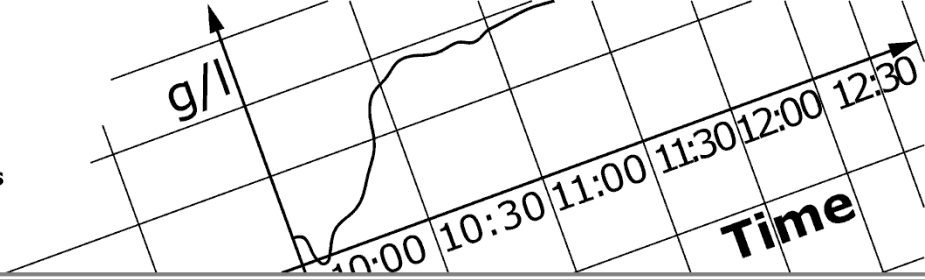
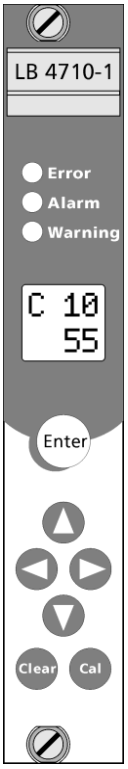


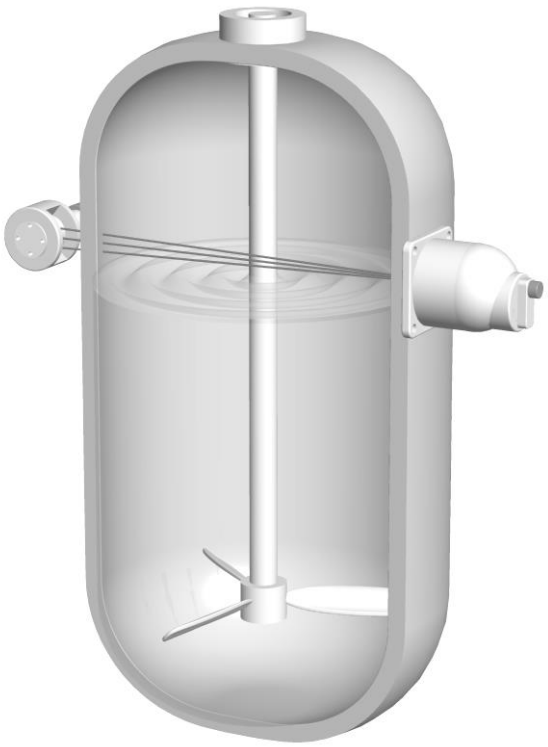
Process Control

detect and identify

Limit Switch
Mini-Switch LB 471

Hardware Manual





User's Guide

ID No. 39505 BA2

Rev. No.: 03 17. Nov. 2015
Soft. Version: 1.12 or higher

The units supplied should not be repaired by anyone other than Berthold Service engineers or technicians by Berthold.
In case of operation trouble, please address to our central service department.

The complete user's guide consists of two manuals, the hardware description and the software description.

The **hardware manual** comprises:

- mechanical components
- assembly
- electrical installation
- radiation protection guidelines
- technical data
- electrical and mechanical drawings

The **software manual** comprises:

- operation of the evaluation unit
- parameter description
- basic setting
- calibration
- error messages

The present manual is the hardware description.

Subject to change in the course of further technical development.

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Chapter 1. General Information

1.1 Use and Function

The limit switch system LB 471 Mini Switch has been designed for monitoring and detection of levels in containers and pipelines.
Licensed as an "overflow protection device for containers storing liquids that are hazardous to waters" in accordance with the Water Resources Act, the system may also be used as overflow protection device.
Beyond this scope, each application is considered as not being in compliance with the law and may result in severe personal injury or property damage.
BERTHOLD TECHNOLOGIES does not assume any liability for this kind of injuries or damage.

1.2 Target Group

This user's guide has been written for operating, assembly and service personnel.

Qualification

The system may only be assembled, serviced and maintained by authorized and trained persons. Any modification of the settings may only be carried out by persons who are familiar with the function of the system. Persons working with ionizing radiation must be familiar with the rules of radiation protection and adequate work techniques.

Training

Personnel have to be specially trained and informed about possible hazards. Detailed knowledge of this user's guide and careful observation of the instructions contained therein is an essential prerequisite.
Each staff member has to know the major rule of the "ALARA principle" (as low as reasonably achievable).
BERTHOLD TECHNOLOGIES is offering appropriate training courses.
Depending on the participant's professional qualifications, two kinds of training can be chosen:

1.3 Radiation Protection Courses

- Special course in radiation protection

  (Duration: 2 days)
  This course is needed if the participant has not yet received any radiation protection training. A successfully completed course has a validity of 5 years.

- Refreshing course in radiation protection

  (Duration: 1 day)
  All persons who have already successfully completed the special course may refresh their special knowledge with this course (Radiation Protection Ordinance of August 1, 2001).
  A successfully refreshing course has a validity of 5 years.

1.4 Definitions

Automatic — Some parameters can either be set to the automatic or manual mode. In the automatic mode the value is calculated using a formula. Enter -1 to enable the automatic mode. The inverted C in the top row indicates whether a parameter has been set to automatic.

EVU — **Ev**aluation **U**nit

Edit — Change value

Edit mode — In this mode, a value can be changed. Not every parameter can be changed since some parameters are only used as display values. Editable Parameters can be set to the edit mode with the "Enter" button. In the edit mode the cursor positioned over a digit is flashing.

GM detector — Detector with **G**eiger-**M**üller counter tube

NaI detector — NaI = sodium iodine crystal = scintillator
Scintillation detectors are very sensitive to Gamma radiation.
See pages 40 and 121.

Super-Sens detector — Detector which is highly sensitive to Gamma radiation with large-volume plastic scintillator 150x150mm
See pages 43 and 125.

Limit value — Count rate or percentage value upon reaching the measurement level

HV	Detector high voltage
Cassette	Case (7 TE) into which the evaluation unit LB 4710 is installed, so it can be used in any 19" rack
Empty	Level below limit value.
Empty count rate	Count rate with empty container
Manual	Some parameters can either be set to the automatic or manual mode. For the manual mode you have to enter a fixed value in the respective parameters.
Nuclide / Isotope	Type of radiation source: Cobalt-60 (Co-60) or Cesium-137 (Cs-137) for level measurements.
Zero count rate	Count rate caused by natural environmental radiation.
Parameters	A value stored under a certain code.
Timeout	Time after which an automatic reset is performed.
Full	Level below limit value.
Full count rate	Count rate with full container.
Count rate	Value of counts relative to one second.
cps	Count rate unit: **C**ounts **p**er **s**econd.
Read in count rate	A process that is started by the user in order to determine the average value of the count rate at the respective level. This count rate is needed to calibrate the measurement. The count rate is averaged over a certain time (standard 60 s) to exclude statistical and process-immanent fluctuations.
Factory setting	All parameters have been preset by the manufacturer using standard values. In most cases this simplifies calibration of the instrument significantly. Despite factory setting, calibration **always** has to be performed.
mSv	Dose rate unit Millisievert

MBq Mega-Becquerel
This unit indicates the source activity. Each Bq corresponds to one decay per second..
1 MBq = one million decays

mCi Milli-Curie
This unit is also used for the activity of a source. However, this unit has been replaced by the unit MBq (1mCi = 37 MBq)

1.5 Safekeeping of the User's Guide

Note!

This user's guide always has to be available at a fixed place. The personnel have to be informed about this place. Any time the device is used by another operator and whenever there is a change in ownership of the device, the user's guide has to be given to the new operator or owner.

Chapter 2. Safety

2.1 Safety Concept

The state-of-the-art system is designed in accordance with accepted safety rules to ensure the greatest possible on-the-job safety. To rule out health hazards when handling radioactive substances, limit values stating the highest acceptable radiation exposure of the operating personnel have been defined on an international level. These limits have to be observed when designing shieldings and planning the configuration of the measuring system at the measurement point.

2.2 Symbols and Pictograms

The following symbols identify safety instructions in this user's guide:

Danger!

Possible danger for life and health hazard

Caution!

Possible hazard
Minor personal injuries

Warning!

Possible hazard
Property damages

Note!

Tips for application and useful information

The safety instructions are supplemented by explanatory pictograms, for example:

2.3 Radiological Safety Officer

To ensure proper handling and the observance of the statutory requirements the operating company has to appoint a radiological safety officer who is in charge of all radiation protection issues in connection with the measuring system.
The radiological safety officer has to:

- monitor working with the radiometric measuring system
- draw up a plan for the organization of radiation protection
- monitor compliance with the regulations of the Radiation Protection Ordinance
- issue directives and carry out training and instruction of the employees
- get on-site information on the situation and takes appropriate actions immediately if operation problems have occurred
- cooperates with the work's council or the personnel office and qualified personnel for on-the-job safety, advises and informs them on important radiation protection issues.

2.4 Duty of Notification

Caution!

Radioactivity!
In case of suspected damage to the shielding, the radiological safety officer has to be informed immediately. Further steps can be taken in consultation with BERTHOLD TECHNOLOGIES.

2.5 Radiation Protection Areas

Radiation protection areas define the boundaries around a radiation source. The maximum dose rate defines the limit. We distinguish three radiation protection areas:

2.5.1 Exclusion Areas

Exclusion areas are areas in which the local dose rate may be exceed 3 Millisievert (mSv) per hour. These areas have to be protected such that nobody has unchecked access to these areas – not even with single body parts. Actually, these areas can occur only in the active beam in the direct vicinity of the shielding.

Caution!

Radioactivity!
The radiation protection directives have to be observed.
Exclusion areas have to be protected such that nobody has unchecked access to these areas – not even with single body parts. This has to be ensured through constructive measures, for example by protective covers.

2.5.2 Controlled Areas

Controlled areas are areas in which persons in one calendar year may receive an effective dose of more than 6 mSv if they stay in this area 40 hours a week and 50 weeks per calendar year. Based on this, the calculated maximum dose rate is 3 µSv/h. These areas should be planned such that accessibility is virtually not possible or that the required safety fences can be installed easily. **If controlled areas are accessible they have to be secured**. Moreover, they have to be identified clearly and permanently by a radiation danger sign and the comment "Controlled Area". Persons may access controlled areas only to carry out maintenance work for the operations going on inside this area (§ 37). Body doses have to be calculated or personal doses have to be measured. The authorities may permit exceptions from the demarcation and identification duty, provided individuals or the general population are not endangered. **Higher limit values are admissible if reliable information is provided that the person affected stays within the controlled area for a shorter period of time.**

Caution!

Radioactivity!
The radiation protection directives have to be observed.
Controlled areas outside the shielding have to be identified and secured if they are accessible.

2.5.3 Monitoring Areas

Monitoring areas are operation areas which do not belong to the controlled area. In these areas, a person may receive an effective dose of more than 1 mSv in one calendar year.

The monitoring area starts at the controlled area. It is an area in which persons staying permanently in this area may be exposed to a radiation level of more than 1 mSv in one calendar year. For a stay of 40 hours per week and 50 weeks per year the area is between the dose rate limit values of 3 µSv/h and 0.5 µSv/h. It has to be ensured that persons are not exposed to a dose exceeding 1 mSv per year, taking into account the actual time they stay in this area. This means that no permanent work place may be set up in this area.

2.6 Safety Installations

2.6.1 Source Shieldings

Caution!

Radioactivity!
The shielding with the source installed may be taken into operation by specially licensed persons who have been trained on handling radioactive materials only after consultation and coordination with the radiological safety officer.
The radiation exit channel must only be opened by authorized persons after consultation with the radiological safety officer.
Modification of or tampering with the shielding construction are prohibited.

Source

Co-60 or Cs-137 point sources ❹ are used for the system. They are tightly welded into a sturdy stainless steel capsule, so that the radioactive substance cannot escape and contamination is prevented. The capsule with the source ❹ is fixed on a holder ❺ and installed into the shielding.

Shielding

The shielding consists of a lead cylinder with radiation exit channel ❸, surrounded by a steel jacket. The locking core ❷ is fixed to a lever ❻. The padlock ❼ secures the open / closed position and protects the source against unauthorized removal.

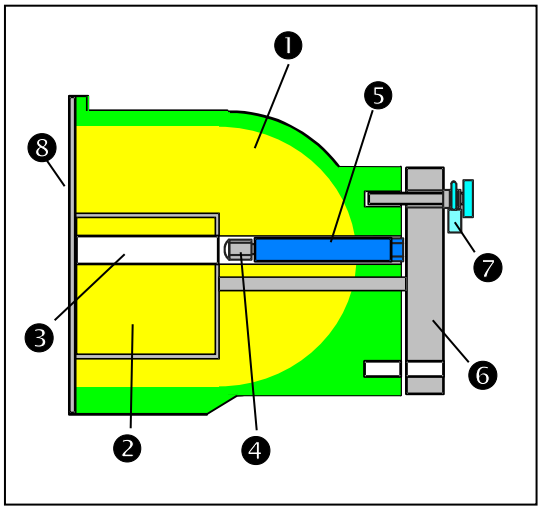


Figure 1: Point source shielding radiation channel open Sectional drawing

❶ Shielding
❷ Locking core
❸ Radiation channel
❹ Point sources
❺ Source holder
❻ Lever
❼ Padlock
❽ Cover plate front

When turning the lever ❻, the locking core is rotated as well and the radiation exit channel is opened towards the detector. The arrow on the lever ❽ is pointing towards "OPEN".

Figure 2: Shielding - view of lock

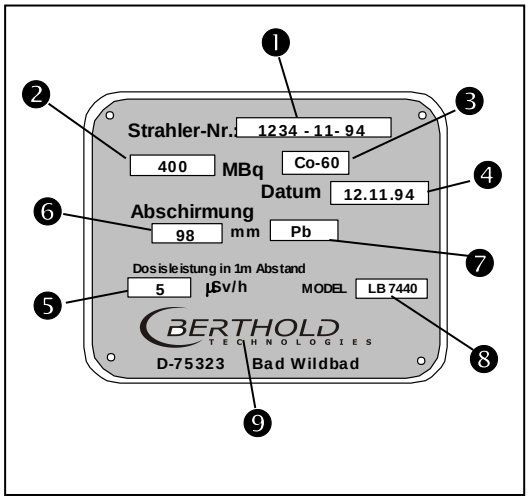
❻ Lever with arrow
❼ Padlock
❾ Cover plate rear

The radiation exit channel has to be closed during transport, assembly and while carrying out work on the container.
The arrow on the lever is then pointing to "CLOSED".
The lever or the locking core is secured by a padlock ❼ in the "OPEN" and in the "CLOSED" position.
Shielding, radiation type, isotope and activity have to be selected for each measuring configuration such that the internationally permissible dose rate limits will not be exceeded.

Type label

The source and shielding version is documented in the supplied technical source documentation and on the type label on the shielding.

Figure 3: Type label on shielding



❶ Source number
❷ Activity
❸ Isotope
❹ Source manufacturing date
❺ Dose rate in 1m distance
❻ Effective shielding thickness
❼ Shielding material
❽ Type of shielding
❾ Shielding manufacturer

2.7 General Safety Instructions

Caution!

The safety instructions in this user's guide have to be observed without fail.
All laws, directives, accident prevention regulations and generally accepted safety regulations have to be complied with!
The system may be used only in technically good order and only for contractual use!
Only persons may work with the system who have been authorized to do this and who have the proper qualification and have received the necessary instructions!
Installations and modifications on the system which may affect the operational safety are prohibited!

2.8 Emergency Instructions

The following basic principles are indispensable for health and safety: Time, distance and shielding. In an emergency, the following provisions have to be taken:

Danger!

Hazard due to radiation damages.
Never touch the source with your hands!

- Restrict access to this area, identify radiation protection areas.
- Check the function of the shielding and measure the dose rate.
- Localize the source.
- Document the event and, if possible, estimate the potential radiation exposure of the persons involved.
- Report event to **BERTHOLD TECHNOLOGIES**.
- In case of loss of radiation sources, the regulatory agency has to be notified immediately.
- In case of suspected damage to the source capsule the following issues have to be taken into consideration:
- Grasp source with a tool (e.g. a pair of pliers or tweezers) and put both (source and tool) into a plastic bag.
- Place plastic bag behind an auxiliary shielding (concrete wall, steel or lead plate).
- Check if environment is free of contamination.
- If a source has any leaks or if you suspect that the permissible dose has been exceeded, the regulatory agency has to be notified immediately.

2.8.1 Theft Protection

Radioactive substances or facilities containing radioactive substances have to be secured such that they are protected against access by unauthorized persons. If you discover that radioactive substances are missing, you have to notify the radiological safety officer and the regulatory agency. In case of theft, the police have to be informed.

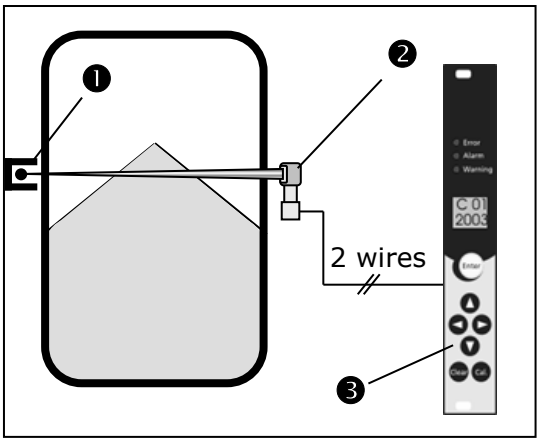
Please see Chapter 11 for more information on radiation protection.

Chapter 3. Functional Safety

3.1 Use and Function

The LB 471 Mini Switch is employed for monitoring and detection of the limit levels of liquids and bulk material in containers and pipelines.

Figure 4: Measuring system



❶ Source
❷ Detector
❸ Evaluation unit

The measuring system can be employed for the detection and indication of maximum levels (overflow protection) and minimum levels (protection against dry running) and fulfills the requirements regarding:

- Explosion protection (depending on version and category),
- Water Resources Act (overflow protection device for containers storing liquids that are hazardous to waters),
- Electromagnetic compatibility according to EN 61326 and Namur NE 21.

If the device is employed in safety-relevant systems (functional safety according to IEC 61508/61511), all information in this User's Manual has to be observed. In particular, the safety-technical data in section 3.8 apply only to the application of the system in the operating mode with low demand mode and taking into account the information in this manual.
Beyond this scope, each application is considered as not being in compliance with the law and may result in severe personal injury or property damage.
BERTHOLD TECHNOLOGIES does not assume any liability for this kind of injuries or damage.

3.2 Safety Function

The safety function of the measuring system comprises the detection and indication of changes in the count rate of the detectors caused by the presence of product being measured in the measuring path between radiation source and measuring system.
The safe status is dependent on the mode of operation:

- Maximum level (overflow protection): Product between radiation source and detector -> low count rate
- Minimum level (protection against running dry): No product between radiation source and detector -> high count rate

3.3 Safety Requirement

Safety integrity level	Operating mode with low demand rate	Operating mode with high or continuous demand rate
SIL	PFD_{avg}	PFH
4	$\geq 10^{-5}$ to $<10^{-4}$	$\geq 10^{-9}$ to $<10^{-8}$
3	$\geq 10^{-4}$ to $<10^{-3}$	$\geq 10^{-8}$ to $<10^{-7}$
2	$\geq 10^{-3}$ to $<10^{-2}$	$\geq 10^{-7}$ to $<10^{-6}$
1	$\geq 10^{-2}$ to $<10^{-1}$	$\geq 10^{-6}$ to $<10^{-5}$

Safe failure fraction	Hardware fault tolerance		
SFF	HFT = 0	HFT = 1	HFT = 2
none: <60%	not allowed	SIL 1	SIL 2
low: 60% to <90%	SIL 1	SIL 2	SIL 3
medium: 90% to <99%	SIL 2	SIL 3	
high: ≥99%	SIL 3		

3.4 Project Planning

General instructions and restrictions

- Please make sure that the measuring system will be used in accordance with its designated function.
- The application-specific limits have to be observed and the specifications must not be exceeded. See also the technical data and ambient conditions in the User's Manual.
- The fault tolerance time of the overall system must be greater than the reaction time of the measuring system.
- The relay contacts have to be protected by a 1A fuse.
- The digital inputs 1 and 2 must not be closed in case of a safety-related application.

- Interfering radiation, e.g. due to welding seam tests, is largely identified and signaled by the measurement. However, in some situations it is conceivable that the intensity of the interfering radiation will increase the radiation level at the detector only slightly, so that no alarm is triggered or not in due time. Therefore, the facility always has to be informed as soon as a welding seam test is carried out in the environment of the facility in which the measurement is employed. In this case, suitable safety precautions have to be taken.
- Interfering radiation from adjacent measuring points has to be avoided.

Assumptions

The FMEDA (Failure Mode Effects and Diagnostics Analysis) is based on the following assumptions:

- The failure rates are constant over the service life of the device.
- The following is not taken into consideration:

  external power supply failure rates

  multiple errors

  operating mode as minimum level switch
- The mean ambient temperature during the operating time is 40°C.
- The environmental conditions correspond to those of an average industrial environment.
- The working life of the components is between 8 and 12 years.
- The time to repair (replacement of the measuring system) after a fault protected from interference is eight hours (MTTR = 8h).

If the demand rate is not more than once a year, the measuring system may be operated as a safety-relevant sub-system in the operating mode with low demand rate (IEC 61508-4, 3.5.12).

Numerical values see section "Safety-Technical Data".

Safe state and fault description

The fail-safe state is reached when the current output indicates the following values.

A safe failure is defined as a failure that causes the measuring system to go to the defined fail-safe state without a demand from the process.

A dangerous undetected failure is present if the measuring system, following a demand from the process, does not go to the defined fail-safe state.

3.5 Getting Started

The conditions at the facility affect the safety of the measuring system. Therefore, the mounting and installation instructions in the User's Manual have to be observed. In particular, the correct setting of the parameters has to be ensured. For more information on the parameters and on getting started, please refer to the User's Manual LB 471 ID No. 39505BA2.
The device may be operated as safety-relevant only in the professional mode.

1 Reset

☞ Keep Clear button pushed and turn the power supply on.
✓ The device is reset to factory setting.

Basic parameter setting

☞ Set parameters according to the following parameter list. The order in which the parameters have to be set is shown in the last column.
Fields that are not numbered in this column are display parameters or parameters that remain on factory setting. If the Value column includes data, then you have to enter this data exactly.
If no data has been entered in the Value column but a number has been entered in the last column, then the value of the parameter has to be adapted to the given measurement situation. However, the value has to be adapted only if this is required by the measurement situation.

Table 1:
Code table
for professional mode

Code no.	Designation	Value range	Factory setting	Value	Order
00	Password	0000 - 9999			
01	Year	1970 - 2099	Current year		**1**
02	Month / Day	01.01-12.31	Current date		**2**
03	Hour / Minute	00.00-23.59	Current time		**4**
04	Operation mode Standard/Professional	0 - 1	0	1	**3**
05	Detector code	0 - 99	99		**5**
06	Nuclide 0=Co60, 1=Cs-137	0 - 1	0		**6**
07	Automatic password protection	0 - 9999	0		
08	Warning relay as second alarm relay	0 – 1 10 – 100	0		
09	Alarm relay follows the error relay	0 - 1	0	1	**7**
10	Reading (%)	-999 - 9999	Display		
11	Average count rate	0 - 999.9	Display		
12	Time constant (s)	0,1 – 999,9	-1		
13	Live count rate	0 - 999.9	Display		
14	Maximum time constant (s)	0 - 999	999		**8**
15	Standard reading	10 - 11	10		
16	Max. or min. limit value switch 0=Max, 1=Min	0 - 1	0		
17	Switching threshold (%)	0 - 100	-1		
18	Switching threshold in (cps)	0 - 999.9	-1		
19	Hysteresis (%)	0 - 999	-1		
20	Empty count rate (no input)	0 - 999.9	Display		
21	Full count rate (no input)	0 - 999.9	Display		
22	Zero count rate (no input)	0 - 9.999	Display		
30	Empty count rate	0 - 999.9	20 GMZ 300 FSK		
31	Full count rate	0 - 999.9	-1		
32	Zero count rate	0 - 9.999	Depending on detector code		
33	Measuring path (in mm)	0 - 9999	0		**9**
34	Gas density (kg/m³)	0 - 9999	0		**10**
35	Bulk density (kg/m³)	0 - 9999	0		**11**
36	Compute	35.01–35.08	Display		
37	Counting time for calibration (s)	5 - 600	60		**12**
38	Bulk cone diameter (mm)	0 - 9999	0		

Code no.	Designation	Value range	Factory setting	Value	Order
39	Half-value layers	1 - 9	2		**13**
40	Interference radiation detection	0 - 1	0	1	**14**
41	Waiting time after interference radiation	0 - 999	20		**15**
42	Signaling interference radiation	0 - 2	0	1	**16**
43	Signaling unlocked	0 - 2	0	1	**17**
44	Signaling minor errors	0 - 2	0	1	**18**
45	Signaling excess temp. Detector (only FSK detector)	0 - 2	0	0	
46	Temperature threshold detector (only FSK)	0 - 99	40		
47	Signaling excess temp. EVU	0 - 2	0	1	**19**
48	Temperature threshold EVU	0 - 99	85	≤50	**20**
50	Limit switch software	1.00 - 9.99	Version		
51	Detector software (only FSK)	1.00 - 9.99	Display		
52	Detector temperature °C (only FSK detector)	-40 - 80	Display		
53	Detector high voltage (only FSK)	500 - 1300	-1		
54	detector HV start value (only FSK)	500 - 1300	HV default		
55	Source replacement	00.00- 99.12	-1		
56	Evaluation unit electronics temperature	-100 - 200	Display		
60	Test pulse generator	0 - 999.9	0		
61	Test error relay	0 - 2	0		
62	Test alarm relay	0 - 2	0		
63	Test warning relay	0 - 2	0		
64	Test display				
65	Test keyboard				
66	Status digital in	00.00 - 01.01	Display		
67	HV max for plateau measurement	500 - 1300	1000		
68	Detector plateau measurement (only FSK)	0 - 5	0		
70	Error log	0 - 1	0		
71	Revision log	0 - 1	0		
72	Save & Load / Reset	0 - 99	0		

Empty calibration

The level must be at least 50 mm below the limit level. The radiation channel of the shielding is open.

☞ Push the "Cal" button for 3 seconds

✓ The empty count rate is read in.
At the end of the measuring time, code 30 is displayed and the read-in empty count rate.

Full calibration

The level must be at least 50 mm above the limit level. If this is not possible, you may also close the source shielding. If only the source shielding is closed to carry out the full calibration, then you have to keep in mind:
- Make sure that the absorption of the closed shielding nearly corresponds to the absorption of the product. If in doubt, please contact BERTHOLD TECHNOLOGIES or your local representative.
- Typically, you will lose some dynamics in the measurement, which results in a higher time constant.

☞ Select code 31.
Push the Enter button
Push the Cal button.

✓ The full count rate is read in.
At the end of the measuring time, code 31 is displayed and the read-in full count rate.

Calibration

☞ Select code 36.
Push the Cal button.

✓ A checkmark and the digits 0000 confirms that the calibration was successful.
If an error message is display, the error has to be removed as described in the User's Manual and in the error list; then the calibration has to be carried out once more.

Test

☞ Write down the empty and full count rate in code 30 and code 31.
Select code 60.
Enter the full count rate in code 60.

✓ The measurement must show 0% in code 10.
If not, check the calibration.

☞ Select code 60.
Enter the full count rate in code 60.

The measurement must show 100% in code 10.
If not, check the calibration.

Function check

- Level is at least 50mm below the limit level when the radiation channel of the shielding is open.
- ✓ The measured value in code 10 has to fluctuate around 0%. The alarm output must not trigger an alarm.
- Increase the level above the limit level or close the shielding.
- ✓ The measured value in code 10 has to fluctuate around 100%. The alarm output must indicate an alarm and must not switch back anymore.

Password

- ☞ Enter a password in code 00.
- ✓ This rules out data manipulation by unauthorized persons. The error relay switches to normal only when the password has been entered and no error message is output.

The calibration is now finished and the measurement has been taken into operation.

3.6 Behavior during Operation and Malfunctions

- The following parameter are automatically adjusted in the course of operation relative to the decay compensation; therefore, their values may change: code 12 and code 18 – 31
- If the operation is changed, please observe the safety functions.
- Malfunctions that may occur are described in the User's Manual.
- If failures have been detected or malfunctions are reported, you have to take the entire measuring system out of service and keep the process in a safe state through other measures.
- Replacement of the measuring system is rather simple; it is described in the User's Manual.
- If parts are replaced as a result of a detected failure, please inform BERTHOLD TECHNOLOGIES (including failure description).
- If modifications in the product, the gas pressure, or the construction of the tank in the area of the radiation path are carried out, the measurement has to be calibrated again.

3.7 Recurrent Performance Test

The recurrent performance test is used to check the safety function to uncover possibly undetected dangerous failure. The operational capability of the measuring system has to be checked in adequate intervals.
It is in the responsibility of the operator to select the type of test and the proof test interval. The intervals are dependent on the PFD_{avg} value defined in the table and chart in the section "Safety-Technical Data" (see also FMEDA Report).
The test has to be carried out such that the proper safety function will be proven through interaction of all components.
This is the case when the level is controlled within the scope of a filling. If a filling is not feasible, the measuring system has to be triggered to respond by suitable simulation of the level or of the physical measurement effect.
The methods and procedures used in the tests have to be named and their degree of suitability has to be specified. The tests have to be documented.
If the function check is negative, you have to take the entire measuring system out of service and keep the process in a safe state through other measures.

3.8 Safety-Technical Data

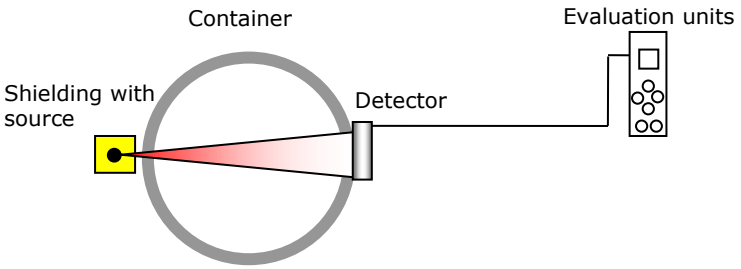
Failure rates of the electronics were determined through FMEDA according to IEC 61508. Calculations are based on the component failure rates according to SN 29500. All numerical values refer to an average ambient temperature of +40°C (104°F) during the operating period. Calculations are further based on the information provided in chapter 3.4 Project Planning.

λ_{sd}	230 Fit	safe detected failure (1 FIT = failure/10^9h)
λ_{su}	536 Fit	safe undetected failure
λ_{dd}	210 Fit	dangerous detected failure
λ_{du}	83 Fit	dangerous undetected failure
SFF	>92%	Safe Failure Fraction

General data

$T_{Reaction}$ Failure reaction time	1.5 sec
max. service life of the measuring system for the safety function.	7 years

Single channel architecture

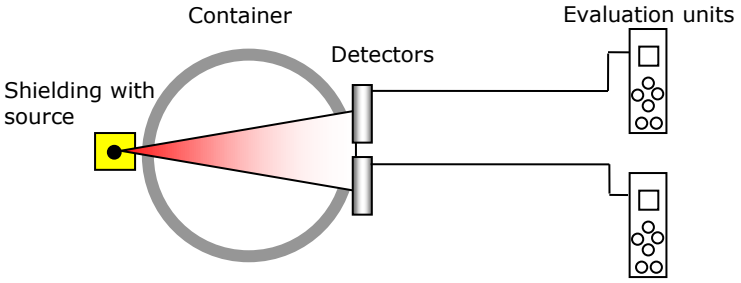


HFT = 0 (Hardware Fault Tolerance)

PFD_{avg}	
T_{Proof} = 1 year	$<0.036 \times 10^{-2}$
T_{Proof} = 2 years	$<0.073 \times 10^{-2}$
T_{Proof} = 5 years	$<0.180 \times 10^{-2}$
T_{Proof} = 10 years	$<0.360 \times 10^{-2}$

Two-channel architecture

HFT = 1 (Hardware Fault Tolerance)



1) for Common cause ß=5%

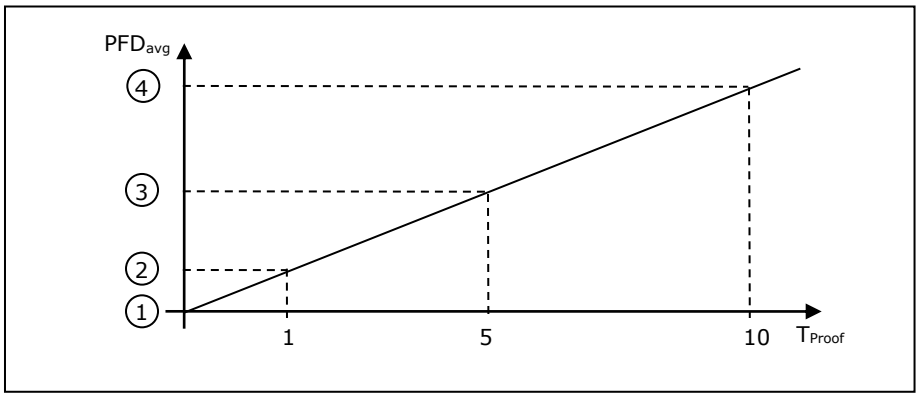
PFD_{avg}	
T_{Proof} = 1 year	$<1.8 \times 10^{-5}$
T_{Proof} = 2 years	$<3.7 \times 10^{-5}$
T_{Proof} = 5 years	$<9.5 \times 10^{-5}$
T_{Proof} = 10 years	$<20 \times 10^{-5}$

2) for Common cause ß=10%

PFD_{avg}	
T_{Proof} = 1 year	$<3.7 \times 10^{-5}$
T_{Proof} = 2 years	$<7.3 \times 10^{-5}$
T_{Proof} = 5 years	$<19 \times 10^{-5}$
T_{Proof} = 10 years	$<38 \times 10^{-5}$

Time-dependent trend of PFD_{avg}

The time trend of PVD_{avg} is nearly linear to the operating time in the period up to 10 years. The above mentioned values apply only to the T_{Proof} interval, according to which a recurrent performance check has to be carried out.



Time-dependent trend of PFD_{avg}

Failure Modes, Effects and Diagnostics Analysis

Project:

Level Switch Grenzhöhenschalter LB471 Geiger Müller

Customer:

Berthold Technologies GmbH & Co. KG
Bad Wildbad
Germany

Contract No.: Berthold Technology 04/08-10
Report No.: Berthold Technology 04/08-10 R002
Version V1, Revision R2, July 2007
Rainer Faller

Management summary

This report summarizes the results of the hardware assessment according to IEC 61508 carried out on the Level Switch Grenzhöhenschalter LB471 Geiger Müller. For safety applications only the relay outputs "Alarm" and "Warning" were considered.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Failure rates used in this analysis are basic failure rates from the Siemens standard SN 29500. For the Geiger Müller sensor field failure evaluations from the manufacturer (VacuTec) were used. For the mechanical design of the detector unit field failure evaluations from Berthold Technologies were used.

The Level Switch Grenzhöhenschalter LB471 Geiger Müller is considered to be a Type B sub-system with a hardware fault tolerance of HFT=0.

It is assumed that the connected logic solver is configured to evaluate both relay outputs "Alarm" and "Warning". Under the assumptions described in section 4 the following table shows the failure rates according to IEC 61508:

Table 1 Summary for the Level Switch Grenzhöhenschalter LB471 Geiger Müller – IEC 61508 Failure rates

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF	DC_S[1]	DC_D
230 fit	537 fit	210 fit	84 fit	92%	30%	71%

These failure rates are valid for operating stress conditions typical of an industrial field environment similar to IEC 60654-1, class C (sheltered location) with an average temperature over a long period of time of 40ºC. For a higher average temperature of 60°C, the failure rates should be multiplied with an experience-based factor of 2.5. A similar multiplier should be used if frequent temperature fluctuation must be assumed.

The failure rates do not include failures resulting from incorrect use of the transmitter, in particular humidity entering through incompletely closed housings or inadequate cable feeding through the PG inlets.

A user of the Level Switch Grenzhöhenschalter LB471 Geiger Müller can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL). A full table of failure rates is presented in section 5.1 along with all assumptions in section 4.

The failure rates are valid for the useful life of the instrument. According to section 7.4.7.4 note 3 of IEC 61508-2, experience has shown that the useful lifetime often lies within a range of 8 to 12 years. This is independent of whether the Level Switch Grenzhöhenschalter LB471 Geiger Müller is used in 1oo1 or 1oo2 configuration.

[1] DC means the diagnostic coverage (safe or dangerous).

The PFD_{AVG} was calculated for four different proof test intervals.

Table 2 Summary for the Level Switch Grenzhöhenschalter LB471 Geiger Müller – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 2 years	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 3,7E-04	PFD_{AVG} = 7,4E-04	PFD_{AVG} = 1,8E-03	PFD_{AVG} = 3,7E-03

The boxes marked in yellow (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 but do not fulfil the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,5E-03. The boxes marked in green (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA–84.01–1996 and do fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,5E-03.

The Level Switch Grenzhöhenschalter LB471 Geiger Müller can be used redundantly with 1oo2 evaluation by the logic solver. This results in a Hardware Fault Tolerance of HFT=1, which make it suitable for SIL 3 safety loops as the Level Switch Grenzhöhenschalter LB471 Geiger Müller shows a Safe Failure Fraction of SFF = 93%.

For the 1oo2 configuration, PFD_{AVG} was calculated for four different proof test intervals and two different Common Cause factors of ß = 5% and ß = 10%.

Table 3 Summary for the Level Switch Grenzhöhenschalter LB471 Geiger Müller in 1oo2 configuration – PFD_{AVG} values

Common Cause	T[Proof] = 1 year	T[Proof] = 2 years	T[Proof] = 5 years	T[Proof] = 10 years
ß = 5%	PFD_{AVG} = 1,8E-05	PFD_{AVG} = 3,7E-05	PFD_{AVG} = 9,5E-05	PFD_{AVG} = 2,0E-04
ß = 10%	PFD_{AVG} = 3,7E-05	PFD_{AVG} = 7,3E-05	PFD_{AVG} = 1,9E-04	PFD_{AVG} = 3,8E-04

The boxes marked in yellow (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 3 according to table 2 of IEC 61508-1 but do not fulfil the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,5E-04. The boxes marked in green (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 3 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA–84.01–1996 and do fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,5E-04.

For two detectors connected to one evaluation unit, the failure behavior can be modeled as 2oo2 configuration of the detector. PFD_{AVG} was calculated for four different proof test intervals.

Table 4 Summary for the Level Switch Grenzhöhenschalter LB471 with 2oo2 Geiger Müller detector configuration – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 2 years	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 5,3E-04	PFD_{AVG} = 1,1E-03	PFD_{AVG} = 2,7E-03	PFD_{AVG} = 5,3E-03

Chapter 4. Instrument Description

4.1 Function

The limit switch system Mini Switch LB 471 is working on the basis of non-contact Gamma absorption measurement. The system can also be employed with heavy process conditions and aggressive media.
In order to obtain an optimum measurement effect at minimum source activity the best measurement geometry is calculated for the respective measuring point and the source is designed on the basis of this calculation.
The system comprises three major components:

- shielding with radiation source ❶
- Detector ❷
- evaluation unit ❸.

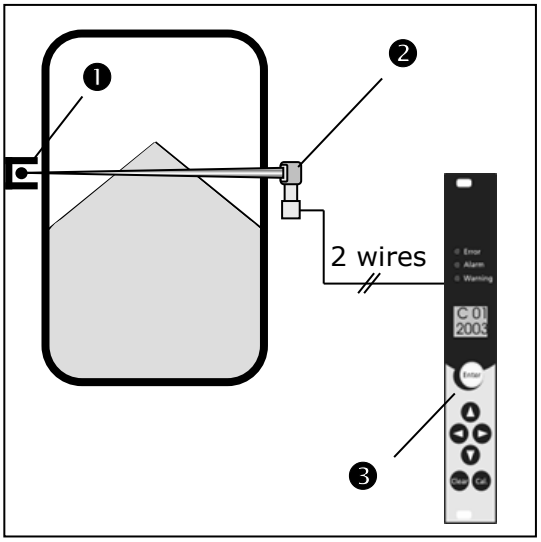


Figure 5: Measuring system

The shielded radiation source ❶ is installed outside the container on the level to be measured. A detector ❷ is installed on the opposite side of the container. The evaluation unit ❸ is connected to the detector by a 2-wire line.
If the level of the medium inside the container comes up to the level of the detector or the source, the radiation is absorbed and the evaluation unit sends a corresponding signal.
The following radiation sources are used:

- Co-60 has a relatively high energy of 1.17 or 1.33 MeV and is used on very thick pipeline or container walls. Its half-life time is 5.27 years.
- In most cases, Cs-137 with an energy of 0.660 MeV is adequate to irradiate common pipeline or container walls. Its half-life time of Cs-137 is around 30 years.

Due to the lower energy, operating expenses for shielding a Cs-137 source are lower than for Co-60.

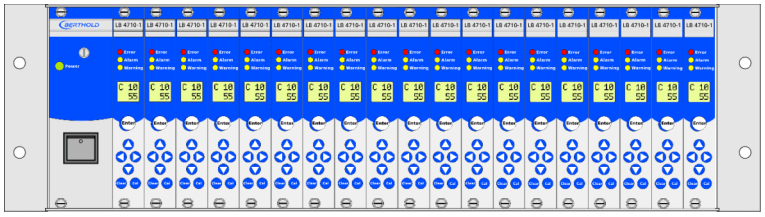
4.2 Mini Switch LB 471 Versions

The Mini Switch LB 471 can either be delivered in a 19" rack, in a wall housing or in a cassette.

Caution!

Observe explosion protection!
Intrinsically safe and not intrinsically safe systems must not be mixed, neither in a 19" rack nor in a wall housing.

In a 19" rack



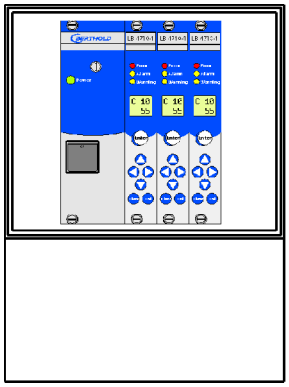
The 19" rack can be mixed with limit switches for GM detectors and fitted for NaI detectors. The 19" rack includes a back plane.
A **filter module** is used (for max. 19 limit switch modules) for 24V AC/DC supply. It includes:

- one mains switch
- on mains On LED
- two fuses (see Technical Data on page 105)
- additional filter section

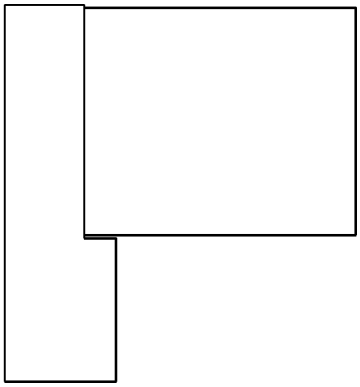
A 85W **transformer module** is used (for max. 18 limit switch modules) for 115/230V supply. In addition to the filter module, the transformer module has:

- a transformer with voltage selector switch 115V/230V

In a wall housing



Front view



Side view

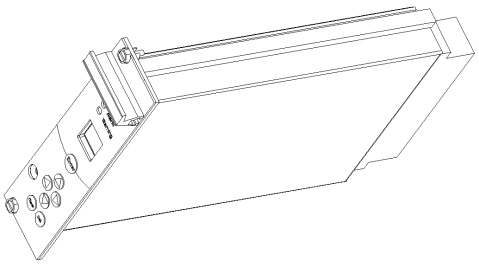
The wall housing can be mixed with limit switches for GM detectors and fitted for NaI detectors. The wall housing includes a back plane.
A **filter module** is used for 24 V AC/DC supply. It includes:

- one mains switch
- on mains On LED
- two fuses (see Technical Data on page 105)
- additional filter section

For 115/230V a 17W **transformer module** is installed. In addition to the filter module, the transformer module has:

- a transformer with voltage selector switch 115V/230V

As cassette



for any 19" rack

The evaluation unit is installed in a cassette with 7TE. Thus, it can be used in any 19" rack without back plane. A 32-pole terminal block is available to connect the wires.

4.2.1 Type Code

The following table shows the type code for the different versions of the evaluation unit LB 471.

Type code evaluation unit

Type	Detector	Det. connection	Version
LB4710-050	GM detector	II (2) G [EEx ib] IIC and I M2 [EEx ib] I	19" rack / wall housing
LB4710-060		II (2) G [EEx ib] IIC and I M2 [EEx ib] I	Cassette
LB4710-080		not Ex	19" rack / wall housing
LB4710-090		not Ex	Cassette
LB4710-150	NaI detector or Super-Sens	II (2) G [EEx ib] IIC and I M2 [EEx ib] I	19" rack / wall housing
LB4710-160		II (2) G [EEx ib] IIC and I M2 [EEx ib] I	Cassette
LB4710-180		not Ex	19" rack / wall housing
LB4710-190		not Ex	Cassette

Depending on the detector type you have to combine the following limit switch modules:

Detector	LB 471 Limit switch module
GM detector	LB 4710-0XX
NaI detector or Super-Sens	LB 4710-1XX

4.3 Detectors

The detector converts the Gamma quanta emitted by the source into electrical pulses and passed them on to the evaluation unit.
All components are installed together with the high voltage generation in a sturdy cylindrical stainless steel case with integrated connection box.
Different versions are available which are selected in accordance with physical, radiation protection or economical considerations in the project planning phase.

4.3.1 GM Detector

Depending on the operation conditions, the GM detector is equipped with one halogen counter tube for standard applications or with two halogen counter tubes for special applications for short switching times or to reduce a high source activity.
GM detectors are installed with the respective electronics including high voltage generation and pulse amplification in a stainless steel case.

The protection type is IP 65.

The connection is made in the integrated connection room with two wires. The maximum cable length is 1000 m at a cable cross-section ≥1.0 mm^2.

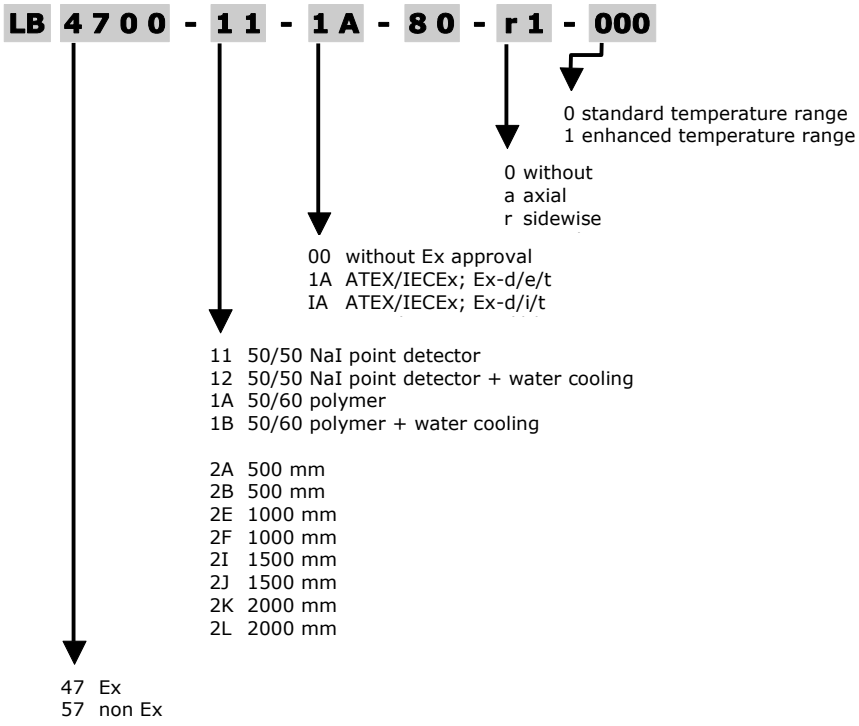
GM detector types

Type	Number of counter tubes	Ex-protection
SZ5 GHS 3171-1Gd	1	pressure-proof casing
SZ5 GHS 3171-2Gd	2	pressure-proof casing
SZ5 GHS 3171-1Gi	1	intrinsically safe
SZ5 GHS 3171-2Gi	2	intrinsically safe
GHS 3172-1	1	no
GHS 3172-2	2	no

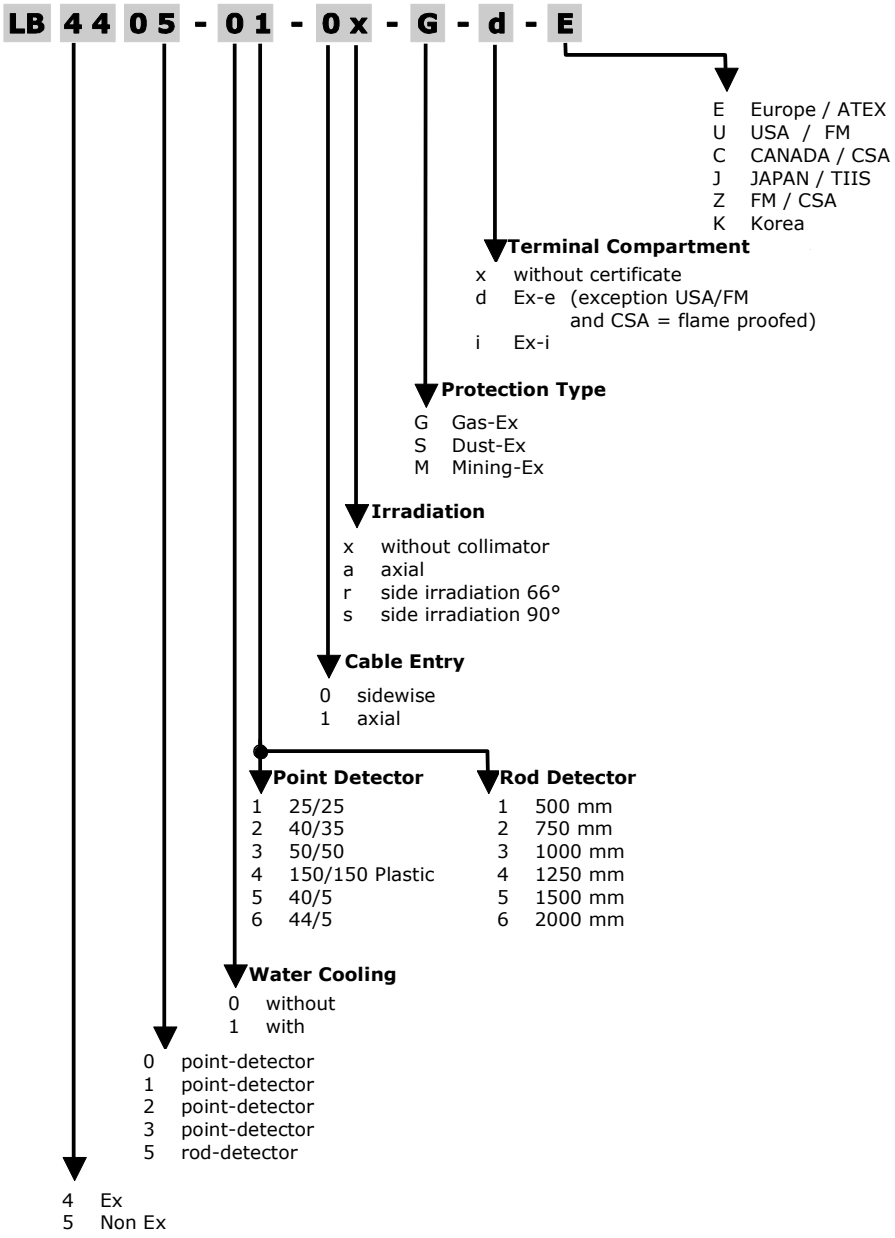
4.3.2 NaI Detector

The detector material is an artificially manufactured and specially dotted NaI crystal. Different crystal sizes are available, depending on the required sensitivity.
Installed in a sturdy stainless steel case, the detector is protected from normal environmental strain which may occur in industrial applications.

LB 4700



LB 44xx


LB 44 05 - 01 - 0x - G - d - E
E Europe / ATEX
U USA / FM
C CANADA / CSA
J JAPAN / TIIS
Z FM / CSA
K Korea
Terminal Compartment
x without certificate
d Ex-e (exception USA/FM and CSA = flame proofed)
i Ex-i
Protection Type
G Gas-Ex
S Dust-Ex
M Mining-Ex
Irradiation
x without collimator
a axial
r side irradiation 66°
s side irradiation 90°
Cable Entry
0 sidewise
1 axial
Point Detector
1 25/25
2 40/35
3 50/50
4 150/150 Plastic
5 40/5
6 44/5
Rod Detector
1 500 mm
2 750 mm
3 1000 mm
4 1250 mm
5 1500 mm
6 2000 mm
Water Cooling
0 without
1 with
0 point-detector
1 point-detector
2 point-detector
3 point-detector
5 rod-detector
4 Ex
5 Non Ex

4.3.3 Super-Sens Detector

The Super-Sens detector is extremely sensitive to Gamma radiation. The high sensitivity is achieved by using a 150x150 mm large plastic scintillator. It is provided with a lead shielding to reduce the zero count rate and to reduce interferences. Working with the Super-Sens detector allows you to reduce the required source activity significantly.

Super-Sens detector types

Standard Gas Ex: EEx de	
LB 4430-04-0a-Gd-E	axial irradiation
LB 4430-14-0a-Gd-E	with WC, axial irradiation
LB 4431-04-0s-Gd-E	lateral irradiation. 90°
LB 4431-04-0r-Gd- E	lateral irradiation. 66°
LB 4431-14-0s-Gd-E	with WC, lateral irradiation 90°
LB 4431-14-0r-Gd-E	with WC, lateral irradiation 66°

Intrinsically safe, Gas Ex: EEx ib	
LB 4430-04-0a-Gi-E	axial irradiation.
LB 4430-14-0a-Gi-E	with WC, axial irradiation
LB 4431-04-0s-Gi-E	lateral irradiation 90°
LB 4431-04-0r-Gi-E	lateral irradiation 66°
LB 4431-14-0s-Gi-E	with WC, lateral irradiation 90°
LB 4431-14-0r-Gi-E	with WC, lateral irradiation 66°

Firedamp protection	
LB 4430-04-1a-Md-E	axial irradiation
LB 4431-04-1s-Md-E	lateral irradiation 90°

Firedamp protection: intrinsically safe	
LB 4430-04-1a-Mi-E	axial irradiation
LB 4431-04-1s-Mi-E	lateral irradiation 90°

not Ex	
LB 5430	axial irradiation
LB 5431	lateral irradiation 66°

WC = water cooling

Chapter 5. Installation

5.1 Transport to the Installation Site

Danger!

Risk of injury!
When unloading heavy system parts, never step under floating loads!
Only use tested separate lifting accessories matching the transport weights.
Observe adequate safety margin.
Wear hard hat and protective gloves.

5.1.1 Transporting Detector and Evaluation Unit

Warning!

Risk of damage!
System parts may get damaged during transport.
Transport detector and evaluation unit in their original packing.
Protect parts against vibrations.

Use the eyebolts for transporting the Super-Sens detectors.

5.1.2 Transport Shielding with Source

Caution!

Radioactivity!
The radiation protection directives have to be observed.
Radioactive substances may be transported on public traffic routes only by persons in possession of the proper transport license!
A source may be transported only in the shielding.

The shielding with the source inside can be lifted onto a palette by a fork-lift and transported to its destination. The shielding includes eyebolts for transportation by a crane.

5.1.3 Temporary Storage of Sources

The operator has to take suitable provisions for intermediate storage of sources at the place of installation between the period from source delivery to the start of the installation work. A source may be stored only in a lockable room which is identified accordingly. Accessible controlled areas have to be identified and, if necessary, secured.

5.1.4 Installation Site

Danger!

Risk of injury and damage!
Heavy system parts may fall down if not installed properly.
The carrying capacity of the container walls or the holders must be adequate to install the source with shielding and the detector.

Free space must be foreseen at the installation site for:

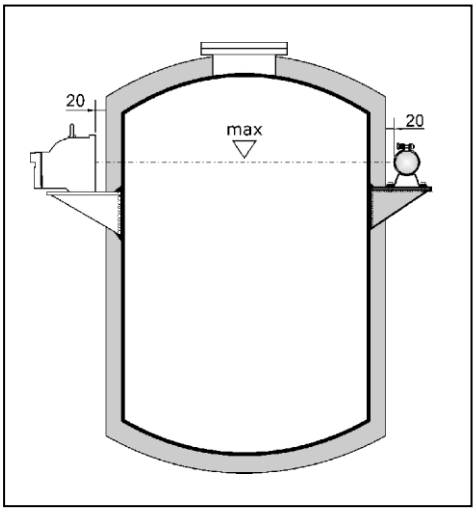
- Freedom of motion for delivery of shielding, detector and evaluation unit
- Servicing and repair work, to install and dismantle parts.

The source with shielding and the detector are horizontally installed on the designated limit level on the outside of the container and outside a possibly installed heat insulation. Any special features at the measuring point have to be taken into account.

5.1.5 Unpacking and Cleaning System Parts

After unpacking, compare all parts with the packing list and check if the shipment is complete and shows any sign of damage. If necessary, you may have to clean parts.
If you detect any damage, notify the forwarder and the manufacturer immediately.

5.2 Installing the Detector



Mark the level to be monitored at the container. Position the detector there in a horizontal line with the source. At the same time, the horizontal line is the limit level where the device is switching. Make sure that the radiation window of the detector is not covered by the holder. The distance to the surface of the container or the heat insulation should be approx 20 mm.

Warning!

Risk of damage!
The detector may be damaged by heavy mechanical strain, vibrations and high temperatures.
The detector has to be mounted free from vibrations. During installation and operation, the detector must not be exposed to mechanical strain.
The ambient temperature must not exceed the values stated in the technical data section (see chapter 13.2). If the ambient temperature is higher, the detector has to be cooled. Appropriate water cooling jackets are available as extras. See also Chapter 6 **Water Cooling** and the technical drawings on pages 121 to 130.
Direct exposure to sunlight is not permitted as this may lead to an unacceptable increase of the surface temperature. In these cases, you have to install a canopy top (see Figure 6).

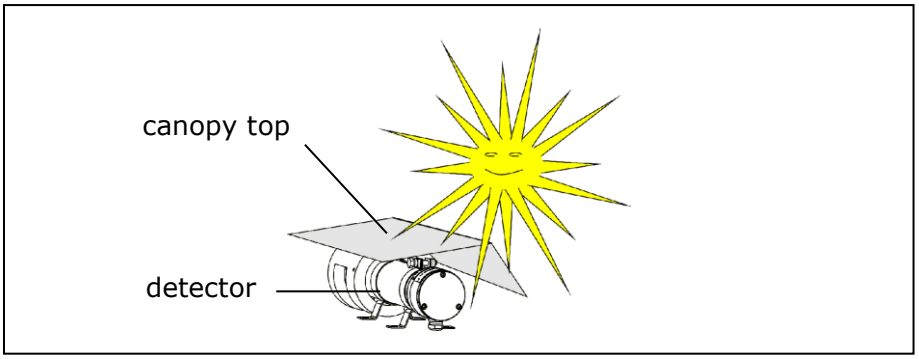
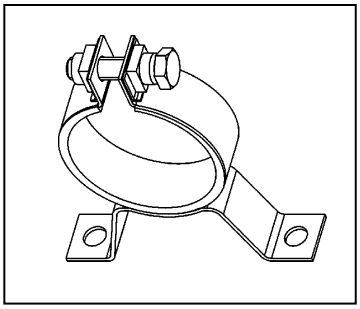


Figure 6: Detector with canopy top

5.2.1 Fastening Clamps for GM Detectors and NaI Counters

Stainless steel clamps are available to install the detector. The dimensions of the clamps are shown in the technical drawings in the Appendix. The technical drawing with dimensions is shown on page 123.

Figure 7: Clamp for GM detectors and NaI detectors

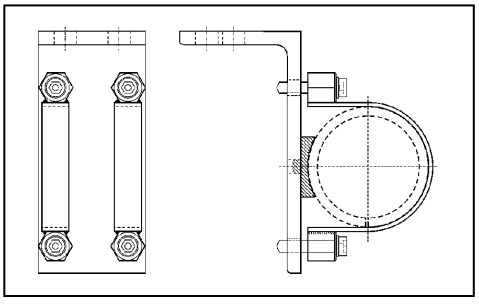


Clamps for detector without water cooling	Clamps for detector with water cooling
ID-NO 31346 (1 set= 2 clamps)	ID-NO 31347 (1 set = 2 clamps)

5.2.2 Stainless Steel Detector Holder (Alternative)

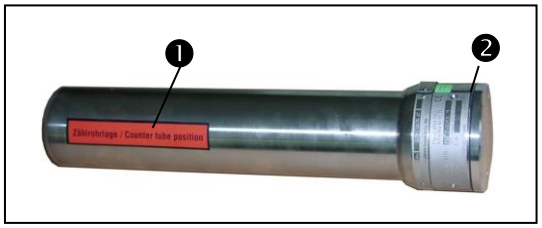
A sturdy stainless steel holder may be used instead of clamps. The holder comprises an angle on which two clamps have already been installed. You can fix the holder on a bracket either **with screws or through welding**. Due to the plastic rings, the same holder may be used for detectors with or without water cooling. All metal parts of this holder are made of stainless steel. The technical drawing with dimensions is shown on page 124.

Figure 8: Detector holder



Holder for detector complete
ID-NO 39246

5.2.3 Installation of the GM Detector



❶ Red marking strip for counter tube position
❷ Connection room

Align the detector horizontally exactly on the level of the source. The red marking strip on the case shows the position of the counter tube in the detector. The counter tube must not be covered by the holder or by clamps, as this would adversely affect the sensitivity of the measurement.

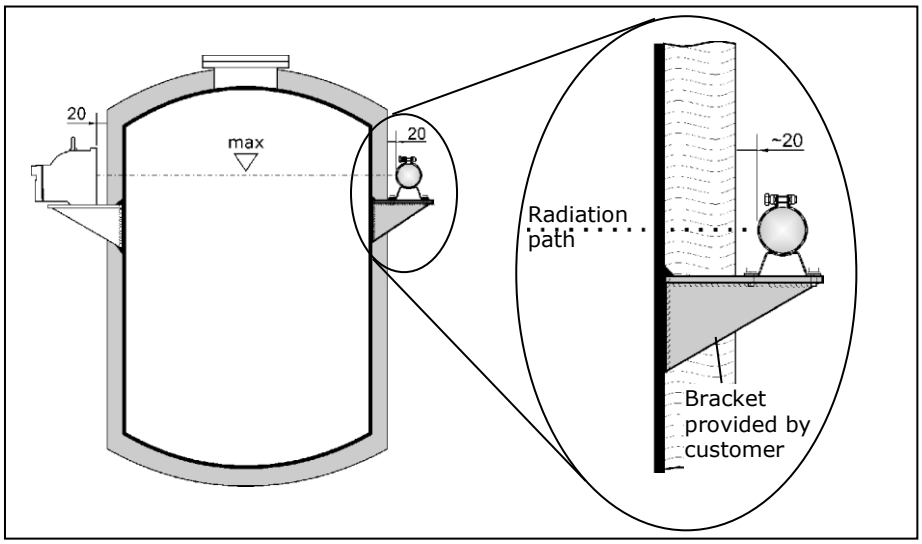


Figure 9: Installation on container GM detector

If the bracket cannot be installed on the container, then it has to be mounted on the girder located in the vicinity. Figure 10 shows three alternative proposals for installing the detector (A, B, C).

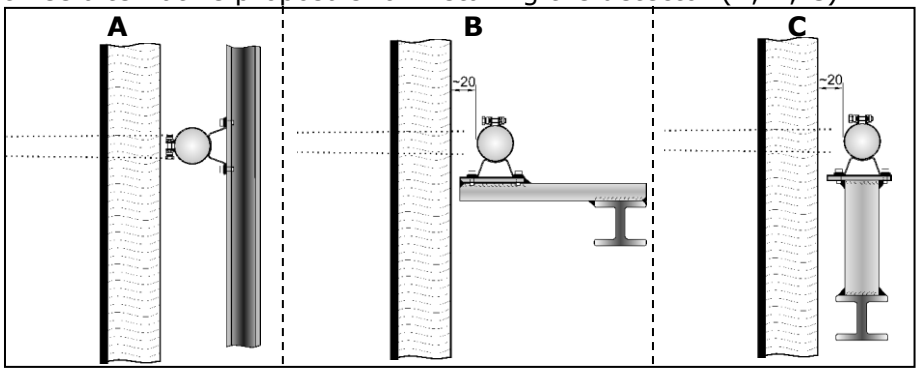


Figure 10: Alternative installations

Installation with clamps

1. Make a suitable bracket for the container.
2. Using the drawing below, drill 4 holes (d=11 mm) into the bracket for the clamps.
3. Install the bracket either directly on the container or on a sturdy girder.
4. Install the detector on the bracket using clamps.

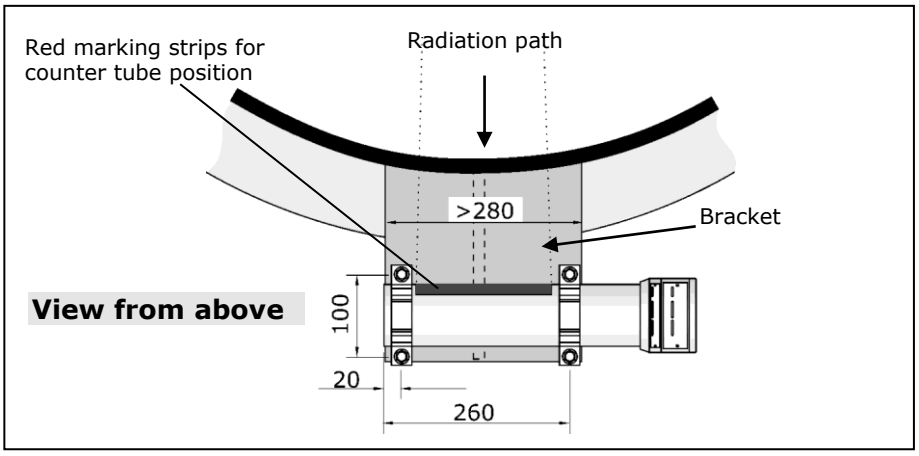


Figure 11: GM detector mounted on bracket

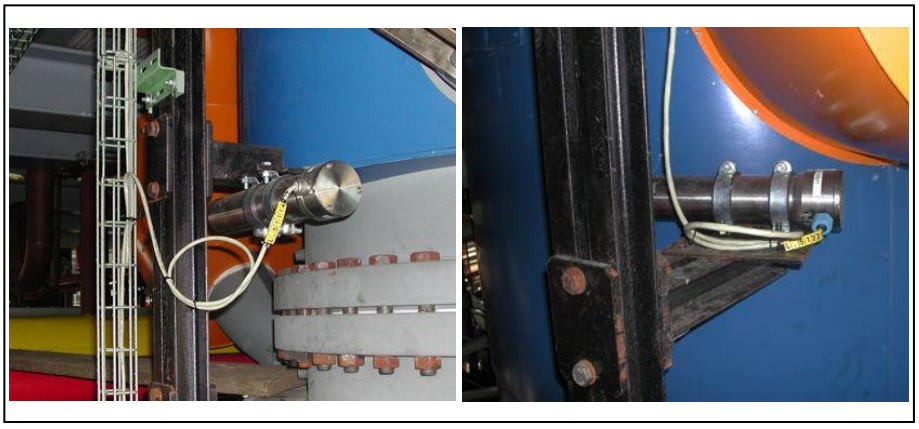


Figure 12: Examples of installed detectors

5.2.4 Installation of the GM Detector

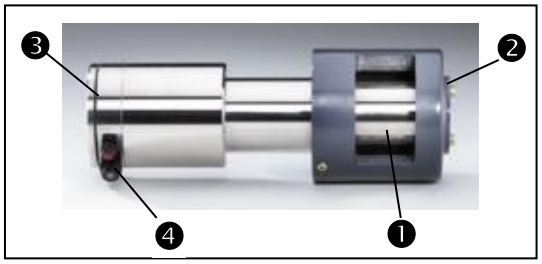


Figure 13: NaI detector

❶ Radiation window
❷ Collimator
❸ Connection room
❹ Screwed cable gland

The lateral opening (radiation window) in the collimator covers the sensitive area of the detector; it has to face the source.

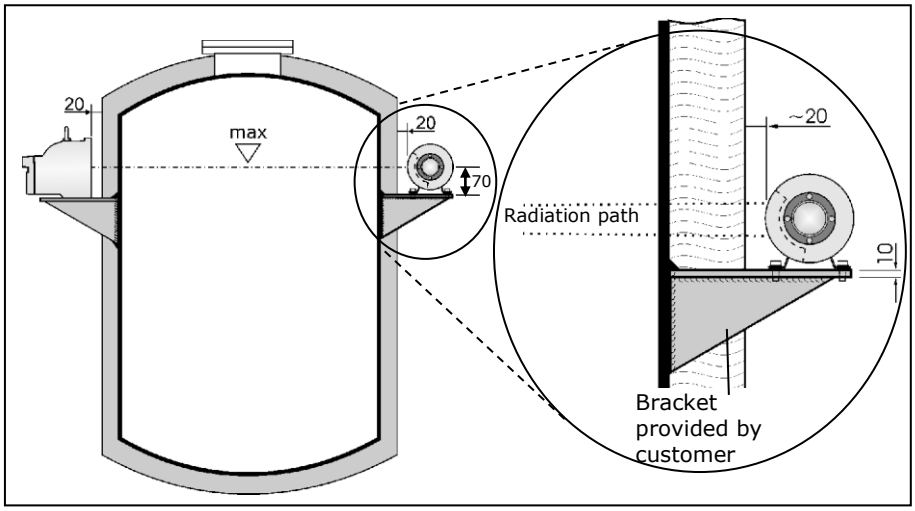


Figure 14: NaI detector mounted on a container

If the bracket cannot be installed on the container, then it has to be mounted on the girder located in the vicinity. Figure 15 shows three alternative proposals for installing the detector (A, B, C).

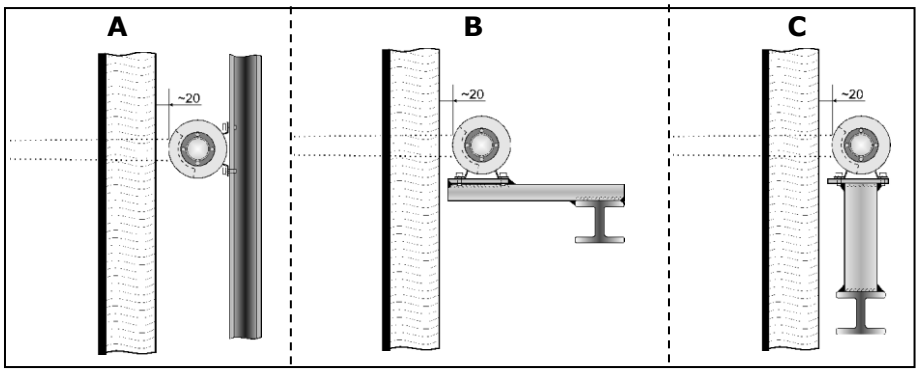


Figure 15: Alternative installations

Installation with clamps

1. Make a suitable bracket for the container.
2. Using the drawing below, drill 4 holes (d=11 mm) into the bracket for the clamps.
3. Install the bracket either directly on the container or on a sturdy girder.
4. Install the detector on the bracket using clamps.

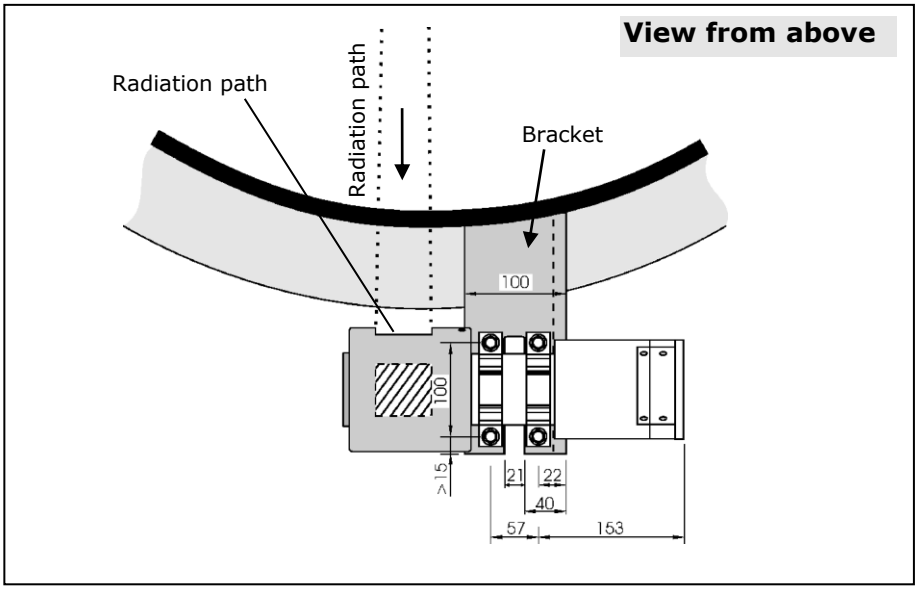
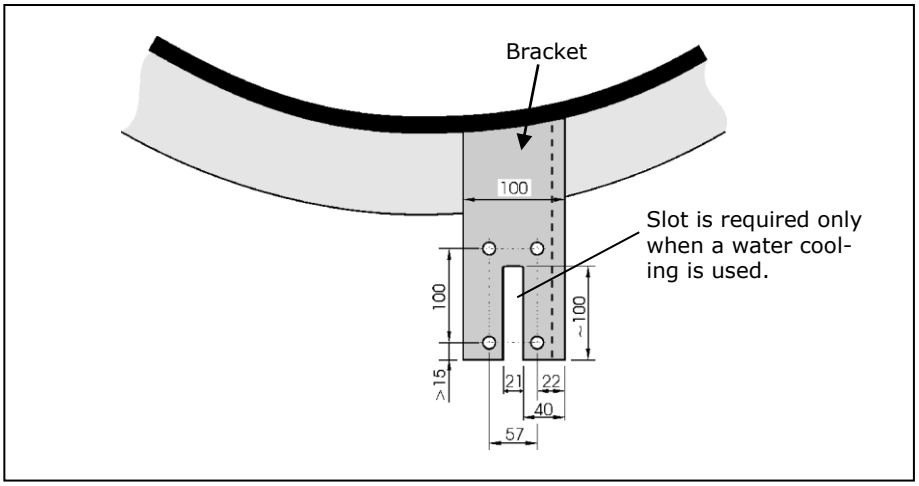


Figure 16: NaI detector mounted on bracket



Installation with detector holder (chapter 5.2.2*)*

1 Make a suitable bracket for the container.

2 If the holder is not welded onto the bracket, drill 2 holes (d=17 mm) for the holder in the bracket, using the drawing below.

3 Install the bracket either directly on the container or on a sturdy girder.

4 Install the holder with the detector on the bracket.

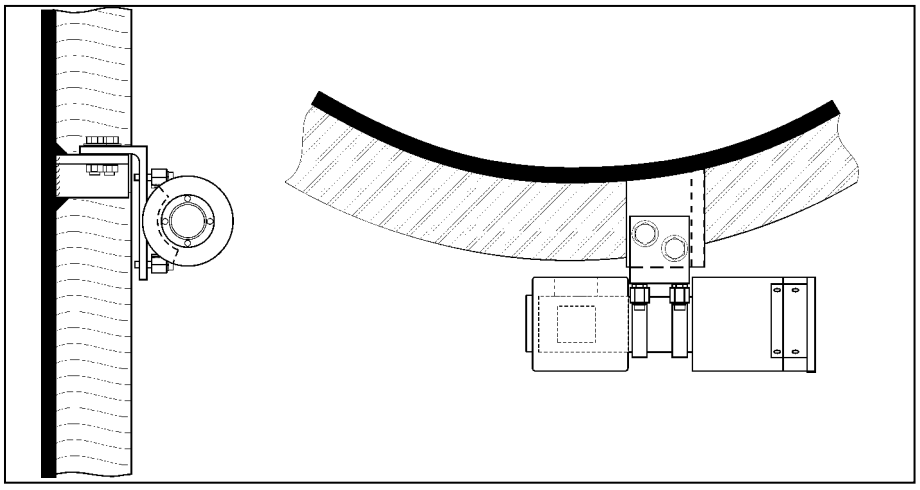


Figure 17: Installation proposal with detector holder

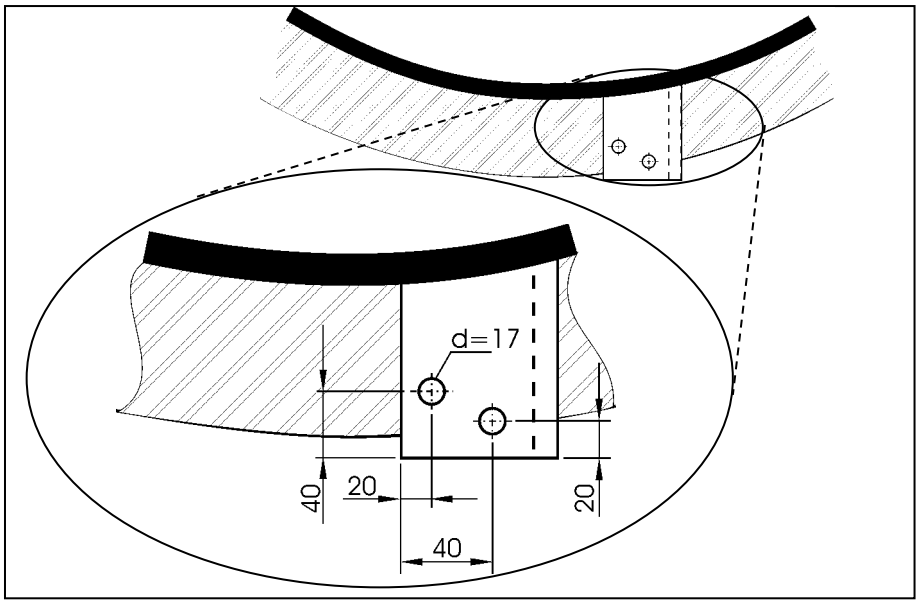


Figure 18: Bracket with drilled holes for detector holder

5.2.5 Installation of Super-Sens with Axial Irradiation

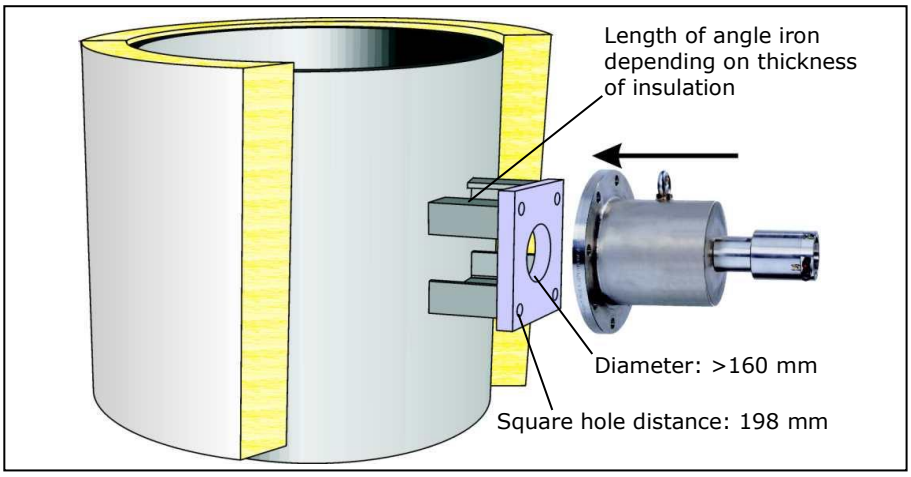


Figure 19: Installation with Super-Sens detector

The axial radiation window, located in the center of the flange, covers the sensitive area of the detector. The radiation window must face the source.

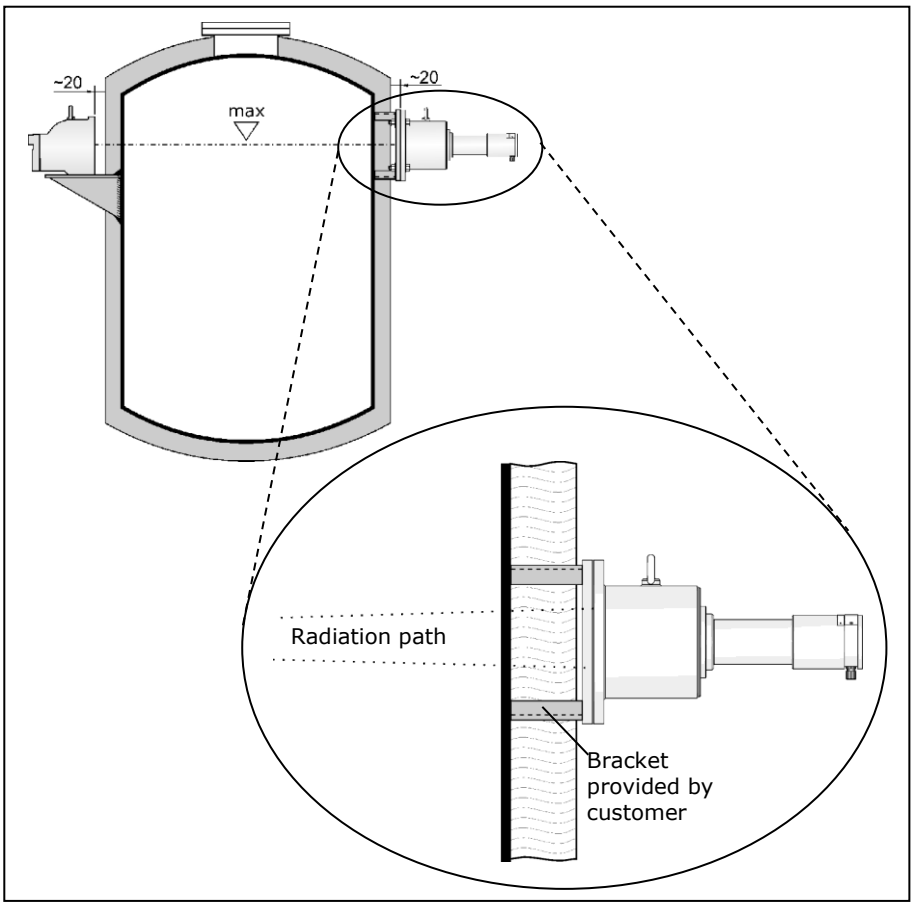


Figure 20: Super-Sens mounted on a container

Installation

1 Make a suitable bracket for the container.

2 Using the drawing below, drill 4 holes (d=18 mm) into the bracket for the flange.

3 Install the bracket either directly on the container or on a sturdy girder.

4 Install the detector on the bracket using the flange.

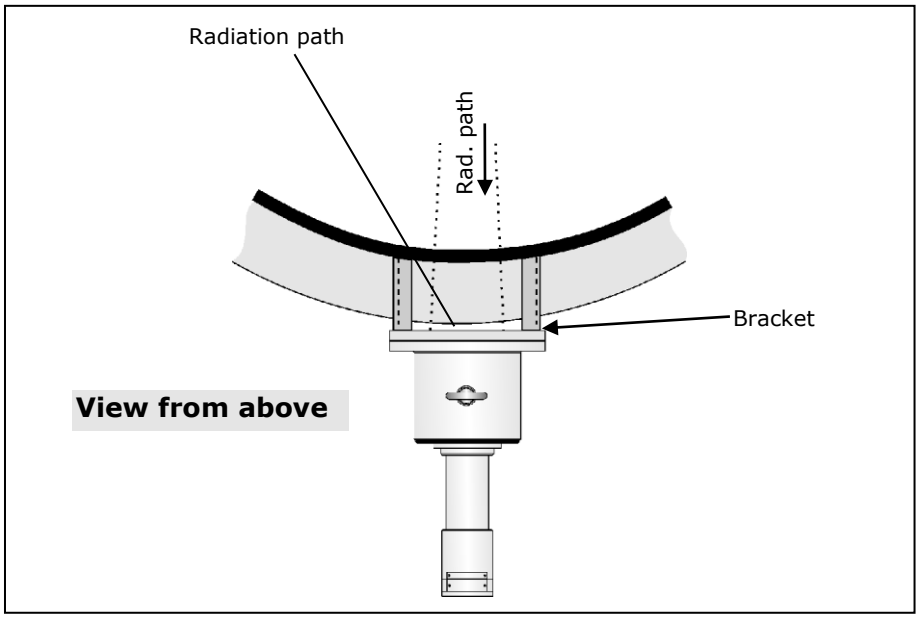


Figure 21: Super-Sens mounted on a container

Warning!

Risk of damage!
Heat conduction above the bracket or heat radiation from the container may destroy the detector.
Heat conduction has to be reduced using a heat-resistant sealing between bracket and flange of the Super-Sens detector.

5.2.6 Installation of Super-Sens with Radial Irradiation

The radial radiation window, located on the side, covers the sensitive area of the detector. The radiation window must face the source.

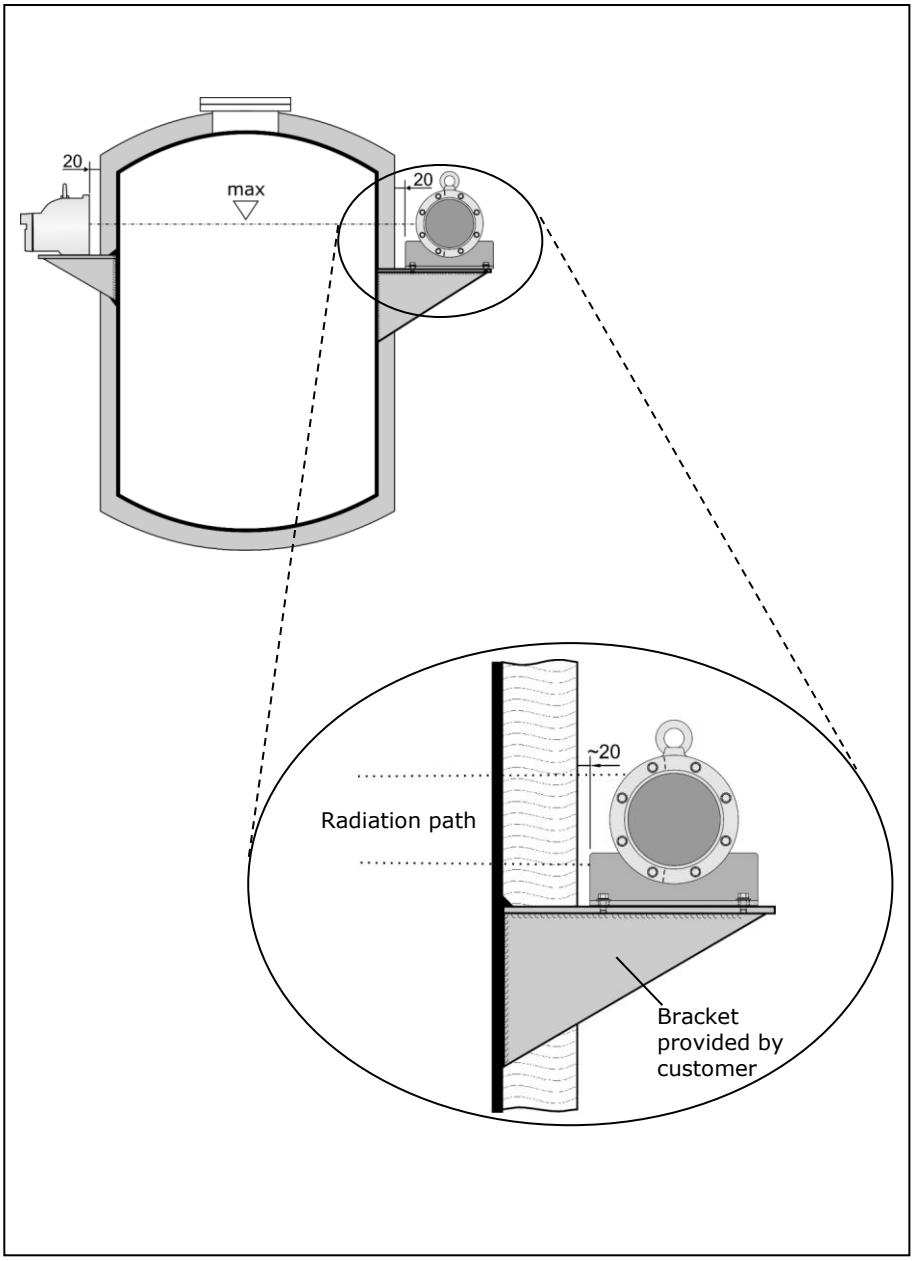


Figure 22: Install Super-Sens with lateral irradiation on container

Installation

1. Make a suitable bracket for the container.
2. Using the technical drawings on pages 127 to 130, drill 4 holes (d=18 mm) into the bracket for the flange.
3. Install the bracket either directly on the container or on a sturdy girder.
4. Install the detector on the bracket.

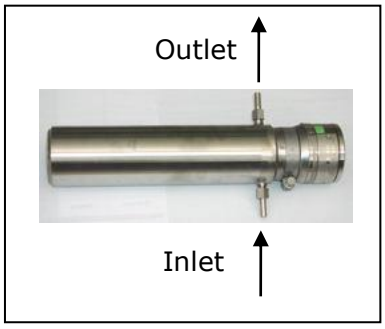
Chapter 6. Water Cooling

A water cooling device is needed if the ambient temperature may rise above the max. permitted value. The maximum operating temperature for the respective detector is listed in the technical data section on page Chapter 13.

Connecting the water cooling device

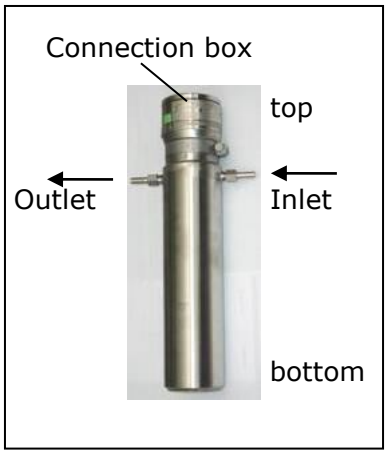
If a water cooling device is installed on the detector, the connection piece has to be aligned such that the water feed pipes can be connected easily. Make sure that the water pipes do not lead past the radiation window.
Keep the following in mind to prevent that an air cushion builds up in the water cooling device:

Horizontal installation:



If the detector is installed horizontally, then the bottom connection piece is to be used as water inlet.

Vertical installation:

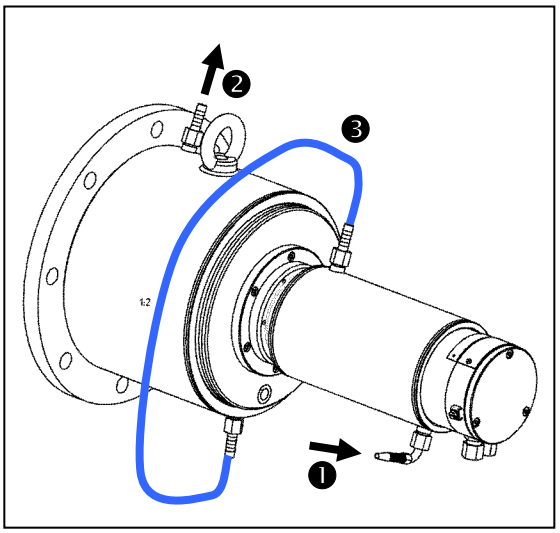


If the detector is mounted vertically, then the connection box has to face up so that the fittings are located on the top end of the water cooling.

This rule applies to all detector types.

Super-Sens with water cooling

In a Super-Sens with water cooling, the water cooling device is integrated in the case. The water cooling comprises two cooling jackets which have to be connected with each other during installation.



❶ Water inlet
❷ Water outlet
❸ Connection between both cooling jackets

Warning!

Risk of damage!
The cooling water flow must not be turned off if the maximum ambient temperature of the detector (see technical data in chapter 13.2) will be exceeded even if the facility is not in operation.
In case of danger of frost the water cooling has to be emptied.
Dirty cooling water may block up the water cooling so that the detector may get overheated and destroyed. Make sure to use clean cooling water!

6.1 Subsequent Installation of Water Cooling (Option)

If you are working with the NaI detectors LB 4401, LB 5401 or GM detectors, you may install a water cooling subsequently. See technical drawings on pages 121 and 122.

Preparation

You need clamps with a large diameter (90 mm) in order to fix the detector later at its position again. These clamps have to be ordered separately in addition to the water cooling. If you are using a detector holder instead of the clamps, you only have to remove the plastic ring. See technical drawings on pages 123 and 124.

Depending on the type of detector, a different type of water cooling may be needed. The assembly instructions apply to the following detector types:

- NaI detector with collimator
- NaI detector without collimator
- GM detector

6.1.1 Water Cooling for NaI Detector with Collimator

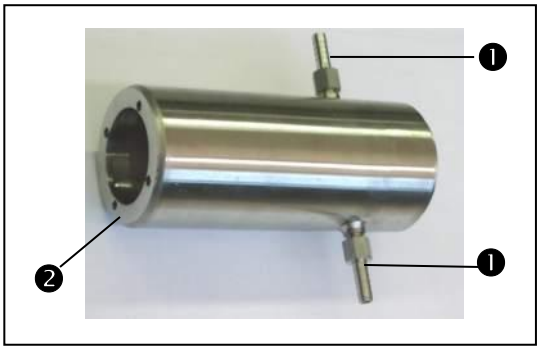


Figure 23: Water cooling for NaI detector

❶ Cooling nozzle
❷ Drilled hole for screws

Collimators only have detectors with 50/50 crystal such as:

- LB 4401-03
- LB 5401-03

Installing the water cooling

1 Pull off collimator from detector. To do this, open the four screws on the front side.

In order to install the collimator and the water cooling again to the detector, you need four screws which are 5 mm longer than the original screws.

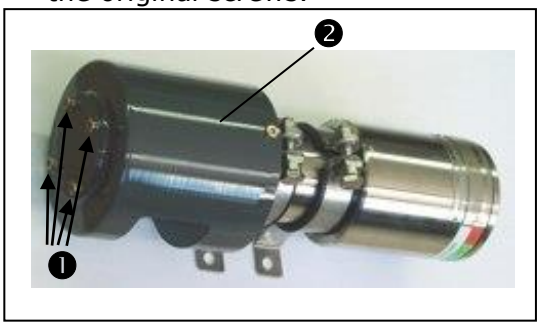


Figure 24: Fastening screws for collimator

❶ Screws (~30mm long)
❷ Collimator

2 Push the cooling jacket over the detector.

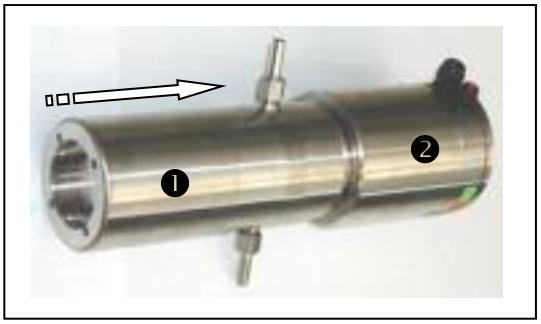


Figure 25: NaI detector with water cooling

❶ Water cooling
❷ Detector

3 Remove the plastic ring ❷ from the collimator by opening the screws ❶ on the side of the collimator.

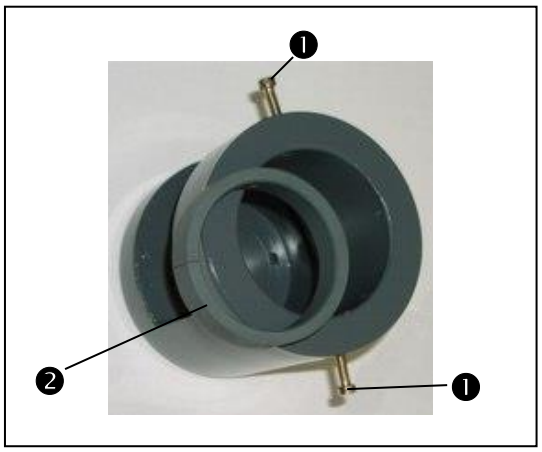


Figure 26: Collimator for NaI detector

❶ Screws
❷ Plastic ring

4 Push the collimator over the water cooling so that the radiation window is facing the source. Position the collimator and water cooling towards the pitch circle of the detector. Make sure that the position of the cooling nozzle is such that you later have unimpeded access to install the water feed pipes.

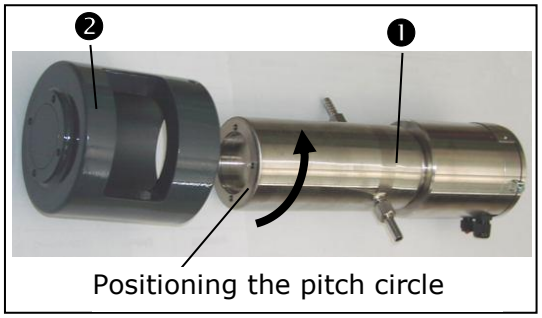


Figure 27: NaI detector with water cooling and collimator

❶ Detector with water cooling
❷ Collimator

5 To install the collimator and the water cooling on the detector, you have to use the 5 mm longer screws mentioned above.

6.1.2 Water Cooling for NaI Detector with Collimator

Installing the water cooling

1 Open the four frontal screws ❶ of the cover plate ❷. Leave the cover plate and the lead plate below it in their position.

In order to install the water cooling to the detector, you need four screws which are 5 mm longer than the original screws (not included in delivery).

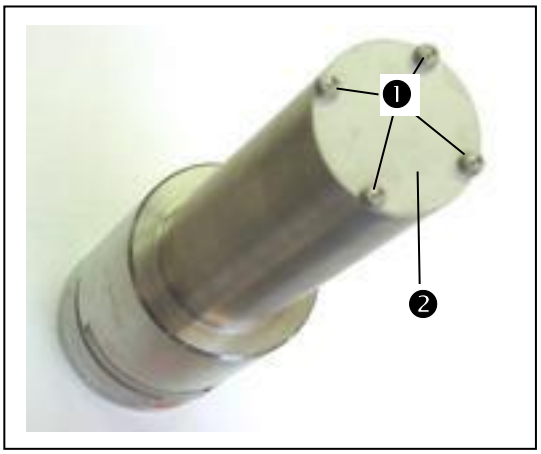


Figure 28: NaI detector without collimator

❶ Screws
❷ Cover plate

2 Push the cooling jacket over the detector.

3 Position the water cooling on the pitch circle of the detector. Make sure that the position of the cooling nozzle is such that you later have unimpeded access to install the water feed pipes.

4 Now fix the collimator with the four screws which are 5 mm longer than the original screws.

6.1.3 Water Cooling for GM Detector

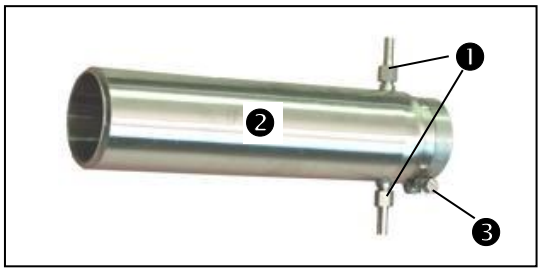


Figure 29: Water cooling for GM detector

❶ Cooling nozzle
❷ Water cooling
❸ Locking screw

Installing the water cooling

1 Push the cooling jacket over the detector.
Make sure that you position the cooling nozzle such that you later have unimpeded access to install the water feed pipes.

Figure 30: Water cooling with GM detector

❶ Water cooling
❷ GM detector

2 Tighten the locking ring ❸ for the water cooling.

Figure 31: Water cooling installed on GM detector

❸ Locking ring

6.2 Amount of Cooling Water Required

Warning!

Risk of damage!
The cooling water flow must not be turned off if the maximum ambient temperature of the detector (see technical data in chapter 13.2) will be exceeded even if the facility is not in operation.
In case of danger of frost the water cooling has to be emptied.
Dirty cooling water may block up the water cooling so that the detector may get overheated and destroyed. Make sure to use clean cooling water!

The amount of cooling water required may be taken from the graph below.

- The X-axis shows the max. achievable ambient temperature.
- The different characteristic curves are valid for the respective feed temperature of the cooling water.
- The Y-axis shows the min. required water flow.

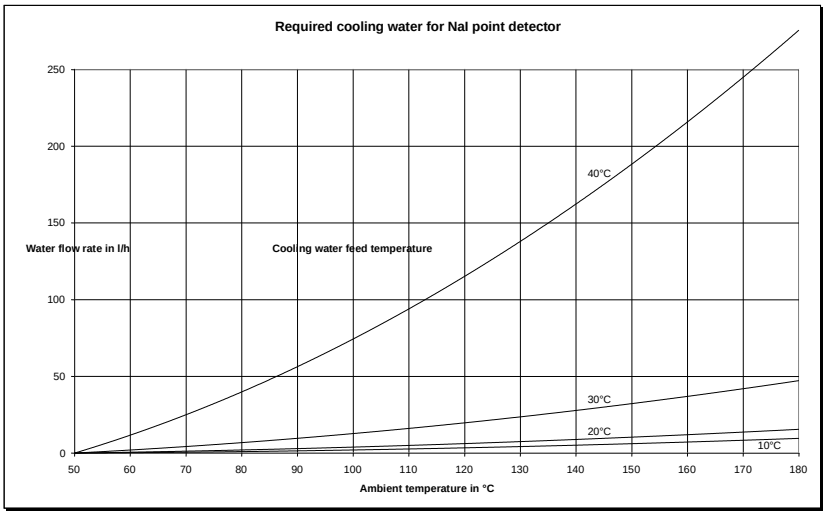


Figure 32: Characteristic curve for cooling water requirement

Chapter 7. Shielding Installation

7.1 General Installation Instructions

Caution!

Radioactivity!
Installation and start-up of radiometric measuring systems may be carried out only by persons who have been instructed adequately by professional personnel!
Work is carried out under the guidance and supervision of the radiological safety officer. It has to be ensured that the lock of the shielding is closed.
Damage on the shielding must be avoided.
The shielding should be positioned as closely as possible to the container surface.
The radiation danger sign has to be installed very close by to the shielding.
The controlled area, if there is one, has to be identified and, if necessary, secured.
How to calculate the radiation exposure during installation of the shielding is described on page 101.
The user has to be familiar with the radiation protection guidelines in Chapter 11.

Note!

Especially for measuring points with Super-Sens detector, the shielding should be installed only after the zero count rate has been determined, since the residual radiation from the shielding (even if the shielding is closed) may distort the measurement of the zero count rate.
See also code 32 in the software description.

Arrangement

Source and center of the detector have to be installed on a horizontal line. At the same time, this horizontal line is the monitoring level where the device switches.
The shielding is installed at the measuring point by means of brackets.

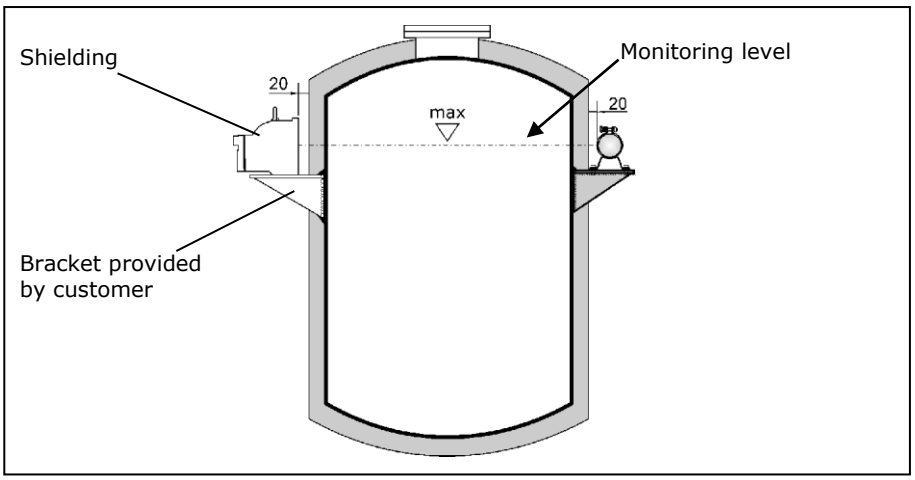


Figure 33: Installation on a container

Installation sequence

1. Install suitable bracket which has to be provided by the customer on the respective level. See installation proposal below.

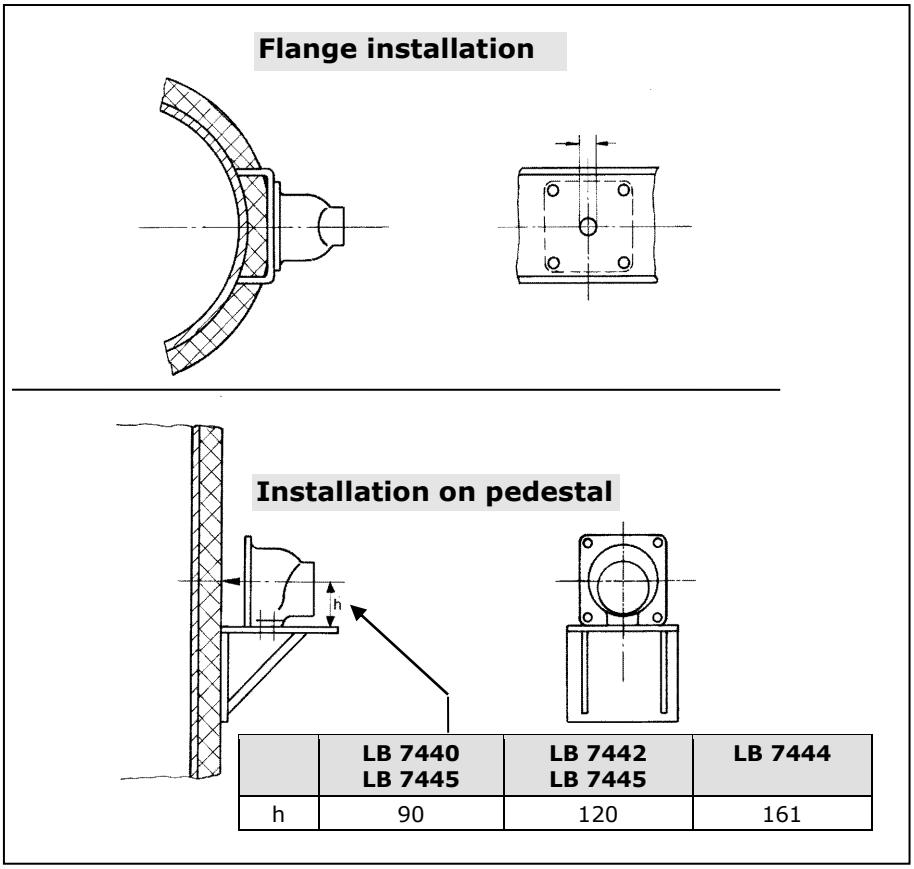
2. Unpack source with shielding and mount it on the respective bracket.

If you are working with a shielding with pneumatic shutter, a compressed air connection has to be available. Signals supplied by an optional limit switch have to be connected via an electrical line (see Shielding LB 744X with Pneumatic on page 132).

7.2 Installation Proposal for Shielding

The shielding container comprises a lead-filled sturdy cast iron case. A revolving shutter is installed to close the radiation exit channel. This shutter is operated from the rear side via a lever, which can be locked by means of a padlock in its open or closed position.
For installation, the shielding container includes a cast-on flange and in addition a fastening foot with threaded holes.
The specifications for the required drilled holes are listed in the Appendix on page 131.

Figure 34: Installation proposal for shielding



	LB 7440 LB 7445	LB 7442 LB 7445	LB 7444
h	90	120	161

Figure 35: Example of flange installation

7.3 Pneumatic Shielding Shutter (Option)

A pneumatically operated shutter is available as a special version. When turning on the compressed air, the locking core moves to the "OPEN" position. In case of failure of the compressed air, the shutter is turned by to the "CLOSED" position by a flat spiral spring. A switching contact indicates the shutter position.
For technical details and drawings see page 132 in the Appendix.

Chapter 8. Electrical Installation

Danger!

The special aspects of intrinsically safe installation have to be taken into consideration.

In Ex-areas the detector has to be connected with the equipotential busbar of the facility.

In Ex-areas and for measurements that are not intrinsically safe the evaluation unit has to be disconnected from power during the electrical installation.

If the intrinsically safe electric circuit is installed in areas engendered of dust explosion which are classified as area 20 or 21, it has to be ensured that the devices which are connected to these electric circuits fulfill the requirements of category 1D or 2D and have been certified accordingly.

A length of thread[1] of 50 mm has to be observed between intrinsically safe connections and connections that are not intrinsically safe.

The maximum cable length between detector and evaluation unit has to be observed. It is dependent on the capacity and inductivity of the cable used and is limited by the max. permissible values stated on the ATEX certificate on page 109. If you are using the cable #32024 supplied by BERTHOLD TECHNOLOGIES, then the max. cable length is 1000m.

The EU type verification documents are shown on page 109.

Warning!

Malfunction due to electromagnetic fields in the line between evaluation unit and detector.

Installation of the line in multi-wire cables is permitted, provided the other parallel running wires are only signal lines, not power lines.

If electromagnetic interference is likely to occur in the line, the cable has to be installed separately in a shielded cable. The screen may be put onto the detector only one-sided.

Strong electromagnetic fields in the line are not permitted. The lines have to be installed such that they do not run parallel to HV-power cable or, for example, frequency converter lines.

The 2-wire connection cable between detector and evaluation unit must not exceed 40Ω[2].

[1] The length of thread is the shortest distance between two points that can be connected by a thread.
[2] Feed and return line

8.1 Connecting Evaluation Unit and Detector

The detector is connected via a 2-wire cable (2 x 1 mm²). In a wall housing one has to observe the permitted cable cross-section of the screwed cable gland. At ambient temperatures >70°C the installed cable has to be protected to ensure that the temperature limits of the cable will not be exceeded. When installing the connection cable, make sure that no water can get inside the connection room via the cable. After connection, the connection room has to be locked again carefully and the cable gland has to be sealed well.

The LB 471 limit switch is available in three different versions:

- In a 19" rack
- In a wall housing
- In a cassette with terminal block for any 19" rack.

The respective connection diagram is shown on page 137 in the Appendix.

On the following pages we will explain how to connect different detector types separately and in detail.

8.1.1 Pin Assignment of Terminal Block

The terminal block of the limit switch includes the following connections:

No.	Designation	
2a / 2c	Detector connection depending on the version: - "intrinsically safe" - "not intrinsically safe"	
12a / 12b / 10c	Relay 2: Alarm relay with change-over contacts SPDT (shutter 12a/c: open in case of alarm and in the idle state break contact: 10c/12c) alternatively configurable as max/min	AC: max. 250V, max. 1A, max 200VA DC: max. 300V, max. 1A, max. 60W at resistive load
14a / 14c	Relay 3: warning relay (shutter: open in case of alarm and in the idle state)	
16a / 16c	Relay 1: collective failure message (shutter: open in case of alarm and in the idle state)	
20a / 20c	Digital input 2 Reserve	Enable the digital inputs by short-circuiting the terminals.
22a / 22c	Digital input 3 for **empty calibration** If this input is enabled, an empty calibration is carried out automatically followed by a calibration.	
30a / 30c	Supply: 18 – 30 V DC or 24V AC Power consumption: approx. 4 VA(AC), 4 W(DC)	
32a / 32c	Grounding terminals	

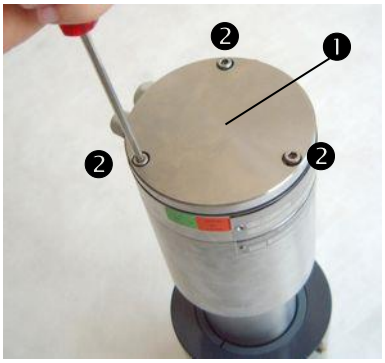
Only in the 7-TE cassette, these contacts are led through directly. In case of the 19" rack and the wall housing, the respectively lead through terminals are used. See connection diagrams in the Appendix on page 137.

8.1.2 Installing NaI Detector or Super-Sens

The connection box for the Super-Sens detector is the same as for a detector with NaI detector with 50/50, 40/35, or 25/25 crystal.

1 Install cable between evaluation unit and detector. For maximum cable length see the technical data on page 105.

2 Unscrew three screws at the detector cover.



❶ Detector cover
❷ Cover screws

Figure 36: NaI detector cover

3 Take off cover.

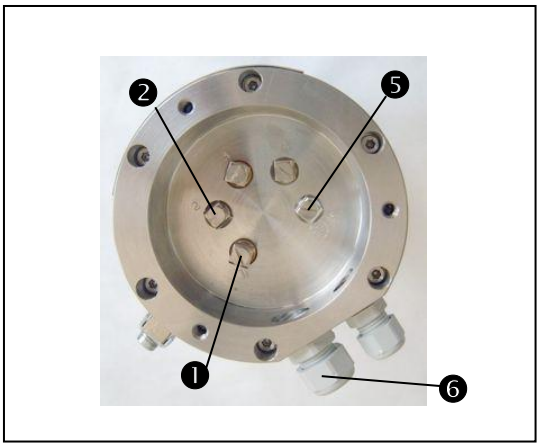
4 Insert line.

Cable bushing (M 16) for cable Ø 8...10 mm. Cable bushing has to face down in order to prevent water from penetrating. For detectors with collimator please keep in mind that the radiation entry window always has to face the source. If necessary, open the collimator at the four frontal screws and adjust the position.

5 If necessary, place screen separately on terminal 5 (⏚). The screen cable must be insulated to avoid a short-circuit with other terminals.

6 Connect line to terminals 1 (+) and 2 (-).

Figure 37: Terminal assignment NaI detector



❶ Terminal 1 (+)
❷ Terminal 2 (-)
❺ Terminal 5 (⏚)
❻ Cable bushing M16

7 Attach cover again and fix it

8 Connect grounding on the outside of the grounding screw at the detector.

9 Place wires on evaluation unit. See connection diagram on page 137.

8.1.3 Installing the GM Detector

1 Install cable between evaluation unit and detector. For maximum cable length see the technical data on page 105.

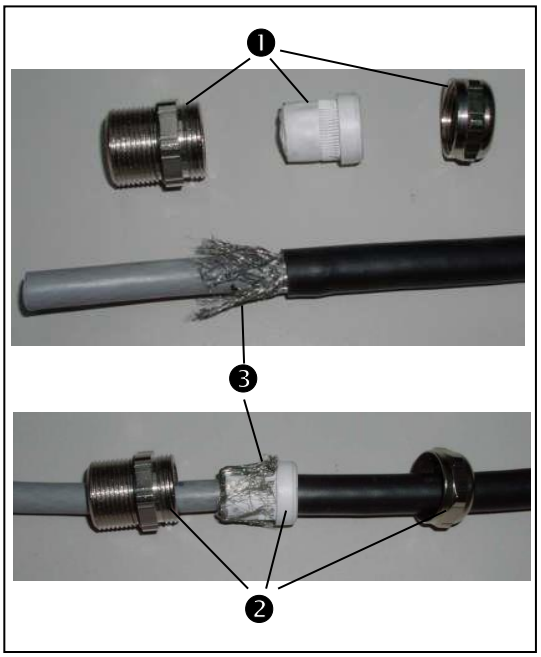
2 Unscrew three screws at the detector cover.

3 Take off cover.

4 Insert line.

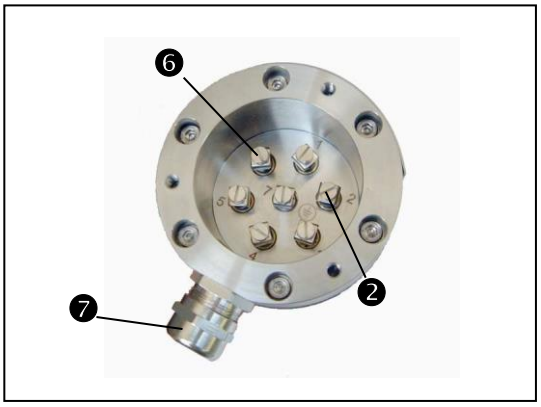
Cable bushing (PG 16) for cable Ø 6 to 8 mm. Cable bushing has to face down in order to prevent water from penetrating.

5 If necessary, place screen separately on the cable bushing.



❶ Screwed cable gland
❷ Install screwed cable gland on line
❸ Screen

6 Connect line to terminals 6 (+) and 2 (-)



❷ Terminal 2 (-)
❻ Terminal 6 (+)
❼ Cable bushing PG 16

Figure 38: Terminal assignment GM detector

7 Attach cover again and fix it.

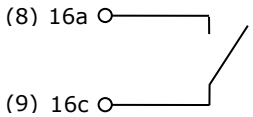
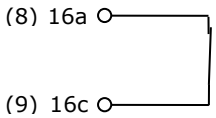
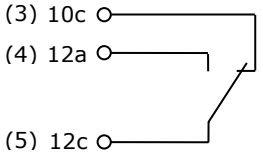
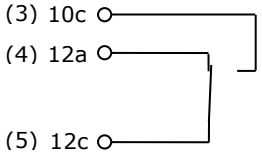
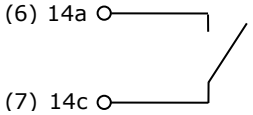
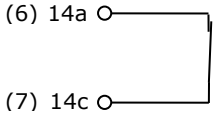
8 Connect grounding on the outside of the grounding screw at the detector.

9 Place wires on evaluation unit. See connection diagram on page 137.

8.2 Digital In-/Outputs

8.2.1 Relays

The status of the measurement is indicated by three relays:

Relay	Alarm or idle state	Normal
Error		
Alarm		
Warning		

Digits in bracket are the connection contacts for the wall housing.

The respective switching state of the relays is also signaled by LED's on the front panel.

8.2.2 Digital Input

The digital input is used to perform an empty calibration from the control station. The following terminals have to be short-circuited with each other to enable external empty calibration:

- 19" rack: „D in –" with „D in +"
- Wall housing: 13 with 14
- Cassette: 22a with 22c

The contacts (20a/c) labeled Reserve are without function.

8.3 Connecting the Evaluation Unit to Power

Danger!

Installation work on the electrical equipment may be carried out only in the idle state.
The components concerned have to be turned off first and have to be secured against restoring power.
The respective VDE and Ex-regulations have to be observed.
In Ex-facilities which are not intrinsically safe voltage may be on the detector line only after the line has been connected to the detector and the connection box has been properly closed.

Warning!

Risk of damage!
Before establishing the connection, check if the line voltage matches the voltage for which the device has been designed.
The supply of the evaluation unit(s) has to be guided via a separate fuse. An easily accessible shut-down has to be foreseen if the power supply unit supplied is not equipped with a power switch.

- In a 19" rack, mains connection is established via the "LINE" terminals on the instrument rear panel.
- Wall housing:
  The terminal clamps are accommodated in the connection box at the bottom of the case. Unscrew cover.
- Cassette
  The terminal clamps are located on the optional terminal block.

Connection diagrams on page 137 in the Appendix.

☑ ***The measurement is ready for operation as soon as the:***
- ***lines have been properly connected***
- ***supply voltage has been turned on***
- ***shielding has been opened***

Note!

Operation and calibration of the evaluation unit is described in the software manual in the second user's guide.

Chapter 9. Maintenance

9.1 Malfunctions

Danger!

Installation work on the electrical equipment may be carried out only in the idle state.

The components concerned have to be turned off first and have to be secured against restoring power.

The respective VDE and Ex-regulations have to be observed.

Malfunction	Cause	Remedy
System does not work or no reading on display	Power supply faulty	Check power supply
	Fuse on power supply unit faulty.	Check fuse, replace it, if necessary
	Fuse on evaluation unit faulty	Check fuse on evaluation unit, replace it, if necessary

9.2 Replacing Fuses

In case of blown fuses you have to investigate the cause first. If you suspect a fault on the board, you have to return if for repair or replace it.

1 Turn evaluation unit off and disconnect it from mains.

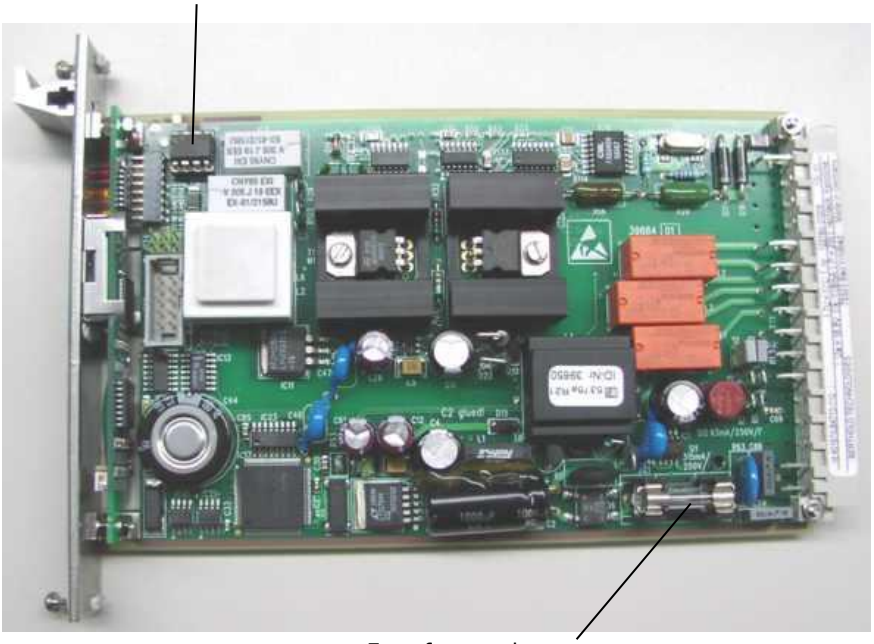
2 Pull evaluation unit out of rack or cassette.

3 Check fuses and replace them, if necessary.

Warning!

Risk of damage!
Use only fuses having the same rating and the same response behavior as the one being replaced.

Figure 39: Board of limit switch evaluation unit



9.3 Replacing the Evaluation Unit

Replacing the EE-Prom

When replacing the evaluation unit, we recommend that you take the plug-in EE-Prom from the old device and insert it into the new one (see Figure 39). All parameters and settings will be retained. The EE-Prom has to be protected against destruction by electro-static charge.

9.4 Repairing the Detector

If you suspect any error in the detector, you may replace the entire detector or individual parts.

- evaluation unit is turned off and disconnected from mains
- radiation exit channel on the shielding containing the source is closed.

9.4.1 Dismantling the NaI Detector

The following parts are available as spare parts for the NaI detector and may be replaced.

Parts to be replaced

- Crystal-multiplier combination
- Crystal
- Multiplier
- Detector electronics complete with base
- Detector case
- Detector cover
- Screwed cable gland

Caution!

Risk of poisoning!
If you touch the coupling ring (see Figure 43) made of lead (only with NaI detector 50/50) there is the risk of poisoning.
Wear protective gloves or wash your hands after installation.

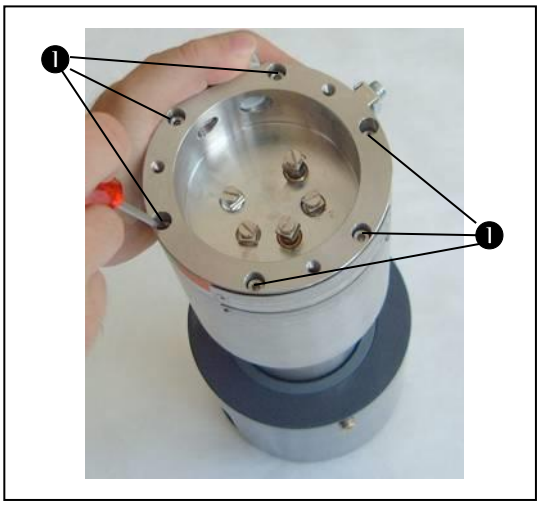
Dismantling the detector electronics

1 Unscrew three screws and take off cover (see also page 74.)

2 Disconnect cable.

3 Open screws of clamps and dismantle detector.

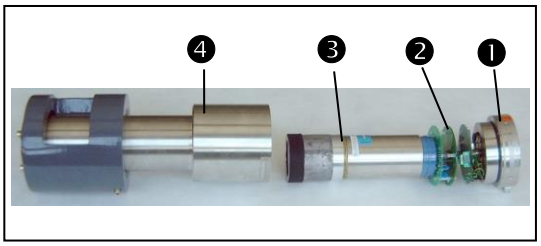
4 Unscrew six screws (Allen screw, size 3).



❶ Allen screws size 3

Figure 40: Base screws NaI detector

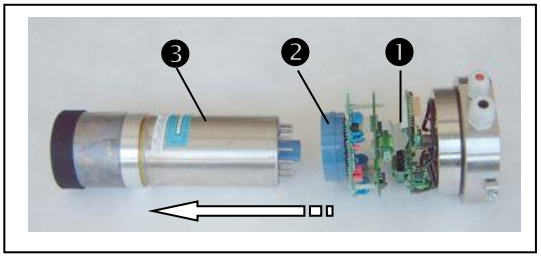
5 Carefully pull electronics base ❶ with electronics ❷ and crystal-multiplier combination ❸ out of the case ❹.
Make sure that the rubber disc at the bottom of the case does not fall out, but remains flat at the bottom of the case.



❶ Electronics base
❷ Electronics
❸ Crystal-multiplier combination
❹ Case

Figure 41: Dismantled NaI detector

6 Pull off crystal-multiplier combination ❸ from blue base ❷.



❶ Electronics
❷ Blue base
❸ Multiplier-crystal combination

Figure 42: Crystal-multiplier combination and electronics

Dismantling the crystal-multiplier combination

7 Unscrew coupling ring ❷ from the Mu-metal shielding ❶.

Warning!

Multiplier may get damaged.
During servicing, the multiplier must not be exposed to bright light.

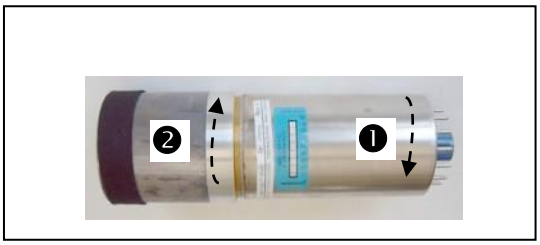


Figure 43: Multiplier-crystal combination

❶ Mu-metal shielding
❷ Coupling ring

8 Twist crystal ❸ sideways (do not pull) to detach it from the multiplier ❷.
Crystal or multiplier can now be replaced separately.

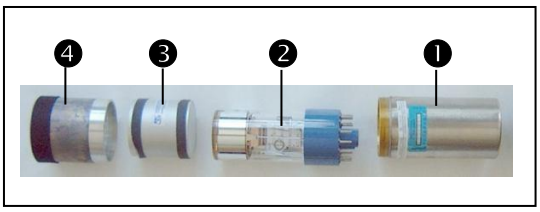


Figure 44: Dismantled crystal-multiplier combination

❶ Mu-metal shielding
❷ Multiplier
❸ Crystal
❹ Coupling ring

9.4.2 Checking the Crystal-Multiplier Combination

Often, faulty parts can easily be detected through visual inspection of crystal and multiplier.

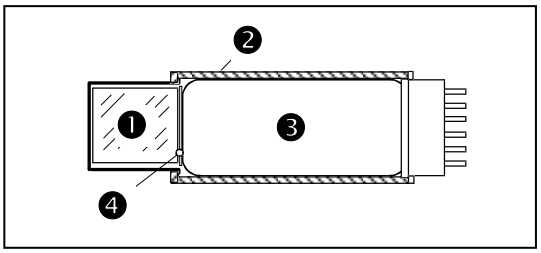


Figure 45: Multiplier-crystal combination

❶ Crystal
❷ Magnetic shielding (Mu-metal)
❸ Photomultiplier
❹ Optical connection

Crystal is OK if	Crystal has to be replaced if
the crystal appears to be crystal-clear inside, does not have any cracks nor milky spots and has a slightly greenish coloring.	the crystal shows a clear yellowish to brownish coloring.

Multiplier is OK if	Multiplier has to be replaced if
the vapor deposited layer in the multiplier window (photo cathode) has a slight brownish or tinted glass like coloring.	the vapor deposited layer is no longer available or spotted (cathode destroyed e.g. due to overheating, breakage of glass or incidence of light).

If no errors are visible, you can check the function of the crystal-multiplier combination by performing a plateau measurement.

9.4.3 Assembly of Crystal-Multiplier Combination

Warning!

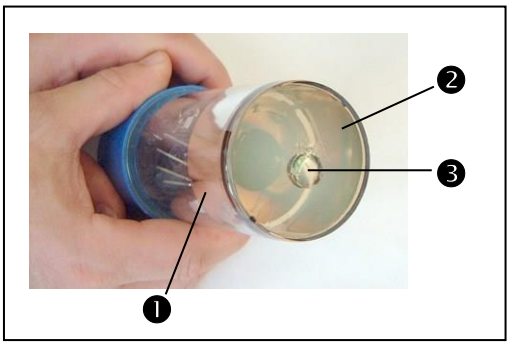
Multiplier may get damaged!
During servicing, the multiplier must not be exposed to bright light.
Do not bolt together Mu-metal and coupling ring too hard, as this may destroy the multiplier.
Tighten parts only until you encounter a slight resistance.

Assembling the crystal-multiplier combination

1 Before assembling the crystal-multiplier combination, clean the optical contact area ❷ with a soft cloth to remove remaining silicon oil residues. The same is true for the crystal.

2 Apply a drop of pure silicon oil ❸ onto the optical contact area ❷ of the multiplier❶.

Figure 46: (Photo) Multiplier



❶ Multiplier
❷ Optical contact area
❷ Drop of silicon oil

3 Attach crystal.
Gently push the crystal with a slightly rubbing motion against the multiplier to distribute the drop of silicon oil and to establish a good optical connection.

4 Push the Mu metal screen over the multiplier and fix the combination again to the coupling ring with screws.

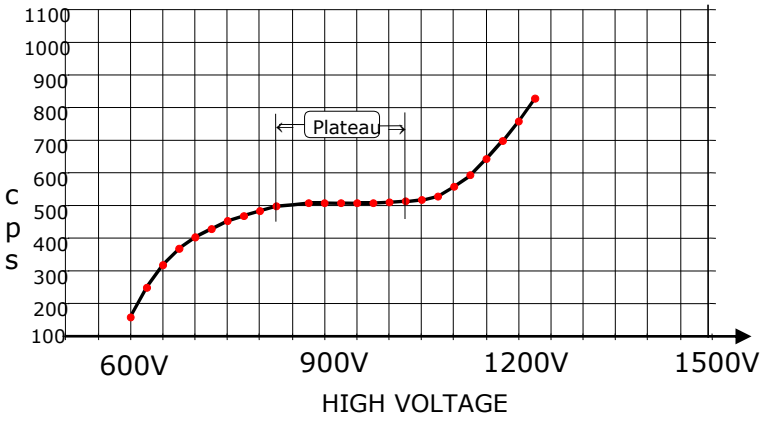
9.4.4 Plateau Measurement

Errors in the crystal-multiplier combination are indicated by a plateau that is either too short or too steep. A plateau measurement is used to check the function of the detector. The result of a plateau measurement is presented in a table or a graph.

Note!

The radiation conditions have to be constant as long as the plateau measurement is running! This means that the level must remain below the limit level during measurement. The radiation channel of the shielding must be open in order to utilize the maximum radiation field for the measurement.

Figure 47: Typical plateau curve



A plateau is the flat section in the characteristic curve and is typically approx. 200 V long.
The crystal-multiplier combination or the complete detector has to be replaced if:

- the plateau is shorter than 50 V
- the count rate changes by more than 5% per 100 V high voltage.

The plateau measurement can be started via a software function. See software manual.

9.4.5 Dismantling the GM Detector

The following parts of the GM detector can be replaced:

- Counter tube
- detector electronics

Dismantling the GM detector

1 Take off cover on connection box and disconnect cables as described on page 75.

2 Unscrew 6 Allen screws (size 4).

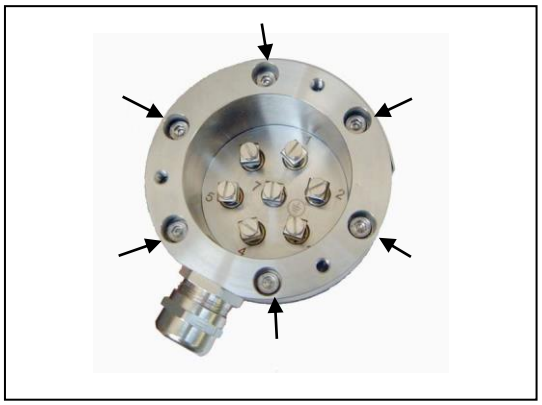


Figure 48: Detector connection box

3 Carefully pull electronic base ❶ with electronics ❷ and counter tube ❸ out of the detector case ❹.

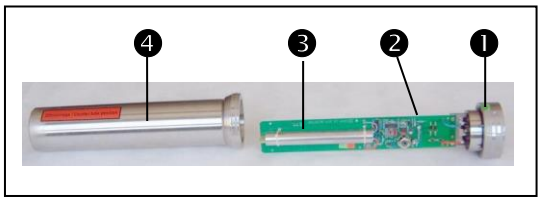


Figure 49: GM detector dismantled

❶ Electronics base
❷ Electronics
❸ Counter tube
❹ Detector case

4 Now you can do a visual inspection of electronics and counter tube. Both parts can be replaced separately, if necessary. The counter tube is fixed to the board by two cable ties and a silicon sealing compound.

9.5 Replacing the Source

A source has to be replaced if the statistical fluctuations reach an unacceptable level in the course of time and compensation by increasing the time constant is not permitted any more, e.g. for control engineering reasons.
If a source has to be replaced, the source number of the previously used source has to be stated on the re-order. The source number is stated on the type label of the shielding and on the seal certificate of the source.

Caution!

Radioactivity!
Only competent and licensed persons, in compliance with the official regulations, may replace radioactive sources. Coordination with the radiological safety officer is required.
All work required has to be prepared such that it can be carried out quickly, so that exposure to the unshielded source is kept to a minimum. Since these persons have to work with an unshielded source for a short time, they have to carry a pocket dosimeter indicating the level of radiation in order to document the actual radiation exposure during work.
The user has to be familiar with the radiation protection guidelines in Chapter 11.

Preparation

Point sources are mounted on source holders which are then screwed into the shielding, positioning the source in the center of the shielding. Prerequisite for this work is that the personnel are familiar with the exact shielding construction; therefore, the relevant drawings have to be available.
You should have the following tools handy:

- Allan keys in the required sizes: 10, 12 and 13
- 2 pairs of pliers to take grasp source and source holder.

If sufficient space is available, the source can be replaced directly in the shielding installed on the container. Prepare an auxiliary shielding (shielding container, lead bricks, concrete stones, etc.) at a suitable place and deposit the old and the new source in its transport shielding there for a short period of time.

Caution!

Radioactivity!

Do not touch the source with your fingers to avoid a high partial body dose.

9.5.1 Replacing the Source

1 Open padlock ❼ on the shielding.

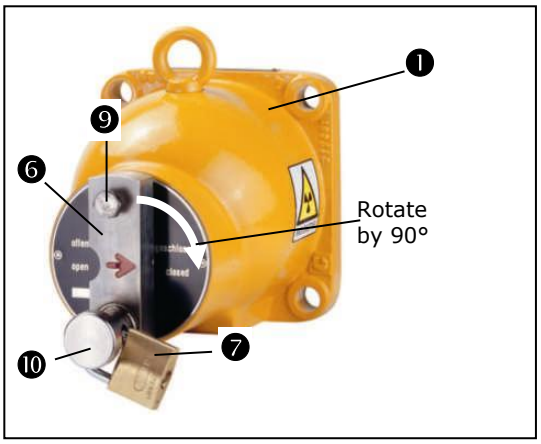


Figure 50: Point source shielding

❶ Shielding
❻ Lever
❼ Padlock
❾ Safety screw
❿ Knob

2 If necessary, unscrew safety screw ❾ from lever.

3 Pull off knob ❿ and rotate lever ❻ to the right by 90 degrees to the center position between "OPEN" and "CLOSED". The Allen screw head of the source holder is now visible. (With some versions the shutter plate has to be removed to be able to unscrew the source holder.)

4 Using a socket wrench (size 12), unscrew the source holder ❺ together with the source ❹.

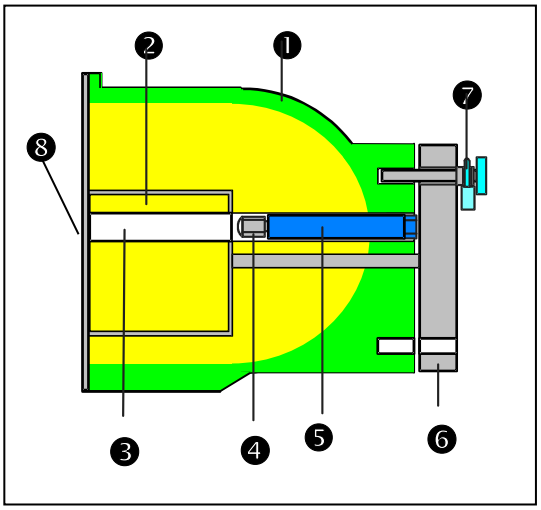


Figure 51: Point source shielding - sectional drawing

❶ Shielding
❷ Locking core
❸ Radiation channel
❹ Point sources
❺ Source holder
❻ Lever
❼ Padlock
❽ Cover plate

5 Grasp the source holder at the rear threaded part and pull it out. Keep source holder with the source far away from your body and put it down behind the shielding or an auxiliary shielding.

6 Grasp source holder with a socket wrench and unscrew the source from the source holder with a second socket wrench (size 10). For this work, you may use the shielding housing as an auxiliary shielding between source and body.

7 Grasp source with a pair of pliers and place it immediately into the auxiliary shielding.

8 If required, clean and grease the thread on the source holder and on the shielding.

9 Using the pair of pliers, take the new source out of the transport shielding and fix it with screw on the source holder together with the snap ring.

Note!

Make sure that no mix-up with other sources occurs.

10 Place source holder with source again into the shielding and fix it with the socket wrench.

11 Check the proper "OPEN/CLOSED" function.

12 Place the old source into the transport shielding and close it carefully.

13 After replacement of a source, attach the new source number on the shielding or replace the type label.

14 Calibrate system new. See software manual.

9.6 Customer's Service

If you wish to get support by our technical customer's service, you should have the following data available:

- Device type or "LB" number: e.g. LB 471
- Error description (symptoms, appearance, operating state before/after)
- Information on application
- Product being measured
- Installation situation
- Measuring system, e.g.: level, point sources with point detector
- Parameter listing
- Source number and / or BERTHOLD commission number
- Contact person and call-back number

Note!

BERTHOLD TECHNOLOGIES phone numbers:

Hotline:	+49 (0)7081 177-111
Switchboard:	+49 (0)7081 177-0
Fax:	+49 (0)7081 177-339
E-Mail:	Service@BertholdTech.com

9.6.1 Sending in the Electronics

If parts or complete devices have to be send in for repair, please include the following information:

- Device type or "LB" number: e.g. LB 471
- Information on error appearance
- Delivery address
- Billing address
- Your order number (if required)
- Preferred mode of shipment (if necessary)
- Customs value (for cross-border shipment)

Note!

Address:
BERTHOLD TECHNOLOGIES GMBH & CO. KG
Service Department
Calmbacher Str. 22
75323 Bad Wildbad

9.6.2 Sending in Source and Shielding

If source and shielding have to be send in for repair, please contact the transport manager of BERTHOLD TECHNOLOGIES:

Note!

Transport Manager
Phone: +49 (0)7081 177 219.

Information required by the transport manager:

- Name, address, phone number of the radiological safety officer
- Number of sources
- Source number(s)
- Isotope, activity
- Date of last wipe test
- Condition of source(s) and shielding(s)
- Information on the type of shielding in which the source will be transported (if available)
- Proforma invoice for source and shielding in which the source is to be shipped back (only for custom's purposes and only for cross-border transport).

The shipment is then carried out, as needed, using a forwarding agency that is specially trained for source transports, or via air freight. Details have to be coordinated with our transport manager.

Chapter 10. Servicing the Shielding

10.1 Checking Shielding and Source

For safety reasons it has to be possible to shut off the active beam any time. Depending on the operating conditions, the performance test has to be repeated in adequate intervals[3], at the latest every six months. In case of malfunction or sluggishness of the rotary shutter the radiological safety officer and the manufacturer have to be notified immediately.

10.1.1 Testing the Locking Mechanism

This test ensures that the locking mechanism functions correctly, the shutter is closed and the source completely shielded if the device handle of cylinder indicates "Closed". This is very important to avoid radiation exposure if for whatever reason (e.g. due to a broken shaft in a point source shielding) "Closed" is indicated although the shutter is still open. The radiation protection agency stipulates that this test be performed in intervals of no more than 6 months. Maybe you will be called upon to present the corresponding documentation on tests carried out in the past and also a time schedule for upcoming tests.

- Notify the process control station that the measuring point is out of operation during the test.
- Read off current count rate on the evaluation unit and write it down.
- Move shutter to the position "Closed" and watch if the displayed count rate goes back to zero or a very low background level (write down data).
- Repeat this process 5 times and write down the results every time.
- Make sure that the shutter is freely movable.
- Notify the radiological safety officer about the result.
- In case of errors or doubt – please contact the service department of BERTHOLD TECHNOLOGIES.
- Document test including date, device model and serial number, test results, name of tester. The regulatory authority may request a copy of the documentation.

[3] In the USA: every six months

10.2 Leak Test

Depending on the regulatory authority of the country in which the source is being used, recurrent leak tests, so-called wipe tests, have to be carried out.

10.2.1 Leak Test Documentation

- Inventory listings of the source to be tested with information on the leak tests carried out in the past.
- Source certificate stating the following information:

  Nuclide, activity, procurement date, physical-chemical form

  Description of encasement and type of sealing

  Resistance to mechanical and thermal effects or classification of the source construction type

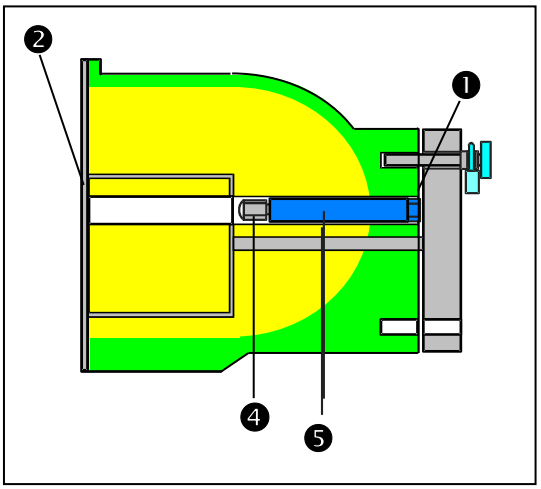
  Information on location, application purpose and the customary maximum mechanical and thermal stress.

Is the source is installed in a device, a drawing has to be enclosed which clearly states the position of the source and all parts serving as protection against external influences. Proposals for the best test method should be provided, e.g. through information on alternative test areas and, if necessary, the required manipulations, i.e. how the test can be carried out without any adverse effect on the operatability of the facility or device.
Certificate on acceptance inspection by the manufacturer.

10.2.2 Performing a Wipe Test

The wipe test is carried out using cotton swabs soaked in solvent. Using the cotton swabs, wipe off the alternative test areas. Any possible contamination is taken up by the cotton swabs. The cotton swabs are then locked air-tight into a repository (plastic bag or plastic container) and checked for contamination.

1 Rotate lever to horizontal position



❶ Alternative test area
❷ Alternative test area, if accessible
❹ Point sources
❺ Source holder

Figure 52: Alternative test areas on shielding

The alternative test area is the head or the visible edge of the source holder, respectively.
If the cover is also accessible, then you have to wipe there as well.

Chapter 11. Radiation Protection

11.1 Basics and Directives

In order to prevent adverse health effects caused by working with the radioactive substances required for our purposes, limits for the maximum permissible radiation exposure of operating personnel have been agreed upon on an international level. The following information refers to the German Protection Ordinance of August 2001.

Appropriate measures in designing the shieldings and arranging the measuring system at the measuring point will ensure that the radiation exposure of the personnel will remain below the maximum permissible value of 1 mSv (100 mrem) per year.

To ensure proper handling and the observance of statutory requirements, the company has to appoint a radiological safety officer who is responsible for all radiation protection issues in connection with the measuring system. The radiological safety officer will monitor work with the radiometric measuring system and, if necessary, formalize the safeguards and any special precautions applicable to a given establishment in formal procedural instructions, which in special cases may serve as a basis for radiation protection guidelines. These may stipulate that access to the container shall only be permitted after the active beam is shielded. Radiation protection areas outside the shielding must be – if they are accessible – marked and guarded. These instructions should also include checks of the shutter device of the shielding and provisions for serious operational trouble - such as fire or explosion. Any special event has to be reported to the radiological safety officer immediately. He or she will then investigate any damage and immediately take suitable precautions if he or she 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 Ordinance will be observed. In particular, his or her duties include instructing the staff on the proper handling of radioactive substances.

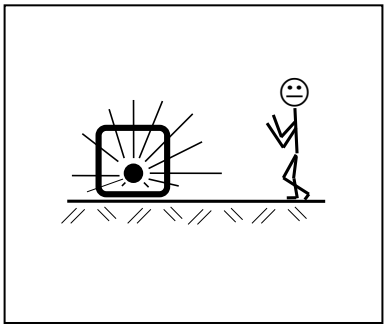
Radioactive sources that are no longer in use or have reached the end of their service life must be returned to the national radioactive waste disposal center or to the manufacturer.

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 of the radiation dose absorbed by a body is determined by three factors. On the basis of these factors, certain fundamental radiation protection rules can be derived:

Distance

Distance



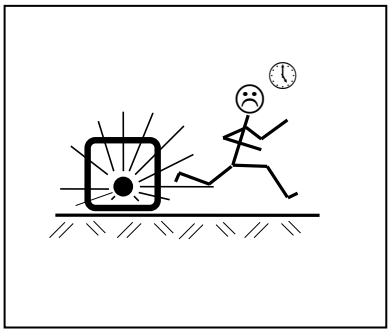
This means the distance between the radioactive source and the human body. The radiation intensity (dose rate) decreases – like light – in proportion to the square of the distance: doubling the distance to the source reduces the dose rate to one quarter.

Conclusion:

If work is to be performed in the vicinity of facilities containing radioactive substances, maximum distance has to be maintained. This is especially true for persons who are not directly involved in this work.

Time

Time



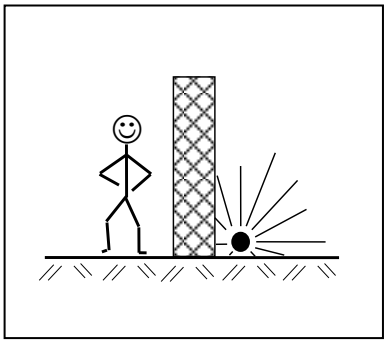
The total time a person stays in the vicinity of a radiometric measuring system and the body is exposed to radiation. The effect is cumulative and increases therefore with the duration of the radiation exposure.

Conclusion:

Any work in the vicinity of radiometric measuring systems has to be prepared carefully and organized such that it can be carried out in the shortest time possible. Having the proper tools and aids handy is of particular importance.

Shielding

Shielding



The material surrounding the source provides the shielding effect. 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 is used for shielding purposes. The shielding supplier usually calculates suitable dimensions.

Conclusion:

Before mounting or dismounting the shielding, make sure that the radiation exit channel is **locked in the closed position.**

You may not remove the source from the shielding!

11.2 Radiation Dose Calculations

When preparing work on radiometric measuring systems, it is important to calculate the radiation exposure to be expected in advance, for this has consequences on the required safety precautions. The expected radiation exposure can be calculated quite easily and with sufficient accuracy, provided you know the isotope and the activity of the source used. You can take this information from the source documentation, or from the type label on the shielding.

11.3 Calculation with a given Dose Rate

In general, the shieldings of measuring systems are designed such that the limit of the controlled area runs in a given distance (in most case less than one meter) around the shielding. A simplified calculation of the radiation exposure during assembly of the shielding is possible with sufficient accuracy by using the dose rate value stated on the type label. This value states the dose rate measured in 1 m distance from the shielding. The radiation exposure D can then be calculated using the following formula:

D = DR * t * 4

D *accumulated dose during assembly (µSv)*

DR *dose rate stated on the type label of the shielding (µSv/h)*

t *time needed for assembly (h)*

4 *safety factor*

In case of exact preparation, one may expect a working time of less than 20 minutes for carrying out work such as assembling the shielding or operating the shutter.

Calculation example:

DR: 3 µSv/h

t: *20 min (1/3 h)*

D = 3 µSv/h * 1/3 h * 4 = 4 µSv

11.4 Activity-based Calculation

The exact calculation of the radiation exposure to be expected for a **shielded** source is carried out using the following equation:

$$\textbf{Dose} \quad D = \frac{A * k * t}{r^2 * s}$$

A *source activity*

k *specific radiation constant*

r *distance between measuring point and source*

T *duration of stay*

s *attenuation factor of shielding*
see technical data on page 108.

When working with an **unshielded** source; s is set equal to 1 for calculation of the dose rate.

Gamma ray constant

Nuclide	k	Dimensions
Co-60	0.35	$\frac{\mu Sv*m^2}{h*MBq}$
Cs-137	0.09	

Calculation example:

The dose in a distance of 50 cm of a Co-60-source with a activity of 350 MBq and a time span of 30 min. has to be calculated. The source is installed in a shielding with a shielding factor of 30:

$$D = \frac{350\text{Mbq} * 0.35\mu\text{Sv} * \text{m}^2 * 0.5\text{h}}{(0.5\text{m})^2 * \text{h} * \text{Mbq} * 30} = 8.2\ \mu\text{Sv}$$

Chapter 12. Disposal

Caution!

Radioactive sources that are no longer in use or have reached the end of their service life must be returned to the national radioactive waste disposal center or to the manufacturer. If you have any questions or if you are unsure what to do about disposal, please contact
BERTHOLD TECHNOLOGIES.
Address see page 94.

Caution!

Laws, regulations and requirements governing the disposal of substances, equipment and electrical appliances that are harmful to health and to the environment, as well as special regulations for operation have to be complied with.
It has to be ensured that replaced parts (spare parts) and waste produced in the course of repair, maintenance and servicing work have to be examined for hazardous waste and the respective parts have to be disposed off accordingly.

The operating company has to take provisions to avoid waste and to ensure its ecologically compatible recycling and disposal. Insofar as this is required in order to comply with the requirements according to §§ 4 and 5 of the closed loop recycling and waste management law, waste has to be kept and treated separately for recycling.
The system itself and its individual components have a long service life. Recyclable and ecologically compatible raw materials were primarily used for construction. At the end of its service life it is suitable for proper recycling and ecological disposal.
All components of the system have to be disposed separately and, depending on the material, recycled:
Components which have been polluted by production equipment have to be thoroughly cleaned prior to further processing.

Chapter 13. Technical Data

13.1 Evaluation Unit

Design	- In 19” rack 3HE, 4TE, max. 19 modules at 24V AC/DC supply max. 18 modules at 110V/230V AC supply Protection type IP 20 - As cassette 3HE 7TE for any 19" rack - In wall housing: for 3 modules + power supply unit
Auxiliary energy (optional) with mains switch	24V filter module 8TE for 19" & wall housing 18 – 30 V DC or 24V AC +10% -15%, 47 - 66Hz, Fuse: T1.0A in wall housing T4.0A in 19" rack
	Transformer module for 19" rack 85W, 12TE 115V/230V AC +10%/-15%, 47 - 66Hz can be switched over Fuses: T1.0A at 230V T2.0A at 115V
	Transformer module for wall housing 18W, 8TE 115V/230V AC +10%/-15%, 47 - 66Hz can be switched over Fuse: T160mA for 230V T315mA for 115V
Power consumption	For each LB 4710 module: approx. 4 VA(AC), 4 W(DC) Fuse: T315mA/250V.
Operating temperature	-30... +60°C (243 ... 333 K)
Weight	approx. 2 kg
Detector connection	intrinsically safe [EEx ib] IIC (option)
Cable for detector connection	e.g. LiYCY 2 x 1.0mm² max. cable resistance 40Ω* Observe L + C with intrinsically safe installation. (With Berthold cable #32024 max. 1000m)

* for feed and return line

Digital outputs	1 relay output for max./min. (changer) 1 relay output for common failure message 1 relay output for warning message AC: max. 250V, max. 1A, max. 200VA DC: max. 300V, max. 1A, max. 60 W at resistive load
Time constant	0,5-999
Decay compensation	automatic: for Cs-137 and Co-60

13.2 Detectors

GM detector

SZ5-GHS-3171-1/2 GHS-3172-1/2	Detector with one or two Geiger-Müller-counter tube(s)
Protection type	IP 65
ATEX protection types for SZ5-GHS-3171-1/2	II 2G EEx ib d IIC T6 II 2G EEx de IIC T6
CSA (Option)	Class I Division 2 Group B,C,D Class II Division 2 Group E,F,G
Case	Stainless steel case 4.5 kg at GHS 3171 or 6 kg at SZ5 GHS 3171
Operating temperature	-40 ... +50°C Water cooling optionally available
Storage temperature	-40 ... +80°C
Cable bushing	PG16 for cable diameter: 5 ... 8 mm

NaI detector

LB 4401.. with EEx LB 5401.. without EEx	Scintillation counter with NaI (TI) crystal 25/25, 40/35, 50/50 Temperature stability: ≤0,1%
Protection type:	IP 65
ATEX protection types	II 2G EEx ib d IIC T6 II 2G EEx de IIC T6 II 2D IP 65 T 80 °C
FM protection type (Option)	Class I Division 1 Group A,B,C,D Class II Division 1 Group E,F,G Temp. Class T6 (85 °C)
Case	Stainless steel 6 kg or 18 kg with collimator
Operating temperature	-40 ... +60 °C Water cooling optionally available

Storage temperature	-40 ... +70 °C
Cable bushing	M16 for cable diameter: 5 ... 8 mm

NaI detector LB 4700

See user manual LB 4700, ID no. 56926BA1
(English: ID no. 56926BA2)

Super-Sens detector

LB 4430.. with EEx LB 5430.. without EEx	Scintillation counter with plastic scintillator 150/150 Temperature stability: ≤0,5%
ATEX protection types	II 2G EEx ib d IIC T6 II 2G EEx de IIC T6
Protection type	IP 65
Dose rate for 1000 $I*s^{-1}$ Cs-137 Co-60	 0.14µSv 0.20µSv
FM protection type (Option)	Class I Division 1 Group A,B,C,D Class II Division 1 Group E,F,G Temp. Class T6 (85° C)
Case	Stainless steel
Weight	54 kg Ex variant 52 kg not-Ex variant
Operating temperature	-20 ... +50 °C Detectors also available with optional integrated water cooling.
Storage temperature	-40 ... +55 °C
Cable bushing	M16 for cable diameter: 5 ... 8 mm
Installation flange	ND 200, NP6, DIN 2527

13.3 Shieldings

	LB 7440 F LB 7440 EF	LB 7442 F LB 7442 EF	LB 7444
Approx. shielding thickness (mm lead)	67	97	132
Approx. attenuation factor for Cs-137 for Co-60	 700 30	 16000 180	 650000 1800
Dose rate on the surface of the shielding (µSv/h) with Cs-137 (A in MBq) with Co-60 (A in MBq)	 $1.6 * 10^{-2} * A$ 1.6 * A	 $4.3 * 10^{-4} * A$ 0.14 * A	 $6.5 * 10^{-6} * A$ $8.1 * 10^{-3} * A$
Dose rate in 1m distance from the surface of the shielding (µSv/h) with Cs-137 (A in MBq) with Co-60 (A in MBq)	 $1.4 * 10^{-4} * A$ $1.1 * 10^{-2} * A$	 $5.4 * 10^{-6} * A$ $1.7 * 10^{-3} * A$	 $1.1 * 10^{-7} * A$ $1.5 * 10^{-4} * A$
Radius of controlled area, cm with Cs-137 (A in MBq) with Co-60 (A in MBq)	 0.74 * A1/2 6.5 * A1/2	 0.15 * A1/2 2.6* A1/2	 0.07 * A1/2 0.82* A1/2
Dimensions (W x H x D), cm with pneumatic locking drive	18 * 20 * 20 18 * 20 * 39	24 * 27 * 27 24 * 27 * 46	30 * 39 * 38 30 * 39 * 57
Operating temperature	max. 200 °C	max. 200 °C	max. 200 °C
Weight	31 kg	81 kg	170 kg

13.4 Pneumatic Locking Drive

Compressed air:	
Min. Max. Connection	4 bar 7 bar G 1/8
Air quality	clean, oil-free
Operating temperature	-20 ... +80 °C
Signaling OPEN/CLOSED Option I Option II Option III	 IP 65, 2 contact, 48 V DC, 1A 2 contact, max. 250 V AC, 1A, EEx e II T6 2 proximity switches, intrinsically safe feed required

Chapter 14. Certificates

14.1 ATEX Certificate for Evaluation Unit LB 4710-XXX

EXAM
BBG Prüf- und Zertifizier GmbH

(1) **EG-Baumusterprüfbescheinigung**

(2) **- Richtlinie 94/9/EG -**
Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen

(3) **BVS 03 ATEX E 219 X**

(4) **Gerät:** **Mini Switch Typ LB4710-*****

(5) **Hersteller:** **Berthold Technologies GmbH & Co. KG**

(6) **Anschrift:** **D 75323 Bad Wildbad**

(7) Die Bauart dieses Gerätes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

(8) Die Zertifizierungsstelle der EXAM BBG Prüf- und Zertifizier GmbH, benannte Stelle Nr. 0158 gemäß Artikel 9 der Richtlinie 94/9/EG des Europäischen Parlaments und des Rates vom 23. März 1994, bescheinigt, dass das Gerät die grundlegenden Sicherheits- und Gesundheitsanforderungen für die Konzeption und den Bau von Geräten und Schutzsystemen zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie erfüllt.
Die Ergebnisse der Prüfung sind in dem Prüfprotokoll BVS PP 03.2135 EG niedergelegt.

(9) Die grundlegenden Sicherheits- und Gesundheitsanforderungen werden erfüllt durch Übereinstimmung mit

EN 50014:1997 + A1 – A2 Allgemeine Bestimmungen
EN 50020:2002 Eigensicherheit 'i'

(10) Falls das Zeichen „X" hinter der Bescheinigungsnummer steht, wird in der Anlage zu dieser Bescheinigung auf besondere Bedingungen für die sichere Anwendung des Gerätes hingewiesen.

(11) Diese EG-Baumusterprüfbescheinigung bezieht sich nur auf die Konzeption und die Baumusterprüfung des beschriebenen Gerätes in Übereinstimmung mit der Richtlinie 94/9/EG.
Für Herstellung und in Verkehr bringen des Gerätes sind weitere Anforderungen der Richtlinie zu erfüllen, die nicht durch diese Bescheinigung abgedeckt sind.

(12) Die Kennzeichnung des Gerätes muss die folgenden Angaben enthalten:

II (2)GD [EEx ib] IIC und
I (M2) [EEx ib] I

EXAM BBG Prüf- und Zertifizier GmbH
Bochum, den 16.07.2003

Zertifizierungsstelle Fachbereich

Seite 1 von 3 zu BVS 03 ATEX E 219 X
Dieses Zertifikat darf nur unverändert weiterverbreitet werden.
Dinnendahlstrasse 9 44809 Bochum Telefon-Phone 0201/172-3947 Telefax-Fax 0201/172-3948
(bis 31.05.2003: Deutsche Montan Technologie GmbH Am Technologiepark 1 45307 Essen)

EXAM
BBG Prüf- und Zertifizier GmbH

(13) Anlage zur

(14) # EG-Baumusterprüfbescheinigung

BVS 03 ATEX E 219 X

(15) 15.1 Gegenstand und Typ

Mini Switch Typ LB 4710-***

Anstelle der *** werden Ziffern eingefügt, die unterschiedliche Ausführungen kennzeichnen.

15.2 Beschreibung

Der Mini Switch, der außerhalb des explosionsgefährdeten Bereiches errichtet wird, dient zur Versorgung von Geräten, die im explosionsgefährdeten Bereich errichtet sind, sowie zur Auswertung von Signalen.

15.3 Kenngrößen

15.3.1 Versorgungsstromkreis (Kontakte –ST1-30a, ST130c und ST1-32a)

Spannung		DC	30	V
		AC	24	V
max. Spannung	Um		30	V

15.3.2 nichteigensichere Relaiskontakte
(Kontakte ST1-12a und ST1-12c, ST1-14a und ST1-14c, ST1-16a und ST1-16c)

Schaltspannung		250	V
Schaltstromstärke		1	A

15.3.3 nichteigensichere Digital-Stromkreise
(Kontakte ST1-10a, ST1-18a, ST1-20a, ST1-20c, ST1-22a und ST1-22c)

Nennspannung		DC	24	V
max. Spannung	Um		30	V

15.3.4 eigensicherer Ausgangsstromkreis (Kontakte ST1-2a und ST1-2c)

15.3.4.1 Typ LB4710-050 und LB4710-060

Spannung	Uo	DC	15,8	V
Stromstärke	Io		83	mA
Leistung	Po		1,3	W
Innenwiderstand			112,5	Ω

trapezförmige Ausgangskennlinie
max. äußere Kapazität und Induktivität gemäß folgender Tabelle: :

		IIC	IIB	I
max. äußere Kapazität	Co	470 nF	2,5 µF	11 µF
max. äußere Induktivität	Lo	1 mH	10 mH	20 mH

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15.3.4.2 Typ LB 4710-110 und 4710-120

		IIB	I
Spannung	Uo	16,8 V	16,8 V
Stromstärke	Io	118 mA	118 mA
Leistung	Po	2 W	2 W
max. äußere Kapazität	Co	2 µF	9 µF
max. äußere Induktivität	Lo	8 mH	20 mH

15.3.4.3 Typ LB 4710-150 und 4710-160

		IIC	I
Spannung	Uo	16,8 V	16,8 V
Stromstärke	Io	81 mA	81 mA
Leistung	Po	1,36 W	1,36 W
max. äußere Kapazität	Co	350 nF	9 µF
max. äußere Induktivität	Lo	1 mH	30 mH

15.3.4.4 Umgebungstemperaturbereich Ta -20 °C bis +70 °C

(16) Prüfprotokoll
BVS PP 03.2135 EG, Stand 16.07.2003

(17) Besondere Bedingungen für die sichere Anwendung

17.1 Der Mini Switch muss außerhalb des explosionsgefährdeten Bereiches errichtet werden.

17.2 Die Montage des Mini Switch hat so zu erfolgen, dass die Luftstrecken von blanken Teilen eigensicherer Stromkreise zu metallischen Gehäuseteilen mind. 2 mm und zu blanken Teilen nichteigensicherer Stromkreise mind. 6 mm und dass die Kriechstrecken von blanken Teilen eigensicherer Stromkreise zu blanken Teilen nichteigensicherer Stromkreise mind. 6 mm betragen.

17.3 Anschlussteile für die äußeren eigensicheren Stromkreise sind von Anschlussteilen nichteigensicherer Stromkreise entsprechend Abs. 6.3.1 von EN 50020:2002 zu trennen.

17.4 Der Mini Switch darf an Betriebsmittel angeschlossen werden, die in staubexplosionsgefährdeten Bereichen errichtet sind. Es ist jedoch sicherzustellen, dass die Geräte die Anforderungen für Kategorie 2D erfüllen und entsprechend zertifiziert sind.

EXAM
BBG Prüf- und Zertifizier GmbH

(1) # EG-Baumusterprüfbescheinigung

(2) **- Richtlinie 94/9/EG -**
Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen

(3) ## BVS 04 ATEX E 129 X

(4) **Gerät:** **Mini Switch Wandgehäuse/Baugruppenträger/Kassette Typ LB471**

(5) **Hersteller:** **Berthold Technologies GmbH & Co.KG**

(6) **Anschrift:** **D - 75323 Bad Wildbad**

(7) Die Bauart dieses Gerätes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

(8) Die Zertifizierungsstelle der EXAM BBG Prüf- und Zertifizier GmbH, benannte Stelle Nr. 0158 gemäß Artikel 9 der Richtlinie 94/9/EG des Europäischen Parlaments und des Rates vom 23. März 1994, bescheinigt, dass das Gerät die grundlegenden Sicherheits- und Gesundheitsanforderungen für die Konzeption und den Bau von Geräten und Schutzsystemen zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie erfüllt.
Die Ergebnisse der Prüfung sind in dem Prüfprotokoll BVS PP 04.2082 EG niedergelegt.

(9) Die grundlegenden Sicherheits- und Gesundheitsanforderungen werden erfüllt durch Übereinstimmung mit
EN 50014:1997 + A1 – A2 Allgemeine Bestimmungen
EN 50020:2002 Eigensicherheit 'i'

(10) Falls das Zeichen „X" hinter der Bescheinigungsnummer steht, wird in der Anlage zu dieser Bescheinigung auf besondere Bedingungen für die sichere Anwendung des Gerätes hingewiesen.

(11) Diese EG-Baumusterprüfbescheinigung bezieht sich nur auf die Konzeption und die Baumusterprüfung des beschriebenen Gerätes in Übereinstimmung mit der Richtlinie 94/9/EG.
Für Herstellung und in Verkehr bringen des Gerätes sind weitere Anforderungen der Richtlinie zu erfüllen, die nicht durch diese Bescheinigung abgedeckt sind.

(12) Die Kennzeichnung des Gerätes muss die folgenden Angaben enthalten:

II (2)GD [EEx ib] IIC und
I (M2) [EEx ib] I

EXAM BBG Prüf- und Zertifizier GmbH
Bochum, den 27. Mai 2004

Zertifizierungsstelle Fachbereich

Dinnendahlstraße 9 44809 Bochum Telefon 0201/172-3947 Telefax 0201/172-3948
(bis 31.05.2003: Deutsche Montan Technologie GmbH Am Technologiepark 1 45307 Essen)

EXAM
BBG Prüf- und Zertifizier GmbH

(13) Anlage zur

(14) # EG-Baumusterprüfbescheinigung

BVS 04 ATEX E 129 X

(15) 15.1 Gegenstand und Typ
Mini Switch Wandgehäuse/Baugruppenträger/Kassette Typ LB 471

15.2 Beschreibung
Das Wandgehäuse/ der Baugruppenträger/ die Kassette, die außerhalb des explosionsgefährdeten Bereiches errichtet werden, dienen der Aufnahme der Mini Switch-Baugruppen Typ LB4710-*** (BVS 03 ATEX E 219 X).

15.3 Kenngrößen

15.3.1	Versorgungsstromkreis				
15.3.1.1	Variante 1 (Klemmen L, N, PE)				
	Bemessungsspannung		AC	250	V
	max. Spannung	Um		375	V
15.3.1.2	Variante 2 (Klemmen L, N)				
	Spannung		AC/DC	40	V
	max. Spannung	Um		60	V
15.3.1.3	bei Kassette Kontakte ST1-30a, ST130c und ST1-32a				
	Spannung		DC	30	V
			AC	24	V
	max. Spannung	Um		30	V
15.3.2	nichteigensichere Relaiskontakte				
15.3.2.1	bei Wandgehäuse Anschl. 3a, 4a, 5a und 3b, 4b, 5b und 3c, 4c, 5c und 6a, 7a und 6b, 7b und 6c, 7c und 8a, 9a und 8b, 9b und 8c, 9c				
	bei Baugruppenträger Klemmen Rel. 1 und Rel. 2 und Rel. 3 je Kanal				
	Schaltspannung			250	V
	Schaltstromstärke			1	A
15.3.2.2	bei Kassette Kontakte ST1-12a und ST1-12c, ST1-14a und ST1-14c, ST1-16a und ST1-16c)				
	Schaltspannung			250	V
	Schaltstromstärke			1	A
15.3.3	nichteigensichere Digital-Stromkreise				
	bei Wandgehäuse Anschl. 10a, 11a und 10b, 11b und 10c, 11c und 13a, 14a und 13b, 14b und 13c, 14c				
	bei Baugruppenträger Klemmen D in + und D in – je Kanal				
	bei Kassette Kontakte ST1-10a, ST1-18a, ST1-20a, ST1-20c, ST1-22a und ST1-22c)				
	Bemessungsspannung		DC	24	V
	max. Spannung	Um		30	V

Dinnendahlstraße 9 44809 Bochum Telefon 0201/172-3947 Telefax 0201/172-3948
(bis 31.05.2003: Deutsche Montan Technologie GmbH Am Technologiepark 1 45307 Essen)

EXAM
BBG Prüf- und Zertifizier GmbH

15.3.4 eigensichere Ausgangsstromkreise
bei Wandgehäuse Anschl. 16a, 17a und 16b, 17b und 16c, 17c
bei Baugruppenträger Klemmen (+) und (–) je Kanal
bei Kassette Kontakte ST1-2a und ST1-2c

15.3.4.1 bei eingesetzter Baugruppe Typ LB4710-050 und LB4710-060

Spannung	Uo	DC	15,8 V
Stromstärke	Io		83 mA
Leistung	Po		1,3 W
Innenwiderstand			112,5 Ω

trapezförmige Ausgangskennlinie
max. äußere Kapazität und Induktivität gemäß folgender Tabelle:

	IIC	IIB	I
max. äußere Kapazität Co	470 nF	2,5 µF	11 µF
max. äußere Induktivität Lo	1 mH	10 mH	20 mH

15.3.4.2 bei eingesetzter Baugruppe Typ LB 4710-110 und 4710-120

		IIB	I
Spannung	Uo	16,8 V	16,8 V
Stromstärke	Io	118 mA	118 mA
Leistung	Po	2 W	2 W
max. äußere Kapazität	Co	2 µF	9 µF
max. äußere Induktivität	Lo	8 mH	20 mH

15.3.4.3 bei eingesetzter Baugruppe Typ LB 4710-150 und 4710-160

		IIC	I
Spannung	Uo	16,8 V	16,8 V
Stromstärke	Io	81 mA	81 mA
Leistung	Po	1,36 W	1,36 W
max. äußere Kapazität	Co	350 nF	9 µF
max. äußere Induktivität	Lo	1 mH	30 mH

15.3.4.4 Umgebungstemperaturbereich Ta -30 °C bis +60 °C

(16) Prüfprotokoll
BVS PP 04.2082 EG, Stand 27.05.2004

(17) Besondere Bedingungen für die sichere Anwendung
Die eigensicheren Stromkreise des/der Mini Switch Wandgehäuses/ Baugruppenträgers/ Kassette dürfen an Betriebsmittel angeschlossen werden, die in staubexplosionsgefährdeten Bereichen errichtet sind. Es ist jedoch sicherzustellen, dass die Geräte die Anforderungen für Kategorie 2D erfüllen und entsprechend zertifiziert sind.

Dinnendahlstraße 9 44809 Bochum Telefon 0201/172-3947 Telefax 0201/172-3948
(bis 31.05.2003: Deutsche Montan Technologie GmbH Am Technologiepark 1 45307 Essen)

BERTHOLD TECHNOLOGIES

14.2 ATEX Certificate NaI Detector

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

PTB

(1) **EG-Baumusterprüfbescheinigung**

(2) Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen - **Richtlinie 94/9/EG**

(3) EG-Baumusterprüfbescheinigungsnummer

PTB 00 ATEX 2108

(4) Gerät: Szintillationszähler / Stabdetektor Typ LB44..F

(5) Hersteller: Berthold GmbH & Co. KG

(6) Anschrift: D-75323 Bad Wildbad

(7) Die Bauart dieses Gerätes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

(8) Die Physikalisch-Technische Bundesanstalt bescheinigt als benannte Stelle Nr. 0102 nach Artikel 9 der Richtlinie des Rates der Europäischen Gemeinschaften vom 23. März 1994 (94/9/EG) die Erfüllung der grundlegenden Sicherheits- und Gesundheitsanforderungen für die Konzeption und den Bau von Geräten und Schutzsystemen zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie.

Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfbericht PTB Ex 00-20186 festgehalten.

(9) Die grundlegenden Sicherheits- und Gesundheitsanforderungen werden erfüllt durch Übereinstimmung mit

EN 50014:1997 EN 50018:1994 EN 50019:1994 EN 50020:1994

(10) Falls das Zeichen „X" hinter der Bescheinigungsnummer steht, wird auf besondere Bedingungen für die sichere Anwendung des Gerätes in der Anlage zu dieser Bescheinigung hingewiesen.

(11) Diese EG-Baumusterprüfbescheinigung bezieht sich nur auf Konzeption und Bau des festgelegten Gerätes gemäß Richtlinie 94/9/EG. Weitere Anforderungen dieser Richtlinie gelten für die Herstellung und das Inverkehrbringen dieses Gerätes.

(12) Die Kennzeichnung des Gerätes muß die folgenden Angaben enthalten:

II 2 G EEx ib d IIC T6 bzw. EEx d e IIC T6

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Braunschweig, 12. Oktober 2000

Dr.-Ing. U. Johannsmeyer
Regierungsdirektor

PHYSIKALISCH-TECHNISCHE BUNDESANSTALT

Seite 1/3

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

Anlage zur EG-Baumusterprüfbescheinigung PTB 00 ATEX 2108

PT100-Stromkreis (Klemmen 3 und4) — in Zündschutzart Eigensicherheit EEx ib IIC;
Höchstwerte:
U_o = 16,8 V
I_o = 34 mA
P_o = 143 mW
lineare Kennlinie
L_i vernachlässigbar klein
C_i = 11 nF

	IIC	IIB
L_o	23 mH	87 mH
C_o	290 nF	1300 nF

Der eigensichere Signal- und Versorgungsstromkreis sowie der PT100-Stromkreis sind betriebsmäßig geerdet.

(16) Prüfbericht PTB Ex 00-20186

(17) Besondere Bedingungen

keine

(18) Grundlegende Sicherheits- und Gesundheitsanforderungen

Durch vorgenannte Normen abgedeckt.

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Dr.-Ing. U. Johannsmeyer
Regierungsdirektor

Braunschweig, 12. Oktober 2000

Seite 3/3

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

(13) **Anlage**

(14) **EG-Baumusterprüfbescheinigung PTB 00 ATEX 2108**

(15) Beschreibung des Gerätes

Der Szintillationszähler/Stabdetektor Typ LB44..F dient zur kontinuierlichen Messung des Füllstandes in Behältern oder Bunkern mit flüssigem, körnigem, viskosem oder krustenbildendem Inhalt sowie zur Messung der Beladung auf Förderbändern. Der Szintillationszähler/Stabdetektor Typ LB44..F dient ebenfalls zur kontinuierlichen Messung der Dichte von Flüssigkeiten, Suspensionen, Trüben und Schüttgüterrn, er wird auch für die kontinuierliche Messung von Flächengewicht, Asche, Schwefel und für andere spezielle Anwendungen eingesetzt.

Der höchstzulässige Umgebungstemperaturbereich beträgt: -40 °C bis +50 °C.

Elektrische Bemessungsdaten

In der Ausführung EEx d e IIC T6 mit PT100-Ausgang

Signal- und Versorgungsstromkreis

Versorgungsspannung max.	16,8 V
Versorgungsleistung max.	2 W

PT100-Stromkreis

Ausgangsspannung max.	16,8 V
Ausgangsstrom max.	34 mA
Ausgangsleistung max.	143 mW

In der Ausführung EEx d e IIC T6 ohne PT100-Ausgang

Signal- und Versorgungsstromkreis

Versorgungsspannung max.	30 V
Versorgungsleistung max.	6 W

In der Ausführung EEx ib d IIC T6

Signal- und Versorgungsstromkreis (Klemmen 1 und 2) — in Zündschutzart Eigensicherheit EEx ib IIC; nur zum Anschluss an separat bescheinigte eigensichere Stromkreise. Höchstwerte:
U_i = 16,8 V
P_i = 2 W
L_i vernachlässigbar klein
C_i = 11 nF

Seite 2/3

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

1. ERGÄNZUNG

gemäß Richtlinie 94/9/EG Anhang III Ziffer 6

zur EG-Baumusterprüfbescheinigung PTB 00 ATEX 2108

Gerät: Szintillationszähler / Stabdetektor Typ LB44..F

Kennzeichnung: Ⓔx **II 2 G EEx ib d IIC T6 bzw. EEx d e IIC T6**

Hersteller: Berthold Technologies GmbH & Co. KG

Anschrift: Calmbacher Str. 22
75323 Bad Wildbad, Deutschland

Beschreibung der Ergänzungen und Änderungen

Der Szintillationszähler / Stabdetektor Typ LB44..F darf in der Ausführung **EEx d e IIC T6 ohne PT100-Ausgang** auch in einem Umgebungstemperaturbereich von: -40 °C bis +60 °C betrieben werden.

Alle anderen Festlegungen und Angaben gelten unverändert.

Prüfbericht: PTB Ex 01-21266

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Braunschweig, 24. Juli 2001

Dr.-Ing. U. Johannsmeyer
Regierungsdirektor

Seite 1/1

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

2. ERGÄNZUNG

gemäß Richtlinie 94/9/EG Anhang III Ziffer 6

zur EG-Baumusterprüfbescheinigung PTB 00 ATEX 2108

Gerät: Szintillationszähler / Stabdetektor Typ LB44..F

Kennzeichnung: Ⓔx **II 2 G EEx ib d IIC T6 bzw. EEx d e IIC T6**

Hersteller: Berthold Technologies GmbH & Co. KG

Anschrift: 75323 Bad Wildbad, Deutschland

Beschreibung der Ergänzungen und Änderungen

Der Szintillationszähler/Stabdetektor Typ LB44..F darf alternativ auch mit den modifizierten Komponenten Elektronik und Gehäuse betrieben werden.
Der Szintillationszähler/Stabdetektor Typ LB44..F dient auch zur kontinuierlichen Messung des Füllstandes bzw. der Dichte von Schüttgütern und kann alternativ zum Beispiel in Behältern oder Bunkern mit brennbarem Staub betrieben werden.
Für diesen Anwendungsfall ändert sich der höchstzulässige Umgebungstemperaturbereich. Der höchstzulässige Umgebungstemperaturbereich in brennbaren Staubatmosphären beträgt:

generell	-20°C bis +50°C
für die Variante ohne PT100 Ausgang	-20°C bis +60°C

Alle anderen Festlegungen gelten weiterhin unverändert.
Die Kennzeichnung des Betriebsmittels wird ergänzt und lautet künftig wie nachstehend.

Kennzeichnung: Ⓔx **II 2 G EEx ib d IIC T6 bzw. EEx d e IIC T6**

Ⓔx **II 2 D IP65 T80°C bzw. IP67 T80°C**

Prüfbericht: PTB Ex 02-22033

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Braunschweig, 10. April 2002

Dr.-Ing. U. Klausmeyer
Regierungsdirektor

Seite 1/1

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

3. ERGÄNZUNG

gemäß Richtlinie 94/9/EG Anhang III Ziffer 6

zur EG-Baumusterprüfbescheinigung PTB 00 ATEX 2108

Gerät: Szintillationszähler LB44..

Kennzeichnung: Ex **II 2 G EEx ib d IIC T6 bzw. EEx de IIC T6**

Hersteller: BERTHOLD TECHNOLOGIES GmbH & Co. KG

Anschrift: Calmbacher Str. 22
75323 Bad Wildbad, Deutschland

Beschreibung der Ergänzungen und Änderungen

1. Neue Konstruktonsvariante mit Aluminium- oder Berylliumscheibe.
2. Kennzeichnung wahlweise mit Klebetypenschild.
3. Die Kennzeichnung des Betriebsmittels wird ergänzt und lautet künftig wie nachstehend:
   - Ex **II 2 G EEx de IIC T6** bzw.
   - Ex **II 2 G EEx ib d IIC T6** bzw.
   - Ex **II 2 G D EEx de IIC T6 IP 65 T 80 °C bzw. IP 67 T 80 °C** bzw.
   - Ex **II 2 G D EEx ib d IIC T6 IP 65 T 80 °C bzw. IP 67 T 80 °C**
4. Wahlweise Anschluß handelsüblicher Gewindeadapter am EEx "e"-Anschlußraum zum nachfolgenden Anschluß eines Conduits:
   M16*1,5 auf ¾ " NPT
   M12*1,5 auf ¾ " NPT
   M16*1,5 auf ½ " NPT
   M12*1,5 auf ½ " NPT
5. Variable Wandstärke des Gehäuseabsatzes im Bereich von 7 bis 10 mm.
6. Erweiterung des Einsatztemperaturbereiches in der Ausführung EEx de IIC T6 ohne PT100-Ausgang auf +73 °C

Besondere Bedingungen

Die Stoßprüfung an der Berylliumscheibe (Szintillationszähler LB44..) wurde nur mit der niedrigen Schlagenergie von 4 J bestanden. In dieser Konstruktionsvariante ist die Kennzeichnung des Betriebsmittels mit dem Symbol "X" hinter der Bescheinigungsnummer entsprechend EN 50014, Abschnitt 27.2 i) erforderlich. Zusätzlich ist ein warnender Hinweis in der Betriebsanleitung hinsichtlich der Schlagempfindlichkeit der Berylliumscheibe erforderlich.

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

3. Ergänzung zur EG-Baumusterprüfbescheinigung PTB 00 ATEX 2108

Zusätzliche Hinweise für den sicheren Betrieb:

Der Szintillationszähler LB44.. darf in der Ausführung **EEx de IIC T6 ohne PT100-Ausgang** bei einer Leistungsaufnahme von 2 W auch bis zu einer maximalen Umgebungstemperatur von +73 °C betrieben werden. Die maximale Leistungsaufnahme von 2 W ist dabei durch geeignete konstruktive Maßnahmen sicherzustellen.

Alle anderen Festlegungen und Angaben gelten unverändert weiter.

Prüfbericht: PTB Ex 03-13123

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Braunschweig, 19. Mai 2003

Dr.-Ing. M. Thedens

EG-Baumusterprüfbescheinigungen ohne Unterschrift und ohne Siegel haben keine Gültigkeit.
Diese EG-Baumusterprüfbescheinigung darf nur unverändert weiterverbreitet werden.
Auszüge oder Änderungen bedürfen der Genehmigung der Physikalisch-Technischen Bundesanstalt.

Physikalisch-Technische Bundesanstalt • Bundesallee 100 • D-38116 Braunschweig

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

(1) **EG-Baumusterprüfbescheinigung**

(2) Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen - **Richtlinie 94/9/EG**

EG-Baumusterprüfbescheinigungsnummer

PTB 01 ATEX 1068

(4) Gerät: Stabdetektor SZ 7... bzw. Detektor LB 3171 Typ SZ5-GHS-3171-.

(5) Hersteller: Berthold Technologies GmbH & Co. KG

(6) Anschrift: 75323 Bad Wildbad, Deutschland

(7) Die Bauart dieses Gerätes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage und den darin aufgeführten Unterlagen zu dieser Baumusterprüfbescheinigung festgelegt.

Die Physikalisch-Technische Bundesanstalt bescheinigt als benannte Stelle Nr. 0102 nach Artikel 9 der Richtlinie des Rates der Europäischen Gemeinschaften vom 23. März 1994 (94/9/EG) die Erfüllung der grundlegenden Sicherheits- und Gesundheitsanforderungen für die Konzeption und den Bau von Geräten und Schutzsystemen zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie.

Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfbericht PTB Ex 01-11049 festgehalten.

Die grundlegenden Sicherheits- und Gesundheitsanforderungen werden erfüllt durch Übereinstimmung mit

EN 50014:1997 + A1 + A2 **EN 50018:2000** **EN 50019:2000**

(10) Falls das Zeichen „X" hinter der Bescheinigungsnummer steht, wird auf besondere Bedingungen für die sichere Anwendung des Gerätes in der Anlage zu dieser Bescheinigung hingewiesen.

(11) Diese EG-Baumusterprüfbescheinigung bezieht sich nur auf Konzeption und Prüfung des festgelegten Gerätes gemäß Richtlinie 94/9/EG. Weitere Anforderungen dieser Richtlinie gelten für die Herstellung und das Inverkehrbringen dieses Gerätes. Diese Anforderungen werden nicht durch diese Bescheinigung abgedeckt.

(12) Die Kennzeichnung des Gerätes muß die folgenden Angaben enthalten:

Ex II 2 G EEx de IIC T6 bzw. EEx ib d IIC T6 bzw. EEx ib d IIB T6

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Dr.-Ing. U. Klausmeyer
Regierungsdirektor

Braunschweig, 09. November 2001

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

Anlage

EG-Baumusterprüfbescheinigung PTB 01 ATEX 1068

(15) Beschreibung des Gerätes

Der Szintillationszähler/Stabdetektor SZ 7... dient zur kontinuierlichen Messung des Füllstandes in Behältern mit flüssigen, körnigen, viskosen oder krustenbildenden Medien sowie zur Messung der Beladung auf Förderbändern. Er dient ebenfalls zur kontinuierlichen Messung der Dichte und des Flächengewichts diverser Medien und wird auch für andere spezielle Anwendungen eingesetzt.

Der Detektor LB 3171 dient zur Überwachung von einer oder mehreren Grenzhöhen an Behältern mit Flüssigkeiten oder Schüttgütern.

Herzstück des Betriebsmittels ist ein Photovervielfacher mit nachgeschaltetem Spannungsverteiler und Vorverstärker, eingebaut in ein Gehäuse der Zündschutzart "Druckfeste Kapselung".

Elektrische Bemessungsdaten

In der Ausführung EEx de IIC T6

Versorgungsspannung max.	30 V
Stromstärke max.	600 mA

In der Ausführung EEx ib d IIC T6

Signal- und Versorgungsstromkreis (Klemmen 1 und 2)	in Zündschutzart Eigensicherheit EEx ib IIC; nur zum Anschluss an separat bescheinigte eigensichere Stromkreise. Höchstwerte: U_i = 15,8 V I_i = 216 mA P_i = 1,5 W L_i vernachlässigbar klein C_i vernachlässigbar klein

Der eigensichere Signal- und Versorgungsstromkreis ist betriebsmäßig geerdet.

(16) Prüfbericht PTB Ex 01-11049

EG-Baumusterprüfbescheinigungen ohne Unterschrift und ohne Siegel haben keine Gültigkeit.
Diese EG-Baumusterprüfbescheinigung darf nur unverändert weiterverbreitet werden.
Auszüge oder Änderungen bedürfen der Genehmigung der Physikalisch-Technischen Bundesanstalt.

Physikalisch-Technische Bundesanstalt • Bundesallee 100 • D-38116 Braunschweig

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

Anlage zur EG-Baumusterprüfbescheinigung PTB 01 ATEX 1068

(17) Besondere Bedingungen

keine;

Zusätzliche Hinweise für den sicheren Betrieb:

Errichtungshinweis

Der eigensichere Signal- und Versorgungsstromkreis ist betriebsmäßig geerdet. Aus diesem Grunde ist längs des gesamten Verlaufes dieses Stromkreises (innerhalb und außerhalb des explosionsgefährdeten Bereiches) Potentialausgleich zu errichten.

Umgebungstemperatur

Der zulässige Umgebungstemperaturbereich beträgt -50 °C ≤ T_U ≤ +60 °C

(18) Grundlegende Sicherheits- und Gesundheitsanforderungen

Erfüllt durch die Übereinstimmung mit den vorgenannten Normen.

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Braunschweig, 09. November 2001

Dr.-Ing. U. Klausmeyer
Regierungsdirektor

Seite 3/3

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

1. ERGÄNZUNG

gemäß Richtlinie 94/9/EG Anhang III Ziffer 6

zur EG-Baumusterprüfbescheinigung PTB 01 ATEX 1068

Gerät: Stabdetektor SZ 7... bzw. Detektor LB 3171 Typ SZ5-GHS-3171-. bzw. Szintillationszähler SZ-5

Kennzeichnung: **II 2 G EEx de IIC T6 bzw. EEx ib d IIC T6 bzw. EEx ib d IIB T6**

Hersteller: BERTHOLD TECHNOLOGIES GmbH & Co. KG

Anschrift: Calmbacher Str. 22
75323 Bad Wildbad, Deutschland

Beschreibung der Ergänzungen und Änderungen

Die Version C, Szintillationszähler SZ-5 (Ident-Nr. 80943) wird hinzugefügt. In dieser Version sind die Konstruktionsvarianten C1, C2, C5 und C6 möglich.

Besondere Bedingungen

Die Stoßprüfung an der Berylliumscheibe (Szintillationszähler SZ-5, Konstruktionsvariante C5) wurde nur mit der niedrigen Schlagenergie von 4 J bestanden. In dieser Konstruktionsvariante ist die Kennzeichnung des Betriebsmittels mit dem Symbol "X" hinter der Bescheinigungsnummer entsprechend EN 50014, Abschnitt 27.2 i) erforderlich. Zusätzlich ist ein warnender Hinweis in der Betriebsanleitung hinsichtlich der Schlagempfindlichkeit der Berylliumscheibe erforderlich.

Zusätzliche Hinweise für den sicheren Betrieb

Für den Szintillationszähler SZ-5 beträgt der zulässige Umgebungstemperaturbereich
-50 °C ≤ T_U ≤ +60 °C.

Für den Detektor LB 3171 Typ SZ5-GHS-3171-. in der Ausführung EEx de IIC T6 beträgt der zulässige Umgebungstemperaturbereich -50 °C ≤ T_U ≤ +73 °C, in der Ausführung EEx ib d IIC T6 hingegen -50 °C ≤ T_U ≤ +50 °C.

Die übrigen "Zusätzlichen Hinweise für den sicheren Betrieb" aus PTB 01 ATEX 1068 behalten ihre Gültigkeit.

Prüfbericht: PTB Ex 03-13122

Zertifizierungsstelle Explosionsschutz
Im Auftrag

Braunschweig, 19. Mai 2003

Dr.-Ing. U. Klausmeyer
Regierungsdirektor

Seite 1/1

14.4 EC Declaration of Conformity

BERTHOLD TECHNOLOGIES GmbH & Co.KG

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EG – Konformitätserklärung

Hiermit erklären wir, daß die Bauart des(r) nachfolgend bezeichneten Gerätes / Systems / Anlage in der von uns in den Verkehr gebrachten Ausführung den unten genannten einschlägigen EG-Richtlinien entspricht.

Durch nicht mit uns abgestimmte Änderungen oder nicht bestimmungsgemäßen Gebrauch verliert diese Erklärung ihre Gültigkeit.

Bezeichnung: **Messgerät für Füllstandgrenzwert**

Typ: **LB 471**

Einschlägige EG-Richtlinien:

89/336/EWG (Elektromagnetische Verträglichkeit)
geändert: 91/263/EWG, 92/31/EWG, 93/68/EWG, 93/97/EWG

73/23/EWG (Niederspannungsrichtlinie)
geändert: 93/68/EWG

Zur Beurteilung des Erzeugnisses wurden folgende Normen herangezogen:

EN 55011:1998 + A1:1999 + A2:2002
EN 61010-1:2002-08
EN 61006-6-2:2001
EN 61000-4-2:1995 + A1:1998 + A2:2001
EN 61000-4-3:2002 + A1:2002
EN 61000-4-4:1995 + A1:2001 + A2:2001
EN 61000-4-5:1995 + A1:2001
EN 61000-4-6:1996 + A1:2001
EN 61000-4-11:1994 + A1:2001

Diese Erklärung wird verantwortlich für den Hersteller:

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Calmbacher Strasse 22
D-75323 Bad Wildbad

abgegeben durch

Dr. J. Briggmann
Entwicklungsleiter
Prozessmesstechnik

Bad Wildbad, den 04.05.2004

Registergericht / Court of Registration: Calw HRA 991
Persönlich haftende Gesellschafterin / Fully liable Associates: BERTHOLD TECHNOLOGIES Verwaltungs-GmbH
Registergericht / Court of Registration: Calw HRB 1520
Geschäftsführung / Management: Hans J. Oberhofer (Vors./CEO), Dr. Wilfried Reuter
Beiratsvorsitzender / Chairman of the Board: Dr. Fritz Berthold
USt.-IdNr. / VAT Reg.No: DE813050511
Deutsche Steuernummer / German Tax No: 49038/08038

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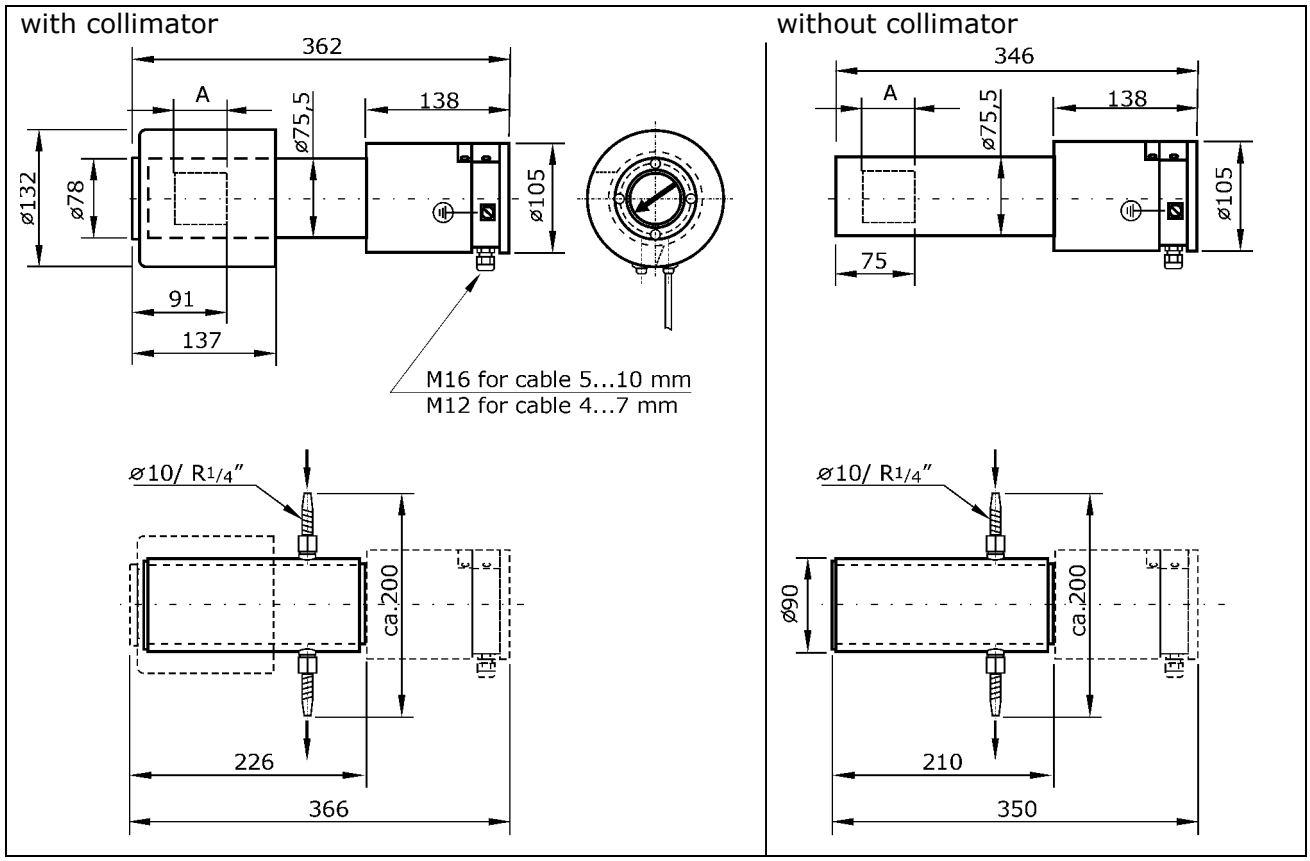
Chapter 15. Technical Drawings

15.1 NaI Detector



Specifications in mm

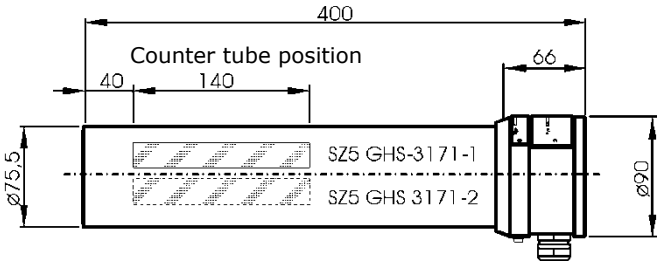
Water conduit connections for water cooling:
Ø 10 mm ($R^1/_4$")
Maximum pressure 6 bar

Type	Crystal	Ex	Collimator	Weight in kg approx.
LB 5401-01	25/25			5
LB 5401-02	40/35			5
LB 5401-03	50/50		X	18
LB 4401-01	25/25	X		5
LB 4401-02	40/35	X		5
LB 4401-03	50/50	X	X	18

15.2 GM Detector

Detector for use in Ex-areas
Sz5-GHS-3171
Cable gland PG 16 for
line diameter 5 to 8 mm

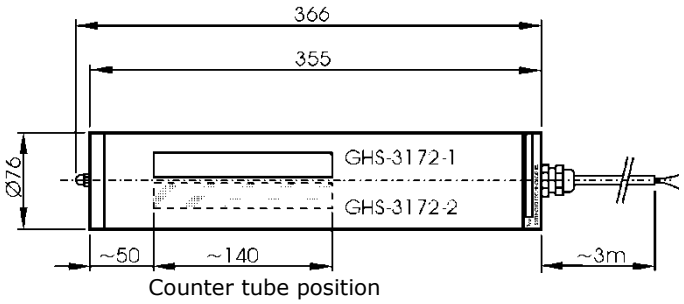
Terminal connection
Terminal 6: + (plus)
Terminal 2: - (minus)
Terminal 5: screen



Non–Ex-detector with 3m cable
GHS-3172

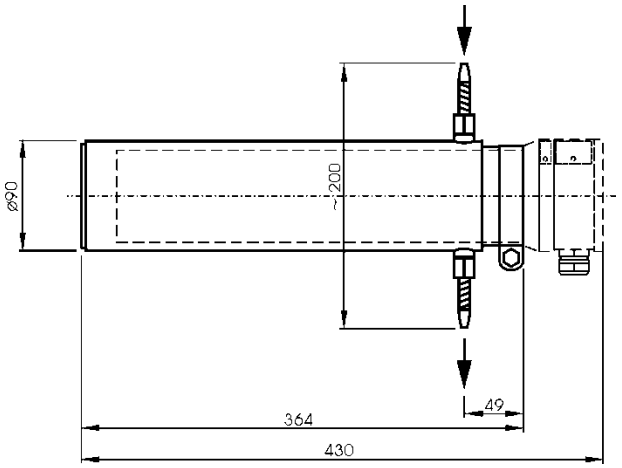
Color code of wires:
brown + (plus)
white - (minus)

Line diameter: 7.5 mm



Water cooling
for installation with
SZ5-GHS-3171 and GHS-3172-1

Water conduit connections:
Ø 10mm ($R^1/_4$")
maximum pressure 6 bar

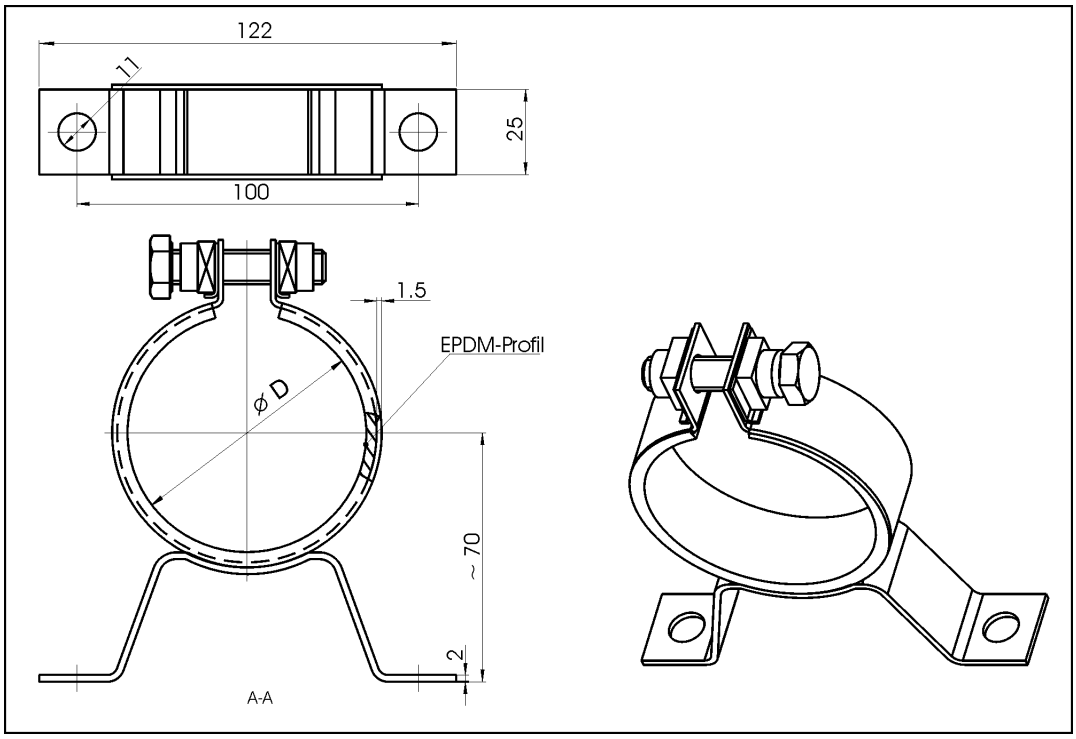


Specifications in mm

Type	ID No.	Ex	Number of counter tubes	Weight (kg)
SZ5-GHS-3171-1Gd	40435-01	pressure-proof	1	6
SZ5-GHS-3171-2Gd	40435-02	pressure-proof	2	6
SZ5-GHS-3171-1Gi	40436-01	intrinsically safe	1	6
SZ5-GHS-3171-2Gi	40436-02	intrinsically safe	2	6
GHS-3172-1	29891	-	1	4,5
GHS-3172-2	29892	-	2	4,5
Water cooling	04504			3,5

15.2.1 Fastening Clamps

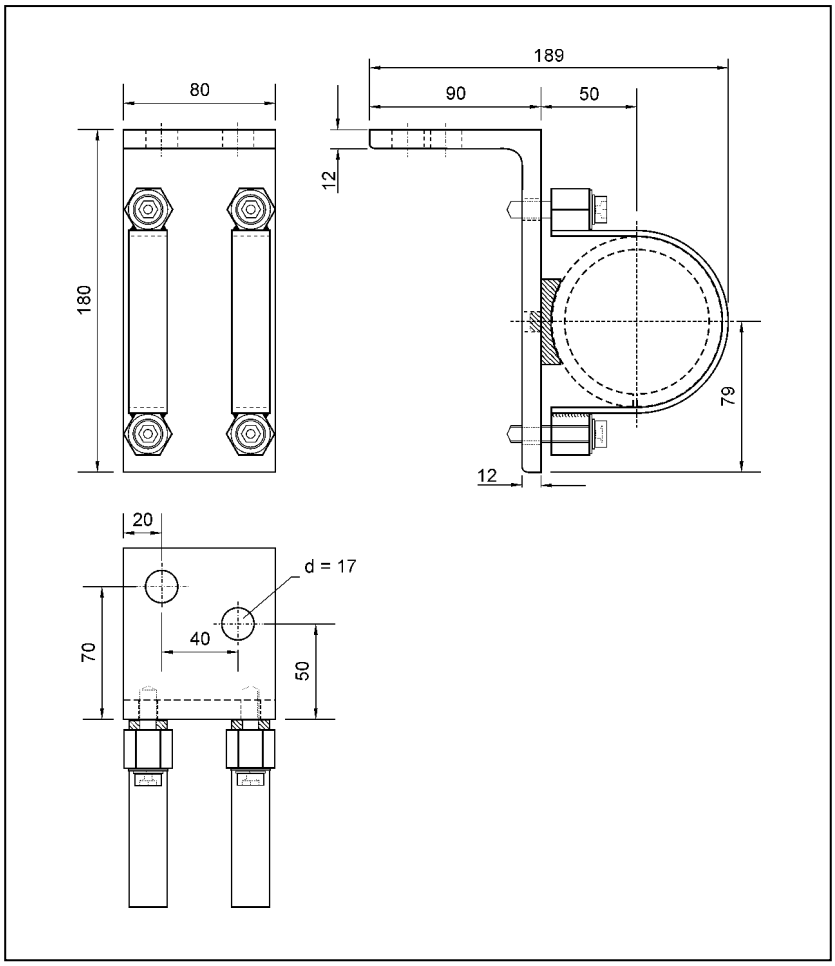
Fastening clamps are used for the assembly of GM detectors and NaI detectors.



For detector without water cooling D = 75	For detector with water cooling D = 90
ID-NO 31346 (1 set= 2 clamps)	ID-NO 31347 (1 set = 2 clamps)

15.2.2 Detector Holder for GM Detector and NaI Counter

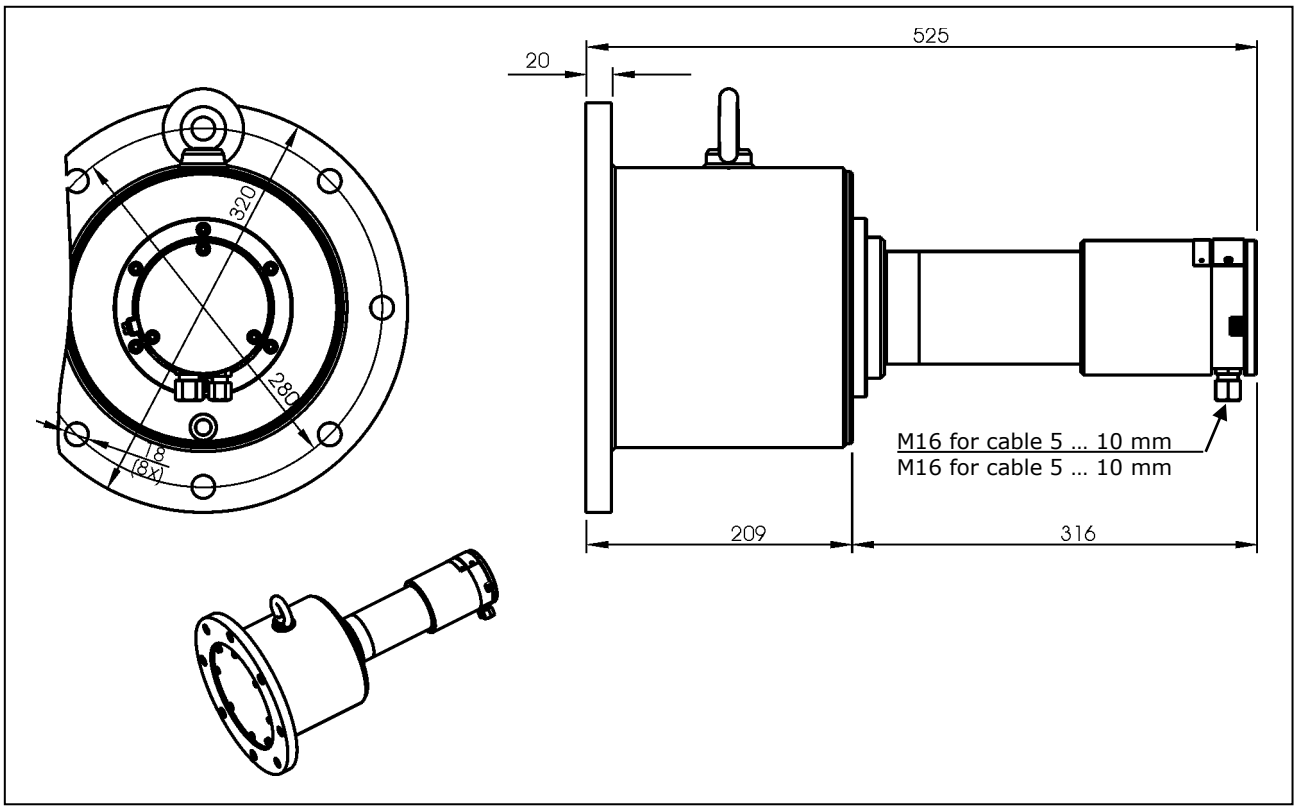
This holder comprises two clamps mounted on an angle. It may be used optionally instead of the fastening clamps. The advantage is that this angle can be welded or screwed directly onto the bracket. Moreover, the holder is very robust and can be used in if little space is available. All metal parts of this fastening set are made of stainless steel.



Holder for:	ID-NO
Point detector without water cooling	39246
Point detector with water cooling	39247

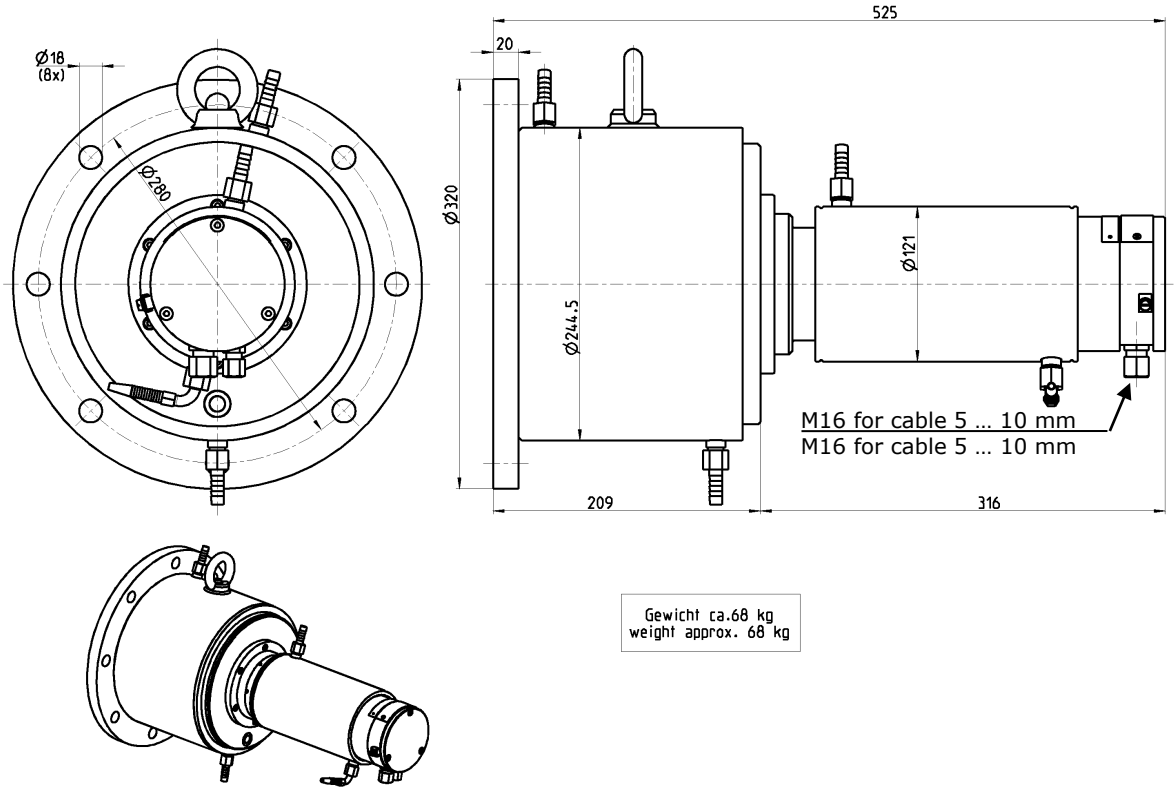
15.3 Super-Sens Detectors

Super Sens with frontal irradiation



Type	ATEX		Weight in kg approx.
LB 4430-04-0a-Gd-E	Gas Ex	II 2 G EEx de IIC T6	54
LB 4430-04-0a-Gi-E	Gas Ex intrinsically safe	II 2 G EEx ib d IIC T6	54
LB 4430-04-1a-Md-E	Firedamp		54
LB 4430-04-1a-Mi-E	Firedamp intrinsically safe		54
LB 5430	-		49

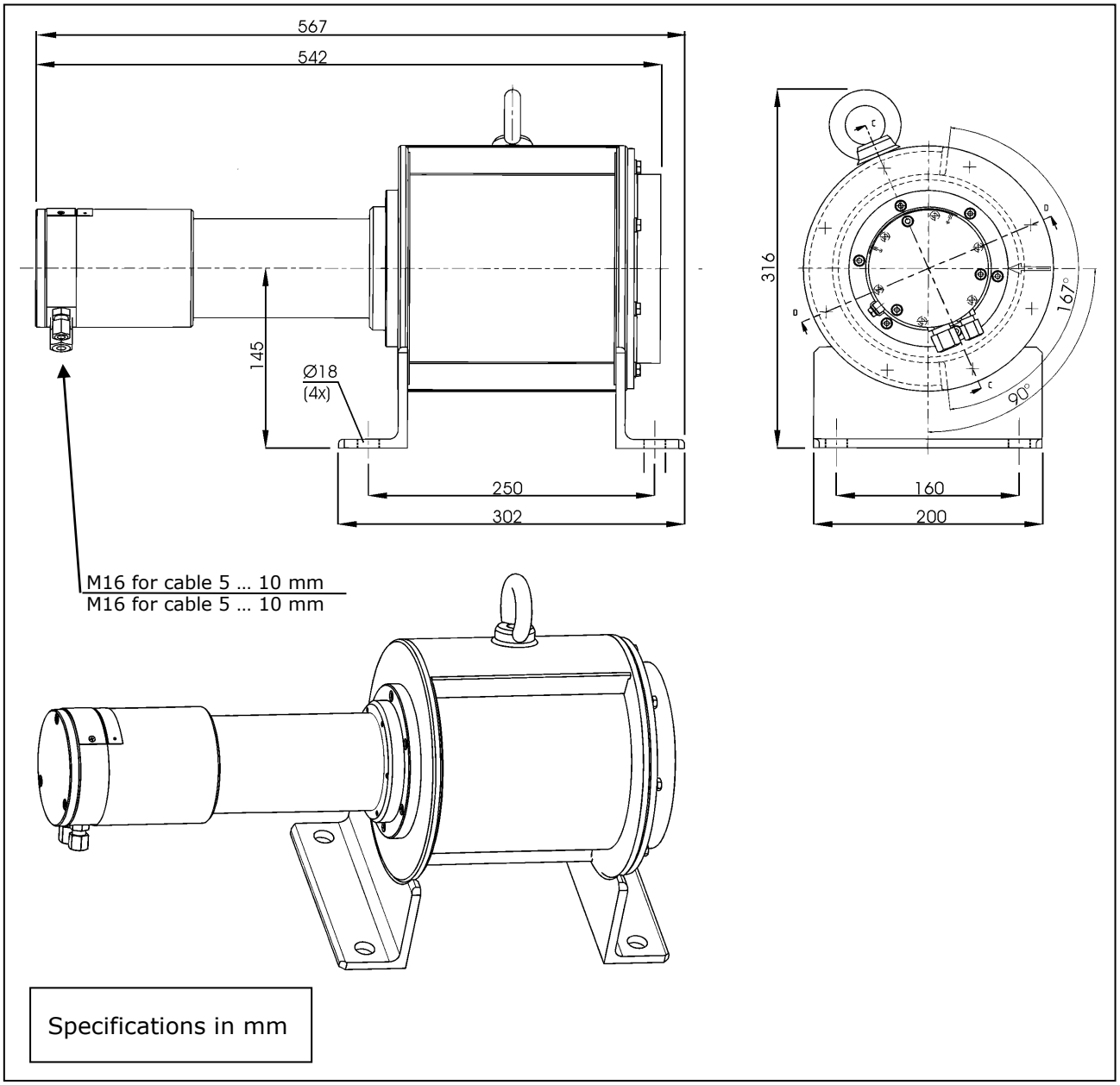
Super-Sens with frontal irradiation and water cooling



Connection seal for water cooling: Ø 10mm ($R^1/_4$")
Specifications in mm

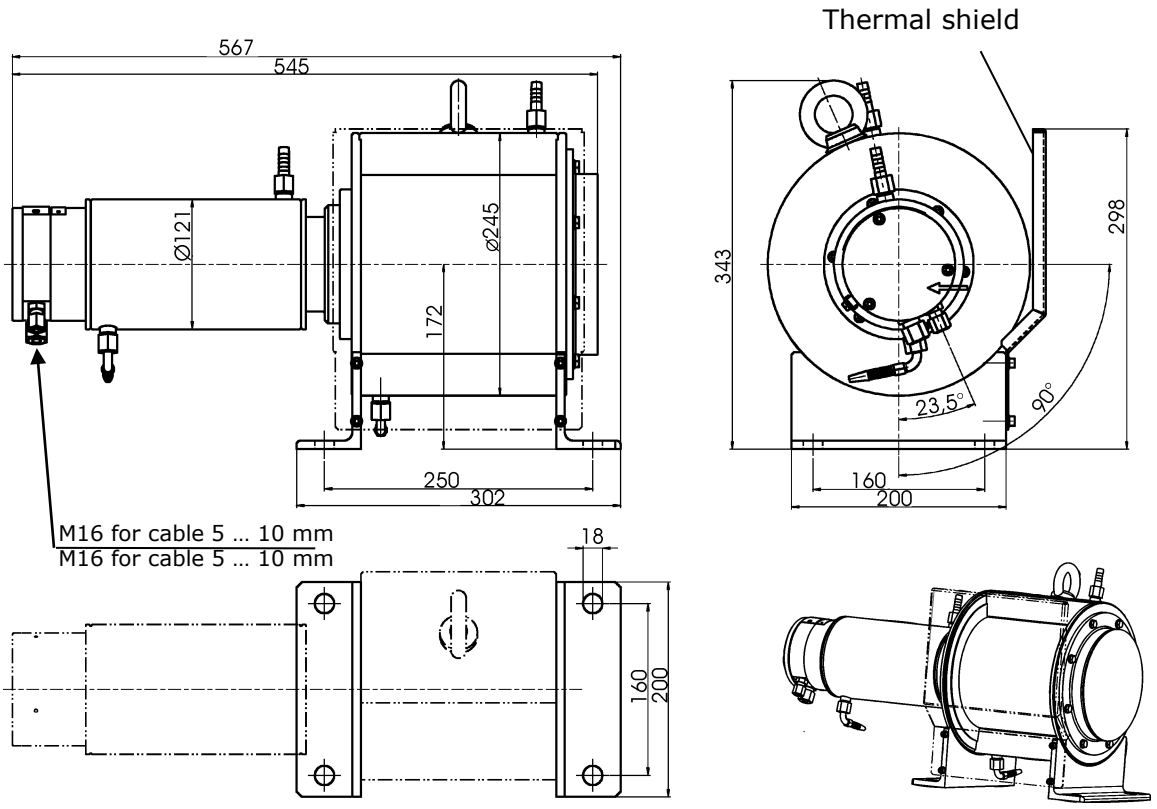
Type	ATEX		Weight in kg approx.
LB 4430-14-0a-Gd-E	Gas Ex	II 2 G EEx de IIC T6	68
LB 4430-14-0a-Gi-E	Gas Ex intrinsically safe	II 2 G EEx ib d IIC T6	68

Super Sens with lateral irradiation 90°



Type	ATEX		Irradiation	Weight in kg approx.
LB 4431-04-0s-Gd-E	Gas Ex	II 2 G EEx de IIC T6	90°	60
LB 4431-04-0s-Gi-E	Gas Ex intrinsically safe	II 2 G EEx ib d IIC T6	90°	60
LB 4431-04-1s-Md-E	Firedamp		90°	60
LB 4431-04-1s-Mi-E	Firedamp intrinsically safe		90°	60

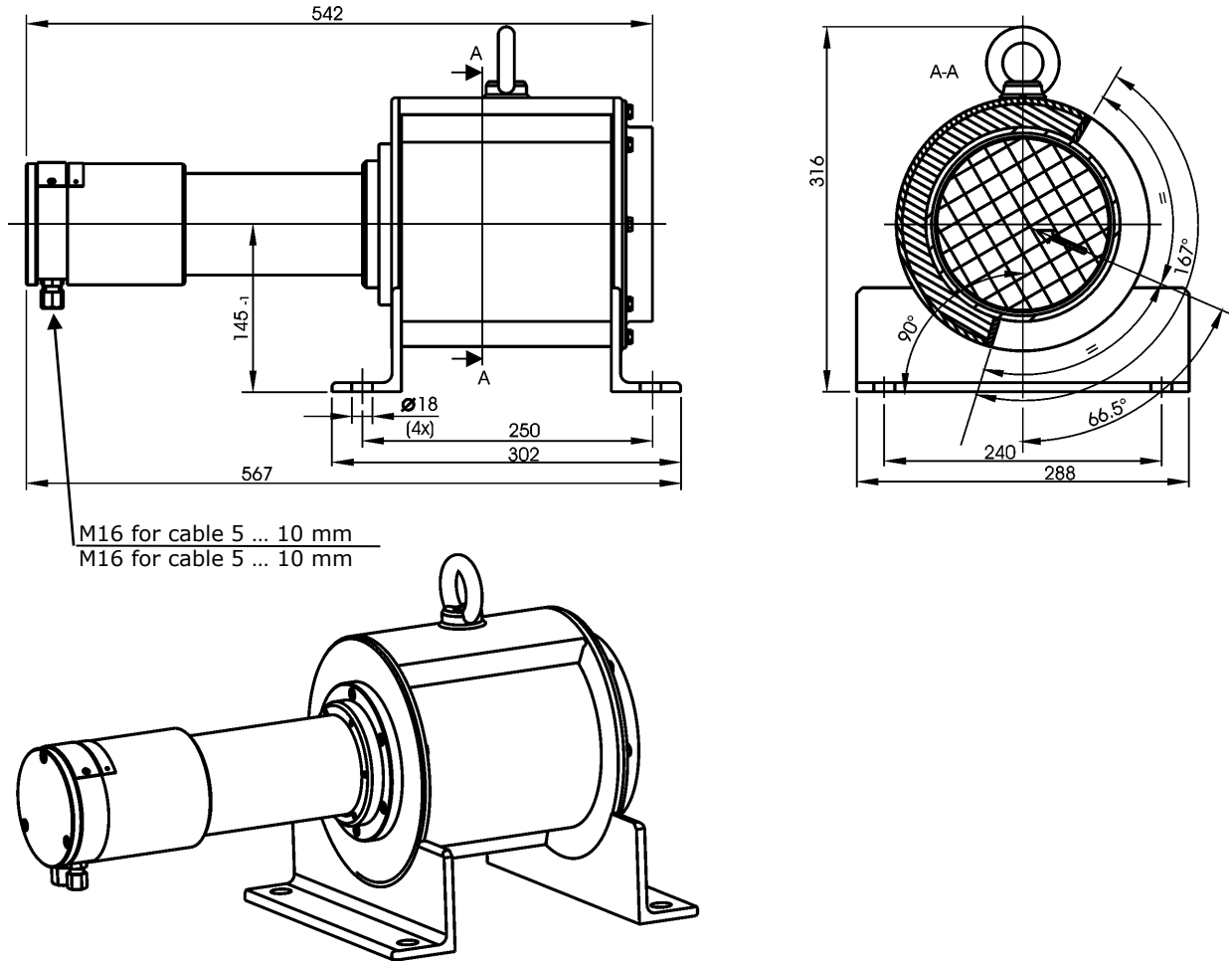
Super Sens with lateral irradiation 90° with water cooling



Connection seal for water cooling: Ø 10mm (R1/4")
Specifications in mm

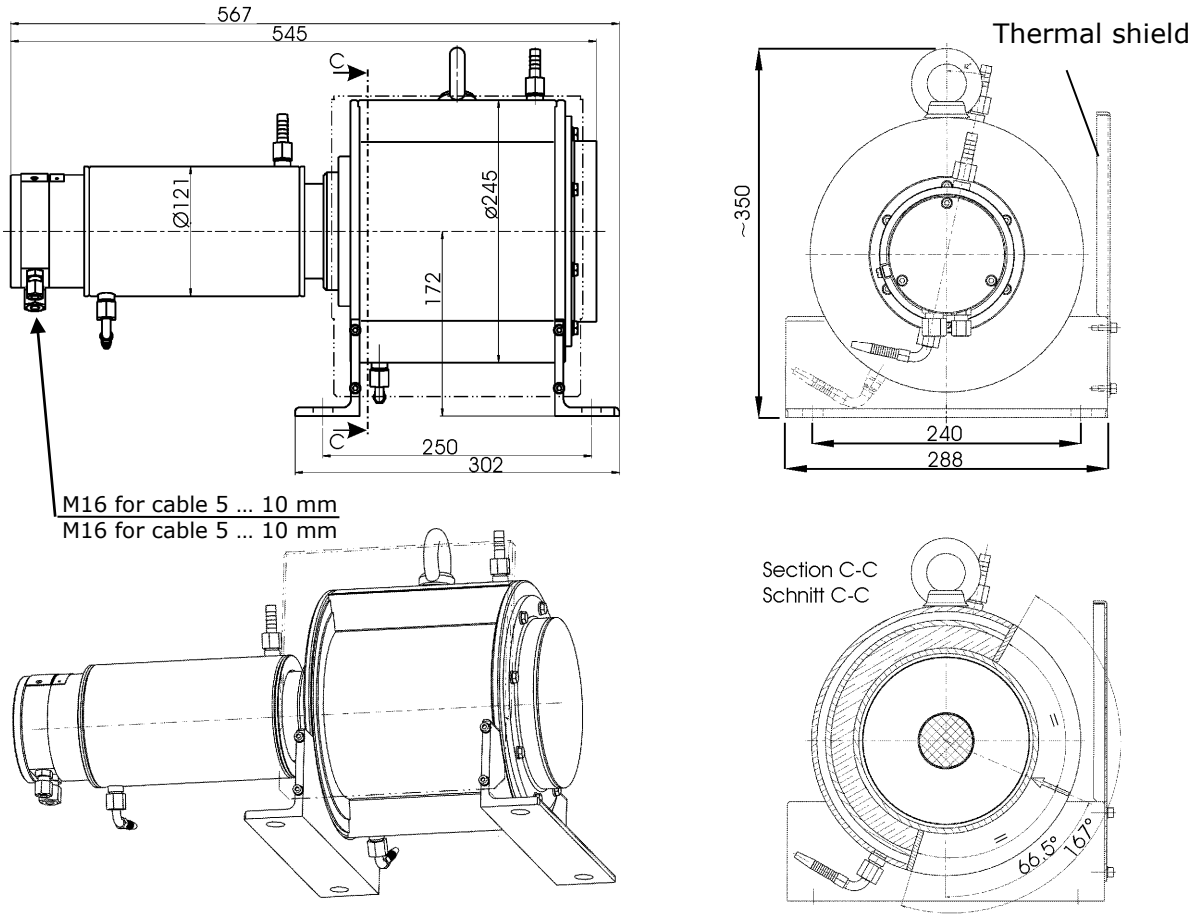
Type	ATEX		Irradiation	Weight in kg approx.
LB 4431-14-0s-Gd-E	Gas Ex	II 2 G EEx de IIC T6	90°	74
LB 4431-14-0s-Gi-E	Gas Ex intrinsically safe	II 2 G EEx ib d IIC T6	90°	74

Super Sens with lateral irradiation 66°



Type	ATEX		Irradiation	Weight in kg approx.
LB 4431-04-0r-Gd- E	Gas Ex	II 2 G EEx de IIC T6	66°	60
LB 4431-04-0r-Gi- E	Gas Ex intrinsically safe	II 2 G EEx ib d IIC T6	66°	60
LB 5431	-		66°	58

Super Sens with lateral irradiation 66° with water cooling

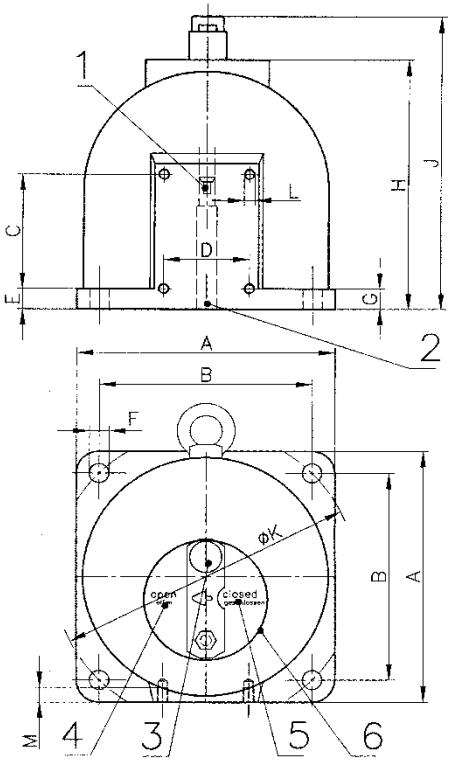


Connection seal for water cooling: Ø 10mm (R1/4")
Specifications in mm

Type	ATEX		Irradiation	Weight in kg approx.
LB 4431-14-0r-Gd-E	Gas Ex	II 2 G EEx de IIC T6	66°	74
LB 4431-14-0r-Gi-E	Gas Ex intrinsically safe	II 2 G EEx ib d IIC T6	66°	74

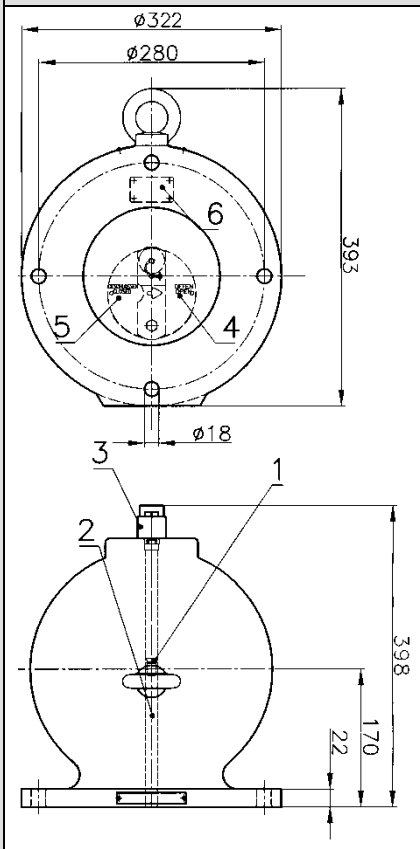
15.4 Point Source Shielding LB 744X

LB 7440 / 7442 / 7445 / 7446



1 Point sources
2 Radiation exit
3 Lock
4 Position **Open**
5 Position **Closed**
6 Type label

LB 7444

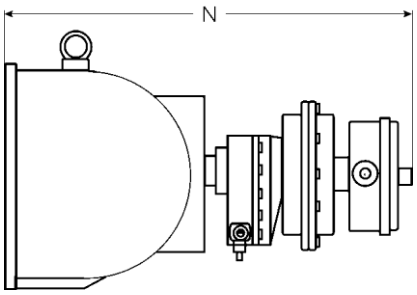


Type	Stainless steel case	A	B	C	D	E	FØ	G	H	J	KØ	L	M	flange	✳	kg
LB 7440 F CR LB 7445 F CR	-	180	142	60	60	15	18	20	173	238	200	M 8	12	ND 125, PN 6	16°	31
LB 7440 FE CR LB 7445 FE CR	X X															
LB 7442 F CR LB 7446 F CR	-	240	198	110	80	20	18	20	242	306	280	M10	14	ND 200, PN 6	9°	81
LB 7442 FE CR	X															
LB 7444 CR	-													ND 200, PN 6	6°	170

✳ ***Angle of reflected beam of shielding***

Shielding LB 744X with Pneumatic Shutter

A pneumatic shutter device is available as an option to remote-control the shutter mechanism. The pneumatic shutter is also available with limit switch for position feedback, in different versions (see table below: Limit switch unit).



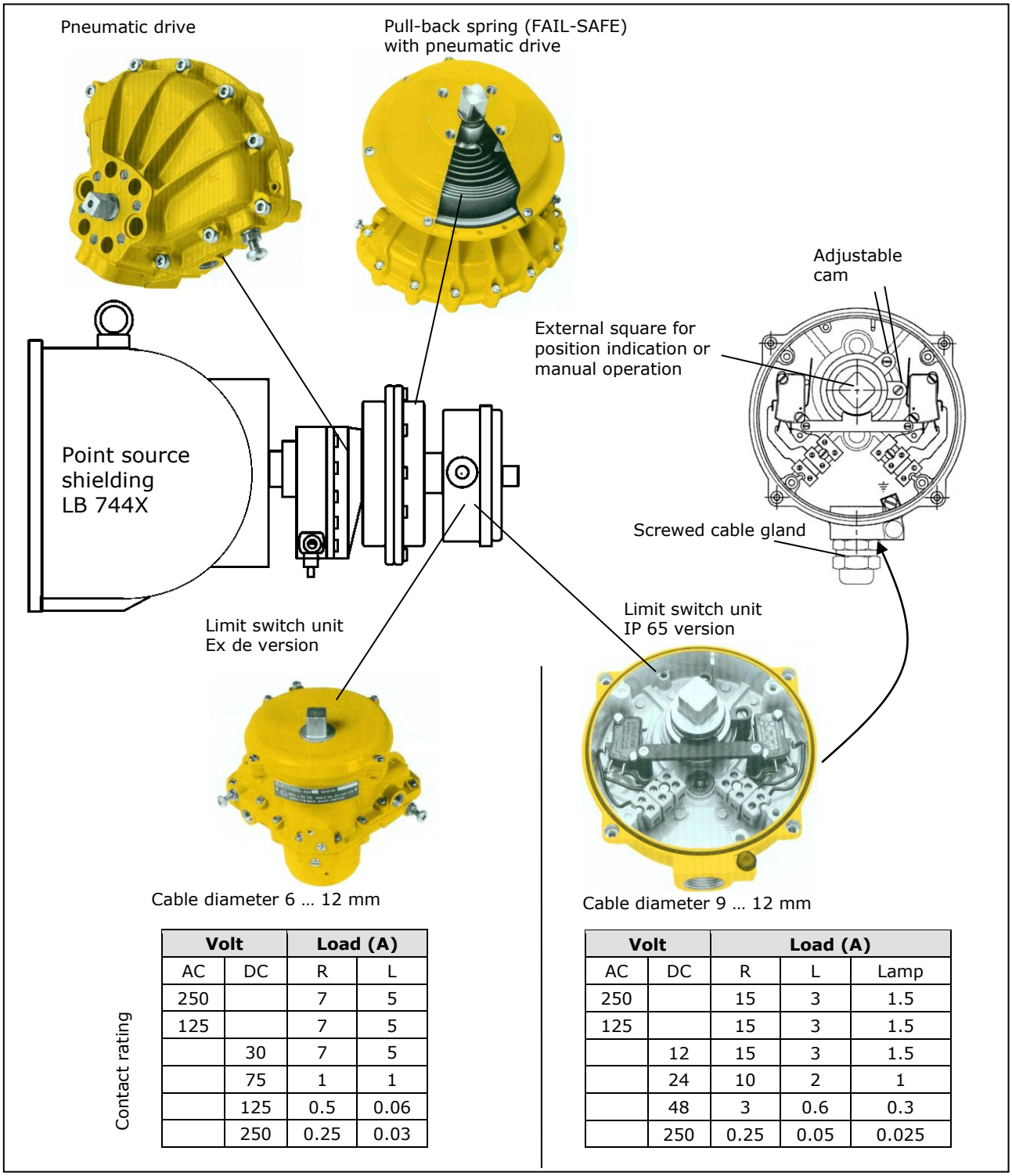
N approx.	Type
390	LB 7440 F CR LB 7440 D CR LB 7440 FE CR LB 7440 DE CR
460	LB 7442 F CR LB 7442 D CR LB 7442 FE CR LB 7442 DE CR
570	LB 7444 CR

ID No. No.	Description
36119	Pneumatic locking drive with limit switch IP 65
80919	Pneumatic locking drive with limit switch, Ex de IIC T6

Data for pneumatic locking drive	
Compressed air:	min. 4 x 105 Pa (4 bar) max. 4 x 105 Pa (7 bar) connection: G 1/8
Air quality:	Clean, as usual for compressed air-tools, oil-free
Temperature range:	-20°C … +80°C

Limit switch unit Options for signaling OPEN / CLOSED	
Option I:	IP 65 2 contact (OPEN/CLOSED) 48 V DC, 1A
Option II:	2 contact (OPEN/CLOSED) max. 250 V AC, 1A, Protection type of micro limit switch: EEx d IIC T6 Case protection type: EEx e II T6
Option III:	2 proximity switches for intrinsically safe feeding

Individual parts of the pneumatic drive



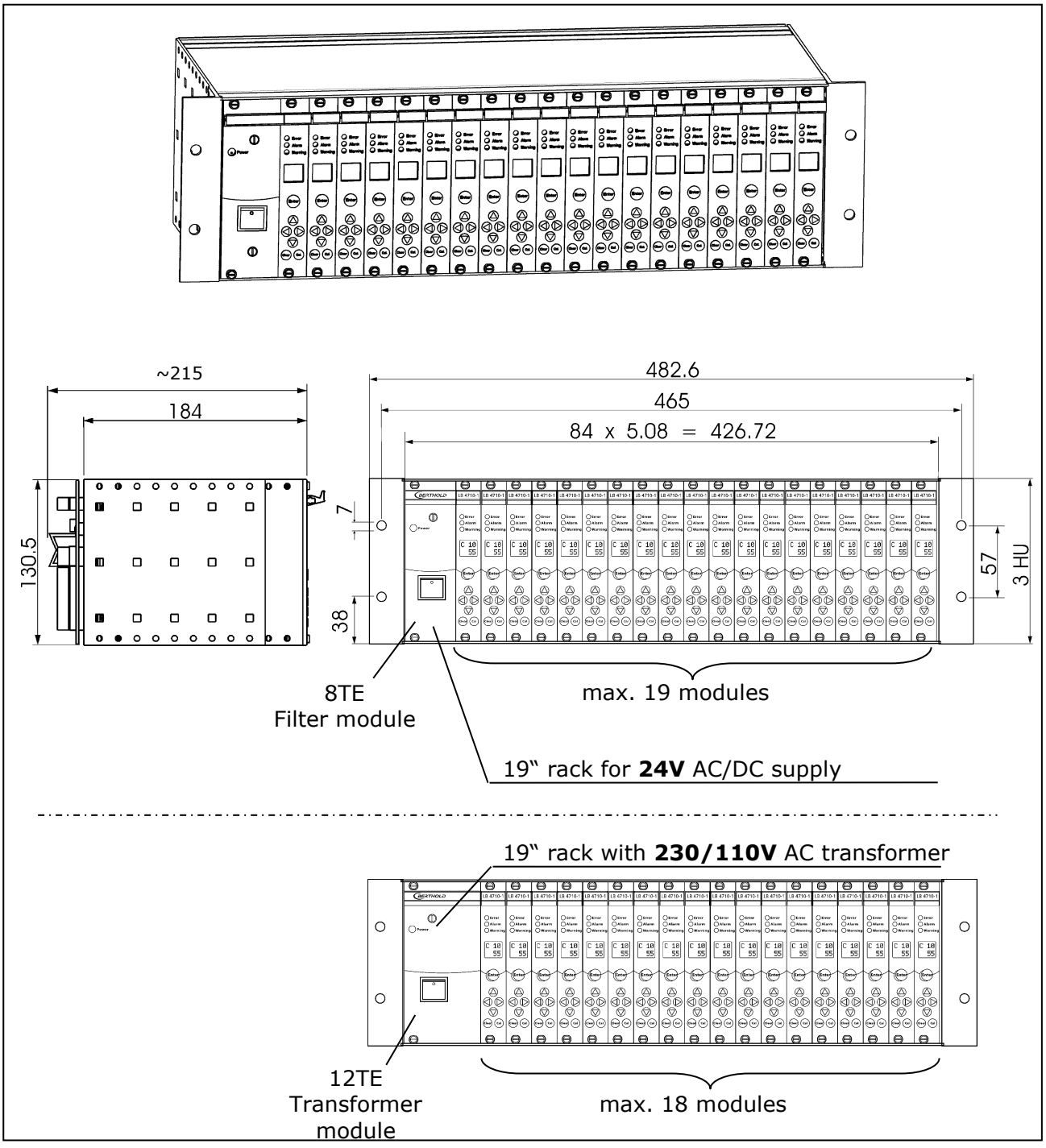
Contact rating

Volt		Load (A)	
AC	DC	R	L
250		7	5
125		7	5
	30	7	5
	75	1	1
	125	0.5	0.06
	250	0.25	0.03

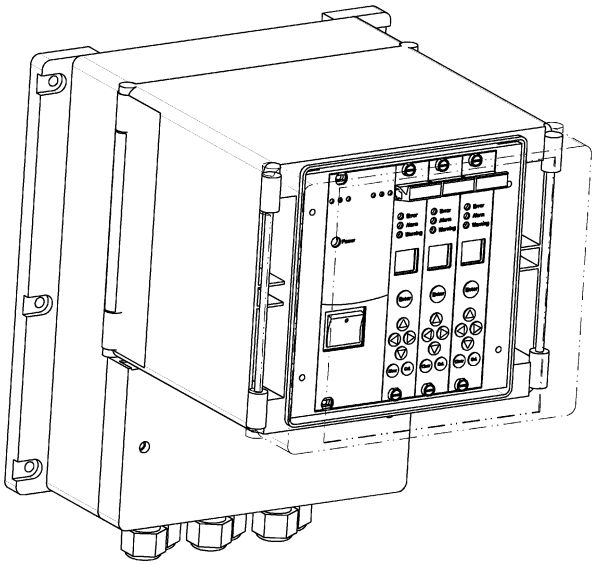
Volt		Load (A)		
AC	DC	R	L	Lamp
250		15	3	1.5
125		15	3	1.5
	12	15	3	1.5
	24	10	2	1
	48	3	0.6	0.3
	250	0.25	0.05	0.025

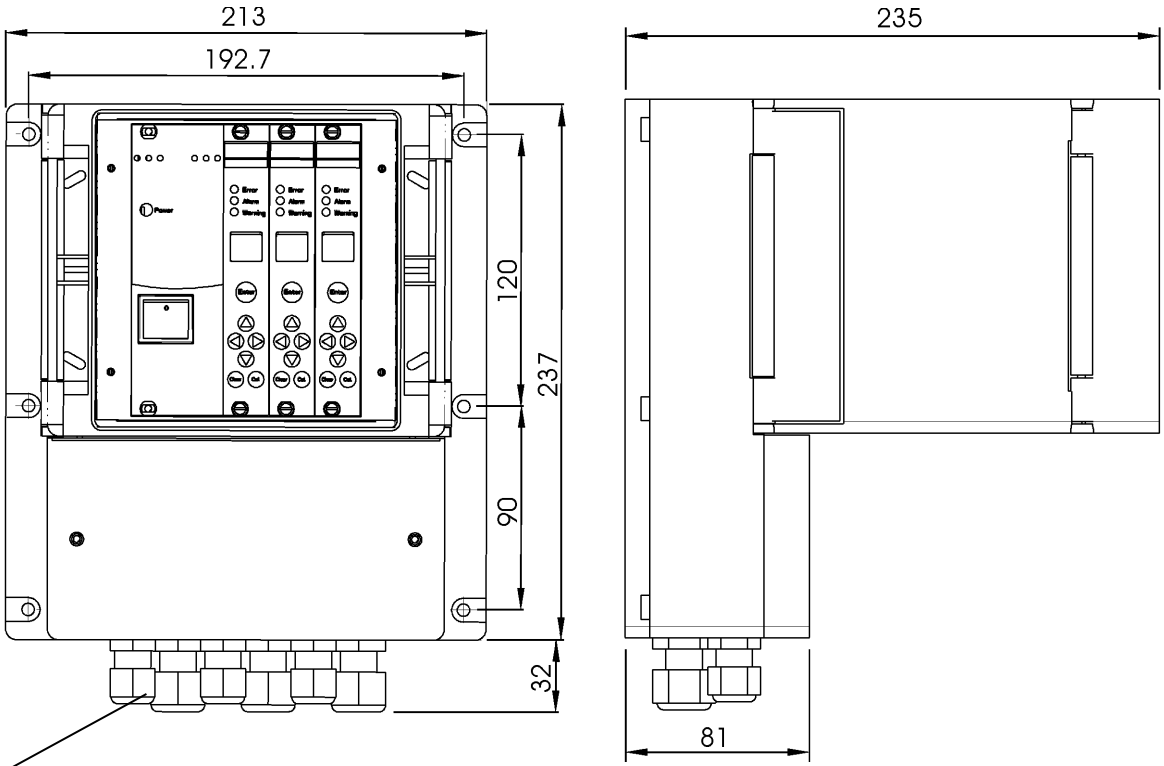
15.5 Dimensions of the Evaluation Unit

15.5.1 19" Rack



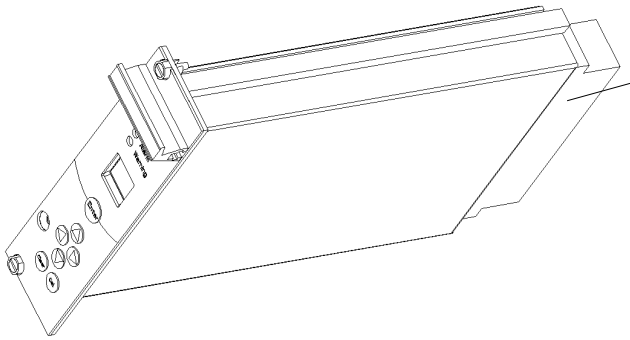
15.5.2 Wall Housing



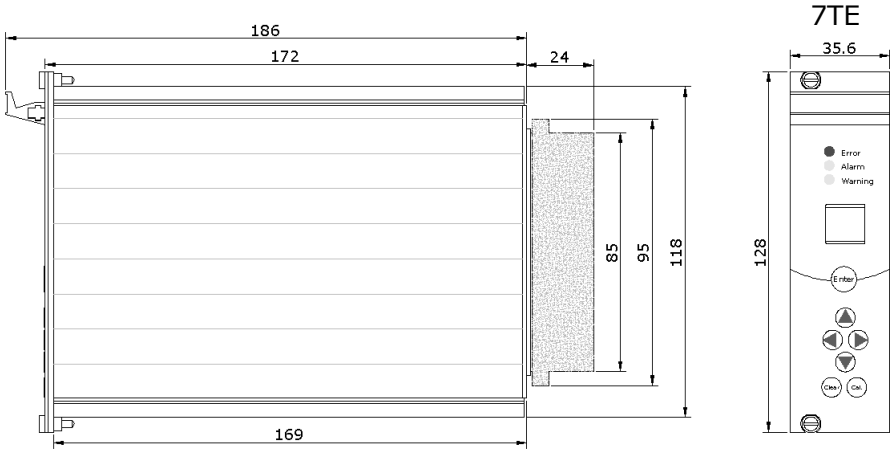


Six screwed cable glands
3 x M12 for cable Ø 4 – 8 mm for detector cable
3 x M16 for cable Ø 6 – 12 mm for out- and inputs

15.5.3 Cassette



Connector strip (Option)
ID No. 42571
For installation in any
19" rack, with plastic divider
for Ex i.



15.6 Connection Diagrams

15.6.1 19" Rack

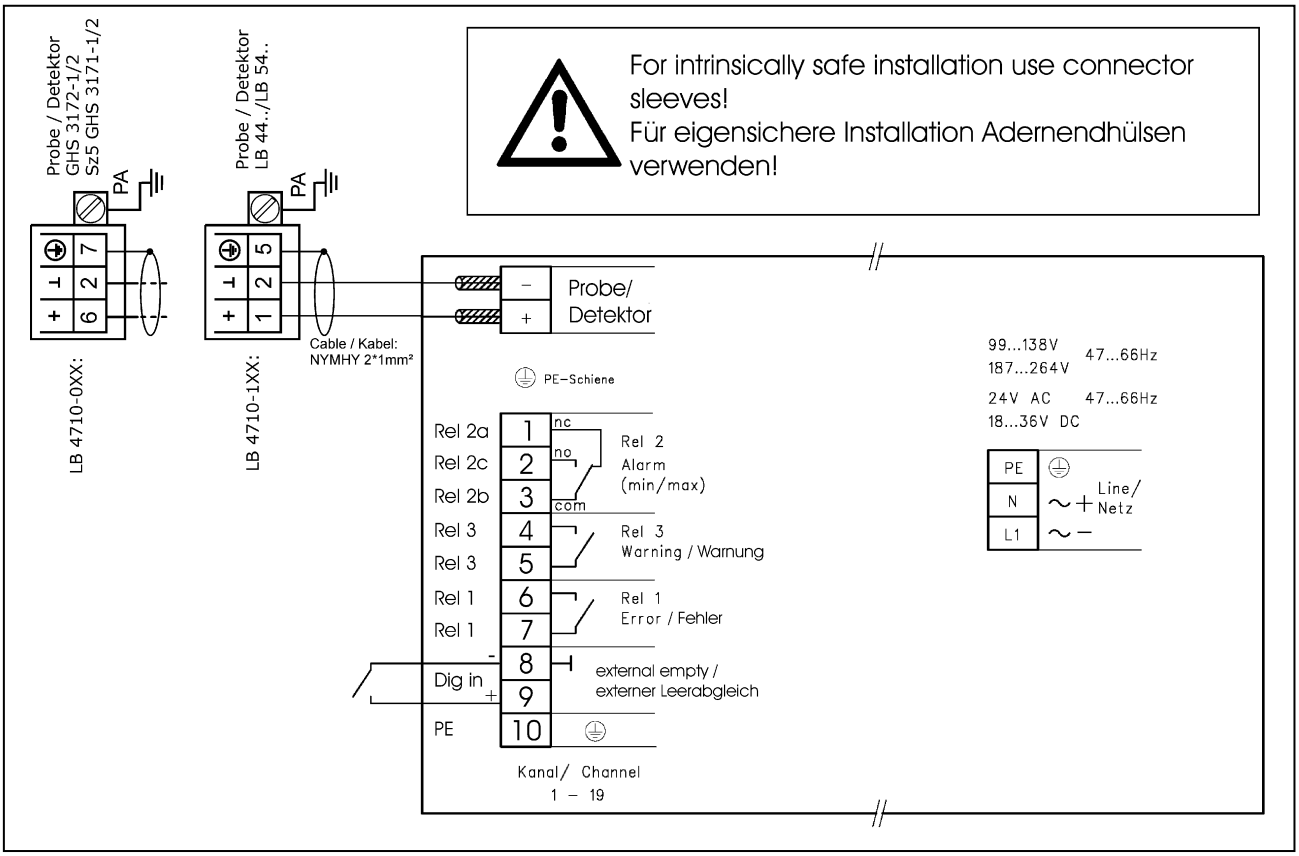


Figure 53: Pin assignment 19" rack

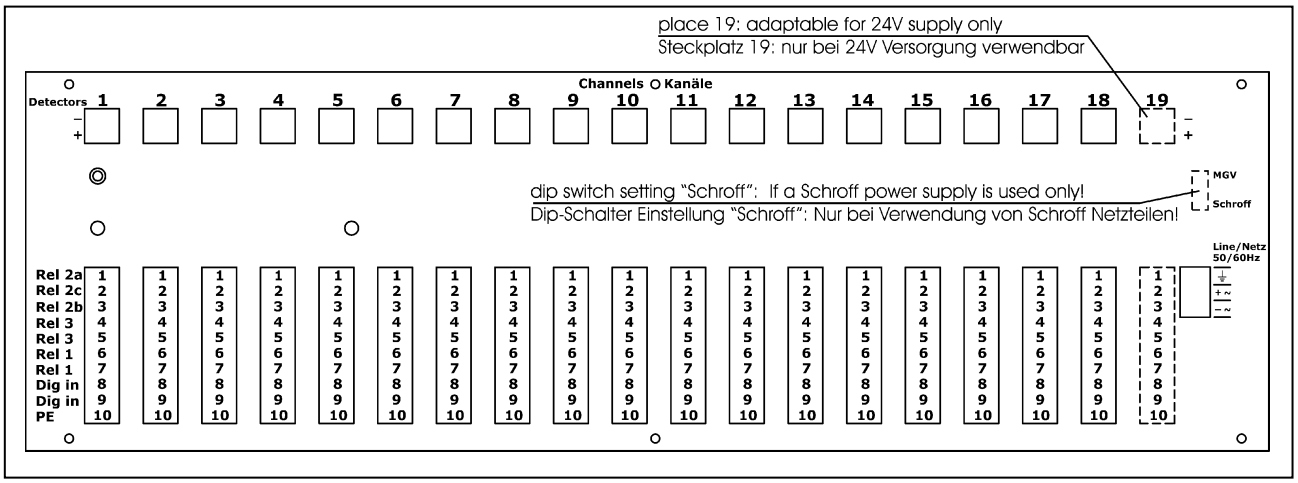


Figure 54: Connection diagram 19" rack

15.6.2 Wall Housing

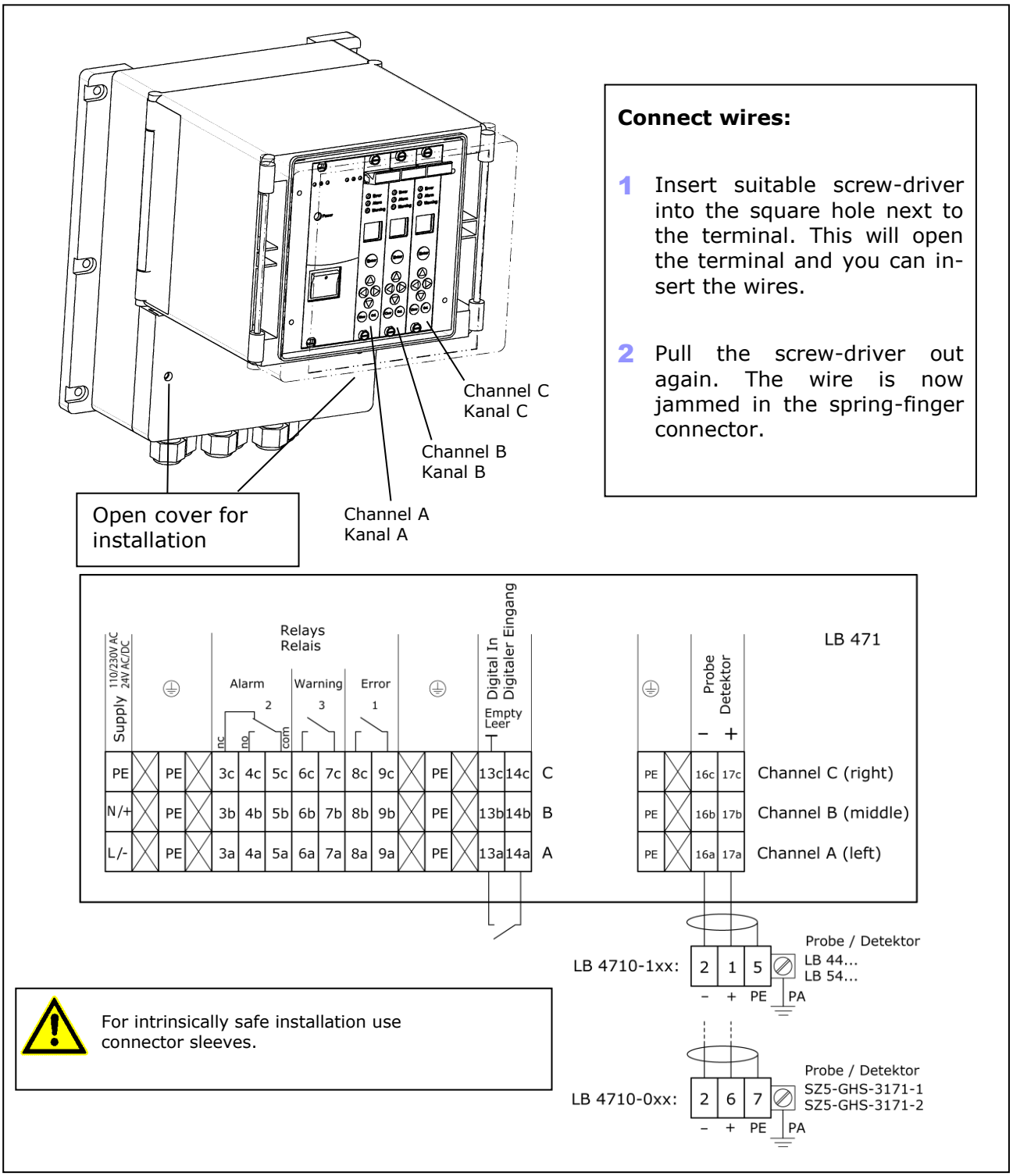


Figure 55: Connection diagram wall housing

15.6.3 Cassette

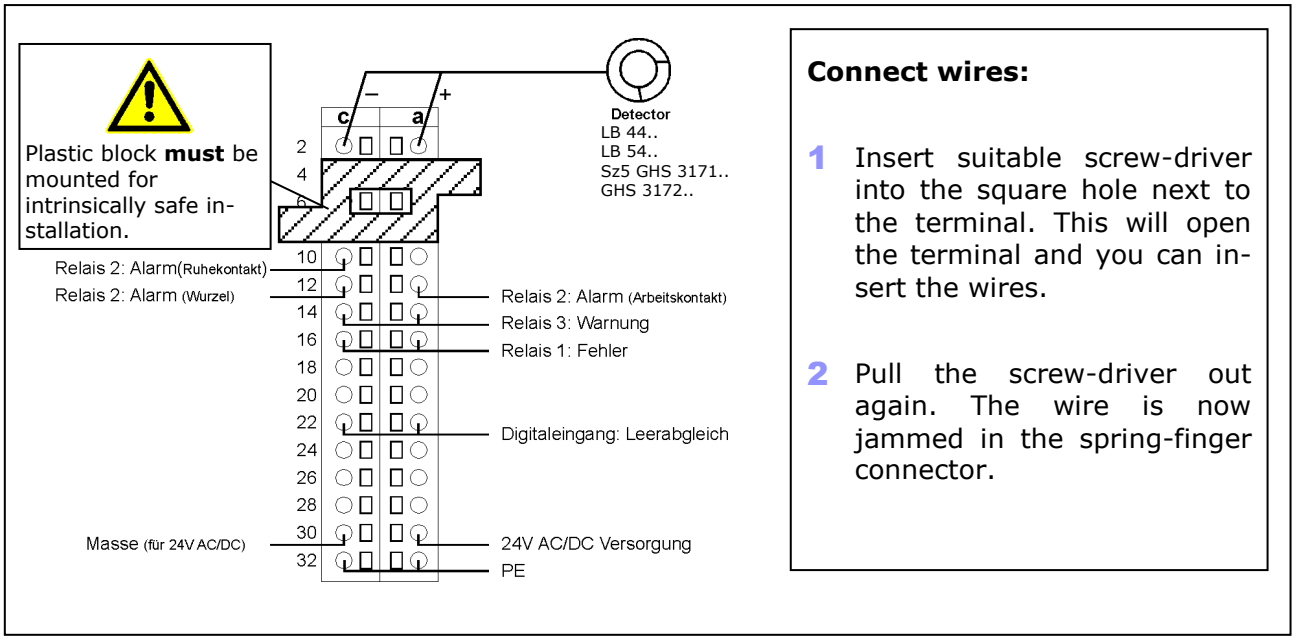


Figure 56: Pin assignment of terminal block

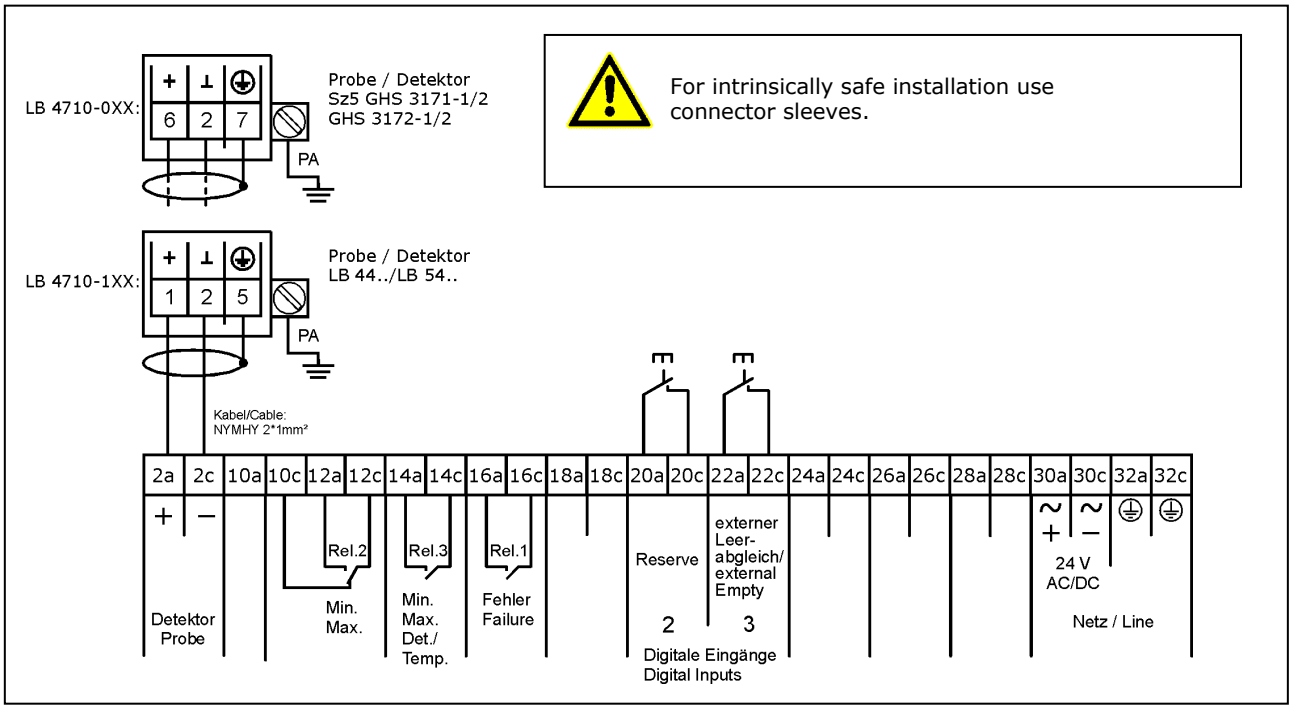
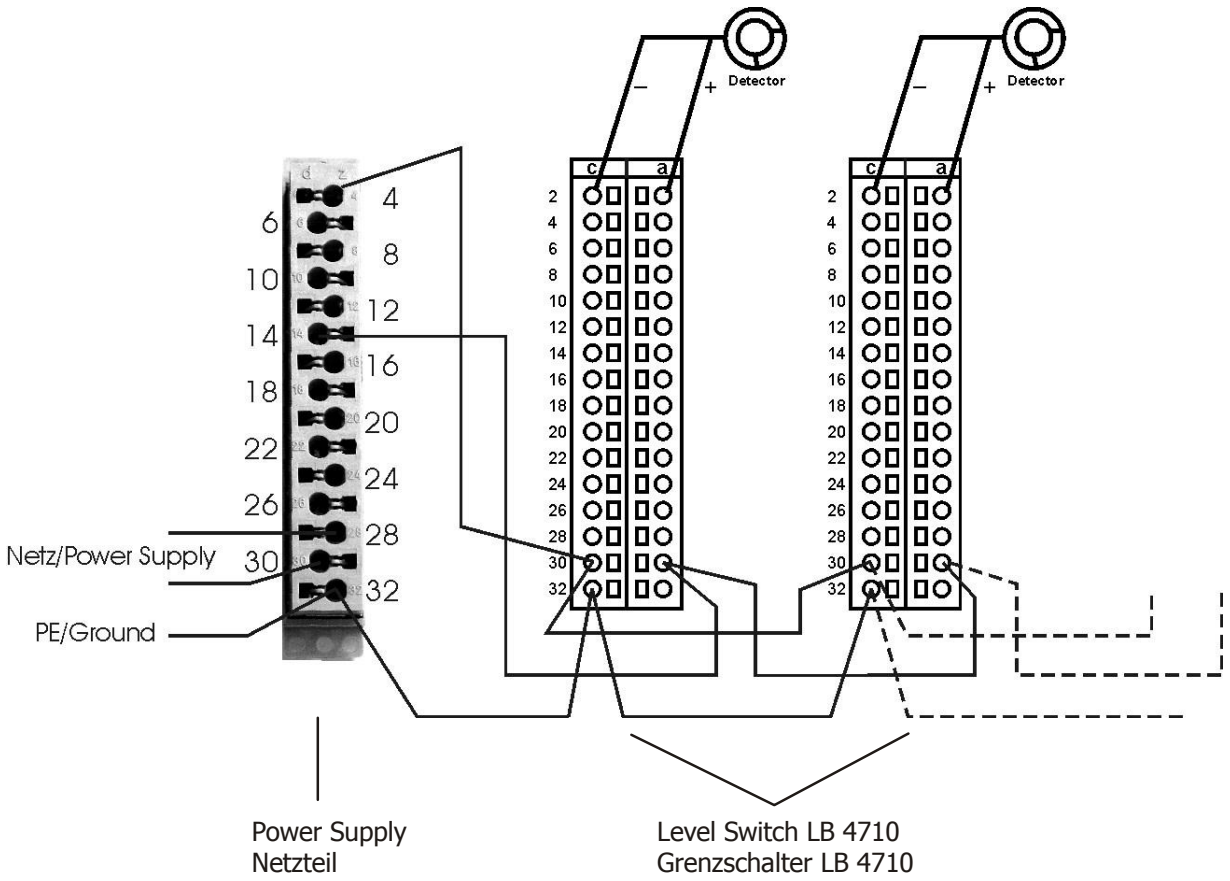
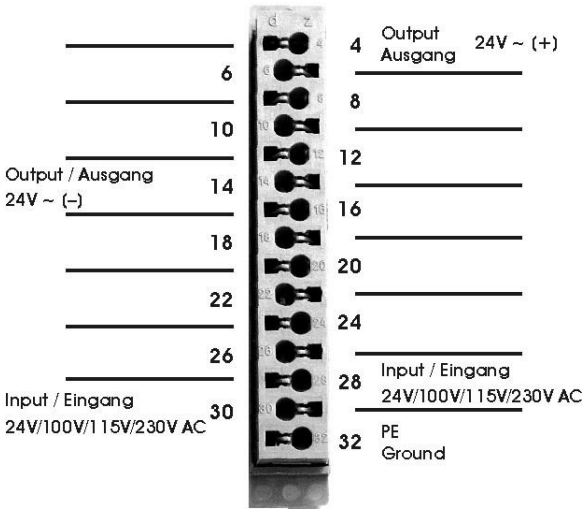


Figure 57: Connection diagram of terminal block

15.6.4 Connection Diagram for Power Supply Unit in 19" Rack



Terminal Block for Power Supply
Steckerleiste für Netzteil



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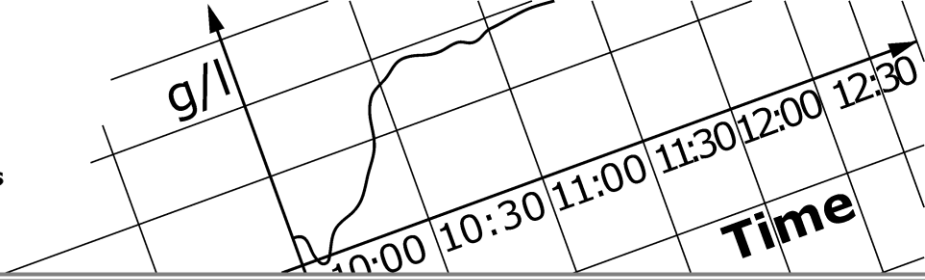
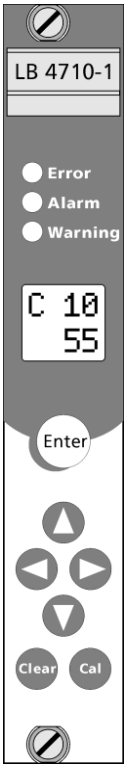


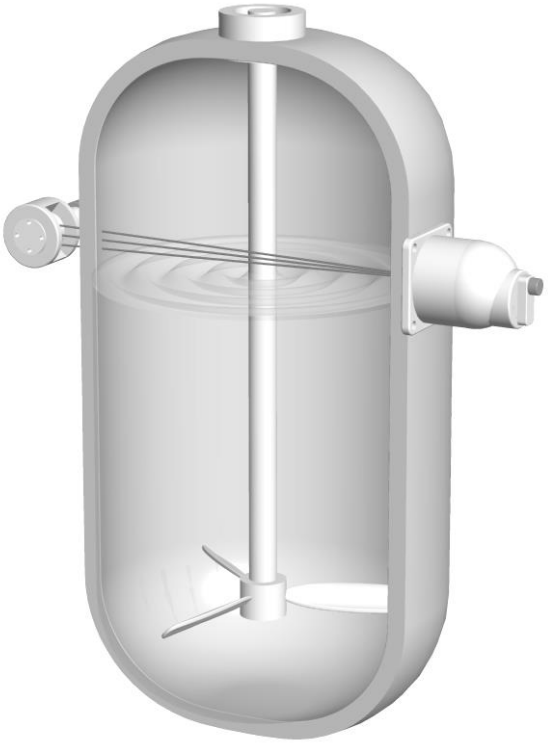
Process Control

detect and identify

Limit Switch
Mini-Switch LB 471

Software Manual





User's Guide

The units supplied should not be repaired by anyone other than Berthold Service engineers or technicians by Berthold.

In case of operation trouble, please address to our central service department.

The complete user's guide consists of two manuals, the hardware description and the software description.

The **hardware manual** comprises:

- mechanical components
- assembly
- electrical installation
- radiation protection guidelines
- technical data
- electrical and mechanical drawings

The **software manual** comprises:

- operation of the evaluation unit
- parameter description
- basic setting
- calibration
- error messages

This manual comprises the software description.

Subject to change in the course of further technical development

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Chapter 1. Definitions

Automatic
The following parameters can be set to automatic or manual mode: In the automatic mode the value is calculated using a formula. Enter -1 to enable the automatic mode. The inverted C in the top row indicates whether a parameter has been set to automatic.

Cassette
Case (7 TE) into which the evaluation unit LB 4710 is installed, so it can be used in any 19" rack

Count rate
Value of counts relative to one second.

cps
Count rate unit: **c**ounts **p**er **s**econd.

Edit
Change value

Edit mode
In this mode, a value can be changed. Not every parameter can be changed since some parameters are only used as display values. Editable Parameters can be set to the edit mode with the "Enter" button. In the edit mode the cursor positioned over a digit is flashing.

Empty
Level below monitoring height

Empty count rate
Count rate with empty container

EVU
Evaluation **U**nit

Operating unit with electronics. Parameters are set and the measurement is calibrated on the EVU. Typically, the EVU is accommodated in the switch room or in a wall housing on site.

Factory setting
All parameters have been preset by the manufacturer using standard values. In most cases this simplifies calibration of the instrument significantly. Despite factory setting, calibration always has to be performed.

Fixed value
Some parameters can be set automatically or manually (see page 14). To set a parameter to manual, you have to enter a fixed value or a value >0.

FSK detector
Detector with digital communication
(FSK = **F**requency **S**hift **K**eying)
FSK detectors are intelligent detectors with self-diagnosis. Information to and from the evaluation unit is transferred via serial data protocols.

All NaI and Super-Sens detectors are FSK detectors
Type designation: LB 54XX and LB 44XX. See also hardware manual.

Full
Level above the monitoring height.

Full count rate	Count rate with full container.
GM detector	Geiger-Müller detector. GM-detectors contain Geiger-Müller counter tubes; they are the classic detectors used in radiation measuring technique. Due to the low zero count rate, they are ideally suited for simple and low-cost limit switch applications.
GMT	**G**eiger-**M**üller-**T**ube GMT is used in this user's guide as short form of GM-detector.
HV	Detector high voltage
Manual	The following parameters can be set to automatic or manual mode: For the manual mode you have to enter a fixed value in the respective parameters. See also under „Automatic".
MBq	Mega-Becquerel This unit indicates the source activity. Each Bq corresponds to one decay per second.
mCi	Milli-Curie This unit is also used for the activity of a source. However, this unit has been replaced by the unit MBq (1mCi = 37 MBq)
mSv	Millisievert Dose rate unit
NaI detector	Detector with sodium iodine crystal and FSK communication. See also hardware manual.
Nuclide / Isotope	Type of radiation source: Cobalt-60 (Co-60) or Cesium-137 (Cs-137) for level measurements.
Parameters	A value stored under a certain code.
Read in count rate	A process that is started by the user in order to determine the average value of the count rate at the respective level. This count rate is needed to calibrate the measurement. The count rate is averaged over a certain time (standard 60 s) to exclude statistical and process-immanent fluctuations.
Statistical fluctuation	An isotope does not emit the same amount of radiation all the time. The radiation emission is subject to statistical fluctuations which are determined and eliminated by the time constant.
Super Sens	Detector with large plastic scintillator and FSK-communication. See also hardware manual.
Switching threshold	Count rate or percentage value upon reaching the measurement level
Timeout	Time after which an automatic reset is performed.
Zero count rate	Count rate caused by natural environmental radiation.

Chapter 2. Operation

2.1 Basics of Operation

Front panel of evaluation unit

2.1.1 Buttons

Enter

- Enable edit mode
  (In windows that cannot be edited, this button is disabled.)
- Exit edit mode; the displayed value is accepted or saved.
- Confirm error.

Left/Right

- Select the digit you want to edit.

Up
Down

- Shows the next or previous code if no digit is flashing. Keep this button pushed down (2s) to accelerate this process.
- Increments or decrements the value of the flashing digit. Keep this button pushed down (2s) to accelerate this process.

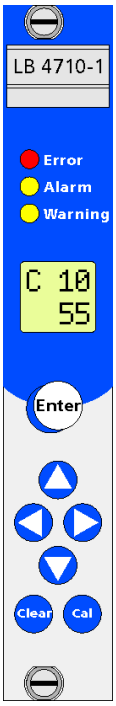
Clear

- Set values to 0 (only in edit mode).
- Exit edit mode without saving the value. To save the value, push the button a second time.
- Interrupt reading-in of the count rate.
- Display code 10
  If the device is not in the edit mode, code 10 is displayed if you keep this button pushed down (2s).

Cal

- Read in empty count rate
  Keep the "Cal." button pushed down more than 2 s.
  (only outside the edit mode).
- Read in count rate
  A count rate parameter, e.g. code 31, has to be in the edit mode.

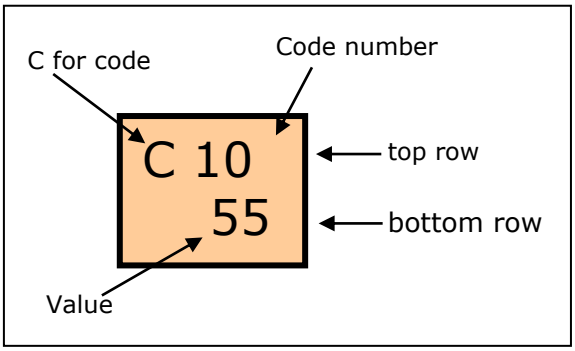
Front panel of evaluation unit



2.1.2 Display

The display is located on the front panel of the evaluation unit.

The display shows in the top row the code number of the parameter and in the bottom row the value of that parameter.



Our example shows a reading of 55% in code 10.

2.1.3 Status LED's

Error LED (red)

Lights up whenever an error is detected.
Whenever the error LED lights up, the error relay indicates an alarm.
See error list on page 66.

Alarm LED (yellow)

Lights up when the monitoring level is exceeded.
Whenever the alarm LED lights up, the alarm relay indicates an alarm.
Depending on the setting, it may follow the error LED.
See code 9.

Warning LED (yellow)

The warning LED can be used in a variety of ways.
See also the following parameters in chapter 3.4:
code 8, 42, 43, 44 and 47.
Whenever the warning LED lights up, the warning relay indicates an alarm.

2.1.4 Count Rate Display

Count rates are displayed in the bottom row. For count rates of 10000 cps and higher a thousands separator is enabled. Thus, it is possible to display count rates >9999 cps on a four-digit display. The digits after the dot are irrelevant for a limit switch.

Count rate	Presentation of count rates on the display
123 cps	0123
1234 cps	1234
12345 cps	12.34
123456 cps	123.4

2.1.5 Select Parameters

Push the arrow keys ▲ / ▼ to select the parameters one after the other.
Most parameter values can be edited. Parameters which only indicate readings cannot be changed (e.g.: result display in code 10).

2.1.6 Edit Mode

To edit the value of a parameter, you have to go to the edit mode. The edit mode is enabled if you push the "Enter" button, provided you have selected a parameter that can be edited. In the edit mode the digit that can be edited is displayed as a flashing digit.

- In the edit mode you can change the value of the digit with the arrow keys ▲ / ▼.
- Push the arrow keys ◄ / ► you can select the next digit.
- Push the Clear button to reset the value to „0".
- Push the Enter button also to exit the edit mode. The last value displayed will be saved.
- To exit the edit mode without changing a value, you have to push the Clear button a second time.

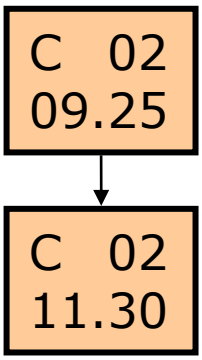
Note!

Entries outside the permissible value range are not accepted. If values are entered incorrectly, the following warning message will be displayed in the top row: „**!!**".

2.1.7 Enter Parameter Value

This process will be explained by using the date in code 02 as an example.

The date (MM.DD) is to be updated.



Old date: 09.25 (September 25)

Current date: 11.30 (November 30)

Enter value:

1 Select code 02 with ▲ / ▼.

2 Select edit mode with Enter – the left digit is flashing.

3 Select the digit you want to edit with ◄ / ►.

4 Edit the respective digit with ▲ / ▼.

5 As soon as all digits match the current date, push Enter to confirm your entry.

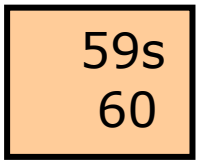
☑ **The value is saved and the edit mode terminated.**

2.2 Reading-in the Count Rate

To determine the count rate at the respective level, the container has to be filled or emptied accordingly. The level must not change while reading in the count rates. Through reading-in, statistical fluctuations are filtered out. You can enter count rates in the following parameters: 30, 31, 32, 18.

1 Reading in count rates is started with the „Cal.“ button.

Push „Clear“ to abort the count rate reading-in process.



While reading in the count rate, the remaining averaging time appears on the display instead of the code number. The averaged count rate is displayed in the bottom row. You can change the start time for averaging in code 37.

2 If the counting time is over, the average value is automatically stored.

☑ **The new count rate has been determined and stored.**

Note!

The process is automatically aborted after 1200 s at the latest.

2.2.1 Measurement Mode

In the regular measurement mode the measured value is displayed in percent in code "10", or the count rate in cps in code 11.
If code 10 (11) is not displayed, push the Clear button (for 2 seconds) to jump to the result display.
The reading in % may fluctuate significantly around 0% if the container is empty, but it must not get close to the switching threshold defined in code 18. To prevent this, the time constant in code 12 has to be big enough or the program has to be set to the automatic mode.

Note!

The reading in % allows you to check the measured values during operation. If you get significantly different values, for example, due to product caking, you may perform a re-calibration any time.

20 minutes after a button has been pushed for the last time, the program automatically goes to code 10 or code 11, provided these codes are not yet displayed. In code 15 you can define if code 10 or code 11 is the standard result display.

2.2.2 Automatic and Manual Mode

The following parameters can be set to automatic or manual mode:
Code 12, 17, 18, 19, 31, 53, 55 (see chapter 3.4).

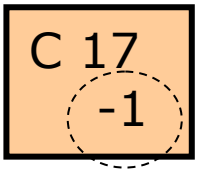
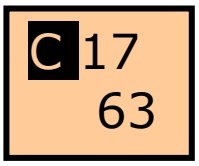
Manual mode

In the manual mode, the above parameters are set to a fixed value.

Automatic mode

Enter -1 to enable the automatic mode.
The value of the respective parameter is calculated automatically in the automatic mode.

Example with code 17, switching threshold in %:

Enter -1!	
After you have pushed the Enter button, an automatically calculated value appears in the second row. The inverted C shows that this parameter calculates its value automatically.	

Note!

To rule out that you change from automatic operation to manual operation by mistake, a manual input value must always differ from an automatic value.

Set parameters to automatic mode

1. Select the respective parameter.
2. Enable edit mode with Enter
3. Push Clear to delete value, if there is any
4. Push ▲ to set first digit to the right to „1".

5 Push ◀ to select the second digit from the right.

6 Set digit with ▼ button to „–„.

7 Confirm with Enter.

☑ **The selected parameter is set to the automatic mode. The C in the top row is displayed inverted.**

Turn off automatic mode

The automatic mode of a parameter can be overwritten any time by entering a fixed value >0 to set the instrument to the manual mode.

1 Select the respective parameter.

2 Enable edit mode with Enter

3 Enter numerical value > 0.

☑ **The selected parameter is set to the manual mode by entering a fixed value. The C in the top row is no longer inverted.**

Chapter 3. Parameters

3.1 Standard Mode / Professional Mode

The operation mode is set in code 04. The following table explains the differences between standard and professional mode.

Table 1: Operation modes Standard / Professional

	Standard mode	Professional mode
Operation	Simple	Access to all additional functions. See parameter list on page 19.
Factory setting	Standard mode is preset by the manufacturer.	
Parameters	Only the major parameters are available.	All parameters are available.
Calibration	Calibration is performed automatically by reading in the empty count rate.	First, all parameters have to be set. You can start a calibration only in code 36.
Behavior of auto / manual parameters during calibration	These parameters are set to automatic to speed up the getting started process.	These parameters are not affected during calibration.
Calibration error	Possible calibration errors are indicated as soon as you start empty calibration.	Possible calibration errors are indicated only after you have started calibration with code 36.
Change between professional and standard mode	**All settings are retained.** The special parameters for the professional mode are hidden.	**All settings are retained.** The special parameters for the professional mode can be displayed in addition.

3.2 Standard Mode Code Table

Table 2: Code table for standard mode

Code no.	Designation	Value range	Factory setting	Page
00	Password	0000 - 9999		21
01	Year	1970 - 2099	Current year	21
02	Month / Day	01.01-12.31	Current date	21
04	Operation mode 0 = Standard 1 = Professional	0 - 1	0	22
05	Detector code	0 - 99	0 or 99	22
06	Nuclide 0=Co60, 1=Cs-137	0 - 1	0	22
10	Reading (%)	-999 - 9999	Reading	25
11	Reading in cps averaged	0 - 999.9	Reading	25
16	Max. or min. limit value switch 0=Max, 1=Min	0 – 1	0	27
20	Empty count rate (no input)	0 - 999.9	Reading	19
21	Full count rate (no input)	0 - 999.9	Reading	29
22	Zero count rate (no input)	0 - 9.999	Reading	30
32	Zero count rate	0 - 9.999	Depending on detector code	32
39	Half-value layers	1-9	2	37
50	Limit switch software	1.00 - 9.99	Version	41
51	Detector software (only FSK detector)	1.00 - 9.99	Reading	41
52	Detector temperature °C (only FSK detector)	-40 – 80	Reading	41
53	Detector high voltage (only FSK detector)	500 - 1300	-1	42
54	Detector HV-default (only FSK detector)	500 - 1300	Set in factory	42

The same table is shown on page 75 with an empty column. In this column you may enter your data after start-up.

3.3 Professional Mode Code Table

Table 3: Code table for professional mode

Code no.	Designation	Value range	Factory setting	Page
00	Password	0000 - 9999		21
01	Year	1970 - 2099	Current year	21
02	Month / Day	01.01-12.31	Current date	21
03	Hour / Minute	00.00-23.59	Current time	22
04	Operation mode Standard/Professional	0 - 1	0	22
05	Detector code	0 - 99	99	22
06	Nuclide 0=Co60, 1=Cs-137	0 - 1	0	22
07	Automatic password protection	0 - 9999	0	23
08	Warning relay as second alarm relay	0 – 1 10 – 100	0	23
09	Alarm relay follows the error relay	0 - 1	0	25
10	Reading (%)	-999 - 9999	Reading	25
11	Average count rate	0 - 999.9	Reading	25
12	Time constant (s)	0,1 – 999,9	-1	25
13	Live count rate	0 - 999.9	Reading	26
14	Maximum time constant (s)	0 - 999	999	26
15	Standard reading	10 - 11	10	26
16	Max. or min. limit value switch 0=Max, 1=Min	0 - 1	0	27
17	Switching threshold (%)	0 - 100	-1	27
18	Switching threshold in (cps)	0 - 999.9	-1	28
19	Hysteresis (%)	0 - 999	-1	29
20	Empty count rate (no input)	0 - 999.9	Reading	19
21	Full count rate (no input)	0 - 999.9	Reading	29
22	Zero count rate (no input)	0 - 9.999	Reading	30
30	Empty count rate	0 - 999.9	20 GMZ 300 FSK	
31	Full count rate	0 - 999.9	-1	31
32	Zero count rate	0 - 9.999	Depending on detector code	32
33	Measuring path (in mm)	0 - 9999	0	33
34	Gas density (kg/m³)	0 - 9999	0	33
35	Bulk density (kg/m³)	0 - 9999	0	34
36	Compute	35.01–35.08	Reading	35
37	Counting time for calibration (s)	5 - 600	60	36
38	Bulk cone diameter (mm)	0 - 9999	0	37
39	Half-value layers	1 - 9	2	37

Table 3: Code table for professional mode

Code no.	Designation	Value range	Factory setting	Page
40	Interference radiation detection	0 - 1	0	38
41	Waiting time after interference radiation	0 - 999	20	39
42	Signaling interference radiation	0 - 2	0	39
43	Signaling unlocked	0 - 2	0	39
44	Signaling minor errors	0 - 2	1	40
45	Signaling excess temp. detector (only FSK detector)	0 - 2	0	40
46	Temperature threshold detector (only FSK)	0 - 99	40	40
47	Signaling excess temp. EVU	0 - 2	0	41
48	Temperature threshold EVU	0 - 99	85	41
50	Limit switch software	1.00 - 9.99	Version	41
51	Detector software (only FSK)	1.00 - 9.99	Reading	41
52	Detector temperature °C (only FSK detector)	-40 - 80	Reading	41
53	Detector high voltage (only FSK)	500 - 1300	-1	42
54	detector HV start value (only FSK)	500 - 1300	HV default	42
55	Source replacement	00.00 - 99.12	-1	42
56	Evaluation unit electronics temperature	-100 - 200	Reading	43
60	Test pulse generator	0 - 999.9	0	43
61	Test error relay	0 - 2	0	44
62	Test alarm relay	0 - 2	0	44
63	Test warning relay	0 - 2	0	44
64	Test display			44
65	Test keyboard			44
66	Status digital in	00.00 - 01.01	Reading	45
67	HV max for plateau measurement	500 - 1300	1000	45
68	Detector plateau measurement (only FSK)	0 - 5	0	45
70	Error log	0 - 1	0	47
71	Revision log	0 - 1	0	48
72	Save & Load / Reset	0 - 99	0	49

Code numbers that are not listed in this table are not used or empty and are skipped on the display.

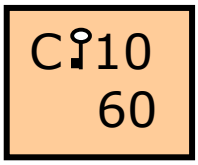
The same table is shown on page 76 with an empty column. In this column you may enter your data after start-up.

3.4 Parameter Description

Code numbers which are visible **only** in the professional mode, e.g. CODE 03, are displayed with a shaded background.

CODE 00 Password

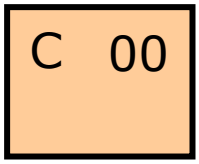
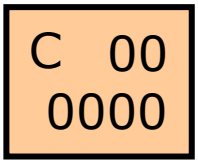
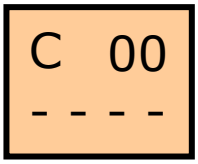
Lock system by entering a 4-digit number



If the device is locked, all codes can be read but not edited. If the device is locked, a **key** appears on the display for all parameters.

- To lock the device, you have to enter a digit unequal to zero. This is the password which can be used to unlock the device again.
- To delete the password, you have to enter 0000. The password can only be deleted when the device is unlocked.

The following illustration explains the display when code 00 is selected.

		
No password known!	Password known! Device not locked!	Password known! Device locked!

CODE 01 Year

Display or enter current year

The year is needed to compensate for the decay of the count rates. Since the activity of the source decreases in the course of time, the count rates have to be compensated for automatically using the date. Therefore, the date always has to be kept up-to-date. The device includes a capacitor-buffered real-time clock, which keeps counting the current time for about 1 month even if the device is turned off.
The device signals a date error if it detects any significant deviation between the actual date and the date last stored. However, the device continues to work with the stored date.

CODE 02 Month/Day

Display or enter current date

The date is entered and displayed in the format MM.DD.
See code 01.

CODE 03 Hour/Minute

Display or enter current time
(Only in the professional mode)

The time is entered and displayed in the format hh.mm.
The time virtually has no influence on the decay compensation; therefore, it does not really need to be set. However, it may be used for test purposes.

CODE 04 Operation mode

Define operation mode

Input	Operation mode
0	Standard mode
1	Professional mode

See operation modes on page 17.

CODE 05 Detector code

Enter detector code for the detector used:

Input for detector code	Designation	Detector type
0	LB 440X	NaI detector (FSK)
0	LB 540X	
23	LB 443X	Super Sens (FSK)
23	LB 543X	
98	SZ5 GHS 3171-2	GM detector
98	GHS 3172-2	
99	SZ5 GHS 3171-1	
99	GHS 3172-1	

The correct detector code is required for the high voltage control and the basic setting of the zero count rate. If the detector code is changed, the standard calibration values of the selected detector are automatically set in code 20, 21 and 22.

CODE 06 Nuclide

Define isotope (source) used

Input	Isotope
0	Co-60
1	Cs-137

This information is needed to calculate the decay compensation.

CODE 07 Automatic password protection

Enable automatic password protection
(Only in the professional mode)

Input	Automatic password protection
0	Disabled
>20	Enabled

To enable automatic password protection, you have to enter a time in minutes. The value must be >20.
For example 21 for 21 minutes
The device locks itself automatically as soon as this time (after the last button operation) is over.

You can only enter one digit in code 7 if a password is known in code 0. For this purpose, the device must have been locked at least once using a password.

CODE 08 Warning relay as second alarm relay

Enable warning relay as second, redundant alarm relay.
(Only in the professional mode)

Input	Function of second alarm relay
0	Disabled
1	as redundant alarm relay
10-100	switching point in % level of code 10

Redundant alarm relay

If the warning relay is working as a second redundant alarm relay, it may be evaluated in series with the alarm relay by the process control system. This will increase the signal safety in case the limit value is exceeded. For an alarm status may still be displayed as reliable if, for example, the contacts of the alarm relay stick together.

Second alarm relay (EVU soft version 1.01 and higher)

The function is foreseen for „requirement-oriented maintenance". It helps, for example, to discover wall caking at an early stage, because wall caking may result in switching errors.

A switch point between 10 to 100% can be set.

Since this function also triggers an alarm when the level changes, a time window has to be set in the PCS which detects the difference between caking and actual level changes.[1] As soon as the warning relay for the wall caking has been enabled, the alarm relay also has to be triggered within e.g. 10 minutes. If the alarm relay does not respond within these 10 minutes, then the signal of the warning relay has to be interpreted as a maintenance alarm in the PCS[1]. For the function to work properly, the time constant has to be set manually to a value to ensure that in the regular course of operation this alarm will not be triggered by statistical fluctuations, but only if a wall caking is actually building up. When setting the time constant to manual, the source decay has to be taken into account as well. Because the source decay requires a larger time constant to ensure that the device will work without stepping errors even after several years.

Example with CS -137 source:

Empty count rate: 300 cps
Full count rate: 40 cps
Warning relay: 30%
Alarm relay: 60%
Maximum fluctuation margin permitted: ±10% (means the reading may not vary by more than ±10%)

1) Calculation of fluctuation margin in cps:
ΔI = 10% of (300-40) = 0.1 x 260 = ±26 cps

2) Calculation of the required time constant:

$T = 18 \times I_{Empty} / (\Delta I_{Empty})^2 = 18 \times 300 / 26^2 = 8s$

The time constant has to be set to 8s in order to limit the maximum fluctuation margin to ±10%.

For a Co-60 source, the source decay has to take into account for the expected service life of the measurement. For a Cs-137 source, the source decay for a service life of approx. 10 years is virtually negligible.

Note!

Automatic monitoring for source replacement is not possible any more when working with a manual time constant. To signal a necessary source replacement, you have to enter the year in which the source replacement is to be indicated in code 55.

[1] PCS = process control system

CODE 09 Reaction of the alarm relay in case of error

Define reaction of alarm relay in case of error
(Only in the professional mode)

Input	Reaction of alarm relay in case of error
0	Alarm relay holds the last status
1	Alarm relay follows the error relay

You have to define if the alarm relay should follow the error relay in case of error.

CODE 10 Reading (%)

Live reading in % level

The reading is dependent on the count rate in code 11 and the measuring range in code 20 and 21, corresponding to 0 to 100%.
The averaging of the reading is dependent on the time constant in code 12.
To be able to jump quickly to code 10 it suffices if you keep the Clear button pushed down for 2 seconds. Prerequisite is that you are not in the edit mode and that code 10 is the standard result display. The standard result display is set in code 15.

CODE 11 Reading (cps)

Live reading in counts per second

The averaging of this count rate is dependent on the time constant in code 12.

CODE 12 Time constant (s)

Time constant for reading averaging
(Only in the professional mode)

Input	Time constant on:	Code
-01.0	Automatic	C
>0	Fixed value	C

If you enter [-01.0] (factory setting), the time constant is averaged automatically. The time constant is continuously adapted to the source decay and is set optimally.
For further explanations see page 66.
A fixed value will be accepted only if the input is equal or greater than the automatically determined time constant.

The dot in the displayed result is a decimal point which separates seconds from tenths of a second.

Note!

Leave the time constant on automatic unless there are good reasons for entering a fixed value.

If you enter a fixed value as time constant, you should keep in mind that a fixed value does not adjust to the source decay. Therefore, enter a value that ensures a safe switching function even after 10 years.
Rule of thumb: automatically calculated time constant x 10.

If the container is under high gas pressure or if significant wall caking is to be expected, then it is absolutely essential that you enter a fixed value. The value should be so great that possible gas density variations or wall caking cannot trigger the alarm.
Rule of thumb: automatically calculated time constant x 30.

CODE 13 Live count rate (cps)

Display of non-average count rate.
(Only in the professional mode)

The displayed count rate comes directly from the detector and is not averaged by the time constant.

CODE 14 Maximum time constant (s)

Upper limit of time constant in code 12
(Only in the professional mode)

Input	Maximum time constant
0	Disabled
> Code 12	Enabled

If the time constant in code 12 is set to automatic, then the time constant in code 12 is automatically increased or adapted to the source decay, so that no false alarm can be triggered by statistical fluctuations. To avoid that the time constant may become too big over the years, you can here enter a value that triggers an alarm as soon as the time constant in code 12 exceeds this value. The display shows the error message 39.01 "Replace source". Code 55 shows the year in which the message is likely to be output.
Please keep in mind: If a fixed value has been entered in code 55, then the error message "Replace source" is displayed as soon as this date is exceeded. Code 14 is then disabled.

CODE 15 Standard reading display

Define standard reading display
(Only in the professional mode)

Input	Standard reading
10	Code 10
11	Code 11

Here you can define to which reading the display will jump if no input has been made for 20 minutes.

CODE 16 Minimum / Maximum Limit Switch

Define mode of operation of the limit switch

Input	Alarm relay function
0	Max. alarm switch
1	Min. alarm switch

Here you can define if the alarm relay should switch as max. or min. alarm.

If set correctly, the relay drops out and the contact between terminal 12a and 12c is open if an alarm is triggered.

Max. alarm switch:

If an alarm is to be triggered in case of overfilling.

Min. alarm switch:

If an alarm is to be triggered in case of underfilling.

CODE 17 Switching threshold (%)

Switching threshold in percent
(Only in the professional mode)

Input	Limit value	Code
-1	Automatic	C
>0	Fixed value in %	C

If the switching threshold is exceeded, the device indicates an alarm.
If the switching threshold is set to automatic (factory setting), it is already set up optimally. If you wish to set another switching threshold, you can enter a fixed value in % level.
You can enter the switching threshold either as a percentage value in this code or in code 18. Every entry in this code automatically calculates the new count rate in code 18. Vice versa: If you enter a fixed value (count rate) in code 18, then the percentage value in code 17 is calculated new.

Note!

Correct selection of the switching threshold is important for a reliable function of the limit value switch. To avoid false alarms if the switching threshold has been set using a fixed value, the time constant has to be set to automatic, or it has to be calculated accurately.

Perform a calibration in code 36 to check if your setting is correct.

CODE 18 Switching threshold in (cps)

Switching threshold in counts/second
(Only in the professional mode)

Input	Limit value	Code
-1	Automatic	C
>0	Fixed value in %	C

If the switching threshold is exceeded, the device indicates an alarm.
If the switching threshold is set to automatic (factory setting), it is already set up optimally. If you wish to set another switching threshold, you can enter a fixed value in cps.
You can enter the switching threshold either as a percentage value in this code or in code 18. Every entry in this code automatically calculates the new count rate in code 18. Vice versa: If you enter a fixed value (count rate) in code 18, then the percentage value in code 17 is calculated new.

The calibration of bulk cone measurements switching at a certain bulk cone diameter is described on page 62.

Note!

Correct selection of the switching threshold is important for a reliable function of the limit value switch. To avoid false alarms if the switching threshold has been set using a fixed value, the time constant has to be set to automatic, or it has to be calculated accurately.

Perform a calibration in code 36 to check if your setting is correct.

CODE 19 Hysteresis (in %)

Hysteresis in percent
(Only in the professional mode)

Input	Hysteresis	Code
-1	Automatic	C
>0	Fixed value in cps	C

The hysteresis increases the safety of the device by reducing the risk of switching errors due to statistical fluctuations. The hysteresis lies symmetrically around the switching threshold. Data is entered or displayed as percentage value between 0 and 100%.
If the hysteresis is set to automatic (factory setting), it is already set up optimally and is constantly updated.

Note!

Perform a calibration in code 36 to check if your setting is correct.

CODE 20 Empty count rate (cps)

Display of empty count rate used by the device for measurement

This parameter serves only for display.
The value is continuously decay-corrected.

Depending on the operation mode, this value is determined as follows:

Standard mode	Professional mode
automatically following empty calibration.	based on code 30 as soon as a calibration in code 36 has been performed.

CODE 21 Full count rate (cps)

Display of full count rate used by the device for measurement

This parameter serves only for display.
The value is continuously decay-corrected.

Depending on the operation mode, this value is determined as follows:

Standard mode	Professional mode
based on code 39 as soon as empty calibration has been performed.	based on code 30 or code 31 (depending on setting) as soon as a calibration in code 36 has been performed.

CODE 22 Zero count rate (cps)

Display of zero count rate used by the device for measurement

This parameter serves only for display.

Depending on the operation mode, this value is determined as follows:

Standard mode	Professional mode
based on code 32 as soon as empty calibration has been performed.	based on code 32 as soon as calibration in code 36 has been performed.

CODE 30 Empty count rate (cps)

Read in or enter empty count rate
(Only in the professional mode)

Input	Function
„Cal" button	Read in count rate
>0	Fixed value

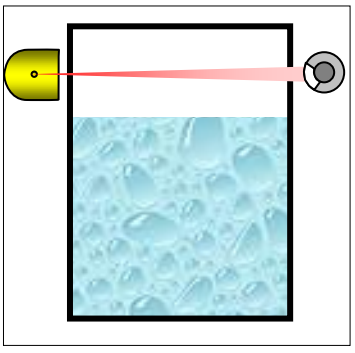


Figure 1: Level below monitoring level

Carry out empty calibration at a level below the monitoring height. Read in the count rate at this level.

The empty count rate can either be:

- read in or
- typed in on the keyboard.

Reading-in the empty count rate:

- Select code 30.
- Push "Enter" to get to the edit mode
- Push the „Cal" button.
- As soon as the counting time is over, the new count rate is stored. The counting time can be set in code 37.

See page 12 for more information on reading in count rates.

Note!

The empty count rate will be used for measurement only after you have set all necessary parameters and have performed a calibration with code 36. The calibration value will then be transferred to code 20. See page 60 for further information on empty calibration.

CODE 31 Full count rate (cps)

Read in, enter or automatically calculate full count rate (Only in the professional mode)

Input	Function
„Cal" button	Read in count rate
>0	Fixed value
-1	Calculate automatically

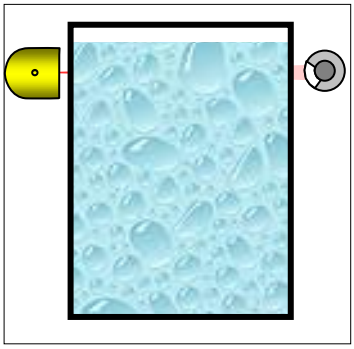


Figure 2: Full container

Carry out full calibration at a level above the monitoring height. Read in the count rate at this level.

Reading-in the full count rate:

- Select code 31.
- Push "Enter" to get to the edit mode
- Push the „Cal" button.
  As soon as the counting time is over, the new count rate is stored. The counting time can be set in code 37.

See page 12 for more information on reading in count rates.

Calculate full count rate automatically:

➢ Enter -1.

The count rate is calculated automatically and continuously updated depending on the half-value layers defined in code 39 and the empty count rate. If values have been set in code 33 and 35, the full count rate is calculated based on these values instead of the data in code 39.

Note!

The full count rate will be used for measurement only after you have set all necessary parameters and have performed a calibration with code 36.
The calibration value will then be transferred to code 21.

For critical applications we recommend reading in the full count rate.

CODE 32 Zero count rate (cps)

Read in or enter zero count rate

Input	Function
„Cal" button	Read in count rate
>0	Fixed value

For more information on the zero count rate see page 58.

The zero count rate is important because it ensures that the count rates in code 20 and 21 are correctly decay-compensated.
The zero count rate has to be determined without radiation being emitted by the source. Therefore, it should be measured before the source has been installed. The bigger the scintillator, the more important the determination of the zero count rate. **If you are working with the Super-Sens, it is absolutely essential that you measure the zero count rate.** However, if you are working with the GM-detector the determination of the zero count rate is not important and the standard value may be retained.

Note!

If the detector code (code 5) has been changed, then code 32 will be overwritten by a standard value.

Reading-in the zero count rate:

- Go to code 32
- Push "Enter" to get to the edit mode
- Push „Cal" button
- As soon as the counting time is over, the new count rate is stored. The counting time can be set in code 37.

See page 12 for more information on reading in count rates.

Note!

If the value is changed, then you have to carry out a new calibration for the change to become effective!

CODE 33 Measuring path (in mm)

Enter container diameter or measuring path in the product (Only in the professional mode)

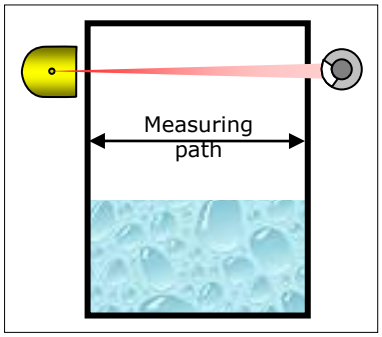


Figure 3: Measuring path in container

This parameter is needed only in connection with code 34 or 35.
Enter here the distance covered by the radiation inside the container (in mm). Typically, this is the internal diameter of the container.
If you enter "0" the function is disabled.

CODE 34 Gas density (in kg/m³)

Enter gas density at high operating pressures (Only in the professional mode)

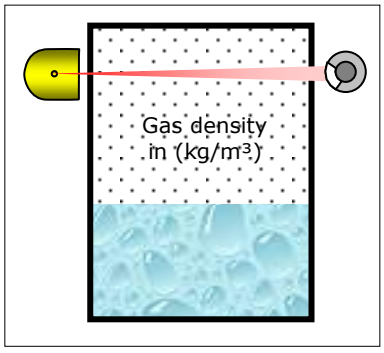


Figure 4: Container with gas pressure

If high gas pressures are expected in the container under operating conditions and you can carry out the empty calibration only in a state without pressure, the empty count rate in code 30 has to be corrected accordingly, because the empty count rate is decreasing as the gas pressure is rising.
You can carry out automatic correction with code 34.
If you enter "0" the function is disabled.

Compensating the empty count rate for gas pressure:

1 Determine empty count rate in code 30.

2 Enter measuring path in code 33.

3 Enter gas density (kg/m³) under operating conditions in code 34.

4 Start calibration with code 36.

☑ **A compensated empty count rate has been calculated in code 20.**

Note!

Any calculation of count rates is always flawed, but in most cases it is sufficient for calibration of the limit value switch.
We recommend reading in the count rates new under operating conditions, if this is possible at a later time.

CODE 35 Bulk density (in kg/m³)

Enter bulk density for automatic calculation of the full count rate. (Only in the professional mode)

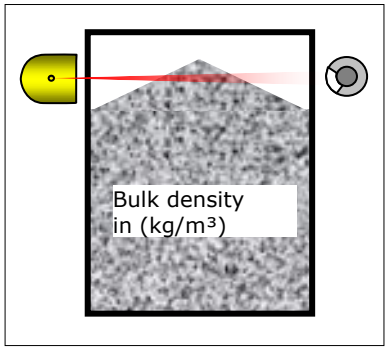


Figure 5: Container with bulk good

If calibration at full container is not possible, you can here enter the density of the product being measured in order to calculate the full count rate automatically.
If you enter "0" the function is disabled.

Calculating the full count rate via the bulk density:

1 Determine the empty count rate in code 30.

2 Enter measuring path in code 33.

3 In code 35, enter the bulk density (for solids) or the density (for liquids) under operating conditions in kg/m³.
Example values for densities and bulk densities (at 20°C):
Water: 1000 (kg/m³)
Gasoline: 700 (Kg/m³)
Coke: 600 (kg/m³)

4 Enter -1 in code 31 to calculate the full count rate automatically.

5 Start calibration with code 36.

☑ **A full count rate has been calculated in code 21.**

Note!

Any calculation of count rates is always flawed, but in most cases it is still sufficient for calibration of the limit value switch.
We recommend reading in the count rates new under operating conditions, if this is possible at a later time.

CODE 36 Calibration

Start calibration
(Only in the professional mode)

In the professional mode, the device is ready for measurement only after successful calibration. Start the calibration only after you have defined all necessary parameters. To start the calibration you only have to push the Enter button in this code.

Reading	Meaning
00.00	Calibration error-free
35.0X	Error, see Table 4 on page 36

During calibration, the values you have entered will be checked. Successful calibration is indicated by a checkmark and the value 0000. If an error number is displayed, then you have to review or change the respective parameter settings using Table 4.

Note!

If the parameters

- time constant (code 12)
- switching threshold (code 17/18)
- hysteresis (code 19)

have been set to automatic, there is only a very small risk that false values have been set.

We recommend to enable code 36 after every parameter change to ensure that an incorrect setting will be recognized immediately.

Calibration error - Table

Table 4: Calibration error

Error code	Sub-code	Designation	Explanation	Remedy
35	01	ECR < FCR	Empty count rate lower than zero count rate.	Determine empty count rate or / and zero count rate new.
	02	ECR < FCR	Empty count rate lower than full count rate.	Determine empty count rate or / and full count rate new.
	03	FCR < ZCR	Full count rate lower than zero count rate.	Determine full count rate or / and zero count rate new.
	05	Distance switch point to FCR	Distance switch point to full count rate is too small. Danger of switching errors.	Adjust switch point, or increase time constant.
	06	Distance switch point to ECR	Distance switch point to full count rate is too small. Danger of switching errors.	Adjust switch point, or increase time constant.
	07	Hysteresis too large	Hysteresis too large.	Increase time constant or reduce hysteresis.
	08	Time constant too small	Time constant too small	Increase time constant or set switch point further into the center.

CODE 37 Counting time for calibration (in seconds)

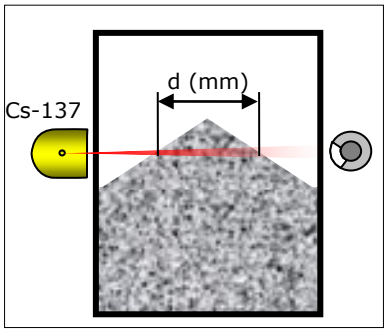
Enter length of time for count rate averaging (Only in the professional mode)

Here you can enter the length of time to be used for averaging of the calibrated count rates in code 30, 31 and 32. The factory setting is 60 seconds.
Input limits: 5 … 600s.

CODE 38 Bulk cone diameter (mm)

Enter diameter of the bulk cone where switching is to be performed.

Bulk cone measurement



You have to enter the bulk cone diameter "d" in mm if measurements on bulk goods should trigger an alarm at a certain bulk cone diameter.
Then the limit value indicates an alarm as soon as the bulk cone has reached the specified diameter "d".

Provided the value in code 38 >0, the switch point in code 17/18 is then calculated based on the bulk density of code 35, the nuclide defined in code 5 and the bulk cone diameter of code 38.

If a gas density has been entered in code 35, this will also be taken into account in calculating the switch point.

For the entries to take effect, you have to calibrate with code 36.

If the isotope is changed later, the switch point will be adjusted automatically, and you do not have to enable code 36.

With [0] you can turn this function off.

CODE 39 Half-value layers

Enter product absorption at full container

Using the number of half-value layers (HVL) the full count rate can automatically be calculated based on the empty count rate.
For code 39 to be effective in the professional mode, code 31 has to be set to [-1] and code 33 and 35 to [0].
The number of HVL's is dependent on the measuring path through the product being measured and the bulk density (with liquids: density) of the product. In most cases, the standard value 2 HVL is adequate for calculating the full count rate automatically.

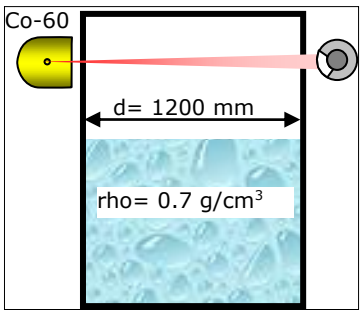
The HVL can be determined as follows:

Formula

HVL = rho * d / k

rho: density of product being measured (g/cm³)
d: measuring path = internal container diameter (mm)
k Co-60: 157
k Cs-137: 110

Example with liquid



Example:
Product: Gasoline rho = 0.7 g/cm³

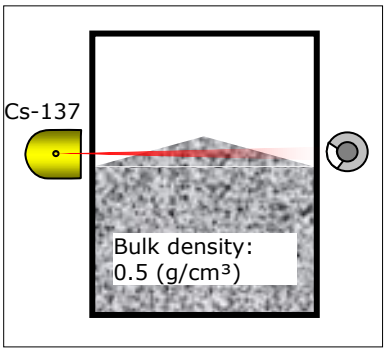
Cylindrical container: d = 1200 mm inside

Source: Co-60

HVL = 0.7 x 1200 / 157 = 5.4

Always round down result!
Input in code 39: 5

Example with bulk good



Example:
Product: Coal rho = 0.5 g/cm³

Container diameter:
d = 1500 mm inside

Source: Cs-137

HVL = 0.5 x 1500 / 110 = 6.8

Always round down result!
Input in code 39: 6

The calibration of bulk cone measurements switching at a certain bulk cone diameter is described on page 62.

Note!

As an alternative to code 39, you may also use - in the professional mode - the bulk density function in code 35.

CODE 40 Interference radiation detection

Enable / Disable interference radiation detection (Only in the professional mode)

Input	Interference radiation detection
0	Disabled
1	Enabled

This function detects interference radiation if the live count rate exceeds the empty count rate in code 30 by a factor of 1.5. If interference radiation has been detected, the measurement is stopped for at least the length of the waiting time defined in code 41. For further information see page 64.

Note!

Function affected by interference radiation.

This type of interference radiation detection does not trigger any alarm if the count rate increase due to interference radiation is below 1.5 x ECR.

For welding seam tests in the vicinity of the measurement point (approx. 300 m), the control center or production have to be informed and, if necessary, the measurement has to be performed manually.

CODE 41 Waiting time after interference radiation (s)

Enter waiting time after interference radiation detection (Only in the professional mode)

If interference radiation is detected, the measurement goes to HALT and returns to RUN again at the earliest after this waiting time is over.
If interference radiation still exists after the waiting time is over, the waiting time will always start once more.
For further information see page 64.

CODE 42 Signaling interference radiation

Select relay to signal interference radiation (Only in the professional mode)

Input	Relay
0	No signaling via relay
1	Signaling via error relay
2	Signaling via warning relay

The warning relay cannot be used for signaling of interference radiation if code 8 is set to 1.
For more information on interference radiation please see page 64.

CODE 43 Signaling unlocked

Select relay to signal „Password unlocked" (Only in the professional mode)

Input	Relay
0	No signaling via relay
1	Signaling via error relay
2	Signaling via warning relay

The process control system can be informed that the device is not protected against unauthorized access.

The warning relay cannot be used for signaling if code 8 is set to 1.

CODE 44 Signaling minor errors

Select relay to signal minor errors
(Only in the professional mode)

Input	Relay
0	No signaling via relay
1	Signaling via error relay
2	Signaling via warning relay

Minor errors are indicated on the display in code 10 by „!!" and are only signaled by the relay if this parameter has been set accordingly.
The distinction between minor and serious errors is shown in the error list on page 68.
Serious errors are always signaled by the error relay. The warning relay cannot be used for signaling if code 8 is set to 1.

CODE 45 Signaling detector limit temperature (only FSK)

Select relay to signal detector limit temperature
(Only in the professional mode and only for FSK detectors)

Input	Relay
0	No signaling via relay
1	Signaling via error relay
2	Signaling via warning relay

The limit temperature is defined in code 46.
The warning relay cannot be used for signaling if code 8 is set to 1.

CODE 46 Detector limit temperature

Limit temperature for signaling excess temperature at the detector (only in professional mode and only FSK detectors)

Input	Function
1-99	Limit temperature in °C

If the temperature is reached at the detector, this will be signaled. The signaling can be used to ensure the reliable function of the detector, or to ensure that the detector cooling water (only if a water cooling device is installed) will flow only at excess temperature. The signal is indicated on the display and, if necessary, also by a relay. The relay for signaling is selected in code 45. The current temperature of the detector is displayed in code 52.

CODE 47 Signaling EVU excess temperature

Select relay to signal EVU excess temperature
(Only in the professional mode)

Input	Relay
0	No signaling via relay
1	Signaling via error relay
2	Signaling via warning relay

The threshold for the excess temperature is defined in code 48.
The warning relay cannot be used for signaling if code 8 is set to 1.

CODE 48 EVU limit temperature

Enter EVU limit temperature (in °C)
(Only in the professional mode)

Input	Function
1-99	Limit temperature in °C

Switching threshold for signaling excess temperature in the evaluation unit electronics. The signaling can be used to ensure the reliability of the measurement. The signal is indicated on the display and, if necessary, also by a relay. The relay for signaling is selected in code 47.

CODE 50 Limit switch software version

Show software version of evaluation unit

A new software version can be uploaded only by means of a programming device or by BERTHOLD TECHNOLOGIES in Bad Wildbad.

CODE 51 Detector software version

Show software version of FSK detector (only FSK detectors)

If necessary, the software in the detector can be replaced by an experienced user.

CODE 52 Detector temperature

Show current temperature inside the detector
(only FSK detectors)

The detector electronics includes a temperature sensor. An alarm is triggered when reaching the temperature set in code 46. The maximum permissible ambient temperature is listed in the technical data in the hardware manual.

CODE 53 Detector high voltage

Show or set current high voltage of the detector (only FSK detectors)

Input	HV mode
-1	Automatic
500 -1300	Fixed value

The automatic HV-control keeps the detector free from drifts in case of temperature fluctuations and ageing.
Enter a value between 500 and 1300 V to set the detector to manual high voltage.

Note!

To ensure a reliable function of the measurement, the HV has to be set to automatic.

If the count rate of a NaI detector drops below 100 counts, the HV is frozen. If it rises again above 200 counts, the HV is again controlled automatically.

CODE 54 HV start value

Set start value of high voltage control (only FSK detector)

Input	HV start value
0	Disabled
500 - 1300	Enabled

A HV start value fulfills the following tasks:

- **Default value**
  After turning on power, the HV starts with this value. The measurement will be ready for operation quickly.
- **Limit value** for the HV control range.
  It limits the HV control range of the detector to max. +40% and min. 20% of the HV start value. A HV that is too high and therefore detrimental to the photomultiplier cannot be generated. An error message is output if the HV touches one of the cut-off regions (see page 71).

The start value is determined in the factory and stored in the detector. If the photomultiplier has to be replaced, the automatic HV value of code 53 automatically has to be entered in code 54.

CODE 55 Source replacement

Read off or enter year for source replacement
(Only in the professional mode)

Input	Function	Code
-1	Calculate automatically	**C**
1970 - 2070	Fixed value	**C**

If the current date in code 01 reaches the year set here, the warning message "39.01" (Replace source) will be output.
The automatic calculation of the date is dependent on the maximum time constant in code 14 and the current time constant in code 12.
A manually entered date value disables the automatic calculation.
If four bars are displayed in this code, then you have to push Clear to reset the value before you enter a date.

CODE 56 Evaluation unit electronics temperature (°C)

Show current EVU temperature
(Only in the professional mode)

The board of the evaluation unit accommodates a temperature sensor.
An error message is output if this temperature exceeds the limits set in code 48.

CODE 60 Test pulse generator

Simulate detector count rate
(Only in the professional mode)

Input	Test pulse generator
0	Off
1 – 999.999	On

Enter the full or empty count rate to simulate the respective container level and to switch the alarm relay.
With the test pulse generator enabled:

- the device acts as if the count rate were coming from the detector.
- the counts coming from the detector will be ignored.
- the error relay is enabled to indicate that the readings do no longer correspond to the level any more.

Note!

For the limit switch to continue working normally, you have to turn off the test generator after the test.

To be on the safe side, the test generator will be turned off automatically after 20 minutes.

The test generator is also disabled if the limit switch is locked by entering the password.

CODE 61 Test error relay

Test error relay
(Only in the professional mode)

Push the Enter button to enable and disable the error relay.
Push Clear to exit the test.

CODE 62 Test alarm relay

Test alarm relay
(Only in the professional mode)

Push the Enter button to enable and disable the alarm relay.
Push Clear to exit the test.

CODE 63 Test warning relay

Test warning relay
(Only in the professional mode)

Push the Enter button to enable and disable the warning relay.
Push Clear to exit the test.

CODE 64 Test display

Test display
(Only in the professional mode)

Push the Enter button to enable the display test. The display shows a number of patterns by means of which the function of each pixel or element can be recognized.
Push Clear to exit the test.

CODE 65 Test keyboard

Test keyboard
(Only in the professional mode)

Push the Enter button to enable keyboard test.
If you push a button now, its function is shown on the display.
Push the Clear button for at least 2s to exit the test.

CODE 66 Status Digital In

Test digital inputs
(Only in the professional mode)

The digit to the left of the decimal period stands for digital input no. 2 and the digit to the right of the decimal period stands for digital input no. 3.

Presentation of value on the display	Digital input short-circuited?	
	Input 2 Backup	**Input 3 Empty calibration**
00.00	no	no
00.01	no	yes
01.00	yes	no
01.01	yes	yes

Push the Clear button to exit the test

CODE 67 HV-Max for plateau measurement

Define maximum high voltage for plateau measurement
(Only in the professional mode)

At this HV, the last measured value will be recorded in the course of a plateau measurement. This rules out that the HV at the multiplier becomes too high and has a detrimental effect. The factory setting is 1000V and this setting is adequate in most cases.

CODE 68 Detector plateau measurement

Plateau measurement for detector function (Only in the professional mode and only for NaI detector and Super-Sens)

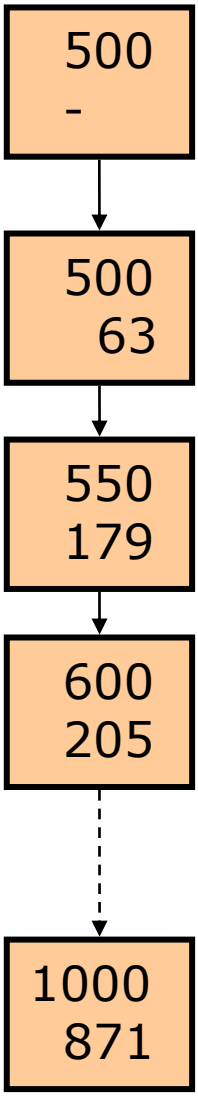
Start plateau measurement:

1 Push Enter to enable this function.

2 Push Cal. to start the plateau measurement.

☑ **The plateau measurement has been started. It may take some minutes until the end of the plateau measurement is reached.**

Operating sequence of a plateau measurement

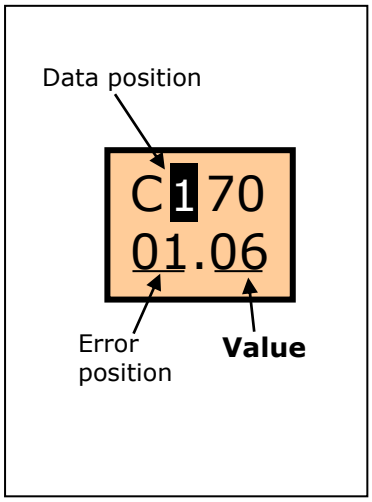


- First, the HV is set. This may take several seconds.
- The plateau measurement is carried out in 50V steps.
- The count rate is averaged at each HV for 60 seconds each (can be set in code 37).
- The HV starts at 500V and ends at the HV set in code 67.
- You have to push the Clear button twice to abort a running plateau measurement.
- After the plateau measurement is finished, you can query the values by pushing the buttons ▲ / ▼.
- The values remain stored until the next plateau measurement is performed.

See also the section „Checking the Crystal-Multiplier Combination" in the hardware manual.

CODE 70 Error log

Query error log
(Only in the professional mode)



The last 26 errors are stored in the error log.

Push the Enter button to invoke the function. The error stored last is displayed.

Push the buttons:

- ◄ / ► to invoke the respective data position of the error.
- ▲ / ▼ to invoke the 26 stored errors using its error position number.
- Push Clear to exit the error list.

Table 5: Error log

		Data position within an error						
		1	2	3	4	5	6	7
		Error code	Error sub code	Minute	Hour	Day	Month	Year
Error position	01	06	04	03	14	10	02	03
	02							
	. . .							
	26							

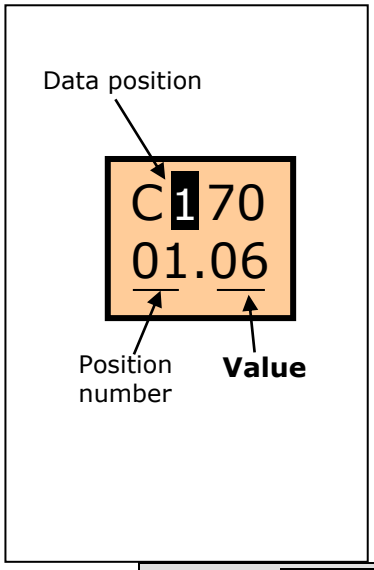
Example: In the table above, an error has been entered under error position number „01" with the following data:

- Error: 06.04 (HV lower limit)
- Date of error detection: 02.10.2003 14:03h

If all positions are occupied by errors and an additional error occurs, then the oldest error will be overwritten;

CODE 71 Revision log

Query revision log
(Only in the professional mode)



The last 26 parameter modifications are stored in the revision log.

Push the Enter button to invoke the function.

Push the buttons:

- ◀ / ▶ to invoke the data position within a parameter modification.
- ▲ / ▼ to invoke the 26 stored parameter modifications using its position number.
- Push Clear to exit the revision log.

Table 6: Revision log

		Data position within a parameter modification							
		0	1	2	3	4	5	6	7
		Changed code	Old value	New value	Minute	Hour	Day	Month	Year
Position number	01	12	02	10	50	15	04	10	03
	02								
	. . .								
	26								

Example: In the table above, a parameter modification has been entered under error position number „01" with the following data:

- Code 12 (time constant) has been increased from 2s to 10s
- Date of revision: 04.10.2003 15:50h

If all 26 positions are occupied by modifications and an additional modification occurs, then the oldest modification will be overwritten.

Note: The position number is not displayed in data position 1 and 2, because these positions are needed for 3- or 4-digit values.

CODE 72 Save& Load / Reset

Save/Load parameter set or initiate reset (Only in the professional mode)

Input	Function
0	Save parameter set
1	Load parameter set
99	Initiate software reset
999	Initiate software reset and reset parameters to factory setting

Save parameter set

The present parameter set is saved to a separate memory on the EVU. We recommend storing the parameter set if you want to save the settings you have defined in order to access them later. The saved setting can be invoked again after a reset.

Load parameter set

A parameter set previously saved on the EVU can be loaded again; the current parameters will be overwritten.

Restart

Software restart without changing the instrument parameters. If mysterious malfunctions occur, the CPU can be reset in this code.

Reset

Same as above but with additional parameter reset to factory setting. This function is comparable with turning on the power supply with the Clear button pushed down (see page 72).

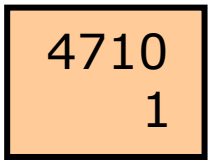
Chapter 4. Getting Started

Errors in calibration or in the parameter setting may lead to incorrect measurement results. This may possibly lead to production downtime or damage to the system.
To check your device settings after commissioning, we recommend using the test settings in the Service menu to simulate the calibration points.
Wherever possible, a test run, if possible under operating conditions, will provide you with a high level of security regarding the accuracy of your calibration. This test run has to cover the entire measuring range.
If a test run is not possible, then you should at least check the reaction of the measurement with empty container and full container should be simulated by closing the source shielding.
Basically, it is advisable to have commissioning carried out by the BERTHOLD TECHNOLOGIES service.

The device is taken into operation as follows:

- Turn on supply voltage
- Open shielding of source (see hardware manual)
- Reset values to standard values
- Define basic setting for standard mode
- Run calibration in standard mode

4.1 Turning On the Supply Voltage



Immediately after turning on the supply voltage, the device shows 4710 in the first row and several seconds later 0 or 1 in the second row. Another second later the display shows the code 10 (or 11); then it is ready for operation.

4.2 Resetting to Standard Values

You have to reset the device to standard values only if you are not sure if the current settings are correct. The device can also be reset if a password is enabled.

1 Turn supply voltage of EVU off or pull EVU out of slot.

2 **Keep Clear button pushed down** and turn supply voltage on again or insert EVU into slot.

3 Release Clear button as soon as bars appears in the bottom row.

☑ **All parameters have been reset to standard values.**

4.3 Basic Setting for Standard Mode

For basic setting you have to set or check at least the sic grey shaded parameters in the code table:

Table 7 Basic setting for standard mode

Code no.	Designation	Value range	Factory setting	Page
00	Password	0000 - 9999		21
01	Year	1970 - 2099	Current year	21
02	Month / Day	01.01 - 12.31	Current date	21
04	Operation mode Standard/Professional	0 - 1	0	22
05	Detector code	0 - 99	0 or 99	22
06	Nuclide	0 - 1	0	22
10	Reading in % averaged	-999 - 9999	Reading	25
11	Reading in cps averaged	0 - 999.9	Reading	25
16	Max. or min. limit value switch	0 – 1	0	27
20	Empty count rate	0 - 999.9	Reading	36
21	Full count rate	0 - 999.9	Reading	
22	Zero count rate	0 - 9.999	Reading	32
32	Zero count rate	0 - 9.999	Depending on detector code	32
39	Half-value layers	1-9	2	37
50	Limit switch software	1.00 - 9.99	Version	41
51	Detector software (only FSK detector)	1.00 - 9.99	Reading	43
52	Detector temperature °C (only FSK detector)	-40 – 80	Reading	41
53	Detector high voltage (only FSK detector)	500 - 1300	-1	43
54	Detector HV-default (only FSK detector)	500 - 1300	Set in factory	44

The parameter setting requires that you are already familiar with the basics of operation (see page 9).

To read in the zero count rate correctly, the source should not yet be mounted when working with the Super-Sens (see page 32).

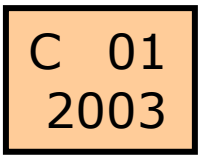
The following parameters have to be checked or set. See chapter 3.4 for a detailed description of the parameters.

Note!

The illustrations contain example values which you have to substitute by actual or suitable values.

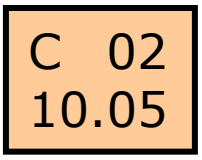
Basic setting:

1 Code 01: check or update year



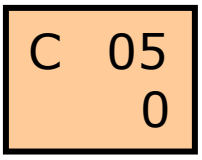
Example: year 2003

2 Code 02: Check or update month /day



Display: MM/DD
Example: October 5

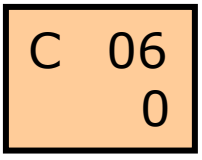
3 Code 05: Enter detector code



Enter detector code
Example: detector code „0" for LB 440X

Detector type	Designation	Detector code
FSK detector	LB 440X	**0**
	LB 540X	**0**
Super Sens	LB 443X	**23**
	LB 543X	**23**
GM detector	SZ5 GHS 3171-2	**98**
	GHS 3172-2	**98**
	SZ5 GHS 3171-1	**99**
	GHS 3172-1	**99**

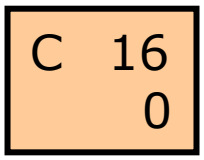
4 Code 06: Select nuclide



Example: Co-60

Input	Isotope
0	Co-60
1	Cs-137

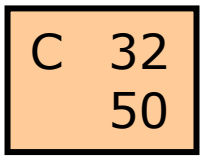
5 Code 16: Select min./max. limit value switch



Maximum value limit switch

Input	Alarm relay function
0	Maximum value switch
1	Minimum value switch

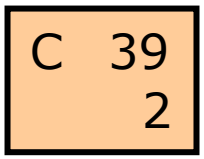
6 Code 32: Read in zero count rate



Example:
50 cps as natural environmental radiation

Input	Function
„Cal" button	Read in count rate

7 Code 39: Enter half-value layers



Example: 2 half-value layers
(sufficient in most cases)

Input	Function
1-9	Number of half-value layers

☑ **This completes the basic setting.**
The measurement can now be calibrated.

4.4 Calibration in Standard Mode

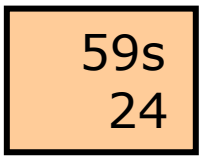
Empty calibration has to be performed in order to calibrate the measurement.

Prerequisites (see also page 60*):*

- Container must be empty or at least below the monitoring level.
- The gas density existing under actual operating conditions is available in the container. If this is not possible, select the professional mode and compensate the gas density value with code 35. The special features of the professional mode have to be taken into account.
- A possible existing heating or cooling jacket is filled with the medium to be used later.
- In agitator containers, the agitator must in operation, if it may have any influence on the limit value.
- The shielding with the source has been installed. The radiation exit channel is open.
- The EVU is not in the edit mode.

Calibration:

Push Cal button for 3 seconds.



The seconds are counted down in the top row.

The bottom row shows the count rate.

In code 20 you can read off the measured zero count rate.

☑ **The measurement is now calibrated and already supplies live measured values.**

Note!

A system check has to be carried out to ensure that the measurement operates correctly.

To do this, fill the container above fill level limit, or alternatively, close the shielding when the container is empty.

4.5 Getting Started in the Professional Mode

Errors in calibration or in the parameter setting may lead to incorrect measurement results. This may possibly lead to production downtime or damage to the system.
To check your device settings after commissioning, we recommend using the test settings in the Service menu to simulate the calibration points.
Wherever possible, a test run, if possible under operating conditions, will provide you with a high level of security regarding the accuracy of your calibration. This test run has to cover the entire measuring range.
If a test run is not possible, then you should at least check the reaction of the measurement with empty container and full container should be simulated by closing the source shielding.
Basically, it is advisable to have commissioning carried out by the BERTHOLD TECHNOLOGIES service.

In the professional mode (code "04" = 1), all parameters can be configured as needed and there is no restriction as to their order, with the exception of code 36 which always has to be enabled at the end of the calibration procedure. For this reason, a calibration sequence cannot be depicted in detail, since other operating sequences are possible, depending on each application, and other parameters have to be set.
The parameters are described in the table on page 19.
On page 17 you find the description of the extended functions of the professional mode.

Note!

If the calibration values in code 30 to 35 are changed, this becomes effective only if the calibration is completed with code 36.

Even if you are changing values in code 12, 17, 18, 19 and 39, we recommend performing a calibration in code 36. Only then you will be alerted to possibly incorrect settings.
On page 36 you find the calibration error table.

Chapter 5. Explanations

5.1 Zero Count Rate

The zero count rate is the count rate caused by natural environmental radiation. In contrast to radiation coming from the source, the zero count rate remains constant. The zero count rate is largely dependent on the scintillator volume. An error in measuring the zero count rate may result in switching errors.
If no zero count rate values have been entered or read-in, the device works with the standard value set in the factory. The standard value is an approximate value defined by the current detector code. Since background radiation is dependent on the geographical location, this value should be read in as soon as possible.
The zero count rate is needed for the correct calculation of the decay compensation.
When reading in the zero count rate, please keep in mind that "residual radiation", even from a closed shielding container, may distort the empty count rate value. Gross falsification may lead to false alarms being triggered over a longer period of operation (months/years).

5.1.1 Determining the Zero Count Rate

The zero count rate is determined according to the best method. Often, however, the best method cannot be employed, depending on the conditions during production or start-up. Below, we will describe three methods for determining the zero count rate.

a) Best method

With empty or full container, but **without** source.

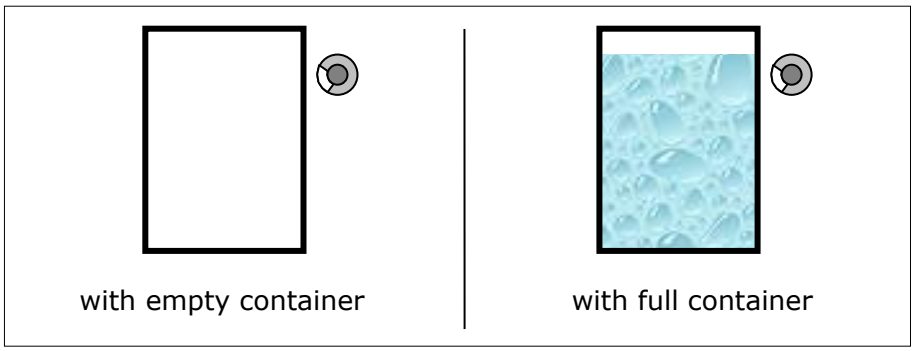


Figure 6: Determining the zero count rate with no source installed

b) Second best method

If the source has already been installed, the following prerequisites should be met:

- **closed** radiation exit channel
- **full** container

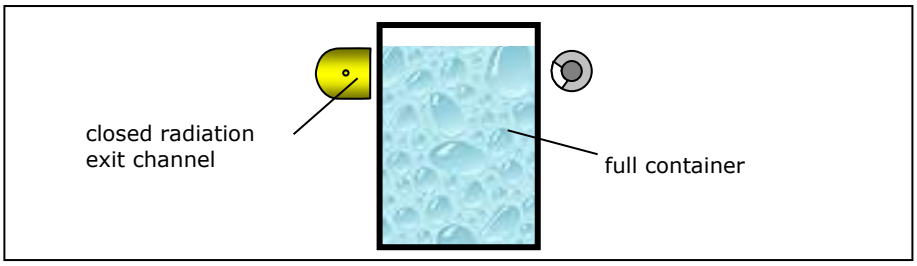


Figure 7: Determining the zero count rate at full container

c) Third best method

If the container cannot be filled above the monitoring level, then at least the radiation exit channel has to be closed.

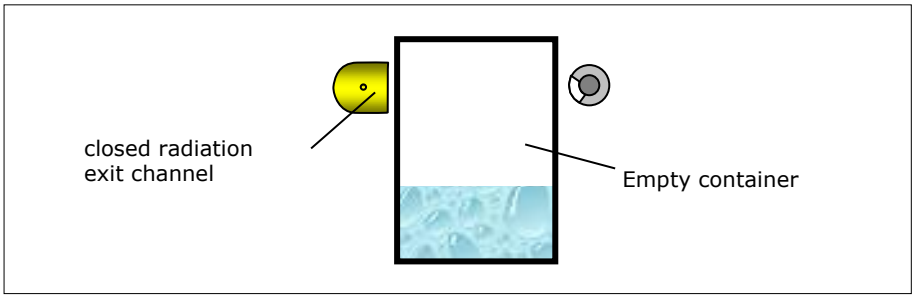


Figure 8: Determining the zero count rate at empty container

If this method is used, the detector often receives a minor amount of residual radiation from the radiation source, which is negligible for Cs-137 sources. For Co-60 sources this method may be used only if the influence of the residual radiation on the measurement can be estimated.

5.2 Empty Calibration

The shielding container of the measuring system has to be installed prior to performing empty calibration. The radiation exit channel has to be open. The container should be empty or filled up to a level below the limit value.

Note!

Empty calibration, especially on high-pressure containers, has to be carried out under operating conditions (pressure, temperature).

The following influences have to be taken into account:

Wall deposits

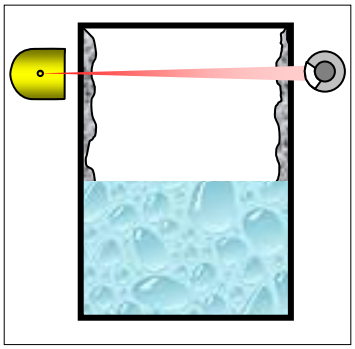


Figure 9: Container with wall deposits

The container has to be emptied thoroughly to ensure that no residues are left in the container.
If wall deposits are likely to build up during operation, another empty calibration should be carried out after some time.

Agitator

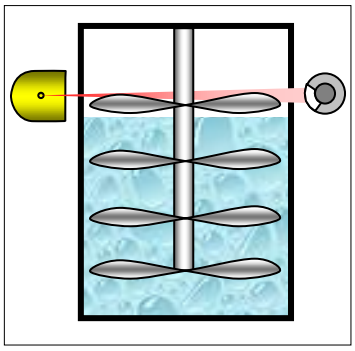


Figure 10: Container with agitator

The agitator has to be in operation if it may have any influence on the measurement.

High gas pressure

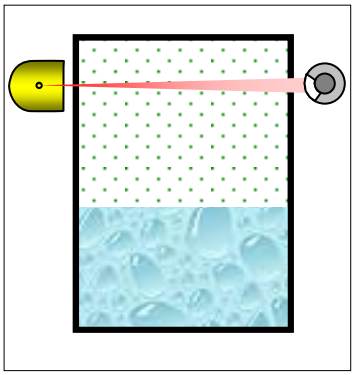


Figure 11: Container with gas pressure

If the container is under gas pressure during operation, empty calibration also has to be carried out under this gas pressure. If this is not possible, then empty calibration may also be carried out without gas pressure, and then it has to be compensated for automatically using the entries in:

- Code 33 (container diameter) and
- Code 34 (gas density).

Cooling or heating jacket

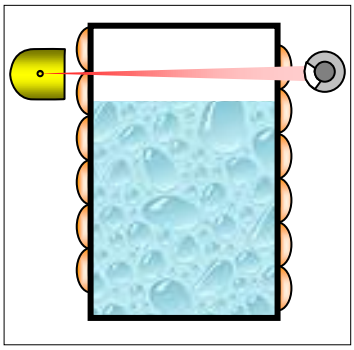


Figure 12: Container with cooling or heating jacket

Cooling or heating jackets have to be filled for calibration. In order to preserve the density of the cooling/heating liquid, it should have the same temperature as under operating conditions.

5.2.1 External Empty Calibration

Wall deposits and caking may trigger false alarms.
If these deposits build up slowly and their layer thickness changes only gradually, you can ensure the safe function of the measurement by carrying out regular empty calibrations. A digital input (terminals 22a/c) allows automatic empty calibration directly from the control room. If the terminals are short-circuited, empty calibration is performed followed by an automatic calibration. **Prerequisite is that the level of filling is below the monitoring level.**

Note!

A measuring system using a Co-60 source is less sensitive to wall deposits than one with a Cs-137 source.

5.3 Bulk Cone Measurement

Note!

Bulk cone measurements can only be carried out with scintillation detectors.

The required calibration has to be carried out in the professional mode, since the limit value has to be set specifically.

With bulk goods, the monitoring level is determined at a defined bulk cone diameter. For the measurement to work well, the count rate at the switch point has to differ significantly from that at full and at empty container. If the configuration has been calculated by BERTHOLD TECHNOLOGIES, this has already been taken into account. The measurement configuration has to be installed at that point where the bulk cone diameter is to be monitored.

Calibration process:

1. Determine empty count rate
2. Full count rate
3. Calibrate with code 36
4. Set switch point
   There are three ways of setting the switch point:

- **Bulk height under operating conditions**
  (often not feasible for technical reasons)
- **Simulate bulk cone using steel or lead plates**
- **Calculate count rate for bulk cone**

  Simulation with steel or lead plates is preferable to calculation.

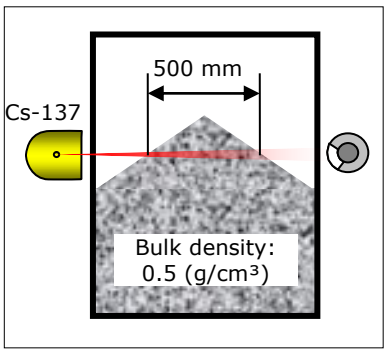
Control bulk height under operating conditions

After the bulk height with the specified bulk cone diameter has reached the monitoring level, read off the count rate in code 11 and enter this value in code 18.

Simulate bulk cone with steel or lead plates

You need steel or lead plates causing the same absorption with respect to Gamma radiation as the bulk cone. Since this is dependent on the mass per unit area, the steel or lead plate must have the same mass per unit area as the bulk cone.
The required thickness of the steel plate is determined as follows:

Determining the plate thickness



Product coal: 0.5 g/cm³
Bulk cone diameter: 500 mm
Source: Cs-137
Steel density: 7.8 g/cm³

HVL=0.5x500/7.8=32mm steel

Alternative for lead plate:

HVL=0.5x500/11.3=19mm lead

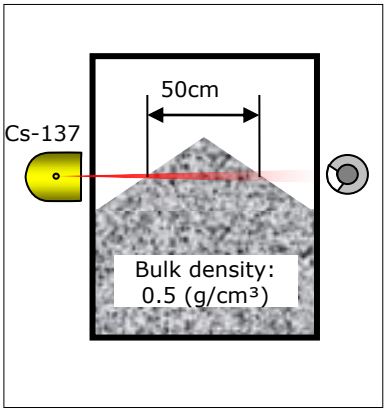
You may also use several plates in order to get the required thickness of the plate.
The container has to be empty to calculate the switch point, or the cone end of the bulk cone must be below the monitoring level. Now use the steel or lead plate and cover the sensitive part of the detector, i.e. the scintillator. Hold the plate between detector and container wall. The plate must have the following minimum dimensions in order to cover the entire detector window or the complete scintillator:

- 70 x 70 mm for NaI detector
- 200 x 200 mm for Super-Sens

While the plate is being held in front of the scintillator, read off the count rate in code 11 and enter this value in code 18.

Calculating the count rate for the switch point

Calculating the switch point



Example with coal
Bulk weight (rho): 0.5 g/cm³
Bulk cone diameter: 50cm
μ for Co-60 source: 0.04
(μ for Cs-137 source: 0.057)
Empty count rate: 300 cps
Full count rate: 40 cps
$\mathbf{I_{use} = I_{empty} - I_{full}}$
I_{use} = 300-40 = 260 cps

$\mathbf{I = I_{full} + I_{use}\, e^{-(\mu * rho * d)}}$

$I = 40+260*e^{-(0.04*0.5*50)}$ = 136 cps
Input into code 18: **136**

5.4 Interference Radiation Detection

The high Gamma sensitivity of scintillation detectors may have the effect that interference radiation aimed at the detector (e.g. radiation emitted during welding seam tests) may trigger a false alarm or not trigger an alarm.

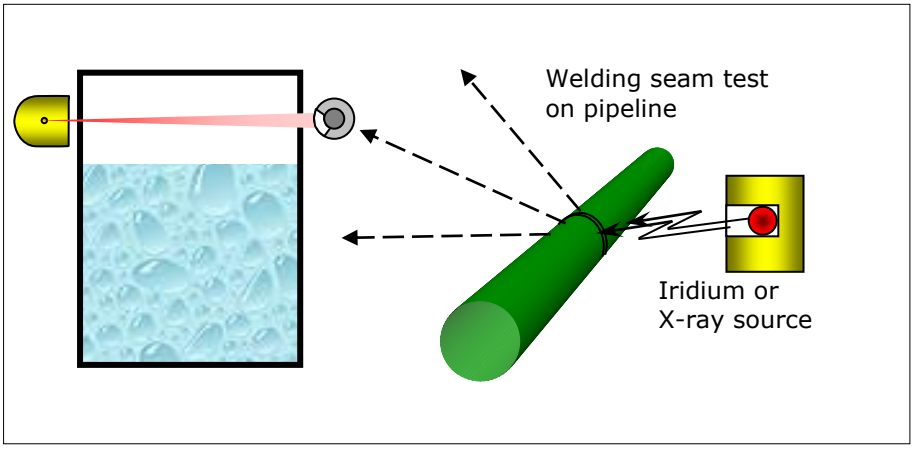


Figure 13: Measurement affected by welding seam test

A simple automatic plausibility check can be enabled to detect interference radiation.
The alarm is triggered by the following condition:

Is > Io * 1.5

Is: live count rate (code 13)
Io: empty count rate (code 20)

Note!

Function affected by interference radiation.

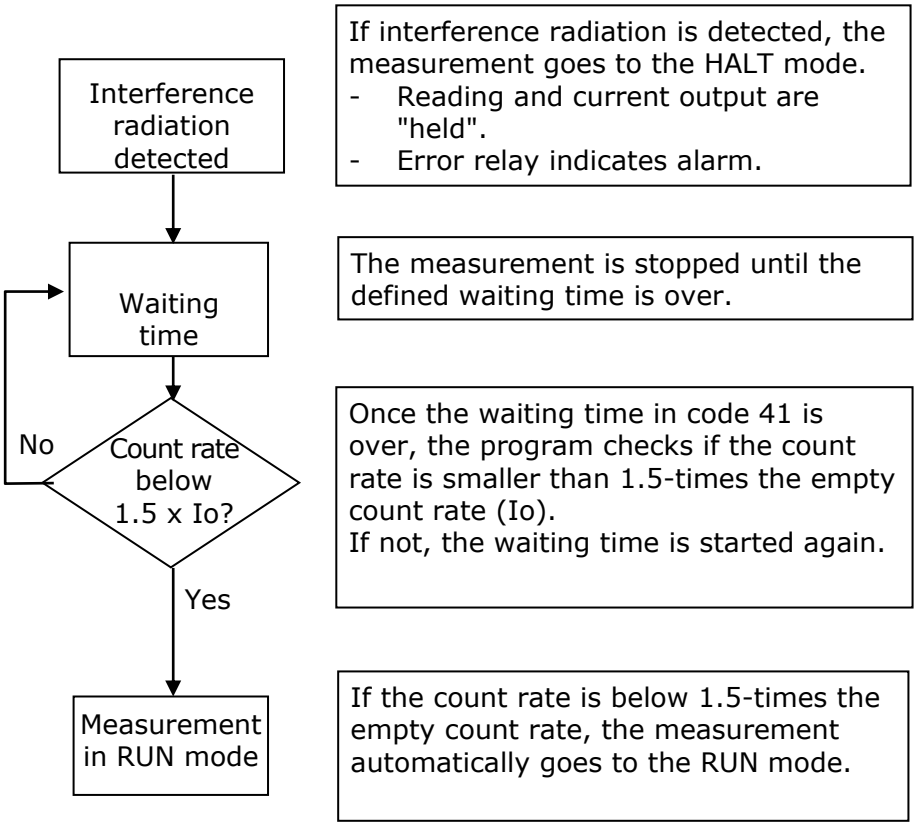
This type of interference radiation detection does not trigger any alarm if the count rate increase due to interference radiation is below 1.5 x ECR.

For welding seam tests in the vicinity (approx. 300 m) of the measurement point the control center or the production have to be informed and, if necessary, the control has to be set to “manual”.

5.4.1 Flow Chart

If interference radiation is detected, the following sequence starts automatically:

Figure 14: Flow chart interference radiation



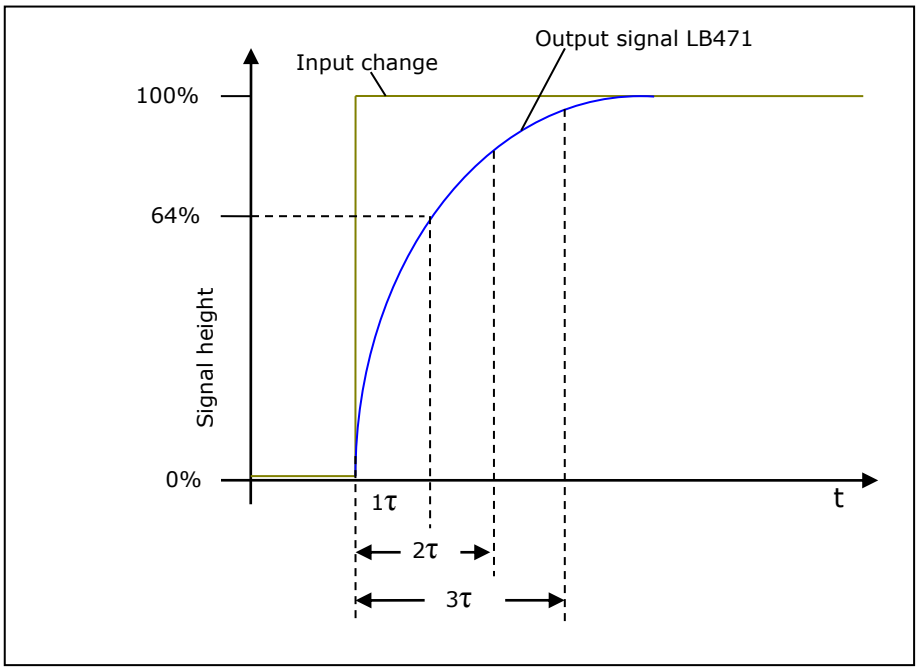
5.5 Time Constant

The time constant smoothes the measured value in code 10 and 11. Statistical fluctuations and process-immanent level variations, e.g. due to agitators, can be smoothed.
The measured values supplied by the detector are averaged using the time constant. A so-called RC-averaging is performed:
$nM = aM + ((AZR - aM) * (1 - e(-t/\tau)$

nM = new average value
aM = old average value
AZR = current, non-averaged count rate
t = time distance of measurements in seconds
τ = time constant in seconds

Figure 15 shows the reaction of the percentage reading in code 10 if the container has not reached or has exceeded its monitoring level. The reading in the instrument is averaged new every 0.5 s.

Figure 15: Time constant



Chapter 6. Error Messages

The device is checked for possible errors during operation and upon turning on of the supply voltage.

We distinguish between error messages and warnings:

Reaction in case of an „Err" error message:

- Code 10 shows "Err" and a two-digit number for the type of error
- Error LED lights up
- Error relay signals alarm
- Measurement goes to halt
- Message is stored in error log

Reaction in case of a minor error "!!":

- "!!" appears on display
- Measurement continues to run (stays in the RUN mode).

Minor errors will be indicated only when the parameters in code 42 through 48 (can only be set in the professional mode) have been set accordingly.

The following table shows an overview of all error messages, their possible causes and the action to be taken to eliminate the error.

Error number	Error sub-code	Designation	Display	Reaction of measurement	Alarming relay	Cause	Remedy
01	XX	Hardware error	Err	Halt	Error relay	Fault in a hardware component or the board	Replace evaluation unit
04	01	Watchdog reset	!!	RUN	Dependent on code 44	High electrical interference or faulty hardware	Check power line for possible interference If necessary, replace evaluation unit
	02	Watchdog reset >2x in 10s	Err	Halt	Error relay	As above, but the malfunction occurred several times within 10s.	Check power line for possible interference If necessary, replace evaluation unit
05	01	No count rate	Err	Halt	Error relay	No counting pulse occurred within 10s (FSK) or 120s (GMZ)	Replace probe
06	01	HV < -20%	Err	Halt	Error relay	HV is 20% below the HV start value of code 54	Check HV and standard HV. If necessary, update standard HV. If necessary, replace detector.
	02	HV > +40%	Err	Halt	Error relay	HV is 40% above the HV start value of code 54	Check HV and standard HV. If necessary, update standard HV. If necessary, replace detector.
	03	HV < 500V	Err	Halt	Error relay	HV is at lower limit at 500V	Check HV. If necessary, replace detector.
	04	HV > 1300V	Err	Halt	Error relay	HV is at upper limit at 1300V	Check HV. If necessary, replace detector.
09	01	Detector temperature exceeded (only FSK)	!!	RUN	Dependent on code 45	Detector heating up > value in code 46 (only FSK)	Reduce ambient temperature on probe: e.g. through heat deflection plate or water cooling.
10	01	EVA temperature exceeded	!!	RUN	Dependent on code 47	EVU heating up > value in code 48	Reduce ambient temperature on evaluation unit
11	01	Communication error	Err	Halt	Error relay	Faulty communication detected (only FSK)	Replace probe or evaluation unit or eliminate line interruption
17	01	Date error	!!	RUN	Dependent on code 44	Date error detected	Check date in code 01/02, if necessary update it
22	01	Interference radiation detection	!!	Waiting time code 41	Dependent on code 42	Interference radiation or faulty calibration. Corresponds to error messages 35.04 to 35.08, will be checked during operation.	See code 40 on page 38.

Error number	Error sub-code	Designation	Display	Reaction of measurement	Alarming relay	Cause	Remedy
35 Checked only in case of a calibration in code 36.	01	[1]ECR < ZCR[2]	!!	RUN	-	Empty count rate lower than zero count rate.	Determine empty count rate or / and zero count rate new.
	02	ECR < FCR[3]				Empty count rate lower than full count rate.	Determine empty count rate or / and full count rate new.
	03	FCR < ZCR				Full count rate lower than zero count rate.	Determine full count rate or / and zero count rate new.
	04	C 12 > C 14				Time constant is higher than the maximum time constant in code 14	Check time constant. Check calibration data or increase code 14.
	05	Distance switch point to FCR				Distance switch point to full count rate is too small. Danger of switching errors.	Adjust switch point, or increase time constant.
	06	Distance switch point to ECR				Distance switch point to full count rate is too small. Danger of switching errors.	Adjust switch point, or increase time constant.
	07	Hysteresis too large				Hysteresis too large.	Increase time constant or reduce hysteresis.
	08	Time constant too small				Time constant too small	Increase time constant or set switch point further into the center.
	09	Time constant too big				Time constant exceeds the maximum value of 999s.	Check the calibration and the parameter settings.
39	01	Source replace-ment	!!	RUN	Dependent on code 44	The source activity is so low that the source has to be replaced within the next 12 months. The error has been triggered by code 14 or code 55.	Check year for source replacement in code 55! Check time constant in code 12 and 14! Check calibration values in code 20, 21! If necessary, replace source.
40	01	Safe switching function not ensured	!!	RUN	Dependent on code 44	Switch point does not have the required distance to empty or full calibration or time constant is too low.	Check calibration. Adjust switch point setting or/and time constant.

Table 8: Error messages

[1] ECR = empty count rate
[2] ZCR = zero count rate
[3] FCR = full count rate

Chapter 7. Service

7.1 Troubleshooting Table

Problem	Cause	Remedy
No display	No power supply	Check power line
		Check fuse
Display not readable	Processor error	Observe error code Perform reset: For a "Total Reset", keep the ***Clear*** button pushed down while you turn on the power supply. Replace evaluation unit
Count rate too low	Shielding not open or not properly open	Check shutter and lock it in position OPEN
	Incorrect alignment of useful radiation towards detector	Correct and optimized alignment
	Container installations in radiation path	Offset irradiation level
	Wall deposits in container	Remove wall deposits
	Source has reached the end of its service life	Replace source
Display varies too much	Time constant too small	Increase time constant
	Count rate too low	Check source age and irradiation level. Replace detector
	Detector stabilization faulty	Replace detector
Display drifts	Wall deposits on the container wall	Carry out new empty calibration
	Photomultiplier faulty	Replace photomultiplier

7.2 Reset

A reset has to be performed if strange malfunctions occur during operation or in the course of a measurement.

First, you should simply turn off the power supply and then turn it on again. The CPU will be started new but the values are not overwritten by standard values.

If this does not help, you have to perform a reset. Please keep in mind that all parameters will be reset to factory setting. Therefore, write down all parameters and the setting values before you perform the reset.

Perform reset:

1. Turn supply voltage of EVU off or pull EVU out of slot.
2. Wait for 5 seconds.
3. **Keep Clear button pushed down** and turn supply voltage on again or insert EVU into slot.
4. Release Clear button as soon as bars appears in the bottom row.

☑ **The CPU has been reset and all parameters have been overwritten by standard values.**

7.3 Check Measurement with Test Generator

You can use the test generator in code 60 to check the calibration of the measurement. The test generator simulates the probe and is enabled by entering a digit larger than 0.
It is advisable to simulate the empty count rate (code 20) as well as the full count rate (code 21) with the test generator. Correct switching of the alarm relay can be checked and the reading can be presented on the display.

If the test generator is turned on:

- the device acts as if the count rate were coming from the detector.
- the counts from the detector will be ignored.
- the error relay is enabled to indicate that the readings do no longer correspond to the level any more.

Note!

For the limit switch to continue working normally, you have to turn off the test generator after the test.

To be on the safe side, the test generator will be turned off automatically after 20 minutes.

The test generator is also disabled if the limit switch is locked by entering the password.

Note!

We recommend documenting all settings in the start-up protocol on the following pages.

7.4 Plateau Measurement

Plateau measurements are carried out to check the detector in case of error (only for NaI detector with NaI crystal-multiplier combination).
The function is started with code 68.
See also the section „Checking the Crystal-Multiplier Combination" in the hardware manual.

Chapter 8. Appendix

Start-up Protocol

TAG no.	Date
Isotope	Activity
Source no.	Detector
Product	HV

Standard Mode Parameters

Code no.	Designation	Value range	Factory setting	Device setting	Page
00	Password	0000 - 9999			21
01	Year	1970 - 2099	Current year		21
02	Month / Day	01.01 - 12.31	Current date		22
04	Operation mode Standard/Professional	0 - 1	0		22
05	Detector code	0 - 99	0 or 99		22
06	Nuclide: 0=Co-60, 1=Cs-137	0 - 1	0		23
10	Reading (%)	-999 - 9999	Display		25
11	Reading averaged	0 - 999.9	Reading		25
16	Max. or min. limit value switch 0=Max, 1=Min	0 – 1	0		27
20	Empty count rate (no input)	0 - 999.9	Reading		19
21	Full count rate (no input)	0 - 999.9	Reading		29
22	Zero count rate (no input)	0 - 9.999	Reading		30
32	Zero count rate	0 - 9.999	Depending on detector code		32
39	Half-value layers	1-9	2		37
50	Limit switch software	1.00 - 9.99	Version		41
51	Detector software (only FSK[5])	1.00 - 9.99	Reading		41
52	Detector temperature °C (only FSK[1])	-40 – 80	Reading		41
53	Detector high voltage (only FSK[1])	500 - 1300	-1		42
54	Detector HV default (only FSK[1])	500 - 1300	Set in factory		42

[5] FSK = Detector with scintillator and FSK communication

Professional Mode Parameters

Code no.	Designation	Value range	Factory setting	Device setting	Page
00	Password	0000 - 9999			21
01	Year	1970 - 2099	Current year		21
02	Month / Day	01.01 - 12.31	Current date		22
03	Hour / Minute	00.00 - 23.59	Current time		22
04	Operation mode Standard/Professional	0 - 1			22
05	Detector code	0 - 99	99 GMZ 0 FSK		22
06	Nuclide: 0=Co-60, 1=Cs-137	0 - 1	0		23
07	Automatic password protection	0 - 9999	0		23
08	Warning relay as second alarm relay	0 – 1 10 - 100	0		23
09	Alarm relay follows the error relay	0 - 1	0		25
10	Reading (%)	-999 - 9999	Reading		25
11	Reading averaged	0 - 999.9	Reading		25
12	Time constant (s)	0.1 – 999.9	-1		25
13	Live count rate	0 - 999.9	Reading		26
14	Maximum time constant (s)	0 - 999	999		26
15	Standard reading	10 - 11	10		26
16	Max. or min. limit value switch 0=Max, 1=Min	0 - 1	0		27
17	Switching threshold (%)	0 - 100	-1		27
18	Switching threshold in (cps)	0 - 999.9	-1		28
19	Hysteresis (%)	0 - 999	-1		29
20	Empty count rate (no input)	0 - 999.9	Reading		19
21	Full count rate (no input)	0 - 999.9	Reading		29
22	Zero count rate (no input)	0 - 9.999	Reading		30
30	Empty count rate	0 - 999.9	20 GMZ 300 FSK		31
31	Full count rate	0 - 999.9	-1		31
32	Zero count rate	0 - 9.999	Depending on detector code		32
33	Measuring path (in mm)	0 - 9999	0		33
34	Gas density (kg/m³)	0 - 9999	0		33
35	Bulk density (kg/m³)	0 - 9999	0		34
36	Compute	35.01 – 35.08	Reading		35
37	Counting time for calibration (s)	5 - 599	60		36
38	Bulk cone diameter (mm)	0 - 9999	0		37
39	Half-value layers	1 - 9	2		36

Code no.	Designation	Value range	Factory setting	Device setting	Page
40	Interference radiation detection	0 - 1	0		38
41	Waiting time after interference radiation	0 - 999	20		39
42	Signaling interference radiation	0 - 2	0		39
43	Signaling unlocked	0 - 2	0		39
44	Signaling minor errors	0 - 2	0		40
45	Signaling excess temp. detector (only FSK[1])	0 - 2	0		40
46	Temperature threshold detector (only FSK[1])	0 - 99	40		40
47	Signaling excess temp. EVU[6]	0 - 2	0		41
48	Temperature threshold EVU[2]	0 - 99	50		41
50	Limit switch software	1.00 - 9.99	Version		41
51	Detector software (only FSK[1])	1.00 - 9.99	Reading		41
52	Detector temperature °C (only FSK[1])	-40 - 80	Reading		41
53	Detector high voltage (only FSK[1])	500 - 1300	-1		42
54	detector HV start value (only FSK[1])	500 - 1300	HV default		42
55	Source replacement	00.00 - 99.12	-1		43
56	Evaluation unit electronics temperature	-100 - 200	Reading		43
60	Test pulse generator	0 - 999.9	0		43
61	Test error relay	0 - 2	0		44
62	Test alarm relay	0 - 2	0		44
63	Test warning relay	0 - 2	0		44
64	Test display				44
65	Test keyboard				44
66	Status digital in	00.00 - 01.01	Reading		45
67	HV max for plateau measurement	500 - 1300	1000		45
68	Detector plateau measurement (only FSK[1])	0 - 5	0		46
70	Error log	0 - 1	0		47
71	Revision log	0 - 1	0		48
72	Save & Load / Reset	0 - 99	0		49

[1] FSK = Detector with scintillator and FSK communication
[6] EVU = Evaluation unit

Notes

Notes

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