



Read this instruction carefully prior to installation and/or use. Pay attention particularly to all advice and safety instructions to prevent injuries. Bühler Technologies GmbH can not be held responsible for misusing the product or unreliable function due to unauthorised modifications.



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1 Important advice

Please check before installation of the device that the technical data matches the application parameters. Also check that the delivery is complete.

Operation of the device is only valid if

- the product is used under the conditions described in the installation- and operation instruction, the intended application according to the type plate and the intended use,
- the performance limits given in the datasheets and in the installation- and operation instruction are obeyed,
- monitoring devices and safety devices are installed properly,
- service and repair is carried out by Bühler Technologies GmbH, unless described in this manual,
- only original spare parts are used.











This manual is part of the equipment. The manufacturer keeps the right to modify specifications without advanced notice. Keep this manual for later use.

- Always be careful when transporting the BA 3500. Strong shocks and vibrations can affect the service life of the measuring cell!
- Condensations inside the housing must be prevented, as this could seriously damage the measuring system. If the gas to be analysed contains condensable components, a sample gas conditioning system must be installed downstream the BA 3500. (Please contact our experts, see chapter 6.3)
- **This unit may not be used in hazardous areas.**
- **It is not suited for analysing explosive or combustible gas mixtures.**
- Be sure to adhere to the permissible data.
- Disconnect from the mains power supply before opening the device.

1.1 General indication of risk

Definitions for warnings:

| | |
|----------------|---|
| NOTE | Signal word for important information to the product. |
| CAUTION | Signal word for a hazardous situation with low risk, resulting in damaged to the device or the property or minor or medium injuries if not avoided. |
| WARNING | Signal word for a hazardous situation with medium risk, possibly resulting in severe injuries or death if not avoided. |
| DANGER | Signal word for an imminent danger with high risk, resulting in severe injuries or death if not avoided. |

| | | | | | |
|---|---|---|--|---|-----------------------|
|  | Warning against hazardous situation |  | Warning against possible explosive atmospheres |  | disconnect from mains |
|  | Warning against electrical voltage |  | Warning against hot surface |  | wear respirator |
|  | Warning against respiration of toxic gases | | |  | wear face protection |
|  | Warning against acid and corrosive substances | | |  | wear gloves |

Installation of the device shall be performed by trained staff only, familiar with the safety requirements and risks.

Check all relevant safety regulations and technical indications for the specific installation place. Prevent failures and protect persons against injuries and the device against damage.









The person responsible for the system must secure that:

- safety and operation instructions are accessible and followed,
- local safety regulations and standards are obeyed,
- performance data and installation specifications are regarded,
- safety devices are installed and recommended maintenance is performed,
- national regulations for disposal of electrical equipment are obeyed.

Maintenance and repair

- Repairs on the device must be carried out by Bühler authorized persons only.
- Only perform modifications, maintenance or mounting described in this manual.
- Only use original spare parts.

During maintenance regard all safety regulations and internal operation instructions.

| | | |
|--|--|---|
|  | <p>⚠ DANGER</p> <p>Electrical voltage</p> <p>Electrocution hazard.</p> <p>Before opening the cover or working on electrical components, disconnect the device from power supply. Make sure that the equipment cannot be reconnected to mains unintentionally.</p> <p>Installation and maintenance must be carried out by by trained staff only. Regard correct mains supply.</p> |  |
|   | <p>⚠ DANGER</p> <p>Toxic and corrosive gases</p> <p>Sample gas can be hazardous.</p> <p>Take care that the gas is exhausted in a place where no persons are in danger.</p> <p>Before maintenance turn off the gas supply and make sure that it cannot be turned on unintentionally.</p> <p>Protect yourself during maintenance against toxic / corrosive gases. Use gloves, respirator and face protector under certain circumstances.</p> |    |
|  | <p>⚠ DANGER</p> <p>Explosion hazard if used in hazardous areas</p> <p>The device is <u>not suitable</u> for operation in hazardous areas with potentially explosive atmospheres.</p> <p><u>Do not expose</u> the device to combustible or explosive gas mixtures.</p> | |

2 Installation and connection

Installation of the device shall be performed by trained staff only, familiar with the safety requirements and risks.

2.1 Figures (Automatic calibration not included)

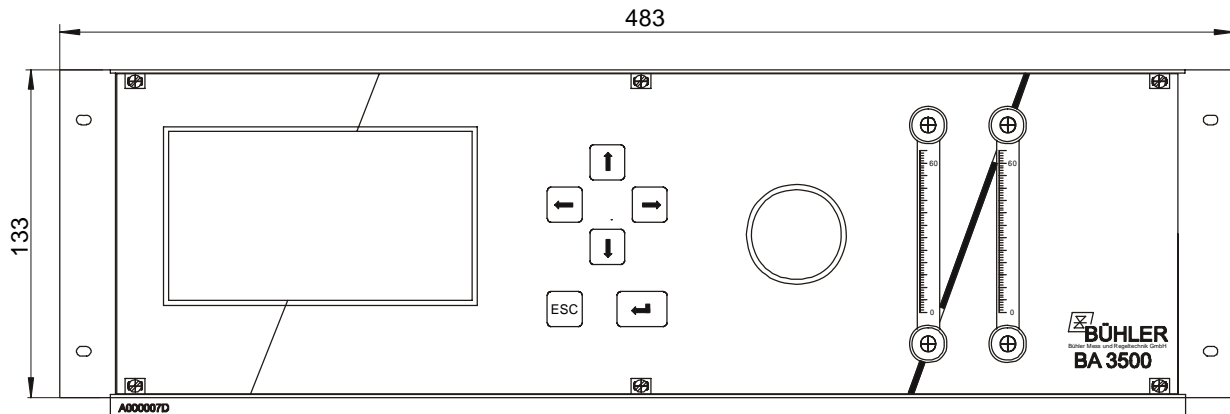


Figure 1: Front of BA 3500

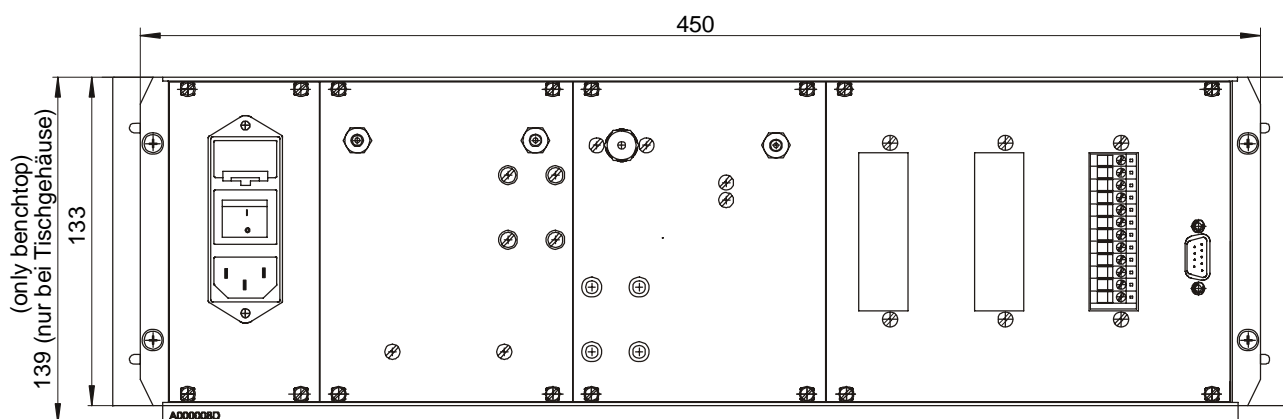


Figure 2: Rear of BA 3500


Please note: the above shown flow meters are optional devices.

2.2 Delivery

The device is delivered in a cardboard box with filling material to protect the unit during transport. Dispose the packing material according to local regulations.


2.3 Location of installation

During operation, the ambient temperature must be between +5°C and +45°C (41°F and 114°F). The measuring cells are temperature-compensated up to approx. 50°C (122°F). Temperature fluctuations are mostly compensated.

| | |
|---|-------------|
|  | NOTE |
| Please note that all changes in temperature and barometric pressure since the last calibration can lead to deviating measuring results. Carry out calibration in regular intervals and after large barometric changes, see chapter 3 and 4. | |

The unit must be installed at a vibration-free location. Especially low-frequency vibrations from traffic and heavy machinery can influence the accuracy of the results.

Protect the device against direct sunlight.

| | |
|--|---------------|
|  | DANGER |
| Explosion hazard if used in hazardous areas | |
| The device is <u>not suitable</u> for operation in hazardous areas with potentially explosive atmospheres. | |
| Do <u>not expose</u> the device to combustible or explosive gas mixtures. | |

2.4 Sample gas requirements

2.4.1 Gas conditioning

Normally, the analyser is one component of a measuring system. For a failsafe and maintenance free operation with accurate results, it is important that all components are assembled in a proper manner. The selection of the gas sampling point, the quality and type of the gas conditioning devices as well as the careful installation are equally decisive factors for the successful operation as the analyser itself.

Please consult the experienced person of our customer service to find the best solution for your specific measuring tasks (see chapter 6.3).

2.4.2 Reference gas inlet

The reference gas should be supplied through the same inlet as the sample gas. Ensure that the reference gas is introduced into the device at the same pressure, temperature and flow as the sample gas.

2.5 Gas connections

2.5.1 Sample gas connections

Sample gas inlet ("Gas in")

The inlet for the sample gas is located at the rear of the BA 3500. It is designed for the connection of a hose with an internal diameter of 4 mm for the paramagnetic and the NDIR measuring cell (options 3 mm Swagelok screw connection). The zirconium dioxide measuring cell is connected with a 3 mm Swagelok fitting. At high gas inlet pressure or high flow rates a bypass (T-piece) should be installed.

Admissible Volume flow



The volume flow must be set between 10 and 100 l/h (0.17 and 1.7 l/min). The gas overpressure should be between 10 and 200 mbar (0.15 psi and 2.9 psi). If the device is operated with an internal sample gas pump, the volume flow is determined by the performance of this pump and the attached gas conditioning devices. Depending on the set-up of the measuring equipment, the pump pressure must be reduced by means of a fine regulation valve at the inlet of the BA 3500.

Exception: ZrO₂-measuring cell

The ZrO₂-module is always equipped with an internal gas pump to control the optimal gas flow rate of 8 l/h (0.13 l/min) for the measuring cell. In case of high gas flow (>8 l/h or 0.13 l/min) we recommend to install an additional bypass (e.g. T-piece) at the gas inlet.

Sample gas outlet ("Gas out")

The gas outlet is located at the rear of the BA 3500 and is suitable for the connection of a hose with 4 mm inner diameter.

| | |
|--|---|
|  |  NOTE |
| <p>Do not install a control valve for the adjustment of the volume flow at the gas outlet, as this could result in measuring errors caused by pressure differences.</p> | |

2.5.2 Sample gas filter

The gas filter is located at the front of the BA 3500. The filter housing can be opened by turning it anticlockwise. The filter sleeve can be reached by lifting the filter plate.

Regularly check the filter sleeve for contamination. If the filter sleeve is highly discoloured, it must be replaced. Certain applications however do not lead to a discoloration of the filter, as the dust is colourless. In this case, the filter must be tested for contamination.

2.6 Power Supply

2.6.1 General

The BA 3500 is equipped with a power supply connection at the rear of the housing.

The supply voltage is 230 V AC 50/60 Hz or 115 V AC 50/60 Hz. Make sure that the plant mains supply fits with the ratings given on the type plate of the BA 3500. If this is not the case send the device for adoption by the supplier.

The internal operating voltage is 24 V DC.

2.6.2 Fuses

Two fuses of 1.25 A (slow).

Always disconnect the BA 3500 from the power supply before you check the fuses.

Replace the fuses only use with fuses of the same type and amperage. (type, cut-off current, protection class, characteristic)

2.7 Signal Connections

The BA 3500 is equipped with up to three terminal blocks for signal connections at the rear. If the optional autom. Calibration is used, there is an additional Sub-D 12 F connector built in at the rear panel, to coordinate the external solenoid valves. For the connection of the individual measuring modules and the optional automatic calibration, please refer to the figures. **The solenoid valves are not included in delivery.**

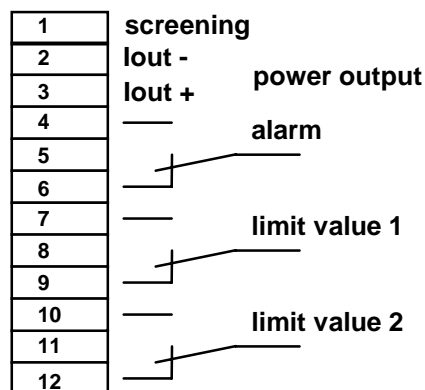


Figure 3: Terminal connections

Sub-D 12 F Connector

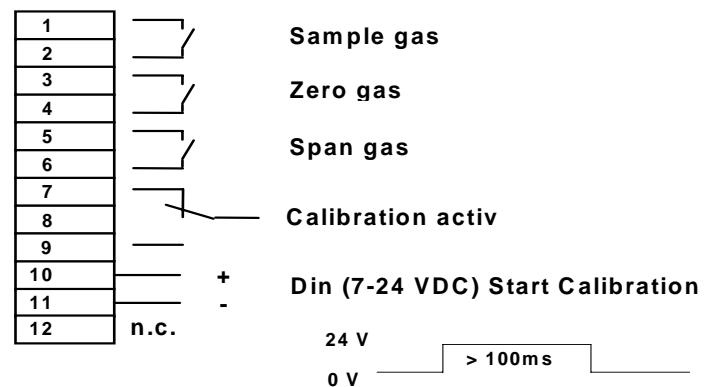


Figure 4: Connector (auto Calibration) optional

2.7.1 Signal output

The Signal output is potential free. The max. load is 500 Ω.

2.7.2 Relay contact

The relay contacts provide a signal for the preset limits as well as for the error signal. For each measured component, two limit signals and one alarm signal are provided. Maximum load of the relays are 125 VAC/ 1 A or 60 V DC/ 1 A

2.7.3 RS-232 interface

Via RS-232 interface, measured data and error messages can be transmitted to a receiver.

Parameters of the RS-232 interface:

| Parameter | Value |
|-----------|-----------------------------------|
| Baud rate | 4800, 9600, 19200 Baud adjustable |
| Stop bits | 1 |
| Data bits | 8 |
| Parity | none |
| Handshake | none |

The transfer time varies; all characters are transferred as ASCII codes.

Every transfer is completed with 'CR'.

Log:

| Command | Response | Description |
|---------|--------------------------|---|
| M1CR | M1 x.xxExxCR | measured value channel 1 |
| M2CR | M2 x.xxExxCR | measured value channel 2 |
| M3CR | M3 x.xxExxCR | measured value channel 3 |
| L1CR | XXXXX: x.xxExx XXX CR | measured value channel 1 with gas type and unit e.g. O2: 2.34E02 ppm |
| L2CR | XXXXX: x.xxExx XXX CR | measured value channel 2 with gas type and unit e.g. CO2: 2.34E01 Vol% |
| L3CR | XXXXX: x.xxExx XXX CR | measured value channel 3 with gas type and unit, e.g. CO: 2.34E01 Vol% |
| | ERRORxx | Error message For description of error messages, please refer to chapter 9 |

Pin assignment:

| Pin | Assignment |
|-----|------------|
| 1 | + 24V DC |
| 2 | RXD |
| 3 | TXD |
| 5 | GND |

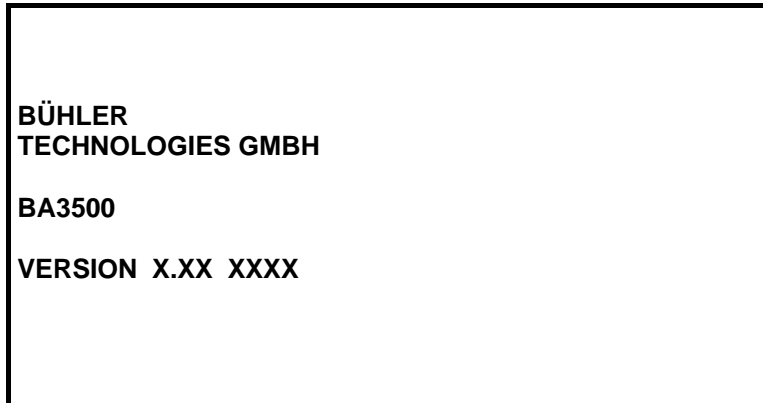
3 Operation

3.1 Switching on the Unit

3.1.1 Switching on of the device

- Ensure that the gas preparation system is fully operational (filter, gas cooling system)
- Ensure that the supply voltage corresponds to the voltage required for your BA 3500
- If this is not the case, the voltage of the device must be adjusted. Please contact your supplier.

After the BA 3500 is switched on, the following information is displayed for a few seconds:



Subsequently, the display changes to the main window.

3.1.2 Warm-up time

The BA 3500 takes approx. 1 hour to achieve a stable temperature of the electronic devices and the measuring cell. After the warm-up time, the BA 3500 is ready for measuring as described in **3.2**.

In the case of suppressed or extremely small measuring ranges, we recommend a warm-up time of 12 hours.

3.2 Preparation of measurements

3.2.1 Calibration

Prior to carrying out the first measuring, always check the calibration of the BA 3500 (see chapter 4). Correct measuring results can only be achieved with a correctly calibrated BA 3500. An optional automatic calibration for a maximum of 2 channels of the BA 3500 can be offered.

3.2.2 Switching on gas supply

If the BA 3500 is equipped with a sample gas pump, the gas supply can now be opened by means of menu item "General settings" (see also 3.5.2).

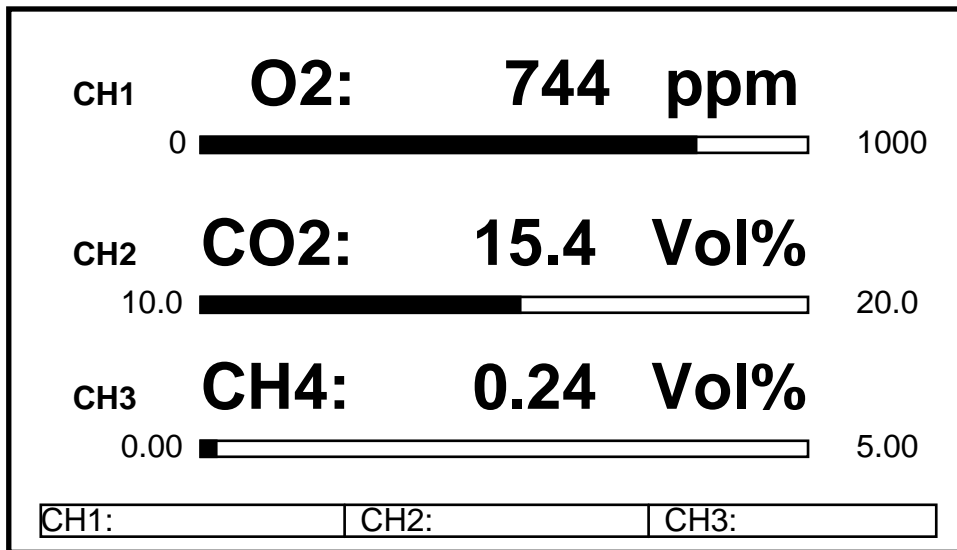
If your BA 3500 has no integrated sample gas pump, switch on the external pump and open the inlet valve.

Exception: ZrO₂-measuring cell

The ZrO₂-module is always equipped with an internal gas pump to control the optimal gas flow rate of 8 l/h (0.13 l/min) for the measuring cell. In case of high gas flow (> 8 l/h (0.13 l/min)) we recommend to install an additional bypass (e.g. T-piece) at the gas inlet.

3.3 LCD display during measuring operation

During standard operation, the display reads as follows:



The measured substance, the set output value range and the current values are displayed. The bottom of the display shows the current status (see chapter 5.4).

3.4 Operation of menu functions







3.4.1 Principle of operation

This summary description is intended for persons that are already experienced in the operation of the BA 3500.

For detailed instructions, please refer to chapters 3.4.2 and 3.5, respectively.

Keys:

The control panel consists of 6 keys with the following functions:

| Key | Functions |
|---|--|
|  | <ul style="list-style-type: none"> ➤ Display of menu options ➤ Activation of a menu option |
|  | <ul style="list-style-type: none"> ➤ Exits active menu item |
|  | <ul style="list-style-type: none"> ➤ Changes from the main display to the status display ➤ Selection of menus for settings in the status display ➤ Selection of a menu option |
|  | <ul style="list-style-type: none"> ➤ Changes from the main display to the status display ➤ Selection of menus for settings in the status display ➤ Selection of a menu option |
|  | <ul style="list-style-type: none"> ➤ Selection of active item in entry fields |
|  | <ul style="list-style-type: none"> ➤ Selection of active item in entry fields |

3.4.2 Detailed description of the principle of operation





The detailed instructions in chapter 3.5 introduce you step by step to the menu options of the BA 3500, therefore no basic knowledge of the system is required.

3.4.2.1 General



User code protection




To prevent unauthorised access to the settings of the BA 3500, you have the option to define a security code in menu option "General settings". If this protection is activated, you are requested to enter the code prior to the first modification. The access is only reset when you leave the menu and go back to the main display.

Edit (edit field)

Fields where entries can be made show a blinking cursor. To increase a value, press the  key. To decrease a value, press the  key. The increase/decrease is always in units. To move the cursor, press the  or  key respectively.




For certain functions, the value to be selected must be within a permitted range based on the configuration of your device.



The entered value only applies, if you exit the edit mode by pressing the  key. Press  to exit the edit mode without accepting the entered values. The previous value (value prior to editing) applies and is displayed again.

| | |
|---|---|
|  | NOTE As long as you don't press the  key in edit mode, you are not making any changes to the settings! If ever in doubt, press  key. |
|---|---|

To permanently save the settings, select the "Save values" function! If the settings are not saved, you are prompted by the program when you exit the respective menu option.

Select (select field)

The select field is similar to the edit field. However, here you must make a selection from a list rather than enter a value. Select the menu option by pressing the  key to view the current setting. Use the  and  keys to move up and down through the option list. If the option at the bottom is reached, the system automatically goes back to the first option. The same applies accordingly when the first option in the list is reached.

The entered selection only applies, if you exit the select mode by pressing the  key. Press  to exit the select mode without accepting the selected values. The previous selection (selection prior to entering the select mode) applies and is displayed again.

3.5 Description of menu functions

3.5.1 Status display

Press the keys  and  to change from the main display to the status display.

The status display contains detailed informations on the status of the respective measuring cell. The displayed data varies depending on the applied measuring module. These values cannot be modified and are displayed primarily for information purposes in the event of errors.

From here, you have the option to access the submenus "General settings", "Channel settings", "Current output" and "Calibration". Activate the cursor by pressing the **←** key. Select the required submenu with **↑** or **↓** and confirm your selection with **↵**.

NDIR status display:

| | | |
|---------------------|------|-------|
| CH1: | CO2: | 5.4 % |
| NDIR-CO2 | | |
| STATUS: | | OK |
| GENERAL SETTINGS... | | |
| CHANNEL SETTINGS... | | |
| CURRENT OUTPUT... | | |
| CALIBRATION... | | |

ZrO2 status display:

| | | |
|---------------------|-----|----------|
| CH2: | O2: | 250 ppm |
| ZrO2 2021 | | |
| STATUS: | | WARM UP |
| CELL VOLTAGE: | | 188.1 mV |
| CELL TEMPERATURE: | | 720 °C |
| CELL RESISTANCE: | | 0.4 Kohm |
| GENERAL SETTINGS... | | |
| CHANNEL SETTINGS... | | |
| CURRENT OUTPUT... | | |
| CALIBRATION ... | | |

Status display of paramagnetic sensor:

| | | |
|---------------------|-----|--------------|
| CH3: | O2: | 10.5% |
| PARAMAGN. | | |
| STATUS: | | ERROR 2 |
| | | OUT OF RANGE |
| PRESSURE COMPENS.: | | EIN |
| SAMPLE PRESSURE: | | 997 hPa |
| GENERAL SETTINGS... | | |
| CHANNEL SETTINGS... | | |
| CURRENT OUTPUT... | | |
| CALIBRATION ... | | |

3.5.2 General settings

This menu concerns settings that concern the entire device. It can be accessed from all status displays and shows the following window:

| | |
|-------------------------|-----------------|
| GENERAL SETTINGS | |
| USER CODE: | 0000 |
| NEW USER CODE: | |
| LANGUAGE: | ENGLISH |
| PUMP 1: | ON |
| PUMP 2: | OFF |
| RS232 BAUD RATE: | 9600 |
| DATE: | 02-10-99 |
| TIME: | 12:23:11 |
| SAVE ! | |
| RETURN ! | |

User code: If user code protection is activated, modifications and settings can only be made after entry of the correct user code.

New user code: Change of user code: Setting "0000" deactivates the user code protection.

Language: Change of language (German / English)

Pump 1: Switching on internal pump 1. (On / Off) (only, if installed)

Pump 2: Switching on internal pump 2. (On / Off) (only, if installed)

RS232 baud rate: Definition of the transfer rate of the RS 232 interface. (4800 / 9600 / 19200)

Date: Entry of current date. (TT-MM-YY)

Time: Entry of current time. (HH:MM:SS)

Save values: Saving of new values

Return: Back to status display

3.5.3 Channel settings

In this menu, you have the option to define settings that concern only the respective measuring module. The following window is displayed:

| | | |
|--------------------------|------------|------------------|
| CHANNEL SETTINGS | | |
| CH1: | O2: | 15 % |
| PARAMAGN. | | |
| PRESSURE COMP. | | On |
| RANGE ZERO POINT: | | 0 % |
| RANGE END MARK: | | 25 % |
| LIMIT VALUE 1: | | < 13 % |
| LIMIT VALUE 2: | | > 17 % |
| DAMPING FACTOR: | | 3 sec |
| SAVE VALUES ! | | |
| RETURN ! | | |

Pressure compensation: Switching on of optional pressure compensation system (On / Off)

Range zero point: Definition of zero point of measuring value output

Range end mark: Definition of range end mark of measuring value output

Limit value 1: Definition of limit value 1 Selection "<" or ">".

Limit value 2: Definition of limit value 2 Selection "<" or ">".

Damping factor: Definition of the damping factor for the measuring signal in seconds.

Save values: Saving of new values

Return: Back to status display

3.5.4 Current output

This menu allows modifications of the current output.

| | |
|-----------------------|---------------|
| CURRENT OUTPUT | |
| CH1: NDIR - CO2 | CO2: 4.5 VOL% |
| CURRENT OUTPUT: | 4 - 20 mA |
| WHILE CALIBR.: | HOLD VALUE |
| TRIM VALUE: | REAL VALUE |
| ZERO POINT: | 0 |
| END POINT: | - 4 |
| SAVE VALUES ! | |
| RETURN ! | |

Current output: Definition of range for signal output (4 - 20 mA / 0 - 20 mA)

While calibrating: Definition of the status of the current output during calibration. (Hold value / Current value)

Trim current: Option to compensate signal output (Actual value or 0...20 mA)

Zero point: Adjustment of zero point to current measured value (Values ± 125)

End point: Adjustment of end point to current measured value (Values ± 125)

Save values: Saving of new values

Return: Back to status display

3.5.5 Calibration

This menu allows the calibration of the measuring module. For more detailed information on the calibration procedure, please see chapter 4.

| | |
|----------------------------------|----------------------|
| CALIBRATION | |
| CH1: NDIR - CO2 | CO2: 4.5 VOL% |
| ZERO GAS: | 0 VOL% |
| CALIBR. ZERO POINT: | START ! |
| VALUE: | - 0.3 |
| SPAN GAS: | 5.0 VOL% |
| CALIBR. SPAN GAS: | START ! |
| VALUE: | 1.111 |
| SAVE CALIBRATION ! | |
| RETURN ! | |

Zero gas: Default value for concentration of zero gas

Calibr. zero gas: Starting of zero gas calibration. The display changes to "Please wait..." After completion of the calibration process, the message "OK" or "Error" is displayed (see also chapter 4.4).

Value: Deviation of calibration from the zero point

Span gas: Definition of concentration of span gas concentration

Calibr. span gas: Starting of span gas calibration. The display changes to "Please wait..." After completion of the calibration process, the message "OK" or "Error" is displayed (see also chapter 4.4).

Value: Deviation of span gas calibration from zero point

Save values: Saving of new values

Return: Back to status display

3.5.6 Automatic Calibration (optional only for channel 1 and/or channel 2)

This menu allows the automatic calibration of the module, which is built in on channel 1 and/or channel 2 (optional). In this case it is not possible to be built in a third module.

| | |
|---------------------------------|---------------------|
| CALIBRATION | |
| CH1: PARAMAGN. | O2: 4.5 VOL% |
| CALIBR. MODE: | AUTOMAT. |
| SETTINGS... | |
| ZERO GAS: | 0 VOL% |
| SPAN GAS: | 5.0 VOL% |
| LAST CALIBR. BEFORE: | 180 h |
| START AUTOCALIBR.: | START ! |
| STATUS AUTOCALIBR.: | OK |
| | SAMPLE GAS |
| RETURN ! | |

Calibr. Mode: Either manual or automatic calibration on channel 1 or channel 2; display automat. or manuel.

Settings: see via point 3.5.8

Zero gas: Definition of zero gas concentration.

Span gas: Definition of span gas concentration.

Last Calibr. before: Displays the time since last calibration.

Start Autocalibr.: Starts the autocal. Display: Start!→ Calibration runs; Wait→ Calibr. mode is not active.

Status Autocalibr.: Shows the actual step of the autocalibr.action. The single steps are shown at point 3.5.8.

Return: Back to status display.

After starting the automatic calibration the BA 3500 checks the stability of the measuring value.

The tolerances of the paramagnetic module and the NDIR module are $\pm 0.1\%$ of the full scale value, for the ZrO₂ module $\pm 0.2\text{mV}$ for the zero point and 1% of the span gas for span calibration.

If the module does not receive the stability within 120 seconds the calibration will be stopped. ERROR 30/X is shown on the display (see 3.8.5.1)

If the measurement value is stable, the deviation from the rated value will be evaluated. The maximum deviation for the paramagnetic module and the NDIR module for the zero point calibration is $\pm 2\%$ of the full scale value. The maximum deviation for the span gas calibration is 25% for the rated value.


3.5.7 Settings (Auto calibration Channel 1 and or Channel 2) optional

In this menu you define the parameters of the automatic calibration.

| AUTOCALIBRATION | |
|---------------------|--------|
| ZERO GAS: | |
| STABIL. TIME min.: | 1 min |
| STABIL. TIME max.: | 10 min |
| SPAN GAS: | |
| STABIL. TIME min.: | 1min |
| STABIL. TIME max.: | 7 min |
| SAMPLE STABIL.TIME: | 5 min |
| RESPONSE TIME max.: | 30 s |
| CYCLE TIME: | 12 h |
| SAVE ! | |
| RETURN ! | |

Here you can set the flushing-time (stabilisation time) for the different gas types (zero gas, span gas, measuring gas). The flushing-time is adjustable from 0 up to 30 minutes. Should the single value during the flushing time not be stabilized, the calibration will be stopped. The display shows a failure code of ERROR 30/X (s. 3.5.8).

Further more you can set the cycle-time of the automatic calibration from 0-999 h.

| | |
|---|---|
|  | NOTE |
| | The automatic calibration has to be activated directly by the keys on the BA 3500 or by an external signal, if any settings had been changed. |

3.5.8 Status Auto calibration

The actual step of the auto calibration is shown.

| STEP | description |
|------|--------------------------|
| 0 | SAMPLE GAS |
| 1 | SPAN GAS |
| 2 | ZERO GAS |
| 3 | ZERO GAS STABIL. |
| 4 | ZERO CALIBRATION |
| 5 | SPAN GAS |
| 6 | SPAN GAS STABIL. |
| 7 | SPAN CALIBRATION |
| 8 | SAMPLE GAS STABIL |

3.5.8.1 The automatic calibration step by step

There are eight steps for the automatic calibration.

| Step | Procedure |
|------|--|
| -1 | Sample gas valve opened , span gas valve closed , zero gas valve closed , normal measurement. |
| 0 | Holds actual value of current output. |
| 1 | Start of the optional automatic calibration. Sample gas valve closed , span gas valve opened , zero gas valve closed Waiting for 90% value → next step, if value not stable within the max. flushing time → Error Error 30/1: no span gas |
| 2 | Sample gas valve closed , span gas valve closed , zero gas valve opened Waiting for 90% value → next step, if value not stable within the max. flushing time → Error Error 30/ 2: no zero gas |
| 3 | Valves like in step 2 Waiting for min. flushing time |
| 4 | Valves like in step 2 Checks the stability of the measured value If in the stability range → ZERO GAS CALIBRATION → next step If value not stable within the max. flushing time → Error Error 30/3: zero gas not stabil or Error 30/5: zero out of range |
| 5 | Sample gas valve closed , span gas valve opened , zero gas valve closed Waiting for 90% value → next step, |

| Step | Procedure |
|------|--|
| | If value not stable within the max. flushing time → Error Error30/1: no span gas |
| 6 | Valves like in step 5 Waiting for min. flushing time → next step |
| 7 | Valves like in step 5 Checks the stability of the measured value If in the stability range → SPAN GAS CALIBRATION → SAVE VALUES ! → next step If value not stable within the max. flushing time → Error Error30/4: span gas not stabil or Error30/6: span out of range |
| 8 | Sample gas valve opened , span gas valve closed , zero gas valve closed Waiting for flushing time sample gas → current output displays measuring value END OF AUTOCAL |

If there are any errors during the calibration, they are shown on the display.

Possible Errors:

| ERROR | Description |
|-------|--------------------------|
| 30/1 | NO SPAN GAS |
| 30/2 | NO ZERO GAS |
| 30/3 | ZERO NOT STABIL |
| 30/4 | SPAN NOT STABIL |
| 30/5 | ZERO OUT OF RANGE |
| 30/6 | SPAN OUT OF RANGE |
| 30/7 | BREAK |

3.5.9 Alarm relays

Three relay contacts are assigned to each measuring component, namely two limit value contacts and one error contact.

The settings for the alarm relays are described in chapter 3.5.3. Each contact can be set to "High" or "Low". In addition to the relay, an alarm message appears on the display.

The error relay responds to faults of the device as well as to disruptions occurring in the respective measuring module. An error code is displayed. For more information on error codes, please refer to chapter 5.4.

An error of the optional automatic calibration activates the error relays of the channel and will be shown as message (**ERROR 30/X**). The current output will not be touched.

4 Calibration

5.1 Introduction

It is a fact that the properties of optical and electronic components change over the period of operation. Even the smallest changes however affect the results of measuring procedures, even if the external conditions remain unaltered. Ambient temperature, air pressure and gas flux deviations can also influence the measured values. Such changes in the measuring behaviour are referred to as drift.

In order to compensate the drift, the BA 3500 must be regularly recalibrated. During the calibration procedure, the behaviour of the device is checked with a reference gas. The detected deviations from the nominal status are subsequently compensated by readjustment of the device (see chapter 3.5.5).

When is recalibration necessary?

The BA 3500 should be recalibrated in the following cases:

- Each time the device is switched on, after starting time
- After considerable changes in the barometric pressure conditions (changes in the weather), unless the unit is equipped with an optional pressure compensation system
- At regular intervals during the operation (weekly or at least monthly)

4.1 Reference gases for calibration

Since the measuring system operates in a linear manner, two calibration points are sufficient for the control

4.1.1 Zero gas/calibration gas 1

The zero gas is used for the calibration of the zero point. The zero gas may not contain the gas component to be measured. A particularly suitable gas for this purpose is nitrogen N₂.

In special cases, the zero gas is a mixture of N₂ and one or more other components.

4.1.2 Reference gas /calibration gas 2

The reference gas is used for the calibration of the sensitivity of the device. A reference gas is a mixture of the gas component to be measured and the zero gas. In addition, it may contain one or more components that are also found in the gas to be measured.



4.1.3 Nominal value for reference gas

The nominal value for the reference gas should correspond to the actual concentration of the gas to be analysed, insofar as this is possible. The nominal concentration should however never be below 50% of the initial measuring output range and should possibly be between 60% and 100% of the measuring output range.



4.2 Supply of reference gas

For devices without integrated sample gas pump, the reference gases must be supplied at the same admission pressure and volume flow as the sample gas.

In devices with an integrated gas pump, the reference gas should be supplied through a T-piece and the running pump. The pressure at the outlet of the gas cylinder must be increased, until the reference gas escapes at the T-piece.

| | |
|---|--|
|  |  NOTE |
| | In principle, the reference gas must be supplied under the same conditions as the gas for analysis. If the device is equipped with a gas preparation unit, the reference gas should also flow through this unit. |

4.3 Calibration

| | |
|--|---|
|  |  NOTE |
| | For suppressed or extremely small measuring ranges, the following instructions apply: <ul style="list-style-type: none">➤ The gas flow should be about 60 l/h.➤ The warm-up phase of the device should be extended by 12 hours.➤ Prior to the calibration of the final value, wait for approx. 3 minutes until a stable value is reached. |

For calibration, following the steps of the individual menu items (see also chapter 3.5.5).

1. In menu item "Zero gas", enter concentration of the component to be measured in the zero gas (normally 0%).
For the ZrO₂ module, the zero gas is always air (20.9% O₂). This value cannot be changed.
2. Supply zero gas to analyser. Wait until the value is stable.
3. Start calibration with menu item "Zero gas calibr.". The display changes to "Please wait..." The device is not checking the stability of the measuring signal. The fluctuation ranges for the paramagnetic module and the NDIR module are $\pm 0.1\%$ of the max. measuring range; for the ZrO₂ module, the respective value is ± 0.2 mV. If no stable value is reached after 120 seconds, the calibration procedure must be stopped. Please check the system. The calibration procedure can be terminated at any time by pressing the "ESC" key.
4. When a stable value has been reached, the deviation for the nominal value is calculated. The max. deviation is thereby $\pm 2\%$ from the max. measuring range for both paramagnetic and NDIR module. For the ZrO₂ module, the max. deviation is ± 10 mV.
5. Confirm value with "OK" or reject with "ERROR". In this case, check the measuring system and the calibration gas and repeat the calibration.
6. Enter the concentration of the gas component to be analysed in sample gas in menu item "Sample gas"
7. Supply sample gas to analyser.
8. Start calibration with menu item "Sample gas calibr.". The display changes to "Please wait..." The device is now checking the stability of the measuring signal. The fluctuation ranges for the paramagnetic module and the NDIR module are $\pm 0.1\%$ of the max. measuring range; for the ZrO₂ module, the respective value is ± 0.2 mV. If no stable value is reached after 120 seconds, the

calibration procedure must be stopped. Please check the system. The calibration procedure can be terminated at any time by pressing the "ESC" key.

9. When a stable value has been reached, the deviation for the nominal value is calculated. The maximum deviation is thereby $\pm 25\%$ from the maximum measuring range for both paramagnetic and NDIR module.
10. Confirm value with "OK" or reject with "ERROR". In this case, check the measuring system and the calibration gas and repeat the calibration.







4.4 Influence of other sample gas components

The selectivity of the different methods of analysis is based on the specific physical/optical properties of the gas component to be analysed (e.g. magnetic susceptibility of O₂ or IR excitation of CO₂ at a defined wavelength). The sensitivity of other gases is normally so small that their presence can be ignored.

Relevant errors only occur if the BA 3500 has been calibrated with nitrogen as a zero gas, while the gas to be analysed contains also other gases of similar physical/optical properties. In such a case, the gas analyser returns a result, even if the analysed gas does not contain the component of interest. It thus indicates an influence of the sample gas in respect to another gas.

Please consult our customer service to find the best solution for your specific measuring tasks. He will be able to recommend suitable counter-measures.

5 Maintenance

| | | |
|---|--|---|
|  | <p>⚠ DANGER</p> <p>Electrical voltage</p> <p>Electrocution hazard.</p> <p>Before opening the cover or working on electrical components, disconnect the device from power supply. Make sure that the equipment cannot be reconnected to mains unintentionally.</p> <p>Installation and maintenance must be carried out by by trained staff only. Regard correct mains supply.</p> |  |
|  | <p>⚠ DANGER</p> <p>Toxic and corrosive gases</p> <p>Sample gas can be hazardous.</p> <p>Take care that the gas is exhausted in a place where no persons are in danger.</p> <p>Before maintenance turn off the gas supply and make sure that it cannot be turned on unintentionally.</p> <p>Protect yourself during maintenance against toxic / corrosive gases. Use gloves, respirator and face protector under certain circumstances.</p> |    |

5.1 Maintenance schedule

| Interval | Maintenance work | See chapter |
|------------------------|--|-------------|
| 1-2 days | Visual inspection | 2.5.2 |
| 1 week | Inspection of gas filter element | 5.2 |
| 1 week to 1 month | Recalibration | 4.4 |
| every approx. 6 months | Inspection of gas line for leaks, inspection of gas pump | 5.3 |



Note: Please always comply with the applicable statutory requirements and internal instructions.

5.2 Replacement of filter element

Interval 1 week

Spare filter element Part No.
Type FE-E2, 5 pcs. 41 15 09 910

The filter element (white fibre-glass sleeve) must be immediately replaced if it shows any discoloration. For new applications, it is recommended to inspect the filter element on a daily basis until you have established the appropriate inspection interval.

| | |
|---|---|
|  |  NOTE Certain applications do not lead to a discoloration of the filter, as the dust is colourless. In this case, the filter must be tested for contamination. |
|---|---|

Procedure:

1. Prior to opening the filter, ensure that there are no hazardous gases or components in the gas filter.
2. Switch off integrated or external gas pump and disconnect gas supply (close valve).
3. Turn filter cover anticlockwise and remove.
4. Pull out top part of filter cover.
5. Pull out filter sleeve and inspect for discoloration and contamination.
6. Insert filter sleeve. Ensure that it is properly placed in the cover.
7. Clean seals and flanges, if necessary.
8. Insert filter cover without damaging filter.
9. Turn filter cover clockwise. Open gas supply.

5.3 Leakage test

Interval: every approx. 6 months (recommended interval)

Procedure:

1. Close gas outlet airtight.
2. Connect pressure meter at gas channel. Measuring range: approx. 25 kPa = 250 mbar = 250 hPa.
3. Close gas channel at gas inlet to gas preparation section airtight in order to ensure that the entire gas channel is tested.
4. Apply gas pressure of approx. 20 kPa from for example a nitrogen gas cylinder connected to any inlet to the gas channel. Subsequently close system airtight.
5. The pressure loss should not exceed 500 Pa or 5 mbar per 10 minutes. If you detect a greater pressure loss, check the gas channel and repair leaks (hoses, defective connections, etc.).

5.4 Status messages

The following status messages inform the user on the actual operation of the BA 3500. They are issued separately for each measuring module.

Status numbers 1 to 8 are status messages based on the set parameters.

Status numbers 9 to 33 are error messages from the measuring modules, the central computer or the internal data transfer system. The messages are primarily devised as an initial diagnostic tool for service staff.

| Nr. | Status | Description |
|-----|-----------------|---|
| 1 | OK | NORMAL USE |
| 2 | LIMIT 1 | LIMIT VALUE RELAIS 1 ACTIV |
| 3 | LIMIT 2 | LIMIT VALUE RELAIS 2 AKTIV |
| 4 | RANGE <<< | LOWER THAN MEASURE RANGE |
| 5 | RANGE >>> | HIGHER THAN MEASURE RANGE |
| 6 | LIMIT 1/2 | LIMIT VALUE RELAIS 1+ 2 ACTIV |
| 7 | WARM UP | HEATING UP PHASE |
| 8 | CALIBR. | AUTOCALIBRATION (optional) |
| 9 | ERROR 30 | ERROR AUTOCALIBRATION (optional) |
| 10 | ERROR 2 | SELF TEST FAILED |
| 11 | ERROR 3 | MODUL NOT DETECTED |
| 12 | ERROR 4 | MODUL SYSTEM ERROR |
| 13 | ERROR 5 | DEFECT OF THERMOCOUP |
| 14 | ERROR 6 | LOW CELL TEMPERATURE |
| 15 | ERROR 7 | BAD CELL RESISTANCE |
| 16 | ERROR 8 | MODUL OUT OF RANGE |
| 17 | ERROR 9 | LOW SAMPLE FLOW |
| 18 | ERROR 13 | Free |
| 19 | ERROR 13 | Free |
| 20 | ERROR 14 | MODUL ERROR 1 |
| 21 | ERROR 15 | MODUL ERROR 2 |

| Nr. | Status | Description |
|------------------------|---------------|--------------------|
| 22 | ERROR 16 | MODUL ERROR 3 |
| 23 | ERROR 17 | MODUL ERROR 4 |
| 24 | ERROR 18 | MODUL ERROR 5 |
| 25 | ERROR 19 | MODUL ERROR 6 |
| 26 | ERROR 20 | MODUL ERROR 7 |
| 27 | ERROR 21 | MODUL ERROR 8 |
| 28 | ERROR 22 | MODUL ERROR 9 |
| 29 | ERROR 23 | MODUL ERROR 10 |
| 30 | ERROR 24 | MODUL ERROR 11 |
| 31 | ERROR 25 | MODUL ERROR 12 |
| 32 | ERROR 26 | MODUL ERROR 13 |
| 33 | ERROR 27 | Free |
| Additional for RS 232: | | |
| | ERROR 0 | Transmission error |
| | ERROR 1 | WARM UP |

6 Storage, Transport, Disposal

6.1 Storage

Protection of internal gas channels

Before storing the device for an longer period of time, rinse gas outlet with dry nitrogen or air. Close all gas inlets and outlets (protection against humidity and dust).

External protection

Store the device only in a dry, well aired room. Cover the unit with suitable wrapping material for protection against liquid contamination and dirt.

6.2 Transport

For transport, place unit in original packaging, or in a large stable transport box made in triple cardboard, plastic or aluminium. Ensure that the device is protected by a layer of insulating material of a thickness of min. 10 cm on all sides.

For postage, label parcel as "FRAGILE".

6.3 Transport to MANUFACTURER for repair

If the device must be returned to the supplier or manufacturer for repairs, always include the following information:

- Detailed description of the error or failure.
- If the behaviour of the value output cannot be explained, include a typical record of this measuring behaviour with details regarding the measuring task.
- Short description of the operating conditions and the attached gas preparation system.
- Note the name of your contact at the supplier with which you have discussed the problem.
- Enclose also your name and telephone number.

Send device to:

Bühler Technologies GmbH
- Reparatur/Service -
Harkortstraße 29
40880 Ratingen
Germany

Tel. +49 (0) 2102 49 89 55

Fax +49 (0) 2102 49 89 20

E-mail: analyse@buehler-ratingen.com

6.4 Disposal

Regard the local regulations for disposal of electric and electronic equipment.

7 Appendix

7.1 Spare parts and consumables

| Part No. | Name |
|-----------------|-----------------------------------|
| 41 15 0991 | Filter sleeve |
| 41 15 099 | Filter housing |
| 55 07 0991 | Paramagnetic measuring cell |
| 55 07 1992 | Paramagnetic transducer, complete |
| 55 07 1991 | Internal pump |
| 91 10 0000 011 | Fuse |
| 55 10 4301 5 | Flow controller |
| 43 46 067 | Hose connector |

7.2 Attached documents

- Declaration of conformity KX 550003
- Data sheet DE/DA 550006