Berthold

October 22, 1991

OPERATING MANUAL

Level Gauge

LB 323

ATTACHMENT 29

Operating Manual

Level Gauge LB 323

Important:

This Operating Manual contains important information and regulations which have to be observed in order to ensure the reliable function of the measuring system and the proper handling of the radioactive substances. The user and the operating staff should therefore be familiar with the contents of this Manual.

Brief Operating Instructions

Please follow the instructions in the long operating manual for information concerning the initial start-up of the Level Gauging System and modification of the system parameters.
For calibration and new setting please observe the following sequence:

A. Unlocking the Keyboard:

As long as the LED "Locked" is lit, the keyboard is locked against unauthorized entries. To unlock the keyboard, proceed as follows:

1. Using the "Code" key, select code number "00" (left half of the display field).
2. Using the key ▲ or ▼, enter the password (numerical value in right half of display).
3. Confirm entry with "Enter". After entry of the correct password the information "Locked" disappears and the keyboard is operational.

B. Calibration:

1. Press the key "Measure" to switch off the measurement mode (LED "Measure" out).
2. EMPTY calibration (vessel empty, radiation exit channel open)
   - 2.1 With "Code", select code number "30".
   - 2.2 Simultaneously press "Enter" and "Measure" (LED "Measure" on). Current count rate is read in. Wait until reading has become stable.
   - 2.3 Confirm entries by pressing "Measure" (LED off).
3. FULL calibration (vessel filled to upper point of measuring range).
   - 3.1 With "Code", select code number "31".
   - 3.2 Simultaneously press "Enter" and "Measure" (LED "Measure" on). Current count rate is read in. Wait until reading has become stable.
   - 3.3 Confirm entries by pressing "Measure" (LED off).
4. Press "Compute"; the instrument performs an automatic calibration.
5. Press "Measure" to switch back to the measurement mode (LED on).

C. Parameter Setup:

1. Select the desired code (see code table) using the "Code" key.
2. Using key ▲ or ▼, make the necessary changes.
3. Press "Enter" to accept the new data.

D. Locking the Keyboard:

1. Select code "00".
2. Enter old or new password.
3. Press "Enter" to accept the entries. The LED "Locked" is lit and the keyboard is inoperational.

Code	Meaning	Code	Meaning
00	Password	18	Max.-Alarm
10	Current filling level	30	Calibration EMPTY (cps)
12	Measuring time/Time constant	31	Calibration FULL (cps)
17	Min.-Alarm	45	Test pulses (cps)

I. System Description

The Level Monitoring System LB 323 is a modern microprocessor-controlled measuring system using scintillation counters as radiation detectors. Together with a source specially designed for the individual application, the system monitors the filling level through the vessel walls without contact with the fluid and without mechanically moving parts or electrical connections with the interior of the vessel.

1. Measuring Arrangement

Fig. 1 shows the schematic layout of a complete level-monitoring system.

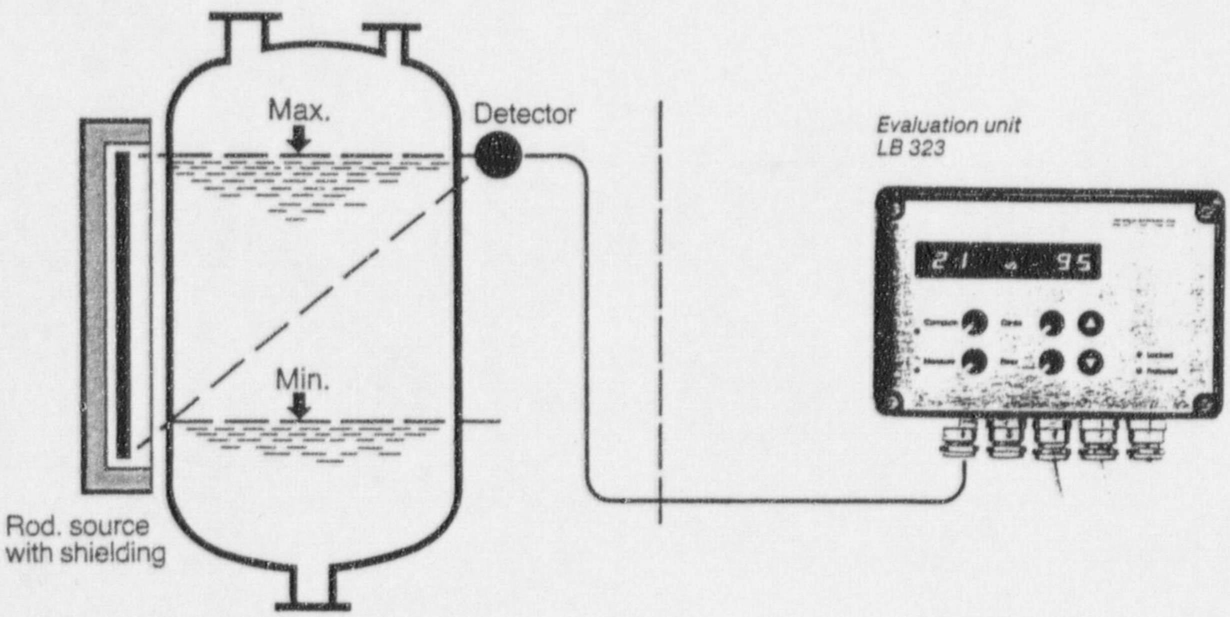


Fig. 1

It consists of the following elements:

- source with shielding designed for the individual application and measuring geometry
- scintillation counter acting as radiation detector
- cable connecting the scintillation counter to the Level Gauge
- Level Gauge LB 323

This measuring arrangement is intended for standard applications. Alternative system configurations adapted to individual requirements can be provided for special applications.

2. Basic Principle and Sources

The measuring principle is based on the physical law of the attenuation of nuclear radiation as it passes through matter. The absorption of gamma radiation follows an exponential law. A beam of rays with the original intensity Io is weakened as it passes through matter having the thickness d and the density ρ:

$$I = Io \times e^{-\mu' \times \rho \times d}$$

The mass weakening coefficient μ' depends on the type of radiation source used. Consequently the measured count rate is determined by the area weight ρ x d of the fluid. Due to the shape of the absorption curve, the measured count rate will in most applications become virtually constant irrespective of the density ρ of the fluid. The thickness of the vessel walls has no influence on the measured count rate but only causes a constant weakening of the radiation, which can be compensated by increasing the source activity accordingly. This also explains the high safety and trouble-free operation of the radiometric measuring method.

For physical reasons, there is no risk that the vessel content or the container walls will be activated by gamma radiation.

The source is constructed as rod-type source; its length depends on the length of the requested measuring range. For large measuring ranges, the rod source consists of several sections. Usually, it is enclosed by a cylindrical lead shielding that opens the radiation field only towards the scintillation counter.

Viewed from the detector, an increasing proportion of the rod source will be marked by the vessel contents as the level rises, and therefore the radiation intensity at the scintillation counter will be reduced in inverse proportion to the filling level.

All non-linearities introduced by the measuring geometry are compensated by a corresponding non-linear activity distribution along the rod source, so that the radiation intensity at the detector will always be in linear proportion to the filling level. This is also true for the critical range at the lower portion of the measuring range. No electronic linearization will therefore be necessary, which greatly simplifies the setting-up and use of the level measuring system.

In the case of Co-60 rod sources, the radioactive substance is incorporated in a metal wire. This wire is wound around a core at varying pitch to produce the required intensity distribution, and the complete assembly is sealed into a welded special steel tube. This qualifies the source as a "sealed source" and, moreover, as a "source in special form". The capsule construction has been examined and is registered and approved.

not a point source description.

3. Shielding

For standard applications the source is permanently installed in a shielding as shown in drawing 21157.001. This shielding consists of a lead cylinder with a radiation exit slot, the cylinder being welded into a steel tube that is sealed with a steel cover. The cylinder is mounted in a structural frame and can be pivoted so that, by turning it through 90°, additional shielding is provided for the effective radiation beam by the structural frame.

The diameter of the shielding, and consequently the effectiveness of the shielding, is matched to the individual activity of each source to ensure that the Radiation Protection Regulations and any special requirements specified by the user are complied with.

For large measuring ranges, the shielding is made of several sections, the sections being simply stacked and bolted together.

4. Scintillation Counter

The radiation detector consists of a scintillation counter whose special features are its high specific sensitivity to gamma radiation and the fact that its useful life does not vary with the radiation exposure. This means that a high count rate is generated, despite the relatively low activity of the source, which gives meaningful results and does not limit the useful life.

The scintillation counters, successfully used for decades, consist of a compact NaI(Tl) crystal which converts the gamma quanta emitted by the radioactive source into light flashes, the frequency of which is proportional to the incident radiation intensity. The crystal is optically coupled with a photomultiplier in whose photosensitive layer the light flashes release electrons. An HV supply applied to this layer accelerates the electrons towards the anode, where they release further electrons as they impinge on a dynode system. Thus, one obtains high amplitude pulses that are subsequently converted into standard pulses of approx. 10 V by a series amplifier. These components, including the HV supply for the photomultiplier, are installed in a robust cylindrical stainless steel housing with an integrated terminal box.

The protection type is IP 65; the scintillation counter is designed to operate in explosive areas and complies with

E Ex de II C T6

The connection of the scintillation counter is made through a 7-core screened cable. This cable transmits the voltage supply of 30 V, the standard pulses of approx. 10 V, and a voltage controlling the HV supply of approx. 6 V.

Scintillation counters with different crystal sizes are available which offer different degrees of gamma sensitivity. The choice depends on radiation protection requirements and economical criteria.

Ambient temperatures above 50°C require a cooling system for the detector. Suitable water cooling jackets are available as standard options. The scintillation counter is installed horizontally at the measuring point as illustrated in Fig. 1.

5. Level Gauge LB 323

The Level Gauge LB 323 is a microprocessor-controlled system that also supplies the operating and control voltage for connection of the scintillation counter. The standard pulses generated by the detector are applied via an opto-electronic coupler to the input of the microprocessor to ensure suppression of interference pulses.

The standard pulses supplied by the detector are processed by a microcomputer system that calculates the averaged count rate in a digital ratemeter and computes the final results on the basis of the parameters entered. All standard parameters are preset by the manufacturer; this simplifies setting up and instrument calibration, which is done by a simple key action.

For special tasks, all important parameters may be changed and optimally adapted to any given application over a wide range of conditions. The system function was designed in such a way that all parameters are stored in code numbers which can be selected in an easy manner. The digital signal processing allows reproduction of all values.

The parameters and measured results are displayed by LED-digits in a display field. A power supply switch, a convenient foil keypad with only 6 push-buttons with distinct action point, and various signal LED's are available for operation. A password prevents unauthorized manipulation of the parameters. All parameters can be displayed any time.

The weakening of the source activity caused by the natural source decay is corrected fully automatically by a built-in clock over any period of time. The system and detector function is monitored continuously; a possible malfunction is indicated immediately, and the respective error code is displayed. In case of a power failure or disabled system, all parameters are stored in an EEPROM. The clock is battery-buffered and works for a period of about 30 days.

A digital/analog converter generates a current output signal, which is isolated from the remainder of the circuit by a buffer amplifier. The relay for max.-min. indication and for error messages operates in a closed circuit with one isolated switchover contact.

An external calibration option via key action or computer signal is provided for special applications requiring frequent EMPTY or FULL calibration.

5.1 Description of the Key Functions

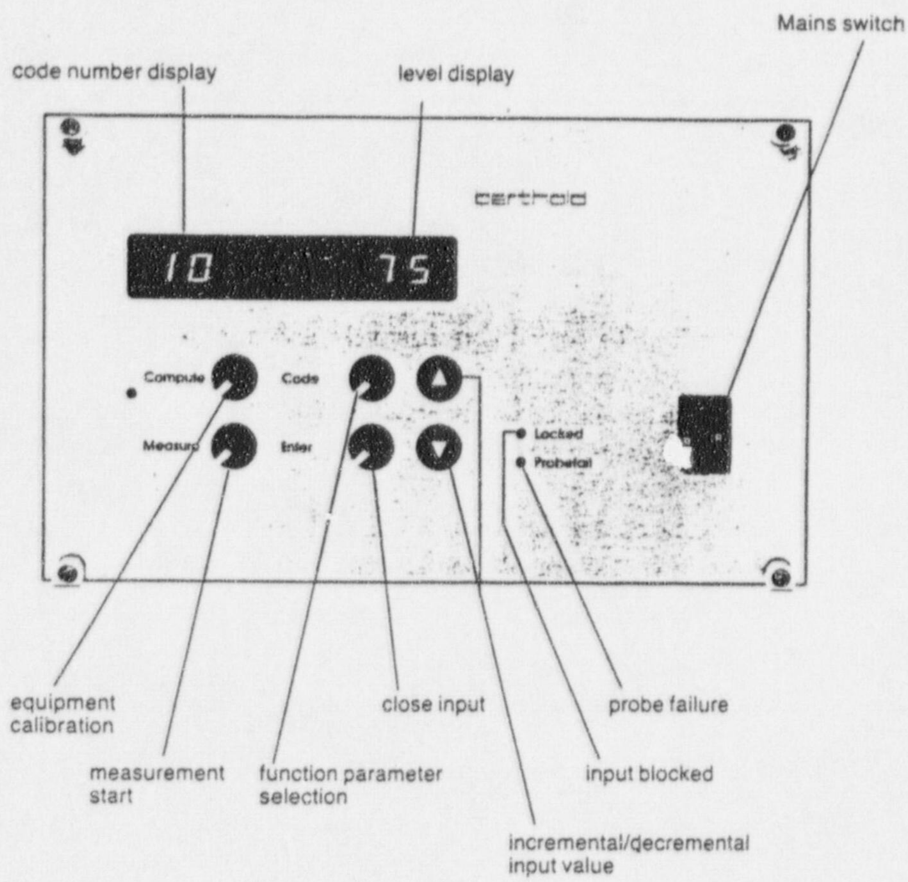


Fig. 2

"<u>Code</u>"

All parameters are stored in code numbers which can be selected with the "Code" key. The code is displayed by two luminous digits in the left hand side of the display field. If you operate the key briefly, the next higher code is selected. If you keep the key pressed down, all code numbers are displayed in rising order and continuously increasing speed, the whole process starting again at zero after reaching the highest level. Reverse counting is possible by pressing the key ▼ together with the "Code" key. The code number is permanently displayed in order to avoid misinterpretations.

This key is operational regardless of the fact whether the measurement mode is switched on or off.

▲ and ▼

Quick operation of the key ▲ or ▼ increases or decreases the value in the display by one. If you keep one of these keys pressed down, the value changes continuously. Starting with the last decade, the system always counts to the full decade and then automatically switches over to the next decade to repeat the same process.

"Enter"

This key is used for the following functions:

a) To accept changed parameter values; then automatic continuation with the next higher code number.
b) To start the pulse reading-in process for EMPTY/FULL-calibration together with the key "Measure" and to stop this process by pressing "Enter" again.
c) To reset and clear error messages.

"Compute"

After input of the EMPTY or FULL count rate, and after changing the parameters in code numbers 20 and 21, you have to operate this key to calculate the position and slope of the curve and to store the associated parameters in code numbers 40 and 41. At the same time, the value in code number 42 is set to "1" and the value in 43 to "0". The LED next to this key lights up during the calculation process.

Important! After changing the calibration points FULL or EMPTY, the measurement mode must be switched off to make the key "Compute" operational and thus to allow calculation of the new calibration curve, taking it into account for the output signal.

"Measure"

This key is used for the following functions:

a) To start and stop the measurement mode.
b) Together with the key "Enter", to start and stop input of the count rates for EMPTY and FULL calibration.

If the key "Measure" is operated alone following the last entry, the system automatically switches to the measurement and display mode.

Note: The key functions "Enter", "Compute", and "Measure" are operational only if the keyboard is unlocked. All parameters may also be changed in the measurement mode.

Power Switch

To connect and disconnect the scintillation counter you absolutely must switch off the instrument!

Although all system parameters are stored in an EEPROM and the clock is battery-buffered, the system should not be switched off for a long time. After a voltage supply interruption of more than one month, the clock has to be reset, and after more than one year, all parameters must be checked and, if necessary, re-entered. After power on, it will take some seconds before the system is ready for operation because the system is running a test program. Any error detected by the system will be displayed (see Service Instructions). In the 19"-rack unit, the power switch is located on the front panel and in the wall mounted unit behind the cover of the connection compartment.

5.2 Description of Code Numbers

Password (00)

Any number comprising up to 6 digits may be selected. The password ensures protection against unauthorized manipulation of parameters.

Year (01)

The two last digits (YY) of the current year are displayed. The correct year is important for the automatic correction of the activity decay of the source.

Date (02)

The current date displayed as month/day (MM.DD). The correct date is important for the automatic correction of the activity decay of the source.

Time (03)

The current time confirms the proper function of the clock. Time deviations, however, have virtually no effect on the correction of the activity decay of the source.

Program (04)

Display of the number of the implemented software version.

Rod Detector LB 3231 (05)

For configurations with rod detector a relative linearization curve, which has been entered earlier, has to be converted automatically when doing an EMPTY calibration. This function is activated by entering "1". The default setting for operation with NaI detector is "0".

Interference Radiation Message (06)

The interference radiation message is output as a collective trouble message via the error relay: Code 06 = 0.

If signaling is requested that is independent of the other trouble messages, the function of the max. relay may be switched over: Code 06 = 1.

Function Min. Relay (07)

The standard setting of the min. relay is the idle current mode when the level set is not reached, i.e. in this situation the relay is deenergized: Code 07 = 0.

To operate the min. relay as a max. alarm in the idle current mode, i.e. it is to be deenergized when exceeding the level set, it is changed as follows: Code 07 = 1.

Background of Detector LB 3231 (08)

The count rate generated by the background of the rod detector has to be read in and stored in this code (possible only with the measurement mode switched off). Please refer to chapter III.9.

Error Processing (09)

With the standard setting code 9 = 0 the measurement is aborted when an error is encountered and can be started new only after having reset the error by pressing the key "Enter". Until then, the error message is displayed and the alarm relay remains deenergized, even though the error may no longer be present.

The usual error message is also initiated with the setting code 9 = 1, but the measurement mode is not quit. As soon as the cause of the error has disappeared, the system automatically continues its operation, the error relay is energized, and the filling level, rather than the error message, is indicated.

Filling Level (10)

In the measurement mode, the current filling level is displayed in the range defined in code 20 and 21.

Count Rate (11)

The count rate currently registered by the detector is displayed to control the function of the system. The displayed values fluctuate owing to the statistical distribution of the radiation quanta and according to the time constant set in code 12.

Because of the natural decay of the source activity, the count rate decreases slightly year by year.

Measuring Time (12)

The time constant for calculation of the sliding average is specified in this code. The largest permissible time constant should be used, so that the reading fluctuations caused by the statistical distribution of the radiation quanta received by the detector will be negligible. During a momentary change of the filling level, the reading error corresponds approximately to the maximum level rise within a time constant. A time constant of less than 20 seconds will therefore be required only in exceptional cases.

Supplementary note:

The natural statistical fluctuations of the output signal (I) around a mean value depend on the selected time constant (τ) and the measured count rate (n). The average reading fluctuations (ΔI) correspond to the 1-sigma value and are calculated as follows:

$$\Delta I/I = \pm \frac{1}{\sqrt{2 \cdot n \cdot \tau}}$$

The 2-sigma value corresponds to the statistical error, and the maximum statistical fluctuations are specified by the 3-sigma value.

Rapid Switchover (13)

The function "Rapid switchover" is useful for special applications with small vessel dimensions where the output signal has to adjust quickly to a new value if the level changes suddenly. For this purpose, a range (window) is defined in code 13 which can be manipulated by corresponding entries. If the displayed value exceeds this range, the selected time constant automatically switches over to a value that is smaller by a factor of 0.1. After a time corresponding to the (long) basic time constant in code number 12, the system switches back to the basic time constant.

If the rapid switchover is to be used, set the range in code no. 13 such that the statistical fluctuations cannot activate the switchover of the time constant. Therefore, you should enter at least "3" in code 13 - this corresponds to the 3-sigma value. If you enter "0", the automatic rapid switchover will not be activated.

0/4 mA (14)

Starting point of the current output within the range defined in code 20. Thus, it is possible - differing from the generally used setting "0/4 mA" - to utilize only a portion of the measuring range defined by the measuring geometry and source length for the lower value of the output signal.

20 mA (15)

Final point of the current output within the range defined in code 21. Thus, it is possible - differing from the generally used setting "100" - to utilize only a portion of the measuring range defined by the measuring geometry and source length for the upper value of the output signal.

Current Output (16)

Switchover for the initial value 0 or 4 mA (LIFE/ZERO) of the current output signal for the EMPTY position.

Min.-Alarm (17)

Switchover point for the alarm within the range defined in code 20 and 21. The relay is deenergized if the displayed value falls below this threshold. If the reading increases again, the relay is energized again, delayed by the value of the set hysteresis.

Max.-Alarm (18)

Switchover point for the alarm within the range defined in code 20 and 21. The relay is deenergized if the displayed value exceeds this threshold. If the reading decreases again, the relay is energized again, delayed by the value of the set hysteresis.

Switchover Hysteresis (19)

The relay is deenergized only after the measured value has changed corresponding to the value entered in %, relative to the difference between the set thresholds (MAX/MIN). The hysteresis should not be selected too small, otherwise relays may switch over several times, due to statistical fluctuations, when the level changes slowly.

Supplementary note:

The value of the hysteresis H is calculated according to the formula:

$$H = \frac{(MAX-MIN) \bullet \langle Code\ 19 \rangle}{100} \%$$

For the reasons mentioned above, this value should at least be equal to the 2-sigma value. For standard applications, this results in a switchover hysteresis of at least 3%.

Calibration EMPTY (20)

The size and position, and thus the lower limit of the measuring range, are determined by the length of the rod source and the measuring geometry. Thus it is possible to define any scale desired within this range. Although often a relative scale with information in % is used, the indication can also be provided in absolute values, for example, filling level in millimeters or filling load.

The lower calibration point of the level indication is fixed. For a reading in %, this value will be "0".

Calibration FULL (21)

The size and position, and thus the upper limit of the measuring range, are determined by the length of the rod source and the measuring geometry.

The upper calibration point of the level indication is fixed on the scale selected. For a relative indication in %, this value will then be, for example, "100".

Linearization (22 through 29)

These code levels are needed, together with code 21, after a switchover (jumper J 2) for a special linearization function. (see III.9).

Count Rate EMPTY (30)

The count rate obtained with empty vessel is entered and stored in this code (Possible only if the measurement mode is switched off). Please note that the value stored is constantly corrected by the clock relative to the decrease in activity, and therefore it will become smaller with time.

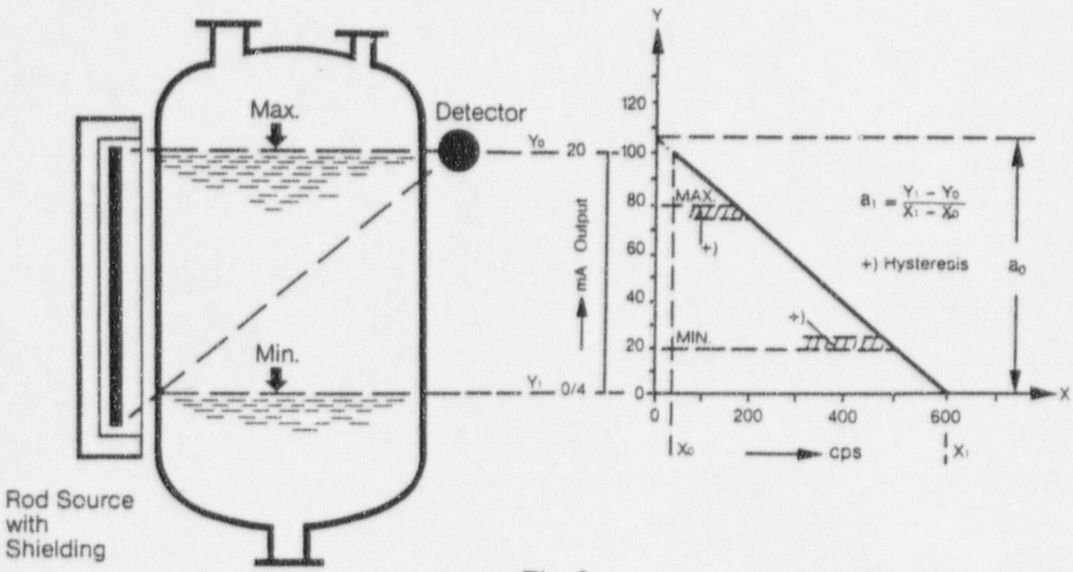


Fig. 3

Count Rate FULL (31)

The count rate obtained with full vessel is entered and stored in this code (Possible only if the measurement mode is switched off). Please note that the value stored is constantly corrected by the clock relative to the decrease in activity, and therefore it will become smaller with time.

Linearization (32 through 39)

These code levels are needed, together with code 31, after a switchover (jumper J 2) for a special linearization function. (see III.9).

a 0 (40)

Value for the position of the curve. Every time the "Compute" key is operated, this value is calculated new on the basis of the calibration data in (20), (21), (30) and (31.) It defines the intersection between the linear curve and the y-axis.

$$y = a1 \bullet X + a0$$

To change the position of the curve, this value may be changed by direct input.

a 1 (41)

Value for the slope of the curve. Every time the "Compute" key is operated, this value is calculated new on the basis of the calibration data in (20), (21), (30) and (31.) It defines the intersection between the linear curve and the x-axis.

Factor (42)

Only for special applications. Entry for intended modification of the slope of the calculated curve characteristic. With each new calibration, this value is automatically set to "1".

Constant (43)

Only for special applications. Entry for intended modification of the position of the calculated curve characteristic (parallel offset). With each new calibration, this value is automatically set to "0".

Nuclide (44)

Enter the nuclide used for the measurement to determine the correction factors for the automatic correction of the natural activity decay.

Test Generator (45)

For function control and simulation, enter an arbitrary count rate simulating a certain filling level. The pulses arriving from the detector will be suppressed and are irrelevant. Please note that entries will be accepted only after pressing "Enter" and then "Measure".

Important! At the end of the test, the value must be reset to "0" to make the system operational again for the detector pulses.

Attenuation Factor (46)

After FULL calibration, this value is automatically calculated from the absorption ratio FULL/EMPTY and stored in this code number. In general, this value should be between 0.25 and max. 1.0. One-point calibration is possible if you enter the attenuation factor, which is either known for this measuring point or calculated (see III. 2.3), into this code number.

Absorption Measurement (47)

Standard setting for the rod source application is "0". For absorption measuring applications with point source, a linearization will become effective by entering "1" (see III. 7.).

Detection of Interference Radiation (48)

The function is activated by entering a number between 1 and 10. For the reasons given in this description, we recommend using a number > 5. In the standard setting defined by the manufacturer this function is not activated. Code 48 = 0.

5.3 CODE Table

Code	Meaning (Unit)	Range	Standard Setting
00	Password	0-999999	
01	Year	YY	current year
02	Date	MM.DD	current date
03	Time	HH.MM	current time
04	Program version	(e.g. 3.8)	
05	Detector LB 3231: no/(yes	0 / 1	0
06	Interf. radiation alarm: error/max	0 /1	0
07	Min. relay: min/max	0 /1	0
08	Background LB 3231 (cps)	0-99999	0
09	Error processing: man/auto	0 / 1	0
10	Current filling level	0-10000	reading
11	Current count rate (cps)	0-99999	reading
12	Time constant	0.2-100.0 s	20
13	Rapid switchover	0-10.00	0
14	0/4mA for EMPTY	0-10000	0
15	20 mA for FULL	0-10000	100
16	Current output	(0 = 0-20mA 1 = 4-20mA)	0
17	Min.-Alarm	0-10000	10
18	Max.-Alarm	0-10000	90
19	Hysteresis for alarm points (%)	0-10.00	5
20	Setting EMPTY (Range)	0-10000	0
21	Setting FULL (Range)	0-10000	100
30	Calibration EMPTY (cps)	0-99999	current count rate
31	Calibration FULL (cps)	0-99999	0
40	a 0 (Curve value)	0-99999	calculated with "Compute"
41	a 1 (Curve value)	-9.99 to +9.99	calculated with "Compute"
42	Correction factor	0-10.00	1
43	Correction constant	-1000 to +1000	0
44	Isotope	1 = Cs-137 2 = Co-60	2
45	Test pulse generator (cps)	0-99999	0
46	Attenuation factor	0-1.00	0
47	Absorption measurement	0 / 1	0
48	Detection of interf. radiation	0 / 1 to10	0

NOTE: Entries in code numbers 22 to 29 and 32 to 39 are required only for operation with the rod detector LB 3231; otherwise these codes must contain "0".

II. Installation and Connection

1. Installation

The physical arrangement of the source with shielding and the scintillation counter at the measuring point will depend on the size and position of the measuring range to be covered. Normally these positions will be sketched into the vessel drawings submitted to Berthold. If no drawings are available and no particular details are indicated, the arrangement will normally be as shown in Fig. 1. The equipment is installed at the meauring point in such a way that the top point of the rod source (see drawing 21157.001) and the centerline of the scintillation counter are level with the top of the measuring range.

Install the scintillation counter horizontally (for example, by using clamping devices) such that it receives the incident radiation radially. If not specified otherwise in the drawing, we will assume a distance of 100 mm from the center of the scintillation counter to the vessel surface. Please see the respective instructions concerning the position of the radiation window in the appropriate outline diagram.

To avoid limiting the working life of the detectors, care should be taken that no excessive vibration is transmitted to the scintillation counters and that the ambient temperature of the scintillation counters does not exceed 50 degrees centigrade, otherwise suitable provisions must be taken for cooling. Water jackets for cooling the scintillation counter are available as optional extras.

Important: For outdoor installations the scintillation counter must be provided with a canopy that also protects the counter against direct sunlight.

The shielding must be installed as closely as possible to the vessel surface. The customer has to provide a suitable supporting construction, for example, a console or a carrier whose stability matches the weight of the shielding.

Single section shieldings are marked TOP and BOTTOM, respectively, to avoid inverse installation. Multisection shieldings are marked A, B, C, etc., always starting from the top.

Multisection shieldings are stacked and bolted together, additional flat iron bars or similar devices providing additional reinforcement.

For special geometries, please observe the written instructions or the projected installation position.

2. Connection

All connections should be made in accordance with the wiring diagram and the special notes applicable to the cable gland. The connection cable consists of a screened 7-core, the diameter being approx. 13 mm. The ends of the cable should be provided with fork terminals. We recommend making the connections in the sequence: terminal 4 - 7 - 5 - 6 - 1 - 2 - 3. See drawing of the connection points for the scintillation counter (Fig. 4).

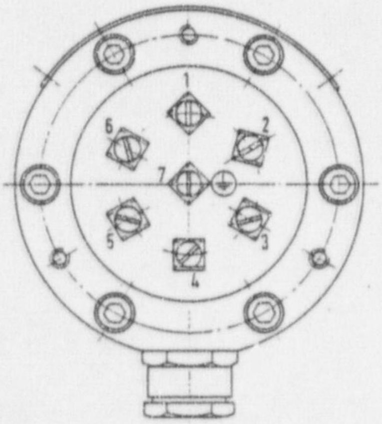


Fig. 4
connection points
scintillation counter

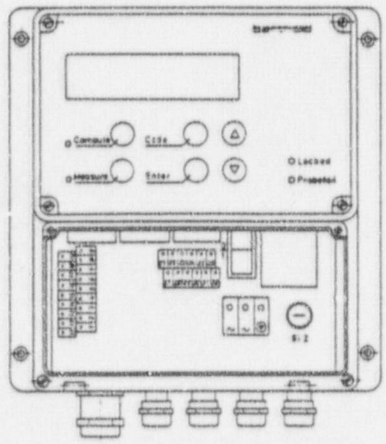


Fig. 5
connection points
wall mounted housing

The relevant specifications must be observed where the equipment is located in hazardous areas (explosion proof).

It is essential that the voltage supply to the Level Gauge LB 323 is identical with the nominal voltage marked on the nameplate.

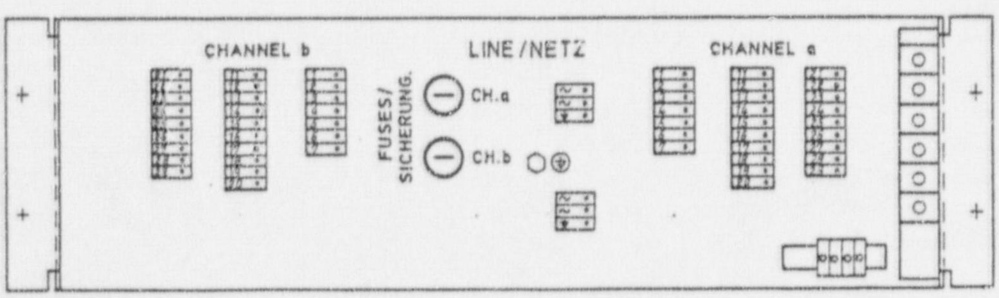


Fig. 6. Connection points of the 19"-rack

Furthermore, the connections must be made in accordance with the wiring diagrams for the wall housing or the 19"-rack. Pictures of the connection points of the the wall housing are shown in Fig. 5 and for the 19"-rack in Fig. 6.

Connections to the output relays must be, if necessary, noise suppressed to ensure a long life of the relays and to prevent interference.

Finally, all connections have to be checked again using the wiring diagram.

III. Operation

Shortly before the system will be put in operation, the source with shielding has to be installed into the vessel. For standard applications, open the locking device of the shielding so that the effective radiation beam can reach the detector. Then all necessary system settings may be performed at the Level Gauge LB 323.

If the system displays an error message after power on, press the "Enter" key to clear it.

The system is delivered with standard factory setting. After power on, check whether the date and parameters entered are correct. Then start up the system or reset the parameters in the following order:

1. Unlocking the Keyboard

As long as the LED "Locked" is lit, the keyboard is locked against unauthorized entries. To unlock the keyboard, proceed as follows:

1.1 With the "Code" key, select Code "00" (left half of the display field).

1.2 Using the key ▲ or ▼, enter the password (numerical value in right half of display).

1.3 Confirm entry with "Enter". After entering the correct password the LED "Locked" goes off and the keyboard is operational.

2. Calibration

The radiation path of the shielding should be open and the EMPTY calibration (or level at bottom point of measuring range) is carried out with empty vessel. FULL calibration can be carried out only at a later date, a one-point calibration with sufficient accuracy is possible as described in 2.6.

2.1 Press "Measure" to turn off the measurement mode (LED "Measure" out).

2.2 EMPTY calibration

2.2.1 With "Code", select code no. "30".

2.2.2 Simultaneously press "Enter" and "Measure" (LED "Measure" on). Current count rate is read in. Wait until the reading has become stable.

2.2.3 Confirm entries with "Measure" (LED off).

Important! The final calibration should be made, particularly with applications involving high-pressure processes, under actual operating conditions (pressure, temperature). For applications involving vessels with stirring devices, the stirrer must be running. If wall deposits are likely to occur, we recommend performing a recalibration with empty vessel occasionally.

Note: Calibration of the lower calibration point may be performed with partially filled vessel, if the current filling level is known. In this case, enter the value associated with this calibration point into code number 20.

2.3 FULL calibration

2.3.1 With "Code", select code no. "31".

2.3.2 Simultaneously press "Enter" and "Measure" (LED "Measure" on). Current count rate is read in. Wait until the reading has become stable.

2.3.3 Confirm entries with "Measure" (LED off).

Note: Calibration of the upper calibration point may be performed even if the vessel is not filled completely, if the current filling level is known. In this case, enter the value associated with this calibration point into code number 21.

2.4 Press "Compute" and the system performs an automatic calibration.

2.5 Press "Measure" to switch back to the measurement mode (LED on).

2.6 One-Point Calibration

If it is not possible to fill the vessel for FULL calibration, you may perform a one-point calibration before doing the EMPTY calibration:

2.6.1 Vessel diameter > 1 m

FULL calibration is usually not required and one operates with the standard value "0" in code number 31.

However, the calibration becomes more accurate, if the detector background is read in or entered in code 31. The reading-in procedure is the same as described under FULL calibration, but the source must not have been installed yet. If the background can only be entered, please consider the following count rates:

SZ5-L3 25/25 —> 6 cps
SZ5-L3 40/35 —> 15 cps
SZ5-L3 50/50 —> 20 cps

2.6.2 Vessel diameter < 1 m

The attenuation factor for the respective measuring point can be calculated according to the following formula and entered in code 46:

$$\text{Attenuation factor} \quad s = e^{-0.0044 \cdot \rho \cdot d}$$

ρ is the density in the vessel filling in g/cm³ and d the vessel diameter in mm.

3. Parameter Setup

The parameter settings may be changed as follows:

3.1 Select the desired code no. (see code table) with the key "Code".

3.2 Using the key ▲ or ▼, make the necessary changes.

3.3 Press "Enter" to accept the entries.

4. Measure

Press the key "Measure" and the instrument switches to the measurement mode (code 10) and displays the current level of filling.

5. Locking the Keyboard

5.1 Select code "00".

5.2 Enter old or new password.

5.3 Press "Enter" to accept the entries. The LED "Locked" is lit and the keyboard is inoperational.

6. External Calibration

If special applications require frequent EMPTY or FULL calibration, this may be done externally, for example, by manual key-action, or automatically by a relay contact or computer signal.

For this purpose, the respective contact (see wiring diagram) must be closed at the respective filling level EMPTY or FULL or at any other calibration position specified. Within a programmend short time the mathematical mean value of the measured count rate is automatically calculated. After this the system automatically exits the calibration mode.

7. Absorption Measurement with Point Sources

Special arrangements for small filling level ranges up to 300 mm may require the use of a point source. The non-linearities obtained with this absorption measurement are automatically corrected by the LB 323. For this purpose, "1" must be in entered code 47.

For calculation of the absorption factor please note that depending on the angle of irradiation the absorption path AW will be larger than the requested measuring range MB (see Fig. 7).

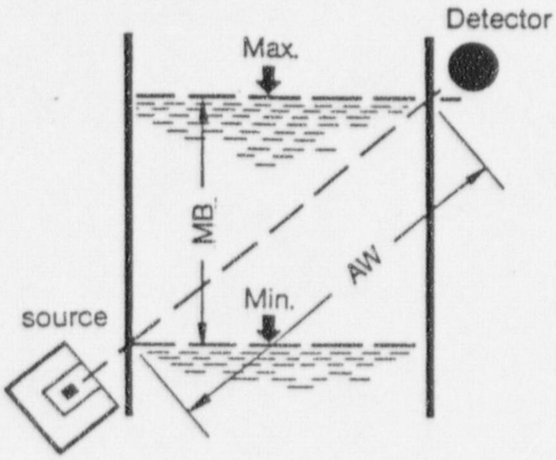


Fig. 7: Arrangement with Point Source

The system calibration is then carried out as described in chapter III. 2.

If the FULL calibration cannot be performed, enter an attenuation factor in code 46; this factor is calculated as follows:

a) for Co-60: attenuation factor $= e^{-0.0044 \cdot \rho \cdot AW}$

b) for Cs-137: attenuation factor $= e^{-0.0068 \cdot \rho \cdot AW}$

ρ is the density of the vessel filling in g/cm³ and AW the absorption path in mm.

8. Detection of Interference Radiation

The high gamma sensitivity of scintillation detectors may result in a false reading when the detector picks up interference radiation (e.g. radiation by welding seam tests) and, as a consequence, the instrument signals a level that is too low.

To identify interference radiation one can activate an automatic plausibility check at the level gauging system LB 323 which monitors a) the maximum possible count rate (EMPTY calibration) and b) the average value of the current count rate. The sensitivity of the system, i.e. the distance of the alarm threshold, is defined as a multiple of the mean statistical variation and can be entered as you wish between 1 to 10 sigma. The time constant is one second. When reaching the alarm threshold, a collective alarm message is triggered via the error relay and the display shows ERROR 4. At the same time, the measurement is aborted and the last measured value retained.

The alarm is triggered if the following two conditions occur:

a) $I_m > I_o + n * \text{sigma}$

b) $I_s > I_m + n * \text{sigma}$

I_s = current count rate integrated over 1 second

I_o = maximum count rate at EMPTY calibration (code 30)

I_m = mean value of current counts over meas. time (code 12)

n = multiple of sigma (code 48)

a) A relative threshold value is monitored, i.e. the alarm threshold is reached when the maximum doserate is exceeded (calibration value with empty vessel). In this case, false alarms caused by operative influences are not possible. However, only strong interference radiation will be detected.

b) A differential threshold value is monitored, i.e. each fast increase of the doserate triggers an alarm. Minor interference radiation influences will be detected. However, extraordinary operative influences may lead to false alarms.

If you wish to get an indication that is independent of the other trouble messages, you may switch over the function of the max. relay. In this case, the trouble message can be reset by an external contact and the measurement may be started again. The function of the min. relay may also be altered such that it can be operated as max. relay in the idle current mode.

Start-Up and Detection of Interference Radiation

1. Relay Functions

1.1 Standard setting: Code 6 —> 0
Interference radiation alarm is triggered as a collective trouble message via the error relay and has to be reset with "Enter". The measurement will be started again.

1.2 Special setting: Code 6 —> 1
Interference radiation alarm is initiated only via the max. relay. The alarm can be reset via an external contact via the terminals 17 and 18 on the LB 323 and the measurement is started again. With this setting the external FULL calibration is not possible at the LB 323.

1.3 Standard setting: Code 7 —> 0
Min. relay operates in the idle current mode for minimum level signaling, i.e. it is deenergized when the minimum level set is not reached.

1.4 Special setting: Code 7 —> 1
Min. relay operates in the idle current mode for maximum level signaling, i.e. it is deenergized when the maximum level set is exceeded. The alarm threshold is entered in code 17 as usual.

2. Activation of the Monitoring Functions

2.1 Standard setting: Code 48 —> 0
The function for detecting interference radiation is turned off.

2.2 Alarm function: Code 48 —> 1 through 10
The interference radiation detection is activated and the number set corresponds to the multiple value of the mean statistical variations.

NOTE:

We recommend entering $n > 5$ in code 48 to obtain a reliable statistical safety against false alarms.

The mathematical formula shows that the distance of the alarm threshold depends on the respective mean count rate I_m: For calculation it holds: sigma = I_m.

Example: count rate I_m = 300 counts, n = 6

$$I_s = I_m + n * I_m$$
$$I_s = 300 + 6 * 300 = 404 \text{ counts}$$

Please note:

Due to the dynamic behavior of the interference radiation detection one may define sudden increases of the count rate caused by the operating conditions (e.g. very fast emptying of the vessel or short-term large level changes caused by stirrers) as interference radiation.

Opening the radiation channel of the shielding results in a rapid increase of the count rate. The alarm triggered by this action must then be reset, or the interference radiation detection is not activated at first (code 48 = 0). The interference radiation detection is turned on only upon completion of the calibration.

9. Operation with Rod Detector LB 3231

Rod detectors with plastic scintillator require a special drift stabilization. The rod detector LB 3231 utilizes the natural ambient radiation for this purpose, thus ensuring an automatic high voltage regulation. The special advantage of this method is that no external stabilization elements are necessary. Moreover, this stabilization technique covers all other relevant components, such as scintillator, photomultiplier and probe electronics. The time constant of the drift stabilization may require a set-up time of up to 30 minutes for the initial start-up. A high voltage pre-setting which then becomes possible allows a reduction of the later set-up time to a few seconds, e.g. after an interruption of the operating voltage.

The linear sensitivity feature of plastic detectors requires an electronic linearization of the non-linearities caused by the measuring geometry. By recording the characteristic curve one can read in all data required for automatic linearization. The start-up procedure is simplified when the measuring geometry is known. The required correction factors can then be calculated in advance and entered into the evaluation unit LB 323. Then it suffices to do a calibration of the EMPTY position for start-up.

At first, one assumes that the active length of the detector has been adapted to the measuring geometry and the size of the desired measuring range, and that the detector and, in particular, the installation position of the shielding including the source is consistent with the specifications (if necessary, see the drawing of the measuring points with installation proposal, dimensional drawings of detector and shielding). For standard arrangements, the maximum filling level, the "G" dimension at the shielding, and the marking ring at the detector should be on a horizontal line, as shown in the illustration below.

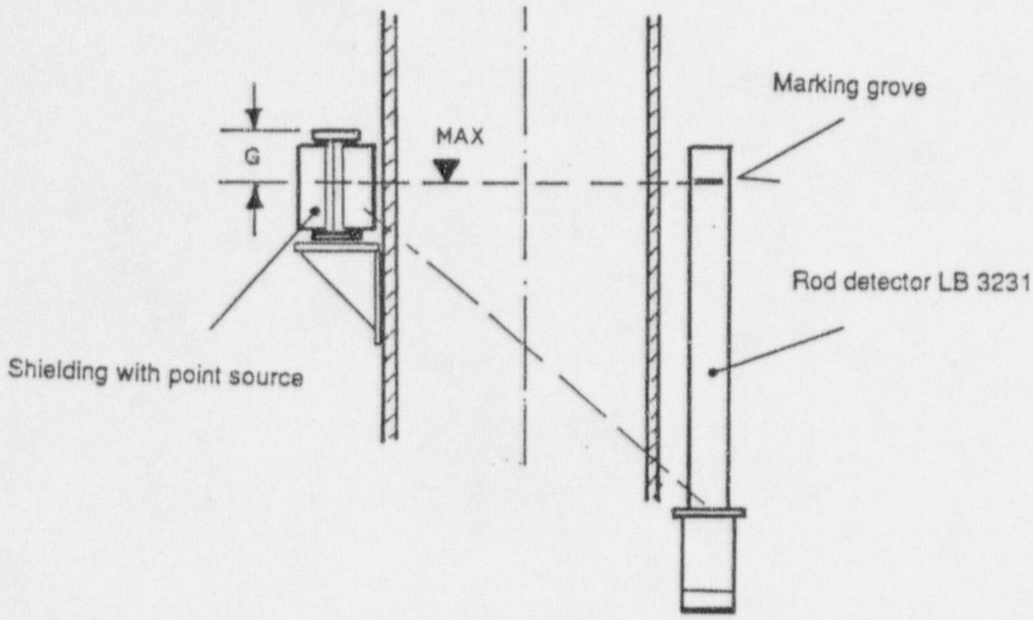


Fig. 8: Schematic layout with rod detector

The operation with the rod detector LB 3231 differs from the description and information given in the Operating Manual LB 323 as follows:

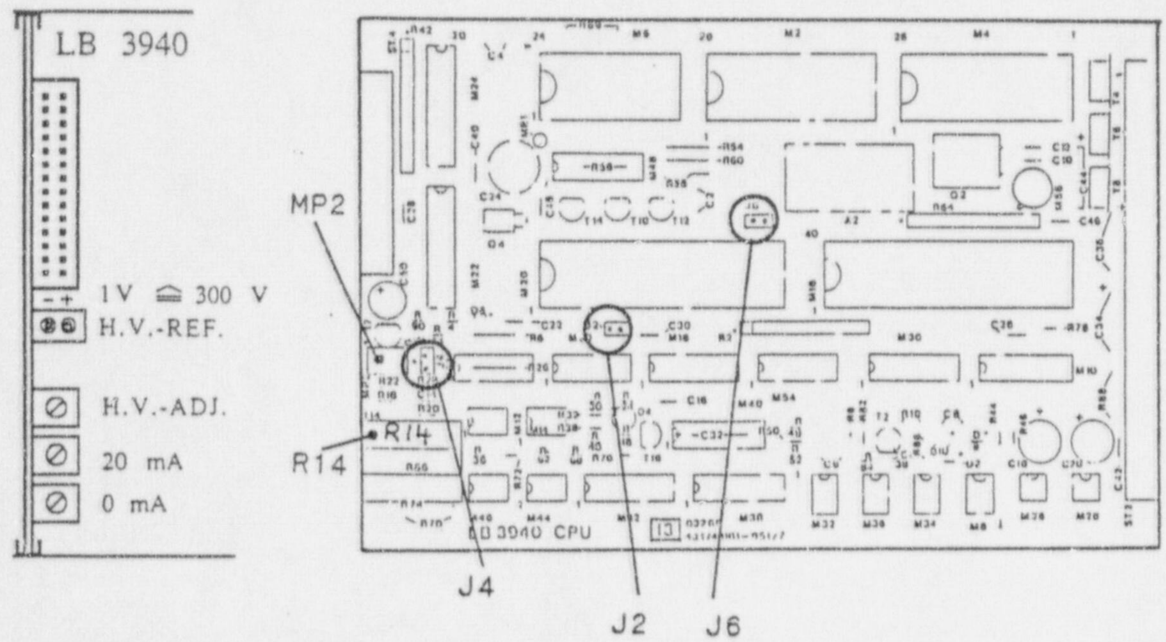


Fig. 9: Operating positions on CPU card LB 3940

1. Basic Settings

The basic settings can be carried out in the workshop and without connected detector.

1.1 Plug jumper J2 into CPU card LB 3940.

1.2 Turn on the instrument and enter "1" in code 5.

1.3 Check the linearization curve defaulted by the manufacturer in codes 20 through 29 and 30 through 39, and, if necessary, enter them new:

1.3.1 Enter "0" in code 8.

1.3.2 Enter relative curve which was calculated in advance and refers to a special measuring point in accordance with the respective table successively into codes 20 through 29 and 30 through 39.

If no table is available with the calculated curve, or if no advance calculation is possible, this point may be omitted and the curve has to be recorded later during start-up of the instrument (see section 5 of this chapter).

Example:

Code	%	Code	cps
20:	0	30:	100
21:	11	31:	94
22:	22	32:	88
23:	33	33:	79
24:	44	34:	70
25:	56	35:	59
26:	67	36:	46
27:	78	37:	31
28:	89	38:	16
29:	100	39:	0

Measuring point no.: LCA 510

2. High Voltage Setting

The high voltage is set to 4 V in the factory. Verify this value at the sockets MP2 on the CPU card before putting the instrument into service, and, if necessary, adjust it as described under 2.1.2.
The background measurement must be performed at the detector's setup location. It is not necessary that the source has already been installed.

2.1 Arrangement with One Detector

2.1.1 Open jumper J4 on the CPU card (high voltage automatism activated) and connect detector LB 3231, turn on the instrument and, after about 30 minutes, measure the high voltage reference voltage HV-ref at the test sockets MP2 on the CPU card. The voltage should be about 3 V.

2.1.2 Close jumper J4 and, using the potentiometer HV-ADJ (R14), adjust the reference voltage measured before.

2.1.3 Open jumper J4 again to activate the high voltage automatism.

The detector is now ready for operation and, after a possible interruption of the power supply, it is again operative after a few seconds.

Due to trouble in the detector system, the control range of the high voltage automatism may be exceeded. In this case, an alarm will be triggered, the "Probefail" LED on the front panel lights up and the display shows ERROR 5.

2.2 Arrangement with Several Detectors

Up to three detectors LB 3231, together with a special evaluation unit LB 323-3 in a 19" module rack with 3-fold Adaption Unit LB 3932, may be employed for larger measuring ranges. In these cases, the high voltage is controlled separately for each detector. Jumper J4 on the CPU card LB 3940 remains plugged in permanently and the settings are done on the 3-fold Adaption Unit for each detector connected as follows:

2.2.1 Set slide switch to position "AUTO" (high voltage automatism activated), turn the instrument on and, after about 30 minutes, measure the high voltage reference voltage HV-ref at the respective test sockets on the Adaption Unit (approx. 3 V).

2.2.2 Set slide switch to position "MAN" and, using the potentiometers HV-ADJ (1 V ≙ 300 V), adjust the reference voltage measured before for the respective detector.

2.2.3 Set slide switch to position "AUTO" to activate the high voltage automatism again.

The detector is now ready for operation and, after a possible interruption of the power supply, it is again operative after a few seconds.

Due to trouble in the detector system, the control range of the high voltage automatism may be exceeded. In this case, an alarm will be triggered, the "Probefail" LED on the front panel lights up and the display shows ERROR 5. After taking off the front panel, the incorrectly operating detector is indicated in the separate error indication on the Adaption Unit.

3. Background Measurement

The background measurement must be performed at the detector's setup location. Since rod detectors feature a high gamma sensitivity, they will register, depending on the setup location, a more or less high background, which has to be taken into account when calibrating the instrument. The background has to be read into code 8 while the effective radiation beam of the shielding is still closed, or before the source has been installed.

3.1 Select code 8, press key "Enter" and keep it depressed and, at the same time, press the key "Measure" (LED "Measure" lights up).

3.2 Wait for display to stabilize.

3.3 Accept the read-in value by pressing "Measure" again (LED "Measure" off).

Please make sure that the background will not be falsified by external radiation, for example, other radiometric measuring systems installed close by. If in doubt, you have to run tests, and, if necessary, resolve the problem, for example, by changing the path of irradiation.

4. Calibration

The electronic linearization function of the evaluation unit LB 323 has been activated by the jumper J2 and the adjustment for the detector probe LB 3231 has been taken into account by setting the software switch in code 5 to position "1".

4.1 Source is installed and the effective beam channel is open.

4.2 Perform EMPTY calibration by reading in the current count rate at empty vessel into code 30 and accept it (as described under 3.1 through 3.3). All stored relative values are converted into the current count rate, taking into account the stored background as well.

4.3 Switch back to the measurement mode by pressing "Measure".

4.4 To improve the accuracy of the measurement we recommend, at the earliest opportunity, to perform a FULL calibration with the vessel filled exactly up to the maximum level, and read in the current counts for this point into code 39.

5. Recording the Characteristic Curve

A characteristic curve has to be recorded only when no curve calculated in advance is available, or no advance calculation of that curve is possible. In these cases it is necessary to measure the current filling level at 10 points, or to determine it volumetrically, and to enter the data in codes 20 through 29. At the same time, the associated count rates have to be read into codes 30 through 39. Make sure to enter the filling levels with the code numbers in **ascending** order, and the count rate in **descending** order for all 10 points (see the following table). It is important that the count rate for EMPTY is always stored in code 30.

Then proceed as follows:

5.1 Fill the vessel step-by-step, determine the exact filling level at each step and enter it into codes 20 through 29. Enter the data in the same unit as in codes 14 and 15 for the current output. Confirm the entry by pressing the "Enter" key.

5.2 Read in the associated count rates into codes 30 through 39 and confirm them (as described under 3.1 through 3.3).

5.3 Press "Measure" to switch back to the measurement mode and the "Measure" LED lights up.

A good approach is to fill the vessel step-by-step and to enter the associated count rates in any, but always the same, code and to write down the value pairs in a table.

Example:

Code	%	Code	cps
20:	0	30:	6660
21:	5	31:	5910
22:	10	32:	5220
23:	15	33:	4530
24:	20	34:	3840
25:	30	35:	3160
26:	40	36:	2470
27:	60	37:	1780
28:	80	38:	1090
29:	100	39:	400

In this manner it is easier to check the plausibility of this data and with more than 10 value pairs a reasonable selection can be made. The selected filling levels are then entered manually, together with their associated count rates, into the respective codes. Please proceed as described in section III.3 (Parameter Setup).

For operation with the rod source we recommend activating the interference radiation detection, as described in chapter III.8.

General Recommendation!

We recommend entering the most important parameters - in so far as they deviate from the standard setting - into a setup protocol, especially the data in codes 20 through 29 and 30 through 39. For later re-calibration please refer to the enclosed Brief Operating Instructions.

IV. Technical Data

1. Level Monitoring System LB 323

Power supply:	AC 220/110 V or 250/115 V +10% to -15% ; 47 to 65 Hz DC 18 to 36 V
Power consumption:	max. 15 VA
Countrate range:	0 to 99999 cps
Time constants:	0.2 to 100 s with automatic rapid switchover 10:1
Long-term stability:	better than ± 1% of radiation intensity
Accuracy:	typically approx. ± 3% of the level measuring range
Half life compensation:	fully automatic
Display:	digital via 5 luminous digits
Operation:	6 push buttons (foil keypad with action point)
Adjustment	automatic via push button for EMPTY and FULL
Analog output:	0 or 4 to 20 mA isolated max. load 500 Ω
Relay output:	1 relay each with 1 X DPST max. 220V / 2A / 30 W non-inductive for MAX/MIN alarms and malfunction
Ambient temperature:	0 to +50°C
Housing:	1. Aluminium compact housing for wall mounting Protection type IP 65 (water proof) Weight: approx. 3.8 kg 2. 19" module chassis (height 3 U), can accommodate max. 2 Level Monitoring Systems Weight: max. 5.1 kg
Dimensions:	see dimensional drawings

2. Scintillation Detectors

2.1 Point Detectors SZ 5 .

Type / Sensitivity:	Sz5-L3 25/25 / 2.7 µSv/h Sz5-L3 40/35 / 1.1 µSv/h Sz5-L3 50/50 / 0.5 µSv/h at 300 cps hard gamma radiation
Ambient temperature:	-20 to +50°C; higher temperatures require a cooling system
Protection type:	IP 65 (water proof)
Explosion protection:	E Ex de II C T6 (designed for hazadous area)
Cable:	7-core, screened (7 x 1.5 mm²); length up to approx. 1500 m
Weight:	Sz5-L3 25/25 - 6 kg Sz5-L3 40/35 - 6 kg Sz5-L3 50/50 - 15 kg
Dimensions:	see dimensional drawings

2.2 Rod Detectors LB 3231

Sensitivity for gamma radiation	1 µSv/h typical doserate with empty vessel
Stability	± 1 % of radiation intensity
Version/Weight:	Housing in stainless steel for the following detector lengths: 500 mm —> 9 kg 750 mm —> 11 kg 1000 mm —> 12 kg 1250 mm —> 14 kg 1500 mm —> 15 kg
Ambient temperature:	-20 to +50°C; higher temperatures require a cooling system
Protection type:	IP 65 (water proof)
Explosion protection:	E Ex de II C T6
Cable:	7-core, screened (7 x 1.5 mm²); length up to approx. 1500 m
Dimensions:	see dimensional drawings

V. Servicing Instructions

1. Maintenance

The Level Monitoring System LB 323 has no wearing parts and no other components requiring special maintenance. Only the (optional) shutter mechanism at the shielding of the radioactive source must be checked for proper function from time to time.

2. Checking Source and Shielding

To ensure reliable radiation protection it is essential to check the general condition of the source shielding and also the optional shutter mechanism for the useful beam periodically. This is particularly important for applications in heavy duty environments. Any damage to the shielding endangering its proper functioning must be immediately reported to the radiological safety officer.

The radioactive source used and the function of the Level Gauge LB 323 ensure a useful life of more than 10 years. The source must be replaced if the statistical fluctuations that increase in the course of time become intolerably high, and if a compensation by increasing the time constant is not permitted any more, for example, for technical reasons.

If a source replacement is necessary, specify the serial number of the source used in your new order. This reference number comprises three groups of digits, for example

1234-11-86

The first group of digits is a consecutive number, the second group identifies the manufacturing month (in this case November), and the third group the year (in this case 1986).

This number is printed on the nameplate of the shielding and also on the seal certificate enclosed with each source.

3. Checking the Level Gauge LB 323

Every time the power is switched on, the system runs an automatic self test. If a malfunction is detected, the following error messages are possible:

ERROR A —> ROM error
ERROR B —> RAM cell error
ERROR C —> RAM decoder error
ERROR 4 —> interference radiation message
ERROR 5 —> detector probe failure
ERROR 8 —> clock failure

After an ERROR indication all inputs are blocked until you have pressed the "Enter" key.

ROM or RAM errors require that the Eurocard with the microprocessor system is completely replaced, as this system part can only be repaired by the manufacturer.

Further checks are possible in case of detector probe failure, as described in "Faults in the Scintillation Counter".

If the system cannot be switched on, check the voltage supply and the mains fuse. With 19"-systems, the fuse is located on the rear panel of the module chassis, and with compact systems, in the connection compartment.

Check the voltage supply at the test sockets located on the front panel of the power supply module, which is accessed by removing the front panel. The following nominal voltages must be measured:

0 / + 10 V ref.	each
+ 5 V	± 10%
+ 15 V	
- 15 V	

If a fault is detected, the complete power supply module should be replaced.

If the microprocessor is completely blocked, please follow these steps:

1. Switch off the mains switch and wait approx. 5 seconds.
2. Press the "Enter" key, keep it pressed down, turn on the mains switch and wait until the display shows "00".

Important!

If the system is still operational, it is essential to check the system parameters in order to avoid errors caused by incorrect parameter setting.

4. Faults in the Scintillation Counter

Malfunctions of the scintillation counter can only be caused by excessive mechanical or thermal strain. Strong vibrations or shocks and temperatures exceeding 60 degrees centigrade must therefore be avoided, for example, by using suitable shock absorbers and water cooling systems.

Malfunctions of the scintillation counter may not always cause total failure of this component; it is also possible that the specific gamma sensitivity decreases or the reading becomes very unstable.

In all these cases, we recommend testing the function of the complete scintillation counter system by checking the plateau.

To check the plateau one has to plot the curve, which can be done in two ways:

A) A quick check may be performed while the Level Gauge is in operation. Make sure that during the check the level reading is constant and between 20% to 80% of the measuring range.

B) For an accurate check, plot the plateau by means of pulse counting. For this purpose, dismantle the scintillation counter and generate the required countrate using a suitable test source (e.g. 370 kBq Cs-137).

Preparation for Plateau Check:

Remove the front panel of the Level Gauge and connect a 10 V voltmeter to the test sockets marked H.V.-REF. on the CPU-Eurocard (see Fig. 10). A HV reference voltage between approx. 2 to 6 V can be measured at these sockets; this HV reference voltage can be adjusted by the trim potentiometer.

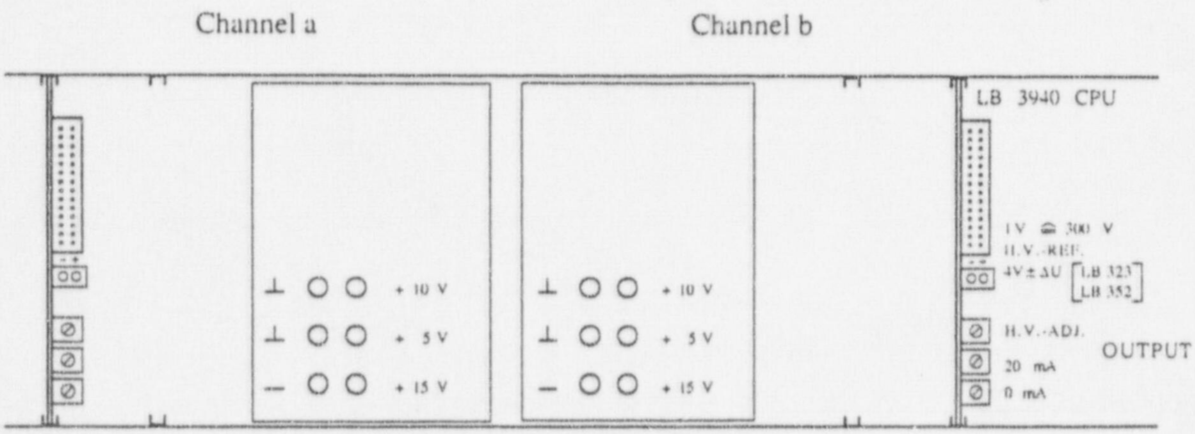


Fig. 10

Quick Check (A):

This check may be performed while the Level Gauge is in operation. Make sure that during the check the level is constant and the level reading is between 20% to 80% of the measuring range.

Operate the system with open front panel in the measuring mode and watch the digital level reading and also the H.V. reference voltage. Adjust this voltage using the trim potentiometer marked H.V.-ADJ. in several steps by + 0.2 V and then by - 0.2 V (e.g., from 4.0 V to 5.0 V and then from 4.0 to 3.0 V). With correct position of the plateau between 3.8 and 4.2 V, the reading must remain practically unchanged, i.e. the slight change cannot be distinguished from the usual statistical fluctuations.

However, if the potentiometer adjustment results in a clear change of instrument reading, then the operating point has shifted or the crystal/ multiplier assembly is damaged. For a more accurate check it will then be necessary to plot the plateau.

Plateau Plotting (E):

Plot the pleateau using a test source located in a fixed distance in the immediate vicinity of the scintillation source. Operate the Level Gauge as follows:

1. Switch instrument to code 30.
2. Press key "Measure". LED goes off and instrument is ready to read in the counts.
3. Simultaneously, press key "Enter" and "Measure". LED "Measure" is on and the respective countrate is read in. Wait until reading has become stable. Read off countrate and plot curve as a function of the HV reference voltage.
4. Using the potentiometer H.V.-ADJ., adjust the reference voltage in small steps of 0.2 V (left turn means rising voltage).
5. Continue with point 2 and repeat several times until you have covered the entire adjustment range of the potentiometer H.V.-ADJ.

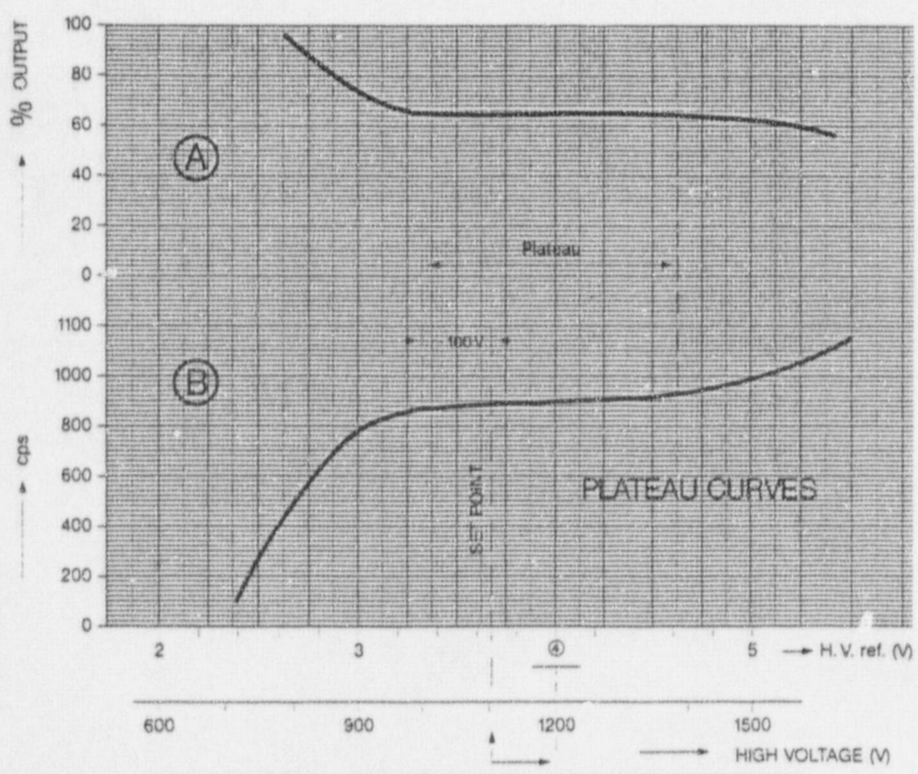


Fig. 11

A clear plateau must show on the graph paper (see Fig. 11), as shown in the example "Plateau Curve", i.e. a horizontal curve section must form over a width which must be equivalent to at least the reference voltage change of 0.5 V. In this range, the reading must only change slightly (approx. 2% to 3 %). The correct voltage operating point should lie roughly at midplateau, or, with very long plateaus, at approx. 0.4 V of the reference voltage in the plateau calculated from the start of the plateau.

If the plateau is found to be too short or too steep, then the scintillation counter does not operate properly, and the entire crystal/multiplier assembly or the complete scintillation counter must be replaced.

Note:

After replacement of the crystal/multiplier assembly, please follow the instructions for proper adjustment. Furthermore, just as after replacement of the complete scintillation counter, the EMPTY calibration should be repeated at the first possible opportunity.

5. Replacing the Crystal/Multiplier Combination

NOTE:

These servicing instructions apply only to NaI point detectors. The rod detectors LB 3231 should be returned to the manufacturer for repair.

Switch off the scintillation counter, open the casing, and carefully withdraw the electronic module including the crystal/multiplier combination, horizontally. Replace the cristal/multiplier combination and close the casing carefully to ensure that the multiplier is protected from incident light; otherwise it will immediately be destroyed when the operating voltage is switched on.

Plot a plateau as described under "Preparations for Plateau Check" and "Plateau Plotting", and plot the curve. As described above, the plot should show a distinct plateau. The correct operating point is the HV value that lies approximately 0.33 V of the HV reference voltage into the plateau, starting from where the plateau begins.

To allow replacement of the complete scintillation counter without having to reset the high voltage, it is advisable to set all detectors to the same plateau position; this is the prodedure used in the factory setting. To do this, set the HV reference voltage to the standard value of 4 V using the trim potentiometer on the CPU-card, and the high voltage to the chosen operating point using trimmer R 110 on the circuit board in the scintillation counter.

Please proceed as follows:

1. Record plateau by plotting the output voltage against the reference voltage.
2. The operating point is chosen at a value that lies approx. 0.33 V into the plateau starting from where the plateau begins. This corresponds to a high-voltage difference of approx. 100 V.

   The relevant reference voltage is determined (in the example, approx. 3.65 V).
3. Switch off the unit, open the scintillation counter casing and withdraw the crystal/multiplier combination. Switch on the unit again and measure the high voltage (max. 1500 V) using a suitable high-impedance voltmeter (point 20 on circuit board 19191.084-000, circuit diagram 19191.905/3 sheet 2).
4. Set the HV reference voltage on the CPU-card to the standard value 4 V.
5. Using R 110 in the scintillation counter, set the high voltage to the value determined in accordance with point 3.
6. Switch off the unit, reinsert the crystal/multiplier combination and make sure the casing is properly closed.

It is advisable to perform the quick check described above. This quick check must now be successful, and thus the system is operational with the standard setting. Plateau resetting is not necessary after replacement of the complete scintillation counter.

Checking the Crystal/Multiplier Assembly

Faults in the crystal/multiplier assembly may result in the plateau becoming too small or too steep. Faults in either the crystal or the multiplier can in some instances be detected by a visual check. For this purpose, the assembly is detached from the electronics and opened, and the crystal is detached from the multiplier. During these checks, the multiplier must not be exposed do direct sunlight. To separate both parts, remove the adhesive tape and the "mu-metal" screen, and carefully detach the crystal from the multiplier window by gently sliding the crystal sideways. Using a soft cloth, remove any traces of silicon oil from the mating faces of crystal and multiplier.

The crystal must be perfectly clear inside and not show any cracks or dull areas. The normal coloring is slightly greenish. A yellowish to brownish coloring is a sign of thermal overloading and indicates that the crystal must be replaced.

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 the window is either crystal clear or 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.

Before reassemlby, apply a drop of clean silicon oil between crystal and multiplier, and distribute it evenly by gentle rubbing to ensure a sound optical connection between the two components. Using the adhesive tape, replace the "mu-metal" screen, making sure that it is only under light tension.

VI. Radiation Protection Guidelines

If the human body is exposed to nuclear radiation, then, depending on the intensity, energy, and duration of exposure, chemical and biological reactions may take place in the body cell that may change, damage, or even destroy individual cells.

In order to prevent such damage, limits have been agreed upon on an international level for the maximum permissible radiation exposure of operating personnel. By taking appropriate measures at the design stage and selecting a suitable system geometry, it has been ensured that the radiation exposure will in any case be below the maximum permissible value of 5 mSv (500 mrem) per year, provided the correct procedures are observed. The controlled areas outside the shielding - insofar as they are accessible - will be provided with warning signs and suitable safety barriers.

Every factory has to appoint a radiological safety officer who is responsible for all questions relating to radiation protection. The radiological safety officer will formalize the safeguards and any special precautions applicable to a given establishment in formal procedural instructions. These may stipulate that access to the vessel shall only be permitted after the beam of rays emitted by the source has been sealed off. These instructions should also include checks of the locking device of the shielding and lay down emergency procedures - such as fire or explosion. After serious disturbances, the radiological safety officer must be immediately notified. He will then investigate any damage and immediately take suitable precautions if he detects defects that may adversely affect the operation or safety of the system.

The radiological safety officer has to make sure that the provisions of the Radiation Protection Regulations will be observed. In particular, his duties include keeping account of, and informing the relevant authorities on, the use of radioactive materials in the factory, as well as instructing the staff on the proper handling of these substances.

Radioactive sources that are no longer needed or have reached the end of their useful life must be returned to the national radioactive waste disposal center or to the manufacturer.

Generally, every member of staff should endeavor to minimize any radiation exposure - even within the permissible limits - by careful and responsible action and by observing certain safety standards.

The total sum - and consequently the effectiveness - of the radiation dose absorbed by a body is determined by three factors. On the basis of these factors, the fundamental radiation protection rules can be derived:

1. Distance

i.e., the distance between radioactive source and human body. The radiation intensity (dose rate) decreases - like light - in proportion to the square of the distance, i.e., doubling the distance to the source reduces the doserate to one quarter.

Conclusion:

When handling radioactive substances, maximum distance to the source should be maintained.

2. Time

i.e., the total time the body is exposed to radiation. The effect is cumulative and increases therefore with the duration of the radiation exposure.

Conclusion:

Operators should not stay longer than absolutely necessary in the direct vicinity of the source.

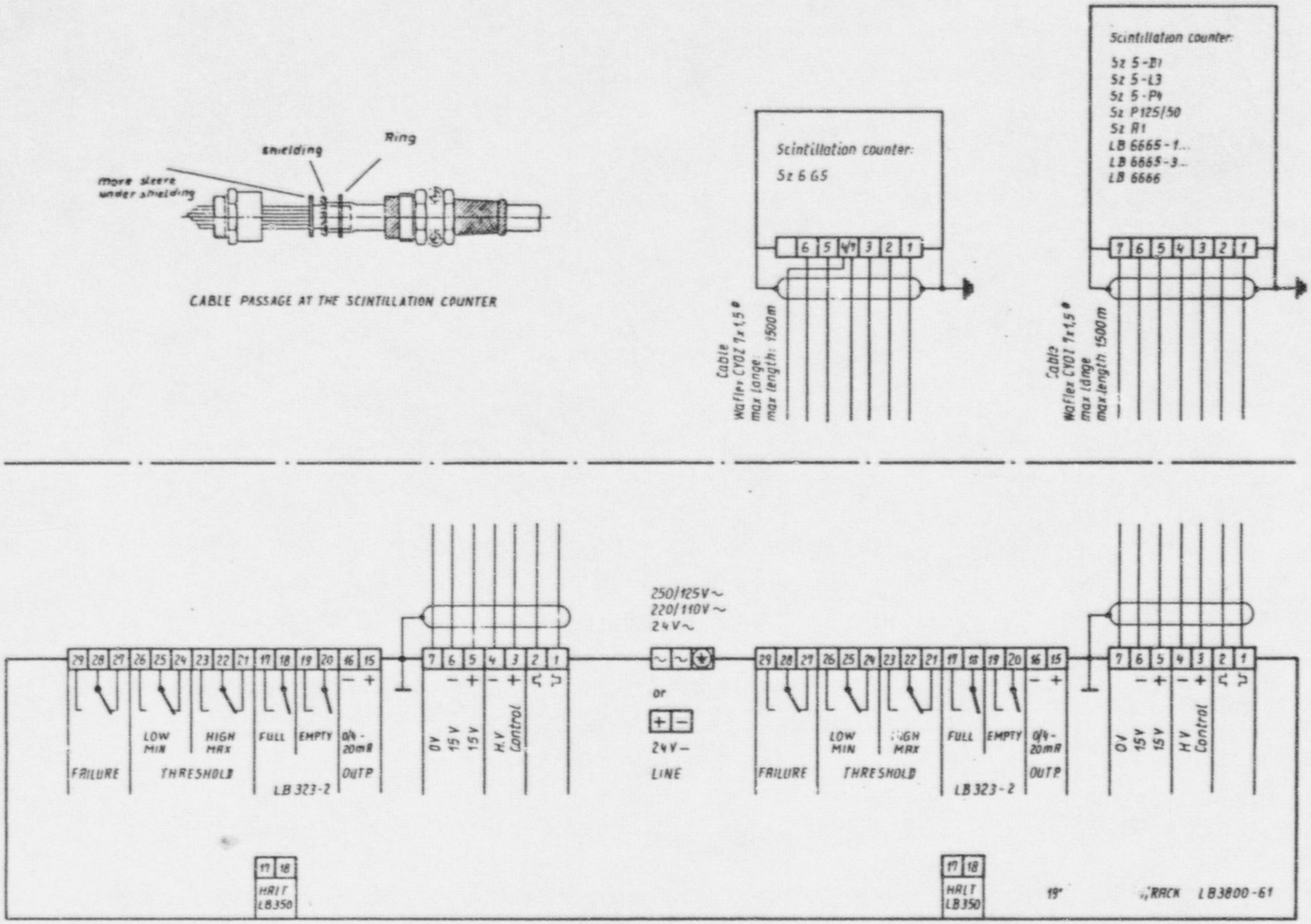
3. Shielding

The shielding effect is provided by the shielding material surrounding the source. Suitable dimensions are usually calculated by the supplier. As the shielding effect depends, following an exponential function, on the product of thickness multiplied by the density, it follows that material with a high specific weight will normally be used for shielding purposes.

Conclusion:

The source must not be removed from the shielding, and if necessary, the useful beam must be shielded.

The provisions in the Radiation Protection Regulations must be observed!



					Datum	Name	berthold	Zeichn.-Nr. (alt)	15187.000-981		
				Bearb.	1.4.87	Horrer					
				Gepr.	24.4.87	Ka.	D 7547 Wildbad/Schwarzw.	Klass.-Nr.		Format	Blatt-Nr. 1
				Benennung	Anschlußplan für, Connection diagram for LB 323-2, LB 350-2, LB 351-2, LB 367-2, LB 369-2			Ident.-Nr.	U-Art / Zust.		1 Bl.
Zust	Änderungs-Nr.	Datum	Name								

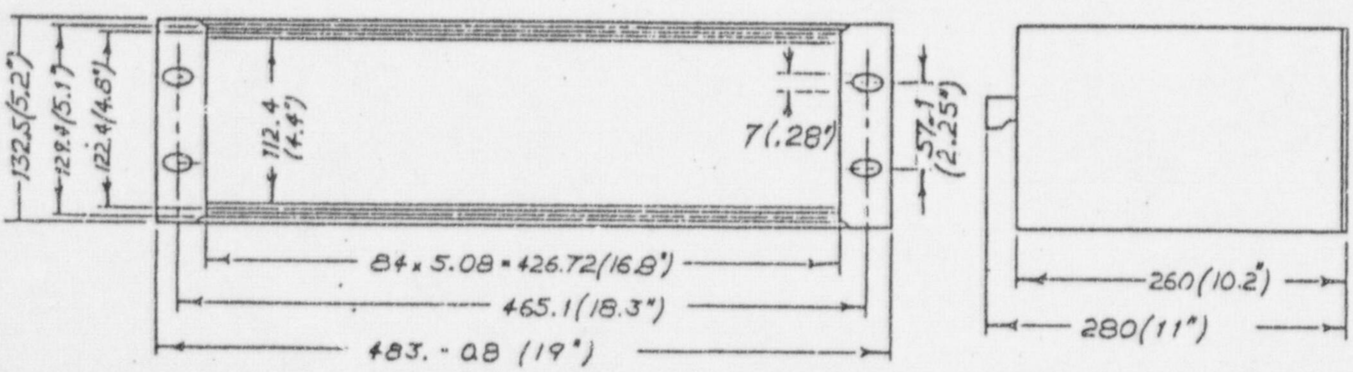
19" RACK

RACK FOR INSTALLATION OF PLUG - IN MODULES.

SIDE-WALL AND MODULE RAILS CONSISTING OF NON-CORROSIVE ALUMINIUM.

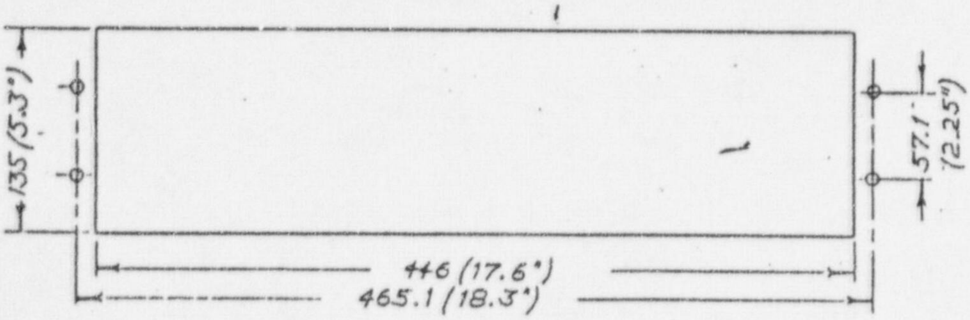
DIMENSIONS IN mm & in.

DIMENSIONAL DRAWING



ADDITIONALLY: FOR OPERATION KNOBS = 15mm (.59")
FOR TERMINAL BOARD = 32mm (1.26")

CUT - OUT - DIMENSIONS FOR 19" - RACK



BERTHOLD SYSTEMS INC.
79 N. INDUSTRIAL PARK
SEWICKLEY, PENNA. 15143

DIMENSIONAL DRAWING
19" RACK

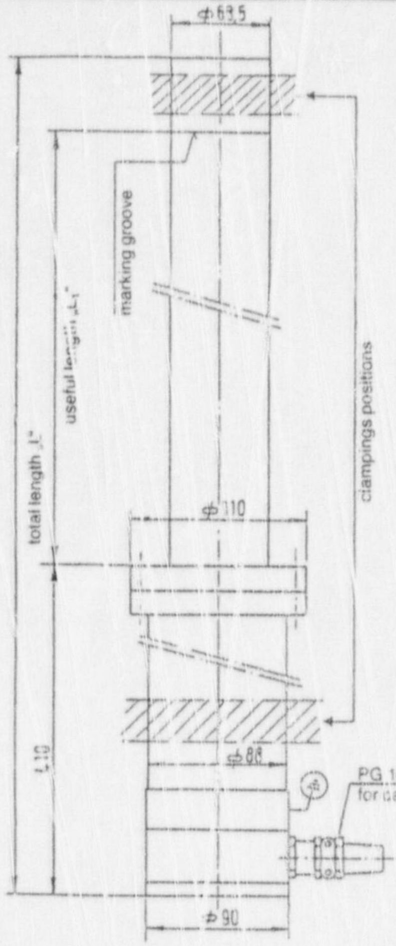
	BY	DATE	REF
DRAWN	W E H	6/11/87	
CHECKED	C. C. E.	10/1/87	
APPROVED	R J F	10/1/87	
SAFETY			

SCALE	DRAWING No.
1:6	SK 1075 - 1

Berthold

Level Measurement with rod detector LB 3231

Dimensions



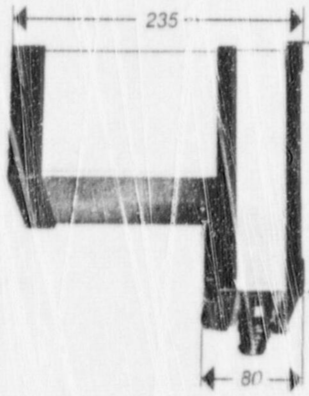
type			weight
LB 3231-...	L1	L	ca. kp
500	458	919	9,0
750	708	1167	10,5
1000	958	1415	12,0
1250	1208	1663	13,5
1500	1458	1912	15,0

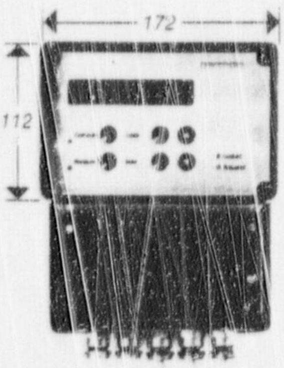
all dimensions in mm

Rod detector LB 3231

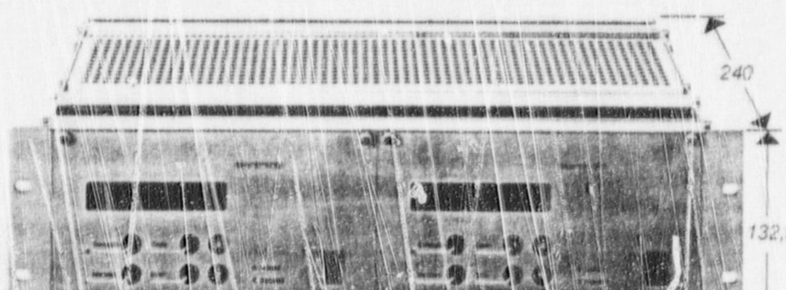
protection class NEMA 4

Compact unit with wall mounted housing





19" rack with 2 channels



EG&G berthold

Laboratorium Prof. Dr. Berthold GmbH & Co.

D-7547 Wildbad 1, P.O. Box 100163
Phone (0 70 81) 177-0, Tx 7 24 019
Fax (0 70 81) 177-100

Radiation Measuring Instruments for Industry, Science and Medicine

Belgium
Benelux Analytical Instruments N.V. – S.A.
Vaartdijk 22, B-1800 Vilvoorde
Phone 02-2 51 60 10

France
Berthold-France S. A.
1, Boulevard Charles de Gaulle
F-92700 Colombes
Phone (1) 47 81 41 06

Great Britain
Berthold UK Ltd., Royal House
28 Sovereign Street
Leeds LS1 4BJ
Phone 05 32-45 87 63

USA
Berthold Systems, Inc.
Hopewell Business and Industrial Park
Pittsburgh, PA 15001-4863
Phone 4 12 : 3 78-19 00

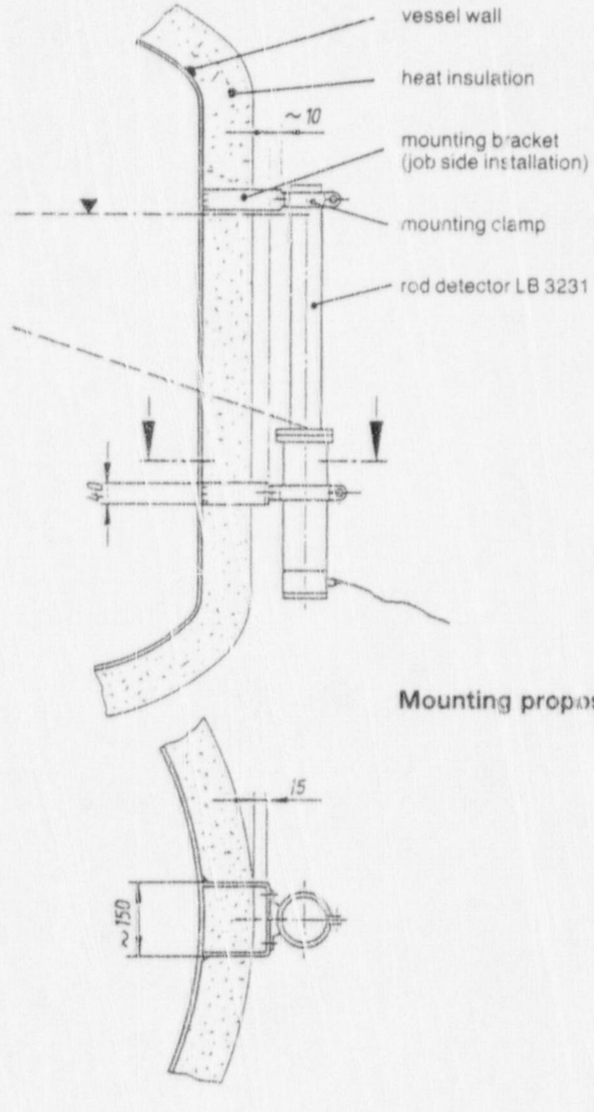
berthold

LB 3231/0192 – 2000 E

Special Features

- When using a rod detector, one may select a point source out of ^{60}Co or ^{137}Cs, if this is required for physical, technical or economical reasons.
- Excellent measuring geometries with low source activities can be realized by using the rod detector together with a rod source for special measuring tasks.
- The linearization of the output signal is done by the manufacturer in accordance according the customer's specifications and saved together with all other parameters in the EEProm of the evaluation unit LB 323.
- The linearization may later be changed within wide limits as desired without requiring any hardware modifications, since the software already includes these options.
- High count rates at relatively low source activities will be available by using large volume plastic scintillator with a high gamma sensitivity.
- Firm graduation of the detector lengths in 5 steps up to a total of 1500 mm for easy adaption to the desired measuring range. Multiple detectors are used for larger measuring ranges.
- The drift stabilization required in generell for plastic scintillators is realized by the natural ambient radiation. Due to this new method one does not need to work with reference sources, such as LED's or additional radioactive sources.

Also, no temperature measurement is required. Moreover, the drift stabilization covers the entire detector system consisting of plastic scintillator, photomultiplier and probe electronics.



Mounting proposal

Technical Datas

Sensitivity for gamma radiation:	1 µSv/h typical dose rate for empty container	Temperature:	− 20° C to + 50° C
Stability:	+/− 1 % of the radiation intensity	Protection class:	IP 65
Version:	stainless steel housing for detector lengths: 500 mm 750 mm 1000 mm 1250 mm 1500 mm	Ex-Protection:	EEx de II C T6
		Connection:	to evaluation unit LB 323

Subject to change without notice

Application

The rod detector LB 3231 is part of a radiometric level gauging system for the continuous control of the level of liquids or bulk goods in vessels, bunkers or silos over measuring ranges of up to several meters. The radiometric method operates non-contacting and without any mechanically moving parts and is therefore insensitive to difficult operating conditions, such as pressure, high temperatures, dust and foam formation. Moreover, the chemical and physical properties of the product to be measured do not affect the functions of the system. Some of the most common areas of application are therefore level gauging measurements on

- Autoclaves
- Container with stirrer
- Storage tanks for chlorine, phosgene, tar, etc.
- High and low pressure reactors
- Bunkers for hot products
- Vacuum evaporators

Arrangement

The continuous level gauging system comprises the following components shown in the above illustration:

① Point source with shielding

② Rod detector adapted to measuring range

③ Connection cable

④ Evaluation unit LB 323

The source and the size of shielding can be selected according to physical, technical or economical considerations. The useful radiation beam of the shielding can be shielded by a rotary lock. The construction of the shielding allows simple installation on a horizontally aligned bracket or mouting device.

The rod detector is adapted to the desired measuring range in graded lengths. A water cooling jacket is used for temperatures above 50° C.

The connection to the evaluation unit LB 323 is done via a 7-core standard cable.

The evaluation unit LB 323 is available in a housing for wall mouting or in a 19" rack for accommodation of max. 2 measuring systems.