Potassium Content Measurement
LB 444 K-40

ID No.  55884BA2
Rev. Nr.: 00
**Operating Manual Potassium Meter**  
**LB 444 K-40**

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Operating Manual
Potassium Meter

LB 444 K-40

Issue

<table>
<thead>
<tr>
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<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01.01.10</td>
<td>First edition</td>
</tr>
</tbody>
</table>
1 General Information

Safety Summary

**Electrical Shock Hazard**
Disconnect power to ensure that contact with energized part is avoided during installation and servicing.

**Specific Warnings**
Never change the installation or the parameter settings without a full knowledge of the relevant part of this manual, the connected controller and the process, if it is controlled by this measuring device.
2 Overview

The Potassium Meter LB 444 K-40 is designed for measurements of the concentration of potassium in bulk materials, suspensions and solutions.

The concentration of potassium in bulk materials or liquid solutions is measured by detecting gamma radiation of the natural isotope K-40. This isotope is contained in natural potassium in a constant percentage (0.0119%). As the isotope K-40 decays, it emits gamma radiation with an energy of 1.46 MeV.

The detector LB 5430 detects radiation using an organic scintillator (PVT), the detector LB 5402 using a NaI crystal. The radiation triggers tiny flashes of light in the scintillator which are converted into electrical pulses by the photomultiplier. The count rate of this radiation is a direct measure for the potassium concentration. In addition, the scintillation detector responds to radiation emitted from the environment, for example, the walls and the floor which are covered with a layer of potassium.

Further radiation is generated by incident cosmic rays at the location of the detector.

Background radiation remains more or less constant for each installation within a plant, provided the location is not changed. To keep the statistical error of the measured result as small as possible, the scintillation detector, fixed at the outside of a bunker or below a belt conveyor, is shielded against background radiation by an additional lead shielding.

If the scintillation detector is inserted into bulk material, solutions or suspensions inside a protection tube, the material itself is acting as a shielding against the background radiation.

Potassium can be found predominantly in the form of KCl. However, to this day the unit K2O is still used in many companies. The evaluation unit LB 444 K40 allows the calibration and measurement in both units. Important: the calibration and measurement have must be performed in the same unit. The following details for “K2O” also apply for “KCl”.

There is a linear relationship between the count rate measured by the scintillation detector and the potassium concentration.

This relationship can be expressed as follows:

\[ K = a \times (N - N_0) \]  

where:

- \( N_0 \) = count rate measured by the scintillation detector if the bulk material or the liquid contains 0% K2O.
- “N” = count rate detected by the scintillation detector at a concentration “K” of K2O.
- “K” = concentration of K2O.
- “a” = reciprocal value of the count rate per % K2O.*

* This value can also be understood as the slope of the linear function. The term \( a \times N_0 \) is the background expressed as a percentage of K2O.
The hardware and software of the LB 444 K-40 system makes it easy to adapt the system to rather different measuring geometries and measuring tasks. Therefore, the settings and parameters of the measuring instrument have to be defined with care for the respective measuring task when taking the system into operation. Important parameters may not be changed later, in order not to compromise the reliable operation of the system. The system should be taken into operation and settings changed only by persons who know how to work with the instrument. Therefore, all users should read these operating instructions carefully. We recommend documenting all settings in a setup protocol.

Before starting any work, please read this operating manual carefully!
3 System Description

The system is comprised of the following components:

- Detector LB 5430 for installation on the outside of the container or
- LB 5402 for installation in a protective pipe inside the container
- Connection cable
- Evaluation unit LB 444 K-40

A 19” rack can be supplied for installation of up to 4 devices or a protective housing for two devices for installation of the evaluation unit.

The device LB 444 K-40 with a software that has been expanded for potassium content measurements is used as evaluation unit. The functions of the density measurement are still available. This operating manual describes only those functions that are relevant to the potassium content measurement.
4 Installation of the Detectors

4.1 Selection of the Measuring Site

Assuming a homogeneous mixture of potassium in the material to be measured, the number of K-40 isotopes increases with increasing amount of material. This means that the count rate of the detector rises when the amount of material in front of the detector rises, although the material contains a constant percentage of the K-40 isotope. The radiation is partially absorbed between its point of origin and the detector. Consequently, material that is farther away from the detector does not contribute much to the result. If the material thickness in front of the detector is increased, or the detector is surrounded by material, the count rate will reach a saturation value and does not rise anymore even if the thickness of the material layer still increases. This material thickness is called saturation thickness which is expressed as follows:

\[ d = \frac{100}{\rho} \text{ cm}, \]

where \( \rho \) is the density of the bulk material in g/cm\(^3\).

Example: For a potassium sample with a bulk weight of 1.2 g/cm\(^3\) the saturation thickness necessary for the measurement would be 100 cm / 1.2 = 83 cm. This means, for a surface probe, the inner diameter of a bunker should be about 83 cm; a dip probe should be inserted in the center of a bunker having an inner diameter of at least 166 cm.

These conditions ensure that the measured value is independent of bulk density variations. If this conditions cannot be fulfilled, one has to calculate if the errors that occur as a result of a smaller volume and a possible change of the bulk weight or the density are still acceptable.

The goal of a continuous measurement of the K\(_2\)O content is to cover the detection device with the total amount of material to be measured, i.e. the position of the scintillation detector has to be selected such that the surrounding material thickness is not much thicker than the saturation thickness.

If this is not the case the material being further away from the detector than the saturation thickness would not contribute to the measurement and therefore its potassium content would not be taken into account (see Figure 2). Provided the product to be measured shows a homogeneous structure, no measurement errors will occur.

\[ S = \text{saturation layer thickness} \]
\[ 1 = \text{measured material layer} \]

Figure 2: Saturation layer
4.2 Installation of the Detector LB 5430 on a Bunker

The LB 5430 detector is installed on the outside wall of a bunker. Typically, it is fixed to the flange of the detector.

![Figure 3: Detector LB 5430](image)

Depending on the version, the detector weighs approx. 60 – 70 kg. Please take this weight into account in your planning. All screws and mounting parts have to be secured such that they cannot come loose during operation, so that the detector cannot fall down.

The detector must not be subject to heavy mechanical vibrations. If extreme vibrations are likely to occur at the installation site, the detector has to be mounted on a damping and shock absorbing arrangement. Care must be taken that no potassium containing material may be deposited between the surface probe and the outside wall. This would result in measurement errors.

The ambient temperature at the installation site of the detector must not exceed 50°C. If the bunker wall is hot (>50°C), you may insert a suitable insulating plate having a thickness of approx. 20 mm between the container wall and the detector or use a detector with water cooling.
4.3 Installation of the Detector LB 5402 in a Bunker

The detector is installed into a protective pipe, front side closed, and inserted into a bunker. The distance of the material surface in front of the detector head sensitive to radiation (position of the scintillation crystal) should on all sides correspond to the calculated saturation thickness.

If hot liquids are used a cooling water jacket for the probe is necessary.

The detector temperature must never exceed 50°C.

No crystallization must occur on the protective pipe. If necessary, the protective pipe has to be provided with a thermal insulation and possibly with a heating jacket. Crystallizations would significantly falsify the measured results, since the potassium concentration in the crystallized layer is typically higher than in the liquid solution.

\[ S = \text{saturation layer thickness} \]
\[ 1 = \text{measured material layer} \]
\[ 2 = \text{material not covered by the measurement} \]

4.4 Measurement in a Pipe

When measuring in a pipe, the saturation layer thickness is usually not achieved or at least not achieved in all directions. In the case of large pipes, the saturation layer thickness is usually achieved in the longitudinal direction of the pipeline. However, transverse to the pipeline axis, the saturation layer is not always achieved. This can have an effect on the measurement result, which is larger:

a) the smaller the pipe is
b) the stronger the density varies in the pipeline, (see Figure 6).

The measurement of the saturation thickness is also affected by the diameter of the pipe, the pipe material and the wall thickness of the pipe.

A correction of the influence is possible in some cases by an additional density measurement.

This will require an extended period of time for the recording of

a) Density values
b) Displayed K2O values and
c) the appropriate, K2O values determined in the laboratory.
A correction function can then be calculated from these values.

**Figure 5: Measurement in a pipeline**

**Potassium measurement. Saturation thickness for different densites resp. bulk densities**

**Figure 6: Influence of thickness and density**

Installation:
The detector should be mounted in a horizontal pipeline at the top or side. This will prevent that the measurement is influenced by any deposits on the ground of the pipeline.

### 4.5 Measurement on a Conveyor Belt

Normally, the required saturation thickness cannot be reached on a conveyor belt, so the measured result will be influenced by changes of the bulk weight and/or changes of the material layer thickness.

However, if it is ensured that

- variations of the bulk weight in the material cannot occur (uniform grain size)
- the height of the material layer is kept constant by leveling device.

a measurement can also be carried out on a conveyor belt. However, the measurement error is larger than with measurements in a bunker.
4.6 Installation of the Evaluation Electronics

The evaluation unit (protection type IP 20) can be installed in a 19” rack. This rack then has to be installed into a suitable measurement cabinet. The wall housing can be fixed directly to a wall using screws. For outdoor installation, you may have to install a sunshield to protect the evaluation unit against solar heating.

4.7 Installation of the Detector

Use a water cooling jacket to protect the detector against temperatures > 50°C.
Cables have to be protected against temperatures > 70°C.

Measuring system installed outdoors have to be protected from rain and direct sunshine by a canopy. The cable entry must not be exposed to temperatures exceeding 70°C. The cable gland and the cable entry must be aligned such that no water can flow along the cable into the connection box.
The detector installation site must not be subject to heavy vibrations as this could damage the detector.

Samples have to be taken for calibration of the measurement. A sampling point has to be foreseen in the direct vicinity of the measuring site.

4.7.1 Installation in a Container

If the detector is installed in a protective pipe inside the container, the protective pipe has to be sealed to prevent the penetration of dust and humidity. The detector includes two suspension eyes. Wire ropes can be attached to these suspension eyes. It is not permitted to suspend the detector on the cable.
The cable should form a loop to allow possibly penetrating water to drip off.
5 Connections

The power supply of the detector and the transfer of the measured values and important information to the evaluation unit LB 444 K-40 takes place via a two-wire screened cable. The possible cable length is dependent on the cross-section of the connection cable used.

<table>
<thead>
<tr>
<th>cross-section in mm²</th>
<th>Max. cable length in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>1.5</td>
<td>1500</td>
</tr>
<tr>
<td>2.5</td>
<td>2500</td>
</tr>
</tbody>
</table>

The cable entry at the detector permits a cable diameter of 6-10 mm.

5.1.1 Evaluation Unit LB 444 K-40

Connect cable on the rear panel of the evaluation unit as shown in the wiring diagram in the appendix to this manual.

Connect the device only to the appropriate line voltage.
All safety previsions regarding the power distributor have to be observed.
The evaluation units do not include a separate mains switch. A separate safeguarding and easily accessible shut-down have to be foreseen.
The device must not be installed in explosive hazardous areas.

Refer to the wiring diagram in the appendix to this manual regarding the connections.
Detector (2a/2c)

Relay 2 (12a/12c)
The relay can be set for the following functions:
Min. – Alarm, Max. – Alarm, Detector temperature,

Relay 3 (4a/14c)
Functions:
Min. – Alarm, Max. – Alarm, Detector temperature,
Relay 1 (16a/16c)
The relay is used to indicate errors. The contact opens in case of error.

External product selection
Digital input 1 (18a/18c)
Digital input 2 (20a/20c)
Calibration data of up to 4 different products can be defined in the evaluation unit LB 444 K-40. These data sets can be selected via digital inputs.

External Start/Stop Signal (22a/22c)
Option to interrupt measurement for the following special applications:
- Start/Stop in batch mode
- Stop of continuous measurement, e.g. to suppress unexpected malfunctions

0/4-20mA (26a+/26c-)
Isolated current output for measured value, max. load 500 Ω.

Current input (28a-/28c+)
Product temperature for temperature compensation (usually not needed for potassium content measurements).

Power supply (30a/30c)
Power supply 115V/230V AC or 24 V AC/DC depending on power supply unit (see label on instrument rear panel!).
Fuses
To replace fuses, you have to open the fuse holder with a screw-driver. Observe fuse type and rating!

Before turning on the power supply, carefully check all connections once more to rule out any damage to the instruments.

RS 232
Port for data transfer from evaluation unit to printer or PC (front panel of evaluation unit).
5.2 Evaluation Unit LB 444 K-40

5.2.1 General Description

The evaluation electronics is designed as a 19” module in the format 3 HE, 21 TE. It includes the microprocessor-controlled evaluation electronics and the power supply for the required operating voltage. A 32 bit microprocessor is used for signal processing.

![Operating elements of the evaluation unit](image)

The instrument is operated via six foil keys:
Three keys work as softkeys which allow user-guided definition of all instrument settings and input of the required parameters.
Three more keys serve as function keys.
The front panel includes a RS 232 interface port. Data can be transferred to a PC using a terminal program.
The terminal strip on the instrument rear panel includes all terminals for power supply, for the detector, and for the analog and digital output signals. The current output is isolated. The built-in relays for max.-min.-indication and for error messages include an isolated contact.
System malfunctions are signaled by error messages.
Calibration data is stored in a FLASH memory and saved, so they will not be lost in case of power failure.

5.2.2 Display

The instrument’s illuminated display comprises four lines. The first three lines show the menu titles, the currently selected parameters or the current measurement value. The bottom line shows the current function of the respective softkey button. If a measurement is running, the "run" status is displayed.

5.2.3 Keypad Function

The Potassium Meter is operated via the softkeys and function keys described below. With these keys you can select the operating level you want within a menu structure in order to select a function or enter parameters.
### 5.2.4 Softkeys

Softkeys are used to select different menu groups and operating levels within the menu structure. Depending on the current position in the menu structure, functions are assigned to these keys, as shown on the display above the respective key.

### 5.2.5 Menu Structure

The menu structure is illustrated on the following pages. Push `<more>` to select the various menu groups. From there you get to the respective menu by pushing `<sk1>` or `<sk2>`. Within the menu, push `<more>` to go to the individual windows and at the end of the menu push `<done>` to return to the menu group.

<table>
<thead>
<tr>
<th>sk1: General Data</th>
<th>sk2: Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>sk1</td>
<td>sk2</td>
</tr>
<tr>
<td>more</td>
<td>Go to the indicated menu</td>
</tr>
<tr>
<td>done</td>
<td>Shows the end of the menu and takes you back to the menu group</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relay 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>50%</td>
</tr>
<tr>
<td>Hysteresis</td>
</tr>
<tr>
<td>5%</td>
</tr>
<tr>
<td>more</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
</tr>
<tr>
<td>20s</td>
</tr>
<tr>
<td>more</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HV (500):</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/s</td>
</tr>
<tr>
<td>HV (560):</td>
</tr>
<tr>
<td>123/s</td>
</tr>
<tr>
<td>HV (560):</td>
</tr>
<tr>
<td>620/s</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>exit</td>
</tr>
</tbody>
</table>

*Figure 10: Softkey functions*
Enter | Accepts the entry and moves the cursor to the next input field or toggles between two input fields.

Run | Starts or stops a measurement or leads directly back to the display and at the start of a measurement automatically changes to the measurement value display.

Clear | Clears the numerical value.

**5.2.6 Menu Potassium Content Measurement**

Select the menu item

Operation mode → more → K20 → ENTER

to automatically select the parameters that are relevant for the potassium content measurement:

- linear characteristic
- time constant 300 s
- measuring path “1”
- no decay compensation

In addition, the detector code has to be checked and changed, if necessary.

<table>
<thead>
<tr>
<th>Detector LB 5430 with organic scintillator (PVT)</th>
<th>Detector code 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector LB 5402 with NaI scintillator</td>
<td>Detector code 0</td>
</tr>
</tbody>
</table>
### Configuration Instrument
- **Density without TK**
- **Density with cur. Inp**

### Measuring Product
- **No.: 1/2/3/4**
- **Product 1**

### Detector and Isotope
- **Code:** 0
- **Isotope:** Cs 137

### Measuring Path
- **Value:** 10.0 cm

### Select: Measure Mode
- **Continuous Measure**
- **Batchmode**
- **Rapid switchover**
  - ***OFF / ON***
- **Sigma:** 3,0000

### Curr. Output Limits
- **Range:** 4 - 20 mA/
  - **0 - 20 mA**
- **Value:** 1.0000

### Relais Nr. 2 setup
- **Minimum**
- **Maximum**
- **Det. Temp**
  - **Hysteresis:** 5%

### Temperature Coeff.
- **TC 1**
  - **Value:** 1.2345e-03

### Radiating Interference
- **OFF**
- **ON**
- **Value:** 10.0 s

### Relay in Error Case
- **Hold State**
- **Current Following**

### Current Output Error
- **HOLD / VALUE**
- **Value:** 12 mA

### Current Input
- **Range:** 0 - 20 mA
  - **4 - 20 mA**

### Temp. Input
- **0 / 4 mA:** 0 °C
- **20 mA:** 10 0 °C

### Product Selection
- **extern / intern**

### Production Selection
- **Nr.: 1/2/3/4**
- **Product 1**

### Unit Select
- **[g/cm2]**
- **[Bx]**
- **[Be]**
- **[g/]**
- **Value:** g/cm3

### Operation Mode
- **Sk1: General Data**
- **Sk2: Operating Mode**

### Language
- **Deutsch**
- **English**
- **Francais**
- **Espanol**

### Factory Setting
- **Password:** xxxx

### Date & Time
- **Date:** 01.02.00
- **Time:** 12.21

### Berthold
- **LB 444 K-40 V. X.XX**
- **Density - Meter**

### Berthold Detector Software
- **Version 1.02**

### Print Parameter?
- **(press Enter)**

### Calibrate
- **Mode:** one / lin / squ / cub / auto
- **Value:** 54321 cps
- **Coefficient a1**
  - **Value:** 6.6400e - 02
- **Coefficient a2**
  - **Value:** 1.23400e - 04
- **Coefficient a3**
  - **Value:** 1.23456e - 06
- **Factor**
  - **Value:** 0.000000

### Square Error
- **Value:** 0.000000

### Offset
- **Value:** 1.0000

### Calibration Value
- **Value:** 0.0000
- **1. Rate:** 12345 cps
- **2. Temp.:** 44.2 °C
sk1: Service Menu
sk2: Mass Flow
sk1  sk2

sk1: Test calculate
sk2: I/O - Test
sk1  sk2  more

Testrate 12345 cps
Output Curr: 10.0 mA
1.2345 g/cm³

Set output cur.
Current: 9.0 mA

View input cur.
Current: 12.0 mA

Relay 1: ON
Relay 2: OFF
Relay 1: ON

Input 1: OFF
Input 2: OFF
Input 3: ON

Set output cur.
Current: 9.0 mA

View input cur.
Current: 12.0 mA

High Voltage
Value: 800 V

Save Default
Value: 850 V

Read Default
Value: 850 V

Temperature = 45.2 °C
Det. Temp. = 28 °C

For Detector - Reset
please press (sk 1 & clear)

Plateau measurement running.....

For Pt 100-Adjust
please press (sk2 & clear)

Plateau

Adj. Cur. input
sk 2: Relay Delaytime
sk 1  sk2  more

Current 1.8 mA
Offset: 4123

Current 18 mA
Offset: 345

Relay delay
Value: 50 ms

Range input (at 20 mA)
Value: 100 m³/h

Flow
Value: 87.00 m³/h

Ext. Mass Counter
Tons per cycle

Erase mass - integrator
no/yes

Unit Mass Flow
[kg/h, t/h]

t/h

Flow
Value: 87.00 m³/h
6 Software Functions and System Configuration

Depending on the selected configuration, some input dialog boxes are dimmed. In chapter 5.2.5 you find an overview of the menu structure. After commissioning, enter the final operating settings in the Configuration list in the Appendix.

Individual options are selected by pushing the <^^^>. Push <enter> to accept the selected value.

After the last entry, the instrument has to be connected to mains for at least 5 minutes to ensure that all values entered have been stored in the FLASH memory and will not be lost if power failure occurs.

6.1 General Data

Password:
You can enter a 6-digit number. Upon confirmation with <enter>, the system is protected against unauthorized manipulation of the parameters.

Display: Keyboard locked.
All parameters can still be viewed, however. Password protection is revoked as soon as you enter the correct numerical value and confirm your entry with <enter>.
To change the password, enter a new password while the keyboard is unlocked.

Date:
Enter the current date in the format DD.MM.YY.

Time:
Enter the current time in the format HH.MM.

System/Version:
Shows the instrument type and software program version. Please have this data handy if you need to consult with the manufacturer.

Detector Software:
Shows the software version installed in the detector. Please have this data handy if you need to consult with the manufacturer.

Language:
German, English, French and Spanish can be chosen as dialog language by pressing the <^^^> key.

Print Parameter:
A printer with serial interface can be connected on the front panel. Push <enter> to print all parameters for documentation. You may also connect a PC and transfer the data to a PC for processing using a terminal program. See also 6.2

Factory setting:
Push <sk1> to reset all parameters to the factory setting.

The current calibration data is lost when the instrument is reset!
6.2 Operating Mode

Measurement mode

<table>
<thead>
<tr>
<th>K20/KCl.</th>
<th>The parameters that are relevant for the potassium content measurement are set automatically.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• linear characteristic&lt;br&gt;• time constant 300 s&lt;br&gt;• measuring path “1”&lt;br&gt;• no decay compensation</td>
</tr>
</tbody>
</table>

Error mode

| in case of error Stop measurement | The measurement process stops if an error occurs. The error is indicated on the display. Push <enter> to clear the error message on the display. If the error has been eliminated, push <run> to start the measurement again. |
| in case of error Continue measurement | If you select “continue measurement” the error is displayed, but the measurement continues. |

Relay in error case

| Hold state | The max./min. relays behave corresponding to the measured Concentration. |
| Current following | The max./min. relays follow the fault current (see chapter 6.4) |

Current output error

| Current: HOLD | The output current is held at the last value where the error has occurred. |
| VALUE | In case of error, a pre-defined output current is selected (see chapter 6.4). |

RS232 Interface:
The RS232 Interface is located on the front panel of the evaluation device. Select baud rate by pressing <^^^> and confirm with <enter>. Select device to which data is to be transferred: select either PC, printer or modem. Terminal program settings:
In LB 444 K-40: Printer
In terminal program: 9600 baud, 8 data bit, 1 stop bit, no parity, protocol: X on / X off.
RS 485: Presently not used.
6.3 Parameter

Measuring product No. 1/2/3/4:
Parameters (detector type, current output range, limit values, etc.) for up to 4 different products can be entered and stored. These parameters have to be entered separately for each product.
The calibration data measured for a product may be copied to other data sets. Thus, different current ranges (0/4-20 mA) can be defined for the same product and can be selected externally by selecting the “new” product, or different limit values can be used.
In the normal measurement mode the product for the current measurement is selected here.

Detector and Isotope

<table>
<thead>
<tr>
<th>Code:</th>
<th>Detector-specific code number taking into account the parameters to be defaulted for the detector type.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Detector LB 5402 Enter code “0”.</td>
</tr>
<tr>
<td></td>
<td>Detectors LB 5430 / LB 4430: Enter code “23”.</td>
</tr>
</tbody>
</table>

Measuring Path (0.1 to 9999.9 cm):
“1” is used for the potassium content measurement.

Select: Measure Mode:

<table>
<thead>
<tr>
<th>Continuous:</th>
<th>Continuous measurement. This is the standard setting for most measurements. With this type of measurement, a sliding average is calculated over the selected time constant.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batchmode</td>
<td>Batch measurement with external start-stop signal (digital input 22a and 22c).</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>via the &lt;run&gt; button.</td>
</tr>
<tr>
<td></td>
<td>We recommend using the “Batch measurement” mode, for example, when a pipeline or container is filled briefly and then emptied again. In this case, shorter measuring times can be used.</td>
</tr>
<tr>
<td></td>
<td>During batch measurement an arithmetic mean is calculated over the measurement time.</td>
</tr>
<tr>
<td></td>
<td>To start a measurement process, either push the &lt;run&gt; button or briefly connect terminals 22a /22c.</td>
</tr>
<tr>
<td></td>
<td>A measurement stops as soon as the entered measurement time is over (time constant). The shortest batch time that can be used is approx. 2 s.</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>if you push the &lt;run&gt; button again.</td>
</tr>
<tr>
<td></td>
<td>See also 7.6</td>
</tr>
</tbody>
</table>

Time constant:
Enter the time constant of the instrument system. It determines the average calculation of the counts supplied by the detector. In order to reduce statistical variations, you should select the highest time constant that is still permissible. The typical input value is 300 s.

A measurement time can be preset for batch measurement. Once this time is over, the measurement stops automatically. The shortest batch time that can be used is approx. 2 s.
Rapid switchover:

<table>
<thead>
<tr>
<th>ON / OFF:</th>
<th>This function (= 1/10 of defined time constant) is needed to adjust the output signal quickly to the new value if sudden Concentration changes occur. This function is not used for potassium content measurements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigma</td>
<td>Sigma defines a range (window) which the display change has to exceed before the selected time constant automatically switches over to a value that is smaller by a factor of 10 (max. 0.8 sec). When using the rapid switchover function, you should at least enter “4” or better “5” as Sigma value to make sure that a switchover of the time constant is not triggered too often by statistical variations or minor Concentration changes. We recommend determining the optimum entry during routine operation (see also chapter 7.5).</td>
</tr>
</tbody>
</table>

Radiating interference:
This function is needed only when unforeseeable influences due to interfering radiation are to be expected, e.g. due to weld seam testing. It is enabled and disabled via <ON> and <OFF>.
Sigma defines a limit value which the display change has to exceed before the measurement is canceled. The value has to be set such that short-term Concentration variations occurring during operation do not trigger this function.

Enabling radiating interference detection disables the rapid switchover function.

Radiating interference delay time: (only with Radiating interference “ON”)
Interference due to radiation is normally only of short duration. After the delay time you have entered here is over, the measurement starts again automatically following detection of radiating interference.

Maximum rate:
The measurement stops automatically as soon as the count rate supplied by the detector exceeds the entered value. The output current signal is held at the last value. The error message “Measurement halted” is displayed. The measurement continues automatically as soon as the count rate has dropped below the entered value. The entered values are permanently corrected during decay compensation. The functions “Maximum Rate” and “Minimum Rate” can be used to “freeze” the measured value in case of malfunctions (e.g. empty measuring path, empty container, increased radiation due to weld seam testing, etc.) and to avoid long response times of the control devices. Select the input values such that that they will not be reached during regular operation.
If this function is not important for your operation, disable it by entering a pulse rate of “0”.

Minimum rate:
The measurement stops automatically as soon as the count rate supplied by the detector falls below the entered value. If this function is not important for your operation, disable it by entering a pulse rate of “0”. For the potassium content measurement you should always enter the value “0”.

Product selection [extern/intern]
Define if the product is to be selected via the keyboard of the evaluation unit (internal) or via digital inputs (external, 18a/c, 20a/c).

<table>
<thead>
<tr>
<th>Product</th>
<th>DI1 a/c</th>
<th>18</th>
<th>DI2 20 a/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

1 = terminal a/c connected
6.4 Product Data
Enter product data for parameter setup and calibration separately for each product.

Product selection
No. 1/2/3/4:
Enter product number for calibration.

Current Output:
Select current output signal 0 or 4 mA.

Current Output Limits:
0/4 mA:
20 mA:

Example:
Measuring range 10 ... 30% K20.
Input: at 4 mA: 10
        at 20 mA: 30

Current Output Error:

<table>
<thead>
<tr>
<th>Current: VALUE</th>
<th>In case of error, the current output jumps to the defined value (0...22 mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOLD</td>
<td>In case of error, the current output holds the last value. Caution: If you have selected “continue in case of error”, the current output operates using a wrong value corresponding to the false value.</td>
</tr>
</tbody>
</table>

Relay No. 2 setup:
Minimum / Maximum / Det. Temp. / Mass pulse:
Different functions can be assigned to the relay. As soon as the status to be signaled
Concentration < minimum or
Concentration > minimum
Detector temperature > X °C
has been reached, the relay is de-energized. If the displayed value drops again, the relay picks up again, delayed by the value of the selected hysteresis.

Hysteresis
The switching hysteresis should be about 5%.

Relay No. 3 setup:
Same as relay no. 2.

Minute printout
Value
The measured value can be printed out in defined time intervals using a printer connected to the RS 232 interface.
6.5 Calibrate

Background for rod detector

N/A

Product selection
No. 1/2/3/4:
Select product to be calibrated and confirm with <enter>.

Suspension measure
No
<enter>.

Unit select
g/cm³, t/m³, Bx, weight %, °Be, g/l, mm, g/m², % K₂O
Select the unit for concentration measurement and area weight measurements (mm, g/m²).

% K₂O
<enter>.

Note:
The selection of the displayed unit does not have any influence on the calibration or the measurement.

Data input
Enter or read in the calibration data for the requested number of calibration points.

Calibr. Data transfer
Select “Yes” to copy the calibration data of a product that has already been calibrated.
In the copy you can change the data then as needed.

Sequence:
Yes <enter>
Product X <enter> → Y <enter>

etc.
Then run through Rate 1 to Rate 10 and correct them if necessary. You may correct the values, if necessary.

1. Rate to 10. Rate
You need at least 2 calibration points (see chapters 6.5 and 7.2.2). You have to run through all 10 points. Calibration points with zero values are not calculated.
Data can be entered manually or read in by pressing the <run> button.
Its also possible to use the background radiation as a calibration point. This has to be measured
a) with empty vessel or
b) with product in the vessel which does not contain any potassium or
c) dismounted detector arranged on a concrete floor or min 20 mm lead or 40 mm steel plate in front of the radiation window.

The count rate is read in automatically. As soon as the measured value is stable, press the <run> button again to stop the reading-in process. Press <enter> to confirm the read-in or entered value.

If you push <more> to go to the next item without pushing <enter> first, the
values will not be saved.

<table>
<thead>
<tr>
<th>Rate:</th>
<th>Count rate in cps is read-in or entered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration:</td>
<td>Enter the concentration value %K2O determined in the lab.</td>
</tr>
</tbody>
</table>

**sk2: Calculate**

Calibrate mode
Select the calibration mode: on/lin/squ/cub/auto
(see also 6.5 and 7.2.2).

**The calibration mode “linear” is used for the K2O measurement.**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-point</td>
<td>One-point calibration. For one-point calibration we only need one value pair (count rate and concentration value) and the absorption coefficient. For common products it can be taken from the table in the Appendix and entered as coefficient a1.</td>
</tr>
<tr>
<td>Linear</td>
<td>Linear curve fit. This mode is used if at least two value pairs are available. It should also be used when several calibration points are available which are very close together, so that not the entire measuring range is covered by samples.</td>
</tr>
<tr>
<td>Square</td>
<td>The square curve fit can be selected if at least 3 calibration points are available which are distributed fairly evenly over the measuring range or if the measurement is carried out in %-concentration, °Bx or in another unit which is not in linear correlation with the concentration.</td>
</tr>
<tr>
<td>Cubic</td>
<td>The curve fit with cubic coefficient should be applied when the same conditions exist as under square, but at least 4 value pairs are available and it becomes apparent during operation that values deviate in some parts when using square.</td>
</tr>
<tr>
<td>Auto</td>
<td>The program automatically selects the best curve fit. At least 4 value pairs must be available for this function.</td>
</tr>
</tbody>
</table>

Select the calibration mode and push `<enter>` to calculate the calibration factors.

**Coefficient a1**
Linear absorption coefficient (range -10 to +10).
The coefficient is calculated by the program. At least two calibration points have to be available.

**Zero count rate Io**
The zero count rate is automatically calculated for calibration. It corresponds to the zero point of the unit of measure, i.e. the concentration value “0”.

**Coefficient a1**
The calculated or entered coefficient a1 is displayed. Do not change it manually; this also applies to coefficients a2 and a3.

**Coefficient a2 N/A**
Square absorption coefficient. This value is automatically calculated for two- or multi-point calibration.

**Coefficient a3 N/A**
Cubic absorption coefficient. This value is automatically calculated for multi-point calibration.

**Square error.**
This value is calculated automatically for two- or multi-point calibration. It indicates the quality of the calibration curve for the selected calibration mode. The smaller the numerical value, the better the curve fit.

**Factor**
Enter a multiplication factor (0 to 10) to correct the measured values. Each measured value is multiplied by this factor. It allows you to change the slope of the calibration curve. When performing a new calibration, the factor is automatically set to “1” (see also chapter 7.4.2).

**Offset**
Additive correction of the measured values; allows parallel offset of the curve. The offset entered here is added to each measured value. When performing a new calibration, the value is automatically set to “0” (see also chapter 7.4.1).

**Calibration value**
N/A
(Only for temperature compensation via Pt 100 or current input:)
The temperature compensated lab values are displayed which were entered at rates 1. to 10 (g/cm³). Scroll with <+> and <->. The calibration curve is calculated using these values.

**6.6 Live Display**

**Start measurement**
A measurement can be started from any menu item by pressing the <run> button (exception: Service menu). The measured values are displayed continuously in the selected unit for the selected product. RUN appears on the display. With <+> and <-> you can cycle through the displays below.

**Menu sk2: Live Display**
Results are displayed in this menu if RUN appears on the display; otherwise the values of the last measurement. With <+> and <-> you can cycle through the displays below.

**Display:**
The actual concentration can be displayed in the defaulted range, e.g. 17.8% K20.

**I-mean**
Shows the averaged count rate. The entered basic time constant is used as time constant.

**I-actual**
Shows the actual count rate. The entered basic time constant is used as time constant.

**HV auto:**
Shows the adjusted high voltage (HV).

**Stop measurement** by pressing <run> again.

**Select product** on the menu sk1: Parameter.

**6.7 Service Menu**
See chapter Service Instructions.
7 Getting Started

7.1 Quick Installation Overview

<table>
<thead>
<tr>
<th>Install detector at the measurement site.</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install water cooling if temperatures exceed &gt;50°C.</td>
<td>10</td>
</tr>
<tr>
<td>Install evaluation unit.</td>
<td>5</td>
</tr>
</tbody>
</table>

Connect detector to LB 444 K-40 via two-wire cable. Connect cable to terminal 2a and 2c of evaluation unit.

External product selection
With the external product selection you can measure up to 4 different products. Both digital inputs have to be used so that 4 different products can be selected.

Digital input 1 (DI 1): 18a / 18c
Digital input 2 (DI 2): 20a / 20c

<table>
<thead>
<tr>
<th>Product</th>
<th>DI 1</th>
<th>DI 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Digital input 3 (DI 3): 22a /22c. External Start/Stop signal
Digital input 3 can be used for the following signals:
   a) Start/Stop in batch mode
   b) Stop continuous measurement. (*freezing” measurement; “HALT” appears on display)

| Digital outputs (relays): These outputs can be used for the following signals: |
|-----------------------------|------------------|------------------|------------------|
| 12a, 12c: Rel. 2: | Min. , max. , detector temperature, |
| 14a, 14c: Rel. 3: | Min. , max. , detector temperature, |
| 16a, 16c: Rel. 1: | Error message |
7.2 Getting Started

7.2.1 Basic Settings

These steps describe how to take the system into operation and how to change the basic system settings.

**Note:** To enter numbers, select the entry position with ←←← and the number you want with ^^^. Confirm your selection or new entry with enter. Press run to return to the display mode directly any time (except in Service menu). If no entry is made, the system automatically switches from the current menu item to the display mode after several minutes.

**Important:**
After data input the system has to remain turned on for at least 5 minutes to ensure that all entered data have been saved.

1. Push <more> to select menu General Data / Operating Mode

   Push <sk1> to select General Data and <more> to call parameters sequentially.
   Enter password and unlock or lock system with enter
   Check date & time and correct it, if necessary
   Check instrument version (e.g. LB444 K-40, version: 3.xx)
   Select language
   Print Parameter, only if needed
   Factory Setting, only if needed (see also Software Functions and System Configuration)
   Push <done> to return to menu group

2. Push <sk2> to select Operating Mode menu and <more> to select parameters.

   Select Config Instrument N/A and continue with <more>
   Select K20
   Define Error mode etc.

3. Push <more> to select menu Parameter / Product Data.

   3.1 Push <sk1> to select Parameter menu and <more> to call parameters sequentially.
   Select product: 1
   Detector (code “0” or “23” and isotope)
   Select “none”
   Measuring path in product “1”
   Select Measure mode (i.e. continuous)
   Enter time constant (e.g.: 300 s)
   Disable rapid switchover “Off”
   Disable Interference Radiation “OFF”.
   Define max. count rate (e.g. 100000 cps)
   Define min. count rate (e.g. 0 cps)

   Product selection
   Select “external” or “internal” (only if different products are to be is measured).

   Push <done> to return to menu group.
3.2 Push <sk2> to select Product Data and <more> to call parameters sequentially.

Select product: “1”
Select current output 0 –20 or 4 – 20 mA
Define current output limit values 0/4 and 20 mA:
x% K20 = 4 mA
y% K20 = 20 mA
Define behavior of the current output in case of error message.
Define relay 2: Function (Min), switch point (e.g. 10% )
Hysteresis (e.g. 5%)
Define relay 3: Function (Max), switch point (e.g. 20% )
Hysteresis (e.g. 5%)
Periodic printout:
e.g. 10 min
Push <done> to return to menu group.

7.2.2 Calibration

Prerequisites
Device and detector have been installed.

The device must be turned on at least 1 h prior to the start of calibration.

Container or pipeline have to be filled with the product to be measured.

The calibration is performed as follows:

At different K₂O concentrations, the counts supplied by the detector are read into the memory. The concentration values determined in the laboratory (analysis values) are entered in a further storage sequence. The correlation of the memories is described below using one calibration data set as an example.

<table>
<thead>
<tr>
<th>Count rates:</th>
<th>Concentration K20 (lab values):</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 405</td>
<td>10.2</td>
</tr>
<tr>
<td>2 : 583</td>
<td>17.3</td>
</tr>
<tr>
<td>3 : 785</td>
<td>25.4</td>
</tr>
<tr>
<td>10 : 0</td>
<td>0</td>
</tr>
</tbody>
</table>

At least 2 calibration points must be available.
The calibration points should be distributed fairly equally over the entire measurement range. However, some calibration points may lie outside the measurement range. A calibration only with points outside the measurement range is not advisable.

It’s also possible to use the background radiation as a calibration point. This has to be measured

d) with empty vessel or
e) with product in the vessel which does not contain any potassium or
f) dismounted detector arranged on a concrete floor or min 20 mm lead or 40 mm
steel plate in front of the radiation window.

A calibration with several very closely adjacent concentration values can easily result in
an incorrect calibration curve.

**Calibration steps:**

Select menu *Calibrate / Live Display* with `<more>`. Push `<sk1>` to call the *Calibrate* submenu.
Select product.
Select “no” for suspension measurement → more
Select % K2O. → more

Push `<sk1>` to call the *Data input* submenu.
Background for rod detector N/A: continue with more
Deselect *Calibr. Data transfer* with "no"

1. **Read in 1. Rate:** cursor appears in the row “1. Rate = cps”.

Push `<run>` . The count rate is read in. Wait until the measured value has become stable
(approx. 100…300 s). While reading-in the count rate, the concentration of the products
must not change.
While reading in the count rate, take a sample of the product from the pipeline or the
container and determine the concentration of the sample in the lab. If the product is very
inhomogeneous, take several samples in quick succession and calculate an average value
from their concentration values.

2. Stop measurement by pressing the `<run>` button again.

3. Accept result with `<enter>`. Cursor jumps to next row.

4. Enter the concentration value of the sample(s) determined in the lab in % K2O and
confirm with `<enter>`. Cursor jumps to third row.
Push `<enter>` to skip the current product temperature.

**Further calibration points:**

Repeat steps 1. – 4. for other different concentrations.

The values must always be available in pairs. If the associated concentration value is
missing, the count rate is automatically assigned the concentration value “0”.

All unused calibration points must contain “0” as count rate. If “0” is already present,
push `<more>`. Otherwise, delete the values with `<clear>` and confirm each with
`<enter>`.
Value pairs where only the count rate but no concentration is entered, will result in an
incorrect calibration curve.
The entered data can be corrected as needed. The calibration process is carried out in
the menu item *Calculate*.

Push `<sk2>` to select *Calculate*.

Select calibrate mode
linear

The calibration is carried out.
The coefficient is calculated by the program.
The calculated zero count rate $I_0$ and the coefficient $a_1$ and the square error are displayed.

If necessary, enter a factor, by which the measured values are multiplied.
If necessary, enter an offset which is added to the measured values.

Push <done> to return to submenu group.
If the current output limits change (see page 26), calculate the calibration curve once more. (Pos. 16.).
When entering the concentration values, you need not observe a falling or rising order.
However, you must make sure that the correlation of count rate/concentration value is correct.

### 7.2.3 Checking the Calibration

To discover errors during calibration, the calibration curve can be plotted, e.g. with EXCEL.

![Calibration curve](image)

\begin{tabular}{|c|c|}
\hline
% K2O & cps \\
\hline
10,2 & 405 \\
18,9 & 582,5 \\
12,6 & 785 \\
16,3 & 557,5 \\
12,8 & 462,5 \\
22,1 & 702,5 \\
19 & 637,5 \\
27,8 & 845 \\
\hline
\end{tabular}

Thus, errors in the calibration (marking) can be detected more easily.

Remedy: Correct or clear values and calculate calibration curve once more.

### 7.3 Live Display

Start measurement: Push <run>.
Stoop measurement: Push <run> again.

Result display % K2O:
Push +...- to call further value

- current measured value in the selected unit
- averaged count rate (averaging according to entered time constant)
- actual count rate
- display of the adjusted high voltage

7.4 Correcting the Results: Addition and Multiplication

This option should not be regarded as a substitute for careful calibration. It should only be used for minor corrections. Otherwise we recommend doing a re-calibration.

An additive constant can be entered at Offset, a multiplication factor at Factor Calibrate menu, submenu Calculate).

7.4.1 Additive Constant

The value stored under Offset is added to the concentration value calculated on the basis of the count rate. This allows a parallel shift of the calibration curve.

Example:
Measuring range 10-30% K20
It is found that the measuring values are too low by 2% K20.

Remedy:
Enter “2.0” at Offset.
All measured values will be increased by 2.0% K20.

Instead of 10% K20, 12% K20 is now indicated and instead of 30% 32% K20. If the measured values are too high by 2% K20, you have to enter “- 2.0”.

7.4.2 Multiplication Factor

Each measured value is multiplied by the value stored as Factor. This allows you to change the gradient of the calibration curve.

Example: Measuring range 10 - 30% K20
If you enter 1.1 at Factor, 11% K20 will be displayed instead of 10% K20. At 30% K20 now the value 33% K20 appears. Thus, even the low point of the measuring range is increased, provided it is not at 0.

Remedy: This can be corrected by entering the appropriate data under Offset and Factor:

Example:
For 10% K20 the indicated value is correct, instead of 20% K20 the reading should show 22 K20.

Input value for Factor:
\[
F = \frac{H_{nominal} - L_{nominal}}{H_{actual} - L_{actual}} = \frac{22\% K2O - 10\% K2O}{20\% K2O - 10\% K2O} = 1.2
\]

Input value for Offset:

\[
K = L_{nominal} - L_{actual} \cdot F = 10 - 10 \cdot 1.2 = -2
\]

H = upper value of the measuring range in g/cm³
H = lower value of the measuring range in g/cm³

The same is true if upper and lower point of the measuring range are to be changed by different values.

Example:

\[
\begin{align*}
L_{actual} &= 11\% K20 \\
L_{nominal} &= 12\% K20 \\
H_{actual} &= 26\% K20 \\
H_{nominal} &= 28\% K20 \\
F &= \frac{28 - 12}{26 - 11} = 1.0666 \\
K &= 12 - 11 \cdot 1.0666 = 0.2674
\end{align*}
\]

### 7.5 Automatic Measuring Time Switchover

To quickly update the measured value if sudden concentration changes occur, you can enable automatic measuring time switchover (*Rapid switchover* on the menu *Parameter*, see chapter 6.36.4).

The smallest value that can be entered is 8 s.

If a sudden concentration change occurs which exceeds the entered threshold (Sigma), the entered *time constant* is reduced to 1/10 of the original value, but not less than 0.8 s. Thus, the output signal adjusts much quicker to the new concentration value. The changed time response of the output signal is illustrated in Figure 13.
When rapid switchover is in effect, the measurement first works with the defined basic time constant. If sudden concentration changes occur which exceed the Sigma band, the system switches to 1/10 of the time constant and reading and output signal can follow the concentration change much quicker. At the same time, statistical variations increase by a factor of about 3. When the concentration value becomes stable again, the system automatically switches back to the longer basic time constant after a time period that corresponds to the basic time constant.

7.6 Batch Measurement

If the measurement is carried out on or in a container which is filled and emptied cyclically, the measurement can be carried out in the batch mode. With the continuous measurement, the measured value at empty container is 0% K2O. After the container has been filled, it takes a very long time until the new measured value is reached again. In the batch mode the measurement can be started when the container has been filled. The earlier available measured value is deleted and the measurement is started new. Thus, the new measured value is available in a much shorter time.

The batch mode is selected via the menu item “Measure mode” → “Batch mode”.

**Variable measuring time:**
Enter “0” as time constant.
The measurement is started in the batch mode by pushing the <run> button and stopped by pushing the Sample <run> button again

or

by connecting the terminals 26a and 26c.

**Fixed measuring time:**
Enter a value > 2 as time constant.
The measurement is started in the batch mode by pushing the <run> button and stops automatically when the entered time is over

or

or briefly (>1s) connecting the terminals 26a and 26c.
Once the entered time is over, the measurement is stopped automatically.

In both cases, the current signal remains on the last value until a new measurement is started.

### 7.7 Radiating Interference Detection

Select the function *Radiating interference* (menu *Parameter*, see page 24) to suppress interfering radiation (e.g. weld seam testing).

**Caution:**
When this function is on (*Radiating Interference* <ON>), the automatic switchover of the time constant (function *Rapid switchover*) is always off. **When turning this function on, you have to define a Sigma value**, which defines a window for the measuring signal. If the detector signal suddenly exceeds this threshold

- the measurement stops
- the error message "*Interference Radiation*" appears on the display.

The measured value and the current outputs are held on the last value. Reset the error message and start the measurement via the keyboard by confirming the error message with <enter>; then start the measurement with <run> or *externally* via the digital input.

**Note:**
Enter n > 5 to rule out false alarms with sufficient statistical safety.

For calculation it holds: \( \text{Sigma} = \sqrt{I/s} \)

**Example:**

Count rate \( I_m = 300 \text{ cps}, \ n = 6 \)

\[
I_S = I_m + n \times \sqrt[3]{I_m}
\]

\[
I_S = 300 + 6 \times \sqrt[3]{300} = 404 \text{ cps}
\]

Thus, an alarm is signaled as soon as \( I/s \) exceeds the value of 404 cps.

**Note:**
Due to the dynamic behavior of radiating interfering detection, a quick increase of the pulse rate due to operative factors (e.g. very fast emptying of the vessel or major short-term concentration changes caused by stirrers) may be interpreted as interfering radiation.

For example, opening the active beam channel on the shielding can also cause a quick increase of the pulse rate. You have to reset the alarm that is then triggered, or better, do not enable radiating interfering detection at first. Enable radiating interfering detection only after calibration has been performed.
7.8 Error Messages

7.8.1 Acknowledging Error Messages

All error messages must be reset with <enter>.

Several simultaneously or consecutively occurring errors are stored in an error register in the order of their appearance; they have to be reset individually by pushing <enter> several times.

All errors are signaled via the “Error” output (relay 16a/16c).

7.8.2 Error Messages during Operation

<table>
<thead>
<tr>
<th>Error no.</th>
<th>Message</th>
<th>Cause, Remarks</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Wrong password</td>
<td>Wrong password entered to unlock the keyboard.</td>
<td>Push “enter” to reset error message. Enter correct password.</td>
</tr>
</tbody>
</table>

7.8.3 Error Messages during Calibration

<table>
<thead>
<tr>
<th>Error no.</th>
<th>Message</th>
<th>Cause, Remarks</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Not calibrated</td>
<td>Calibration incomplete</td>
<td>Perform calibration</td>
</tr>
<tr>
<td>36</td>
<td>Missing calib. points</td>
<td>Not enough points entered for selected calibration mode</td>
<td>Enter further calibration points or select another calibration mode</td>
</tr>
<tr>
<td>37</td>
<td>Curve not clear</td>
<td>System could not calculate a clearly rising or falling curve.</td>
<td>Check calibration points for input errors. Select calibration mode “linear”.</td>
</tr>
<tr>
<td>38</td>
<td>Error one-point calibration</td>
<td>Absorption coefficient = 0</td>
<td>Absorption coefficient = 0</td>
</tr>
<tr>
<td>39</td>
<td>Measuring path not defined</td>
<td>Measuring path = 0</td>
<td>Enter measuring path “1”</td>
</tr>
<tr>
<td>56</td>
<td>Range overflow</td>
<td>Measuring path = 0</td>
<td>Enter measuring path “1”</td>
</tr>
</tbody>
</table>
# 7.8.4 Error Messages during Measurement

<table>
<thead>
<tr>
<th>Error no.</th>
<th>Message</th>
<th>Cause, Remarks</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rate Overflow</td>
<td>Count rate &gt; 520000</td>
<td>High voltage wrong. Replace detector</td>
</tr>
<tr>
<td>2</td>
<td>No Detector Rate</td>
<td>Detector faulty</td>
<td>Replace detector</td>
</tr>
<tr>
<td>3</td>
<td>Wrong HV</td>
<td>Detector faulty</td>
<td>Replace detector</td>
</tr>
<tr>
<td>4</td>
<td>Pt 100 wrong temperature</td>
<td>Temperature measurement activated and no Pt100 connected. Cable faulty.</td>
<td>Check cable, replace detector or Pt 100. Disable temperature measurement.</td>
</tr>
<tr>
<td>5</td>
<td>4–20 mA faulty</td>
<td>Input current below 4 mA, evaluation unit faulty.</td>
<td>Check input current, replace, evaluation unit.</td>
</tr>
<tr>
<td>6</td>
<td>Detector temperature &gt; 65°C</td>
<td>Detector temperature too high, detector faulty</td>
<td>Cool detector, if necessary, replace it</td>
</tr>
<tr>
<td>7</td>
<td>Trouble with detector communication</td>
<td>Cable detector – evaluation unit interrupted or too long or cable resistance too high, detector faulty evaluation unit faulty.</td>
<td>Replace cable or use bigger wire cross-section. Replace detector Replace evaluation unit.</td>
</tr>
<tr>
<td>8</td>
<td>Measurement stopped</td>
<td>Measurement process stopped via digital input or measurement stopped because count rate threshold has been exceeded or not reached.</td>
<td>Open digital input. Disable count rate thresholds to identify fault.</td>
</tr>
<tr>
<td>9</td>
<td>Detector temperature &gt; 80°C</td>
<td>Detector temperature too high, Detector faulty</td>
<td>Replace detector</td>
</tr>
<tr>
<td>10</td>
<td>Not calibrated</td>
<td>Measurement was started without calibration</td>
<td>Perform calibration</td>
</tr>
<tr>
<td>11</td>
<td>Power fail &gt; 1 month</td>
<td>Check date after long period of power failure</td>
<td>When the If this error message appears already after a brief period of power failure: replace Li-battery.</td>
</tr>
<tr>
<td>12</td>
<td>No input allowed</td>
<td>Input locked via password</td>
<td>Enter password</td>
</tr>
<tr>
<td>47</td>
<td>Rate &lt; Minimum</td>
<td>Enter actual count rate &lt; than entered min. count rate: shielding container closed? detector fault?</td>
<td>Replace detector Replace detector Open shielding container</td>
</tr>
<tr>
<td>48</td>
<td>Rate &gt; Maximum</td>
<td>Enter actual count rate &gt; than entered max. count rate: detector fault? pipeline empty and shielding container not closed?</td>
<td>Replace detector Replace detector Close shielding container</td>
</tr>
<tr>
<td>61</td>
<td>Replace photomultiplier</td>
<td>High voltage increased too much.</td>
<td>Check plateau. Possibly replace photomultiplier.</td>
</tr>
<tr>
<td>Message</td>
<td>Cause, Remarks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement halted &lt;HALT&gt;</td>
<td>Measurement process stopped via digital input or measurement stopped because count rate threshold has been exceeded or not reached.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate Overflow</td>
<td>Detector faulty. High voltage outside of the plateau.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Fail</td>
<td>Complete failure or drop of power supply below tolerance level.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Detector Rate *)</td>
<td>Detector supplies no pulses for at least 60 s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrong HV *)</td>
<td>HV reference voltage of detector too high or too low. Measurement is stopped when this error occurs and has to be restarted by pushing the &lt;run&gt; button. Measurement is not stopped. Relay “Failure” is de-energized.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error temperature measurement</td>
<td>Temperature input faulty (see chapter “Temperature Compensation” and “Service Instructions”).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power failure &gt; 1 month *)</td>
<td>After a long period of power failure you have to check and, if necessary, correct the date to ensure correct decay compensation. Even if the date is correct, you have to enter one digit of the year and confirm the input with &lt;enter&gt;.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) When these error messages are displayed, the measurement stops automatically and has to be restarted by pushing the <run> button.
7.9 System Start/Stop

To **stop operation** of the measuring system, proceed as follows:

Turn system off.

The water cooling device has to be used if the detector temperature may rise above 50°C even though the instrument is not in operation.

*In case of sub-zero temperatures, empty the water cooling.*

To **start operation** of the measuring system:

Put water cooling in operation again, if it was disabled.

Turn instrument on.

If instrument has been disabled for more than one month, the error message “Power failure > 1 month” is displayed.

In this case, check and, if necessary, correct the date and time again in the menu *sk1: General Data.*
8 Technical Data

8.1 Evaluation Unit LB 444 K-40

Assembly: 19” module 3 HE, 21 TE; protection type IP 20

Power supply: 115 V ± 10%, 230 V ± 10%, 18-32 V AC/DC

Power consumption: approx. 30 V or 30 W

Temperature range:
- Operating temperature: 0 - 50 °C; no condensation
- Storage temperature: - 40 to + 70 °C

CPU: 32 bit computer, data storage in FLASH- E- PROM.

Weight: approx. 2 kg

Display: LCD display with 4 x 20 characters, illuminated.
- Data input via keyboard.
- Softkey guided dialog;
- Languages: German, English
- Data editing possible only after entry of a freely selectable password.

Time constant: 0.5 – 9999 s with automatic reduction to 1/10 of the values in case of sudden concentration changes (can be turned off).
- Adjustable response threshold for time constant switchover.

Automatic decay compensation: for $^{241}$Am, $^{137}$Cs, $^{60}$Co, $^{244}$Cm, $^{85}$Kr and $^{90}$Sr.

Inputs/Outputs:

Detector connection: Ex II (2) G [EEX ib] II B or Ex II (2) G [EEX ib] II C

Digital inputs:
- 2 digital inputs for external product selection
- 1 digital input for external start/stop of measurement:
  - Start/Stop in batch mode,
  - Stop of continuous measurement or Restart after interruption of measurement due to interfering radiation.

Analog output: 0/4 - 20 mA isolated (max. 500 Ω) for measured value

Limit value outputs:
- 2 relay outputs for measured value max. / min., detector temperature, mass pulse, correlation freely selectable
- 1 relay output for collective failure message

Loading capacity:
- AC: Max. 250V, max. 1A, max. 200VA
DC: Max. 300V, max. 1A, max. 60 W non-reactive load

Current input: 0/4 - 20 mA isolated for input of temperature signal or volume current signals

Interfaces: RS 232. Port for data transfer from evaluation unit to printer or PC

### 8.2 Detectors

<table>
<thead>
<tr>
<th>Type</th>
<th>Crystal Ø / l in mm</th>
<th>Weight kg</th>
<th>Detector code</th>
<th>Ex protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB 5401-03</td>
<td>50/50</td>
<td>18</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>LB 5430</td>
<td>150/150</td>
<td>52</td>
<td>23</td>
<td>No</td>
</tr>
</tbody>
</table>

- **Protection type:** IP 65
- **Housing:** Stainless steel housing
- **Cable entry:** M16 external cable diameters 7...10 mm for connection cable detector - evaluation unit and M 12 for external cable diameter 7...10 for connection of Pt 100
- **Temperature range:**
  - **Operating temperature:** -20 to +50°C. A water cooling device is available for higher temperatures. Monitoring of detector temperature and alarm if max. permissible temperature is exceeded.
  - **Storage temperature:** -40 to +70 °C

**Connection cable evaluation unit - detector**

<table>
<thead>
<tr>
<th>Cross-section in mm²</th>
<th>Max. cable length in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>1.5</td>
<td>1500</td>
</tr>
<tr>
<td>2.5</td>
<td>2500</td>
</tr>
</tbody>
</table>
9 Service Instructions

9.1 General Safety Precautions

Any time you are working on electrical components, you have to observe the relevant safety regulations. Please refer to the Safety Summary at the beginning of this operating manual.

9.2 Evaluation Unit LB 444 K-40

The evaluation unit is provided with an error control which also monitors the detector functions. An error code appears on the display if an error is detected. For information about the error and possible causes please refer to the error code list. In case of hardware errors the evaluation unit has to be replaced.

If no error code is displayed, the electronics is working properly and all measured values and parameters lie in the normal possible range. Possible function problems must then have another cause.

"Total Reset“ should be performed only in exceptional cases and after consultation with Berthold.

To perform a "Total Reset", turn the instrument off; then push the Clear button while you turn the instrument on.

All entered date will be deleted and the default values restored.

Error code list

<table>
<thead>
<tr>
<th>No.</th>
<th>Problem</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rate Overflow</td>
<td>Count rate &gt; 520000 cps</td>
</tr>
<tr>
<td>2</td>
<td>No Detector Rate</td>
<td>Error in detector or during transmission</td>
</tr>
<tr>
<td>3</td>
<td>Wrong HV</td>
<td>HV &lt; 500V or &gt; 1500V, outside control range</td>
</tr>
<tr>
<td>6</td>
<td>Detector temperature &gt; 65°C</td>
<td>Detector temperature has exceeded &gt; 65°C</td>
</tr>
<tr>
<td>7</td>
<td>Trouble with detector</td>
<td>Data transfer between detector and evaluation unit faulty</td>
</tr>
<tr>
<td>8</td>
<td>Measurement stopped</td>
<td>Measurement stopped by closed contact 22 a/c</td>
</tr>
<tr>
<td>9</td>
<td>Detector temperature &gt; 80°C</td>
<td>Detector temperature has exceeded &gt; 80°C</td>
</tr>
<tr>
<td>10</td>
<td>Missing calibration</td>
<td>Calibration has to be terminated with &lt;enter&gt; and &lt;more&gt;</td>
</tr>
<tr>
<td>11</td>
<td>Power fail &gt; 1 month</td>
<td>Instrument has been turned off for more than one month. Enter new date</td>
</tr>
<tr>
<td>12</td>
<td>No input allowed</td>
<td>Device locked by password or wrong password entered</td>
</tr>
<tr>
<td>33</td>
<td>Wrong password</td>
<td>Wrong password entered</td>
</tr>
<tr>
<td>36</td>
<td>Missing calib. points</td>
<td>Not enough calibration points available</td>
</tr>
<tr>
<td>37</td>
<td>Curve not clear</td>
<td>Calibration not steady</td>
</tr>
<tr>
<td>39</td>
<td>Measuring path not defined</td>
<td>Measuring path not yet entered</td>
</tr>
<tr>
<td>46</td>
<td>Radiating interference</td>
<td>New start with &lt;run&gt; or via input 3 (22a/22c)</td>
</tr>
<tr>
<td>Problem</td>
<td>Possible Cause</td>
<td>Potential Solution</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>No display</td>
<td>No power supply</td>
<td>Check mains cables</td>
</tr>
<tr>
<td>Display unreadable</td>
<td>Processor error</td>
<td>Note error code, Perform total reset, Replace evaluation unit</td>
</tr>
<tr>
<td>No pulse rate (Error code 2)</td>
<td>Power supply for detector interrupted</td>
<td>Check cable to detector</td>
</tr>
<tr>
<td>Result reading shows drifts</td>
<td>Detector stabilization faulty</td>
<td>Replace detector</td>
</tr>
<tr>
<td></td>
<td>Photomultiplier faulty</td>
<td>Replace photomultiplier</td>
</tr>
<tr>
<td></td>
<td>Decay compensation activated</td>
<td></td>
</tr>
</tbody>
</table>
10 Service

10.1 Service Menu Overview
10.2 Service Menu

The Service menu functions support input of test values (output current, count rates) to simulate instrument functions:
- check of outputs and inputs
- adjustment of analog outputs and inputs
- adjustment of Pt 100 input (N/A)
- plateau recording of detector
- manual setting of high voltage for test purposes.

The individual functions are described below.

**Test calculate:**
Any pulse rate within the calibration range can be entered. The count rate supplied by the detector will then be ignored.
The respective output current is calculated from the count rate and the concentration value.
Output current and the respective concentration value are displayed as a result of the defaulted pulse rate.

---

The product temperature supplied via Pt 100 or as current signal is taken into account when calculating the measured value. Therefore, the temperature compensation for the test has to be disabled. To do this, select “Density without TC”.

*After completion of the test, reset the test count rate to “0”!*  

**I/O Test Output Current:**
To use this function, the measurement must not be in the RUN mode.
To test the connected instruments, you can set any output current between 0 – 22 mA.

**View input current:**
Shows the current measured at the current input.

**Relay 1/2/3:**
The relays can be switched to test the signal circuits (ON = relay energized)

**Input 1/2/3:**
Shows if the inputs are open or closed. (OFF = input open)

**HV Adjustment:**

**Set HV detector**
With the standard setting “0” the detector works with automatic high voltage control. If you enter a high voltage value for special tests, the high voltage control is disabled. The entered value is used as fixed high voltage. In this case, the info HV-Test is displayed in the measurement menu or the live display (instead of HV auto).

*Set this value to “0” again when you exit the Service menu. Otherwise, the measurement device will not work correctly.*

**Status request**
This menu item includes the detector temperature
current counts
high voltage.
**Reset Detector:**
To reset the detector you have to push the buttons <sk1> and <clear> at the same time. This will interrupt the plateau recording and reset the detector electronics. A reset also has to be performed when the microprocessor of the detector has been replaced.

**Pt 100 Adjust (N/A)**
The Pt 100 input is adjusted by the manufacturer. New adjustment is necessary only when detector boards or the microprocessor of the detector have been replaced.
Apply resistance with 100 Ω (with lowest tolerance) at Pt 100 input of the detector (terminals 3 and 4).
Select menu item “Pt 100 Adjust”
Push <sk2> and <clear> at the same time. The message “Pt 100 adjustment running...” is displayed. The adjustment is finished after approx. 5 s.
Then connect resistance thermometer to detector, terminals 3 and 4.
Pt 100 adjustment should be performed by trained personnel only!

---

**10.2.1 Plateau Check**

**Measure Plateau**
A detector plateau can be recorded automatically in steps of 60 V, e.g. to check the proper function of the NaI crystal multiplier combination.

*Working principle of scintillation counters*
The detector (scintillation counter) is comprised of:
- an organic scintillator (PVT)
- a sodium iodide crystal doped with Thallium
- photomultiplier
- electronics unit

As the gamma radiation hits the detector, it triggers minute flashes of light in the crystal which are invisible to the naked eye. These flashes of light release electrons from the light-sensitive cathode (photo cathode) of the photomultiplier. This electron current is amplified via a dynode system resulting in an electrical impulse at the photomultiplier output for each light flash.
The high voltage required for operation of the photomultiplier is generated in the electronic unit.
The scintillation counter is equipped with a drift compensation which compensates for the effects of aging and temperature-related gain variations, thus ensuring high long-term stability.
Malfunctions of the scintillation counter are not always indicated by a missing pulse rate. It is also possible that the specific Gamma sensitivity appears to have changed or obvious instabilities are apparent. This error can be detected only by means of a plateau check. The evaluation unit LB 444 K-40 includes a function for automatic plateau recording.
Please keep in mind:
The scintillation counter may remain at the measuring point if it is certain that the concentration in the measuring path will remain absolutely constant during the time of the check (approx. 10 min.). Otherwise, the check has to be carried out in the workshop. An appropriate amount of potassium salt (10 kg) has to be provided directly in front of the detector.
Select Plateau / Measure Plateau in the Service menu.
Upon completion of the plateau measurement, you may invoke the function Request Plateau to display the value pairs HV-steps/count rate.
The detector works properly if a clear plateau is visible; the position of the plateau is
irrelevant.

Figure 14: Plateau curve with Na I crystal (LB 5402)

![Plateau curve with Na I crystal (LB 5402)](image1)

Plot the count rate vs. the high voltage, as shown in the diagram above.

If the count rate in the flattest part of the curve changes

a) by more than 5% per 100 V high voltage for the LB 5402,

b) by more than 15% per 100 V high voltage for the LB 5430,

the scintillation counter will operate unstable. The detectors or at least the crystal
multiplier combination have to be replaced.

**Request Plateau**
The value pairs of the plateau measurement may be displayed here and may be plotted to assess the curve.

**Adjust current output**
Current 1.8 or 18 mA:
Adjustment of output current to the values 1.8 mA and 18 mA by incrementing or decrementing the numerical value on the display.

**Adjust current input**
Target value/Actual value
Adjustment of input current. Feed current of 1.8 mA.
Confirm display with <enter>.
RUN appears on the display, the adjustment is running. Push <more> to stop the adjustment and continue with the next item.
Then feed 18 mA current and confirm with <enter> and push <more> to continue.
10.3 Detector

10.3.1 Checking the Crystal-Multiplier Assembly

A plateau that is too small or too steep indicates faults in the crystal-multiplier assembly. Please proceed as follows to perform a visual inspection of crystal and multiplier:

**Switch off the scintillation counter before opening the instrument.**

**Do not perform the check in bright daylight, as this may damage the photo cathode of the photo multiplier.**

Open the scintillation counter by removing the cover of the connection box first and then the screws of the base. The entire electronics (1) with the crystal/multiplier combination can then be detached from the housing. Remove photo multiplier combination from base (2) and unscrew ring nut (3) on front panel. The multiplier (4) including crystal (5) can now be detached from the Mu-metal shielding (6).

A thin layer of silicone oil between crystal and multiplier ensures optical coupling; silicone oil is rather viscous, particularly at low temperatures. Carefully detach the crystal from the multiplier window by gently sliding the crystal sideways. Do not wipe off the silicone oil layer if no new silicon oil is available!

**Check:**

The **crystal** must be perfectly clear inside and not show any dull areas. Its typical color is white. A yellowish to brownish coloring is a sign of thermal overload and indicates that the crystal has to be replaced. The surrounding white reflecting layer must not be damaged. You can only check the photo multiplier for glass breakage or other mechanical damage. Other faults cannot be identified by visual checks alone. However, if the crystal does not show any faults, a bad plateau indicates that the photo multiplier is faulty.

![Figure 16: Assembly of the scintillation counter](image)

1 = electronics part with (a) CPU, (b) HV, (c) voltage divider
2 = base
3 = ring nut
4 = photomultiplier
5 = crystal
6 = Mu-metal shielding
The **multiplier window** is coated with a vapor-deposited layer acting as photocathode. This layer gives the window a brownish tint similar to smoked glass. If this layer is no longer present or if it is stained, then the photocathode has been destroyed (e.g. by overheating, glass breakage, or incident light), and the multiplier must be replaced. Faults caused by damage to the dynode systems (e.g. by excessive vibration) cannot be identified by appearance. If in doubt, replace the multiplier.

The glass pane at the mating face to the photo multiplier must not show any cracks. Before re-assembly, apply a drop of clean silicon oil between crystal and multiplier and distribute it evenly by gentle rubbing to ensure sound optical connection between both components. Attach the Mu-metal screen and fix it with screws, making sure that the Mu-metal screen is only under light tension.

**Re-assembly:**
Set the crystal again onto the front face of the photo multiplier and twist both components several times counter-clockwise. If you have to replace a component, apply 1 or 2 drops of silicone oil on the mating faces of the new and old component. It may also suffice to press the new component against the mating face of the old one and to turn it several times. Reassemble parts properly.
Just as after replacement of a complete detector, the calibration should be checked immediately.

### 10.3.2 Testing and replacement of the photomultipliers in the detector LB 5430

The organic scintillator is in the front housing part of the detector LB 5430 (1 in Fig. 17 ).

**This housing should only be opened by the service staff from Berthold.**

The detector electronics and the photomultiplier are located in the rear housing part (2 in Fig. 17 ).

The same rules and criteria apply as for the detector LB 5430 regarding dismantling and inspection.

The detector must stand upright on the flange for dismantling and installation of the detector electronics. An installation of the electronics in horizontal position of the detector is very difficult. The multiplier can get damaged.

1. Dismantle electronics with photomultiplier (see above)
2. Check photomultiplier and replace if necessary.
3. Put 1-2 drops of silicone oil on the frontal area of the photomultipliers before assembly
and rub it in gently with your finger.
4. Guide the electronics and the photomultiplier back into the housing until the photomultiplier stands up on the ground of the detector housing. Turn the electronics without exerting pressure several times at about 90° back and forth. This distributes the oil on the frontal area of the photomultipliers evenly.
5. Screw the electronics on at the base.
6. Screw on lid.

**10.4 Replacing the Evaluation Unit LB 444 K-40**

To replace the entire LB 444 K-40 evaluation unit, please proceed as follows:
Connect new evaluation computer.
In submenu Calculate (menu Calibrate), select the calibration mode (K2O).
Enter data using the set-up protocol and date of the original set-up.
Start calibration process: select calibration more with <enter> and then push <more>.
Start measurement again with <run>.

Example:

<table>
<thead>
<tr>
<th>Calibration point</th>
<th>Count rates</th>
<th>% K2O</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>405</td>
<td>10,2</td>
<td>01.02.96</td>
</tr>
<tr>
<td>2</td>
<td>583</td>
<td>16,9</td>
<td>01.02.96</td>
</tr>
<tr>
<td>3</td>
<td>785</td>
<td>22,5</td>
<td>01.04.96</td>
</tr>
<tr>
<td>4</td>
<td>558</td>
<td>22,1</td>
<td>01.04.96</td>
</tr>
<tr>
<td>5</td>
<td>703</td>
<td>19</td>
<td>01.10.96</td>
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## 10.5 Setup Protocol

Measuring Point ............................................ Date: ................................

Product: ........................................................

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Value</th>
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<tbody>
<tr>
<td>Password</td>
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<tr>
<td>Instrument ID</td>
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<tr>
<td>Program version</td>
<td></td>
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<tr>
<td>Configure instrument</td>
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<td></td>
</tr>
<tr>
<td>Radiation measure</td>
<td>yes / no</td>
<td></td>
</tr>
<tr>
<td>Error mode</td>
<td>Hold/continue</td>
<td></td>
</tr>
<tr>
<td>Product no.</td>
<td>1/2/3/4</td>
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<tr>
<td>Measuring path</td>
<td>cm</td>
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</tr>
<tr>
<td>Measure mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time constant</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Rapid switchover</td>
<td>ON/OFF</td>
<td></td>
</tr>
<tr>
<td>Sigma for radiating interference</td>
<td>0-10</td>
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</tr>
<tr>
<td>Count rate limit (min)</td>
<td>cps</td>
<td>-1</td>
</tr>
<tr>
<td>Count rate limit (max.)</td>
<td>cps</td>
<td>-1</td>
</tr>
<tr>
<td>Current out for concentration</td>
<td>0-20mA or 4-20mA</td>
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</tr>
<tr>
<td>0/4 mA</td>
<td>20 mA</td>
<td></td>
</tr>
<tr>
<td>Current output error</td>
<td>Hold</td>
<td>Value: 0-22mA</td>
</tr>
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<td>Parameter</td>
<td>Range</td>
<td>Value</td>
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<tr>
<td>-----------------</td>
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<td>-----------</td>
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<tr>
<td>Relay 2 setup</td>
<td>Min or Max:</td>
<td></td>
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<tr>
<td>Hysteresis :</td>
<td>0-10%</td>
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<tr>
<td>Relay 3 setup</td>
<td>Min or Max:</td>
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<tr>
<td>Hysteresis :</td>
<td>0-10%</td>
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Data input:

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<tr>
<th>Count rate cps</th>
<th>Concentration (lab values)</th>
<th>Date</th>
<th>Temperature °C</th>
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Calculation:

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<th>Range</th>
<th>Value</th>
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<tbody>
<tr>
<td>Calibrate mode</td>
<td>on/lin/squ/cub/auto</td>
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<tr>
<td>Result a1</td>
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<tr>
<td>Background count rate Io</td>
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<tr>
<td>Coefficient a1</td>
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<tr>
<td>Coefficient a2</td>
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<tr>
<td>Coefficient a3</td>
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<tr>
<td>Square error</td>
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<tr>
<td>Factor</td>
<td>1 to 10</td>
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<td>Offset</td>
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11 Dimensional Drawings

11.1 LB 5402
Weight approx. 6 kgs

Cable gland M16 for cable dia. 7-10 mm

11.2 LB 5430

<table>
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<tr>
<th></th>
<th>LB 5430</th>
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</thead>
<tbody>
<tr>
<td>Weight appr.</td>
<td>52 kg</td>
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11.3 LB 444 K-40

19” module

Installation in 19” rack

Installation in wall housing

10 M16 cable gills for cable Ø 6–10
Wiring Diagram Cabinet LB 4460 for Density Measuring LB 444