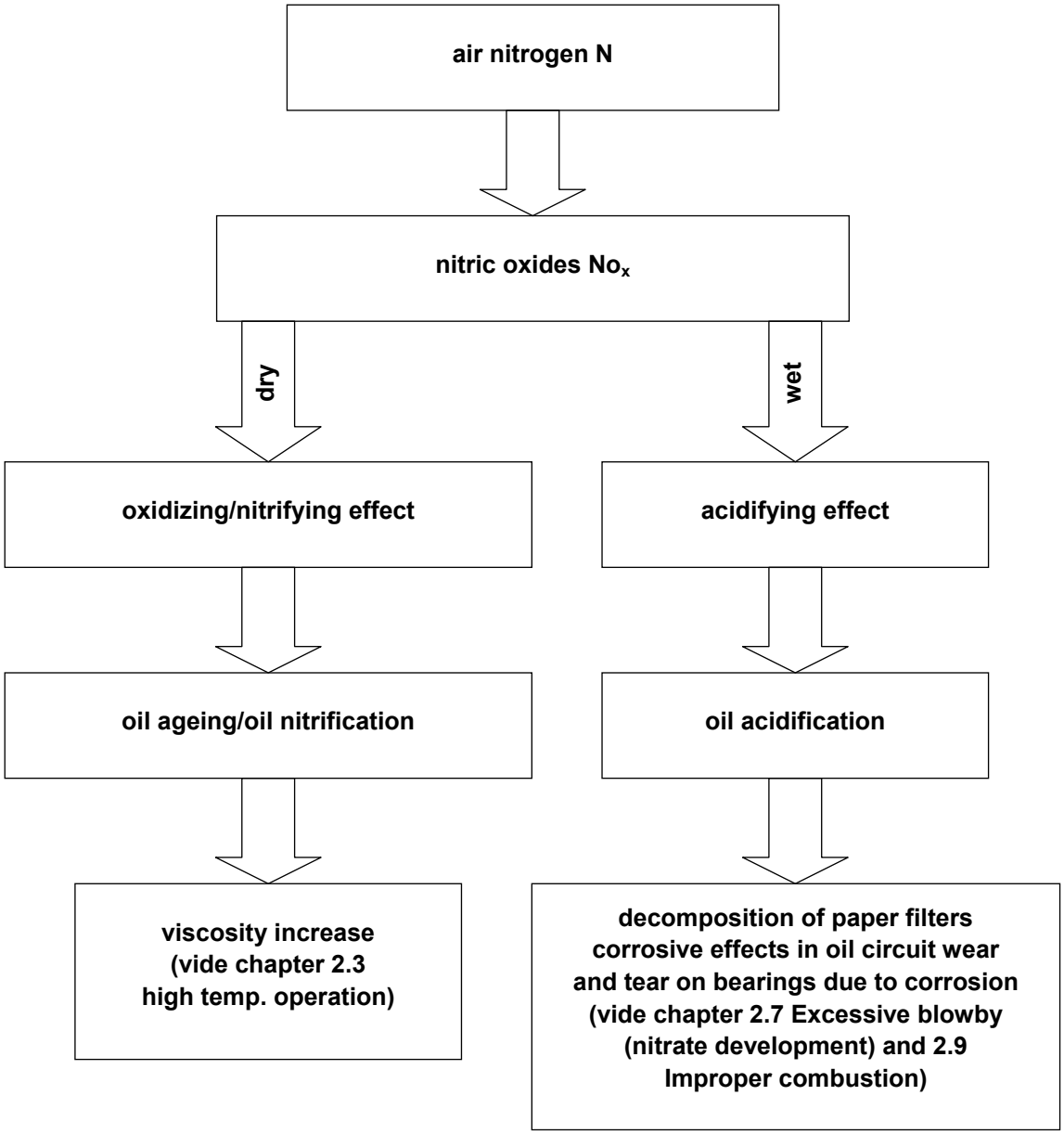
### 2.9 Infrared analysis (gas einges) increased absorption at 6.1 µm (1630 Hz):

| Primary Causes | Specific Factors | Engine/Oil/Coolant Conditions Responsible |
|---|---|---|
| Nitrogen fixation (Nitration) | Improper combustion | Improper and/or poor operating practices such as:<br>poor combustion, engine overload, faulty crankcase ventilation, improper spark timing, excessive blowby (piston, cylinder liner).<br>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:

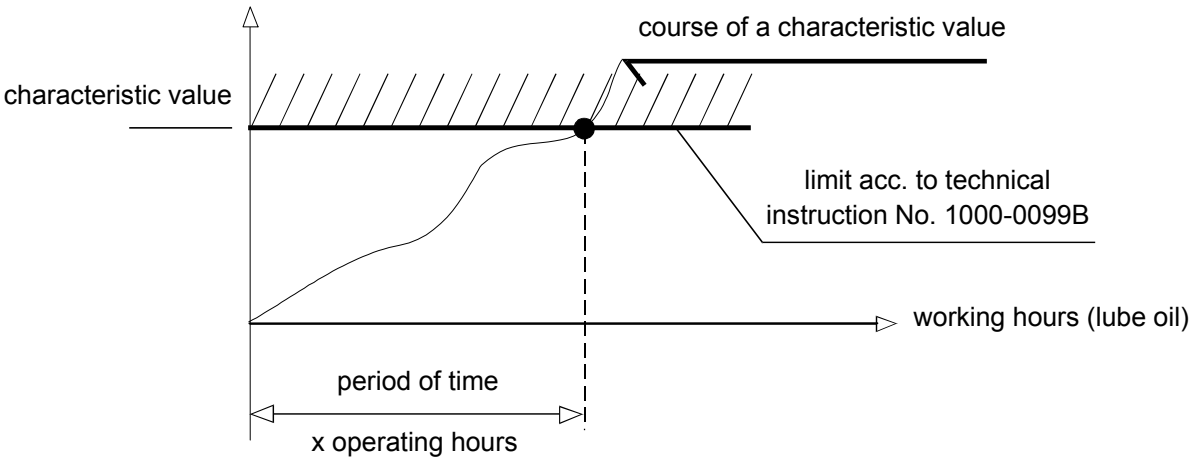


## 5. Additional valuation of the concentration of harmful substances in fuel gas by means of regular lube oil analyses:

### 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 |

GE Energy

# TA 1000-0200

## Composition of cooling water in closed primary circuits

## Technical Instruction

3 2 4 9 2 0 3 1 2 3 1 6 6 2 0 2 3 8 4 2 2 7 5 6 1 3 4 5 1 5 3 6 2 5 4 1

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

# Technical Instruction: TA 1000-0200
# Composition of cooling water in closed primary circuits



**The target recipients of this document are:**

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



## 1 General

An aqueous solution is used as the coolant in GE Jenbacher engines. Corrosion inhibitors and anti-freeze products need to be added to the cooling circuits of GE Jenbacher engines.

## 2 Validity

This Technical Instruction applies to all GE Jenbacher engines with closed primary cooling circuits (engine cooling circuit, low-temperature circuit)

**ATTENTION**

This does not apply to heating circuits (see TI 1000-0206)

## 3 Water quality

The following water quality is necessary for mixing with anti-freeze products and corrosion inhibitors.

| Analysis value | Unit | Permissible range |
|---|---|---|
| Appearance | - | clear, free of sediment and suspended matter |
| Odour | - | neutral |
| pH value at 25°C | - | 6.5 - 7.5 |
| Total Hardness (CaCO3) | °dH<br>ppm | < 15<br>< 250 |
| Calcium | mg/l | < 100 |
| Sulphates | mg/l | < 100 |
| Chlorides | mg/l | < 80 |
| Iron | mg/l | < 0.2 |
| Zinc | mg/l | < 0.1 |
| Fluorides | mg/l | < 20 |
| Electrical conductivity | µS/cm | <500 |

Rainwater, brackish water, sea water and condensate do not possess the required properties without appropriate treatment

Both the water analyses and professional sampling must be carried out by a suitable firm.

The water quality tests, which are required for mixing with anti-freeze and corrosion protection products, must be carried out at least once a year. The analysis reports must be documented and kept by the customer, and made available to GE Jenbacher on request.

## 4 Information

If water with the properties demanded in the table is mixed with anti-freeze or corrosion inhibitor, the pH, hardness and conductivity values will automatically change.

## 5 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 2 | 13.01.2012 | Fundamental revision NEW | **Chvatal**<br>*Provin* |
| 1 | 26.05.2010 | Change to Content Management System<br>replaced Index: h | **Schartner**<br>*Giese* |

GE Energy

# TA 1000-0201

## Anti-freeze products and testing the coolant

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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



## 1 General

An aqueous solution is used as the coolant in GE Jenbacher engines. Corrosion inhibitors and anti-freeze products need to be added to the cooling circuits of GE Jenbacher engines.

Anti-freeze products are available both as concentrates and as premixed solutions ready for use.

GE Jenbacherexpressly recommends the addition of anti-freeze products to the cooling water even if there is no need for frost protection. . Checking the required concentration of anti-freeze products can be carried out on site very easily with a refractometer.

**ATTENTION**

Anti-freeze products already contain corrosion inhibitors. To ensure that sufficient corrosion inhibitor is present, the minimum anti-freeze concentration laid down by the manufacturer must be observed. The necessary minimum concentration is given in the product description. A concentration lower than the specified minimum will lead to corrosion.

The permissible maximum concentration of anti-freeze product depends on the design of the cooling circuits and can be taken from the "Heat Recovery" section in the Technical Description.

Depending on the technology used in the corrosion inhibitors, the product manufacturers recommend changing the coolant after 2 to 5 years. These are only general recommendations. Due to the wide range of applications and operating conditions under which GE Jenbacher engines are used, it may be necessary to change the coolant earlier. If the corrosion inhibitors in the coolant are used up, this indicates a significantly increased danger of corrosion rather than an absence of corrosion protection.

The coolant must therefore be tested regularly to check that the anti-freeze protection and corrosion inhibition are adequate and that the water quality is suitable.

## 2 Testing the coolant

- Testing the anti-freeze protection with a refractometer: at least quarterly .
  If the glycol content is in the specified range, adequate corrosion inhibitor is also present.
- Testing the quality of the water to which the anti-freeze is added: annually (see TI 1000-0200 for the limit values)
- If premixed products are used, the water quality check can be omitted.

## 3 Coolant change

- Change coolants with corrosion protection products based on OAT technology every 5 years at the latest.
- Change coolants with mineral corrosion protection products every 2 years at the latest
- If anti-freeze protection will definitely not be needed in the coolant, corrosion protection alone may be added to the coolant. (See TI 1000-0204 for products)

## 4 Information on filling the cooling circuit

Always clean the entire cooling system thoroughly by flushing with water and check the system for any leaks before adding the anti-freeze.

Pour the required amount of anti-freeze into the cooling system and top up the system with water, as described in TI 1000-0200.

Run the engine for 30 minutes afterwards.

Always bleed the cooling system because corrosion may form in spots where air has collected.

## 5 Selection overview

**Coolants with anti-freeze are SUBJECT TO DISPOSAL REGULATIONS!**

**Selection overview**

| | | | |
|---|---|---|---|
| Texaco / Chevron / Caltex | Havoline XLC 40/60<br>Havoline XLC | Castrol | Antifreeze NF |
| arteco | Havoline XLC 40/60<br>Havoline XLC | OMV | Coolant Plus |
| TOTAL | Coolelf CHP<br>Coolelf CHP Supra | Deicer | Deicer E |
| BASF The Chemical Company | Glysantin Protect Plus G48 | FUCHS | Fricofin |

**Selection overview**

| | | | |
|---|---|---|---|
| Mobil | Antifreeze Extra | Härtol | Frostox W206 |
| | Antifreeze Extra | coracon | BF6 |

Products not or no longer mentioned in this Technical Instruction are not necessarily unsuitable for GE Jenbacher engines. However, the data or test methods necessary to assess their suitability are not available.
Use of such products is under operator's own responsibility.

## 6 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 3 | 23.01.2012 | Firmenlogo Chevorn getauscht ÄNDERUNG / replacement of brand logo "Chevron" CHANGE | **Chvatal**<br>*Provin* |
| 2 | 13.01.2012 | Grundlegende Überarbeitung NEU / Fundamental revision NEW | **Chvatal**<br>*Provin* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to Content Management System<br>ersetzt / replaced Index: h | **Schartner**<br>*Giese* |

GE Energy

# TA 1000-0204

## Corrosion protection products for cooling water for GE Jenbacher engines and testing the coolant

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

# Technical Instruction: TA 1000-0204
# Corrosion protection products for cooling water for GE Jenbacher engines and testing the coolant



**The target recipients of this document are:**

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



## 1 General

An aqueous solution is used as the coolant in GE Jenbacher engines. Corrosion inhibitors and anti-freeze products need to be added to the cooling circuits of GE Jenbacher engines.

Anti-freeze products are available both as concentrates and as premixed solutions ready to use.

Depending on the technology used in the corrosion inhibitors, the product manufacturers recommend changing the coolant after 2 to 5 years. These are only general recommendations. Due to the wide range of applications and operating conditions under which GE Jenbacher engines are used, it may be necessary to change the coolant earlier.

If the corrosion inhibitors in the coolant are used up, the danger of corrosion is significantly higher than with pure water.

The coolant must therefore be tested regularly to check that the anti-freeze protection and corrosion inhibition are adequate and that the water quality is suitable.

Comment:

Since checking the required concentration of anti-freeze products can be done very easily on site with a refractometer, GE Jenbacher recommends the addition of an anti-freeze product to the cooling water even if frost protection is not necessary. However, check whether the design of the cooing circuits allows the addition of anti-freeze; this can be taken from the "Heat Recovery" section of the technical description. See TI 1000-0201 for further information on using anti-freeze products.

## 2 Testing the coolant

- Due to the different technologies and different concentrations of corrosion inhibitors used, no generally applicable tests or limit values can be given for monitoring the coolant.
- If the control range and limit values are not attached in the Appendix, the product descriptions of all the products named in this Technical Instruction explain how the coolant is to be tested, or else the information is deposited with GE Jenbacher.
- The following applies to all the products named in this Technical Instruction:
  During the first 5 months after commissioning the engine, the coolant must be tested monthly. If the coolant data is stable within its specifications, the interval can be extended to 2000 engine operating hours.
  If the coolant data is outside the specified range, then according to the coolant manufacturer the product must be brought within the specified range.
  The analyses must be documented by the customer and presented on request by GE Jenbacher.
- Testing the quality of the water to which the corrosion protection is to be added:
  Once per year (see TI 1000-0200 for the limit values).
  The analyses must be documented by the customer and presented on request by GE Jenbacher.

## 3 Information on filling the cooling circuit

Always clean the entire cooling system thoroughly by flushing with water and check the system for any leaks before adding corrosion inhibitors.

Pour the required amount of corrosion protection into the cooling system and top up the system with water, as described in TI 1000-0200.

Run the engine for 30 minutes afterwards.

Always bleed the cooling system because corrosion may form in spots where air has collected.

## 4 Selection overview

| Company | Product name | Concentration % |
|---|---|---|
| | Corrshield NT4201 | 0.6 to 1 |
| | Havoline XLI | 5 to 10 |
| | Havoline XLI | 5 to 10 |
| | Nalco2000 | 3 to 4 |

| Company | Product name | Concentration % |
|---|---|---|
| DREW AMEROID | Maxigard | 1.6 to 2 |
| coracon | BL1 | 4 to 6 |
| | BL6 | 3 to 6 |

Products not or no longer mentioned in this Technical Instruction are not necessarily unsuitable for GE Jenbacher engines. However, the data or test methods necessary to assess their suitability are not available.

Use of such products is under the operator's own responsibility.

# 5 Appendix

## 5.1 Scope of analysis and admissible range for coolants with Corrshield NT4201, Nalco2000 and Maxigard corrosion inhibitors.

| | | | Corrshield NT4201 | Nalcool 2000 | Maxigard |
|---|---|---|---|---|---|
| **Interval** | **Test** | **Unit** | **Limit values** | **Limit values** | **Limit values** |
| annually | Corrosion | ‰ per year | < 1 low-carbon steel<br>< 0.1 copper/brass | < 1 low-carbon steel<br>< 0.1 copper/brass | < 1 low-carbon steel<br>< 0.1 copper/brass |
| annually | microbiolog-ical | colony-forming units per mm | < $10^3$ | < $10^3$ | < $10^3$ |
| annually | Iron | ppm Fe | < 3 | < 3 | < 3 |
| annually | copper | ppm Cu | < 0.2 | < 0.2 | < 0.2 |
| each sample | pH | - | 8.0 – 9.5 | 11.0 – 12.0 | 9 – 10 |
| each sample | nitrite | ppm NO2 | 1000 - 1200 | 1000 - 1200 | 700 - 900 |
| each sample | nitrate | ppm NO3 | document | document | document |
| each sample | ammonia | ppm NH3 | <3 | <3 | <3 |
| each sample | electrical conductivity | µS/cm | document | document | document |
| each sample | Total hard-ness | ppm CaCO3 | < 20 | < 20 | < 20 |
| each sample | chloride | ppm Cl | < 150 | < 150 | < 150 |
| each sample | sulphate | ppm SO4 | < 150 | < 150 | < 150 |
| each sample | quartz | ppm SiO2 | < 200 | < 200 | < 200 |

## 5.2 Test standards for coolants with Corrshield NT4201, Nalco2000 and Maxigard corrosion inhibitors.

| | | |
|---|---|---|
| conductivity | | EN 27888(C8) |
| pH | | DIN 38404-C5 |
| chloride [ppm] | EPA Method 9056A | EN ISO 10304-1 |

| | | |
|---|---|---|
| nitrite [ppm] | EPA Methode 9056A | EN ISO 10304-1 |
| phosphate [ppm] | EPA Methode 9056A | EN ISO 10304-1 |
| nitrate [ppm] | EPA Method 9056A | EN ISO 10304-1 |
| iron [ppm] | EPA 200.8 | EN ISO 11885 (E22) |
| calcium [ppm] | EPA 200.8 | EN ISO 11885 (E22) |
| silicon [ppm] | EPA 200.8 | EN ISO 11885 (E22) |
| boron [ppm] | EPA 200.8 | EN ISO 11885 (E22) |
| aluminium [ppm] | EPA 200.8 | EN ISO 11885 (E22) |
| copper [ppm] | EPA 200.8 | EN ISO 11885 (E22) |
| magnesium | EPA 200.8 | EN ISO 11885 (E22) |
| sulphate | EPA Method 9056A | EN ISO 10304-1 |

## 6 Revision code

**Revision history**

| **Index** | **Date** | **Description/Revision summary** | **Creator**<br>*Auditor* |
|---|---|---|---|
| 4 | 04.06.2012 | Änderung Anhang / changes to attachment | **Chvatal**<br>*Provin* |
| 3 | 23.01.2012 | Firmenlogo Chevorn getauscht ÄNDERUNG / replacement of brand logo "Chevron" CHANGE | **Chvatal**<br>*Provin* |
| 2 | 13.01.2012 | Grundlegende Überarbeitung NEU / Fundamental revision NEW | **Chvatal**<br>*Provin* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to Content Management System<br>ersetzt / replaced Index: h | **Schartner**<br>*Giese* |

## 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<br>µS/in | 100 - 1500<br>254-3810 | < 100 |
| Oxygen content $O_2$ | mg/l<br>grain/gallon | < 0,02<br><0,00117 | < 0,05<br>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<br>grain/gallon | < 20<br><1,168 | < 20<br><1,168 |
| Phosphate $PO_4$ | mg/l<br>grain/gallon | 5 - 15<br>0,292 - 0,876 | 5 - 10<br>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].

**5.2** 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.

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

**5.4** 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.

**5.5** 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.

**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

## Blank Page for Notes

GE Energy

# TA 1000-0300

## Fuel gas quality - natural, associated petroleum, bio- and landfill gas

## Technical Instruction

3 2 4 9 2 0 3 1 2 3 1 6 6 2 0 2 3 8 4 2 2 7 5 6 1 3 4 5 1 5 3 6 2 5 4 1

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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



## 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 geared to 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 no. 1000-1109

TI 1000-0099B

TI 1000-0099C.

## 2 Gas types

**Fuel gas quality - 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 values

Fuel gases are composed of various individual components. These include 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, respectively, 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 operating for a certain period of time.

**General limiting conditions** [1]

| Fuel gas must not be potentially explosive (no ATEX rating) | | |
|---|---|---|
| Gas pressure | - | In accordance with project specifications |
| Gas pressure, max. fluctuation rate | 10 mbar/sec. | |
| Gas temperature | 0°C < T < 40°C | Other temperatures should be checked in individual cases. |
| Gas moisture content | < 80% relative | We advise against using an active carbon filter. However, there must be no condensate in the gas train up to the gas mixer. |
| | < 50% relative | A requirement when applying a GE Jenbacher activated carbon filter at the intake of the activated carbon filter.<br>Applies to any gas temperature. |
| | Dew point <18°C | Requirement for ClAir supplementary firing 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. |
| Hu fluctuation rate | 1% / 30 sec. | |
| Methane value fluctuation speed | 10 MN/30 sec. | |
| Oxygen content | < 3 %Vol | When using a TSA gas cleaning system |

[1]) Condition at the interface to GE Jenbacher scope of supply

**Dust**

| A filter in the gas train protects the system against particles. The filter in the gas train is not used as a work filter [3]) |
|---|

**Trace and accompanying elements**

| Si: total silicon as $Si_{BG}$ [2]) | 0.02 | Without catalytic converter |
|---|---|---|
| | 0.0005 | With catalytic converter |

[2]) 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:

$\Delta$ Si $_{\text{content in engine oil}}$: the increase in the Si content of the engine oil in ppm between two analyses, and

The operating time in hours between the two oil analyses.

$$Si_{\text{Operational value}}\ [Si_B] = \frac{\Delta Si_{\text{content in engine oil}}\ [\text{ppm}] \times \text{oil capacity (l)}}{\text{Average engine power output [kW]} \times \Delta \text{ oil service life (h)}} \times 1.1$$

**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 |

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

$Si_B$=0.018 actual value

$Si_{BG}$=0.02 $Si_B < Si_{BG}$ ⇨ OK

In the preparatory phase of the project, GE Jenbacher are able to make an estimate of the expected operational value SiB based on a fuel gas flow which is characteristic of the engine operation. GE Jenbacher can then offer their clients maintenance schedules and/or make recommendations for improvement measures, based on the result. During operation, adherence to the limit levels found in the oil analysis is necessary to ensure the contractual maintenance plan remains valid. The prerequisites and the sample taking procedure are described in more detail in chapter 5, Appendix II.

**Trace and accompanying elements**

| | | |
|---|---|---|
| Total sulphur [5] | < 700 mg/10kWh [4] | Without catalytic converter |
| | < 1200 mg/10kWh [4] | Without catalytic converter, limited warranty [6] |
| | < 200 mg/10kWh [4] | with catalyst for CO[7] |
| | < 20 mg/10kWh [4] | with catalyst for formaldehyde [8] |
| | < 500 mg/10kWh [4] | Limit does not relate to downstream components when using an active carbon filter (see above). |
| | < 700 mg/10kWh [4] | Limit does not relate to upstream components when using a ClAir system (see above) |
| halogen compounds [5]<br>Total Cl + 2 * total F | < 100 mg/10kWh [4] | Without catalytic converter |
| | < 400 mg/10kWh [4] | Without catalytic converter, limited warranty [6] |
| | < 200 mg/10kWh [4] | Limit does not relate to downstream components when using an active carbon filter (see above) |
| | < 200 mg/10kWh [4] | Limit does not relate to upstream components (see above) when using a ClAir system |
| | < 20 mg/10kWh [4] | With catalytic converter |

**Trace and accompanying elements**

| | | |
|---|---|---|
| Ammonia | < 50 mg/10kWh [4)] | 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 [4)] | |
| 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.<br>▪ Sulphur, phosphorus, lead, mercury, arsenic, antimony, zinc, copper, tin, iron, nickel and chromium.<br>▪ The warranty will cease to apply if the cumulative volume of these elements exceeds 350 g/m³ of catalytic converter. The evidence will be provided by quantitative analysis of a used sample. The exhaust gas must always be free of silicon compounds, such as siloxanes. | |

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 train is compromised, measures must be taken by the customer to improve the situation.

If a work filter is necessary, it must have a filtration efficiency of at least 99.99% with particle diameters greater than 3 µm.

[4)] 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, Hu approx. 10 kWh/Nm³).

$$S = \frac{\text{Measured concentration [mg / Nm}^3\text{]}}{\text{Calorific value [kWh/Nm}^3\text{]}} \times 10$$

Concentrations are frequently expressed 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.

$$S' \text{ [mg / Nm}^3\text{]} = \text{Measured concentration [ppm] x element density [kg / Nm}^3\text{]}$$

Comment: expressing the quantity as ppm (=$10^{-6}$) 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 = 1.52 kg/Nm³) |
| Lower calorific value | 6 kWh/Nm³ (= 60% of 100% $CH_4$ = 10 kWh/Nm³) |

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

$$S'_1 \text{ [mg / Nm}^3\text{]} = 260 \text{ [ppm]} \times 1.52 \text{ [kg / Nm}^3\text{]} \qquad S'_1 = 395 \text{ mg / Nm}^3$$

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

$$S' \text{ [mg / Nm}^3\text{]} = \frac{\text{Sulphur molar mass}}{\text{H2S molar mass}} \times S'_1 \qquad S' \text{ [mg / Nm}^3\text{]} = \frac{32}{34} \times 395 \text{ [mg / Nm}^3\text{]}$$

$S'_1 = 372$ mg / Nm³

Step 3: conversion of measured value in mg/Nm³ to comparable value (mg/10 kWh)

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

Without catalytic converter ⇨ $S_G = 700$ mg/ 10 kWh $S < S_G$ ⇨ OK

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

[5]) 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.

[6]) 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 must be fitted, as designed by GE Jenbacher. For plants using heat recovery, care must be taken to ensure that the temperature does fall below the acid dew point in the waste heat boiler, taking partial load operation into account.

[7] $SO_2$ is converted into $SO_3$ in the catalytic converter. 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.

[8]) 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/10 kWh. 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 $C_4H_{10}$: | | |

**Chemical fuel gas characteristics**

| | | |
|---|---|---|
| Pentane $C_5H_{12}$: | | |
| Hexane $C_6H_{14}$: | | |
| Carbon monoxide CO: | | |
| Hydrogen $H_2$: | | |
| Carbon dioxide $CO_2$: | | |
| Nitrogen $N_2$: | | |
| Oxygen $O_2$: | | |
| Other: | | |

**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 they are 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 limiting values as indicated in this TI are based on extensive experience on the part of GE Jenbacher and offer a basis for uninterrupted operation.

GE Jenbacher offer their clients 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 acknowledge warranty claims related to problems caused by exceeding one or more of the limiting values mentioned 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 - customer-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 have therefore set the energy content of 1 standard cubic metre of methane at 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 plants (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 activated 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 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 offer their clients a tried and tested analysis technique developed by GE Jenbacher. 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.

## 6 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 3 | 13.09.2011 | Grenzwerte für Staub geändert / Limit values regarding dust changed | **Provin**<br>*Ast* |
| 2 | 17.06.2010 | Fußnoten geändert / footnotes changed | **Provin**<br>*Hillen* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **z** | **Schartner**<br>*Giese* |

## 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.

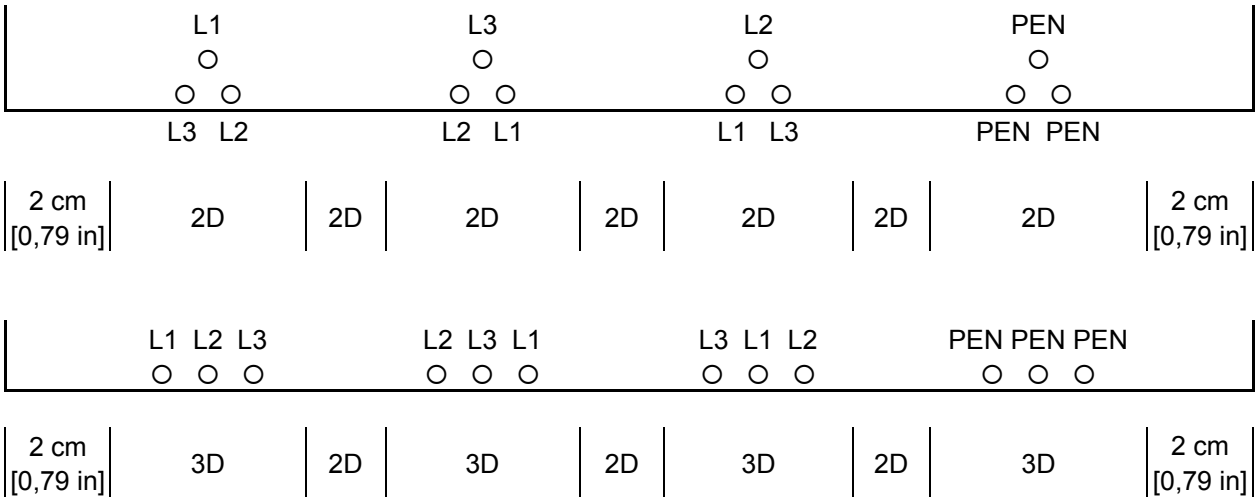
Bend radii of the cables must be taken into account.

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).

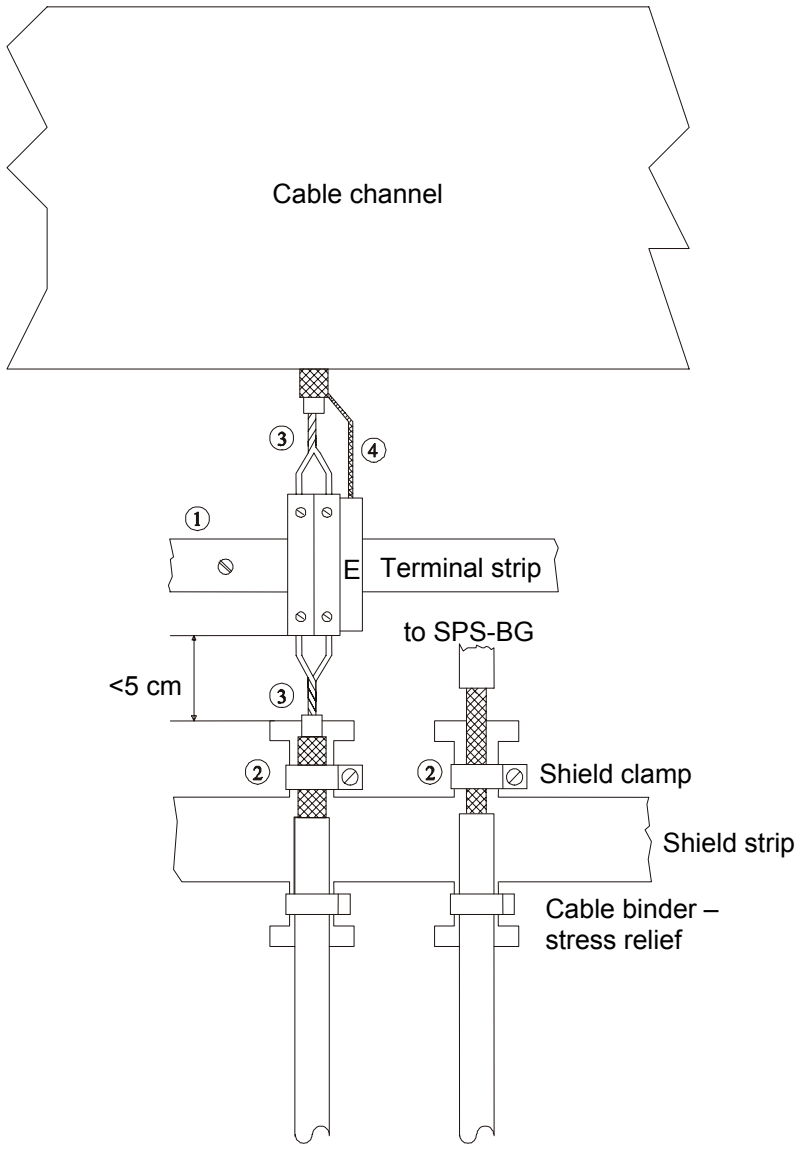
Grounding lines must be laid as directly as possible.

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].

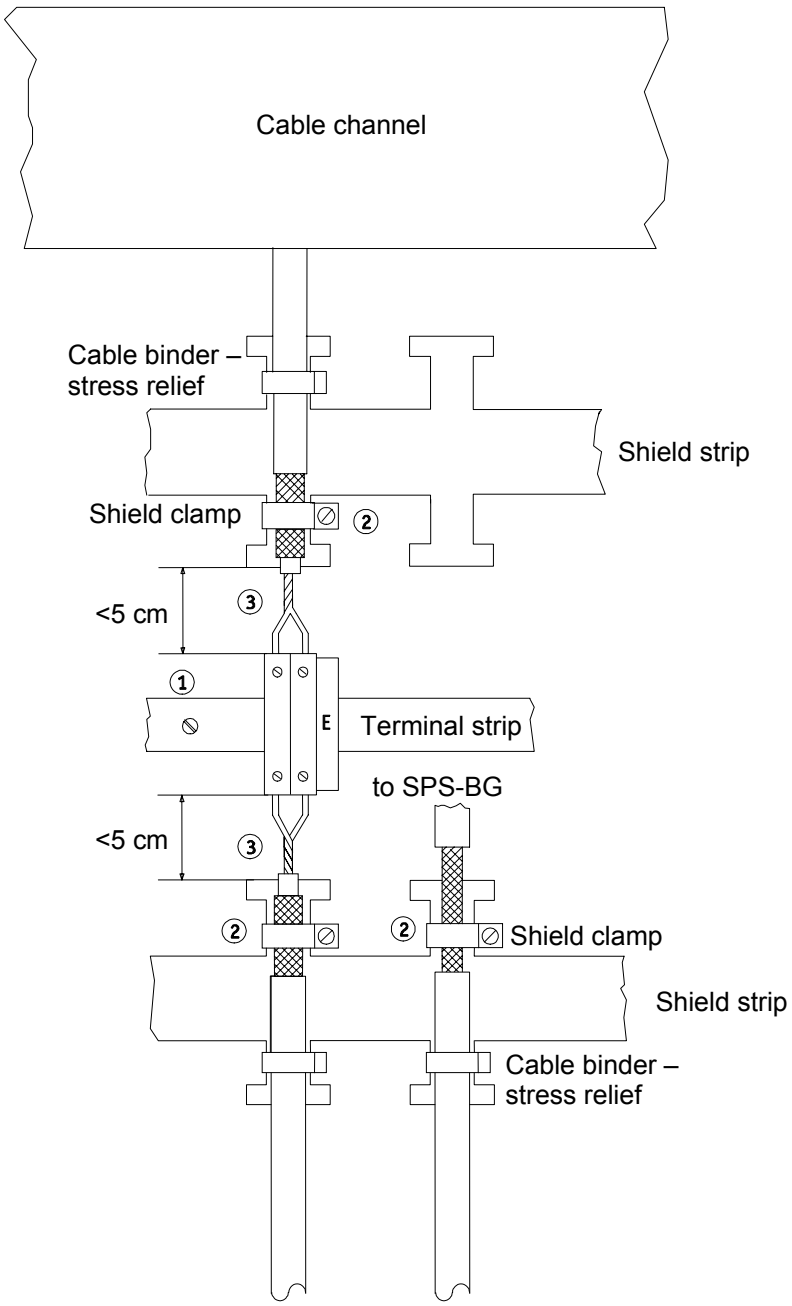
**Shield Treatment on the Shield Bus**
Lay shields so that they are spread out as far as possible and use suitable shield clamps.
Place shields with an as great a surface as possible with the corresponding shielding spots.
Connect shield bus in well conductive manner with assembly plate, or cabinet housing!
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

## Blank Page for Notes

## 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)

GE Energy

# TA 1000-1109

## Lubricating oil for type 2, 3, 4 and 6 GE Jenbacher engines

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**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, see also the following Technical Instructions:

TI 1000-0112

TI 1000-0099 A, B, C, D.

**Product names (in boldface)*** are suitable for prolonged oil change intervals in GE Jenbacher gas engines.

**Mobil Pegasus 1005**** can be assessed using increased oil limit values (see TI 1000-0099B).

## 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<br>Pegasus 805<br>**Pegasus 1005**** | Pegasus 710 | Pegasus 610 | Pegasus 705 |
| bp | Energas NGL | Energas NGL<br>Energas LFM | Energas LFM | Energas NGL |
| Castrol | Duratec L | Duratec L<br>Duratec MX | Duratec MX | Duratec L |
| Shell | Mysella LA 40<br>**Mysella XL 40*** | Mysella MA 40 | Mysella MA 40 | Mysella LA 40<br>**Mysella XL*** |
| PETRO-CANADA | **Sentron LD 5000*** | | | |
| Chevron | Geotex LA SAE 40<br>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 | Geotex LA SAE 40<br>HDAX Low Ash Gas Engine Oil SAE 40 | Geotex LF SAE 40<br>HDAX LFG SAE 40 | HDAX LFG SAE 40 | HDAX Low Ash<br>Gas Engine Oil SAE 40 |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| CALTEX | Geotex LA SAE 40<br>HDAX Low Ash Gas Engine Oil SAE 40 | Geotex LF SAE 40<br>HDAX LFG Gas Engine Oil SAE 40 | HDAX LFG Gas Engine Oil SAE 40 | HDAX Low Ash Gas Engine Oil SAE 40 |
| TOTAL | Nateria MH 40 | Nateria ML 406 | | |
| FUCHS | Titan Ganymet LA<br>**Titan Ganymet Ultra*** | Titan Ganymet plus<br>Titan Ganymet Ultra | Titan Ganymet | Titan Ganymet Ultra<br>Titan Ganymet LA |
| CEPSA | Troncoil Gas 40 | | | |
| OMV | LEG 40 | Gas HD 40 | | |
| Agip | | AUTOL BGJ 40 | | |
| Q8 Oils | Mahler G4 | Mahler HA<br>Mahler G5 | Mahler HA<br>Mahler G5 | |
| REPSOL | **Long Life Gas 4005***<br>Super Motor Gas 4005 | | | |
| ROLOIL | Mogas G4 | Mogas AC-40<br>Mogas G5 | Mogas AC-40<br>Mogas G5 | |
| Roloil | Mahler G4 | Mahler HA<br>Mahler G5 | Mahler HA<br>Mahler G5 | |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| ADDINOL | MG 40 Extra LA<br>**MG 40 Extra Synth*** | MG 40 Extra Plus | | MG 40 Extra LA |
| NILS | | Burian SAE 40 | | |
| ENEOS | NOC ENEOS M40(M) | | | |
| TECTROL | Methaflexx NG<br>**Methaflexx HC Premium*** | Methaflexx HC plus<br>Methaflexx HC Premium<br>Methafllexx GE-M<br>Methafllexx MD | Methaflexx D<br>Methafllexx GE-M | Methaflexx NG<br>Methaflexx HC Premium |
| SRS | | Mihagrun 40 | | |
| Valvoline | GEO LA 40 | | | |
| CENEX | | NGEO 2500 MA | | |
| Zeller+Gmelin | Divinol Spezial Typ 4 SAE 40 | Divinol Spezial HA SAE 40 | Divinol Spezial HA SAE 40 | |
| AVIA | | Gasmotorenöl HA SAE 40 | | |
| EUROLUB | | Gasmotorenöl HGM SAE 40 | | |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| galp energia | GN LX4005 | | | GN LX4005 |
| oilfino | | Famagas HA 40 | | |
| MOL | | Mol GMO MA 40 | | |
| pakelo lubricants | | Geoterm MA SAE 40 | | |

## 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<br>Pegasus 805<br>**Pegasus 1005**** | Pegasus 705<br>Pegasus 805 | Pegasus SR Pegasus 605 | Pegasus 705 |
| bp | Energas NGL | Energas NGL | | Energas NGL |
| Castrol | Duratec L | Duratec L | | Duratec L |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| Chevron | HDAX Low Ash SAE 40 | | | HDAX Low Ash SAE 40 |
| | HDAX Low Ash SAE 40 | | | HDAX Low Ash SAE 40 |
| FUCHS | **Titan Ganymet Ultra*** | | | Titan Ganymet Ultra |
| | Mysella LA 40<br>**Mysella XL*** | | | Mysella LA 40<br>**Mysella XL*** |
| ENEOS | NOC Eneos M40(M) | | | |
| Q8 Oils | Mahler G4 | Mahler G4<br>Mahler G5 | Mahler G5 | |
| REPSOL | **Long Life Gas 4005***<br>Super Motor Gas 4005 | | | |
| ROLOIL | Mogas G4 | Mogas G4<br>Mogas G5 | Mogas G5 | |
| Roloil | Mahler G4 | Mahler G4<br>Mahler G5 | Mahler G5 | |
| ADDINOL | **MG 40 Extra Synth*** | | | |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| TECTROL | **Methaflexx HC Premium*** | | | 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 | | |
| galp energia | GN LX4005 | | | GN LX4005 |

## 5 Lubricating oil requirements for GE Jenbacher type 6 engines (version E)

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<br>Pegasus 805<br>**Pegasus 1005*** | Pegasus 705<br>Pegasus 805 | Pegasus SR Pegasus 605 | Pegasus 705 |
| bp | Energas NGL | Energas NGL | Energas NGL | Energas NGL |
| Castrol | Duratec L | Duratec L | Duratec L | Duratec L |
| | Mysella LA 40<br>**Mysella XL 40*** | | | Mysella LA 40<br>**Mysella XL*** |
| PETRO-CANADA | **Sentron LD 5000*** | | | 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*** | | | Methaflexx HC Premium |
| TOTAL | Nateria MH 40 | Nateria MH 40 | Nateria MH 40 | |
| FUCHS | **Titan Ganymet Ultra*** | | | 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<br>Mahler G5 | Mahler G5 | |
| REPSOL | **Long Life Gas 4005***<br>Super Motor Gas 4005 | | | |
| ROLOIL | Mogas G4 | Mogas G4<br>Mahler G5 | Mahler G5 | |
| Roloil | Mahler G4 | Mahler G4<br>Mahler G5 | Mahler G5 | |
| ADDINOL | **MG 40 Extra Synth*** | | | MG Extra Synth |
| ENEOS | NOC ENEOS M40(M) | | | |
| OMV | Gas LEG 40 | | | |
| Zeller+Gmelin | Divinol Spezial Typ 4 SAE 40 | Divinol Spezial Typ 4 SAE 40 | | |
| galp energia | GN LX4005 | | | GN LX4005 |

## 6 Lubricating oil requirements for GE Jenbacher type 6 engines (as from version F)

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<br>Pegasus 805 | Pegasus 705<br>Pegasus 805 | Pegasus SR Pegasus 605 | Pegasus 705 |
| bp | Energas NGL | Energas NGL | Energas NGL | Energas NGL |
| Castrol | Duratec L | Duratec L | Duratec L | Duratec L |
| Shell | Mysella LA 40<br>**Mysella XL 40*** | | | Mysella LA 40<br>**Mysella XL*** |
| PETRO-CANADA | **Sentron LD 5000*** | | | Sentron LD 5000 |
| Chevron | HDAX Low Ash SAE 40 | | | HDAX Low Ash SAE 40 |
| Texaco | HDAX Low Ash Gas Engine Oil SAE 40 | | | HDAX Low Ash Gas Engine Oil SAE 40 |
| TECTROL | **Methaflexx HC Premium*** | | | Methaflexx HC Premium |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| TOTAL | Nateria MH 40 | Nateria MH 40 | Nateria MH 40 | |
| FUCHS | **Titan Ganymet Ultra*** | | | Titan Ganymet Ultra |
| CALTEX | HDAX Low Ash Gas Engine Oil SAE 40 | | | HDAX Low Ash Gas Engine Oil SAE 40 |
| Q8 Oils | Mahler G4 | Mahler G4<br>Mahler G5 | Mahler G5 | |
| REPSOL | **Long Life Gas 4005***<br>Super Motor Gas 4005 | | | |
| ROLOIL | Mogas G4 | Mogas G4<br>Mahler G5 | Mahler G5 | |
| Roloil | Mahler G4 | Mahler G4<br>Mahler G5 | Mahler G5 | |
| ADDINOL | **MG 40 Extra Synth*** | | | MG Extra Synth |
| ENEOS | NOC ENEOS M40(M) | | | |
| OMV | Gas LEG 40 | | | |

| | A | B | C | [CAT] |
|---|---|---|---|---|
| Zeller+Gmelin | Divinol Spezial Typ 4 SAE 40 | Divinol Spezial Typ 4 SAE 40 | | |
| galp energia | GN LX4005 | | | GN LX4005 |

## 7 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 9 | 10.05.2012 | Type 2,3 Produkt "Geterm MA SAE40" Class B fuel gas.<br>Type 4,6 Produkt "Mysella XL" [CAT] fuel gas.<br>Type 6 E-version Produkt "Pegasus 1005" Class A fuel gas. | **Bilek**<br>*Chvatal Susanne* |
| 8 | 24.04.2012 | type 2,3,4,6 Produkt "Fuchs" Class A fuel gas, type 2,3,4,6 Produkt "Q8" Class B,C fuel gas, type 2,3,4,6 Produkt "ROLOIL" Class BC fuel gas, type 2,3,4,6 Produkt "ADDINOL" Class A fuel gas, type 2,3,4,6 Produkt "TECTROL" Class A fuel gas, type 2,3,4,6 Produkt "galp energia" Class A, [CAT] fuel gas, type 2,3 Produkt "olfino" Class B fuel gas, type 2,3 Produkt "MOL" Class B fuel gas. | **Bilek**<br>*Chvatal Susanne* |
| 7 | 30.05.2011 | Pos. 3 Treibgas Klasse A / Point 3 Class A fuel gas Produkt / Product "Fuchs, Repsol, Tectrol, Total und/and Adinol".<br>Treibgas Klasse B / Class B fuel Produkt / Product "Fuchs und/and Tectrol".<br>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**<br>*Chvatal Susanne* |
| 6 | 21.02.2011 | Pos. 3 Treibgas Klasse B / Point 3 Class B fuel gas. Produkt / Product Fuchs. | **Bilek**<br>*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**<br>*Chvatal Susanne* |
| 4 | 15.10.2010 | Entwicklungsfreigaben/Development release: 071_2010-NOC ENEOS M40(M) BR/type 6. | **Bilek**<br>*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. | |

**Revision history**

| | | | |
|---|---|---|---|
| | | Freigabe - Mittlg / release No. 035/2010 Neu/new: Zeller/Gmelin, AVIA, Eurolub. | |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **c** | **Schartner**<br>*Giese* |

GE Energy

# TA 1100-0110

## Boundary conditions for GE Jenbacher gas engines

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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

## 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 Gas engines and products (e.g. PC compressors) may not be operated in zones 2, 1 or 0 (under IEC 60079-10-1:2008). The plant operator is responsible for ensuring that these conditions are observed throughout the entire period of operation (including engine starts and shut-downs).

## 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.**

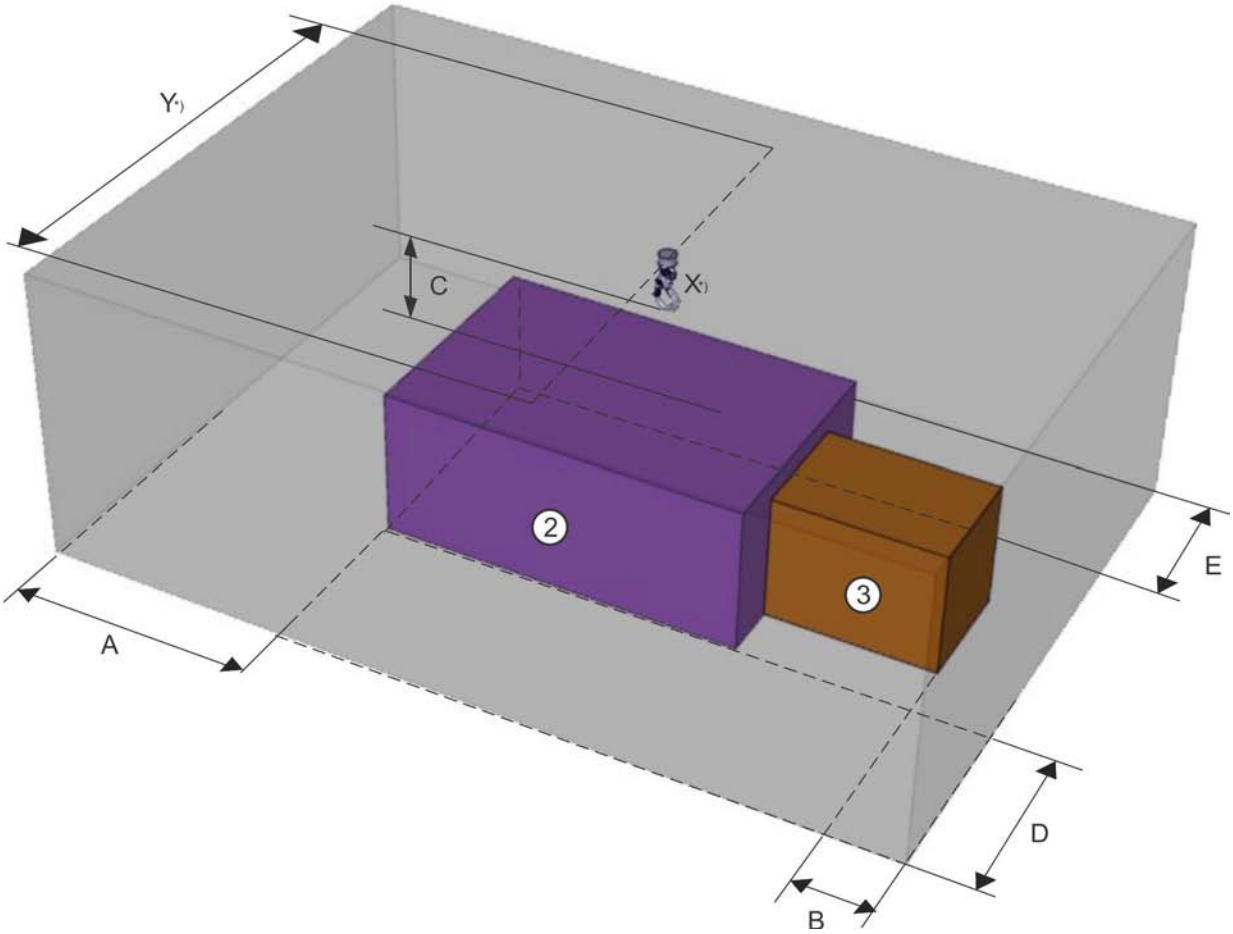
When installing Jenbacher container modules, a manually operated emergency stop facility (EMERGENCY STOP button) must be fitted on the customer side - on the outside of the container - and integrated into the Jenbacher control system.

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

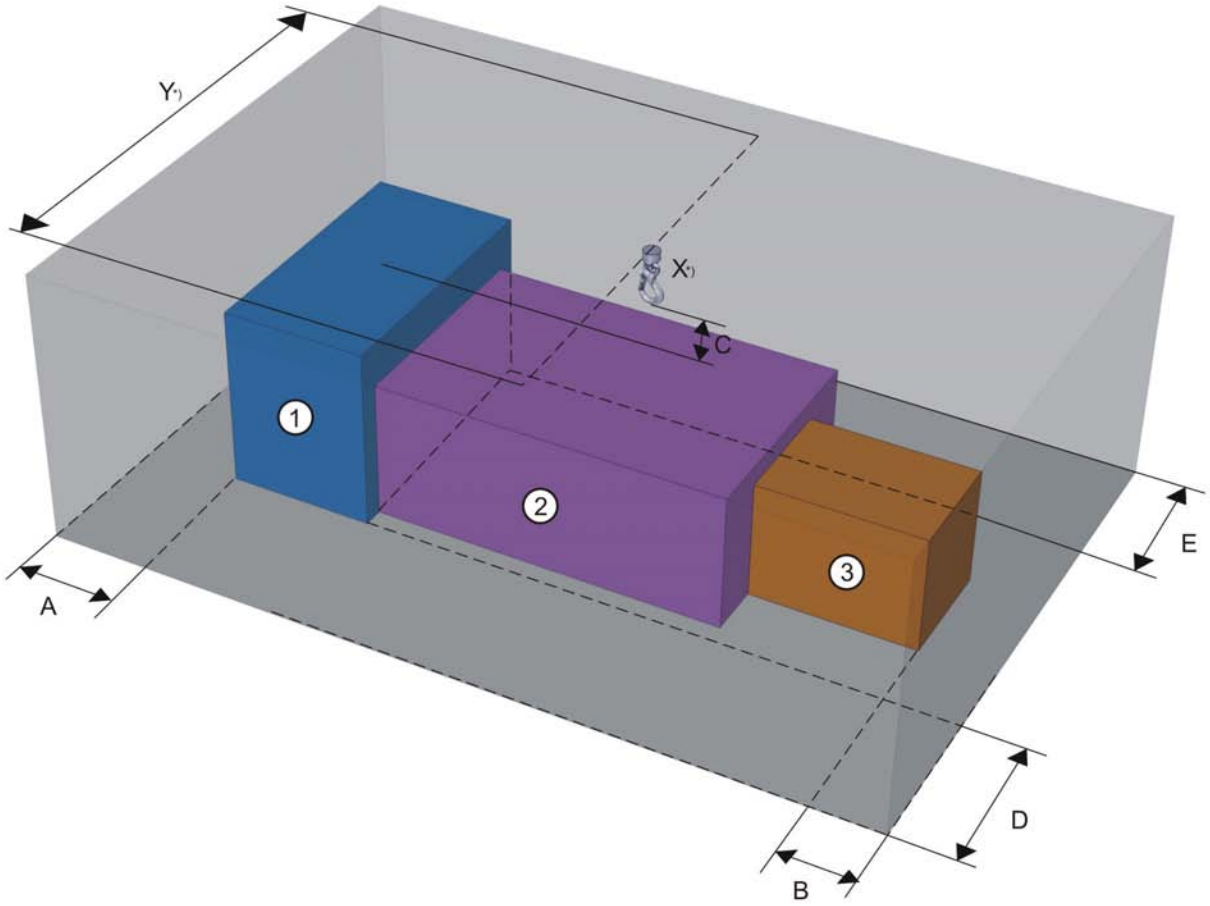
## 4 Minimum clearance to be left around the module for maintenance work

The carrying power 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 make sure there are freely accessible areas. If necessary, contact GE Jenbacher for advice.

There must be room to use the crane to put cylinder heads of type 6 and 9 engines and/or turbochargers and mixture coolers/intercoolers (of all engine types) in a temporary storage location or on pallets after removal.




*Minimum clearance for modules without a turbocharger module*




*Minimum clearance for modules with a turbocharger module*

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

| | A*) | B*) | C | D*) | E*) | X*) | Y´*) |
|---|---|---|---|---|---|---|---|
| J 208 | 1,000 mm | 1,000 mm | 1,500 mm | 1,000 mm | 1,000 mm | 100 kg | - |
| Type 3, 4 engine | 1,000 mm | 1,000 mm | 1,500 mm | 1,000 mm | 1,000 mm | 500 kg | 1,600 mm |
| Type 6 engine | 1,500 mm | 1,000 mm | 1,500 mm | 1,000 mm | 1,000 mm | 1,000 kg | 1,600 mm |
| J 624 TSTC | 1,500 mm | 1,000 mm | 1,500 mm | 1,000 mm | 1,000 mm | 1,000 kg | 2500 mm |
| Type 9 engine | 2500 mm | 2500 mm | 2500 mm | 1,000 mm | 1,000 mm | 5,000 kg | 8500 mm |

**Y*) type 3, 4, 6, and 9 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.

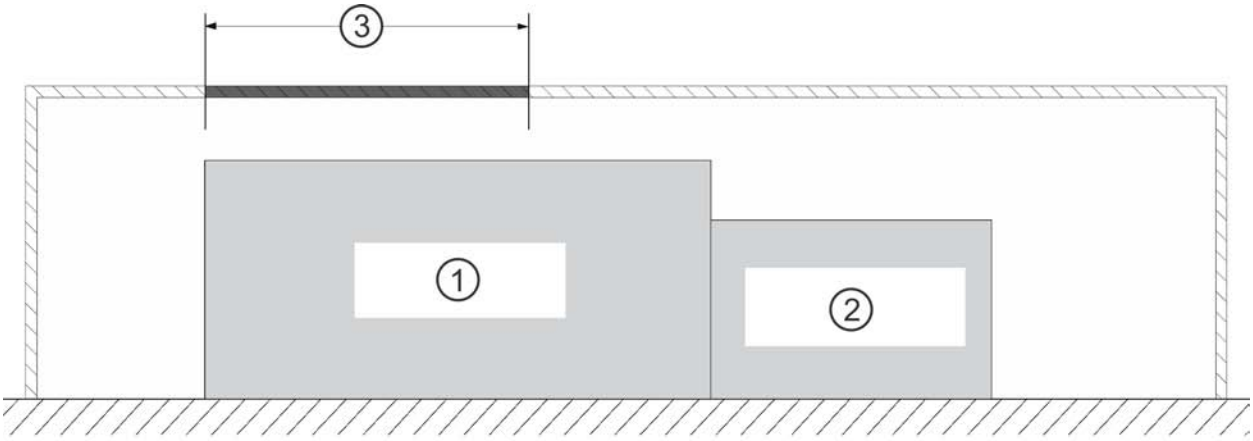
**X*)** The stated weight is the minimum crane load capacity (not including the generator).

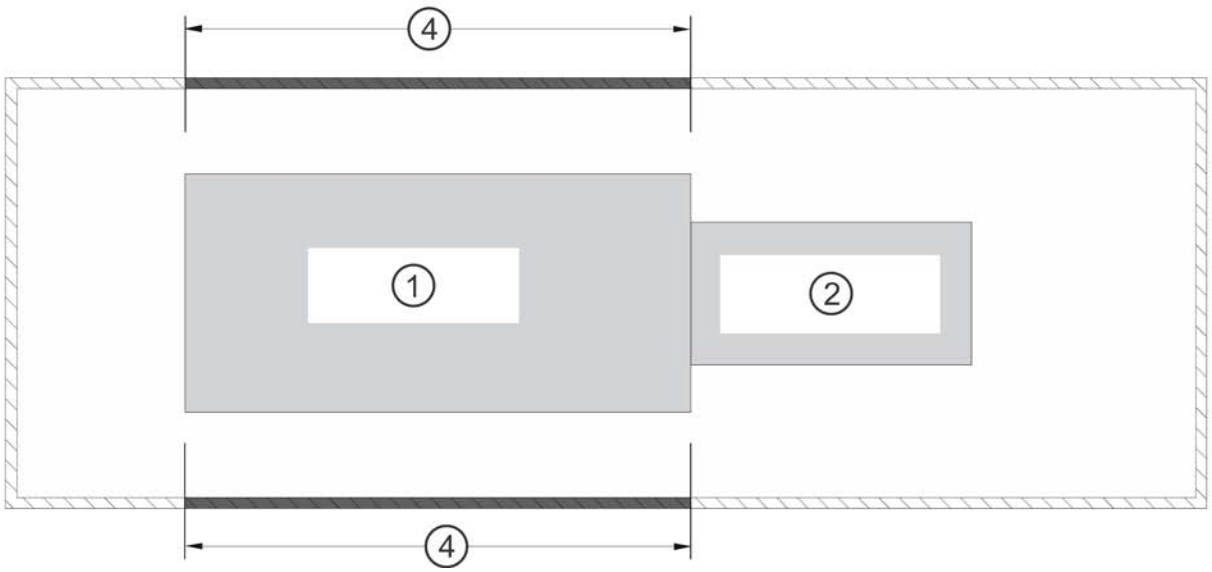
**J 208:** An overhead crane (trolley) with a rails above the cylinder heads would be helpful, but is not necessary.

**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 be provided on one side to store any removed parts during an overhaul.

**type 2 to 6 engines: 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 in the engine room in accordance with the 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 %.**
  - if the gas contains an **odorant** and the **CO content** of the fuel gas is **>0.5 %.**
  - in areas where people circulate, particularly hazardous areas (in the vicinity of gas-carrying components).
  - in dead zones in terms of air flow (insufficient ventilation).
- The sensors must be installed at breathing height.

## 6 Fuel gas

In accordance with the following Technical Instruction:

- 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 of special gas
- TI 1100-0112: Installation of GE Jenbacher modules

The gas train is normally designed for a project-specific pressure. Precautions must therefore be taken in the customer's plant design before the interface to the GE Jenbach scope of supply to prevent the gas pressure from ever exceeding the admissible maximum pressure at any time.

GE Jenbacher Equipment may only be supplied with fuel gases that - if situated in conditions outside the engine (mixture connection interface) - are not ignitable. Where required, appropriate additional technical measures

must be taken (e.g. monitoring / controlling the oxygen concentration in the gas => emergency shutdown), taking into account any specific national regulations.

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

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

**In case of CO in fuel gas:** If the CO content in the fuel gas is **>5 %**, a **nitrogen flushing installation** 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 Function lines in the fuel-gas system

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

Function lines are defined in DVGW G 491 as controller purge lines, vent lines from the leak tester and blow-off lines from safety valves that have to be run to atmosphere from the engine room. Purge, vent and blow-off lines must not be run into a common manifold. Function lines of the same kind may be grouped together if this does not adversely affect the operation of the individual items of equipment (follow the manufacturers' information). The function line diameters must be dimensioned in compliance with local conditions and as a function of the pressure loss (piping, bends, etc.).

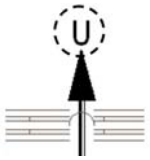
Function lines are not included in the GE Jenbacher scope of supply. The design of a permanently technically leakproof, well-made function line (e.g. to TRBS2152 Part 2) is the responsibility of the plant planner/builder.

The gases discharged at the outlets must be conducted away safely. The function line outlets must be situated at a safe distance from ignition sources and protected against the ingress of foreign matter (e.g. rain) that could clog or adversely affect the operation of the equipment.

The area around the function line outlets must be evaluated and designed in accordance with current local explosion protection and industrial safety regulations (e.g. 94/9/EG, IEC 60079, EN 1127-1).

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

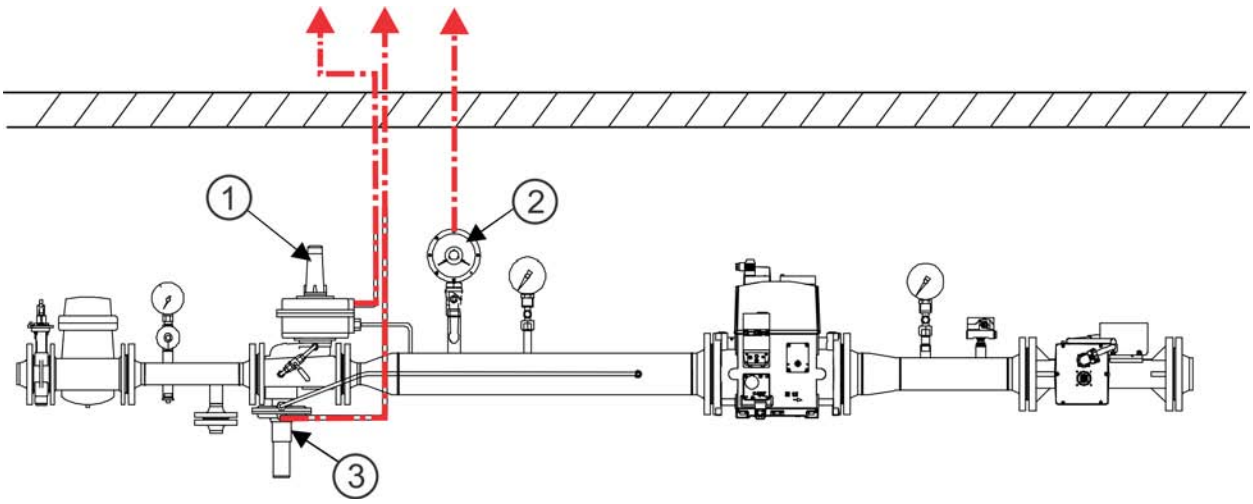
Details of the exact points at which gas should be extracted can be found in the specific Technical Diagram for the plant.




*Symbols used in the technical diagram*

**Run the function lines out of 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 |

Function lines (shown as dotted red lines in the above illustration) are not included in the GE Jenbacher scope of supply!

### 6.2 Condensate removal in the fuel-gas system

Cooling of gases in the fuel gas system can cause the entrained water in the gas to condense, with the resulting formation of condensate. The condensate must be drained from the gas system in a gas-tight way and disposed of in accordance with 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 scope of supply. The plant planner/builder is responsible for designing and constructing a gas-tight, well-made condensate drain in accordance with current local regulations relating to explosion protection and safety at work.

**Notes on condensate drain lines:**

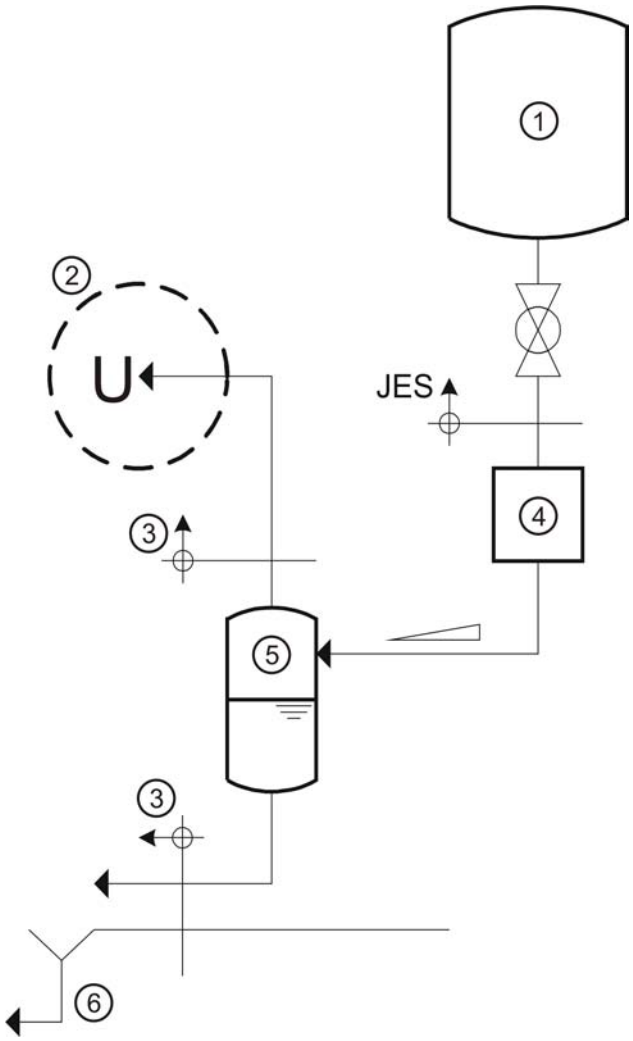
- Not all commercially-available condensate drain lines are gas-tight, and some line can leak in the course of operation (e.g. due to dirt and vibration). The suitability for use as a gas-tight condensate drain line for fuel gases and the conditions for securing permanent gas-tightness must be expressly confirmed by the manufacturer/supplier and observed accordingly.
- Gases dissolved in the condensate may be liberated around the condensate drain (pressure release), 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.

  The interior of the condensate drain line and the area around the venting point must be evaluated and designed as a function of the maximum gas quantity released in accordance with current local industrial safety regulations (definition and designation of potentially explosive atmospheres e.g. on the basis of DIN EN 1127).

  The illustration below shows the layout 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 | Vent point | ⑤ | Water trap |
| ③ | Immediate environment | ⑥ | Condensate disposal |

### 6.3 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

Forced-draught fans must be installed for the engine-room ventilation. If this rule is not to be applied, a special technical approval must be obtained from GE Jenbacher.

**TIP**

**Air pressure fluctuations e.g. due to switching processes by the ventilation system can affect the engine mixture formation. This can result in false starts and deflagrations.**

a) When the module is demanded, it is essential that the engine room ventilation is switched on by the "Auxiliaries On" outgoing contact. This activates defined background conditions during start-up and accelerating to speed.

b) During the starting and accelerating procedure, including synchronisation, no switching of the engine-room ventilation system should occur until conditions have stabilised.

**Air supply to the engine room:**

Dust-free air of purity class G3 (type 2 - 6 engines) and F6 (type 9 engine) according to EN 779 and/or a filter degree of 85 % according to ASHRAE is required. If required, install a coarse-dust filter of the relevant filter class.

**Combustion air aspiration from the engine room:**

The combustion air is aspirated from the engine room through a combustion air supply system upstream of the engine. Dust-free air of purity class F6 as per EN 779 must be provided. In addition, the engine room cladding surfaces must be sealed and free of loose dust and fibres. The mesh size of air filters must not be less than that required. If refrigeration compressors are installed in the engine room, the intake air should be drawn in from the outside atmosphere.

**Max. engine-room temperature:**

The cooling and combustion intake air for the engine and generator must be as close as possible to the outside temperature. Any temperature difference should not exceed 10 °C. Intake temperatures into the engine room should be under 40 °C. In the event of a deviation from this, the module must be specially designed after approval is given by GE Jenbacher.

The resulting engine room temperature should not exceed 47 °C (45 °C for Type 4 engines).

A temperature difference of 10 K must be assumed during the design process when specifying the air quantity.

**Max. air intake temperature (at the engine air filter):**

Suitable measures must be taken to keep the combustion air temperature low ( +10 °C to +25 °C); this must remain constant and may only vary by ±X °C. Controlled-speed fans must be used if necessary to achieve this.

**TIP**

The limit values as per ISO 3046 apply to air pressure, air intake temperature and air humidity: 1000 mbar, +25 °C, 30 % humidity. In the case of differing conditions at the installation site, the specific engine performance will be reduced. This corresponds to the standard constraints as assumed by all engine manufacturers.
Other conditions may have been agreed upon prior to completion of the order, however, e.g. full load at an intake temperature of 40 °C. In this case, the pressure-charging system would have to be modified and the technical specifications amended. Such agreements should be set out in writing in the specification.

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

The starting behaviour of the engine, the starter motor power and the starting batteries (only for engine type with electric starters) are designed for a minimum ambient temperature of +10 °C. Every engine is equipped with electrical preheating for the oil and cooling water. Close off the intake and exhaust sound dampers, doors, gates etc. and switch off the fans when the electrical preheating systems are in operation.

**Engine-room air:**

Maximum sulphur concentration in the engine-room air < 1.5 mg/m$^3$

Dust content: ≤ 1 mg/m$^3$

**Engine room ventilation:**

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

- ensure that the entire engine room is properly ventilated (to prevent unwanted gas accumulations and heat pockets),
- guarantee a directed airflow across the engine to ensure the surface temperatures of electrical components mounted on the engine such as the ignition system, ignition coils, ignition cable conduits, gas injection valves, knock controller and charge pressure sensors, actuators, etc.) do not exceed +70 °C! If this is not ensured and the surface temperatures exceed this temperature, the service life of these components will be considerably reduced and the failure frequency will increase sharply. Damage and downtime caused by such a situation are excluded from the warranty. The speed of the frequency-controlled fan is controlled by a temperature sensor. The sensor should be fitted near the XXXXX.
- that outside air is forced into the engine room by the frequency-controlled fans and the engine room is slightly pressurised.

  Engine-room gauge pressure: 0.1 mbar < p < 0.5 mbar.

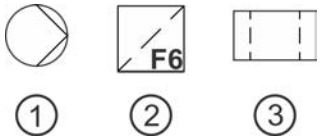
The effect of this is that when the engine is at rest, particularly in multiple-engine installations, there is always a defined air flow direction through the engine towards the exhaust chimney and no acidic exhaust gas can be aspirated by the engine. Not only does this avoid corrosion, but in the event of a false start (which can never be fully prevented) it also prevents unburned mixture from flowing back to the engine.

If the engine room is under a vacuum, however, e.g. as in greenhouse applications, precautions must be taken to ensure that no exhaust gas is drawn into the ventilation system (exhaust gas scavenging fan).

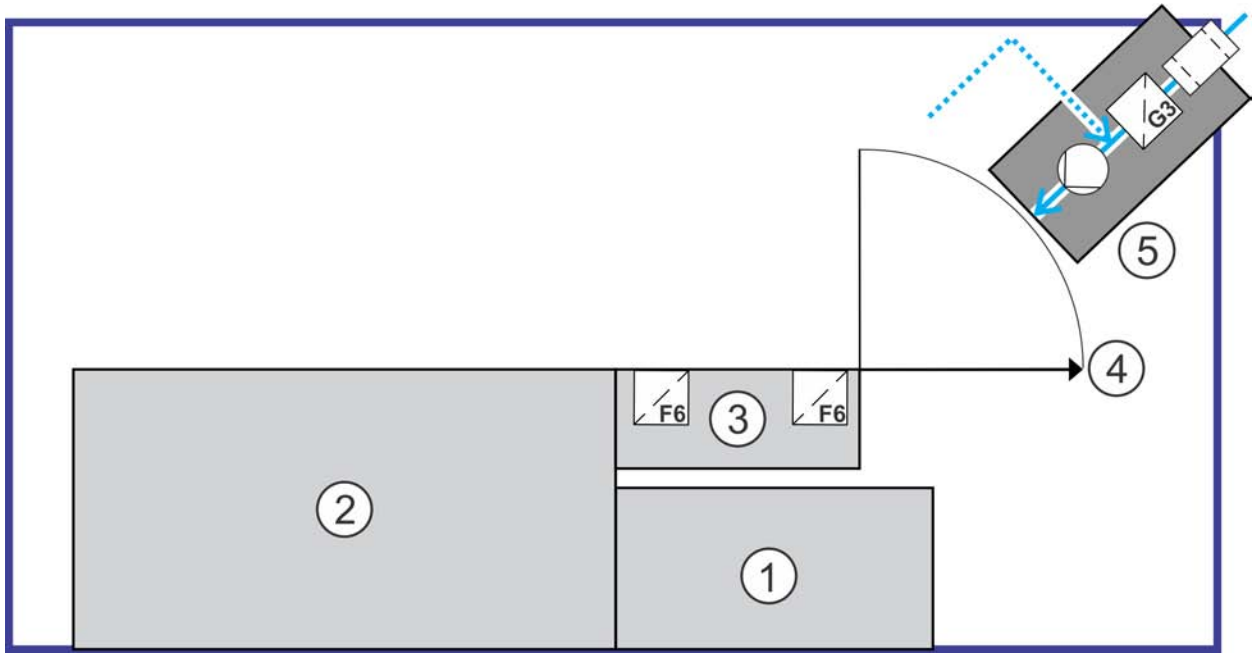
The direct air flow to the engine must be designed not only to meet the filtration requirements but also to ensure that if the external air is very cold (<10 °C), the air reaching the engine is mixed with warmer engine room air to ensure it is at 10 °C at least (air circulation control).

### 7.1.1 type 2 & 3 engines

The following symbols are used in the graphics below:



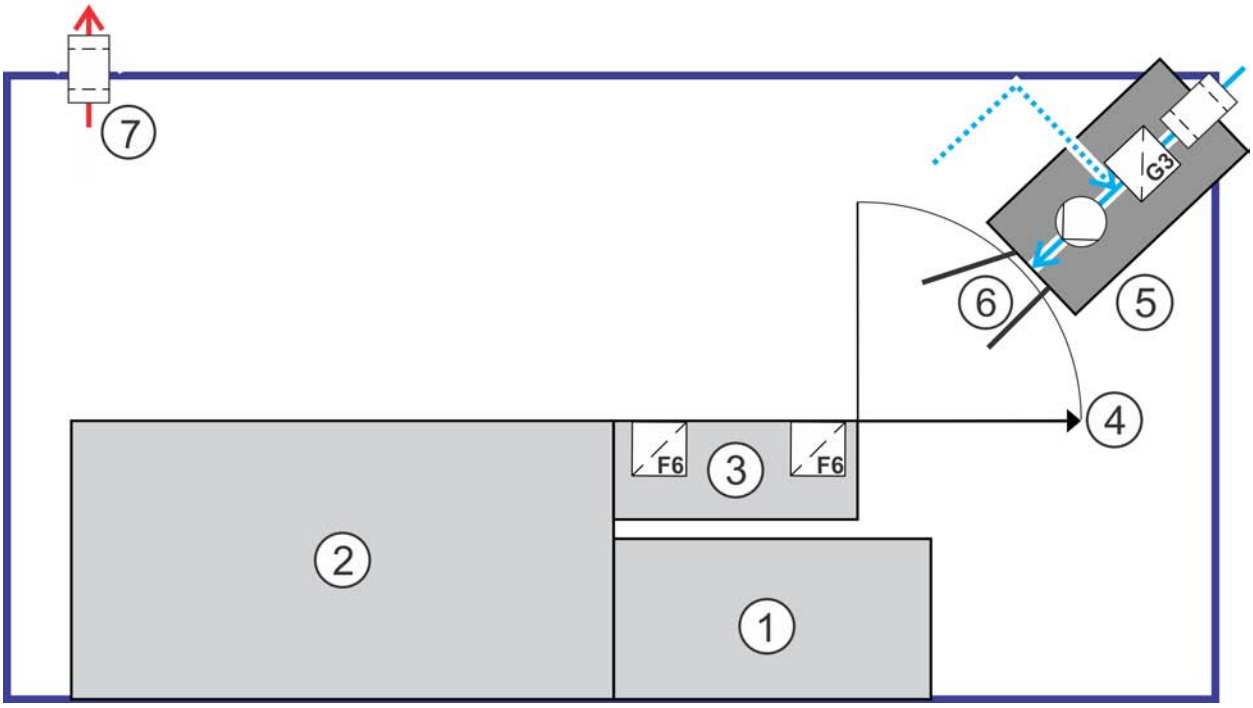

| | | | |
|---|---|---|---|
| 1 | Fan | 3 | Silencer |
| 2 | Filter, stating the purity class | | |




*Engine room ventilation for type 2 and 3 engines*

| | | | |
|---|---|---|---|
| 1 | Generator | 4 | R = 3 - 4 m 90° if possible |
| 2 | Engine | 5 | Fan |
| 3 | Intake filter | | |

### 7.1.2 type 4 & 6 engines




*Engine room ventilation for type 4 and 6 engines*

| | | | |
|---|---|---|---|
| 1 | Generator | 5 | Fan |
| 2 | Engine | 6 | Baffle plates |
| 3 | Intake filter | 7 | Air outlet |
| 4 | R = 3 - 4 m 90° if possible | | |

**Incoming air:**

The engine room air intake must be fitted at the generator end. The incoming air must be distributed over the generator engine and turbocharger end in the ratio 45%:25%:30% by two baffle plates.

**Outgoing air:**

The air outlet from the engine room must be situated at the other end of the engine, so that the air flow passes over the entire engine and helps to cool the engine surface.

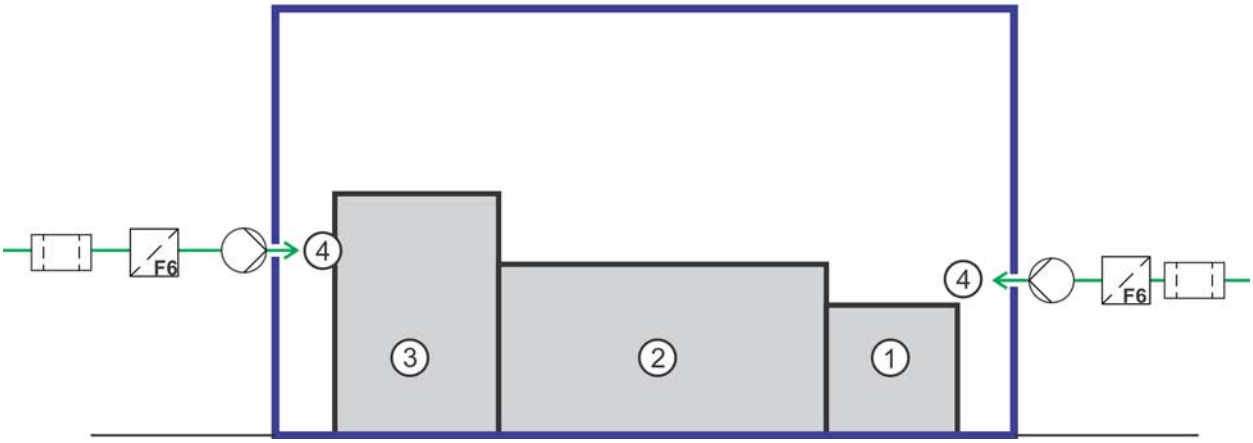
### 7.1.3 Type 9 engine

**Incoming air:**

The engine room air intake must be fitted at both the generator end and the turbocharger end.

**Outgoing air:**

The air outlet from the engine room must be situated above the middle of the engine, so that the air flow passes over the engine from both the generator and the turbocharger ends and helps to cool the engine surface.




*J920 engine room ventilation*

| | | | |
|---|---|---|---|
| ① | Generator | ③ | Turbocharger module |
| ② | Engine | ④ | Intake air |

The engine aspirates the filtered engine intake air from the room. Consequently, the more highly-filtered air supplied by the engine air intake system must be ducted to a point close to the turbocharger air intake. Attention should be paid to ensuring that the temperature differential between the left and right air intakes is less than 5 °C.

Design information:

- generator-end air: generator cooling air + ½ radiant heat
- turbocharger-end air: combustion air + ½ radiant heat

### 7.2 Generator cooling air

| | |
|---|---|
| Air inlet temperature: | maximum 40 °C |
| Relative humidity: | maximum 80 % |
| Dust content: | ≤ 1 mg/m³ |
| $SO_2$ content | ≤ 1.5 mg/m³ |

At air inlet temperatures greater than 40 °C, check the generator design.

The Pt100 temperature-control sensor must be positioned in the middle of the engine room in front of the exhaust air splitter.

### 7.3 Cooling air for switchgear cabinets on the module/generating set

Make sure that the ambient temperature of switchgear cabinets mounted on the module/generator set does not exceed 47°C. The switchgear cabinets are equipped with natural or forced draught ventilation, depending on their internal power losses. This ensures that the maximum temperature of 55°C is not exceeded inside the cabinet.

If the ventilation system cannot ensure this maximum ambient temperature (47°C) at the switchgear cabinet, GE Jenbacher must be informed. The optional installation of air-conditioning units means that ambient temperatures of up to 53°C are possible.

| Switchgear cabinets mounted on the module/generating set: | |
|---|---|
| type 2, 3 and 4 engines: | Module interface cabinet |
| type 4, 6 and 4 engines: | Module interface cabinet, prelubrication pump cabinet |
| Type 9 engines: | TCA interface cabinet, TCA sensor cabinet, ENGINE interface cabinets, GENERATOR control cabinet |
| For medium-voltage generators (type 3, 4, 6 and 9 engines): | GENERATOR surge suppressor (JUNCTION BOX) |

Other switchgear cabinets such as the module control cabinet (DIANE), power cubicle, station control cubicle, .... are not intended for installation in the engine room. The maximum ambient temperature for these cubicles is 40°C, and they are intended for installation in an electrical switchgear room.

# 8 Cooling water

## 8.1 General

The cooling water heat exchangers are designed on the cooling circuit side for a maximum water pressure of 10 bar. The maximum admissible rate of change of the hot water return temperature is 10°C per minute.

Permissible deviation in the hot water return temperature from the customer:

| | |
|---|---|
| 70°C | +0 / -10°C |
| 55°C | +0 / -5°C |

(Intermediate values can be calculated by interpolation)>

The specified warm-water return temperature should not be exceeded (install emergency cooling, otherwise the module will shut down). Temperatures above 50°C are not allowed!

Integration into the heating installation and the operating conditions in accordance with GE Jenbacher drawing No. E 92684 and/or after consultation with GE Jenbacher.

We advise installation of a thermostatic control to achieve a constant return temperature at the intake of the module.

Dirt trap: Mesh size ≤ 0.25 mm

In the event of discrepancies between the Technical Diagram and this TI, the values in the Technical Diagram shall prevail.

## 8.2 Cooling water quality

The following Technical Instruction applies:

- TI 1000-0200: Quality of cooling water in closed circuits
- TI 1000-0201: Antifreeze
- 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 cooling circuits

### 8.3 Engine cooling water

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

**Max. operating pressure at the crankcase inlet**

| | |
|---|---|
| **Type 2, 3, 4 and 6E engines (average pressure 20 bar)** | 2.5 bar |
| **Type 6F engine (average pressure 22 bar), J624G, J624H** | 3.5 bar |
| **Type 6F101 -112 engine, J624H101-112 (hot-country version) in generating set version** | 5.5 bar |
| **Type 9 engine** | 3.5 bar |

If there is more than one engine in a plant, the engine cooling water circuits must be designed as separate.

### 8.4 Cooling water for the mixture and oil

- Maximum intake temperature: refer to the technical diagram and/or the relevant technical specification
- Maximum permissible overpressure: refer to the technical diagram.

#### 8.4.1 Minimum water volumetric flow and water pressure in the high-temperature circuit (HT) of type 6 engines

Irrespective of the integration variant of the intercooler (parallel, serial, etc.), the water flow and pressure values at the HT stage outlet must at least comply with the limit values from diagram 1. The volumetric flow must not drop below the minimum in any operating mode. For example, if a constant warm water circuit inlet temperature is required (greenhouse application), as a general rule water recirculation is to be preferred to pump speed control.

The static system pressure at the expansion vessel must be selected so that the limit values for the inlet pressure to the crankcase and the minimum pressure at the intercooler are maintained.

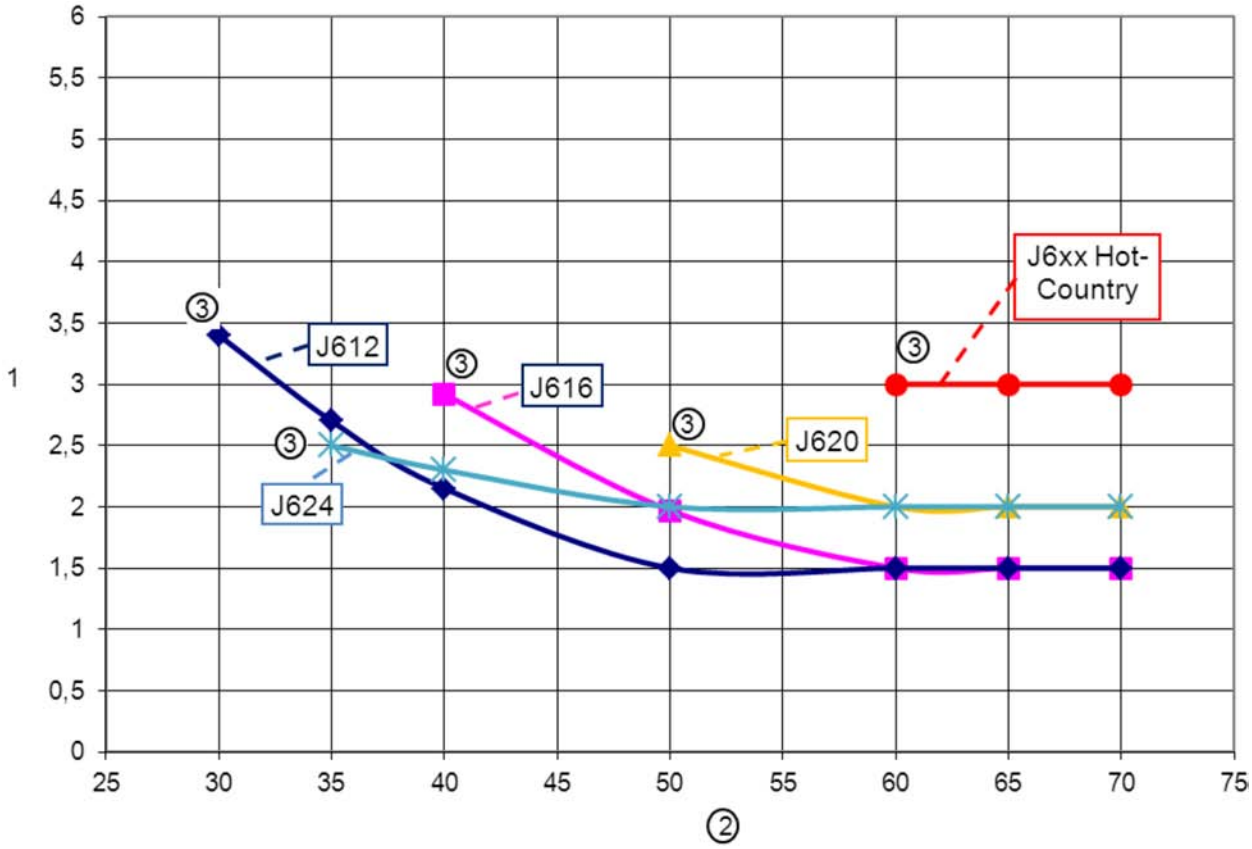



*Diagram 1: Water volume flow and minimum pressure to avoid steam bubble formation in the type 6 engine intercooler HT stage for cooling-water temperatures less than 80 °C.*

| | | | |
|---|---|---|---|
| ① | Minimum water pressure at the outlet from the intercooler HT stage [bar gauge] | ③ | Minimum water volumetric flow at the intercooler HT stage [m³/h]<br>(For the J624TSTC: referred to single coolers connected in parallel) |
| ② | Water volumetric flow through the intercooler HT stage [m³/h] | | |

### 8.4.2 Minimum water volumetric flow, minimum pressure and return temperature in the low-temperature circuit (LT) of type 6 and 9 engines

The cooling water temperature deviation must not exceed ±2 °C.

The following minimum flow values must be maintained in the LT circuit, since otherwise the the cooling effect of the LT stage will be reduced.

**Volumetric flow and minimum pressures in the low-temperature circuit**

| Engine type | Volumetric flow [m³/h] | Minimum pressure (bar gauge) |
|---|---|---|
| J612 | 25 | 0.5 |
| J616 | 30 | 0.5 |
| J620 | 40 | 0.5 |
| J624 | 50 | 0.5 |
| J920 | 70 | 0.5 |

### 8.4.3 Minimum fill pressure in hot water circuits in plants with exhaust-gas heat recovery

When using an exhaust-gas heat exchanger, the minimum pressure requirements for the heating circuit must comply with TI No. 1000-0206.

Whichever value is higher from diagram 1 or TI No. 1000-0206 must be selected.

### 8.4.4 Circulation pump demand – pump after-run

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

Customers must ensure at least 5 minutes' after-run, especially for plants with exhaust gas heat recovery where 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 in bypass operation.

## 9 Operation 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.

## 10 Lubricating oil

In accordance with the following Technical Instruction:

- TI 1000-1108: Lubricating oils for type 9 engines
- TI 1000-1109: Lubricating oil for type 2, 3 and 4 GE Jenbacher engines

Oil change in accordance with the following Technical Instructions:

- TI 1000-0099A: Approval procedure for various engine oils
- TI 1000-0099B: Limit values for used oil in GE Jenbacher gas engines
- TI 1000-0099C Procedure for testing plant-specific oil service life
- TI 1000-0099D Determining the initial pH value (ipH) for used lube oil as defined in TI 1000-0099B

**Oil analysis results**

*TIP*

**Incorrect diagnoses possible due to the presence of copper!**
Copper has a major oxidising effect on lubricating oil, especially at high temperatures, and accelerates its ageing. An increased copper content in oil leads to incorrect diagnoses.

a) Pure copper must not be used as a material for oil piping to the engine or valves or other fittings.

b) Use copper-nickel alloys with a nickel content of ≥ 10 %. These alloys can also be used instead of the steel piping normally used.

**See also**

- Link to TI 1000-1109 Lubricating oil type 2, 3, 4 and 6 engines [⇨ TA 1100-0110, Page 0 ]

## 11 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 transient 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 chimneys are used (DIN 4133).

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

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

**Exceptions:**

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

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.

## 12 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.

## 13 Operation and maintenance

**Minimum operation time:**

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

Increased corrective maintenance costs must be calculated if there are any deviations from this.

**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**

You must always aim for full load operation.

| | |
|---|---|
| Type 2, 3 and 4 engines | Unrestricted partial-load operation as from 40 % of rated load |
| Type 6 engine | Unrestricted partial-load operation as from 50 % of rated load (type 6F, G engines: 22 bar' type 6H engines; 24 bar) |
| Type 9 engine | Unrestricted partial-load operation as from 40 % of rated load, where $p_{me}$ = 22 bar. |

Emission values referred to in the technical specifications only apply where a load exceeds 50 %.

**Island operation**

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

**Daily inspection**

- Maintain an engine log.
- Maintenance as per GE Jenbacher maintenance plan.
- All conditions as described in the TIs should be complied with.

**See the following TIs for oil changes and oil analyses and assessment:**

- TI 1000-0099A: Approval procedure for various engine oils
- TI 1000-0099B: Limit values for used oil in GE Jenbacher gas engines
- TI 1000-0099C Procedure for testing plant-specific oil service life
- TI 1000-0099D Determining the initial pH value (ipH) for used lube oil as defined in TI 1000-0099B

## 14 Piping

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.

The instructions in

- TI 1400-0131: Piping

must be observed.

The revision applicable when the contract was signed is valid.

## 15 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.

## 16 Refer to the TIs listed below

The revision applicable when the contract was signed is valid.

**General conditions**

- TI 1100-0111: General Conditions Operating & Maintenance
- TI 1100-0112: Installation of GE Jenbacher modules

**Signage**

- TI 1000-0330: Signs 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 of special gas
- TI 1100-0091: Fuel gases, freedom from condensate

**lubricating oil**

- TI 1000-0099A: Approval procedure for various engine oils
- TI 1000-0099B: Limit values for used oil in GE Jenbacher gas engines
- TI 1000-0099C Procedure for testing the oil service life specific to the plant
- TI 1000-0099D Determining the initial pH value (ipH) for used lube oil as defined in TI 1000-0099B
- TI 1000-1108: Lubricating oils for type 9 engines
- TI 1000-1109: Lubricating oil for type 2, 3, 4 and 6 GE Jenbacher engines

**Cooling water**

- TI 1000-0200: Quality of cooling water in closed circuits
- TI 1000-0201: Antifreeze
- 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 cooling circuits

**Wiring**

- TI 1000-0505: EMC routing of wiring and earth connections to/between engine modules and control cabinets

## 17 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 8 | 28.02.2012 | Kapitel 15 an BR 9 angepasst / Section 15 adapted to series 9 | **Boxleitner**<br>*Stellovsky E.* |
| | | Kapitel 11 an BR 9 angepasst / Section 11 adapted to series 9 | **Boxleitner**<br>*Burkhardt W.* |
| | | Kapitel 10 an BR 9 angepasst / Section 10 adapted to series 9 | **Boxleitner**<br>*Chvatal S.* |
| | | Kapitel 5, 12 an BR 9 angepasst / Sections 5, 12 adapted to series 9 | **Boxleitner**<br>*Grain W.* |
| | | Kapitel 4 an BR 9 angepasst / Section 4 adapted to series 9 | **Boxleitner**<br>*Müßiggang R.* |
| | | Kapitel 3 an BR 9 angepasst / Section 3 adapted to series 9 | **Boxleitner**<br>*Thaler J.* |
| | | Kapitel 8, 9, 14 an BR 9 angepasst / Sections 8, 9, 14 adapted to series 9 | **Boxleitner**<br>*Häusl G.* |
| | | Kapitel 1, 2, 7, 13 an BR 9 angepasst / Sections 1, 2, 7, 13 adapted to series 9 | **Boxleitner**<br>*Chvatal D.* |
| | | Abschnitt Ansaugluft/ Maschinenraum GEÄNDERT / Chapter Intake air/ engine room CHANGED | **Provin**<br>*Pichler R.* |
| 7 | 19.10.2011 | Kapitel 6 (Treibgas) an BR 9 angepasst / Section 6 (power gas) updated to series 9 | **Boxleitner**<br>*Laucher R.* |
| 6 | 04.10.2011 | Anschnitt Rohrleitungen GEÄNDERT / Chapter Pipelines CHANGED | **Provin**<br>*Madl* |
| | | neues/new - update | **Bilek**<br>*Schmitz* |
| 5 | 08.06.2011 | Motorkühlwasserkreis -> max. Betriebsdruck um andere Baureihen erweiter / Engine cooling water circuit -> added new engine types to max. operating pressure<br>Kühlwasser für Gemischkühlung und Ölkühlung -> Diagramm neu (HotCountry hinzugefügt) / Cooling water for the mixture and oil -> New diagram (HotCountry added)<br>Rohwasser, Warmwasser, Heißwasser -> Inhalte geändert und verschoben nach "Kühlwasser für Gemischkühlung und Ölkühlung" / Raw water, warm water, hot water -> Moved and altered several paragraphs to section "Cooling water for the mixture and oil" | **Schartner**<br>*Schulze* |
| 4 | 14.01.2011 | 4. Einhaltung Mindestfreiräume nicht möglich / 4. Compliance with minimum clearance not possible | **Pichler**<br>*Verbanck / Widner M.* |

**Revision history**

| | | | |
|---|---|---|---|
| 3 | 08.11.2010 | 4. Mindestfreiraum/Minimum clearance J 620- Version „H“ | **Bilek**<br>*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- Kruckenhauser* |
| | | 15. Inselbetrieb/Isolated operation | *TCC- Hirzinger* |
| 1 | 31.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem<br>ersetzt / replaced Index: **as** | **Provin**<br>*Provin* |

GE Energy

# TA 1100-0111

## General conditions - Operation and Maintenance

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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



# 1 General conditions - Operation and maintenance

## 1.1 Basic 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 scope of supply)

When integrated into the hot water system, appropriate measures must be taken to prevent dirt or sediment building up in these components on the water side.

Refer to technical diagram and technical instructions for settings.

### 1.3 Interfaces/limits of supply

The conditions specified must be fulfilled and the equipment to be supplied for each specific system in accordance with the boundary conditions, the technical diagram, the schematic diagram, the interface list and the technical specification for the control system must be available within the limits of supply/interfaces. Failure to comply with these requirements may have an adverse effect on the characteristics of the product and on its reliability of operation and, in the end, restrict or invalidate warranty claims.

### 1.4 Maintenance staff

Work on the plant may only be carried out by specialist staff who have received relevant electrical and mechanical training. It is possible to conclude service contracts with GE Jenbacher, withGE Jenbachersubsidiaries or authorised specialist contractors. 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).

Upcoming maintenance work must be carried out before the maintenance interval is reached to ensure smooth operation or to avoid interruptions in operation, for example, during the heating season. Maintenance intervals may not be extended to avoid downtime during the heating season.

### 1.5 Safety instructions

Always follow the safety instructions in the operator's manual. Statutory safety regulations and accident prevention rules must be observed. Before performing any maintenance work on the plant, the customer must make sure that the relevant safety instructions are being followed. For work which may only be carried out when the engine has been shut down, the system must be shut down as specified in TI 1100-0105 and measures must be taken to ensure that it cannot be started accidentally.

The operator is responsible for ensuring that the workplaces for service and maintenance work are adequately lit; additional mobile lighting must be provided if necessary.

### 1.6 Cleanliness when working on GE Jenbacher plants

- When working on GE Jenbacher engines, installations and components, always adhere to the strictest standards of cleanliness.
- Thoroughly clean all engine components or parts within working environment and remove all dirt and deposits on the outside of the engine before opening the engine.
- Whenever maintenance or revision work is carried out, no dirt from the outside or inside (e.g. from deposits) may enter the engine or other installation parts. Thoroughly remove any remains of gaskets or deposits on engine components using suitable means of removal.
- Make sure to select the right covers and means of protection for properly carrying out the work.
- When re-assembling components make sure to remove all covers on the outside and inside of components and lines.
- Ensure that before recommissioning all systems are free of foreign bodies, dirt and loose bolts or tools.

**Failure to comply with this instruction can result in serious damage to components or systems or to personal injury!**

### 1.7 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.

### 1.8 Start-up conditions

All GE Jenbacherengines are fitted with a preheating system for the engine cooling water. Only preheated engines with a cooling water temperature of >55°C may be started, loaded and operated at full-load, otherwise engine damage may result.

### 1.9 Failures

When a failure results in the engine automatically being switched off by the module control, the cause of the failure should be remedied first before the module is started again! It is not permissible simply to reset a failure and then restart the engine, as critical or wear-induced damage could possibly result in premature 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 (max. 5 times every 6 hours' running under load).

| Failures: | Diane No.: | National restrictions | Risk category |
|---|---|---|---|
| Misfiring | 1047, 3005 - 3024 | | 0 |
| Cooling water temperature maximum | 1021 | * | 0 |
| Engine room temperature maximum | 1135 | * | 0 |
| Failure of auxiliary equipment | 1129 | | 0 |
| Synchronising failure | 1039 | | 0 |
| Supply water temperature maximum | 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 |
| ADMISSIBLE CONTROL DEVIATION OF LEANOX controller EXCEEDED | 1080 | | 1 |

| Failures: | Diane No.: | National restrictions | Risk category |
|---|---|---|---|
| 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.

Single or multiple resetting of all other trip-generating failures without remedying the cause first will result in a considerable potential risk of injury or damage. The customer (or the party responsible for the remote resetting) will be entirely liable for such injury or damage.

### 1.10 Recording operational data, maintenance record sheet

It is mandatory for all operational data to be recorded and all out-of-the-ordinary events to be described.

**Please note:**

It is not enough merely to record the facts in writing. The data should be compared with the commissioning data and be checked for plausibility. In case of deviations, abnormal noises etc. the cause must be investigated and rectified. If you cannot find the cause, the GE Jenbachercustomer-service department should be notified immediately.

It is in the operator's best interests to maintain and record operational data (maintenance record sheet, operational data journal, data recorded in the "Maintenance file"). Properly maintained operational data journals and data record sheets are important documents, enabling analysis and support in case of failures. Moreover, these documents are also important when deciding on warranty claims.

### 1.11 Spare parts

Only original GE Jenbacherspare parts (e.g. oil filters!) should be used. Warranty claims in respect of defects and damage will be invalidated by the use of non-original spare parts.

Important: In order to avoid unscheduled downtimes it is strongly recommended that a stock of spare parts be held.

### 1.12 Lubricating oil

No specific maintenance interval is specified for lubricating oil. It is the operator's responsibility to take all necessary measures to ensure the protection and safe operation of the plant and guarantee the plant's availability.

The oil service life (depending on gas quality, mean pressure, engine type, oil consumption, oil temperature and oil type) can be prolonged by fitting an additional oil tank. If premature wear is claimed, the results of the lubricating oil analysis, subject to the limit levels laid down in Technical Instruction No. 1000-0099B, must be presented in full, even after the warranty period has expired.

### 1.13 Spark plugs

No specific maintenance interval is specified for spark plugs. It is the operator's responsibility to take all necessary measures to ensure the protection and safe operation of the plant and guarantee the plant's availability. Spark plug service life depends on the boundary conditions of the plant (e. g. type of spark plugs, gas type, mean pressure, gas mixing temperature, ignition system, emission limits).

### 1.14 Elastomer components

Elastomer components age and become brittle, even when engines are not operational. That is why the service life of these components does not depend solely on the length of time for which the module has been in service, the cooling water temperature and pressure, etc. With a normal running time of 5,000-6,000 operating hours annually and a maximum cooling water temperature of 90°C, all elastomer components are replaced at the normal intervals as described in the maintenance plan. If this number of operating hours is not reached, the elastomer components (e.g. O-rings on cylinder liners, flexible coupling, etc.) should still be replaced as a precautionary measure after a maximum of 5 years.

### 1.15 Decommissioning the plant

When prolonged scheduled or unscheduled downtimes occur, such as after the heating season in the case of power plants, the engine systems must be prepared (preserve, change old lubricating oil, close off the flue-gas

connection, etc.) for their downtime according to their geographical location (climate, proximity to the sea, gas type, etc.)

As conditions can vary enormously, we recommend that you consult a suitable specialist firm concerning the measures to be taken or contract it to carry out the work.

Of course, before recommissioning the plant, you must make sure that it has been restored to its normal operational condition.

### 1.16 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.

Before any welding work is carried out on the generating set, the ignition rail must be removed to prevent any possible damage to it and it must be stored in a dry place. The ignition rail may not be refitted and correctly connected until the welding work on the generating set has been completed.

### 1.17 Components coming into contact with exhaust gas

All parts that come into contact with exhaust gas are state-of-the-art materials with a specified service life. Due to the different operating modes and different fuel gas content (including traces of harmful substances), no binding guarantee can be given on the service life of components such as the exhaust manifold, etc. Where silencers are situated in the open air without external heat insulation, condensate (acid, water) can occur even in installations without heat exchangers (hot exhaust gases) and shorten the service life. This also applies to silencers with internal insulation, where the temperature in the rock wool insulation can fall below the dew point.

### 1.18 Fuels

The service life and safe operation of the plant depend to a considerable extent on the operating materials used. Only use operating materials such as fuel gas, engine cooling water, warm water, anti-freeze agent, anti-corrosive agent, lubricating oil, etc. as specified in the respective GE JenbacherTechnical Instructions.

### 1.19 Fuel gas quality

The operator is obliged to check the quality of the fuel gas in terms of thermal value, methane number and content of harmful substances at regular intervals. If these values differ from the values stipulated in the contract, immediate measures must be taken by agreement with the GE Jenbachercustomer service department. If the content of harmful substances increases (e.g. sewage gas, landfill gas) the lubricating oil can become heavily acidified within a fraction of the normal oil change interval and acute or irreparable damage and increased wear occur all of a sudden, for example on cylinder liners and bearings and/or oil consumption increases.

If the methane number fluctuates downwards (within the range stipulated in the contract) the engine is protected against harmful knock operation by the control system (automatic ignition point adjustment, power reduction).

**Note:**

During the commissioning process the engine is adjusted to the optimum setting for the methane number given at that time.

If the methane number increases after commissioning (for a prolonged period or a major part of the plant's operating time) the engine setting should be adjusted so as to optimise operational efficiency. This task must be carried out by specialist staff.

### 1.20 J624 TSTC turbocharger unit

This pressure equipment is part of the generating set and may only be used in the intended manner. The entire engine and generating set documentation therefore applies in addition to these Instructions and must be taken into account as well.

Use of the pressure equipment is only permissible if the stated limits are observed.

**Connection information:**

- The operator must arrange for the recurrent tests required by the law of the country of operation.
- The introduction of additional loads (lifting, pushing) is prohibited.
- No welding, heat treatment or metal-cutting machining may be carried out on the cast parts.
- The bolted joints between the cast parts must never be touched in any way, unless instructed in the maintenance instructions.

Since these are open pressure equipment items, static overpressures are not possible. However, to avoid exceeding the design pressures during engine operation, bypass valves and pressure sensors are fitted, which must be fully functional.

Safety cannot be assured in the event of improper use.

## 2 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 4 | 19.06.2012 | Punkt 1.6 neu / Point 1.6 new | **Bilek**<br>*Häusl* |
| 3 | 04.01.2012 | Punkt 1.15 / Point 1.15<br><br>Punkt 1.5 / Point 1.5 | **Bilek**<br>*Rupprechter, Norbert*<br>**Boxleitner**<br>*Strube* |
| 2 | 04.05.2011 | Punkt 1.19 neu / Point 1.19 new | **Bilek**<br>*Becker* |
| 1 | 31.05.2010 | Umstellung auf CMS / Change to Content Management System ersetzt / replaced Index: I | **Schartner**<br>*Provin* |

GE Energy

# TA 1100-0112

## Installation of GE Jenbacher Units

## Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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



## 1 Tips

⚠ Before performing any work on the plant, 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 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 ground connection (earth cable) though.

All the operations described must be carried out by the plant designer/builder or operator.

# 2 Transport and installation

Deals with the lifting, transportation, unloading and installation of GE Jenbacher modules and switchgear cabinets

## 2.1 Lifting and transportation

- TI 1000-0042: Lifting and transporting GE Jenbacher modules and positioning them in engine rooms
- TI 1000-0043: Transporting and setting up GE Jenbacher control cabinets
- TI 1000-0044: Transport protection

## 2.2 Installation (requirements for arrangement surface)

- TI 1000-0041: Requirements on the installation surface for GE Jenbacher plant

# 3 Fuel gas

Describes requirements for fuel gas (in terms of mechanical and chemical characteristics) and gas piping.

## 3.1 Fuel gas quality

- TI 1000-0300 Fuel gas quality - natural, associated petroleum, bio- and landfill gas
- TI 1000-0301: Fuel-gas quality of mine gas
- TI 1000-0302: Fuel-gas quality of special gas
- TI 1100-0110: Boundary conditions for GE Jenbacher gas engines

## 3.2 Gas pipes and gas train

- TI 1100-0110: Boundary conditions for GE Jenbacher gas engines
- TI 1510-0064: Gas Quantity Controller (TecJet 110 and 50 Plus)

Gas piping to be dimensioned such that the requisite gas prepressure is reached (at the inlet to the gas train).

Only specifically qualified technical staff may perform welding work on gas piping (regional regulations must be observed).

Gas piping must be subjected to a leak test (with test report) in accordance with accepted technical regulations.

The interface between the module (engine gas inlet) and gas line (gas train) must be designed as a flexible connection, without exceeding the following lengths:

| | |
|---|---|
| Distance between zero pressure regulator and engine connection: | 2 m max. (including hose) |
| TecJet: | 1.3 m max. (including hose) |

For technical control reasons, the zero pressure controller and the TecJet must be positioned with the flexible connection as close as possible to the engine gas intake on the gas mixer. The gas train supplied must be regarded as a single unit, and subsequent changes by the customer are not allowed. This also applies to the prechamber gas pressure controller (for type 6 engines only).

**TecJect installation:**

The unit must be installed horizontally with the sensor box at the top. The direction of flow is indicated by means of an arrow on the cast-iron housing.

# 4 Lubricating oil

Describes the requirements for engine lubricating oil

Construction of lubricating oil piping

Dimensioning of tanks for additional fresh oil and used oil

## 4.1 Lubricating-oil requirements

- TI 1000-0099A: Approval procedure for various engine oils
- TI 1000-0099B: Limit values for used oil in GE Jenbacher gas engines
- TI 1000-0099C Procedure for testing plant-specific oil service life
- TI 1000-0099D Determining the initial pH value (ipH) for used lube oil as defined in TI 1000-0099B
- TI 1000-0099K: Aid to interpreting used oil analyses of engine lubricants

## 4.2 Oil piping

- TI 1400-0131: Piping

Oil piping to be manufactured from seamless steel (not copper) pipes.

**TIP**

**Incorrect diagnoses possible due to the presence of copper!**
Copper has a major oxidising effect on lubricating oil, especially at high temperatures, and accelerates its ageing. An increased copper content in oil leads to incorrect diagnoses.

a) Pure copper must not be used as a material for oil piping to the engine or valves or other fittings.

b) Use copper-nickel alloys with a nickel content of ≥ 10 %. These alloys can also be used instead of the steel piping normally used.

Connect pipe ends with screwed pipe joints. Do not weld, as dirt may enter the engine and cause damage.

Subject pipe system to leak test (test certificate required).

## 4.3 Oil system

Dimension the fresh oil tank so that the planned oil change interfaces can be achieved.

Used-oil tank to be dimensioned to accommodate the total volume (of oil pan and fresh-oil tank).

Bottom edge of fresh-oil tank to be positioned a minimum of 1 metre and a maximum of 10 metres above the oil connection on the module in order to ensure gravity filling.

Separate pumps to be provided for fresh oil and waste oil.

# 5 Exhaust gas

Dimensioning and construction of the exhaust gas system

- TI 1100-0110: Boundary conditions for GE Jenbacher gas engines

The locating bearing for the exhaust gas piping must be designed so that the exhaust gas turbocharger is not subjected to any mechanical stress (provide a compensator at the interface between the turbocharger outlet and the exhaust gas pipe inlet).

The exhaust gas piping must be designed for brief pressure shocks of up to 6 bar (operating pressure: 0.05 bar).

Exhaust gas piping must be dimensioned so that its resistance (= total of pipe resistance of all components starting from the turbocharger outlet) does not exceed the maximum permissible exhaust gas back pressure 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; drains must be individually piped into the water tank.

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

**Exceptions:**

- 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 draught in the chimney).

Important: Allow space for insulation of exhaust gas piping!

Make sure to leave enough room in front of and behind the boiler to clean the exhaust gas heat exchangers of standard series 6 machines.

# 6 Engine-cooling, warm and hot water

Describes the requirements for hot and warm water in closed heating systems.

Requirements for engine cooling water (protection against freezing and corrosion).

Construction of piping (commissioning strainer).

## 6.1 Hot water and warm water in heating systems

- TI 1000-0206: Quality of circuit water in hot water and warm water heating systems

## 6.2 Requirements as to engine 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

### 6.2.1 Quality of cooling water in open circuits

- TI 1000-0208: Quality of cooling water in open cooling circuits

### 6.3 Piping

- TI 1400-0131: Piping

A water speed of 2 m/sec should be assumed when dimensioning pipes.

Flexible connections must be provided at the interfaces between the module and the customer's water systems.

The warm-water system must be kept clean by means of suitable filters

**Important:** Allow space for the insulation of water pipes!

Monitoring systems must be provided in accordance with specific national regulations (e.g. maximum pressure, maximum temperature, maximum flow).

The piping system must be cleaned before commissioning.

A leak test must be carried out (test certificate required).

We recommend engaging a suitable, experienced firm to install the water system.

## 7 Ventilation

Describes the requirements for the technical equipment for the ventilation of the engine room, generator and engine.

- TI 1100-0110: Boundary conditions for GE Jenbacher gas engines

## 8 Electrics

- TI 1100-0110: Boundary conditions for GE Jenbacher gas engines

General protective measures for installing high-voltage circuits

Requirements for the customers control power supply

Cabling; cable dimensions; installation.

Handling electronic components.

### 8.1 Protective measures for installing high-voltage circuits

- TI 1000-0515: Protective measures for installation of high-voltage circuits

### 8.2 Customer's control power supply

| | |
|---|---|
| Voltage: | 24 VDC * |
| Ripple: | Max. $U_{SS}$ 2.4 V |

* At least 22 V, maximal 30 V at GE Jenbacher–terminals inclusive of ripple

### 8.3 Starting system (Batteries)

Only applicable to engines with electric starter motors

- TI 1000-0050: Initial commissioning-up and maintenance of acid-filled lead storage batteries

- Link to TI 1000-0052, TRIO-PS/3AC/24DC/40 battery charger

### 8.4 EMC cabling and cable dimensions

- TI 1000-0505: EMC routing of wiring and earth connections to/between engine modules and control cabinets

### 8.5 Handling electronic components

- TI 1000-0510: Handling of electronic components/modules

### 8.6 Energy output cable at the generator

Generator power cable:

The diameter of the power cables must be determined or checked in accordance with VDE 298, Parts 1 - 4 (cabling method, bundled cables, etc.) or IEC 364-5-523 by the company carrying out the work. Generator current: IN = ..... A, where cos phi = 0.8.

The connection guidelines laid down by the generator supplier must be observed.

When connecting the cable, make sure that no force is exerted on the generator terminals.

This also applies during assembly.

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

To enable insulation resistance tests at generator cables, these must be disconnected from the generator.

#### 8.6.1 Low-voltage generators

The output cable must be laid horizontally 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 terminal lugs:**max. 45 mm wide (because of distance between connection bar holes).

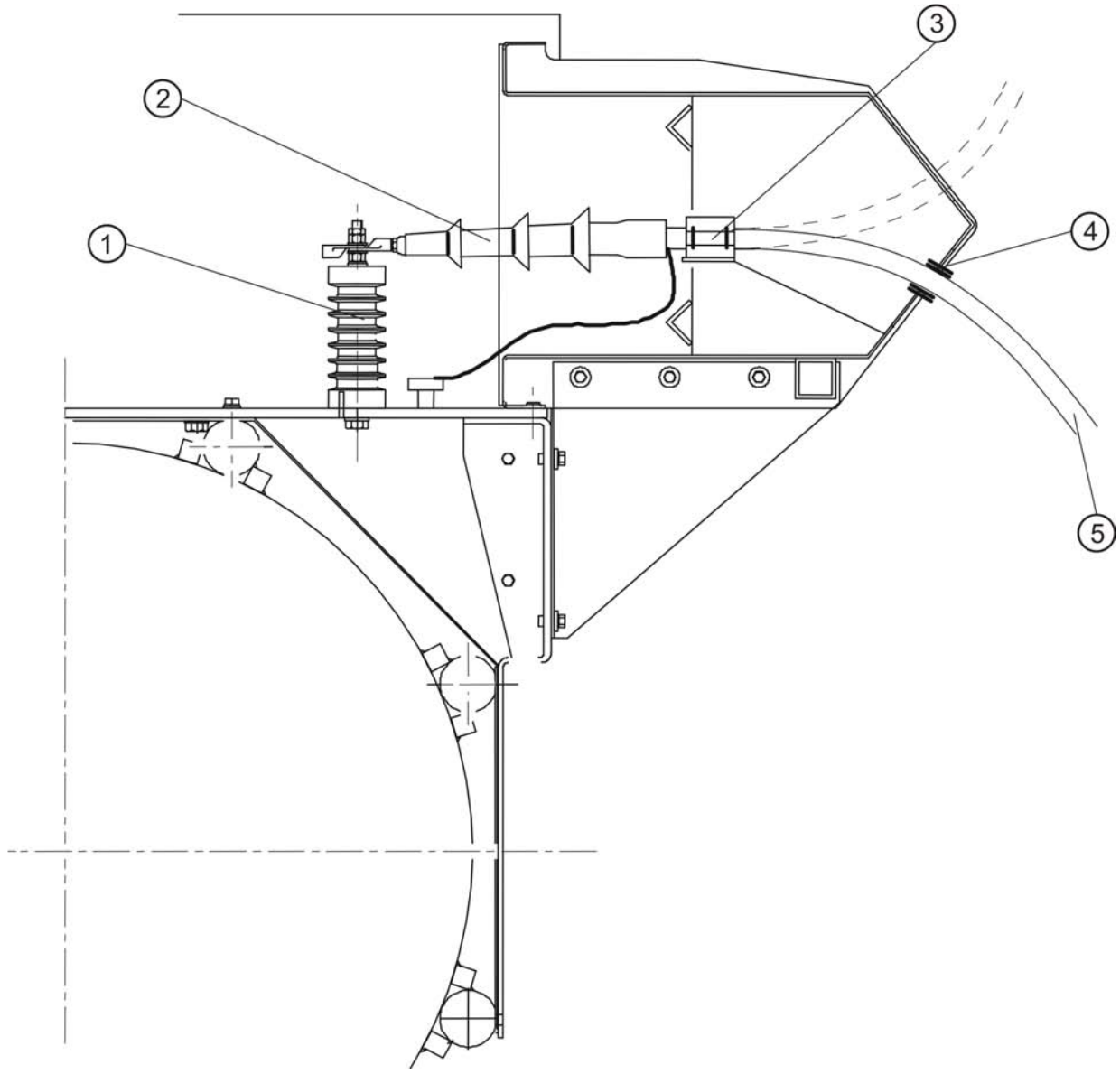
**Screwed cable glands:** Nickel-plated brass Plastic glands may only be used in exceptional cases if highly-flexible Class 5 rubber leads are used and it can be ensured that no static loads are applied to the gland, such as the dead weight of the cable. (Plastic cable glands subjected to loads cannot withstand vibrational loads for extended periods).

**Output using bus bars:**

To ensure that vibrations are not transmitted on and to compensate for any movements of the module, short high-flexibility cable connections must be installed between the generator connection bars and the output bars.

Note: compensators such as the wire mesh type have in practice been unable to withstand the vibrational loadings in the long term.

### 8.6.2 Medium-voltage generators




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

| | | | |
|---|---|---|---|
| ① | Isolators | ④ | Threaded joint |
| ② | Sealing ends | ⑤ | Middle tension cable with free cable length |
| ③ | Depending on the generator type, strain-relief brackets can also be mounted outside the connection box. | | |

In the case of elastically-mounted modules (see drawing) sufficient "free cable length" must be provided to compensate for the movement of the module when starting, stopping and shutting off 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 single-core cabling must be used.

Conductor stranding: Class 5 in accordance with IEC 60228/ CENELEC HD 383/ VDE 0295.

Recommended cable for medium-voltage generators:

e.g.:

- FELTOFLEX NTMCWOEU (single-core cable),
  manufacturer: Draka Industrial Cable GmbH http://www.draka.dk/cableteq/pdf/7_11.pdf
- PROTOLON NTMCGCWÖU (single-core cable),
  http://www.prysmian.com

**Cable sealing ends for generator connection >4.2 kV:**

The available space between the terminal clamps (isolator) and the strain relief brackets is approx. 320 mm. Consequently, only "short" sealing ends are involved.

Recommended sealing ends:

e.g.: - 3M QUICK TERM III (24kV)
Set 93-EP630-1 for 95 – 240 mm² 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

Screened medium-voltage cables are not necessary for voltages < 4.2 kV Appropriate shrink tubing can be used instead of sealing ends.

**Connectable power cables:**

| Nominal voltage | Rated current | Connection cable / phase | Connection cable / star point |
|---|---|---|---|
| 3.3 kV and 4.16 kV | < 840 A | 1 unscreened cable | 1 unscreened cable |
| 3.3 kV and 4.16 kV | > 840 A | 2 unscreened cables | 1 unscreened cable |
| > 4.16 kV | < 500 A | 1 screened cable | 1 screened cable |
| > 4.16 kV | > 500 A | 2 screened cables | 1 screened cable |

**Cable terminal 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 sockets:

Nexans Company: Type KU-F-V (more information at 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

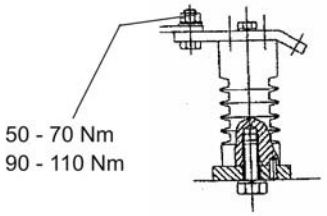
power, so only washers or safety plates made of a copper/zinc alloy (brass) can be used. Materials which are at least equivalent in terms of electrical and mechanical properties are to be used.

When connecting lugs, the lugs must be protected with washers on both sides to prevent bending.

**Tightening torques:**

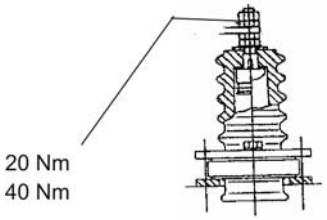
Insulated supports for indoor systems

Tightening torque M12
Tightening torque M16
Hexagonal head screw: steel 8.8




Capacitor-type terminal to DIN 46265

Tightening torque M12
Tightening torque M16
Connecting bolts: Ms
Connecting nuts: Ms




### 8.7 Generator protection against transient surge voltages

High voltage transient surges caused by switching operations and lightning strikes on powerlines, can damage the insulation of generator windings and measuring equipment. The generator must therefore be fitted with surge suppression devices.

Protection level: The impulse voltage withstand level of the main insulation and the interturn insulation of rotating AC machines with form-wound stator coils is defined in the standards IEC 34-15, IEC 71-1 and IEEE C62.21.

**Rating of the surge protection:** The peak value of the voltage transients at the generator terminals with a rise time less than or equal to 0.2 microseconds must be reduced to a value below the following:

Peak value in kV = 0.65 × (4 × U Ph-Ph + 5kV).

e.g. for an 11 kV generator: 0.65 × (4 × 11 + 5) = 31.8 kV

This can be achieved using a combination of capacitors and varistors/resistors.

**Info:** Although varistors limit the voltage peak value, they have no effect on the rise time of voltage transients and therefore do not protect the interturn insulation. Capacitors, on the other hand, lengthen the rise time of the voltage pulses so that the pulse voltage is spread over a greater portion of the winding which reduces the individual interturn voltages.

The installation of separate interconnected capacitors and varistors or the use of combined elements is therefore necessary.

Examples of combined high-frequency overvoltage surge suppressors:

- ZORC from STRIKE technologies ltd. http://www.strike.co.za/Products_zorc.html or

- PROTEC Z from NTSA – Defined Power Protection http://www.ntsa.co.za/protecz.html

**Place of installation:** The best practice for protection from voltage 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 25 m. If this is the case, a separate earth cable must be run between the surge suppressor and the generator housing (resistance less than 0.5 ohms).

If the cable length between generator and switchgear is more than 25 m the device needs to be installed beside the generator.

Enclosure acc. to IEC 62271-200 and IEC 60204-11, metal enclosed and capable of withstanding an internal arc fault (Internal Arc Classification IAC AFLR acc. to IEC 62271-200), minimum degree of protection of IPXXDH, and clearly marked to distinguish it from LV equipment.

### 8.8 Cabling for current transformers

⚠ **Due to the danger of overvoltages, current transformers may not be operated with open secondary terminals but only with these short-circuited or with a rated burden at the most.**

Current transformer cores output:

The rated output on the rating plate (in VA) is the product of the rated burden (in ohms) and the square of the secondary rated current (in A).

If the operating current is less than the rated current, the secondary output of the current transformer decreases quadratically.

Example: On a current transformer with a rated output of 15 VA and a load of half the rated current, the output decreases to one quarter, i.e. 3.75 VA.

Rated outputs of current transformers and maximum permissible burdens:

| Rated output | Max. permissible burden |
|---|---|
| 10 VA | 10 Ohm |
| 15 VA | 15 Ohm |
| 20 VA | 20 Ohm |
| 30 VA | 30 Ohm |

*Secondary rated current 1 A*

| Rated output | Max. permissible burden |
|---|---|
| 10 VA | 0.4 Ohm |
| 15 VA | 0.6 Ohm |
| 20 VA | 0.8 Ohm |
| 30 VA | 1.2 Ohm |

*Secondary rated current 5 A*

Taking into account the measuring and protective equipment connected by GE Jenbacher, the following minimum cross-sections are necessary for the cabling between the current transformers and GE Jenbacher:

| Current transformer rated output | Current transformer cabling length | Minimum cross section of current transformer cabling | |
|---|---|---|---|
| 10 VA | up to 100 m | 2.5 mm² | |
| 15 VA | up to 100 m | 2.5 mm² | |
| 20 VA | up to 100 m | 2.5 mm² | |
| 30 VA | up to 100 m | 2.5 mm² | |

*Secondary rated current 1 A*

| Current transformer rated output | Current transformer cabling length | Minimum cross section of current transformer cabling | |
|---|---|---|---|
| *up to 30m* | | | |
| 10 VA | up to 30 m | 4 mm² | |
| 15 VA | up to 30 m | 2.5 mm² | |
| 20 VA | up to 30 m | 2.5 mm² | |
| 30 VA | up to 30 m | 2.5 mm² | |
| *up to 50m* | | | |
| 10 VA | up to 50 m | 10 mm² | #) |
| 15 VA | up to 50 m | 4 mm² | |
| 20 VA | up to 50 m | 4 mm² | |
| 30 VA | up to 50 m | 2.5 mm² | |
| *up to 100m* | | | |
| 10 VA | up to 100 m | 16 mm² | #) |
| 15 VA | up to 100 m | 10 mm² | #) |
| 20 VA | up to 100 m | 6 mm² | #) |
| 30 VA | up to 100 m | 4 mm² | |

*Secondary rated current 5 A*

#) these marked combinations should be avoided if at all possible.

## 9 Employee protection

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

- TI 2300-0001: Employee protection

## 10 Technical Instructions, standards and guidelines

The revision applicable when the contract was signed is valid.

**General conditions**

- TI 1100-0110: Boundary conditions for GE Jenbacher gas engines
- TI 1000-0111: General conditions - Operation and maintenance
- TI 1000-0112: Installation of GE Jenbacher modules [⇨ TA 1100-0112, Page 1]
- TI 2300-0001: Employee protection

**Transport and installation**

- TI 1000-0041: Requirements on the installation surface for GE Jenbacher plant
- TI 1000-0042: Lifting and transporting GE Jenbacher modules and positioning them in engine rooms
- TI 1000-0043: Transporting and setting up GE Jenbacher control cabinets
- TI 1000-0044: Transport protection
- TI 1000-0050: Initial commissioning-up and maintenance of acid-filled lead storage batteries
- Link to TI 1000-0052, TRIO-PS/3AC/24DC/40 battery charger

**Signage**

- 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 of mine gas
- TI 1000-0302: Fuel-gas quality of special gas
- TI 1000-0091 Fuel gases, freedom from condensate

**lubricating oil**

- TI 1000-0099A: Approval procedure for various engine oils
- TI 1000-0099B: Limit values for used oil in GE Jenbacher gas engines
- TI 1000-0099C Procedure for testing plant-specific oil service life
- TI 1000-0099D Determining the initial pH value (ipH) for used lube oil as defined in TI 1000-0099B
- TI 1000-0099K: Aid to interpreting used oil analyses of engine lubricants
- TI 1000-1108: Lubricating oils for type 9 engines
- TI 1000-1109: Lubricating oil for type 2, 3, 4 and 6 GE Jenbacher engines

**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 cooling circuits

**Piping**

- TI 1400-0131: Piping

**Electrics**

- TI 1000-0505: EMC routing of wiring and earth connections to/between engine modules and control cabinets
- TI 1000-0510: Handling of electronic components/modules

**Drawings**

- Link to E 9684-1 Heat generator
- Link to E 9684-2 Operating modes

## 11 Installation documentation

Technical project documentation, e.g.

- Technical diagram
- Arrangement plan / terminal diagram
- View of unit
- Circuit diagram
- Cable list
- Interface list
- Technical specification of the control system
- Description – Operation
- Maintenance
- Spare parts catalogue

These technical documents are binding in every case!

## 12 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 8 | 17.04.2012 | Punkt 8.7 / Point 8.7 | **Bilek**<br>*Kruckenhauser* |
| 7 | 27.03.2012 | Punkt 8.8 Verkabelung für Stromwandler NEU / Point 8.8 wiring of power transformers NEW | **Provin /** *Thaler J.*<br>*Grain W.* |
| 6 | 29.02.2012 | Punkt 8.3 Startanlage / Point 8.3 Starting system | **Bilek**<br>*Grain W.* |
| 6 | 04.01.2012 | Punkt 8.6.1 Kabelverschraubungen / Point 8.6.1 Cable glands | **Bilek**<br>*Kruckenhauser* |
| 5 | 24.11.2011 | TecJet-Installation hinzugefügt / TecJet installation added | **Boxleitner**<br>*Laucher R.* |
| 4 | 15.11.2011 | Kap. 9: Inhalte für BR 9 hinzugefügt / Section 9: contents for series 9 added | **Boxleitner**<br>*Thaler J.* |
| | | Kap. 8: Inhalte für BR 9 hinzugefügt / Section 8: contents for series 9 added | **Boxleitner**<br>*Grain W. / Kruckenhauser* |
| | | Kap. 7: Inhalte für BR 9 hinzugefügt / Section 7: contents for series 9 added | **Boxleitner**<br>*Häusl / Stellovsky* |
| | | Kap. 6: Inhalte für BR 9 hinzugefügt / Section 6: contents for series 9 added | **Boxleitner**<br>*Häusl* |

**Revision history**

| | | | |
|---|---|---|---|
| | | Kap. 5: Inhalte für BR 9 hinzugefügt / Section 5: contents for series 9 added | **Boxleitner** *Burkhardt W.* |
| | | Kap. 4: Inhalte für BR 9 hinzugefügt / Section 4: contents for series 9 added | **Boxleitner** *Chvatal S.* |
| | | Kap. 3: Inhalte für BR 9 hinzugefügt / Section 3: contents for series 9 added | **Boxleitner** *Laucher R.* |
| | | Kap. 2: Inhalte für BR 9 hinzugefügt / Section 2: contents for series 9 added | **Boxleitner** *Eberharter Alex. / Häusl G.* |
| 3 | 03.05.2011 | Punkt 8.7 – neu : Gehäuse gem. IEC 62271-200 ...../ Section 8.7 – new : Enclosure acc. to IEC 62271-200 ..... | **Bilek** *Thaler* |
| 2 | 12.08.2010 | Abschnitt „Energieausleitung Generator“ überarbeitet / Revised section „Energy output cable at the generator“ | **Bilek** *Schartner* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **u** | **Schartner** *Giese* |

## Blank Page for Notes

## 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.

## Blank Page for Notes

# 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.

## Blank Page for Notes

GE Energy

# TA 2300-0005

## Safety instructions

# Technical Instruction

3249203123166202384227561345153625 41

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

**The target recipients of this document are:**

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

# 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 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).

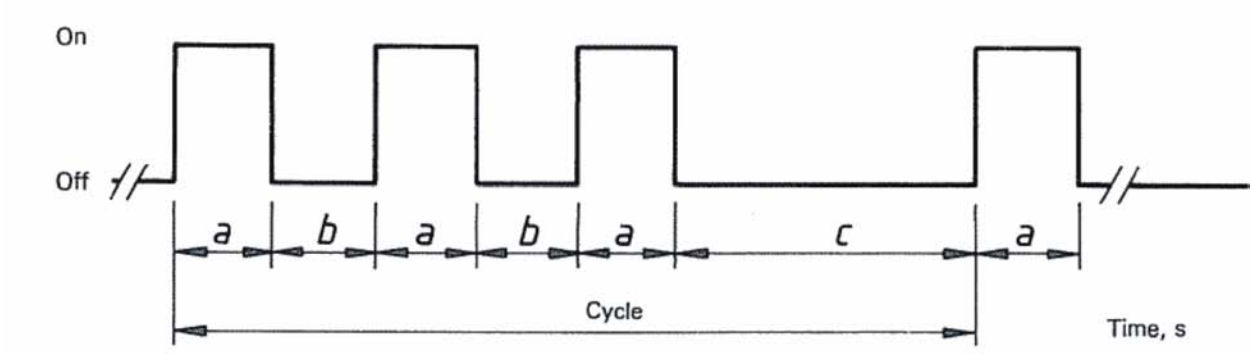
If the contractor encounters any hazardous material at the site which requires special handling and/or disposal, the customer will immediately take whatever precautions are required to legally eliminate such hazardous conditions so that the work under contract may proceed safely. The customer must ensure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




| | |
|---|---|
| *a* | Phase *a* signal is "On" for 0.5 s ± 10% |
| *b* | Phase *b* signal is "Off" for 0.5 s ± 10% |
| *c* | Phase *c* signal is "Off" for 1.5 s ± 10% (c = a + 2b) |
| Cycle | 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 engine 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 to 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, damper, 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 making safe


**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 – 40 kV!**

**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 provides 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.


**Toxic gases (e.g.: CO, H2S, 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 inflammable** 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 **odorants** 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, dizziness, fainting after several hours |
| ▪ 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 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!

Please note: 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. (see 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!


**Toxic gases (e.g.: CO, H2S, 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 train and the gas pipes. These components contain quantities of residual gas which will escape when, for example, the gas filter is being changed!**

### 9.4 Cooling system

When the engine is at operating temperature, the coolant is hot and pressurised.

Damaged or weathered pipes, gaskets, hoses and hose clips and other components must be replaced immediately. If these components break or fracture, hot coolant could injure people and cause a fire.

Keep clear of pressure relief valves when operating the plant.


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

Depressurise these components accordingly before carrying out maintenance work on them!

Fractured components allow hot coolant to escape, posing a risk of injury.

Regular maintenance/inspection of components. Wear personal protective equipment (safety glasses, protective clothing and thermal insulation gloves). Keep away from pressure relief valves.


**Hot surfaces!**

Risk of burns

Allow the engine cool down, wear personal protective equipment!

Wear thermal insulation gloves and protective clothing!

**To replace pipes and components:**


**Shut down and secure.**

**Shut-down procedure and securing → Refer to the "Shut-down procedure and securing" section 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!.

**Observe any disposal requirements.**

### 9.5 heat exchanger

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


**Risk of escaping liquids** (during normal operation, lubricants are hot and under pressure)

The actuation of safety valves causes hot liquids to escape, thereby posing a risk of injury.

Wear personal protective equipment (safety glasses, 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.) and the oil itself are hot and can cause severe burns when working on the lube oil system (e.g. changing the oil or the oil filters).

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 – 40 kV!**

**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 has been remedied.

During commissioning, the manufacturer of the power supply cubicle must implement the protective measures required under local regulations.


**Ensure proper earthing!**

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, safety glasses and safety footwear when handling battery acid!


**Risk of explosion!**

During 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 lights, no sparks!

The battery acid level must always be between the minimum and maximum markings.

Proper maintenance according to the maintenance schedule is a condition!

**There is an acute explosion hazard under the following conditions:**

▷ The battery's acid level is lower than the acid-level "min" mark.

▷ The battery is short-circuited or heavily overloaded (e.g. attempted engine start when the engine is blocked).

▷ Excessive charge voltage (> 30 V).


Battery acid may leak if batteries are damaged (e.g. during repair work), its corrosive action causing damage to the environment and property. Acid can also cause a chemical reaction with the lime in the concrete and damage the floor.

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, damper, 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


**Note: The engine is liable to start without warning.**

**The customer must make sure that the relevant safety precautions have been taken before performing any maintenance work on the engine.**

**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 inadvertently.**


**Shut down and secure!**

**Shut-down procedure and securing: Refer to section on "Shut-down 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 contract (maintenance or servicing 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 a harness and associated equipment (safety rope, carabiner hook, energy absorber, rope shortener or fall arrester).


**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. condensate tanks).

Ensure proper ventilation or extraction to remove gas concentrations.

Check the maximum permissible workplace values (gas concentration).

Wear **gas sensors (appropriate to the poisonous gas components)** as personal protective equipment.

**If the maximum admissible workplace values cannot be guaranteed, suitable breathing apparatus must be worn.**

Before carrying out any work on the plant, 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 bolts, which have a specified tightening torque, contrary to the instructions
- 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 may to be used.

**DANGER**

**If the safety equipment for maintenance/servicing work has been dismantled or rendered ineffective:**
All the safety equipment must be restored to its original condition and its effectiveness checked.

## 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, etc.) 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.

## 13 Revision code

**Revision history**

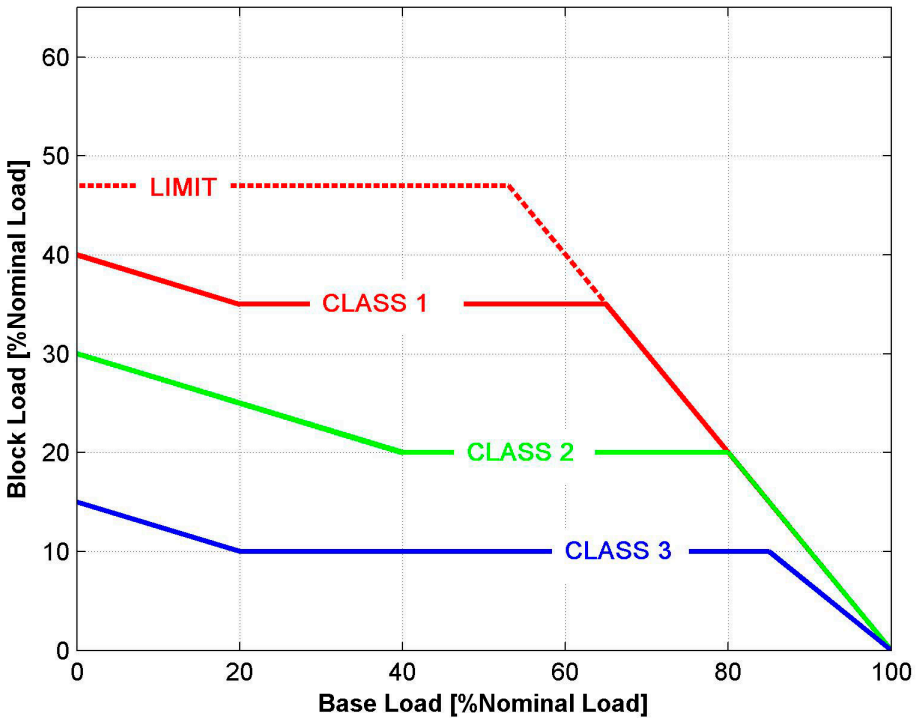
| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 4 | 20.06.2012 | Gefahrenhinweise Schmiersystem, Regelsystem, Batterie ergänzt / Added safety notes for lubrication system, control system and batteries | **Boxleitner**<br>*Pichler* |
| | | Ergänzung Gefahrenhinweis – Batterie / hazard warning – battery supplement | **Provin**<br>*Flössler* |
| 3 | 08.11.2011 | Ergänzung Gefahrenhinweis – Batterie / hazard warning – battery supplement | **Bilek**<br>*Fahringer* |
| 2 | 23.02.2011 | Erweiterung Gefahrensymbole<br>Enhancement safety signs | **Provin**<br>*Pichler* |
| 1 | 31.05.2010 | Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **j** | **Provin**<br>*Provin* |

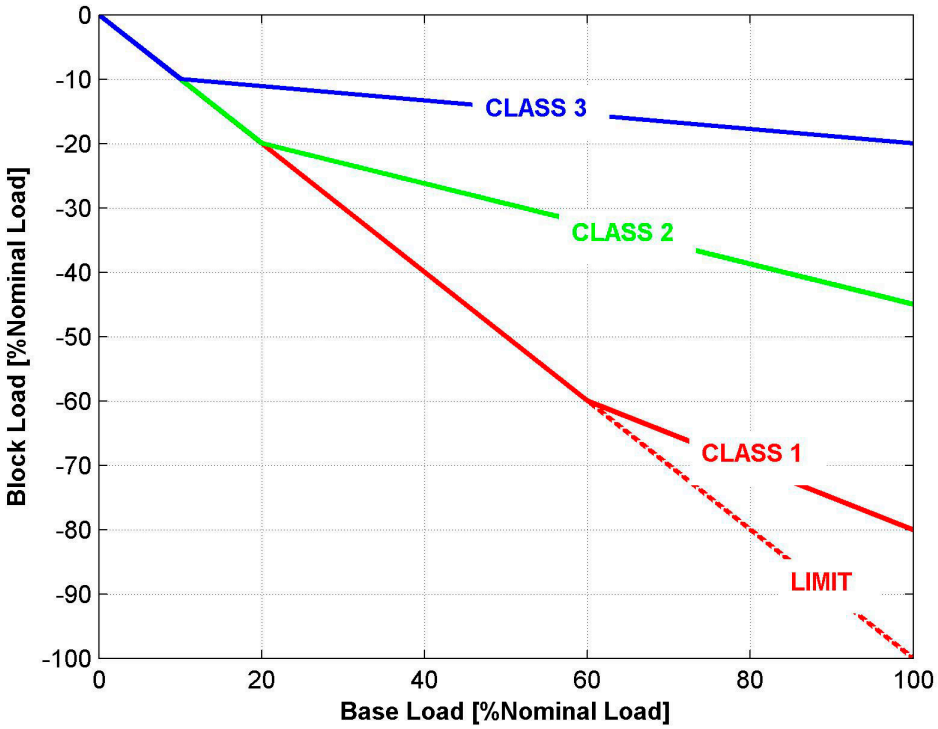
See Technical Instruction 2108-0031 for general instructions and explanations on the isolated operation of GE Jenbacher gas engines.

# 1. Power shift diagrams type 3 engines in compliance with ISO 8528, Part 5:

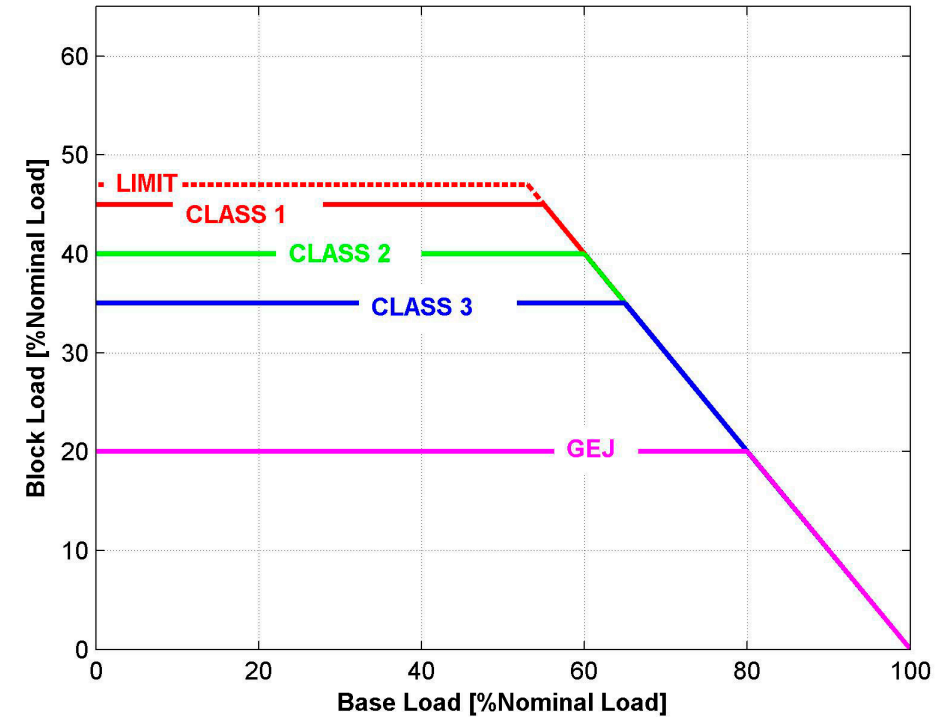
## 1.1 Power shift diagrams Version C105:

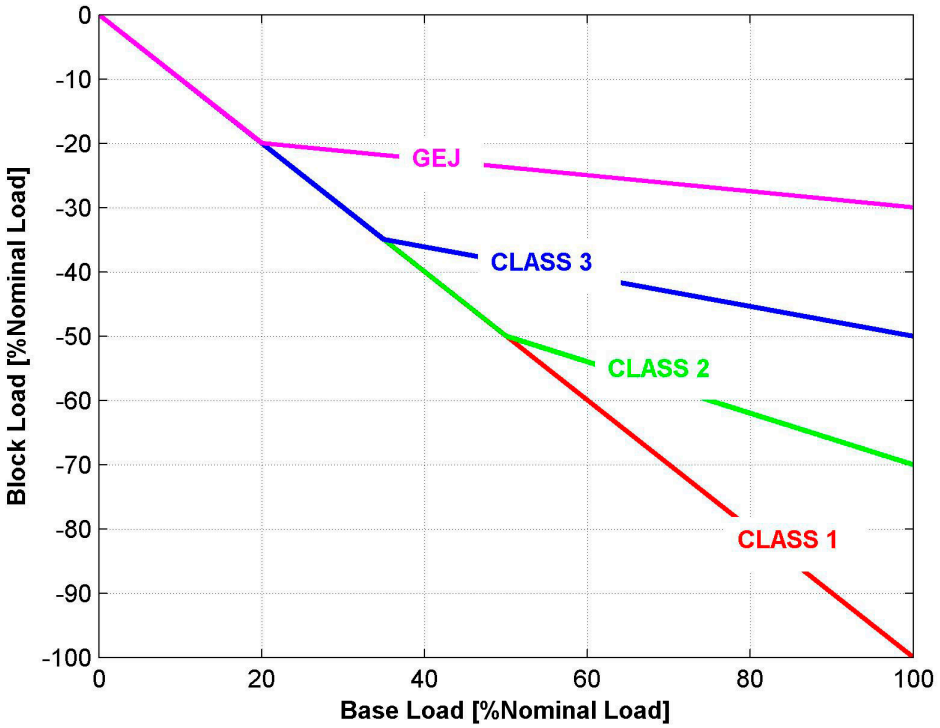
### 1.1.1 Taking frequency deviation and adjustment time into account:



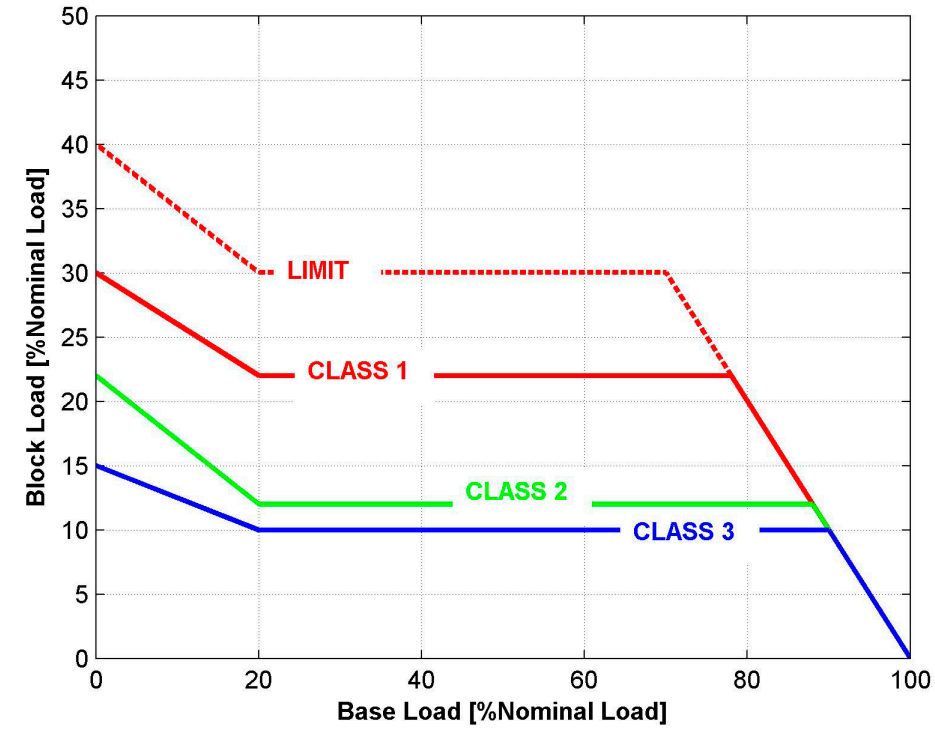
### 1.1.2 Taking frequency deviation into account without adjustment time:

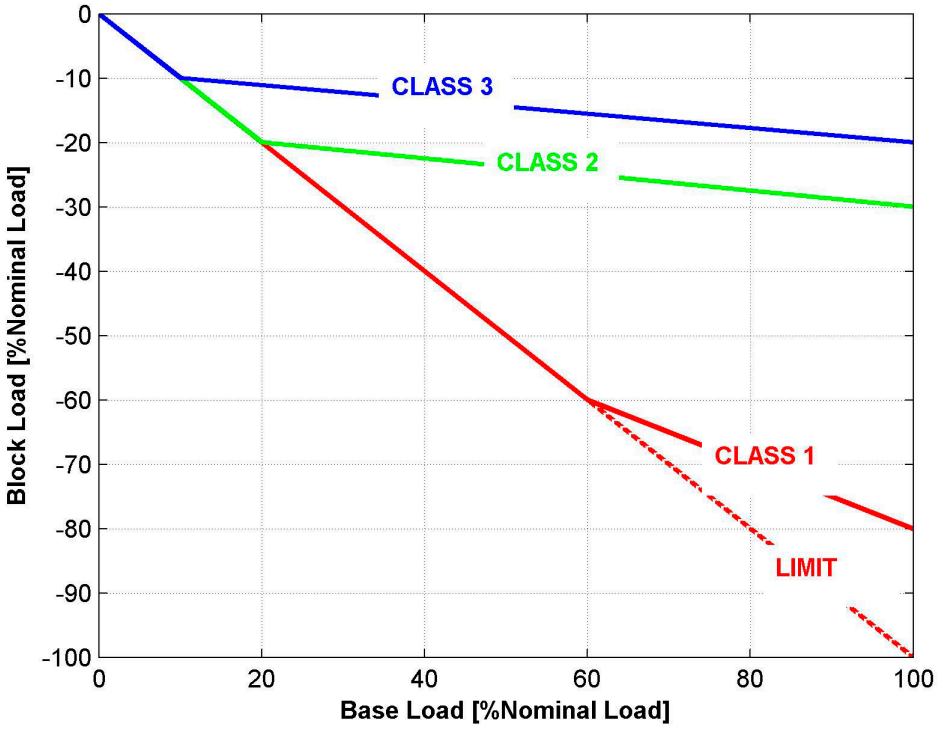


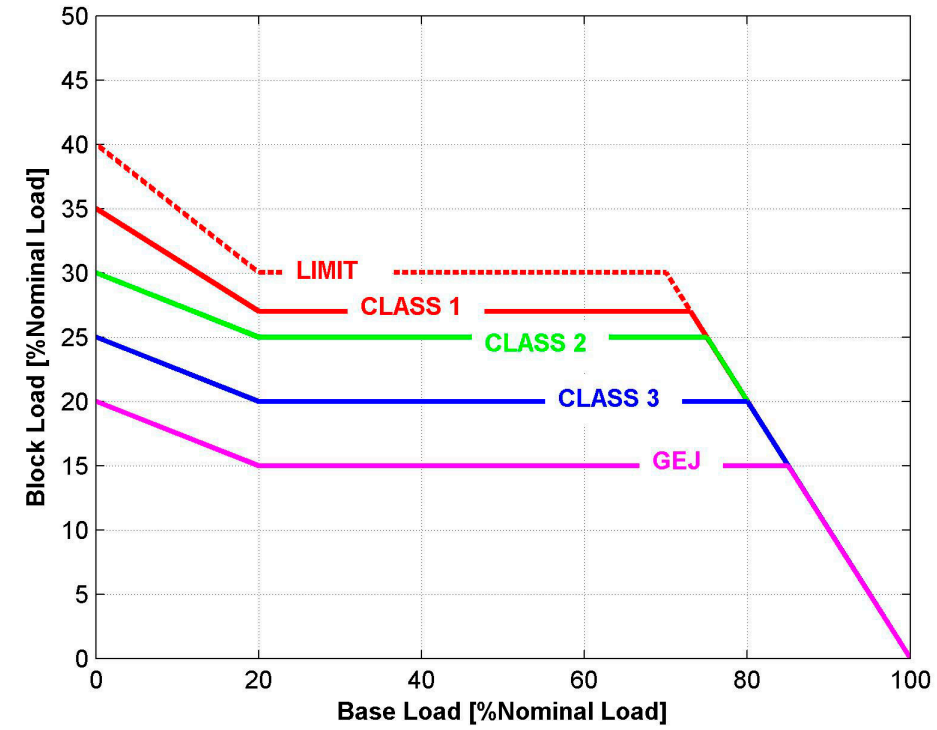
### 1.2 Power shift diagrams for remaining versions:

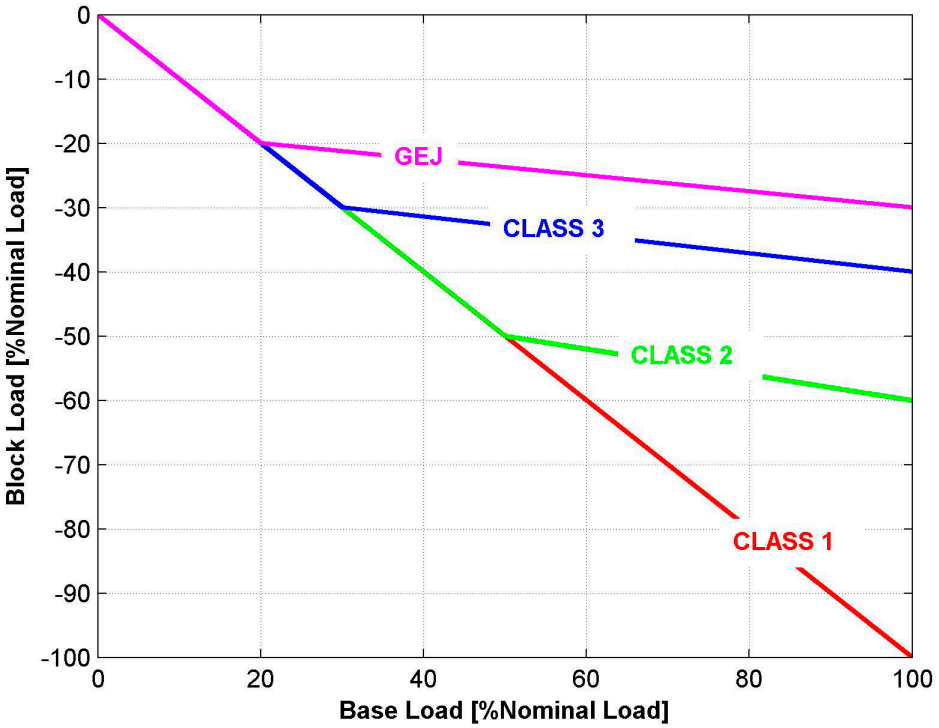
#### 1.2.1 Taking frequency deviation and adjustment time into account:



### 1.2.2 Taking frequency deviation into account without adjustment time:



GE Energy

# TA 2108-0031

## Isolated operation - general

# Technical Instruction

3 2 4 9 2 0 3 1 2 3 1 6 6 2 0 2 3 8 4 2 2 7 5 6 1 3 4 5 1 5 3 6 2 5 4 1

Tekniske anvisninger

Technical instruction

Technische Richtlijnen

技术指导

Indicazioni tecniche

Технические инструкции

Τεχνικές οδηγίες


Achenseestr. 1-3
A-6200 Jenbach (Austria)
www.gejenbacher.com

GE imagination at work

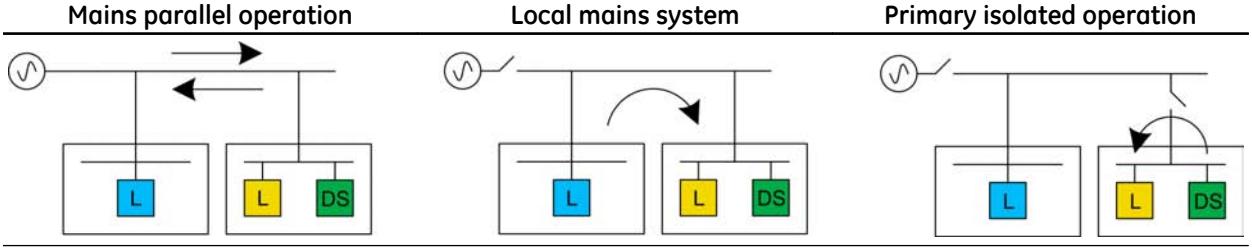
**The target recipients of this document are:**

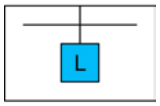
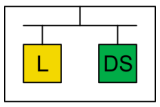
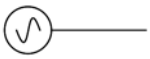
Customer, Service Partner, Commissioning Partner, Subsidiaries/Branches, Location Jenbach

# 1 Definition

Gas engines are said to be in isolated/emergency power/standby operation when the plant is required to maintain the power supply to the consumers in the absence of the public power grid (see Figure 1). As soon as this occurs, the bus bar frequency and voltage must be maintained within defined limits.

**Figure 1: Mains configurations**




| | |
|---|---|
|  | Local mains (A)<br>L: Load |
|  | Local mains (B)<br>L: Load<br>DG: Distributed generation |
|  | Mains |

If the consumers are supplied with energy by a generator driven by a reciprocating internal combustion engine, referred to below as the generating set, the frequency is regulated by the engine speed and voltage control is effected by the automatic voltage regulator - AVR - incorporated as an integral part of the generator.

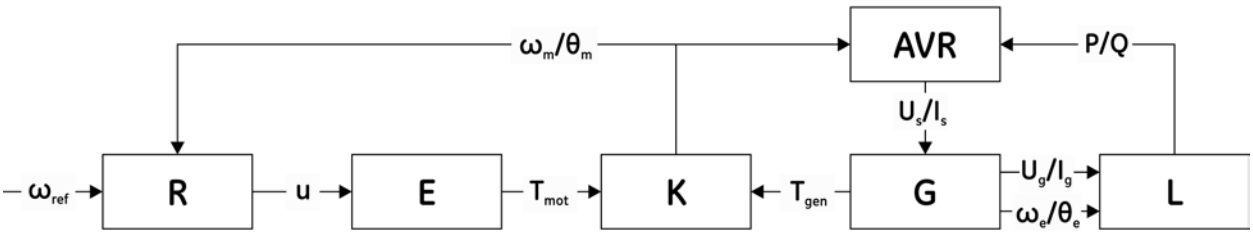



*Figure 2. Isolation operation*

| | | | |
|---|---|---|---|
| E | GE Jenbacher Engine | L | Load |
| K | Coupling | AVR | Automatic Voltage Regulator |
| R | Controller | G | Generator |
| u | Controlled variable | $U_s/I_s$ | Excitation voltage/current |

| | | | |
|---|---|---|---|
| $\omega_e/\theta_e$ | Generator electrical speed/angle position | $U_g/I_g$ | Generator voltage/current |
| $\omega_e/\theta_e$ | Generator mechanical speed/angle position | $T_{gen}$ | Generator torque |
| $\omega_{ref}$ | Set point value | $T_{engine}$ | Engine torque |
| P/Q | Active / reactive power | | |

In plants with more than one engine or with generating sets from other manufacturers in a local mains system, the frequency and voltage are regulated by one part or by all the generating sets. The active and reactive power must then be controlled by the load management system. A small proportion in terms of power can be power-controlled in this local system. In must be ensured here that variations in output can be called up quickly, and as a result high dynamic properties are necessary.

## 2 Categories of isolated operation

| | |
|---|---|
| **Stand-by operation** | Isolated operation of the gas engine is only required as a stand-by solution for the mains supply, and is not designed for continuous operation. |
| **Primary operation (100% isolated)** | Isolated operation of the gas engine is used as the primary energy source for the consumers. Diesel sets or the mains can be available as stand-by energy sources. |
| **Emergency power operation** | This is the same as stand-by operation, but with far higher demands on the start-up time (e.g. 15 seconds start-up time, black start) and maximum availability. |
| **Supplying local mains systems** | The gas engine operates as part of a local mains system which is not connected to the public mains system. This operation presents particular requirements regarding short interruptions, loading and load shedding, and redundant operation (n-1). |
| **Greenhouse applications** | Very gentle power shifts due to relatively small loads combined with extensive load management for power shifts, transition from mains to isolated operation. The gas engine is generally operated at 100% of its rated load, since suitable small load stages are available. |
| **Fire pump systems** | The gas engine is designed to supply fire pumps. Special requirements are placed on the engine regarding the time until the load can be applied. The gas engine must have the maximum possible availability (even if suffering from faults) and must not be shut down without valid reasons during operation in support of firefighting operations. |

## 3 Factors influencing isolated operation

The dynamics of a generating set are affected by a large number of factors. The step response is determined by both mechanical and electrical phenomena. In order to state the frequency and voltage behaviour of a generating set under load changes, the maximum load application and rejection capabilities must be ascertained. Attention must be paid to the following, among other things:

- coincidence factor of the consumers
- intermittent output in the course of operation

The required generating set rated power can only be laid down if the electrical consumers to be supplied are known. This entails above all taking note of the occurring load surges when consumers are switched on, e.g. lifts.

pumps, fans, lighting and non-linear consumers. Once the consumer profile is known, the following must be taken into account:

### 3.1 Load application

The load assumption capability of the generating set depends primarily on the mean effective pressure (BMEP) of the engine at the rated frequency and power, the pressure-charging dynamics (dynamics of the exhaust gas turbocharger), and characteristics and settings of the AVR, and the total engine-generator moment of inertia.

Since the function of all the influences cannot be expressed in terms of values, recommended mean values for load application should be given, taking a maximum permissible frequency dip as the criterion.

Due to the high mean effective pressure, the load must be applied in stages (see ISO 8528-2:2005). Since the times between the individual power stages depend on the BMEP as well as the effective moment of inertia of the generating set, these may need to be agreed with the plant operator as necessary. If the load must be applied in a number of stages, the need for the appropriate circuitry for this must be taken into account. The permissible values for the dynamic frequency and voltage fluctuations at load changes can be taken as the criterion.

The generating set requires approx. 15 seconds between load applications for the control system to stabilise itself, and approx. 30 seconds to stabilise itself thermally. This must be adhered to, especially when the engines have not yet reached their operating temperature.

In order to prevent overloads and the consequential failure of the generating set, it must be ensured that at the moment when the load is applied, the existing power requirements of the consumer equipment at the time does not exceed the power output of the particular generating set and engine type.

### 3.2 Load shedding

The response of the generating set after load shedding depends on the actuator and gas dynamics. On some engines with pressure-charging, a load-shedding limit is laid down to avoid the risk of turbocharger pumping or deflagrations.

The limits for load shedding are specified separately for each engine type (see TI-2108-002, Load-shedding capability). Further information can be found in Section 6.2.

## 4 Factors influencing locals mains systems (multi-engine plants)

The following can influence parallel operational behaviour:

- load distribution
- speed drop of the speed controller
- dynamic behaviour of the engine in question
- AVR droop
- dynamic behaviour of the generator taking into account the damping characteristics of the mains system in question .

More detailed information about the factors influencing the distribution of active and reactive power in accordance with ISO 8528-5:2005 can be found in TI 1530-0182.

Where different energy generators are being used in combination (generating sets from different manufacturers or different types of energy generators), other options besides a load distribution line or the standard speed-drop control are provided by a higher-order load management system, but these options should be checked first for each specific project. Further information can be found in Section 7.5.

## 5 Assessment of isolated operation performance

The operational behaviour of a generating set powered by a reciprocating internal combustion engine is assessed in compliance with ISO 8528, Part -5. This Standard replaces DIN 6280, which is no longer valid.

Depending on the specific application, different design classes ranging from G1 to G4 will apply. The figures given in *Table 1* for the respective design classes are permissible limit values, which unless otherwise stated may not be exceeded in the course of operation (see ISO 8528-5:2005 *Table 4 - Performance Class Operating Limit Values*). The limit values below refer to external-ignition gas engines under load.

The respective design class always applies to a power generation plant if all the limits laid down to this design class have been met. If customers request deviations from the limit values in terms of higher quality, these must be agreed in writing. The design classes do not change in this case.

Class G4 is freely definable - in accordance with customer-specific requirements (CSR) and is specifically stipulated for GE Jenbacher at ± 7% for the dynamic frequency and voltage difference, disregarding the control stabilisation time. Other limit levels can be defined and displayed to take account of application-specific issues.

If an emergency power supply is provided for hospitals or communal facilities (in compliance with DIN VDE 0100, Part 710 and Part 718 respectively), operational behaviour is assessed in accordance with ISO 8528-12:2005. In both cases, special attention must be paid to the required interruption times/transition times. The assessment criteria laid down in ISO 8528-12 are equivalent to those laid down in ISO 8528-5.

**Table 1. Design class operating limits:**

| Parameters | Icon | Unit | Limit values | | | |
|---|---|---|---|---|---|---|
| | | | Class 1 | Class 2 | Class 3 | Class 4 |
| Frequency deviation bandwidth | $\alpha_f$ | % | 3.5 | 2 | 2 | CSR |
| Steady-state frequency bandwidths | $\beta_f$ | % | ≤2.5 | ≤1.5 | ≤0,5 | CSR |
| Dynamic frequency deviation after a load application | $\delta^-_{dyn}$ | % | ≤-25 | ≤-20 | ≤-15 | CSR |
| Dynamic frequency deviation after load rejection | $\delta^+_{dyn}$ | % | ≤+18 | ≤+12 | ≤+10 | CSR |
| Frequency control settling time after load application | $t_{f,app}$ | s | ≤10 | ≤5 | ≤3 | CSR |
| Frequency control settling time after load rejection | $t_{f,shed}$ | s | ≤10 | ≤5 | ≤3 | CSR |
| Static voltage difference | $\delta U_{st}$ | % | ≤±5 | ≤±2.5 | ≤±1 | CSR |
| Dynamic voltage deviation after a load application | $\delta U^-_{dyn}$ | % | ≤-25 | ≤-20 | ≤-15 | CSR |
| Dynamic voltage deviation after load rejection | $\delta U^+_{dyn}$ | % | ≤+35 | ≤+25 | ≤+20 | CSR |
| Voltage control settling time after load application | $t_{U,app}$ | s | ≤10 | ≤5 | ≤5 | CSR |
| Voltage control settling time after load rejection | $t_{U,shed}$ | s | ≤10 | ≤5 | ≤5 | CSR |

The parameters set out in Table 1 are described in Table 2 and illustrated in Figures 8 and 9.

## 6 Power shift diagrams for isolated operation

The power shift diagrams of the respective engine types are available in the following Technical Instructions:

- Type 2 engine - J208 with DIANE XT TI 2108 - 0030
- Type 3 engine with DIANE XT TI 2108 - 0025
- Type 4 engine with DIANE XT TI 2108 - 0029
- Type 6 engine with DIANE XT TI 2108 - 0026

The diagrams listed above provide information on the permissible, switchable effective electrical power *block load* (both positive and negative) plotted on the y axis as a function of the current effective power "base load" on the x axis for each individual class as specified in ISO 8528.

The specified power outputs are shown as a percentage of the rated power (after allowing for given reductions), rated frequency and cosϕ=1 of the engine version concerned, in accordance with the product range.

### 6.1 Power shift diagrams

The diagrams in the Technical Instructions for each of the engine types apply to engines at operating temperature.

The diagrams show design classes G1 to G4 and the limit outputs (the outputs at which load can still be applied, taking all limit values - minimum and maximum frequency and voltage - into account (see Figures 3 and 4). The lines show the maximum load that can be applied or shed, as the respective limit values correspond to the design class. Where special requirements have been specified for loads to be added or shed, suitable concepts (choice of shedding stages, mains interconnection control unit, load management system) must be drawn up.

The specific TI for the various engine types each include two (2) diagrams for load application and shedding. One is shown in accordance with ISO 8528-5:2005, and one disregarding the frequency and voltage control settling time. The second form takes the criterion of maximum frequency dip into account (see Appendix A). The x axis describes the starting load (base load) and the y axis the switching load (block load), each as a percentage [%] of the rated power.

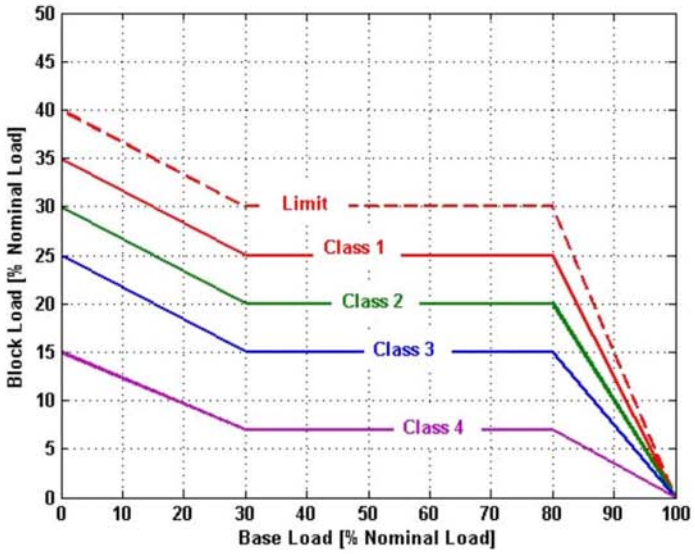



*Figure 3. Load application diagram*

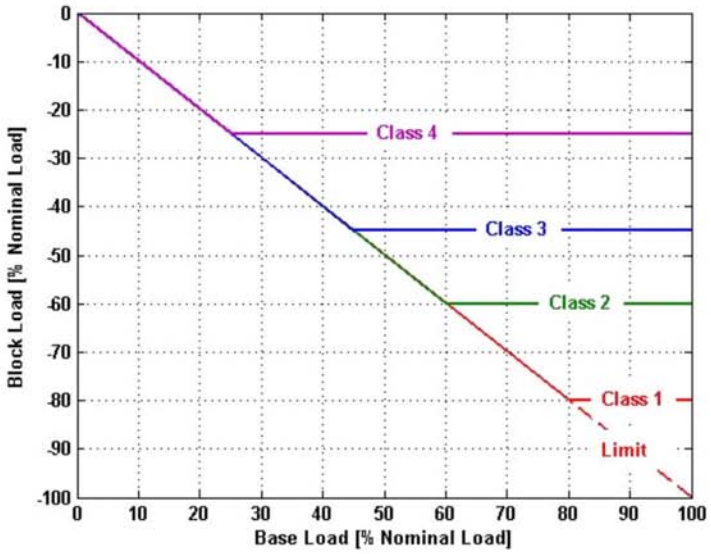



*Figure 4. Load-shedding diagram*

### 6.2 Load shedding

Normally, load reduction on the gas engine will occur during the transition from mains parallel operation to isolated operation or during isolated operation. Because of the design of the turbocharger, this can cause "pumping behaviour" in the turbocharger. No limitations on the load shedding behaviour are required for type 2, 3 and 4 engines.

Currently, type 6 engines are subject to individual limit levels for load-shedding capability (see TI 2108-0026, load-shedding capability).

## 7 Planning and technical features

The classification into one of the design classes described in Section 5 depends on the consumers to be supplied during isolated operation and must therefore be determined by the customer. This therefore results in the maximum possible power shift. Careful coordination with the customer during the tender and planning stage is therefore essential. The size and type of the electrical consumers and their starting and operational characteristics must be known by this stage. In the case of electric motors the magnitude of the effective starting power is relevant, as this determines the effective torque at the motor shaft. The torque depends on the type of electric motor and the starting conditions (star-delta starting, soft start, thyristor-controlled drives, heavy starting, etc.).

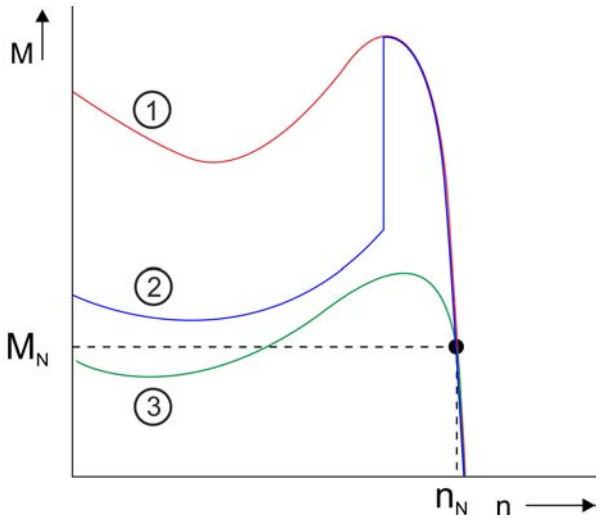



*Figure 5. Torque profile for an electric motor start*

| | |
|---|---|
| ① | Direct start |
| ② | Star-delta starting |
| ③ | Soft start |

You must take into account that during isolated operation, the power consumption by single "rotating" consumers with comparatively high moments of inertia J (large fans, pumps, etc.) must not exceed approx. 40% of the rated power of the generating set. In addition, remember that the starting current of electric motors is several multiples of the nominal value. This percentage is based on empirical data and indicates the point from which dynamic interactions between the generating set and the consumer can occur. Cases like this require special measures, which can be determined by means of simulations. Power flow analyses are used for this.

In isolated operation with several engines, it is the case that the first module must already supply consumers while the other modules are synchronised to it. In such cases, you must ensure that only very limited load fluctuations (max. 2% of the rated module load) occur during the synchronisation process. The more frequent such load fluctuations are, the longer the synchronising procedure will take.

Since the current and cos(ϕ) curve of consumers define the engine dynamics, these must be specifically obtained from the customer and passed on.

### 7.1 Supplying power to installations with an uninterruptible power supply (UPS installations)

When supplying power to UPS installations, it is essential to use their interaction features (e.g. staggered switching in, ramp-shaped loads). This will reduce the effect of added loads and result in a generally more efficient use of the generating set. Normally, strict tolerances apply to the maximum admissible voltage and frequency differences on the input side of UPS systems. It is absolutely essential that this fact is taken into account.

### 7.2 Parallel operation with UPS systems

Because of the differing voltage forms and dynamic characteristics (frequency control of a generating set is based on "rotating masses", while in UPS systems the frequency control is inertia-free using power electronics), parallel operation with standard software is not possible. Clarification for the specific project in question is necessary.

### 7.3 Automatic backup time of 15 s in conformity with DIN VDE 0100, Part 710 and/or 718

Supplying emergency power consumers in conformity with the above standard within a 15 s timeframe is not currently possible for type 2, 3 and 4 GE Jenbacher gas engines. Due to the design of the auxiliary equipment on type 6 engines, emergency power can only be supplied to emergency consumers after clarification for the specific project.

### 7.4 Soft magnetisation of transformers

Where transformers must be accelerated in self-contained start mode, the acceleration power must be monitored to ensure that the generating set not overloaded. By way of guidance, transformers with a **rated power of 2 or more times rated generator power** can be accelerated. However, the method described below should be used as standard.

In the case of very large isolated operation loads, e.g. large transformers, which cannot be added directly because of excessive starting currents, it is possible to soft-magnetise them. The generating set is started, the generator de-energised, and the generator breaker is then closed which re-energises the excitation.

### 7.5 Black start

In a black start, the plant is completely disconnected from the public power grid. The GEJ product (generating set, module, ...) is the prime mover and must start with a 24 V DC power supply and close the generator breaker at rated speed in order to supply the plant with AC power.

A black start can take place on an engine that was previously not in operation (cold start) or an engine that has been shut-down (hot start).

### 7.6 Several generating sets operating in parallel

With regard to the generators used, please bear in mind that a specific reactive-load distribution using voltage droop takes place as well as an identical voltage reduction using a voltage knee. You should also take into account the pitch factor of the winding if the generator star points are connected. If this is not identical, star-point throttles must be used.

During parallel operation of GE Jenbacher generating sets, what is referred to as a load distribution line is normally used. This process is required in order to ensure the desired load distribution between the various generating sets. The use of measuring transducers should be considered if the load distribution line is subject to different loads.

#### 7.6.1 Speed drop (P-gradient)

In this case, the engine speed is changed by means of a preset power gradient (speed drop) in order to produce a desired percentage of the rated load as the isolated load. By varying the slope it is possible to increase the load on more heavy-duty engines (e.g. diesel generating sets or gas engines with low mean pressure). Make sure here that the speed drop setting does not adversely affect the plant dynamics (frequency and voltage) in any way.

#### 7.6.2 Load distribution line

In this case, the power generated from each module is transmitted by a mA output signal and the average engine power loaded by a mA input. Both signals have been scaled as standard to the range 0... 100% of the nominal power of the module concerned, corresponding to 4... 16 mA. Unlike the speed droop load distribution, the rated speed is not changed for control purposes and can therefore be held constant. The distribution percentages between engines can be adjusted (the standard distribution is equal percentages). When switching individual engines in and out, load application and shedding is effected using a ramp.

The sometimes different scales and input resistors from different manufacturers as well as different engine control systems and their implementation of this concept must be taken into account.

#### 7.6.3 Load management

If a local mains system is operated using different types of energy generators (gas engine, diesel engine, gas turbine, solar power, wind turbine, water power) or at least several energy generators of the same type, this is described as a micro- or minigrid. In such cases, grid simulations are essential and energy storage estimates helpful. Where specific projects are in the analysis phase, the inertia of the subsystems and the transfer functions for engines, controllers and generators must be regarded as essential system input values. On this basis it is possible to select and simulate the above or other combined load estimates. In the case of particularly stable basic energy generators, it is possible to switch less rigid systems in a power-controlled form to rigid systems in isolated operation.

The rule of thumb for this eventuality is to apply a **ratio of module inertias of about 2:1**. If the plant has to meet high technical demands, the dimensioning must be tested and validated by simulations.

### 7.7 Points requiring special attention

#### 7.7.1 Information on operational condition from breaker statuses – delay times

The operational condition of the engine is assigned on the basis of feedback from the generator breaker and the mains breaker. There are essential transition points in operating conditions at which feedback is required as rapidly as possible from the breaker in order to activate the corresponding controller functions.

In some field plants, it is precisely this immediate feedback that is causing difficulties. There are the non-reducible switch times (permitted up to < 60 ms). If this feedback is additionally transmitted via relays or even station control systems (software), further undesirable delay times are added. For example, even a doubling of the time can result in engine trips due to "overspeed" on the transition from mains-parallel operation to isolated operation at low load.

#### 7.7.2 Unknown customer load ratios – capacitive loads

If the ratio of capacitive to inductive loads (e.g. in the lower load range, when all the compensators have been added) is very large, this can result in unexpectedly large generator loads, pole slip and generator damage. It is therefore essential to ensure that the generator is always operated in the inductive range. *Worst-case* scenarios cab be simulated using grid stability analysis.

#### 7.7.3 System interconnection control system

If the currently required power for the operation to be supplied is recorded at the point of supply, a mains inter-connection control unit may be sensible from a financial and technical point of view. The recorded power is produced by the gas engine up to a certain necessary difference and because of this the transition from network to isolated operation results in a particularly clean transition behaviour.

#### 7.7.4 Auxiliaries

The exhaust gas system is not purged for emergency power operation.

As a result, due to the prelubrication the maximum time from emergency power activation to the engine start (when the engine turns) is 60 seconds for an engine previously not in operation.

# 8 Design constraints

## 8.1 Rated engine load

The relevant rated load for each engine version can be found in the product range and adjusted in accordance with the appropriate reduction diagrams. These produce the actual 100% rated load which is used as a reference value in the load diagrams.

Increased-load versions are operated in isolated operation at their original rated load. Furthermore, only the rated loads corresponding to the gas type used are permissible for generating sets with multiple or mixed gas operation.

## 8.2 Emissions

Isolated operation is subject to active emission control at a defined exhaust gas emission level of 500 mg/Nm$^3$ @ 5% O2 NOx irrespective of the emissions required in mains-parallel operation. Parameters in the engine control system make it possible to ensure that during the transition to isolated operation, the control automatically switches to higher emission values. To a certain extent, this will improve the control quality in the overall control range as well as increasing the load-adding capabilities and availability. The switch can be parameterised but this is not obligatory.

If the emissions are kept below the value stated above, e.g. 250 mg/Nm $^3$ @5%O2 NOx, special approval will be needed.

## 8.3 Mixture cooling water temperature, mixture temperature

The power shift diagrams apply to a mixture temperature corresponding to the product range. In this case too, the reduction of the mixture temperature results in an increased load-adding capability and therefore an increase in availability.

## 8.4 Ignition timing point

The power shift diagrams apply when the ignition point matches the default parameter values. Any change in the ignition point to the "retarded" setting will improve the load-adding capability.

## 8.5 Intake temperature

The power shift diagrams apply to intake temperatures corresponding to the product range. Any reduction in the intake temperature will improve the load-adding capability.

## 8.6 Exhaust gas back pressure

The power shift diagrams apply up to a maximum exhaust gas back pressure of 60 mbar. Reducing the exhaust gas back pressure improves load-adding behaviour.

## 8.7 Isolated operation with biogas, landfill gas and sludge gas

The use of biogas, landfill gas and sludge gas does not require special approval for the isolated operation of type 2, 3 and 4 engines. Modules in dual-gas operation require project-specific clarification due to the energy content of the gas. Mixed-gas operation and switching gas types during isolated operation both need special approval.

When changing over from mains-parallel operation to isolated operation, particular care must be taken to ensure that the requirements for constant gas pressure and quality are met (TI 1000-0300).

The gas supply to the gas compressor must be guaranteed for black start capability.

The use of gas engines in isolated operation with non-natural gas in life-preserving systems is not permitted due to the uncertainty of the gas supply!

### 8.8 Gas supply

To ensure appropriate operational behaviour of the modules, the fuel gas must be of consistent quality and at constant supply pressure (TI 1000-0300).

The module's black-start capabilities can only be deduced subject to the proviso that there is suitable gas quality and sufficient gas pressure. Type 6 engines with prechambers are approved for black starts in the product range (as from 2012), as they require prelubrication and a drive for the prelubrication pump.

In the case of multi-gas operation, this gas should therefore have the best possible availability for island operation

### 8.9 Generator

To keep the speed drop within the limit levels permitted for the control class in the event of added loads, the generator voltage is reduced selectively and dynamically by the "generator voltage knee point". In the case of multi-engine systems, special care must be taken to ensure that these settings are identical on all generating sets.

The setting of the generator voltage knee (starting point and steepness) is laid down in accordance with the ISO 8528-5:2005 standard. The following setting points are used for GE Jenbacher.

Standard settings based on two generating sets with different rated speeds.

| **1500 min$^{-1}$ generating set** | **1800 min$^{-1}$ generating set** | |
|---|---|---|
| 1500 - 1470 rpm | 1800 - 1764 rpm | Rated voltage |
| 1370 rpm | 1644 rpm | 0.9 x rated voltage |

The diagram below illustrates the voltage knee point.

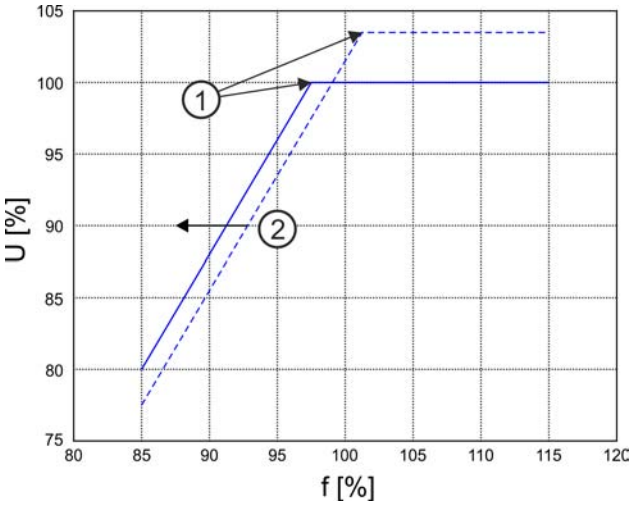



*Figure 6. Frequency/voltage characteristic*

| | | | |
|---|---|---|---|
| U [%] | Voltage (% rated value) | ① | Voltage knee point |
| f [%] | Frequency (% rated value) | ② | Slope |

In order to increase engine stability, the voltage knee point can be set to more than 100% of the rated speed (dotted line) by coordinating the consumers.

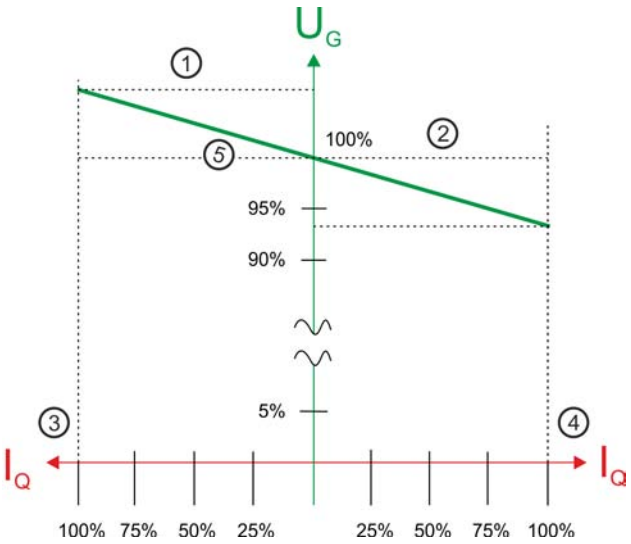



*Figure 7. Reactive load distribution*

| | | | |
|---|---|---|---|
| ① | Underexcitation | ② | Overexcitation |
| ③ | Load assumption | ④ | Load discharge |
| $U_G$ | Generator voltage | | |

The reactive power required by the consumers in the case of multi-engine systems is shown by means of an equal distribution to the generators running in the local grid. The distribution is achieved by adjusting the voltage droop. The essential point in this regard is that all the generators must have the same settings for rated voltage, voltage droop (typically 3%), voltage knee point (trip point, gradient, dwell) and AVR response times. Different settings may result in pole slip and therefore damage to the generator.

# 9 Appendix A. Isolated Operation Performance Assessment Characteristics

## A.1. Generator frequency

If synchronous generators are used, the static frequency characteristics are dependent on the engine speed controller. The dynamic characteristics are influenced by the complete control system (engine control, AVR, mass moment of inertia, etc.).

Figure 8 shows the relevant parameters for assessing the steady-state and transient frequency behaviour of a generating set in accordance with ISO 8528-5:2005. The characteristics can be taken from Table 2 (see ISO 8528-5:2005 *Table 1 - Symbols, Terms and Definitions*)

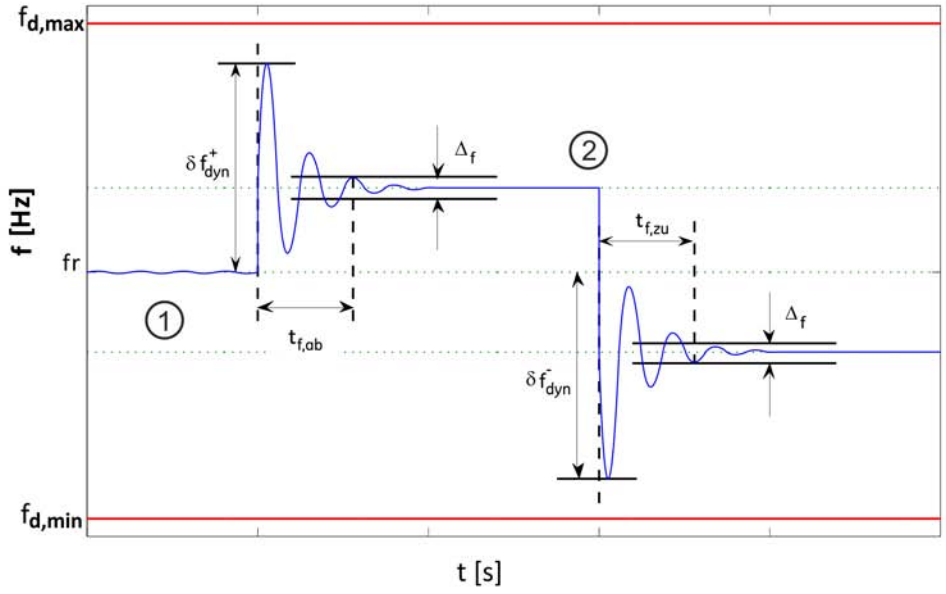



*Figure 8. Frequency stabilisation behaviour*

| | | | |
|---|---|---|---|
| f | Frequency | t | Time |
| ① | Load reduction | ② | Load reduction |

**Table 2. Characteristics for describing the static and dynamic frequency behaviour**

| Parameter | Icon | Unit | Description |
|---|---|---|---|
| Frequency deviation bandwidth for determining the stabilisation time | $\alpha_f$ | % | Frequency band around the equilibrium frequency where the frequency settles permanently within a specified stabilisation time after switching power on or off , expressed as a percentage of the rated frequency.<br>$\alpha_f = \frac{\Delta_f}{f_r} \times 100$ |
| Steady-state frequency bandwidth | $\beta_f$ | % | Zone of a frequency fluctuation occurring around a stationary mean value at constant power output, expressed as a percentage of rated frequency. |
| Undershoot frequency | $f_{d,min}$ | Hz | Minimum permissible frequency deviation after a sudden load application. |
| Overshoot frequency | $f_{d,max}$ | Hz | Maximum permissible frequency deviation after a sudden load rejection. |
| Dynamic (temporary) frequency deviation (from the mains frequency) after a load application | $\delta f^{-}_{dyn}$ | % | Temporary frequency difference between the undershoot frequency and the rated frequency, occurring during the stabilisation process after a sudden load application and expressed as a percentage of the rated frequency.<br>The dynamic frequency deviation must not exceed the permissible frequency tolerance. |

| | | | |
|---|---|---|---|
| Dynamic (temporary) frequency deviation (from the mains frequency) after a load rejection. | $\delta f^{+}_{dyn}$ | % | Temporary frequency difference between the overshoot frequency and the rated frequency, occurring during the stabilisation process after a sudden load rejection and expressed as a percentage of the rated frequency<br>The dynamic frequency deviation must not exceed the permissible frequency tolerance. |
| Frequency control stabilisation time after load application | $t_{f,zu}$ | s | Time between the sudden load application and the frequency permanently settling in the stationary tolerance band. |
| Frequency control settling time after load rejection | $t_{f,ab}$ | s | Time between the sudden load rejection and the frequency permanently settling in the stationary tolerance band. |

### A.2. Generator voltage

The voltage behaviour of the generating set is influenced mainly the voltage behaviour of the generator and possibly the voltage controller. The static and dynamic frequency behaviour of the generating set also influences the static and especially the dynamic behaviour in the rated zone. This also depends on the individual design of the generating set. Figure 9 shows the voltage limits after a load step change.

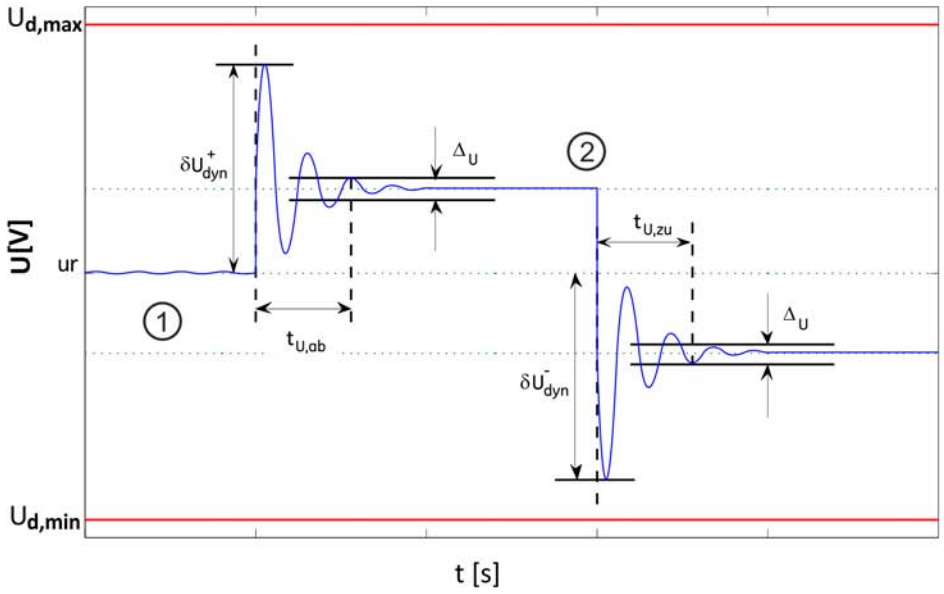



*Figure 9. Voltage stabilisation behaviour*

| | | | |
|---|---|---|---|
| U | Voltage | t | Time |
| ① | Load reduction | ② | Load reduction |

**Table 3. Characteristics for describing the static and dynamic voltage behaviour**

| | | | |
|---|---|---|---|
| Voltage deviation bandwidth for determining the stabilisation time | ΔU | V | Frequency band around the equilibrium voltage, where the terminal voltage settles permanently within a specified stabilisation time after switching power on or off , expressed in volts.<br>$\Delta U = 2\delta U_{st} \times \frac{U_r}{100}$ |
| Static voltage deviation | $\delta U_{st}$ | % | Maximum deviation by the voltage from rated voltage after the decay of dynamic processes in the zone between no-load and rated power output, taking into account the heating effect and the frequency behaviour of the generating set.<br>The static voltage deviation is expressed as as percentage of the rated voltage<br>$\delta U_{st} = \pm \frac{U_{st,max} - U_{st,min}}{2U_r} \times 100$ |
| Undershoot voltage | $U_{d,min}$ | V | Minimum permissible voltage deviation after a sudden load application. |
| Overshoot voltage | $U_{d,max}$ | V | Maximum permissible voltage deviation after a sudden load rejection. |
| Dynamic (temporary) voltage deviation (after a load application) | $\delta U^-_{dyn}$ | % | Difference between the minimum peak value of the terminal voltage after a sudden load application and the rated voltage peak value, referred to the rated voltage peak value and expressed as a percentage of rated voltage. |
| Dynamic (temporary) voltage deviation (after a load rejection) | $\delta U^+_{dyn}$ | % | Difference between the minimum peak value of the terminal voltage after a sudden load rejection and the rated voltage peak value, referred to the rated voltage peak value and expressed as a percentage of rated voltage. |
| Voltage control settling time after load application | $t_{U,zu}$ | s | Time between a sudden load application and the terminal voltage returning permanently to the within the static voltage deviation, taking the frequency stabilisation time into account.<br>Note: The magnitude and change over the time of the dynamic speed variation of the engine are the influencing factors. |
| Voltage control settling time after load rejection | $t_{U,ab}$ | s | Time between a sudden load rejection and the terminal voltage returning permanently to the within the static voltage deviation, taking the frequency stabilisation time into account.<br>Note: The magnitude and change over the time of the dynamic speed variation of the engine are the influencing factors. |

## 10 Revision code

**Revision history**

| Index | Date | Description/Revision summary | Creator<br>*Auditor* |
|---|---|---|---|
| 3 | 05.03.2012 | Überarbeitung / revision | **Bilek**<br>*Graus* |
| 2 | 16.02.2011 | Komplette Überarbeitung / complete revision | **Provin**<br>*Samiento* |
| 1 | 26.05.2010 | Umstellung auf CMS / Change to Content Management System ersetzt / replaced Index: - | **Schartner**<br>*Pichler* |