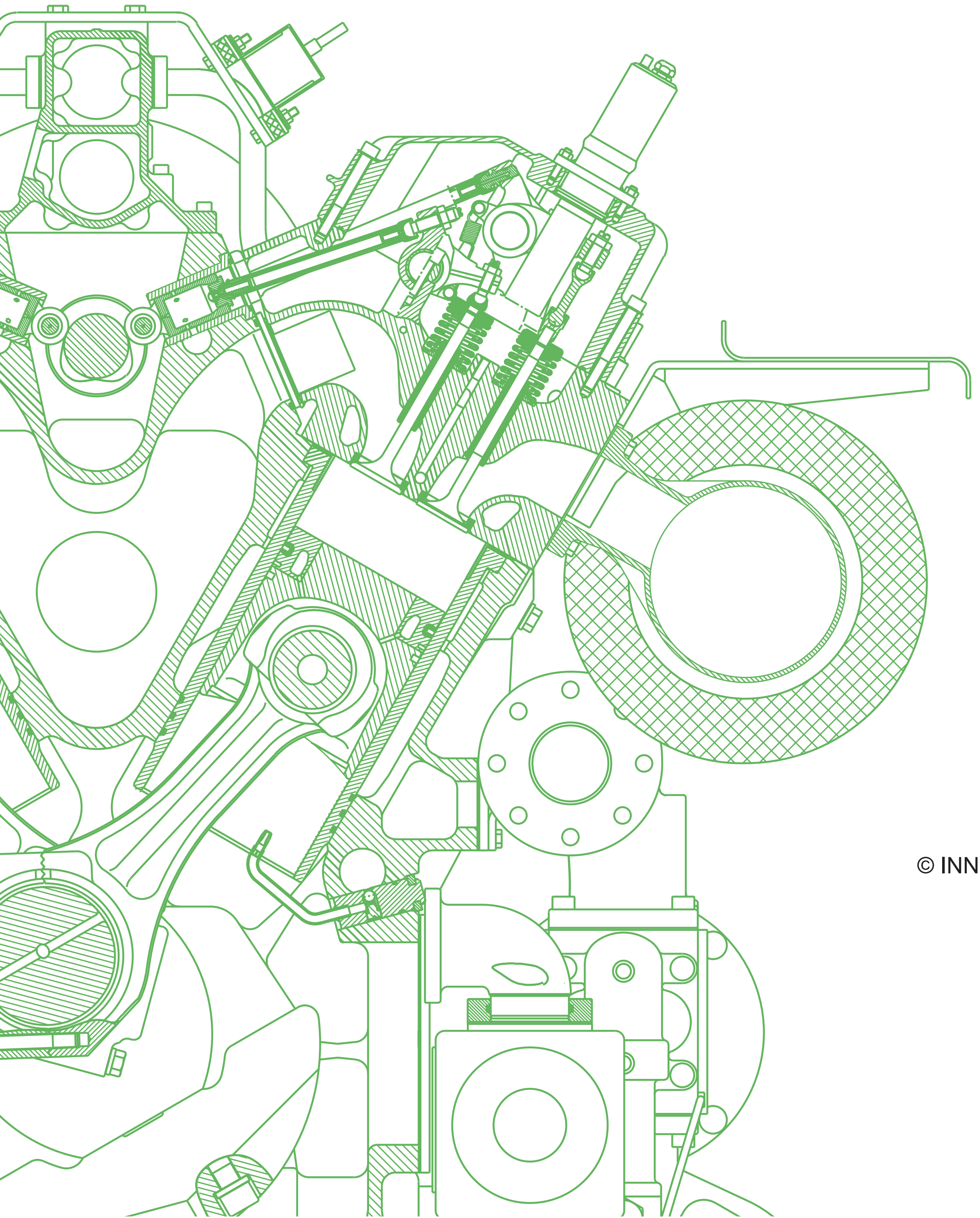
JENBACHER

# TA 1510-0070

Technical Instruction

## Special gas mixer for Type 6 engines





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## 1 Scope

This Technical Instruction [TA] applies to the following Jenbacher Gas Engines:

- Type 6 engines

## 2 Purpose

Technical Instruction [TA] describes the design, commissioning, setting and troubleshooting of the special gas mixer.

## 3 Additional information

Reference should be made to the Technical Instructions listed below when carrying out commissioning. If there are any problems, ask the SES (Service Expert System) for help.

**Relevant documents:**

**TA 1000-0531** - AUTOTUNE controller

**TA 1100-0110** - Boundary conditions for GE Jenbacher gas engines

**TA 1100-0112** - Installation of GE Jenbacher modules

**TA 1400-0100** - Running-in procedure for Jenbacher engines

**TA 1400-0154** - Knock control system KLS98

**TA 1502-0068** - MORIS ignition

**TA 1502-0069** - MPM (MORIS Power Module)

**TA 1502-0070** - Rail System

**TA 1502-0071** - SAFI (Sensor Actuator Function Interface)

**TA 2110-0023** - Prechamber differential and gas pressure monitoring on Type 6 engines

**W 0701 M6** - Gas mixer

## 4 General

The special gas mixer is designed for use on Type 6 engines. Although it can operate both with natural gas and with special gases, its preferred use is with large volumes of gas. It differs from the former standard four-mixer configuration as follows:

- One special gas mixer instead of four standard gas mixers.
- Reduced pressure loss with special gas applications.
- There is no need to change the spacer rings, as an equivalent effect is achieved by two stepper motors which can be adjusted via the visualisation unit (air throttle bank A and bank B).
- A stepper motor for the Leanox control (gas throttle).

- Direct position feedback via an incremental transducer.
- Suitable for gas mixtures that would require six standard gas mixers.


*Figure 1: Special gas mixer (Part no. 370125)*

| | | | |
|---|---|---|---|
| ① | Natural gas flange | ④ | Air intake side |
| ② | Special gas flange | ⑤ | Protective caps for air throttle drive motors |
| ③ | Gas throttle drive shaft | | |

## 5 Mechanical structure

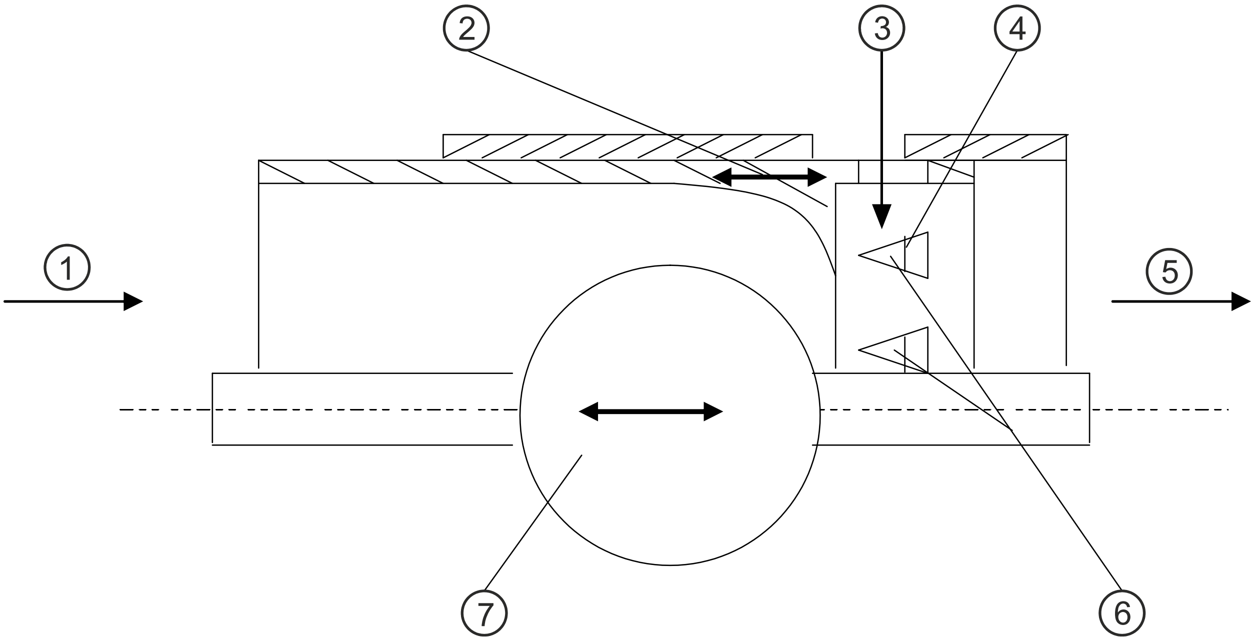



*Figure 2: Basic structure of the special gas mixer*

| | | | |
|---|---|---|---|
| ① | air | ⑤ | Mixture |
| ② | Gas throttle (adjustable) | ⑥ | Gas intake openings |
| ③ | Gas | ⑦ | Air throttle (adjustable) |
| ④ | Control side | | |

The intake air flows into the special gas mixer from the left, as shown in Illustration 2. The air first passes through the air throttle, which is used to vary the underpressure around the gas intake openings. It has the same function as the spacer rings on the standard gas mixer. The air throttle position is preset by the control system and adjusted by a stepper motor.

The fuel gas is added through the gas intake openings. Its diameter is changed by moving the gas throttle and this process is also set by the control system by means of a stepper motor.

Three flanges built into the mixer are available for the gas supply:

Flanges with rated width of 150 mm:

These are used for special gas applications involving large gas volume flows. When two zero pressure controllers are used, each of them must be connected to a 150 mm flange. If only one 150 mm zero pressure controller is used, the gas supply must be divided equally over the two 150 mm flanges. In both cases, it is essential to ensure an equal gas supply through the two 150 mm flanges. During commissioning, the zero pressure controllers must be set so that the output pressures of the two controllers are as near identical as possible when under load.

Flange with rated width of 100 mm:

This is used in applications involving small volumes of gas (a gas control system with a 100 mm zero pressure controller or smaller).

Both types of gas supply (i.e. all three flanges) can be accommodated at the same time.

## 5.1 Gas intake opening

The position of the gas throttle, i.e. the gas throttle opening, is entered in the control system as a percentage, where 0 % means fully closed and 100 % fully open. An equal gas supply is produced automatically on both sides of the gas mixer.

The parameters are set in the Gas mixer recipe under Gas type 1-4. Guideline values for commissioning are given in the table in Section ⇨ Setting the reference parameters.

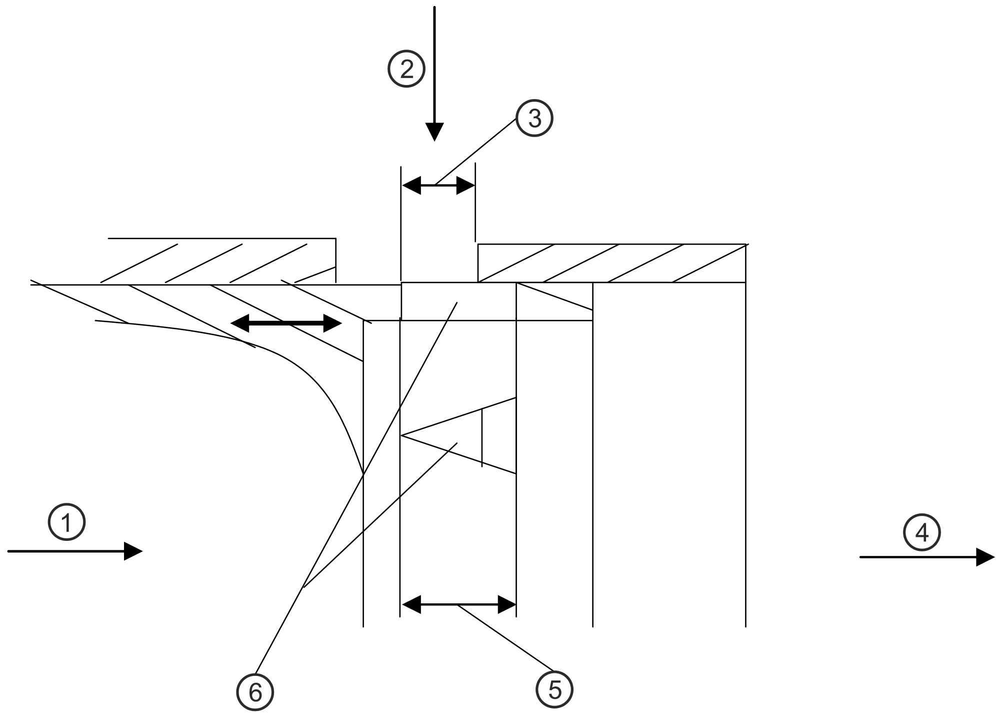



*Figure 3: Detail of the gas intake opening*

| | | | |
|---|---|---|---|
| ① | Air | ④ | Mixture |
| ② | Gas | ⑤ | Maximum opening (100 %) |
| ③ | Current opening (e.g.: 75 %) | ⑥ | Gas intake opening |

## 5.2 Air throttle

The position of the air throttle is entered in the control system in millimetres. In the case of the air throttle, there is no difference between manual mode and automatic mode.

The parameters are set in the special gas mixer recipe under Gas type 1-4. Guideline values for commissioning are given in Table 2 in Section ⇨ Setting the reference parameters.

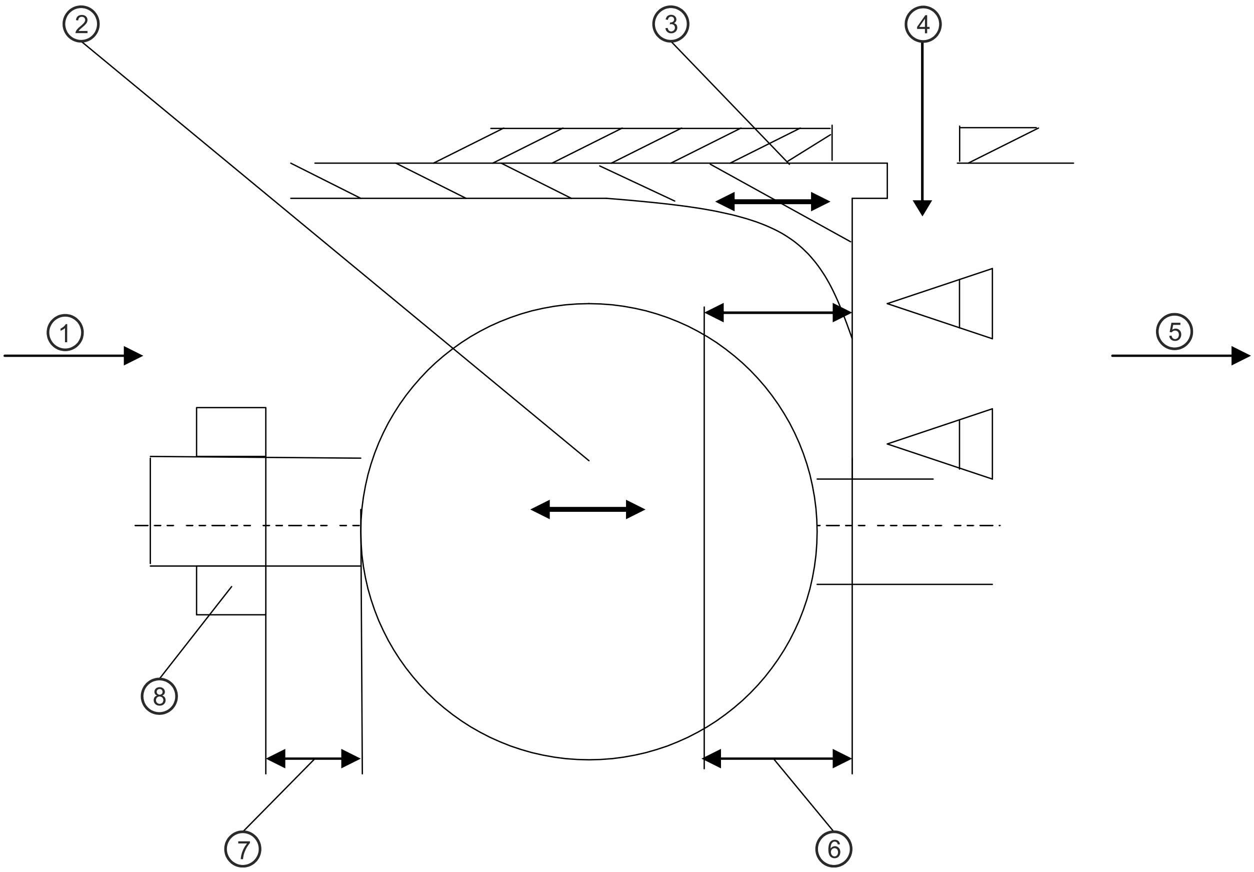



*Figure 4: Detail of air throttle*

| | | | |
|---|---|---|---|
| ① | Air | ⑤ | Mixture |
| ② | Air throttle (moveable) | ⑥ | Offset air throttle |
| ③ | Gas throttle (moveable) | ⑦ | Distance |
| ④ | Gas | ⑧ | Stop |

# 6 Electrical structure

## 6.1 Visualisation system

### 6.1.1 Display of positions

The “CTR1” and “Leanox controller” screens show the actual position of the gas throttle (as a percentage) and the actual distance of the air throttle on cylinder bank A (in mm, relative to the gas throttle). The positions are detected by means of position encoders mounted directly on the shafts of the stepper motor.

### 6.1.2 Screen showing details of the special gas mixer

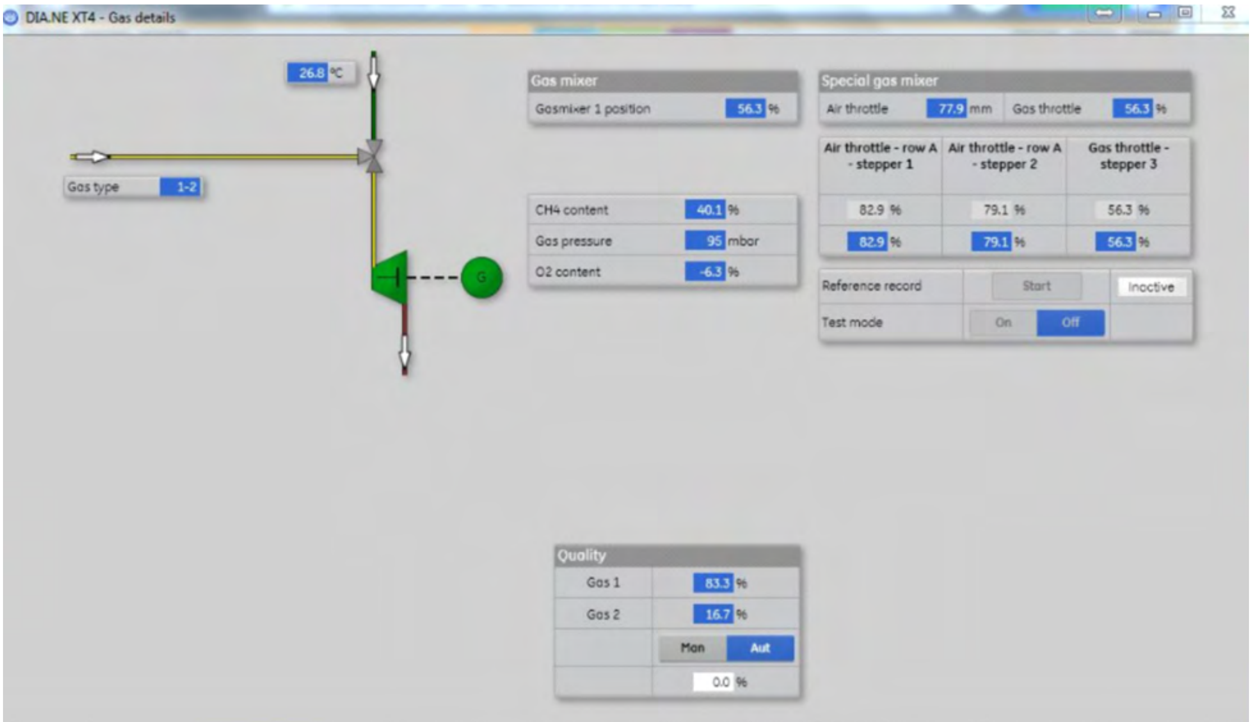
An additional screen showing gas mixer details has been created to improve functional testing. It must be activated as a subscreen in the Leanox controller screen (gas mixer details). The top half of the screen is split into three columns corresponding to the stepper motor units (air throttle bank A, air throttle bank B and gas throttle).

The following subjects are displayed:

- Set point position as a % of the mechanical adjustment travel (gas throttle 150 mm, air throttle 78.5 mm)
- Measured encoder feedback position as a % (actual position) of the mechanical adjustment travel
- Control card status

To calculate the mechanical position in mm, multiply the displayed percentage value by 1.5 for the air throttle and by 0.875 for the gas throttle.

The bottom half of the screen allows you to switch from automatic to manual mode (not to be confused with switching operating modes for the Leanox controller: Automatic (Auto button) and Manual (Man button) in the Leanox screen). In manual mode, any adjustment of the set point positions of the air throttles and gas throttle is possible. In this screen, you can basically locate a faulty stepper motor unit by comparing the set point position and the encoder feedback. However, you should bear in mind that a mechanical collision of the air throttle and the gas throttle is possible in manual mode and a deviation may therefore also arise between the set point and the actual position.




You can also use the bottom half of the screen to manually activate the referencing system (only when the engine is at a standstill). The number of referencing operations and, where appropriate, the error message "Gas mixer control failed" are then displayed. During the referencing process you move to the zero position (reference for gas throttle), then the 100 % position (reference for the air throttles) and finally the operating positions of all three gas mixer elements.

### 6.1.3 Important parameters

| | |
|---|---|
| Air throttle Bank A/B full number of steps | 30,000 |
| Air throttle Bank A/B step speed | 1,410 Hz |
| Gas throttle full number of steps | 17500 |
| Gas throttle step speed | 1,410 Hz |

From a control point of view, the Leanox controller parameters are equal to the gas mixer controller parameters. Typical values are Kp -10 to -20, Ki 20 to 25. These can, however, be adjusted for each individual installation. From a control point of view, the stationary lambda controller parameters are equal to the standard gas mixer controller parameters.

See the default parameter set for other parameters.

## 6.2 Hardware – electronics

### 6.2.1 Stepper motor

Three 3-phase stepper motors with integrated shaft encoders are used. Originally, the cabling was direct but now there is a connector output.


*Figure 6: Stepper motor with connector output*

The terminal configuration is described in Table 3.

| Designation | Colour (cable output) | Colour (connector output) | Pin (connector output) |
|---|---|---|---|
| Motor phase U | White | White | 1 |
| Motor phase V | Green | Black | 2 |
| Motor phase W | Brown | Brown | 3 |
| Encoder signal A | White | White | 6 |
| Encoder signal A/ | | Blue | 7 |
| Encoder signal B | Green | Green | 8 |
| Encoder signal B/ | | Yellow | 9 |
| 5V encoder power supply | Pink | Pink | 5 |
| GND encoder power supply | Brown | Brown | 12 |

### 6.2.2 Power control card

The appropriate electronics are needed to provide the stepper motors with a power control system. Their function is to produce the digital signals from the control system for each motor. In total, three of these cards are used. Illustration 7 shows, from left to right, the five status display LEDs, the DIP switch, the selector switch for the motor phase current and the hook switch for microstep mode. These power cards (D920) were fitted until 2011. As they were discontinued by the manufacturer at the end of 2011, they have been replaced by the D930 power card. Figure 8 shows from left to right the DIP switch, the selector switch for the motor phase current and the red status LED.

| | D920 | D930 successor |
|---|---|---|
| DIA.NE XT | D920.50 + fixed-frequency oscillator | D930.20-O (with oscillator) |

| | | |
|---|---|---|
| | Part No. 375429 | Part No. 1216669 |
| DIA.NE BLUE | **D920.51** | **D930** |
| | Part No. 340,000 | Part No. 1216713 |

### 6.2.2.1 D920 power card

**Status LEDs:**

LED 1 (green), lights up to indicate correct operation and release

LED 2 (red), lights up to indicate short circuit between two motor phases

LED 3 (red), lights up to indicate overtemperature (>75 °C) at the heat sink

LED 4 (red), lights up to indicate overvoltage (>40 V)

LED 5 (red), lights up to indicate undervoltage (<18 V)

LEDs 2, 3, 4 and 5 light up simultaneously to indicate excessive pulse frequency or interference pulses

LEDs 4 and 5 light up simultaneously in disable mode (no release)

**DIP switches:** all the switches are in OFF position. For dia.ne XT, switch 4 is in ON position

**Selector switch:** the switch is at position C (motor current 4.9 A)

**Hook switches:** both hook switches are open

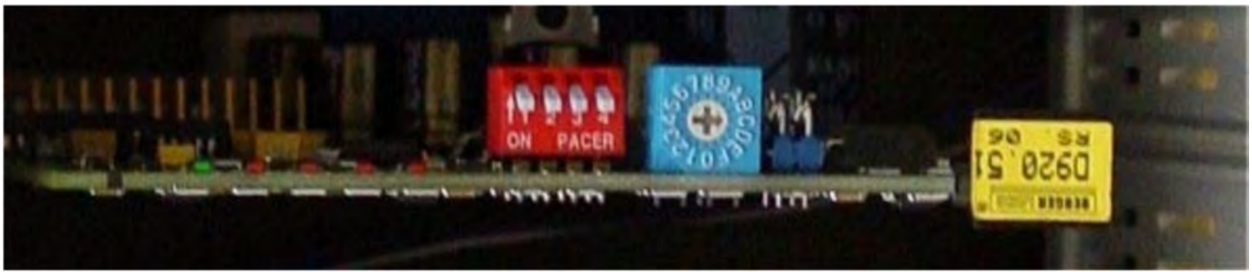



*Figure 7: D920 power control card*

For DIA.NE XT the control card is fitted with an **'RSO14 add-on board'** which generates the control pulse internally. No configuration is required as the jumper settings are set by the manufacturer. The card step frequency is increased from 120 Hz to 1,500 Hz in the start-up mode. That is why the recipe parameter is set at 1,450 Hz.

**Jumper settings for the add-on board (prerelease)**

| | |
|---|---|
| JP1 | closed |
| JP2 | open |
| JP3 | in lengthwise position on the board (closer to the LED) |
| JP4 | closed |
| JP5 | open |

For the RSO14 add-on board no jumper settings are required nor possible any more.

### 6.2.2.2 Power card D930

The D930 is the successor to the D920 and can be used to replace latter without any conversion measures. However, a few technical differences need to be observed.

**LED status indicator:**

LED 1 (red) lights up continuously to indicate correct operation and release

LED 1 (red), flashes twice to indicate undervoltage (<21 V)

LED 1 (red), flashes three times if the heat sink temperature is too high (>130°C)

LED 1 (red), flashes four times to indicate an overcurrent (> 5.5 A)

The overvoltage fault indication no longer exists, as the power card can withstand up to 130 V and 8 A.

The short-circuit fault indication has been replaced by the overcurrent fault indication.

**DIP switch:** switch 1 is in the ON position, switches 2 & 3 are in the OFF position, switch 4 is in the ON position (1000 Microsteps & Motor Current reduction ON)

**Caution: The DIP switches have a different function compared to the D920**.

**Selector switch:** the switch is at position C (motor current 4.9 A)

Gate: The gate function on the D920 was selected with no. 4 DIP switch. On the current D930 the function is activated by a jumper. On cards with oscillators, the jumper is automatically connected when the oscillator card is plugged in (DIA.NE XT). **Note this jumper must not be plugged in with DIA.NE blue** - see Figure 9.


*Figure 8: D930 power control card*

With DIA.NE XT the D930 power card is extended by an add-on board (D930.20-O), the same as with the D920.

ID of the add-on board: 59300000354.

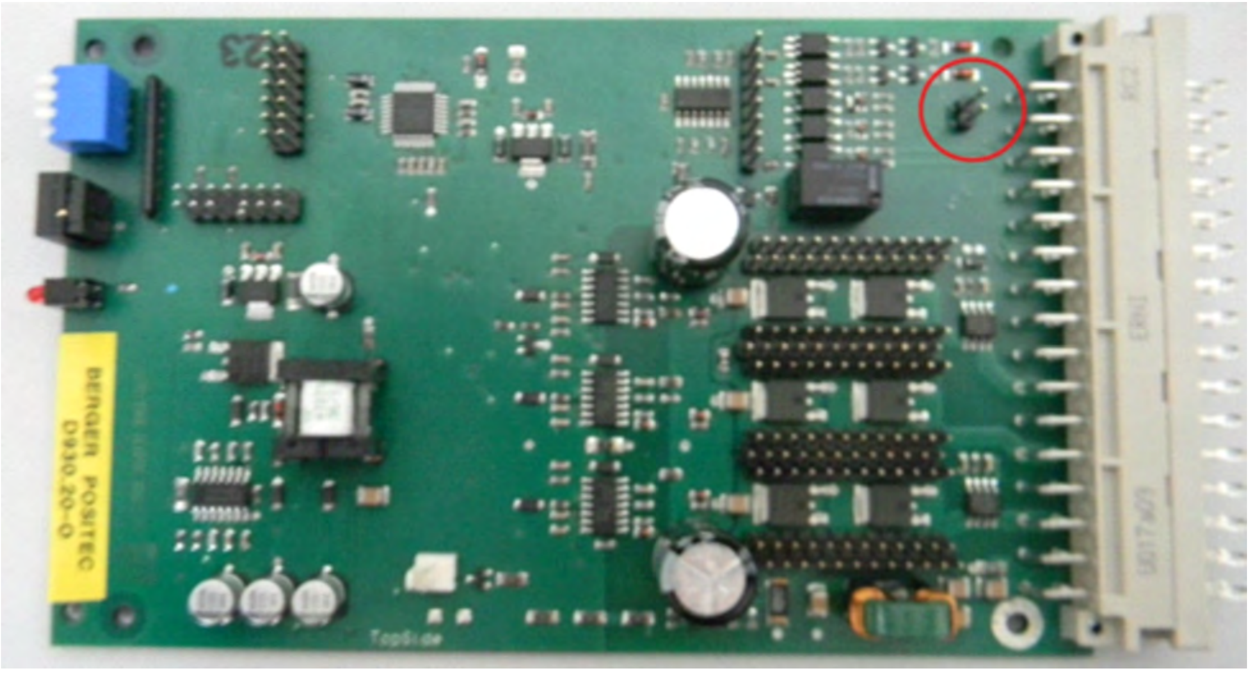



*Figure 9: Jumper contacts for the gate / enable function (D930 without oscillator)*

**Always observe the following before installing the card:**

**Never connect the power card while a voltage is present.**

**Never disconnect or connect the connection between the motor and power card during operation, as this can damage the power card.**

### 6.2.3 Encoder interface

In order to receive encoder signals suitable for the control system, the signal has to be converted and the encoder interface BH240-10 is used (see Illustration 10). This module is not required for DIA.NE XT. The two yellow LEDs at the top indicate the signal of the two encoder phases A and B while the green LED at the bottom left indicates that the supply voltage interface temperature is OK.


*Figure 10: Encoder interface*

| Description | Connection | Colour - cable output |
|---|---|---|
| No function | Screw, top left | |
| Encoder signal B for control | Screw, top centre | |

| Description | Connection | Colour - cable output |
|---|---|---|
| Encoder signal A for control | Screw, top right | |
| GND power supply interface | Screw, bottom left | |
| 24 V power supply interface | Screw, bottom centre | |
| No function | Screw, bottom right | |
| Encoder signal A | DSUB Pin 1 | Yellow |
| Encoder signal B | DSUB Pin 12 | Green |
| 5 V encoder power supply | DSUB Pin 2 | White |
| GND encoder power supply | DSUB Pin 3 | Brown |

### 6.2.4 Encoder module NC161

In the case of DIA.NE XT, the encoder feedback signals can be processed without an encoder interface, and the Encoder Module NC161 is used instead. This means that the encoder module on the stepper motor both supplies 5 V and processes the signals.

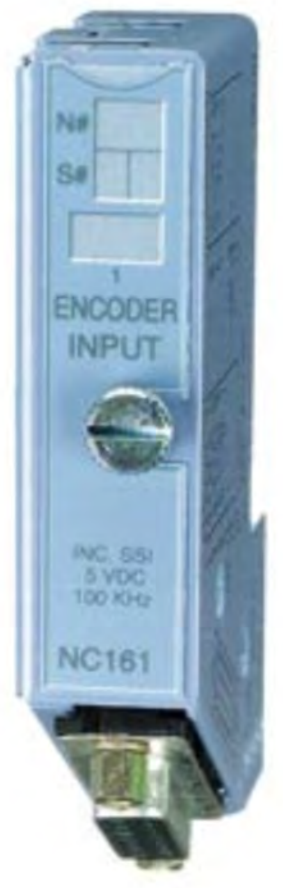



*Figure 11: Encoder module*

| Description | Connection | Colour - cable output |
|---|---|---|
| Encoder signal A | DSUB Pin 1 | White |
| Encoder signal A/ | DSUP Pin 2 | Grey |
| Encoder signal B | DSUB Pin 3 | Green |
| Encoder signal B/ | DSUP Pin 4 | Yellow |

| Description | Connection | Colour - cable output |
|---|---|---|
| 5 V encoder power supply | DSUB Pin 9 | Pink |
| GND encoder power supply | DSUB Pin 12 | Brown |

# 7 Commissioning

Check the switches on the power cards and check the LEDs for the power supply and overtemperature of the encoder converter. When the control power supply is switched on, the collision distances between the air throttles and the gas throttles are determined (the air and gas throttles first close completely and then open, after which air throttle A and air throttle B carry out separate collision motions to balance out the manufacturing tolerances), and a reference motion is also carried out (test movement through the full adjustment range of the air and gas throttles, in which all the throttles are opened from 0 % to 100 % and then closed again). Unless the error message "Gas mixer control failed" is then displayed, the gas mixer is ready for operation. Further checks can be carried out with the aid of the detail screen for the special gas mixer (see Section ⇨ Screen showing details of the special gas mixer).

# 8 Before starting the engine

## 8.1 Commissioning check list

**Commissioning must follow the specific check list for the plant.** All the mechanical and functional checks, setting parameters, and also setting the controller in accordance with the additional documentation (technical diagram, technical descriptions, training material) must be completed before the engine is started.

**No monitoring parameters that are activated according to the check list may be deactivated without consulting the Excellence Center in Jenbach!**

## 8.2 Gas train

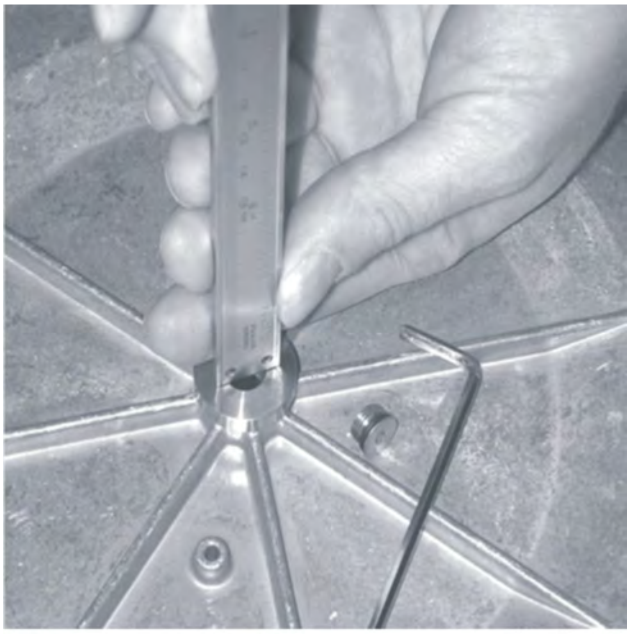
The gas trains must be assembled as set out in the technical description (TA 1100-0112) and the technical diagram. The zero pressure controller must not be positioned more than 2 m away from the gas mixer.

### 8.2.1 Zero position controller basic setting (Messr. DUNGS: TYPE FRNG 5150, DN 150 / PN 16)

This adjustment is carried out without supplying any gas to the zero pressure controller.

The bottom cap of the zero pressure controller contains an opening which is closed by a hexagonal socket screw. After removing the hexagonal socket screw, use a depth gauge to measure the distance from the bottom cap to the centre of the controller. With the gas solenoid valves closed, release the spring in the zero pressure controller (by turning the pressure adjusting screw anti-clockwise until it stops). Then turn the pressure adjusting screw clockwise until a dimension of 59-60 mm results (typically 19-21 turns on the zero pressure controller). After the presetting procedure, close off the inspection hole with the screw plug again.

The final adjustment of the zero pressure controller is carried out with the engine idling. The measurement with the water column must be made in the immediate vicinity of the gas mixer. When the engine is idling, the gas pressure after the zero pressure controller should be +1 mm to +2 mm water column. The controller may need to be adjusted as described above when the engine is at rest.



*Zero position controller (Messr. DUNGS: TYPE FRNG 5150, DN 150 / PN 16)*

Once the hexagonal socket screw has been removed, the distance to the centre of the controller can be measured.

## 8.3 Setting the reference parameters

The parameters set out in this section should be regarded as guideline values for commissioning and must be optimised and identified separately for each plant. These parameters refer to a methane content in the fuel gas (non-natural gases: biogas, landfill gas, sludge gas and mine gas) of 48 to 53%. The parameters must be entered and changed under Gas mixer / Gas type 1-4, Idle mode lambda controller and Special gas mixer. If the permitted adjustment ranges are exceeded, the Excellence Center in Jenbach must be contacted.

### 8.3.1 Gas mixer / air throttle parameters for non-natural gases (biogas, landfill gas, sludge gas and mine gases)

Table 1: Parameters for setting the air throttle, guide values for landfill gas and biogas

| Recipe: Gas mixer | J6xx | Note |
|---|---|---|
| Gas mixer position point 1 | 43 % | Starting position 1 at oil temperature point 1 30°C |
| Gas mixer position point 2 | 39 % | Starting position 2 at oil temperature point 2 75 °C |
| Gas mixer offset for engine start | -20 % | -15 % … -25 % adjustment range<br>1st start -20% -5% = -25% |
| Speed limit for gas mixer offset | 250 | 200 rpm … 300 rpm<br>1st start 250 rpm + 0 = 250 rpm |
| Gas mixer position offset for mains parallel and isolated operation | 2 % | 0 % … 4 % adjustment range |
| Speed controller active | 900 rpm | |
| Gas mixer position control range | 2 % | 0 % … 2 % adjustment range |
| Throttle valve set position | 10 % | 10 % … 15 % adjustment range |

| Recipe: Gas mixer | J6xx | Note |
|---|---|---|
| Offset air throttle starting position | 15 mm | 12 mm … 18 mm adjustment range |
| Offset air throttle idling position | 19 mm | 16 mm … 22 mm adjustment range |
| Offset air throttle mains-parallel operation position | 23 mm | 20 mm … 26 mm adjustment range |
| Difference between air throttle position and 100 % at P max | 0 mm | |

### 8.3.2 Gas mixer / air throttle - parameters for natural gas operation only

Table 2: Parameters for setting the air throttle, guide values for natural gas operation

| Recipe: Gas mixer | J6xx | Note |
|---|---|---|
| Gas-mixer position point 1 | 24.5 % | Starting position 1 at oil temperature point 1 30°C |
| Gas-mixer position point 2 | 24 % | Starting position 2 at oil temperature point 2 75 °C |
| Gas mixer offset for engine start (reserve parameter 4) | 0 | |
| Speed limit for gas mixer offset (reserve parameter 5) | 0 | |
| Gas mixer position offset for mains parallel and isolated operation | 1 % | 0 % … 4 % adjustment range |
| Speed controller active | 900 rpm | |
| Gas mixer position control range | 1 % | 0 % … 2 % adjustment range |
| Throttle valve set position | 10 % | 10 % … 15 % adjustment range |
| Offset air throttle starting position | 40 mm | |
| Offset air throttle idling position | 40 mm | |
| Offset air throttle mains-parallel operation position | 40 mm | |
| Difference between air throttle position and 100 % at P max | 0 mm | |

## 8.4 Expanded offset parameters

### 8.4.1 Offset air throttle start

**Function:**

From engine start-up until the STARTING SPEED (recipe: Speed / Limit values) the two air throttles are operated with the constant offset "Offset air throttle start" (in mm relative to the gas throttle). When the gas throttle position changes, this offset is automatically adjusted to the value in the "Offset air throttle start" parameter or kept constant.

**Remark:**

When starting it is advisable to keep the offset low, as the zero pressure controller setting has less effect on starting.

If the "Offset air throttle start" parameter is set to 0 mm, the distance between the gas throttle and the air throttle is set to the minimum permissible dimension (near-collision between air throttle and gas throttle) and kept constant. The maximum possible underpressure is produced in this position. Offsetting the air throttle to 0 mm has the effect of making the mixture richer. The gas throttle is designed so that the airway is not fully closed when the throttle is offset to 0 mm.

**Input limits**: 5-50 mm

### 8.4.2 Offset air throttle idling

**Function:**

Once the STARTING SPEED (recipe: Speed / Limit values) has been exceeded, the distance between the gas throttle and the air throttle is offset to the pre-set value (in mm relative to the gas throttle) in the "Offset air throttle idling" parameter. When the gas throttle position changes (irrespective of whether the change is made manually or by the idling controller) this offset is automatically adjusted to the value in the parameter "Offset air throttle idling" and then kept constant.

**Remark:**

It should be set so that the offset relative to the start position is slowly increased. The guideline value is that the offset should be approx. 5 - 10 mm bigger than at start-up. If the "Offset air throttle idling" parameter is set to 0 mm, the distance between the gas throttle and the air throttle is set to the minimum permissible dimension (near-collision between air throttle and gas throttle) and kept constant. The maximum possible underpressure is produced in this position. Offsetting the air throttle towards 0 mm has the effect of making the mixture richer. The gas throttle is designed so that the airway is not fully closed when the throttle is offset to 0 mm.

**Input limits:** 5-50 mm

### 8.4.3 Offset air throttle mains-parallel

**Function:**

On completion of synchronisation until the Leanox start-up power level is reached, the distance between the gas throttle and the air throttle is offset to the pre-set value (in mm relative to the gas throttle) in the "Offset air throttle mains-parallel" parameter. When the gas throttle position changes, this offset is automatically adjusted to the value in the "Offset air throttle mains-parallel" parameter and kept constant.

**Remark:**

It should be set so that the offset relative to the idling position is slowly increased. The guideline value is that the offset should be approx. 5 - 10 mm bigger than when idling. If the "Offset air throttle mains-parallel" parameter is set to 0 mm, the distance between the gas throttle and the air throttle is set to the minimum permissible dimension (near-collision between air throttle and gas throttle) and kept constant. The maximum possible underpressure is produced in this position. Offsetting the air throttle towards 0 mm has the effect of making the mixture richer. The gas throttle is designed so that the airway is not fully closed when the throttle is offset to 0 mm.

**Input limits:** 5-50 mm

### 8.4.4 Distance of air throttle at full load

**Function:**

On activation of the Leanox controller (Leanox start-up power) an adjustment is made to an offset which is a function of the current power level.

At the power level required for Leanox activation, the offset between the gas throttle and the air throttle is in accordance with the "Offset air throttle mains-parallel" parameter.

At full load, the distance between the air throttle and the mechanical stop is in accordance with the "Offset/distance air throttle, full load" parameter.

The distance between the two positions is linearly interpolated as a function of the power level (see illustration 5).

**Caution:**

The "Offset/distance air throttle, full load" parameter no longer indicates the offset between the gas throttle and the air throttle but is a distance between the air throttle and the mechanical stop when fully opened.

**Remark:**

The distance between the air throttle and the stop should be set to be as small as possible. Ideally, the "Offset/distance air throttle, full load" parameter should be 0 mm. This minimises the pressure drop through the gas mixer and improves the efficiency of the engine when operating at full load. If the plant-specific gas supply pressure is too low at high loads, it may be necessary to close the air throttle partially (empirical value 80 mm).

**Input limits:** 0-150 mm

Gas types 1-4 can be used. In addition, operation with gas type 1-2 is possible.

#### 8.4.5 Gas mixer operating modes

**Manual / hand mode**

In manual mode, the position of the gas throttles can be set as a percentage of the gas mixer position.

**Automatic / auto mode**

In automatic mode, the gas mixer position is set in accordance with the parameters in the Gas mixer recipe. Guideline values for commissioning are given in the tables in Section ⇨ Setting the reference parameters, which must be optimised specifically for each plant. For commissioning with special gases, the Excellence Center at Jenbach must be contacted.

#### 8.4.6 Checking the exhaust system

The entire exhaust gas system must be checked. If a SCR cat or an oxi cat is present, particular attention should be paid to the installation position of the explosion flap. The safety package must be installed as described in TA 1100-0110 Section 13. In addition, it should be ensured that no flammable items come into contact with hot parts of the exhaust gas system.

**Exhaust gas scavenging time**

It should be ensured that the exhaust system is adequately scavenged between individual start-up procedures. The scavenging times defined for whichever exhaust gas system is installed must be entered in seconds in the **Exhaust gas / Scavenging time** parameter. The values entered in the table are standard values, depending on the design of the exhaust system. With very complicated exhaust systems, the Excellence Center at Jenbach must be contacted.

Summary of scavenging times

| Exhaust gas system | J612, J616, J620 |
|---|---|
| Standard single silencer | 100 sec |
| Standard for two silencers and exhaust gas heat exchangers | 180 sec |
| Standard for SCR cat and greenhouse application | 225 sec |

# 9 Engine start

## 9.1 Starting the engine for the first time

Before starting the engine for the first time, ensure that it is being supplied with fuel gas of the required quality.

Experience has shown that a somewhat more open gas mixer position is required to start a cold engine. Make sure that opening the gas mixer position further (enriching the mixture, making the prechamber too rich) does not increase the misfire frequency. The oil temperature is used as the basis for the engine temperature.

### 9.1.1 Basic gas mixer position for an engine start

The values given in the table ⇨ Setting the reference parameters are only guidance values for the first engine start. A lean starting position should always be selected.

Any changes in the values given must be made in accordance with TA 1503-0046.

#### Gas mixer and air throttle position range

The graph in Figure 1 below shows the changes in the gas mixer and air throttle positions from engine start-up to reaching rated power. The air throttle setting should mean that the gas mixer position only changes very slightly between engine start-up and reaching rated power. **(Special gas mixer guideline value 15% max.)**

The graph in Figure 1 also shows the adaptive gas mixer position for the engine start.

If the actual speed is below that set in the parameter **Speed limit for gas mixer offset**, the value entered in the parameter **Gas mixer offset for engine start** is subtracted from the gas mixer position dependent on the oil temperature. As soon as this speed is exceeded, this offset is deactivated.

Tis function avoids the engine starting with too rich a mixture in the lower speed range.

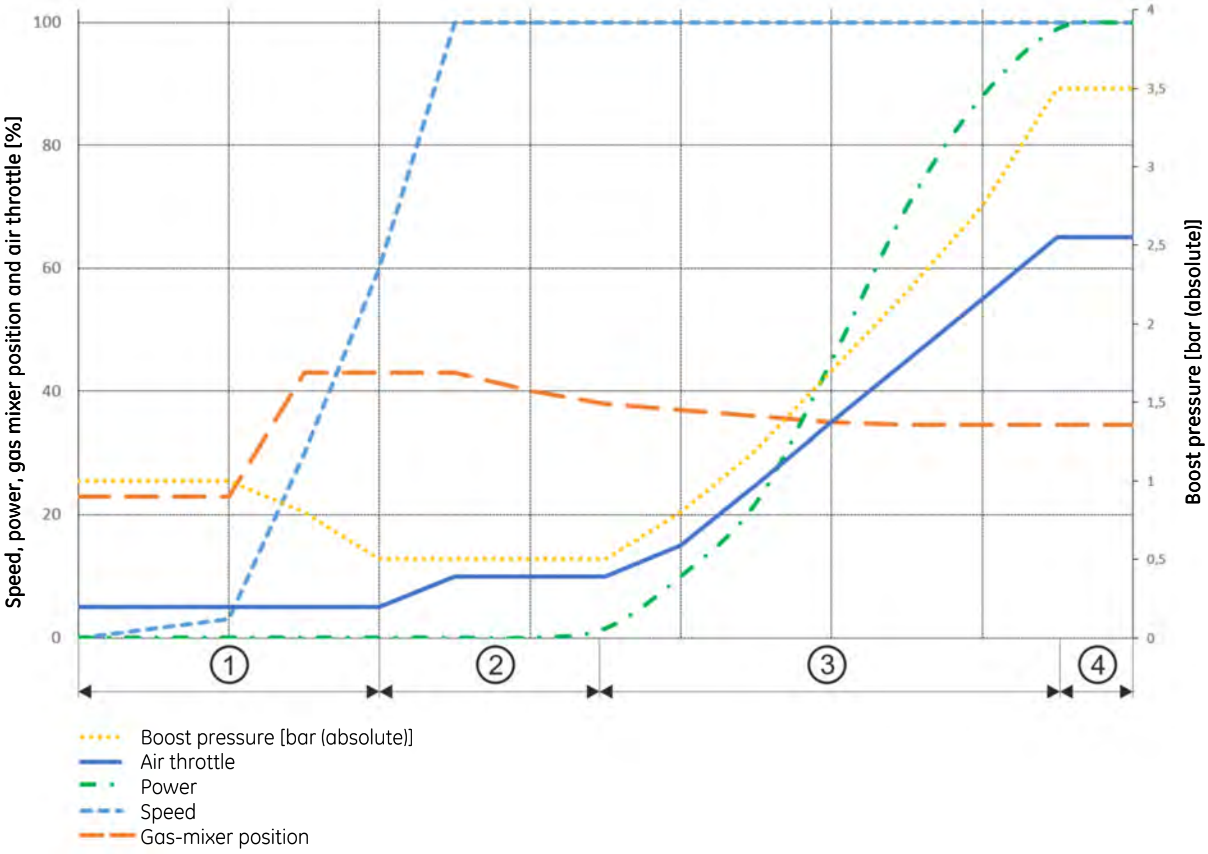



*Diagram 1: Gas mixer and air throttle position range*

| | | | |
|---|---|---|---|
| ① | Engine start | ② | Speed controller active |
| ③ | Power build-up | ④ | Full load |

**WARNING**

**Deflagration and ejected debris**

If the differences between idling and full load are greater than 15 %, the Leanox controller may become unstable at load application and the transition to Leanox controller operation and the mixture can become inadmissibly rich. This could result in undesirable instability or shutdowns and possible deflagration in the exhaust system, posing a risk of ejected debris.

- The difference between the positions for engine starting and full load should not be more than a maximum of 15 %.

## 10 Checking and optimizing engine operation

Once the engine has been successfully started and is **idling**, carry out the following checks:

- check the zero pressure controller with a water column
- check the exhaust gas temperatures
- check the speed fluctuations
- check the charge pressure
- check the prechamber gas differential pressure
- check the exhaust gas emissions
- check the speed changes when starting

The table below shows the expected values for this operating point. Operating points must be optimised and adjusted in accordance with TA 1503-0046.

| Control parameter | Measured value | Note |
|---|---|---|
| **Zero pressure controller** | + 1 to 2 mm water column | |
| **Cylinder exhaust gas temperature** | < 680 °C | **No** individual cylinder > 700 °C |
| **Exhaust gas temperature after TC** | < 570 °C | |
| **Speed fluctuations** | < ±5 rpm | |
| **Charge pressure p2' [bar(a)]** | 0.45 … 0.6 | |
| **Prechamber differential pressure** | 50 mbar | 50 ... 100 mbar acceptable for NNG |
| **NOx exhaust gas emissions [ppm]** | 60…200 | Misfires increase the $O_2$ content |
| **O2% exhaust gas emissions [% by vol.]** | 3.5 … 8.0 | Misfires increase the $O_2$ content |
| **NOx exhaust gas emissions [mg/Nm³]** | 130 … 450 | Misfires increase the $O_2$ content |

The graph in Figure 2 shows a comparison of three different speed curves at start-up.

The dashed speed curve (brown) shows an engine start with an over-rich mixture - the engine comes up to speed very quickly but this is followed by a longer period of fluctuations around the set speed. If the engine were idled with these settings, this would in all likelihood result in inadmissibly high exhaust temperatures and misfiring due to the over-rich mixture.

The dotted dashed curve (orange) shows an engine start with too lean a mixture - the engine has difficulty in coming up to speed and there is a noticeable kink in the activation of the speed controller. These settings can result in increased misfiring when idling, which ultimately results in significant increase in the concentration of unburnt fuel. This must always be avoided.

After the start parameters have been optimised, the starting behaviour should look like the solid line (green). The engine should come up to speed smoothly and quickly, and fluctuations around the set speed should be kept within limits.

The parameters in this document are only guidance values, and must be optimised on site for whatever gas is available at commissioning or after maintenance work.

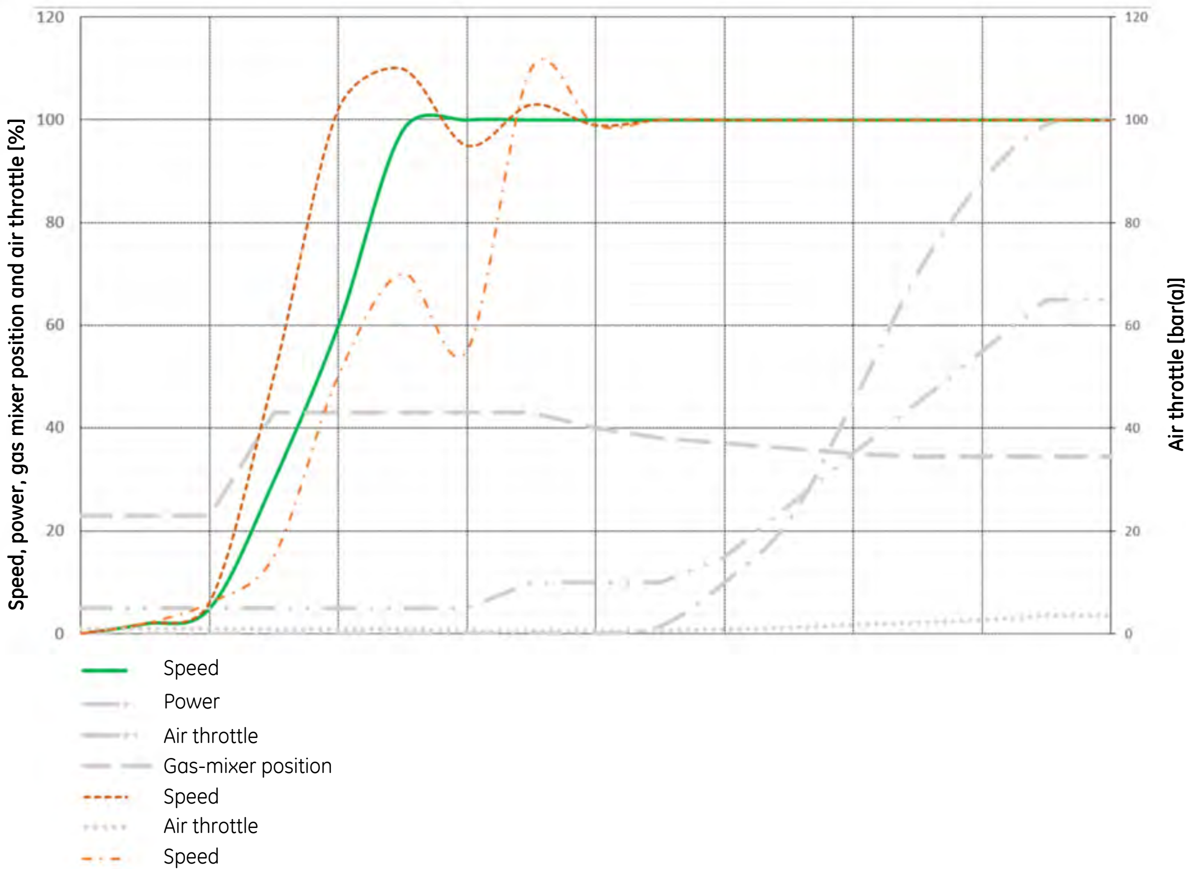



*Diagram 2: Comparison of different start-up curves*

# 11 Troubleshooting

## 11.1 Error messages

### 11.1.1 Warning

| Message text and number | Error | Solution |
|---|---|---|
| Measuring signal failed in gas mixer | | |

| Message text and number | Error | Solution |
|---|---|---|
| 2086 (currently not in use) | | |

### 11.1.2 Tripping

| Message text and number | Error | Solution |
|---|---|---|
| Gas mixer control faulty<br>1083 – Priority 1 | Deviation between setpoint and actual position too great | |

## 11.2 Troubleshooting

### 11.2.1 Power supply, electronics, visualisation

| Symptoms | Error | Solution |
|---|---|---|
| **Power control card:**<br>LED 2 lit | Short circuit between two motor phases | Fix short circuit at U/V/W |
| LED 3 lit | Overtemperature at heat sink in control card | Check ventilation in interface cabinet, check ventilation in power card box, reduce motor current (selector switch to C) |
| LED 4 lit | Overvoltage (>40 V) | Test power supply (battery, charger) |
| LED 5 lit | Undervoltage (<18 V) | Test power supply (battery, charger) and starter |
| LED 4 and 5 lit | Missing release signal for control function | Check digital signal (release and gate) |
| LED 2, 3, 4 and 5 lit | Interference pulses or excessive pulse frequency | Check shielding, check DIP switch and hook switch settings |
| **Converter:**<br>Power supply LED not lit | 24 V power supply faulty; converter faulty | Test 24 V power supply; test for reversed polarity; replace converter |
| **Visualisation:**<br>Red marks appearing in screen 411 (gas mixer details) | Control program does not contain the necessary variables | Add program section for special gas mixer |
| **Stepper motor operation:**<br>Setpoint preset and encoder feedback do not match | No or faulty referencing carried out (GAS MIXER CONTROL FAULTY).<br>Encoder phases wrongly connected.<br>Stepper motor phases wrongly connected.<br>Encoder module on stepper motor or converter faulty. | Carry out new referencing operation.<br>Check encoder and stepper motor cabling.<br>Replace stepper motor or converter. |

### 11.2.2 Mechanical problems

| Symptoms | Error | Solution |
|---|---|---|
| **General:**<br>Gas mixer elements do not appear to be moving | Electrical or mechanical problem | Open the windows on the sides of the gas mixer tubes and observe the movement of the elements |
| Strong contamination through accompanying elements in the fuel gas (e.g. tar) | Plastic components can swell up, moving parts can get stuck | Replace the plastic components |
| **Stepper motor:**<br>Deviation between setpoint and actual position | Preset position is losing steps | Check signal transmission paths (see 5.2.1); test shielding as instructed |
| Deviation between setpoint and actual position | Poor transmission of mechanical power | Check stepper motor – spindle coupling for slippage |
| Deviation between setpoint and actual position | Mechanical wedging, adhesion to stops, too little power supplied by the stepper motor | Check stops for dirt; check mechanical stopping faces; check that spindles are running smoothly; defective stepper motor |
| **Smooth running of engine:**<br>Unstable engine running, gas pressure fluctuations | Zero pressure not achieved on gas side | Check gas pressure control system for adjustment to zero pressure level |
| Unstable engine running<br>Shutdown at “Lox-Limit” | Significant fluctuations in gas quality | Check on gas supply, current gas analysis and volume of gas produced |

## 12 Revision code

**Revision history**

| Index | Date | Description / Revision summary | Expert<br>*Auditor* |
|---|---|---|---|
| 5 | 15.04.2019 | GE durch INNIO ersetzt / GE replaced by INNIO | **Opoku**<br>*Pichler R.* |
| 4 | 15.12.2016 | Strukturelle Anpassungen / Structural adaptions<br>Kapitel 8, 9, 10 hinzugefügt / Added chapter 8, 9, 10 | **Prankl S.**<br>*Boewing R.* |
| 3 | 08.08.2012 | Punkt 3.1.2 korrigiert. / Point 3.1.2 corrected | **Bilek**<br>*Greuter* |
| 2 | 09.07.2012 | Punkt 3.2.2 und 4. / Point 3.2.2 and 4. | **Bilek**<br>*Condin* |
| 1 | 31.05.2010 | Umstellung auf CMS / Change to Content Management System ersetzt / replaced Index: c | **Schartner**<br>*Provin* |