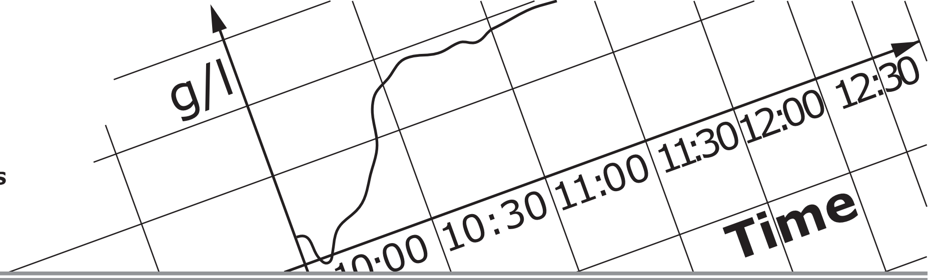
BERTHOLD TECHNOLOGIES

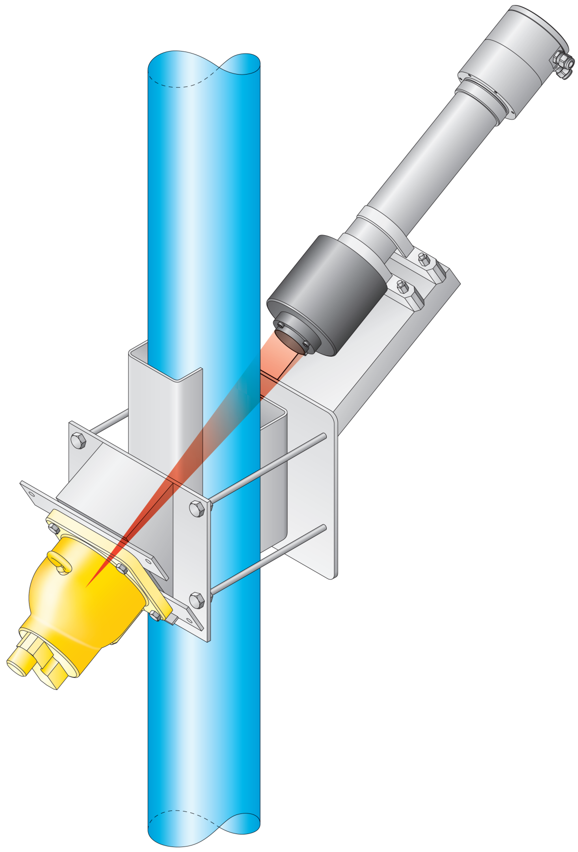


detect and identify

Process Control

sensseries LB 480

Density Measurement



User's Manual

Id. No. 54733-30BA2D
Rev. No. 05 09.2023
Embedded Soft. from Rev. 1.00.00
Device Description from Rev. 01

Volume 1: Safety Manual 1

Volume 2: Installing SENSseries 2

Volume 3: Operation with HART® Communicator 3

General Information

Dear customer

Thank you for purchasing the measuring system SENSseries LB 480 by BERTHOLD TECHNOLOGIES.

The scope of supply also includes this User’s Manual. Keep this User’s Manual on hand for reference at any time.

Please observe the warnings and safety instructions given in this User’s Manual to rule out personal injury and property damage. They are identified by the following symbols: DANGER, WARNING, CAUTION or IMPORTANT. In *Volume 1*, *Meaning of Other Symbols Used in this Documentation* you find an overview of the hazards to be observed and instructions on how to deal with these hazards.

Please read this User’s Manual prior to installation to get familiar with the product.

If you do encounter problems despite careful study of the User’s Manual, please do not hesitate to contact us.

Your BERTHOLD team

Volume 1 Safety Manual

Volume 2 Installing SENSseries

Volume 3 Operation with HART® Communicator

Volume 1 Safety Manual

1 About this User's Manual

1.1 Typographical Conventions

The symbols and typefaces used in this User's Manual have the following meaning:

▶	prompts you to carry out an action.
1, 2, 3, …	identifies items in a graphic.
•	identifies enumerations.
italic typeface	highlights important information.
bold typeface	indicates commands or menu items.
bold italic	identifies user entries.

The term BERTHOLD TECHNOLOGIES is used in this User's Manual for the company BERTHOLD TECHNOLOGIES GmbH & Co. KG.

Please observe the warnings and safety instructions given in this User's Manual to rule out personal injury and property damage. They are identified by the following symbols: DANGER, WARNING, CAUTION or IMPORTANT.

⚠ DANGER

Indicates a direct threat of danger. The consequences will be death or most severe personal injuries.

⚠ WARNING

Indicates a possibly dangerous situation. If the situation is not avoided, death or serious bodily injury could result.

⚠ CAUTION

Indicates a possibly dangerous situation. If the situation is not avoided, minor or moderate bodily injury could occur.

NOTICE

Indicates a situation which could result in material damage if the instructions are not observed.

IMPORTANT

Paragraphs marked with this symbol provide important information on the product and on handling the product.

Tip

Includes application tips and other helpful information.

1.2 Meaning of Other Symbols Used in this Documentation

Warning: Do not step or stand under a suspended load.

Warning: Radiation

Warning: Ex-protection

Warning: Risk of crushing

Requirement: Switch off power

Requirement: Wear a hardhat

Requirement: Wear safety shoes

1.3 Meaning of Warning Signs on Detectors and Source Shieldings

Warning: Radiation
This warning is located on the source shielding.

Warning: Please read the User's Manual prior to installation
This warning is located on or in the terminal compartment of the detector.

1.4 Terms Used in this User's Manual

CrystalSENS
Standard point detector version in the SENSseries LB 480.

UniSENS
Standard rod detector version in the SENSseries LB 480.

SuperSENS
Highly sensitive detector with large volume plastic scintillator 150 x 150 mm for large pipe or tank diameter.

TowerSENS
Rod detector with an especially large potential measuring length. In contrast to multi-detector configurations, only one detector is required here.

NaI detector
NaI = sodium iodide crystal = scintillator

Scintillation detectors are very sensitive probes for gamma radiation.

Isotope
Substance of the radiation source, e.g. Cobalt 60 (Co-60) or Cesium 137 (Cs-137).

Count rate
Value for the number of pulses standardized to one second.

Background
The count rate caused by the natural environmental radiation.

Cps
Unit for the count rate: *C*ounts *p*er *s*econd.

Factory setting
In the factory setting, all parameters are preset with default values. In most cases, this makes calibration of the detector a lot easier. Nevertheless, a calibration must *always* be carried out.

mSv
Milli-Sievert: The unit indicates the dose rate (dose equivalent).

mrem
Milli-rem (roentgen equivalent in man): traditional unit for the dose rate (100 mrem = 1 mSv).

MBq
Mega Becquerel: The unit indicates the activity of a source. Each Bq corresponds to one disintegration per second, i.e. 1 MBq equals one million disintegrations.

mCi
Milli-Curie: Traditional unit for the activity of a source (1 mCi = 37 MBq).

ATEX
Atmosphère explosive: is used as a generic term for the ATEX Product Directive 94/9/EC and the ATEX Workplace Directive 1999/92/EC. The directives contain provisions for equipment and components for use in explosion hazardous areas.

FM
Factory Mutual: an American industrial property insurance company that, among other things, issues certifications in the field of explosion protection.

CSA

Canadian Standard Association: sets norms and standards that are important for Canada (and America), among other things, the Directive for Explosion Protection and Low Voltage.

PMT

Photomultiplier or only multiplier: converts the flashes of light generated by the radiation in the detector into electrical signals.

HV

HV = High voltage

The multiplier is operated at high voltage, so that flashes of light can be converted into electrical pulses.

The high-voltage control allows for measurements that are stable to temperature and aging. Each multiplier has a slightly different sensitivity, and must therefore be operated at a different high voltage.

The multiplier is operated at high voltage, so that flashes of light can be converted into electrical pulses.

The high-voltage control allows for measurements that are stable to temperature and aging. Each multiplier has a slightly different sensitivity, and must therefore be operated at a different high voltage.

Zero count rate

Count rate where the measurement indicates the measured value 0. For example, if g/cm^3 has been selected as the unit, 0 g/cm^3 will be displayed at this count rate. The count rate is calculated from the calibration points after **Calibrate** has been enabled. Together with the coefficients A1, A2 and A3, it determines the characteristic curve of the measurement.

active / passive (Source / Sink)

Depending on the detector type, the current output can be configured as a current source or current sink. The following terms are used interchangeably:

- Current source: active / Source Mode
- Current sink: passive / Sink Mode

1.5 General Information

The most important safety measures are summarized in this volume. It supplements the appropriate provisions which the staff in charge is *obliged* to follow.

Please pay attention to:

- the national safety and accident prevention regulations
- the national assembly and installation directions (for example, EN 60079)
- the generally accepted engineering rules
- the information on transport, assembly, operation, service, maintenance in this User's Manual
- the safety instructions and information in this User's Manual and the enclosed technical drawings and wiring diagrams
- the parameters, limit values and the information on operating and ambient conditions on the type labels and in the data sheets
- the labels on the device

Depending on the field of application, the corresponding chapters have to be taken into account.

2 Proper Use

The measuring system SENSseries LB 480 is a detector which, depending on its design, can be used for different measurement tasks:

- Level measurement
- Limit monitoring
- Density measurement

The measurement system is designed for the continuous monitoring and detection of levels and limit levels of liquids and bulk solids in bins, or to determine the density of liquids in tanks and pipes. The proper use is defined in the project planning stage by BERTHOLD TECHNOLOGIES, the system delivered may be used only for this purpose.

If the detector is used in a way which is not provided for during the project planning stage and which is not described in the User’s Manual, then the detector's protection is compromised and the guarantee claim becomes invalid.

BERTHOLD TECHNOLOGIES only accepts liability for / guarantees the correspondence of the systems of the SENSseries LB 480 to its published specifications. The detectors of the SENSseries may only be installed in an undamaged, dry and clean condition.

Conformity to standards

The standards and guidelines the SENSseries complies with are itemized in the CE conformity declaration.

Warning about misuse

The following use is inappropriate and has to be prevented:

- Use under other conditions and prerequisites than those specified by the manufacturer in his technical documents, data sheets, operating and assembly instructions and other specifications.
- The repair of detectors that are used in explosion hazardous areas by persons who were not authorized by BERTHOLD TECHNOLOGIES.
- Using the device in a damaged or corroded condition.
- Operation with open or inadequately closed cover.
- Operation with inadequately tightened adapters and cable glands.
- Operation without observing the safety precautions foreseen by the manufacturer.
- Manipulating or bypassing existing safety installations.

Maintenance

The measuring system of the SENSseries LB 480 may only be installed, serviced and repaired by trained persons (see *chapter 3.2*, *page 1-22*).

Repair

Spare parts for detectors used in the Ex-area may be assembled only by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

Parameter settings

Never change the parameter settings without a full knowledge of this User’s Manual, as well as a full knowledge of the behavior of the connected controller and the possible influence on the operating process to be controlled!

Sources and shieldings

This measuring system uses radioactive sources. The radiation protection instructions in this User’s Manual and the relevant statutory provisions are to be observed strictly, see also *chapter 8, "Visual Inspection"*, *page 1-121* following.

3 Qualification of the Personnel

At different parts in this User's Manual, reference is made to personnel with certain qualifications who can be entrusted with different tasks during the installation, operation and maintenance.

These three groups of people are:

1. Persons with a general knowledge, see *chapter 3.1*.
2. Experts, see *chapter 3.2*.
3. Authorized persons, see *chapter 3.3*.

The following chapters explain the meaning of these terms and the prerequisites for the particular group of people.

IMPORTANT
All work on and with the measurement systems SENSseries LB 480 must be performed by persons having at least a general knowledge; they must always be guided by an expert or an authorized person.

3.1 Persons with a General Knowledge

Persons with a general knowledge are e.g. technicians or welders who can undertake different tasks during the transportation, assembly and installation of the measuring systems SENSseries LB 480 under the guidance of an authorized person. This can also refer to construction site personnel. The persons in question must have experience in the transportation and assembly of heavy component parts.

Persons working with Ex devices must in addition have knowledge on how to work with these devices, for example, that the devices must not be subject to mechanical damage (blow, etc.).

IMPORTANT
Persons with a general knowledge must always be guided by a trained expert at the very least.
When dealing with radioactive substances, a Radiation Safety Officer must also be consulted.

3.2 Experts

Experts are persons who have sufficient knowledge in the required area due to their specialist training and who are familiar with the relevant national health and safety regulations, accident prevention regulations, guidelines and recognized technical rules. Expert personnel must be capable of safely assessing the results of their work and they must be familiar with the content of this User's Manual.

3.3 Authorized Persons

Authorized persons are those who are either designated for the corresponding task due to legal regulations or those who haven been authorized by BERTHOLD TECHNOLOGIES for particular tasks. When dealing with radioactive materials, a Radiation Safety Officer must also be consulted.

4 Transport and Assembly

The weight of the source shielding may be up to several 100kg, depending on the version. Please keep in mind:

- The load capacity of the container walls and the brackets must be suitable for the mounting of the source with the shielding and the detector. Otherwise, system parts may fall off and cause severe injuries or bodily harm with fatal consequences.
- Make sure that the mechanical stability of the fixing devices matches the weight of the shielding.

Please keep in mind:

– Never step under hovering loads while unloading heavy system parts!

– Only use tested lifting equipment matching the transport weights.

– Maintain adequate safety margin.

– Wear hard hat and safety shoes.

– Always ensure good stability for all types of use.

– Make use of the prepared mounting options.

– Work during assembly and installation of heavy and unwieldy subassemblies should be carried out by at least two people.

– System components must be mounted vibration-free.

– Hold the housing cover firmly to prevent the housing cover from falling down when opening and closing the terminal compartment.

5 Explosion Protection

SENSseries

LB 480 - .. 1C
LB 480 - .. 2C
LB 480 - .. 3C
LB 480 - .. 4C
LB 480 - .. FA
LB 480 - .. GA

Safety Manual

Explosion Protection

for (Class I) Zone 1 / Zone 21
for Class I, II, III Division 1
ATEX / IECex / UKCA / NEC / CEC

Id.-Nr. 54733BA26

Rev.-Nr.: 07 03/2023

(bg) Инструкции за безопасност за употреба в потенциално експлозивни райони. Това ръководство за безопасност е и на разположение на официалните езици на Европейския съюз.

(cs) Bezpečnostní pokyny pro použití v oblastech, kde hrozí nebezpečí výbuchu. Tato příručka s bezpečnostními pokyny je k dispozici i v úředních jazycích Evrospké unie.

(da) Skkerhedsvejledning til brug i eksplosionsfarlige omgivelser. Denne sikkerhedsmanual findes på alle officielle sprog i det Europæiske fælleskab.

(de) Sicherheitshinweise für den Einsatz in explosionsgefährdeten Bereichen. Dieses Sicherheitshandbuch ist auch in den Amtssprachen der europäischen Gemeinschaft erhältlich.

(el) Υποδείξεις ασφάλειας για χρήση σε περιοχές με κίνδυνο έκρηξης. Αυτό το εγχειρίδιο ασφάλειας διατίθεται επίσης στις επίσημες γλώσσες της Ευρωπαϊκής Ένωσης.

(en) Safety instructions for use in potentially explosive areas. This safety manual is available also in the official languages of the European Community.

(et) Ohutusjuhised kasutamiseks plahvatusohtlikes piirkondades. Käesolev ohutuskäsiraamat on saadaval ka Euroopa Ühenduse ametlikes keeltes.

(fi) Räjähdysvaarallisilla alueilla käyttöä koskevat turvallisuusohjeet. Tämä turvaohjekirja on saatavilla myös Euroopan yhteisön virallisilla kielillä.

(fr) Consignes de sécurité relatives à une utilisation en zones explosives. Le présent manuel de sécurité est également disponible dans les langues officielles de la communauté européenne.

(ga) Treoracha sábháilteachta le haghaidh úsáide I limistéir inphléasctha Tá an lámhleabhar sábháilteachta seo ar fáil i dteangacha oifigiúla an Aontais Eorpaigh, chomh maith.

(hu) Biztonsági utasítások robbanásveszélyes területeken történő alkalmazáshoz. Ez a biztonsági kézikönyv az Európai Közösség hivatalos nyelvein is rendelkezésre áll.

(it) Istruzioni per l'impiego in ambienti a rischio di deflagrazione. Il presente manuale contiene le disposizioni di sicurezza ed è disponibile in tutte le lingue ufficiali della comunità europea.

(lt) Saugumo nurodymai naudojimui potencialiai sprogiose zonose. Šį saugumo vadovą taip pat galima gauti Europos Bendrijos oficialiomis kalbomis.

(lv) Drošības noteikumi piemērošanai jomās, kas saistītas ar sprādzienbīstamību. Šī drošības noteikumu rokasgrāmata ir pieejama arī citās Eiropas Kopienas oficiālajās valodās.

(mt) Istruzzjonijiet dwar is-sigurtà li għandhom jintużaw f'żoni potenzjalment splussivi. Dan il-manwal tas-sigurtà huwa disponibbli wkoll fl-ilsna uffiċjali kollha tal-Komunità Ewropea.

(nl) Veiligheidsinstructies voor de inzet in gebieden met gevaar voor explosies Dit veiligheidshandboek is ook in officiële talen in de EuropeseGemeenschap verkrijgbaar.

(pl) Przepisy bezpieczeństwa dotyczące użytkowania na obszarach zagrożonych wybuchem. Niniejsza instrukcja bezpieczeństwa dostępna jest również w językach urzędowych Unii Europejskiej.

(pt) Indicações de Segurança para a utilização em áreas potencialmente explosivas. Este Guia de Segurança também está disponível nas línguas oficiais da Comunidade Europeia.

(ro) Instructiuni de siguranţă pentru utilizarea în zone periculoase. Acest manual de siguranţă este de asemenea disponibil în limbile oficiale ale Comunităţii Europene.

(sk) Bezpečnostné pokyny pri použití vo výbušnom prostredí. Táto bezpečnostná príručka je k dispozícii aj v úradných jazykoch Európskej únie.

(sl) Varnostna navodila za uporabo v eksplozijsko ogroženih območjih. Ta varnostni priročnik je na voljo tudi v uradnih jezikih Evropske unije.

(sp) Instrucciones de seguridad para el uso en áreas explosibles. El presente manual de seguridad está disponible también en las lenguas oficiales de la Comunidad Europea.

(sv) Säkerhetshänvisningar till användning i områden som är utsatt för exlposionsfara. Denna handbok finns även tillgänglig i alla officiella språk av den europäiska gemenskapen.

5.1 Declaration of Conformity

5.1.1 Hazardous Environments

BERTHOLD

Berthold Technologies GmbH & Co. KG
Calmbacher Straße 22
75323 Bad Wildbad, Germany
info@berthold.com
www.berthold.com

EU-Declaration of Conformity (original) File No.: CE20023-4

We, hereby declare under our sole responsibility that the design of the following products / systems / units brought into circulation by us comply with the relevant harmonized rules of the EU.

This declaration loses its validity should modifications or unsuitable and improper use take place without our authorisation.

Description: ***detector for radiometrical measurement system in hazardous environments***

Typ: ***LB 480-xx-ee-xx-xx-xxx-x***

e = all letters except 0 (Zero) and Z
x = all letters

	directive	applied standards	
EMC	2014/30/EU	EN 61326-1	2013
RoHS	2011/65/EG	EN 50581	2012
ATEX	2014/34/EU	EN IEC 60079-0	2018
	PTB 11 ATEX 1032 X	EN 60079-1	2018
		EN 60079-7	2018
		EN 60079-11	2012
		EN 60079-31	2014
notified body: 0102 PTB Braunschweig, Germany		IEC 61010-1	2010

This declaration is issued by the manufacturer

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Calmbacher Str. 22, D-75323 Bad Wildbad, Germany

released by

Dr. J. Briggmann

Head of R&D
Bad Wildbad, 29rd of May, 2020

Registergericht / Court of Registration			Stuttgart HRA 330991	
Persönlich haftende Gesellschafterin / Fully liable Associates			Berthold Technologies Verwaltungs-GmbH	
Registergericht / Court of Registration			Stuttgart HRB 331520	
Geschäftsführung / Management			Andreas Dobratz	
USt.-Id-Nr. / VAT Reg. No.			DE813060511	
Deutsche Steuernummer / German Tax No.			49038/08038	
WEEE-Reg. No.			DE99468690	
Bankverbindungen / Bank Details	IBAN	BLZ	Konto / Account	Swift BIC
Sparkasse Pforzheim-Calw	DE37	6665 0085	0008 0450 03	PZHSDE66
Volksbank Pforzheim	DE85	6669 0000	0000 9570 04	VBPFDE66
Commerzbank Pforzheim	DE05	6668 0013	0651 1120 00	DRESDEFF666

detect and identify

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Fon +49 7081 177-0
Fax +49 7081 177-100
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www.berthold.com

UK Declaration of Conformity

File No.: UK20023-01

We hereby declare, under our sole responsibility, that the design of the following detector placed on the market by us complies with the relevant U.K. legislation for UKCA-marking.

Unauthorized modifications or unintended use of the product make the declaration invalid.

Product name: ***detector for radiometrical measurement system in hazardous environments***

Type / model: ***LB 480-xx-ee-xx-xx-xxx-x***
e = all letters except 0 (Zero) or Z
x = all letters

Regulation		**applied standards**
Equipment and Protective System Intended for Use in Potentially Explosive Atmospheres Regulations 2016	SI 2016/1107	EN IEC 60079-0:2018 EN 60079-1:2014 EN IEC 60079-7:2015/A1:2018 EN 60079-11:2012 EN 60079-31:2014 IEC 61010-1:2010/AMD1:2016
Electromagnetic Compatibility Regulations 2016	SI 2016/1091	EN 61326-1:2013
The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012	SI 2012/3032	

approved body / number	**measure**	**certificate**
Element Materials Technology / 0891	type examination production control	EMA21UKEX0050X

This declaration is issued by the manufacturer.

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Calmbacher Str. 22, D-75323 Bad Wildbad, Germany

released by

Dr. Jürgen Briggmann

Head of R&D
Bad Wildbad, 15^{th} of March 2023

Registergericht / Court of Registration: Stuttgart HRA 330991
Persönlich haftende Gesellschafterin / Fully liable Associates: Berthold Technologies Verwaltungs-GmbH
Registergericht / Court of Registration: Stuttgart HRB 331520
Geschäftsführung / Management: Thomas Bogner
USt.-Id-Nr. / VAT Reg. No.: DE813050511
Deutsche Steuernummer / German Tax No.: 49038/08038
WEEE-Reg. No.: DE99468690

Sparkasse Pforzheim-Calw	DE37	6665 0085	0008 0450 03	PZHSDE66XXX
Volksbank pur eG	DE37	6619 0000	0029 1282 51	GENODE61KA
Commerzbank Pforzheim	DE05	6668 0013	0651 1120 00	DRESDEFFXXX

Transforming science into solutions

5.1.2 Non Hazardous Environments

Berthold Technologies GmbH & Co. KG
Calmbacher Straße 22
75323 Bad Wildbad, Germany
info@berthold.com
www.berthold.com

EU-Declaration of Conformity (original) File No.: CE20023-6

We, hereby declare under our sole responsibility that the design of the following products / systems / units brought into circulation by us comply with the relevant harmonized rules of the EU.

This declaration loses its validity should modifications or unsuitable and improper use take place without our authorisation.

Description: ***detector for radiometrical measurement system in non hazardous environments***

Typ: ***LB 480-xx-e0-xx-xx-xxx-x***

e – 0 or Z
x = all letters

	directive	applied standards	
EMC	2014/30/EU	EN 61326-1	2013
RoHS	2011/65/EG	EN 50581	2012
LVD	2014/35/EU	IEC 61010-1	2010

This declaration is issued by the manufacturer

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Calmbacher Str. 22, D-75323 Bad Wildbad, Germany

released by

Dr. J. Briggmann

Head of R&D
Bad Wildbad, 29rd of May, 2020

Registergericht / Court of Registration			Stuttgart HRA 330991	
Persönlich haftende Gesellschafterin / Fully liable Associates			Berthold Technologies Verwaltungs-GmbH	
Registergericht / Court of Registration			Stuttgart HRB 331520	
Geschäftsführung / Management			Andreas Dobratz	
USt.-Id-Nr. / VAT Reg. No.			DE813050511	
Deutsche Steuernummer / German Tax No.			49038/08038	
WEEE-Reg. No.			DE99468690	
Bankverbindungen / Bank Details	IBAN	BLZ	Konto / Account	Swift BIC
Sparkasse Pforzheim-Calw	DE37	6665 0085	0008 0450 03	PZHSDE66
Volksbank Pforzheim	DE83	6669 0000	0000 9570 04	VBPFDE66
Commerzbank Pforzheim	DE05	6668 0013	0651 1120 00	DRESDEFF666

detect and identify

5.2 General Information

This safety manual provides operating instructions in accordance with the directive 2014/34/EU, the standards mentioned in the declaration of conformity, the National Electrical Code (NEC: ANSI/NFPA 70), the Canadian Electrical Code (CEC) and the UK regulations resulting from the UKCA certificate.

National responsible authorities can claim additional requests. Please observe the instructions given in this safety manual to avoid personal injury and property damage and to ensure safe operation.

The manual must be consulted in all cases where this symbol is marked, in order to find out the nature of the potential hazards and any actions which have to be taken to avoid them.

5.3 Improper Use

Warning about misuse

The following use is inappropriate and has to be prevented:

- Use under other conditions and prerequisites than those specified by the manufacturer in his technical documents, data sheets, operating and assembly instructions and other specifications.
- The repair of detectors that are used in explosion hazardous areas by persons who were not authorized by BERTHOLD TECHNOLOGIES.
- Using the device in a damaged or corroded condition.
- Operation with open or inadequately closed cover.
- Operation with
  - inadequately sealed glands,
  - inadequately tightened or damaged screwed fittings, i.e. cable glands, adapters and sealing plugs.
- Operation without paying attention to the manufacturer's safety precautions.
- Manipulating or bypassing existing safety installations.

5.4 Safety Instructions

5.4.1 Safety Instructions for Assembly and Operating Personnel

Assembly, installation, commissioning, operation and maintenance must only be carried out by authorized and trained personnel.

Before assembly/commissioning:

- Read the safety manual
- Read the operating manual
- Provide adequate training for assembly and operating personnel
- Ensure that the contents of the safety manual and the operating manual is fully understood by the relevant personnel.

If you are unclear:

- Mit Hersteller Kontakt aufnehmen.
- Reparatur

Repair

Spare parts may solely be assembled by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

5.5 Application Range and Technical Data

5.5.1 Ex-Protection and Temperature Limits

Test certificates:	PTB 11 ATEX 1032 X IECEx PTB 12.0038X EMA21UKEX0050X CSA 70009819 FM16US0282X / FM16CA0144X
Protection type:	IP66 / IP68 to IEC 60529 IP69K to ISO 20653 NEMA Type 4X
Air pressure:	80 kPa (0.8 bar) to 110 kPa (1.1 bar) Oxygen content of the air, typically: 21 % (Vi/V)

5.5.2 Detector Versions and Application Range for ATEX/IECEx/UKCA/NEC/CEC

Design		LB 480-1x-xx-... CrystelSENS (point detector)			LB 480-3x-xx-... SuperSENS	
		LB 480-2x-xx-... UniSENS (rod detector)			LB 480-4x-xx-... TowerSENS	
Protection concept		**LB 480-xx-1x LB 480-xx-2x**		**LB 480-xx-3C LB 480-xx-4C**	**LB 480-xx-1x LB 480-xx-2x**	**LB 480-xx-3C LB 480-xx-4C**
Signal circuits		**not intrinsically safe**		**Intrinsically safe**	**not intrinsically safe**	**Intrinsically safe**
Ex concept						
All rooms		Ex-t				
Housing (electronics compartment)		Ex-d				
Terminal compartment		Ex-e		Ex-e[1]/Ex-i	Ex-e	Ex-e[1]/Ex-i
Ambient temperature						
min.		$T_a \geq$ -40 °C				
max.		$T_a \leq$ +80 °C	$T_a \leq$ +65 °C	$T_a \leq$ +50 °C	$T_a \leq$ +60 °C[2]	$T_a \leq$ +50 °C
Zone 1 + 2, category II 2 G Class I Zone 1		**Gas**				
Temperature class		T5	T6	T6	T6	T6
Identification	ATEX/IECEx /UKCA/CEC	Ex db eb IIC Gb		Ex db eb [ia Ga] IIC Gb	Ex db eb IIC Gb	Ex db eb [ia Ga] IIC Gb
	NEC	AEx db eb IIC Gb		AEx db eb [ia Ga] IIC Gb	AEx db eb IIC Gb	AEx db eb [ia Ga] IIC Gb
Zone 21 + 22, category II 2 D		**Dust**				
Temperature class		T95 °C	T80 °C	T80 °C	T80 °C	T80 °C
Identification	ATEX/IECEx /UKCA/CEC	Ex tb IIIC Db		Ex tb [ia Da] IIIC Db	Ex tb IIIC Db	Ex tb [ia Da] IIIC Db
	NEC	AEx tb IIIC Db		AEx tb [ia Da] IIIC Db	AEx tb IIIC Db	AEx tb [ia Da] IIIC Db
Protection principle		Ex-d/ -e/ -t		Ex-d/ -e/ -i/ -t	Ex-d/ -e/ -t	Ex-d/ -e/ -i/ -t

1) Internal IP30 protection cover 2) some detectors support $T_a \leq$ +65 °C (see nameplate)

5.5.3 Detector Versions and Application Range for Divisions according NEC/CEC

Bauform	**LB 480-1x-xx-... CrystelSENS (point detector)** **LB 480-2x-xx-... CrystelSENS (rod detector)** **LB 480-3x-xx-... SuperSENS** **LB 480-4x-xx-... PowerSENS**	
Schutzkonzept	**LB 480-xx-Fx-...** **LB 480-xx-Gx-...**	
Signal circuit	not intrinsically safe	
Schutzprinzip		
Housing (electronic compartment)	explosion Proof (XP)	
Terminal compartment	explosion Proof (XP)	
Ambient temperature		
min.	$T_a \geq -40$ °C	
max.	$T_a \leq +80$ °C	$T_a \leq +60$ °C
Temperature class	T5	T6
Class I Division 1 US, NEC 500, 501	Gas Group A, B, C, D	
Class I Division 1 C (Canada) CEC 18	Gas Group B, C, D	
Class II Division 1 US, NEC 500, 502 C (Canada) CEC 18	Dust Group E, F, G	
Class III Division 1 US, NEC 500, 503 C (Canada) CEC 18	Fibers	

5.5.4 Electrical characteristics for supply and RS485

	LB 480-xx-xx-x1[3)]	LB 480-xx-xx-x2
Supply (terminal 1,2 or 3,4)	U = 18 … 32 V_{DC}, 12W U_m = 250 V	U = 100 … 240 V_{AC}, 50/60 Hz, 12 VA U_m = 250 V
RS485 circuit[2)] (terminals 5/5A, 6/6B)	U_m = 5 V_{DC} I_m = 20 mA	

2) Only for connection to RS485 interfaces of type LB 480

3) For NEC and CEC installations, refer to CSA Certificate (Conditions of Acceptability)

Please note that the maximum permissible ambient temperature at the detector surface should not be exceeded in case of failure of any connected water cooling.

Please refer to the technical data of the operating manual for information on the ambient temperature of the water cooling required so protect the electronics from damage by overheating.

The max. ambient temperature decreases when the detector is not mounted freestanding; the maximum surface temperature must not be exceeded.

5.5.5 Electrical safety characteristics of the associated equipment

Signal circuits	LB 480-...-3C (Sink)	LB 480-...-4C (Source)	
Current output (isolated) (Terminals 17, 18 resp. 19, 20)	**HART® / 4 ... 20 mA linear characteristic curve**		
max. output voltage		U_a = 25.2 V	
max. output current		I_a = 101 mA	
max. output rating		P_a = 635 mW	
max. input voltage	U_i = 30 V		
max. input current	I_i = 152 mA		
max. input rating	P_i = 1.14 W		
max. internal inductance	L_i = 20 µH		
max. internal capacitance	C_i = 3 nF		
Individual reactances according to EN 60079-11, Table A2, Figure A4 / A6		IIC	IIB
		L_o = 17 mH	L_o = 4 mH
		C_o = 0.82 µF	C_o = 0.107 µF
Signal output (isolated) (Terminals 11, 12)	Open collector circuit linear characteristic curve		
max. input voltage	U_i = 15 V[1]		
max. input current[2]	I_i = 26.6 mA		
max. input rating	P_i = 100 mW		
max. internal inductance	negligibly small		
max. internal capacitance	C_i = 11 nF		
Signal output (Terminals 15, 16)	Thermometer circuit (PT100) linear characteristic curve		
max. output voltage	U_o = 14 V		
max. output current	I_o = 27.7 mA		
max. output rating	P_o = 97 mW		
max. internal inductance	negligibly small		
max. internal capacitance	C_i = 11 nF		
Maximum permissible external values jointly acting reactances (C_i is not taken into account)	IIB		
	L_o = 0.1 mH, C_o = 4.6 µF		
	L_o = 0.5 mH, C_o = 4.0 µF		
	L_o = 1.0 mH, C_o = 3.3 µF		
Maximum permissible external values jointly acting reactances (C_i is not taken into account)	IIC		
	L_o = 0.1 mH, C_o = 0.73 µF		
	L_o = 0.5 mH, C_o = 0.71 µF		
	L_o = 1.0 mH, C_o = 0.59 µF		

1) minimum 5 V 2) Leakage current in closed state <0.01 mA

In gas atmospheres, when selecting group IIB or IIC for the intrinsically safe circuits, all intrinsically safe circuits and the LB 480 detector must be operated completely in the selected group IIB or IIC.

The probe must not be installed in zone 0 or zone 20. The protection level "ia" allows the safe use of measuring equipment that may otherwise only be used in Zone 0 or Zone 20.

5.6 Installation

- Observe the installation and safety instructions in the operating manual.
- Install according to manufacturer's instructions and applicable local standards and regulations, especially when installing other than with ATEX/IECEx regulations.
- Do not operate device outside of the electrical, thermal and mechanical characteristics.
- Install the housing cover and the screwed fittings (cable glands, adapters and sealing plugs) correctly to maintain the housing protection.
- Unused entries must be sealed with metal sealing plugs.
- Please note also the operating and assembly instructions of the screwed fittings.
- Evidence of intrinsic safety has to be provided prior to the installation of intrinsically safe circuits (see IEC 60079-14). The connection of measuring and test equipment must be considered! The installation must be carried out based on this proof.
- Connect the electrical equipment to the local potential equalization.
- With shielded cables, the shielding has to be placed on the detector side. Observe an adequate insulation >500 V between the screen and the lines.
- The current output and the open-collector circuit are each floating and have a dielectric strength of at least 500 V_{eff}. The circuit of the resistance thermometer is electrically connected to the PA port. For the supply voltage the dielectric strength is at least 1500 V_{eff}.
- Use a connection cable that is permitted and suitable for the application conditions. Observe local regulations!
- The connection cable (conductor and insulation) must be suitable for a continuous operating temperature ≥ T_a +15 K.
- Connected cables must be installed strain-relieved and fixed.
- Do not disassemble the detector housing from the detector base (see Fig. 11).
- Use the detectors exclusively for stationary installation.
- Devices that have been used under "non-Ex conditions"/Ordinary locations must not be used in the Ex-area/Hazardous Locations.
- If with intrinsically safe detectors it cannot be excluded that the intrinsically safe protective circuitry in the detector has been damaged by previous activities, the detector must no longer be used in intrinsically safe installations.
- Use a checklist to document the correctness and completeness of your work. We recommend to use the checklists in in chapter 1.9.1 and 1.9.2.

5.6.1 Increased Safety "e" in the Terminal Compartment

Housing Cover

- Take the weight (approx. 1.5 kg) of the housing cover into consideration when open and closing it so that it doesn't smash down.
- Install all four Allen screws (cylinder screws ISO 4762 M5 x 20 - A4 - 70) for the housing cover with a torque of 4 Nm. Use spring washers (DIN 127 - B5 - 1.4310) for housing covers with flat gaskets. For housing covers with O-Rings, use Nord-Lock-washers (NL5 SS from NORDLOCK®).

Screwed fittings

- Use only metallic screwed fittings and M20 x 1.5 screwed fittings suitable for the type of protection, depending on their application, but at least IP65.
- Only screwed fittings are permitted for ambient temperatures between -20 °C and +40 °C that technically meet at least the standard listed on the cover page of LB 480 EU type-examination certificate. Only screwed fittings which have been approved by BERTHOLD TECHNOLOGIES may be used outside this temperature range.
- Use only cables and fittings approved in accordance with local installation regulations. This could require special cables to prevent gas migration and, in particular, fittings with compound filling.
- Use only screwed fittings that are suitable for the type of cable (reinforced, non-reinforced, ...) and the cable cross-section.
- When using adapters for thread adjustment (e.g., thread reduction), only one adapter may be used in each entry.
- Replace the screwed fittings only by screwed fittings of the same type.

Terminals

- Permissible wire cross-section:
  - with ferrules 0.5 - 1.5 mm² (AWG 21 - 16 flexible)
  - without ferrules 0.5 - 2.5 mm² (AWG 21 - 14 flexible or solid)
- Both stranded leads as well as solid wires are permitted.
- To connect stranded leads, the following can be used: Ferrules or direct insertion of the strand into the terminal. The connection of fine-wire stranded lead class 6, according to IEC 60228, is only permitted with ferrules. Wire end sleeves according to DIN 46228 Part 1 + Part 4 are permitted.
- Tools used to manufacture crimped conductors must meet the requirements for a pull-out test according to DIN 46228 Part 4. They should withstand a pull-out force of 30 N at 0.5 mm² cross-section and 50 N at 2.5 mm² cross-section.
- Install the connecting cables in the terminal compartment so that ...
  - dirt and moisture are avoided in the terminal compartment;
  - the wires are not damaged when stripping;
  - the conductor insulation or the collar of the ferrule extends into the housing of the terminal body;
  - bare conductive parts of the lines (e.g., small wires of a strand) do not protrude from the terminal body;

- the length of the outer conductive part of the ferrule or the stripped wire must be 10 mm, so that the wire is securely held in the spring-type terminal;
- if ferrules are used, the conductor insulation extends into the collar of the ferrule.

5.6.2 Intrinsically Safe Installation Ex "i"

The sections "Screwed fittings" and "Terminals" in chapter 1.6.1 also apply to the intrinsically safe installation.

- The housing cover (metal lid) covers the entire terminal compartment (see Fig. 3).
- Take the weight (approx. 1.5 kg) of the housing cover into consideration when open and closing it so that it doesn't smash down.
- Install all four Allen screws (cylinder screws ISO 4762 M5 x 20 - A4 - 70) for the housing cover with a torque of 4 Nm. Use Nord-Lock-washers (NL5 SS from Nord-Lock®).
- Seals of the screwed fittings must be designed in such a way that the separation between intrinsically safe and non-intrinsically safe terminal room is not voided.
- The semicircular plastic cover (Ex-e cover) covers the non-intrinsically safe terminals (see Fig. 3).
- The Ex-e cover must prevent access to non-intrinsically safe circuits with IP30 protection.
- After installation, the Ex-e cover must completely cover the terminal compartment for the power supply and RS485 interface again.
- Both screws (flat head screw ISO 7045 - M3 x 8 - 4.8) for fixing the Ex-e cover must be mounted.
- The housing cover is mounted correctly only if the pin on the Ex-e cover smoothly clicks into the blind hole of the housing cover.
- With intrinsically safe versions
  - the metal cover to the terminal compartment may be opened only for a short time for testing and adjustment.
  - the semicircular cover in the terminal compartment may be opened only if the terminal compartment is no longer energized and no explosive atmosphere is present.
- Devices with intrinsically safe circuits must not be connected to intrinsically safe circuits any more if they have not been used intrinsically safe before.

5.6.3 Explosion Proof (XP)

The paragraph "Terminals" in chapter 1.6.1 is also valid in this chapter.

- The threads (cable entries 1/2" NPT and housing cover) must be protected against damage.
- The threads (cable entries 1/2" NPT and housing cover) must be protected against moisture and corrosion. Therefore, always lubricate the complete thread with grease OKS 217 in order to achieve the degree of protection NEMA Type 4X.

Housing Cover

- Take the weight (approx. 1.5 kg) of the housing cover into consideration when open and closing it so that it doesn't smash down.
- Fix the housing cover thoroughly (> 10 turns), til the O-Ring is covered. Tight the housing cover with a torque moment of 25 Nm.

Cable Glands

- Only use metallic cable glands with 1/2" NPT thread.
- Only use cable glands that correlate to the local valid standards and legal regulations.
- When using conduits, install sealing boxes direct at the cable entries.

5.6.4 Commissioning

- The HART® Communicator used must be capable of operating within the respective Ex zone.
- For intrinsically safe current output, the HART® Communicator must also be intrinsically safe. The level of protection (ia, ib, ic) of the Communicator must be at least the level of protection of the installed circuit.

5.6.5 Protection Principle Ex-d/-e/-t and XP

- Do not open the terminal compartment while voltage is applied.
- If there is an explosive atmosphere: Waiting time before opening the electronics compartment after turning off the power supply: 2 minutes.
- Continued operation is not allowed if:
  - the detector is damaged
  - threads on the housing are corroded
  - the detector housing is badly corroded
  - blanking elements are badly corroded or damaged
  - cable glands are corroded or damaged
  - adapters are badly corroded or damaged
  - seals are damaged, show visible aging, or settlement.

5.6.6 Protection Principle Ex-d/-e/-i/-t (intrinsically safe current output)

When opening the terminal compartment during operation, pleasekeep in mind:

- The housing cover may only be opened for a short time for repair and maintenance.
- The semicircular cover (Ex cover) must remain closed as long as the supply voltage is applied.
- Please proceed as described in chapter 5.2.4 if the non-intrinsically safe part of the terminal compartment is to be opened. Waiting time before opening the Ex-e cover after turning off the power supply: 2 minutes.

5.7 Control Drawing

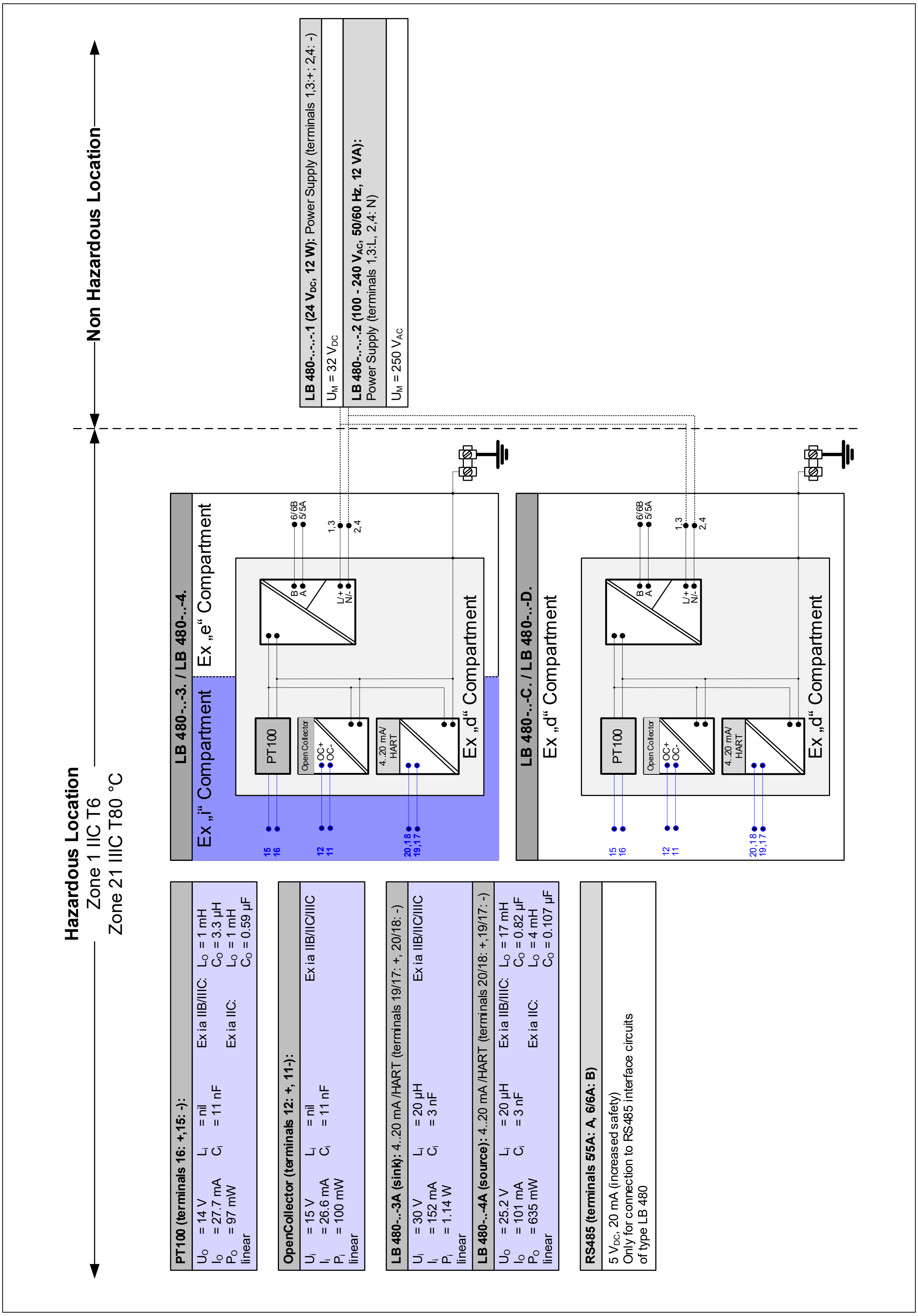
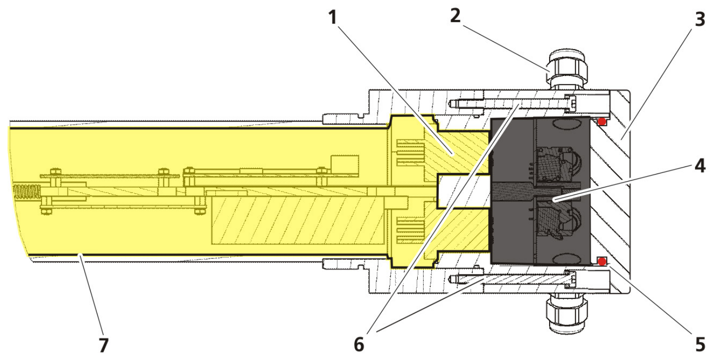


Fig. 1 Control Drawing

5.8 Ex – Concept

5.8.1 Ex-e – Concept

LB 480-xx-1C
LB 480-xx-2C



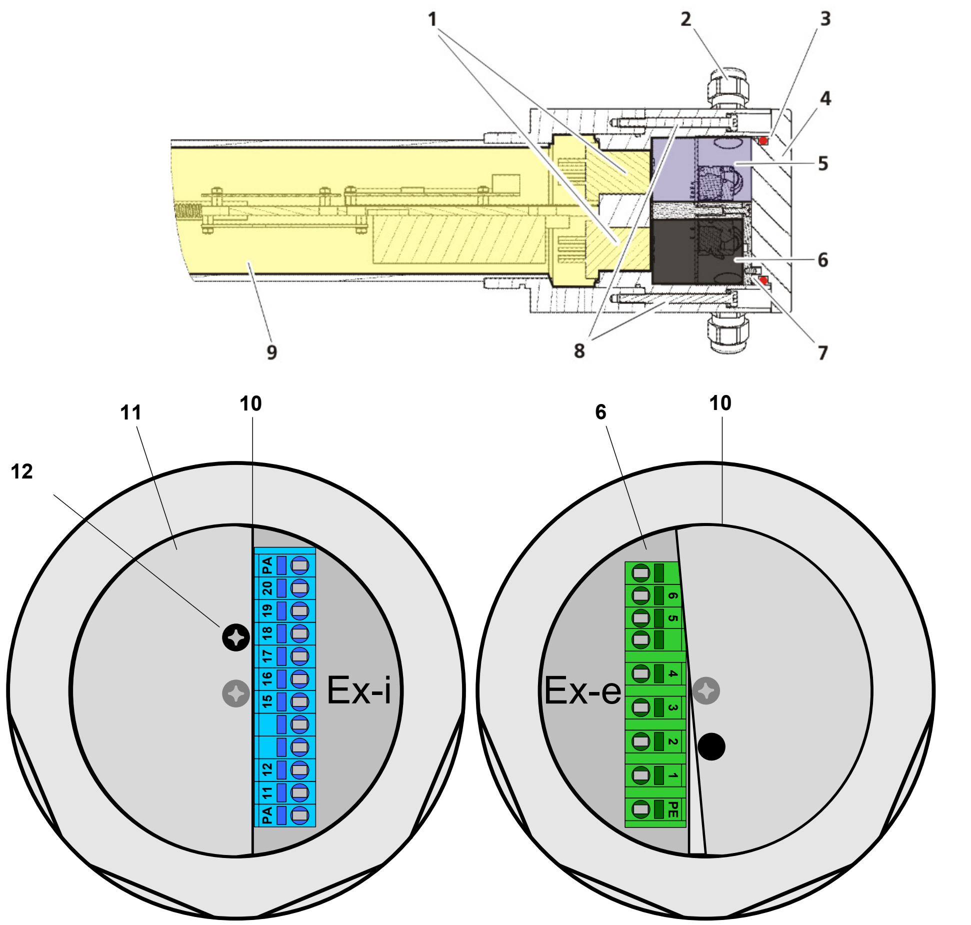
1 Pressure proofed line bushings
2 Cable glands (Ex e) max. 4
3 Lid for terminal compartment
4 Terminal compartment (Ex e)
5 Lid gasket (O-ring)
6 6 Screws **(do not loosen!)**
7 Pressure proofed housing (Ex d)

Fig. 2 Ex-e - Concept LB 480-xx-1C, LB 480-xx-2C

5.8.2 Ex-i – Concept

The RS485 connection to any connected type LB 480 interfaces is designed with increased safety.

LB 480-xx-3C
LB 480-xx-4C

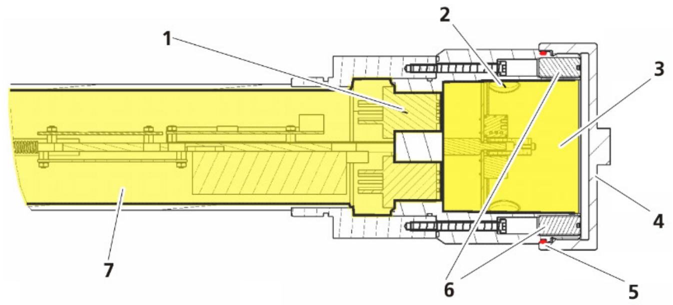


1	Pressure proofed cable bushings
2	Cable glands (Ex-e) max. 4
3	Lid gasket (O-ring)
4	Metal lid
5	Terminal compartment (Ex-i)
6	Terminal compartment (Ex-e)
7	IP 30 cover for Ex e compartment
8	6 Screws **(do not loosen!)**
9	Pressure Proofed Housing (Ex-d)
10	Master Terminal Compartment
11	Semicircular cover for Ex-e compartment with IP30 protection type
12	Unscrew to allow access to Ex-e terminal compartment after twisting of semicircular cover
13	Ex-e terminal compartment

Fig. 3 Ex-i - Concept LB 480-xx-3C, LB 480-xx-4C

5.8.3 XP – Concept

LB 480-xx-FX
LB 480-xx-GX



1 Bushings (explosion proof)
2 4x ½" NPT cable entry
3 Terminal compartment (explosion proof)
4 Lid for terminal compartment
5 Lid gasekt (O-ring)
6 Slotted set screw (**must not be unscrewed**!)
7 Housing (explosion proof)

Abb. 4 XP - Concept LB 480-xx-FX, LB 480-xx-GX

5.8.4 Installation Plan for the Type of Protection Increased Safety "e" and Intrinsic Safety "i"

Types
LB 480-..-1
LB 480-..-2
LB 480-..-3
LB 480-..-4

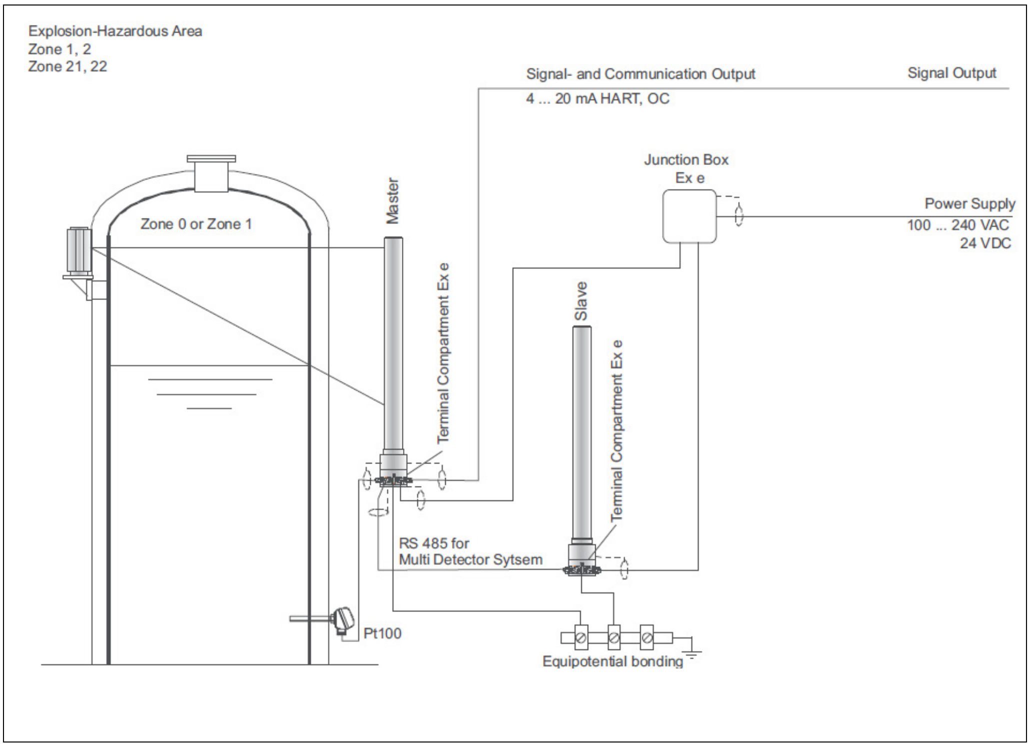


Fig. 5 Installation plan type of protection

5.8.5 Terminals

Terminal Compartment Master Ex-e and XP

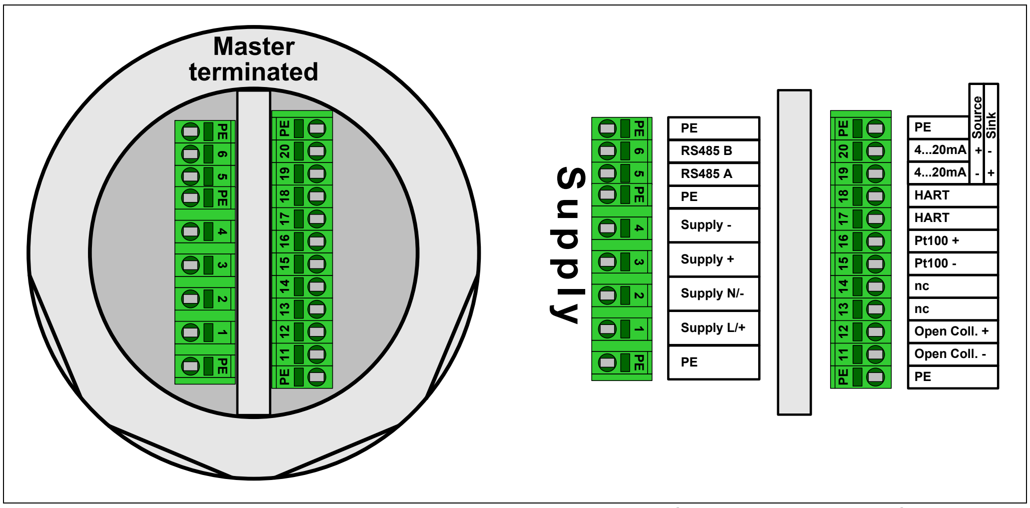


Fig. 6 Terminal Compartment Master Ex-e und XP (RS485 terminated)

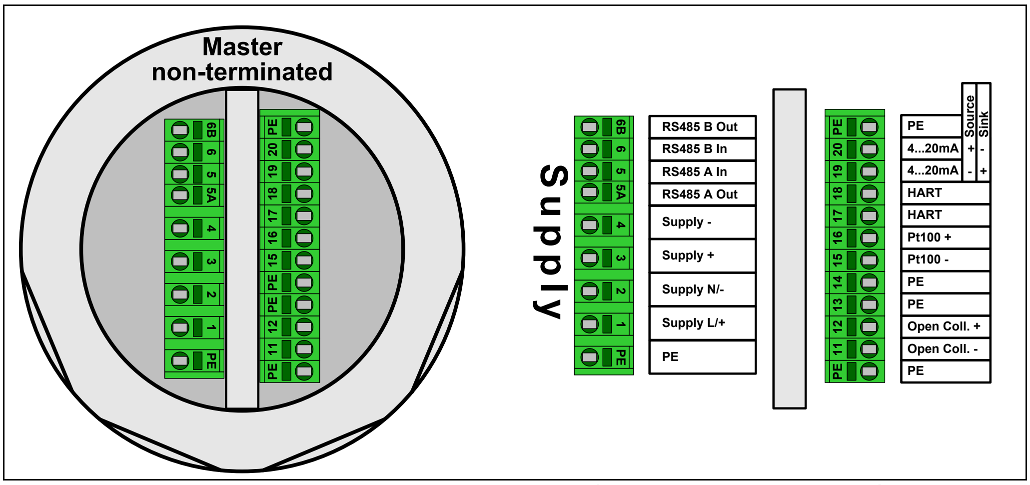


Fig. 7 Terminal Compartement Ex-e and XP (RS485 non-terminated)

Power supply

	Terminal	Labelling	
Type DC supply LB 480 - .. - .. - 11	1	Supply +	U_e = 24 V_{DC}, max. 12 W
	2	Supply -	
	3	Supply +	to forward to the next slave
	4	Supply -	
Type AC supply LB 480- .. - .. - 12	1	Supply L	U_e = 100 ... 240 V_{AC}, 50/60 Hz, max. 12 V_{AC}
	2	Supply N	
	3	Supply +	Do not use to loop through the supply!
	4	Supply -	

Do not connect any wires to the terminals "n.c.", as they are connected to the chassis ground.

Digital interface RS485

Terminal	
5/6	RS485: for multi-detector operation, connection of slave detectors or non-terminated master-detectors, service interface and for software update
5A/6B	RS485 feed through: only present in non-terminated master-detectors

Terminal Compartment Master Ex-e / Ex-i (after removing semicircular cover)

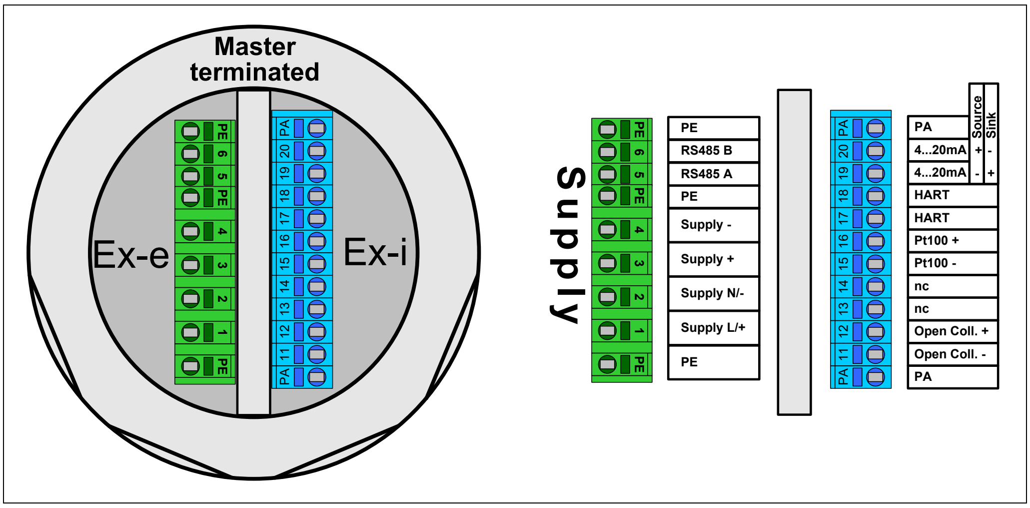


Fig. 8 Terminal compartment Ex-e / Ex-i (terminated)

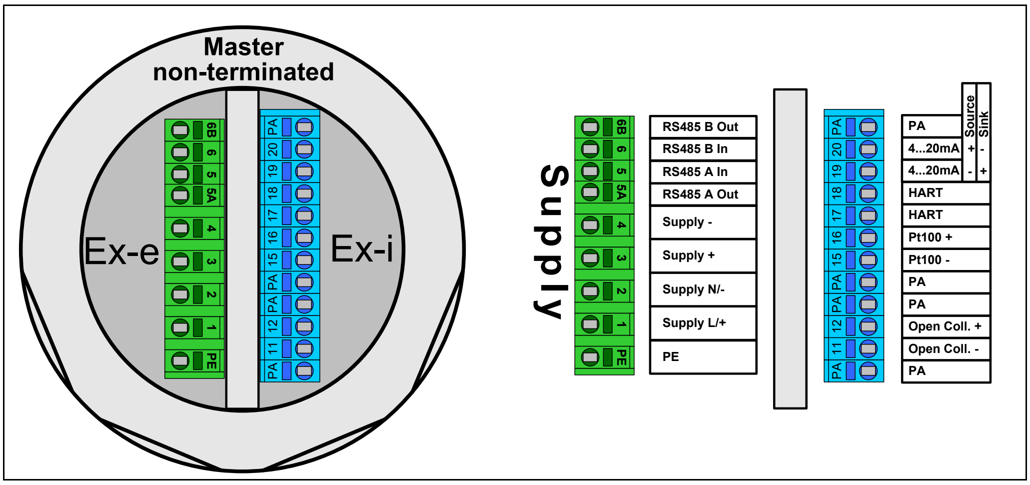


Fig. 9 Terminal compartment Ex-e / Ex-i (not-terminated)

Power Supply

<table>
<tr><th></th><th>Terminal</th><th>Labelling</th><th></th></tr>
<tr><td rowspan="4">Typ DC supply
LB 480 - .. - .. - 11</td><td>1</td><td>Supply +</td><td rowspan="2">U_e = 24 V_{DC},
max. 12 W</td></tr>
<tr><td>2</td><td>Supply -</td></tr>
<tr><td>3</td><td>Supply +</td><td rowspan="2">To forward the supply to the next slave</td></tr>
<tr><td>4</td><td>Supply -</td></tr>
<tr><td rowspan="4">Typ AC supply
LB 480- .. - .. - 12</td><td>1</td><td>Supply L</td><td rowspan="2">U_e = 100 ... 240 V_{AC},
50/60 Hz, max. 12 V_{AC}</td></tr>
<tr><td>2</td><td>Supply N</td></tr>
<tr><td>3</td><td>Supply +</td><td rowspan="2">Do not use to loop through the supply!</td></tr>
<tr><td>4</td><td>Supply -</td></tr>
</table>

Do not connect any wires to the terminals "n.c.", as they are connected to the chassis ground.

Digital interface RS485

Terminal	Labelling
5/6	RS485: for multi-detector operation, connection of slave detectors or non-terminated master-detectors, service interface and for software update
5A/6B	RS485 output: only present in non-terminated master-detectors

The OC (open collector) and the current output can only be connected to an intrinsically safe repeater. Otherwise, all circuits are no longer intrinsically safe! Only a passive component may be connected as Pt100.

Slave Terminal Compartment

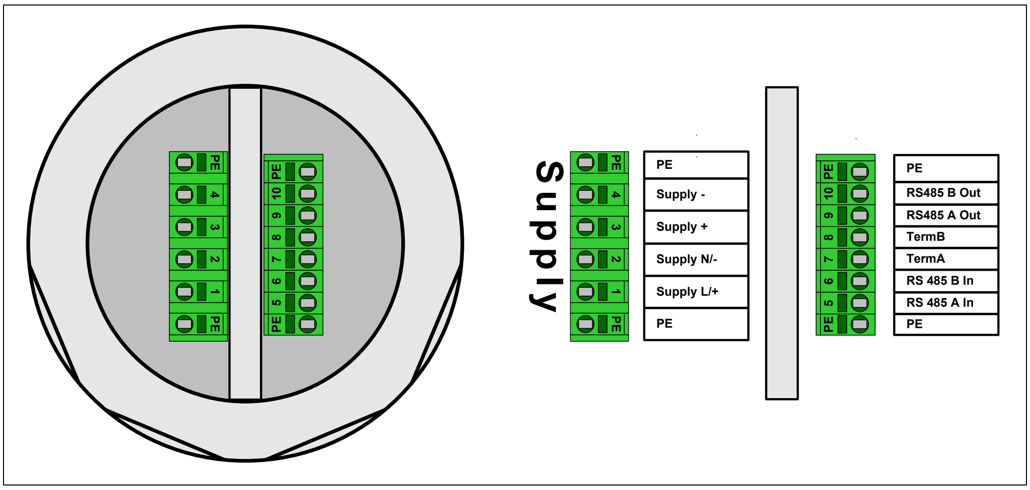


Abb. 10 Terminal compartment slave

Power supply

	Terminal	Labelling	
Typ DC supply LB 480 - .. - .. - 01	1	Supply +	U_e = 24 V_{DC}, max. 12 W
	2	Supply -	
	3	Supply +	To forward the supply to the next slave
	4	Supply -	
Typ AC supply LB 480- .. - .. - 02	1	Supply L	U_e = 100 ... 240 V_{AC}, 50/60 Hz, max. 12 VA U_m = 253 V_{AC}
	2	Supply N	
	3	Supply +	Do not use to loop through the supply!
	4	Supply -	

Digital interface RS485

Terminal	Labelling
5	RS485 A In
6	RS485 B In
9	RS485 A Out
10	RS485 B Out

Installation Instructions Cable Fittings and Dummy Plug

The cable glands are used only for the introduction of fixed cables. Please note the torques, cross sections and protection types of the screwed fittings in the following table.

The torques specified in the table below are typical values for the screwed fittings listed in the table, which essentially depend on the cable used. The pressure screw must be tightened so that the IP protection is permanently guaranteed.

Cable fittings

<table>
<tr><th rowspan="2">Type</th><th rowspan="2">Mate-rial</th><th rowspan="2">ID No.</th><th rowspan="2">EX labeling / Protection type</th><th rowspan="2">Cable cross-section for the sealing rings</th><th rowspan="2">A/F*</th><th colspan="2">Torque / Sealant</th></tr>
<tr><th>Pressure screw</th><th>Fitting body</th></tr>
<tr><td rowspan="4">Standard</td><td rowspan="2">Brass nickel-plated</td><td>55412</td><td>PTB 11 ATEX 1007 X
IP66 / IP68 / IP69K</td><td>6 - 9 mm
9 - 14 mm</td><td>24 mm</td><td colspan="2">10 Nm
Silicone</td></tr>
<tr><td>59030</td><td>IMQ 13 ATEX 018 X
IP66 / IP68
IMQ 13 ATEX 038 X
IP66 / IP68</td><td>4 - 6 mm
6 - 9 mm
9 - 12 mm</td><td>22 mm</td><td>16 Nm
Silicone</td><td>6 Nm
Neoprene</td></tr>
<tr><td rowspan="2">Stainless steel</td><td>56086</td><td>PTB 11 ATEX 1007 X
IP66 / IP68 / IP69K</td><td>6 - 9 mm
9 - 14 mm</td><td>24 mm</td><td colspan="2">10 Nm
Silicone</td></tr>
<tr><td>59033</td><td>IMQ 13 ATEX 018 X
IP66 / IP68
IMQ 13 ATEX 038 X
IP66 / IP68</td><td>4 - 6 mm
6 - 9 mm
9 - 12 mm</td><td>22 mm</td><td>16 Nm
Silicone</td><td>6 Nm
Neoprene</td></tr>
<tr><td>EMC</td><td rowspan="3">Brass nickel-plated</td><td>56091</td><td>PTB 11 ATEX 1007 X
IP66 / IP 68 / IP69K</td><td>9 - 14 mm
(7 - 12 mm screen)</td><td>24 mm</td><td colspan="2">10 Nm
Silicone</td></tr>
<tr><td rowspan="2">screen</td><td>56088</td><td rowspan="2">PTB 11 ATEX 1007 X
IP66 / IP 68 / IP69K</td><td>9 - 14 mm
(9 - 13 mm internal)</td><td>24 mm</td><td colspan="2">10 Nm
Silicone</td></tr>
<tr><td>56103</td><td>12 - 20 mm
(10 - 15 mm internal)</td><td>30 mm</td><td colspan="2">10 Nm
Silicone</td></tr>
</table>

*) A/F = across flats (wrench size)

Plugs M20 x 1.5

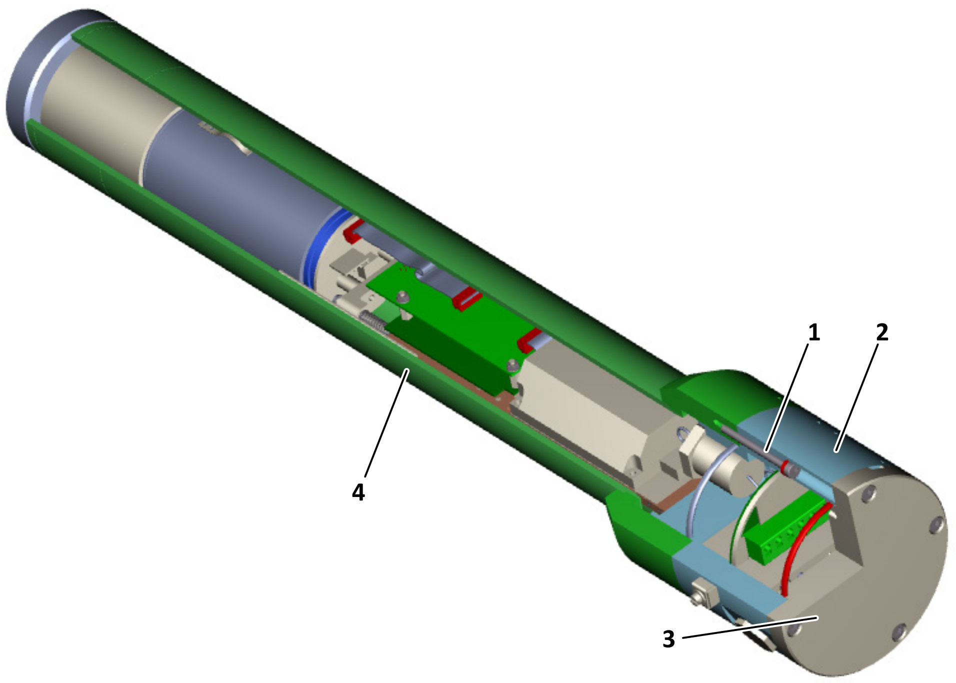
Material	ID No.	Certification No. / Protection type	A/F	Torque
Brass nickel-plated	56093	PTB 09 ATEX 1002 X IP66 / IP68 / IP69K	22 mm	10 Nm Silicone
	59031	SIRA 10 ATEX 1224 XITS 16 ATEX 101335 X IP66 / IP68 / IP69K	24 mm	6 Nm Neoprene
Stainless steel	56094	PTB 09 ATEX 1002 X IP66 / IP68 / IP69K	22 mm	10 Nm Silicone
	59032	SIRA 10 ATEX 1224 XITS 16 ATEX 101335 X IP66 / IP68 / IP69K	24 mm	6 Nm Neoprene
	68464	PTB 11 ATEX 1032 X IP66 / IP68	24 mm	10 Nm Silicone

Plugs 1/2" NPT

Material	ID No.	Certification No. / Protection type	A/F	Torque
Brass nickel-plated	33910	CSA: LR11716 UL: 10514	10 mm	30 Nm
Stainless steel 316L	66050	CSA: 2310046 IP66, NEMA 4X	10 mm	30 Nm

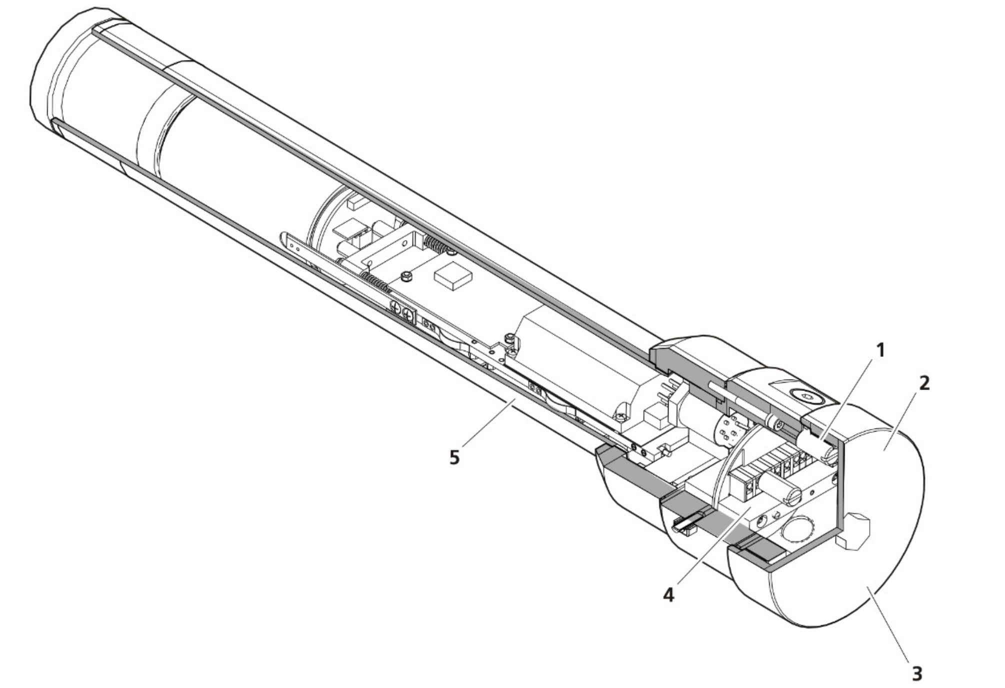
5.9 Maintenance and Visual Inspection

For detectors that are used in hazardous areas, the detector housing (Fig. 11) and thus the pressure-proof enclosure of the electronics may be opened only by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES.



1 6 screws **(must not be opened!)**
2 Connection head
3 Housing cover
4 Detector housing

Fig. 11 Detector housing with connection head with M20 cable entries for zone classification



1 Terminal room
2 Hosuing cover (lid)
3 Set screws* **(must not be unscrewed!)**
4 Connection head
5 Detector housing

Fig. 12 Detector housing with connection head for Class/Divisions with 1/2" NPT cable entries

*) The slotted set screws which are visible after opening the lid must not be unscrewed. Should one or more of these 6 screws be missing, the detector cannot be used in an Ex-area.

Use a checklist during commissioning, maintenance or repair to document the correctness and completeness of your work. We recommend to use the checklists in chapter 1.9.1 und 1.9.2.

Visual inspection

Carry out regular visual inspections of the SENSseries measuring system, at least once every three years. We recommend to use the checklist from chapter 1.9.1. Take appropriate actions immediately if you detect damage in the course of the visual inspection; if necessary, disconnect the detector from power supply immediately. To determine the inspection intervals for the visual inspection, take the following conditions into consideration:

- ambient conditions (temperature, humidity, corrosive atmosphere, shock and vibrations)
- operating conditions (degree of utilization, operating errors
- major changes in the overall system (e.g. changes in zoning)

Seals

If the cover or the housing is opened, the respective seals must be checked and replaced if necessary.

Cleaning

Take care not to damage the cable glands and the type plates during cleaning. Remove coarse debris with a stainless-steel wire brush. Grinding, filing or chipping away deposits with the hammer is not permitted.

5.9.1 Plan for Visual Inspection of the Detector

If you answer one of the following questions with "No", you have to record the action you have taken to remedy this deficiency in the last column. Make sure before you take the device into operation again that the provisions you have taken are correct by consulting with the person in charge of explosion protection.

Tests	YES	NO	Measures
General test			
Is the housing free of corrosion, dents, cracks, holes and warps?			
Is the housing cover of the detector firmly attached?			
Are the permissible functional and safety-related temperatures observed?			
Are the external connections of the potential equalizer in good working order?			
Is the surface of the detector free of contact with other non-alloy steel parts?			
Are the connected cables installed strain-relieved?			
Is a separator in place?			
Is the separator easily accessible for maintenance personnel?			
Test of screwed fittings (cable glands, adapters, sealing plugs)			
Were only metallic fittings used?			
Are the screwed fittings suitable for the ambient conditions?			
Are screwed fittings used for the normal ambient temperature range between -20 °C and +40 °C that at least meet the standards specified on the cover page of the EC type-examination certificate or are screwed fittings used that have been approved for use in the LB 480 by BERTHOLD TECHNOLOGIES?			
Is the permissible temperature range of the screwed fittings suitable for the temperatures encountered?			
Are the screwed fittings suitable for the required protection type (at least IP 65)?			
Are the screwed fittings free of corrosion?			

Is more than one adapter (reduction or extension piece) used?			
Is the total length of the cable glands plus any possibly used adapters less than 10 cm?			
Are the cable diameters of the cables used permitted for the cable glands?			
Are the connected cable suitable for the ambient conditions?			
Are the connected cables suitable for a temperature which is 15 °C above the maximum ambient temperature?			
Are the screwed fittings undamaged?			
Are there any doubts concerning the sealing of the screwed fittings?			
Are the cables firmly clamped in the cable glands?			
Are the screwed fittings firmly tightened?			
Are all unused openings provided with blanking plugs?			
Are the blanking plugs adequate for the required explosion group?			
Applies only to detectors with XP protection (Explosion proof)			
Is the detector cover thoroughly screwed in and is the O-ring thoroughly covered?			
Are sealing boxes at the cable entries on the housing available and are they in suitable condition?			
Date: Name:			

5.9.2 Plan for Inspection of the Terminal Compartment

If you answer one of the following questions with "No", you have to record the action you have taken to remedy this deficiency in the last column. Make sure before you take the device into operation again that the provisions you have taken are correct by consulting with the person in charge of explosion protection.

Tests	YES	NO	Measures
Test in the terminal compartment			
Is the interior (terminal compartment) in perfect order?			
Is the interior dry, clean and free of foreign material?			
Are the cables connected firmly?			
Are the terminals in perfect order?			
Is the interior free of corrosion?			
Is the insulation free of damages or trails?			
Is the mechanical fastening of the fixtures in good working order?			
Is the detector installed according to the local constructor regulations (e.g. EN 60079-14)?			
Does the cable insulation extend into the terminal compartment?			
Does the wire isolation reach into the sleeve of the terminals, respectively the sleeve of the ferrules?			
When using ferrules: Does the sleeve of the ferrule extend into the terminal sleeve?			
Are all the wires of a fine-wire strand covered by the terminal and clamped?			
Is the grounding conductor properly installed?			
Is the screened cable properly insulated electrically up to the terminal (e.g. with shrink tubing)?			
Applies only to detectors with intrinsically safe installation (Ex-i)			
Does the semicircular lid cover the terminal compartment (Ex-e)?			
Are the screws for the semicircular lid tightened?			

Has it been ensured that no wires are trapped between the semicircular cover and the underlying holder?			
Have both screws (flat head screw ISO 7045 - M3 x 8 - 4.8) of the semicircular cover been installed?			
Can the pin of the semicircular cover smoothly click into place during the assembly of the housing cover?			
Applies only to detectors with XP protection (Explosion proof)			
Are all 6 set screws are screwed in?			
Is the thread for the detector cover lubricated with grease OKS 217, in order to avoid corrosion?			
Leak test			
Is the sealing inside the screwed fittings OK?			
Is the sealing of the cover in the terminal compartment undamaged and free of cracks and settlement?			

Date:

Name:

5.10 ATEX Certificate – PTB 11 ATEX 1032 X

PTB Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

(1) **EU-TYPE-EXAMINATION CERTIFICATE**
(Translation)

(2) Equipment or Protective Systems Intended for Use in Potentially Explosive Atmospheres - **Directive 2014/34/EU**

(3) EU-Type Examination Certificate Number:

PTB 11 ATEX 1032 X **Issue: 3**

(4) Product: Scintillation measuring equipment type LB480

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

(6) Address: Calmbacher Straße 22, 75323 Bad Wildbad, Germany

(7) This product and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) The Physikalisch-Technische Bundesanstalt, notified body No. 0102 in accordance with Article 17 of the Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres, given in Annex II to the Directive.

The examination and test results are recorded in the confidential Test Report PTB Ex 22-11191.

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:
EN IEC 60079-0:2018 EN 60079-1:2014+AC:2018-09 EN IEC 60079-7:2015+A1:2018
EN 60079-11:2012 EN 60079-31:2014

(10) If the sign "X" is placed after the certificate number, it indicates that the product is subject to the Specific Conditions of Use specified in the schedule to this certificate.

(11) This EU-Type Examination Certificate relates only to the design and construction of the specified product in accordance to the Directive 2014/34/EU. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

(12) The marking of the product shall include the following:

Ex **II 2 G Ex db IIC T6 Gb bzw.**
Ex **II 2 G Ex db eb IIC T5 G bzw. II 2 G Ex db eb IIC T6 Gb**
Ex **II 2 G Ex db [ia Ga] IIC T6 G bzw. II 2 G Ex db eb [ia Ga] IIC T6 Gb**
Ex **II 2 D Ex tb IIIC T95 °C Db bzw. II 2 D Ex tb IIIC T80°C Db bzw.**
Ex **II 2 G Ex tb IIIC T60°C Db**
Ex **II 2 D Ex tb [ia Da] IIIC T80 °C Db bzw. II 2 D Ex tb [ia Da] IIIC T60 °C Db**

ZSEx001e c

Konformitätsbewertungsstelle, Sektor Explosionsschutz Braunschweig, May 2, 2022
On behalf of PTB:
D. Markus
Dr.-Ing. D. Markus
Direktor und Professor

PHYSIKALISCH-TECHNISCHE BUNDESANSTALT

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EU-Type Examination Certificates without signature and official stamp shall not be valid. The certificates may be circulated only without alteration. Extracts or alterations are subject to approval by the Physikalisch-Technische Bundesanstalt. In case of dispute, the German text shall prevail.

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Braunschweig und Berlin
Nationales Metrologieinstitut

(13) **SCHEDULE**

(14) **EU-Type Examination Certificate Number PTB 11 ATEX 1032 X, Issue: 3**

(15) Description of Product

The scintillation measuring equipment type LB 480 is part of a measuring system for monitoring industrial processes. It is used for continuously measuring the level in tanks or bins that contain liquid, granular, viscous or encrustation-forming media, and for measuring conveyor belt charges, and the density of liquids, suspensions, slurries and bulk solids. It is also used for continuously measuring level, weight per unit area, ash, sulphur, hydrogen and other specific application.

The measuring principle is based on the absorption of gamma rays. The radiation source does not part of the measuring equipment and not part of this certificate.

The scintillation measuring equipment consists of a scintillation detector with associated electronics in a common housing type of protection Flameproof Enclosure "d" or in type of protection Dust Protection by Enclosure "t".

The type LB 480 of measuring equipment is extended to the choice of execution as associated electrical equipment to the signal outputs OC-input, PT100 and HART current output in type of protection Intrinsic Safety "i".

The power supply and the interface RS485 are designed not intrinsically safe.

The integrated with the detector-housing connector housing is either in type of protection Flameproof Enclosure "d", or in type of protection Increased Safety "e", or in type of protection Dust Protection by Enclosure "t" or in each case in combination with the type of protection Intrinsic Safety "i "equipped.

The relevant options are listed in a new type of key and read in future as indicated below.

The relationship between variation, type of protection, temperature class and ambient temperature is re-codified and is listed in the table below.

Assignment of the ambient temperature

Protection	Temperature class	Variant	Product key	Ambient temperature
Ex db IIC Gb Ex tb IIIC Db	T6 T75 °C	A1, B1, E1	LB 480-xx-AC-xx LB 480-xx-BC-xx	-40 °C ≤ T_a ≤ +60 °C
Ex db eb IIC Gb Ex tb IIIC Db	T6 T80 °C	E2	LB 480-xx-1C-xx LB 480-xx-2C-xx	-40 °C ≤ T_a ≤ +60 °C
Ex db eb IIC Gb Ex tb IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-1C-xx LB 480-xx-2C-xx	-40 °C ≤ T_a ≤ +65 °C

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SCHEDULE TO EU-TYPE EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X, Issue: 3

Protection	Temperature class	Variant	Product key	Ambient temperature
Ex db eb IIC Gb Ex tb IIIC Db	T5 T95 °C	A2, B2	LB 480-1x-1C-xx LB 480-1x-2C-xx LB 480-2x-1C-xx LB 480-2x-2C-xx	-40 °C ≤ T_a ≤ +80 °C
Ex db [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A1, B1, E1	LB 480-xx-CC-xx LB 480-xx-DC-xx	-40 °C ≤ T_a ≤ +50 °C
Ex db eb [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-3C-xx LB 480-xx-4C-xx	-40 °C ≤ T_a ≤ +50 °C

<u>Type code</u>

LB480		-	.	.	-	.	.	-	.	.	-	..-...-	Variante	Beschreibung
			1	1									Bx	Point Detector 50x50
			1	2									Bx	Point Detector 50x50 + WC
			1	..									Bx	Point Detector ...
			2	A									Ax	Rod Detector 500 mm
			2	B									Ax	Rod Detector 500 mm + WC
			2	..									Ax	..
			2	K									Ax	Rod Detector 2000 mm
			2	L									Ax	Rod Detector 2000 mm + WC
			3	1									Ex	Super-Sens
			3	2									Ex	Super-Sens + WC
			3	.									Ex	
			4	1									Ex	Tower-Sens
			4	2									Ex	Tower-Sens + WC
			4	.									Ex	
						0	0							without Ex-type approval
						1							x2	ATEX/IECEx Ex det (passive / slave)
						2							x2	ATEX/IECEx Ex det (active)
						3							x2	ATEX/IECEx Ex deit (passive)
						4							x2	ATEX/IECEx Ex deit (active)
						A							x1	ATEX/IECEx Ex dt (passive / slave)
						B							x1	ATEX/IECEx Ex dt (active)
						C							x1	ATEX/IECEx Ex dit (passive / slave)
						D							x1	ATEX/IECEx Ex dit (active)
							A							Ex-Revision
							B							Ex-Revision (1. Supplement)
							C							Ex-Revision (2. Issue)
							.							
									.					Signal Output (Slave, HART, etc.)
										1				Power supply 24 V_{DC}
										2				Power supply: 100 - 240 V_{AC}
												.		none Ex-relevant parameter
	The "x" in the "Variant" column has the function of a placeholder.													

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SCHEDULE TO EU-TYPE EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X, Issue: 3

Electrical data

Power supply (Terminal 1, 2) (Terminal 3, 4)	max. 240 V, 50/60 Hz, max. 12 VA or max. 24 V (DC), max. 12 W U_m = 250 V
Interface circuit RS485 (Terminal 5, 5A, 6, 6A)	type of protection Increased Safety Ex ib IIB/IIC; 5 V (DC), 20 mA Only for connection to RS485 interface circuits other scintillation instruments LB 480 and an evaluation unit with equivalent means of protection
Thermometer circuit (PT100) (Terminal 15, 16)	type of protection Intrinsic Safety Ex ia IIB/IIC; maximum Values: U_o = 14 V I_o = 27.7 mA P_o = 97 mW Characteristic linear C_i = 11 nF L_i negligible small

Maximum permissible external values for common effective reactances (Ci is not considered). (according to ISpark-6.2)

L_o (mH)	IIB	IIC
	C_o (µF)	C_o (µF)
0,1	4,6	0,73
0,5	4,0	0,71
1,0	3,3	0,59

The RTD circuit is electrically connected to the internal supply circuit and the earth.

Open collector circuit (Terminal 11, 12)	type of protection Intrinsic Safety Ex ia IIB/IIC; maximum Values: U_i = 15 V I_i = 26.6 mA P_i = 100 mW C_i = 11 nF L_i negligible small

The open collector circuit is safely electrically isolated from earth and all other circuits.

HART-current output (Source Mode)	type of protection Intrinsic Safety Ex ia IIB/IIC;

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SCHEDULE TO EU-TYPE EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X, Issue: 3

(Terminal 17, 18)

maximum Values:
U_o = 25.2 V
I_o = 101 mA
P_o = 635 mW
Characteristic linear
C_i = 3 nF
L_i = 20 µH

Maximum permissible external values for common effective reactances (Ci is not considered). (according to ISpark-6.2)		
L_o (mH)	IIB	IIC
	C_o (µF)	C_o (µF)
0,44	0,52	0,084
0,8	0,45	0,066
1,6	0,38	0,049
13,0	0,37	-----

Single reactances to table A.2 and figure A.4 or A.6 of EN 60079-11			
IIB		IIC	
L_o (mH)	C_o (µF)	L_o (mH)	C_o (µF)
17	0.820	4	0.107

or

HART- current output (Sink Mode)
(Terminal 17, 18)

type of protection Intrinsic Safety Ex ia IIB/IIC; Only for connection to a certified intrisically safe circuit. Maximum Values:
U_i = 30 V
I_i = 152 mA
P_i = 1.14 W
C_i = 3 nF
L_i = 20 µH

The HART current output (source mode or sink mode) of the current output module are safely electrically isolated from earth and all other circuits.

Changes in this issue with respect to further issues

1. For the mounting of the glass window, in addition to the previously used casting compound, the following materials may also be used:

3M Scotch-Weld™ DP 105
Master Bond EP41S-6
Panacol Vitralit® 2028
When the material 3M Scotch-Weld™ DP 105 is used, the maximum ambient temperature is reduced to +60 °C.

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SCHEDULE TO EU-TYPE EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X, Issue: 3

2. Terminal board with modified pin assignment at the RS485 interface to allow terminated and non-terminated Master detector and connection of an evaluation unit with equivalent protection circuits..

Changes in issues 1 and 2

Electronic components were changed for new product groups.

The core material of the used current compensation chokes was exchanged.
The temperature class description in the Ex marking has been changed.
Adjustment of the special condition "X" for equipment types with intrinsically safe "ia" output circuits.

Electronic components were exchanged for new product groups with identical parameters. The components are located in the Ex-d housing.

The core material of the current compensation inductors used has been changed. The current compensation inductors are located in the Ex-d housing and are galvanically isolated from the intrinsically safe circuit section via transformers and optocouplers. The component cannot act externally via voltage and current limitations.

The temperature class designation in the Ex marking has been changed.

Adaptation of the specific conditions of use for device types with intrinsically safe "ia" output circuits.

(16) Test Report PTB Ex 22-11191

(17) Specific conditions of use

For the future the special conditions and the notes for manufacture and operation are defined as follows:

1) Due to the requirements of clause 5.1, EN 60079-1 it shall be pointed out that the joint dimensions of the flameproof enclosure deviate from the values tabulated in EN 60079-1. Repairing of flameproof joints exclusively according to the values specified in table 1 or table 2 of EN 60079-1 is not permitted and may only be carried out in accordance with the constructive specifications given by the manufacturer.

2) The interface circuit RS485 serves exclusively for intercommunication of the probes and an evaluation unit with equivalent means of protection and must not be connected to an external RS485 circuit.

3) In gas atmospheres must be fully operated in the selected group IIB or IIC in the choice of group IIB or IIC for the intrinsically safe circuits, all intrinsically safe circuits and the scintillation meter type LB 480.

4) The probe must not be installed in zone 0 or zone 20. The protection level "ia" allows the safe use of measuring equipment that may otherwise only be used in zone 0 or zone 20.

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SCHEDULE TO EU-TYPE EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X, Issue: 3

(18) Essential health and safety requirements

Met by compliance with the aforementioned standards.

Konformitätsbewertungsstelle, Sektor Explosionsschutz
On behalf of PTB:

Braunschweig, May 2, 2022

Dr.-Ing. D. Markus
Direktor und Professor

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5.11 IECEx Certificate – IECEx PTB 12.0038X

IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx PTB 12.0038X**	Page 1 of 4	Certificate history:
Status:	**Current**	Issue No: 4	Issue 3 (2020-09-18) Issue 2 (2020-03-23) Issue 1 (2013-11-28) Issue 0 (2012-07-26)
Date of Issue:	2022-04-08		
Applicant:	**Berthold Technologies GmbH & Co. KG** Calmbacher Str. 22 75323 Bad Wildbad **Germany**		
Equipment:	**Scintillation measuring equipment of the LB 480 series**		
Optional accessory:	Component certificates IECEx KEM 07.0057U , IECEx EPS 13.0045U		
Type of Protection:	**Ex db eb [ia] IIC Ex tb [ia Da] IIIC**		
Marking:	Ex db IIC T6 Gb, Ex db eb IIC T5 Gb, Ex db eb IIC T6 Gb, Ex db [ia Ga] IIC T6 Gb, Ex db eb [ia Ga] IIC T6 Gb, Ex tb IIIC T95°C Db resp. Ex tb IIIC T80°C Db resp. Ex tb IIIC T60°C Db, Ex tb [ia Da] IIIC T80°C Db resp. Ex tb [ia Da] IIIC T60°C Db		

Approved for issue on behalf of the IECEx Certification Body:	**Dr.-Ing. Detlev Markus**
Position:	**Head of Department "Explosion Protection in Energy Technology"**
Signature: (for printed version)	D. Markus
Date: (for printed version)	04.05.22

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:

Physikalisch-Technische Bundesanstalt (PTB)
Bundesallee 100
38116 Braunschweig
Germany

PTB
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

IECEx Certificate of Conformity

Certificate No.: **IECEx PTB 12.0038X** Page 2 of 4

Date of issue: 2022-04-08 Issue No: 4

Manufacturer: **Berthold Technologies GmbH & Co. KG**
Calmbacher Str. 22
75323 Bad Wildbad
Germany

Manufacturing locations: **Berthold Technologies GmbH & Co. KG**
Calmbacher Str. 22
75323 Bad Wildbad
Germany

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0 — Explosive atmospheres - Part 0: Equipment - General requirements

IEC 60079-1:2014-06 Edition:7.0 — Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"

IEC 60079-11:2011 Edition:6.0 — Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"

IEC 60079-31:2013 Edition:2 — Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"

IEC 60079-7:2017 Edition:5.1 — Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Report:

DE/PTB/ExTR12.0052/04

Quality Assessment Report:

DE/PTB/QAR06.0011/06

IECEx Certificate of Conformity

Certificate No.: **IECEx PTB 12.0038X** Page 3 of 4

Date of issue: 2022-04-08 Issue No: 4

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

See the attached Data Sheet.

SPECIFIC CONDITIONS OF USE: YES as shown below:

1. Due to the requirements of clause 5.1, EN 60079 - 1 it shall be pointed out that the joint dimensions of the flameproof enclosure deviate from the values tabulated in EN 60079 - 1. Repairing of flameproof joints exclusively according to the values specified in table 1 or table 2 of EN 60079 - 1 is not permitted and may only be carried out in accordance with the constructive specifications given by the manufacturer.

2. The interface circuit RS485 serves exclusively for intercommunication of the probes and must not be connec ted to an external RS485 circuit.

3. In gas atmospheres must be fully operated in the selected group IIB or IIC in the choice of group IIB or IIC for the intrinsically safe circuits, all intrinsically safe circuits and the scintillation meter type LB 480

4. The probe must not be installed in zone 0 or zone 20. The protection level "ia" allows the safe use of measuring equipment that may otherwise only be used in zone 0 or zone 20.

IECEx Certificate of Conformity

Certificate No.: **IECEx PTB 12.0038X** Page 4 of 4

Date of issue: 2022-04-08 Issue No: 4

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)

1. For the mounting of the glass window, in addition to the previously used casting compound, the following materials may also be used:

3M Scotch-Weld™ DP 105

Master Bond EP41S-6

Panacol Vitralit® 2028

When the material 3M Scotch-Weld™ DP 105 is used, the maximum ambient temperature is reduced to +60 °C.

2. Terminal board with modified pin assignment at the RS485 interface to allow terminated and non-terminated Master detector and connection of an evaluation unit with equivalent protection circuits.

Attachment to Certificate
IECEx PTB 12.0038 X Issue 04

Applicant:	Berthold Technologies GmbH & Co. KG Calmbacher Straße 22, 75323 Bad Wildbad, Germany
Electrical Apparatus:	Scintillation measuring equipment type LB480

Description of equipment

The scintillation measuring equipment type LB 480 is part of a measuring system for monitoring industrial processes. It is used for continuously measuring the level in tanks or bins that contain liquid, granular, viscous or encrustation-forming media, and for measuring conveyor belt charges, and the density of liquids, suspensions, slurries and bulk solids. It is also used for continuously measuring level, weight per unit area, ash, sulphur, hydrogen and other specific application.

The measuring principle is based on the absorption of gamma rays. The radiation source does not part of the measuring equipment and not part of this certificate.

The scintillation measuring equipment consists of a scintillation detector with associated electronics in a common housing type of protection Flameproof Enclosure "d" or in type of protection Dust Protection by Enclosure "t".

The type LB 480 of measuring equipment is extended to the choice of execution as associated electrical equipment to the signal outputs OC-input, PT100 and HART current output in type of protection Intrinsic Safety "i".

The power supply and the interface RS485 are designed not intrinsically safe.

The integrated with the detector-housing connector housing is either in type of protection Flameproof Enclosure "d", or in type of protection Increased Safety "e", or in type of protection Dust Protection by Enclosure "t" or in each case in combination with the type of protection Intrinsic Safety "i "equipped.

The relevant options are listed in a new type of key and read in future as indicated below.

The relationship between variation, type of protection, temperature class and ambient temperature is re-codified and is listed in the table below.

The marking of the equipment reads in the future as follows.		
Ex db IIC T6 Gb Ex db eb IIC T6 Gb Ex db eb IIC T5 Gb	resp. resp.	
Ex db [ia Ga] IIC T6 Gb	resp. Ex db eb [ia Ga] IIC T6 Gb	
Ex tb IIIC T95°C Db	resp. Ex tb IIIC T80°C Db	resp. Ex tb IIIC T60°C Db,
Ex tb [ia Da] IIIC T80°C Db	resp. Ex tb IIIC T60°C Db	

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Attachment to Certificate
IECEx PTB 12.0038 X Issue 04

Assignment of the ambient temperature

Protection	Temperature class	Variant	Product key	Ambient temperature
Ex db IIC Gb Ex tb IIIC Db	T6 T75 °C	A1, B1, E1	LB 480-xx-AC-xx LB 480-xx-BC-xx	-40 °C ≤ T_a ≤ +60 °C
Ex db eb IIC Gb Ex tb IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-1C-xx LB 480-xx-2C-xx	-40 °C ≤ T_a ≤ +65 °C
Ex db eb IIC Gb Ex tb IIIC Db	T5 T95 °C	A2, B2	LB 480-1x-1C-xx LB 480-1x-2C-xx LB 480-2x-1C-xx LB 480-2x-2C-xx	-40 °C ≤ T_a ≤ +80 °C
Ex db [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A1, B1, E1	LB 480-xx-CC-xx LB 480-xx-DC-xx	-40 °C ≤ T_a ≤ +50 °C
Ex db eb [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-3C-xx LB 480-xx-4C-xx	-40 °C ≤ T_a ≤ +50 °C

Type code

LB480	-	.	.	-	.	.	-	.	.	-	..-	Variante	Beschreibung
		1	1									Bx	Point Detector 50x50
		1	2									Bx	Point Detector 50x50 + WC
		1	..									Bx	Point Detector ...
		2	A									Ax	Rod Detector 500 mm
		2	B									Ax	Rod Detector 500 mm + WC
		2	..									Ax	..
		2	K									Ax	Rod Detector 2000 mm
		2	L									Ax	Rod Detector 2000 mm + WC
		3	1									Ex	Super-Sens
		3	2									Ex	Super-Sens + WC
		3	.									Ex	
		4	1									Ex	Tower-Sens
		4	2									Ex	Tower-Sens + WC
		4	.									Ex	
					0	0							without Ex-type approval
					1							x2	ATEX/IECEx Ex det (passive / slave)
					2							x2	ATEX/IECEx Ex det (active)
					3							x2	ATEX/IECEx Ex deit (passive)
					4							x2	ATEX/IECEx Ex deit (active)
					A							x1	ATEX/IECEx Ex dt (passive / slave)
					B							x1	ATEX/IECEx Ex dt (active)
					C							x1	ATEX/IECEx Ex dit (passive / slave)

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Attachment to Certificate
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						D							x1	ATEX/IECEx Ex dit (active)
							A							Ex-Revision
							B							Ex-Revision (1. Supplement)
							C							Ex-Revision (2. Issue)
							.							
									.					Signal Output (Slave, HART, etc.)
										1				Power supply 24 V_{DC}
										2				Power supply: 100 - 240 V_{AC}
														none Ex-relevant parameter
	The "x" in the "Variant" column has the function of a placeholder.													

Electrical data

Power supply (Terminal 1, 2) (Terminal 3, 4)	max. 240 V, 50/60 Hz, max. 12 VA Or max. 24 V (DC), max. 12 W U_m = 250 V
Interface circuit RS485 (Terminal 5, 6)	type of protection Increased Safety Ex ib IIB/IIC; 5 V (DC), 20 mA Only for connection to RS485 interface circuits other scintillation instruments LB 480
Thermometer circuit (PT100) (Terminal 15, 16)	type of protection Intrinsic Safety Ex ia IIB/IIC; maximum Values: U_o = 14 V I_o = 27.7 mA P_o = 97 mW Characteristic linear C_i = 11 nF L_i negligible small

Maximum permissible external values for common effective reactances (Ci is not considered) (according to ISpark-6.2).

L_o (mH)	IIB	IIC
	C_o (µF)	C_o (µF)
0,1	4,6	0,73
0,5	4,0	0,71
1,0	3,3	0,59

The RTD circuit is electrically connected to the internal supply circuit and the earth.

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Attachment to Certificate
IECEx PTB 12.0038 X Issue 04

Open collector circuit (Terminal 11, 12)

type of protection Intrinsic Safety Ex ia IIB/IIC;
maximum Values:
U_i = 15 V
I_i = 26.6 mA
P_i = 100 mW
C_i = 11 nF
L_i negligible small

The open collector circuit is safely electrically isolated from earth and all other circuits.

HART-current output (Source Mode) (Terminal 17, 18)

type of protection Intrinsic Safety Ex ia IIB/IIC;
maximum Values:
U_o = 25.2 V
I_o = 101 mA
P_o = 635 mW
Characteristic linear
C_i = 3 nF
L_i = 20 μH

Maximum permissible external values for common effective reactances (Ci is not considered). (according to ISpark-6.2)

L_o (mH)	IIB	IIC
	C_o (μF)	C_o (μF)
0,44	0,52	0,084
0,8	0,45	0,066
1,6	0,38	0,049
13,0	0,37	-----

Single reactances to table A.2 and figure A.4 or A.6 of EN 60079-11

IIB		IIC	
L_o (mH)	C_o (μF)	L_o (mH)	C_o (μF)
17	0.820	4	0.107

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Attachment to Certificate
IECEx PTB 12.0038 X Issue 04

or

HART- current output (Sink Mode) (Terminal 17, 18)	type of protection Intrinsic Safety Ex ia IIB/IIC; Only for connection to a certified intrisically safe circuit. Maximum Values: U_i = 30 V I_i = 152 mA P_i = 1.14 W C_i = 3 nF L_i = 20 µH

The HART current output (source mode or sink mode) of the current output module are safely electrically isolated from earth and all other circuits.

Special conditions for safe use

For the future the special conditions and the notes for manufacture and operation are defined as follows:

1) Due to the requirements of clause 5.1, EN 60079-1 it shall be pointed out that the joint dimensions of the flameproof enclosure deviate from the values tabulated in EN 60079-1. Repairing of flameproof joints exclusively according to the values specified in table 1 or table 2 of EN 60079-1 is not permitted and may only be carried out in accordance with the constructive specifications given by the manufacturer.

2) The interface circuit RS485 serves exclusively for intercommunication of the probes and must not be connected to an external RS485 circuit.

3) In gas atmospheres must be fully operated in the selected group IIB or IIC in the choice of group IIB or IIC for the intrinsically safe circuits, all intrinsically safe circuits and the scintillation meter type LB 480.

4) The probe must not be installed in zone 0 or zone 20. The protection level "ia" allows the safe use of measuring equipment that may otherwise only be used in zone 0 or zone 20.

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5.12 UKCA Certificate – EMA21UKEX0050X

element

1 UNITED KINGDOM CONFORMITY ASSESSMENT

UK TYPE EXAMINATION CERTIFICATE

2 **Product or Protective System Intended for use in Potentially Explosive Atmospheres**
SI 2016:1107 (as amended) – Schedule 3A, Part 1

3	Type Examination Certificate No.:	**EMA21UKEX0050X**
4	Product:	**Scintillation Measuring Equipment, LB 480**
5	Manufacturer:	**Berthold Technologies GmbH & Co. KG**
6	Address:	**Calmbacher Strasse 22, 75323 Bad Wildbad, Germany**

7 This product and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

8 Element Materials Technology, Approved Body number 0891, in accordance with Regulation 42 of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016, SI 2016:1107 (as amended), certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Schedule 1 of the Regulations.
The examination and test results are recorded in the confidential report **PTB Ex 22-11191**.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018 **EN 60079-1:2014** **EN IEC 60079-7:2015 + A1:2018**
EN 60079-11:2012 **EN 60079-31:2014**

Except in respect of those requirements listed at section 18 of the schedule.

10 If the sign "X" is placed after the certificate number, it indicates that the product is subject to specific conditions of use specified in the schedule to this certificate.

11 This TYPE EXAMINATION CERTIFICATE relates only to the design and construction of the specified product. Further requirements of the Regulations apply to the manufacturing process and supply of this product. These are not covered by this certificate.

12 The marking of this product shall include the following:

- Ex **II 2 G Ex db IIC T6 Gb**
- Ex **II 2 G Ex db eb IIC T5 G**
- Ex **II 2 G Ex db [ia Ga] IIC T6 G**
- Ex **II 2 D Ex tb IIIC T95 °C Db**
- Ex **II 2 G Ex tb IIIC T60 °C**
- Ex **II 2 D Ex tb [ia Da] IIIC T80 °C Db**
- Ex **II 2 G Ex db eb IIC T6 Gb**
- Ex **II 2 G Ex db eb [ia Ga] IIC T6 Gb**
- Ex **II 2 D Ex tb IIIC T80 °C Db**
- Ex **II 2 D Ex tb [ia Da] IIIC T60 °C**

This certificate and its schedules may only be reproduced in its entirety and without change. This certificate is issued in accordance with the Element Materials Technology Ex Certification Scheme.

S.P. Winsor

S P Winsor, Certification Manager

Issue date: 2023-04-14 Page 1 of 7 CSF341 4.0

Unit 1, Pendle Place, Skelmersdale, West Lancashire, WN8 9PN, United Kingdom
Element Materials Technology Warwick Ltd
Company Reg No. 02536659

UKAS PRODUCT CERTIFICATION 0178

SCHEDULE TO UK TYPE EXAMINATION CERTIFICATE

CERTIFICATE NUMBER EMA21UKEX0050X

15 Description of Product

The scintillation measuring equipment type LB 480 is part of a measuring system for monitoring industrial processes. It is used for continuously measuring the level in tanks or bins that contain liquid, granular, viscous or encrustation-forming media, and for measuring conveyor belt charges, and the density of liquids, suspensions, slurries and bulk solids. It is also used for continuously measuring level, weight per unit area, ash, sulphur, hydrogen and other specific application.

The measuring principle is based on the absorption of gamma rays. The radiation source does not part of the measuring equipment and not part of this certificate.

The scintillation measuring equipment consists of a scintillation detector with associated electronics in a common housing type of protection Flameproof Enclosure "d" or in type of protection Dust Protection by Enclosure "t".

The type LB 480 of measuring equipment is extended to the choice of execution as associated electrical equipment to the signal outputs OC-input, PT100 and HART current output in type of protection Intrinsic Safety "i".

The power supply and the interface RS485 are designed not intrinsically safe.

The integrated with the detector-housing connector housing is either in type of protection Flameproof Enclosure "d", or in type of protection Increased Safety "e", or in type of protection Dust Protection by Enclosure "t" or in each case in combination with the type of protection Intrinsic Safety "i "equipped.

The relevant options are listed in a new type of key and read in future as indicated below.

The relationship between variation, type of protection, temperature class and ambient temperature is re-codified and is listed in the table below.

<u>Assignment of the ambient temperature</u>

Protection	Temperature class	Variant	Product key	Ambient temperature
Ex db IIC Gb Ex tb IIIC Db	T6 T75 °C	A1, B1, E1	LB 480-xx-AC-xx LB 480-xx-BC-xx	-40 °C ≤ Ta ≤ +60 °C
Ex db eb IIC Gb Ex tb IIIC Db	T6 T80 °C	E2	LB 480-xx-1C-xx LB 480-xx-2C-xx	-40 °C ≤ Ta ≤ +60 °C
Ex db eb IIC Gb Ex tb IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-1C-xx LB 480-xx-2C-xx	-40 °C ≤ Ta ≤ +65 °C
Ex db eb IIC Gb Ex tb IIIC Db	T5 T95 °C	A2, B2	LB 480-1x-1C-xx LB 480-1x-2C-xx LB 480-2x-1C-xx LB 480-2x-2C-xx	-40 °C ≤ Ta ≤ +80 °C
Ex db [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A1, B1, E1	LB 480-xx-CC-xx LB 480-xx-DC-xx	-40 °C ≤ Ta ≤ +50 °C
Ex db eb [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-3C-xx LB 480-xx-4C-xx	-40 °C ≤ Ta ≤ +50 °C

SCHEDULE TO UK TYPE EXAMINATION CERTIFICATE

CERTIFICATE NUMBER EMA21UKEX0050X

Type code

LB480		-	.	.	-	.	.	-	.	.	-	..-...-	Variante	Beschreibung
			1	1									Bx	Point Detector 50x50
			1	2									Bx	Point Detector 50x50 + WC
			1	..									Bx	Point Detector ...
			2	A									Ax	Rod Detector 500 mm
			2	B									Ax	Rod Detector 500 mm + WC
			2	..									Ax	..
			2	K									Ax	Rod Detector 2000 mm
			2	L									Ax	Rod Detector 2000 mm + WC
			3	1									Ex	Super-Sens
			3	2									Ex	Super-Sens + WC
			3	.									Ex	
			4	1									Ex	Tower-Sens
			4	2									Ex	Tower-Sens + WC
			4	.									Ex	
						0	0							without Ex-type approval
						1							x2	ATEX/IECEx Ex det (passive / slave)
						2							x2	ATEX/IECEx Ex det (active)
						3							x2	ATEX/IECEx Ex deit (passive)
						4							x2	ATEX/IECEx Ex deit (active)
						A							x1	ATEX/IECEx Ex dt (passive / slave)
						B							x1	ATEX/IECEx Ex dt (active)
						C							x1	ATEX/IECEx Ex dit (passive / slave)
						D							x1	ATEX/IECEx Ex dit (active)
							A							Ex-Revision
							B							Ex-Revision (1. Supplement)
							C							Ex-Revision (2. Issue)
							.							
									.					Signal Output (Slave, HART, etc.)
										1				Power supply 24 V_{DC}
										2				Power supply: 100 - 240 V_{AC}
												.		none Ex-relevant parameter
	The "x" in the "Variant" column has the function of a placeholder.													

Electrical data

Power supply (Terminal 1, 2) (Terminal 3, 4)	max. 240 V, 50/60 Hz, max. 12 VA or max. 24 V (DC), max. 12 W, U_m = 250 V
Interface circuit RS485 (Terminal 5, 5A, 6, 6A)	type of protection Increased Safety Ex ib IIB/IIC; 5 V (DC), 20 mA Only for connection to RS485 interface circuits other scintillation instruments LB 480 and an evaluation unit with equivalent means of protection.
Thermometer circuit (PT100) (Terminal 15, 16)	type of protection Intrinsic Safety Ex ia IIB/IIC; maximum Values: U_o = 14 V L_o = 27.7 mA P_o = 97 mW Characteristic linear C_i = 11 nF L_i = negligible small

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SCHEDULE TO UK TYPE EXAMINATION CERTIFICATE

CERTIFICATE NUMBER EMA21UKEX0050X

Maximum permissible external values for common effective reactances (C_i is not considered). (according to ISpark-6.2)		
L_o (mH)	IIB	IIC
	C_o (µF)	C_o (µF)
0.1	4.6	0.73
0.5	4.0	0.71
1.0	3.3	0.59

The RTD circuit is electrically connected to the internal supply circuit and the earth

Open collector circuit (Terminal 11, 12)

type of protection Intrinsic Safety Ex ia IIB/IIC;
Maximum Values:

U_i = 15 V
I_i = 26.6 mA
P_i = 100 mW
C_i = 11 nF
L_i = negligible small

The open collector circuit is safely electrically isolated from earth and all other circuits.

HART-current output (Source Mode)
(Terminal 17, 18)

type of protection Intrinsic Safety Ex ia IIB/IIC;
maximum Values:

U_o = 25.2 V
I_o = 101 mA
P_o = 635 mW
Characteristic linear
C_i = 3 nF
L_i = 20 µH

Maximum permissible external values for common effective reactances (C_i is not considered). (according to ISpark-6.2)		
L_o (mH)	IIB	IIC
	C_o (uF)	C_o (uF)
0.44	0.52	0.084
0.8	0.45	0.066
1.6	0.38	0.049
13.0	0.37	----

Single reactances to table A.2 and figure A.4 or A.6 of EN 60079-11			
IIB		IIC	
L_o mH	C_o µF	L_o mH	C_o µF
17	0.820	4	0.107

SCHEDULE TO UK TYPE EXAMINATION CERTIFICATE

CERTIFICATE NUMBER EMA21UKEX0050X

HART- current output (Sink Mode) (Terminal 17, 18)	type of protection Intrinsic Safety Ex ia IIB/IIC; Only for connection to a certified intrinsically safe circuit. Maximum Values: U_i = 30 V I_i = 152 mA P_i = 1.14 W C_i = 3 nF L_i = 20 µH

The HART current output (source mode or sink mode) of the current output module are safely electrically isolated from earth and all other circuits.

16 Test report No. (associated with this certificate issue): None

17 Specific Conditions of Use

1) Due to the requirements of clause 5.1, EN 60079-1 it shall be pointed out that the joint dimensions of the flameproof enclosure deviate from the values tabulated in EN 60079-1. Repairing of flameproof joints exclusively according to the values specified in table 1 or table 2 of EN 60079-1 is not permitted and may only be carried out in accordance with the constructive specifications given by the manufacturer.
2) The interface circuit RS485 serves exclusively for intercommunication of the probes and must not be connected to an external RS485 circuit.
3) In gas atmospheres must be fully operated in the selected group IIB or IIC in the choice of group IIB or IIC for the intrinsically safe circuits, all intrinsically safe circuits and the scintillation meter type LB 480.
4) The probe must not be installed in zone 0 or zone 20. The protection level "ia" allows the safe use of measuring equipment that may otherwise only be used in zone 0 or zone 20.

Attention is drawn to the operating and installation instructions which may contain useful information in relation to conditions of use.

18 Essential Health and Safety Requirements (Regulations Schedule 1)

In addition to the Essential Health and Safety Requirements covered by the standards listed at item 9, all other requirements are demonstrated in the relevant test reports.

The test reports were considered to satisfy the requirements of Schedule 1 with the exception of Essential Health and Safety Requirements 5 and 6, which were separately satisfied by the content of the label drawings and the instructions.

19 Drawings and Documents

The list of controlled technical documentation is given in Appendix A to this schedule.

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SCHEDULE TO UK TYPE EXAMINATION CERTIFICATE

CERTIFICATE NUMBER EMA21UKEX0050X

20 Routine Tests

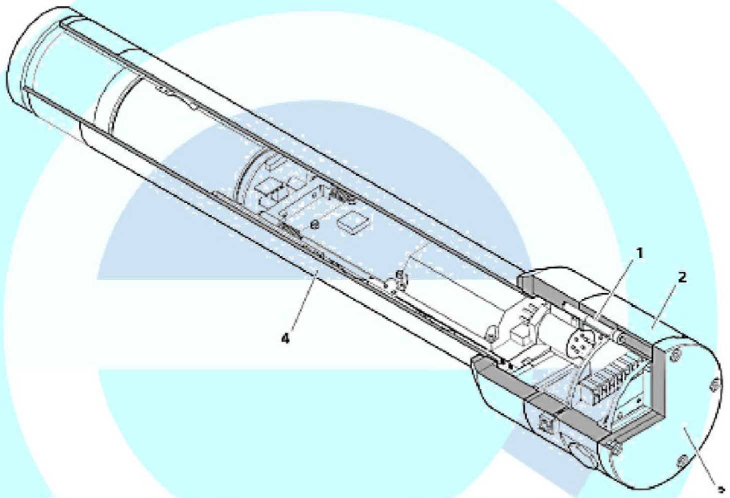
Overpressure test according to IEC 60079-1, clause 15.1 with 27.2 bar (for -60 °C) and 22.7 bar (for -20 °C) for welded enclosure.

Construction without welding is exempted from routine test as the overpressure test was performed with 4 times reference pressure.

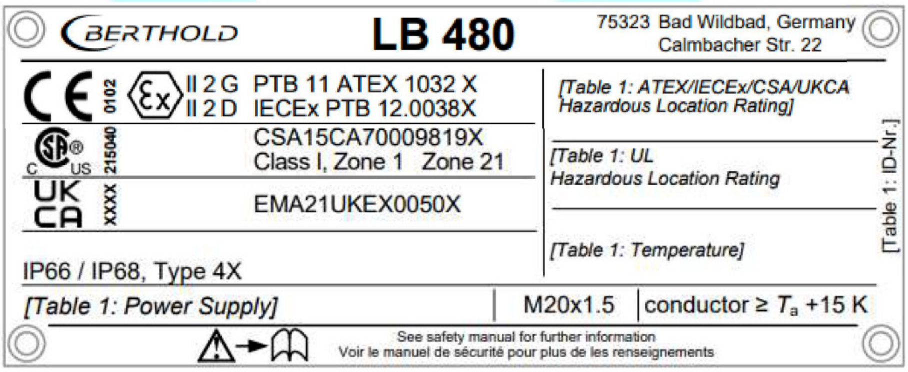
21 Specific Conditions for Manufacture

None.

22 Photographs



23 Details of Markings



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SCHEDULE TO UK TYPE EXAMINATION CERTIFICATE

CERTIFICATE NUMBER EMA21UKEX0050X

24 Certificate History

Original certificate 2023-04-14 First issue.

This certificate is a consolidated certificate and reflects the latest status of the certification, including all variations and amendments.

25 Notes to UKCA marking

In respect of UKCA Marking, Element Materials Technology accepts no responsibility for the compliance of the product against all applicable Regulations in all applications.

26 Notes to this certificate

Element Materials Technology certification reference: TRA-054560-00 i3. (GU-BERQ-0003).

Throughout this certificate, the date format yyyy-mm-dd (year-month-day) is used.

Approved Body 0891 is the designation for Element Materials Technology Warwick Ltd.

27 Conditions for the validity of this certificate

This certificate remains valid for so long as:

(i) The equipment listed in section 4 is manufactured in accordance with the documents listed in Appendix A of this certificate.

(ii) The standards listed in section 9 of this certificate continue to satisfy the Essential Health and Safety Requirements of Schedule 1 of the Regulations SI 2016:1107 (as amended by SI 2019:696) and the generally acknowledged state of the art (e.g. as determined by the publishers of those standards).

APPENDIX A - TECHNICAL DOCUMENTS

Title:	Drawing No.:	Rev. Level:	Date:
Element list of scheduled drawings for this certificate	Scheduled drawings list for EMA21UKEX0050X	1	2023-04-13

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5.13 CSA Certificate - 70009819

Certificate of Compliance

Certificate: 70009819 **Master Contract:** 215040

Project: 80137855 **Date Issued:** March 03, 2023

Issued To: **Berthold Technologies GMBH & CO KG**
Calmbacher Str 22
Bad Wildbad, Baden-Württemberg, 75323
Germany

Attention: Juergen Betzelt

The products listed below are eligible to bear the CSA Mark shown with adjacent indicators 'C' and 'US' for Canada and US or with adjacent indicator 'US' for US only or without either indicator for Canada only.

C US

Issued by: M. Munro

M Munro

PRODUCTS

CLASS 2258 02 – PROCESS CONTROL EQUIPMENT – For Hazardous Locations
CLASS 2258 82 – PROCESS CONTROL EQUIPMENT – For Hazardous Locations – Certified according to US standards.

Ex db IIC T6 Gb
Class I, Zone 1 AEx db IIC T6 Gb

Scintillation Counter. Model LB 480 ab-cd-.e-*
-40 °C ≤ T_a ≤ +60 °C, IP66/IP68, Type 4X

Where:
a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
3 – Version Ex (Detectors with glass window for SuperSENS)
4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify sensor length and additional water cooling option.
c = A – Socket x1; Ex d (passive/slave)
B – Socket x1; Ex d (active)
d = C – Latest Ex-revision
e = 1 – (rated 24Vdc, 12W)

DQD 507 Rev. 2019-04-30 Page 1

Certificate: 70009819
Project: 80137855

Master Contract: 215040
Date Issued: March 03, 2023

2 – (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex tb IIIC T75°C Db
Zone 21 AEx tb IIIC T75°C Db

Scintillation Counter. Model LB 480 ab-cd-.e-*
-40 °C ≤ T_a ≤ +60 °C, IP66/IP68, Type 4X

Where:
a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
3 – Version Ex (Detectors with glass window for SuperSENS)
4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify sensor length and additional water cooling option.
c = A – Socket x1; Ex t (passive/slave)
B – Socket x1; Ex t (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex db eb IIC T6 Gb
Class I, Zone 1 AEx db eb IIC T6 Gb

Scintillation Counter. Model LB 480 ab-cd-.e-*
-40 °C ≤ T_a ≤ +65 °C, IP66/IP68, Type 4X

Where:
a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
3 – Version Ex (Detectors with glass window for SuperSENS)
4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify sensor length and additional water cooling option.
c = 1 – Socket x2; Ex d, Ex e (passive/slave)
2 – Socket x2; Ex d, Ex e (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex tb IIIC T80°C Db
Zone 21 AEx tb IIIC T80°C Db

Scintillation Counter. Model LB 480 ab-cd-.e-*
-40 °C ≤ T_a ≤ +65 °C, IP66/IP68, Type 4X

CSA GROUP™

Certificate: 70009819
Project: 80137855

Master Contract: 215040
Date Issued: March 03, 2023

Where:

a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
3 – Version Ex (Detectors with glass window for SuperSENS)
4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify sensor length and additional water cooling option.
c = 1 – Socket x2; Ex t (passive/slave)
2 – Socket x2; Ex t (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex db eb IIC T5 Gb
Class I, Zone 1 AEx db eb IIC T5 Gb

Scintillation Counter. Model LB 480 ab-cd-.e-*
-40 °C ≤ T_a ≤ +80 °C, IP66/IP68, Type 4X

Where:

a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
b = Any alphanumeric character to signify sensor length and additional water cooling option.
c = 1 – Socket x2; Ex d, Ex e (passive/active)
2 – Socket x2; Ex d, Ex e (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex tb IIIC T95°C Db
Zone 21 AEx tb IIIC T95°C Db

Scintillation Counter. Model LB 480 ab-cd-.e-*
-40 °C ≤ T_a ≤ +80 °C, IP66/IP68, Type 4X

Where:

a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
b = Any alphanumeric character to signify sensor length and additional water cooling option.
c = 1 – Socket x2; Ex t (passive/slave)
2 – Socket x2; Ex t (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

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Conditions of Acceptability:

1) The interface circuit RS485 serves exclusively for intercommunication of the probes and must not be connected to an external RS485 circuit.
2) Repair of flameproof joints is not permitted. If repair is required, the equipment shall be returned to the manufacturer.
3) For 24Vdc models: This equipment may only be powered by a power supply unit with a limited energy electric circuit in accordance with CAN/CSA C22.2 No. 61010-1-12 and ANSI/UL 61010-1, or Class 2 as defined in the Canadian Electrical Code C22.1, Section 16-200 and/or National Electrical Code (NFPA 70), article 725.121.

Class 2258 04 – PROCESS CONTROL EQUIPMENT – Intrinsically Safe Entity – For Hazardous Locations
Class 2258 84 – PROCESS CONTROL EQUIPMENT – Intrinsically Safe Entity – For Hazardous Locations – Certified to US Standards

Ex db [ia Ga] IIC T6 Gb
Class I, Zone 1 AEx db [ia Ga] IIC T6 Gb

Scintillation Counter. Model LB 480 ab-cd-.e-*
Associated Intrinsically Safe wiring for EPL Ga, when connected per drawing 45190VP10.
-40 °C ≤ T_a ≤ +50 °C, IP66/IP68, Type 4X

Where:

a =	1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
	2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
	3 – Version Ex (Detectors with glass window for SuperSENS)
	4 – Version Ex (Detectors with glass window for TowerSENS)
b =	Any alphanumeric character to signify specifications and features
c =	C – Socket x1; Ex d, Ex i (passive)
	D – Socket x1; Ex d, Ex i (active)
d =	C – Latest Ex-revision
e =	1 (rated 24Vdc, 12W)
	2 (rated 100Vac-240Vac, 50/60Hz, 12VA)

* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex tb [ia Da] IIIC T80°C Db
Zone 21 AEx tb [ia Da] IIIC T80°C Db

Scintillation Counter. Model LB 480 ab-cd-.e-*
Associated Intrinsically Safe wiring for EPL Da, when connected per drawing 45190VP10.
-40 °C ≤ T_a ≤ +50 °C, IP66/IP68, Type 4X

Where:

a =	1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
	2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
	3 – Version Ex (Detectors with glass window for SuperSENS)

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Certificate: 70009819 **Master Contract:** 215040
Project: 80137855 **Date Issued:** March 03, 2023

4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify specifications and features
c = C – Socket x1; Ex i, Ex t (passive)
D – Socket x1; Ex i, Ex t (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex db eb [ia Ga] IIC T6 Gb
Class I, Zone 1 AEx db eb [ia Ga] IIC T6 Gb

Scintillation Counter. Model LB 480 ab-cd-.e-*
Associated Intrinsically Safe wiring for EPL Ga, when connected per drawing 45190VP10.
-40 °C ≤ T_a ≤ +50 °C, IP66/IP68, Type 4X

Where:
a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
3 – Version Ex (Detectors with glass window for SuperSENS)
4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify specifications and features
c = 3 – Socket x2; Ex d, Ex e, Ex i (passive)
4 – Socket x2; Ex d, Ex e, Ex i (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)
2 (rated 100Vac-240Vac, 50/60Hz, 12VA)
* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Ex tb [ia Da] IIIC T80°C Db
Zone 21 AEx tb [ia Da] IIIC T80°C Db

Scintillation Counter. Model LB 480 ab-cd-.e-*
Associated Intrinsically Safe wiring for EPL Da, when connected per drawing 45190VP10.
-40 °C ≤ T_a ≤ +50 °C, IP66/IP68, Type 4X

Where:
a = 1 – Version Bx (Rod detectors with plastic scintillator for UniSENS detector)
2 – Version Ax (Point detectors with NaI scintillator for CrystalSENS detector)
3 – Version Ex (Detectors with glass window for SuperSENS)
4 – Version Ex (Detectors with glass window for TowerSENS)
b = Any alphanumeric character to signify specifications and features
c = 3 – Socket x2; Ex d, Ex i, Ex t (passive)
4 – Socket x2; Ex d, Ex i, Ex t (active)
d = C – Latest Ex-revision
e = 1 (rated 24Vdc, 12W)

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2 (rated 100Vac-240Vac, 50/60Hz, 12VA)

* May be followed by additional alphanumeric digits, specifying features that are not relevant to certification.

Conditions of Acceptability:

1) The probe must not be installed in zone 0 or zone 20.
2) The interface circuit RS485 serves exclusively for intercommunication of the probes and must not be connected to an external RS485 circuit.
3) Repair of flameproof joints is not permitted. If repair is required, the equipment shall be returned to the manufacturer.
4) For 24Vdc models: This equipment may only be powered by a power supply unit with a limited energy electric circuit in accordance with CAN/CSA C22.2 No. 61010-1-12 and ANSI/UL 61010-1, or Class 2 as defined in the Canadian Electrical Code C22.1, Section 16-200 and/or National Electrical Code (NFPA 70), article 725.121.

Entity Parameters:

Thermometer Circuit (PT100) (Terminal 15- and 16+)

Type of protection Intrinsic Safety Ex ia IIB/IIC/IIIC Maximum Values:

U_o = 14.0 V L_i = nil
I_o = 27.7 mA C_i = 11 nF
P_o = 97.0 mW
Linear

Maximum permissible external values for common effective reactance's (C_i is not considered)		
L_o (mH)	**IIB (IIIC)**	**IIC**
	C_o (µF)	**C_o (µF)**
0.1	4.6	0.73
0.5	4.0	0.71
1.0	3.3	0.59

The RTD circuit is electrically connected to the internal supply circuit and the earth.

Open Collector Circuit (Terminal 11-, 12+)

Type of protection Intrinsic Safety Ex ia IIB/IIC/IIIC Maximum Values:

U_i = 15.0 V L_i = nil
I_i = 26.6 mA C_i = 11 nF
P_i = 100.0 mW
Linear

The open collector circuit is safely electrically isolated from earth and all other circuits.

HART-current output (Source Mode) (Terminal 17/19-, 18/20+)

Type of protection Intrinsic Safety Ex ia IIB/IIC/IIIC Maximum Values:

U_o = 25.2 V L_i = 20.0 µH
I_o = 101.0 mA C_i = 3.0 nF
P_o = 635.0 mW
Linear

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Maximum permissible external values for common effective reactance's (C_i is not considered)		
L_o (mH)	**IIB (IIIC)**	**IIC**
	C_o (µF)	**C_o (µF)**
0.44	0.52	0.084
0.8	0.45	0.066
1.6	0.38	0.049
13.0	0.37	-

Single reactance's to table A.2 and figure A.4 or A.6 of 60079-11			
IIB		**IIC**	
L_o (mH)	**C_o (µF)**	**L_o (mH)**	**C_o (µF)**
17.0	0.820	4.0	0.107

Or

HART-current output (Sink Mode) (Terminal 17/19+, 18/20-)
Type of protection Intrinsic Safety Ex ia IIB/IIC/IIIC Maximum Values:

U_i = 30.0 V; L_i = 20.0 µH
I_i = 152.0 mA C_i = 3.0 nF
P_i = 1.14 W
Linear

***Note:** the HART current output (source mode or sink mode) of the current output module are safely electrically isolated from earth and all other circuits.

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APPLICABLE REQUIREMENTS

CAN/CSA-C22.2 No. 60529:16	Degrees of protection provided by enclosures (IP Code)
CAN/CSA C22.2 No. 94.2-15	Enclosures for Electrical Equipment, Environmental Considerations
CAN/CSA C22.2 No. 61010-1-12 + AMD 1-18	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements
CAN/CSA C22.2 No. 60079-0:2019	Explosive atmospheres. Part 0: Equipment - General requirements.
CAN/CSA C22.2 No. 60079-1:2016	Explosive atmospheres. Part 1: Equipment protection of flameproof enclosures “d”.
CAN/CSA C22.2 No. 60079-7:2016	Explosive atmospheres. Part 7: Equipment protection by Increased Safety ‘e”.
CAN/CSA C22.2 No. 60079-11:2014 (R2018)	Explosive atmospheres. Part 11: Equipment protection by Intrinsic Safety “i”.
CAN/CSA C22.2 No. 60079-31:2015	Explosive atmospheres. Part 31: Equipment dust ignition protection by enclosure “t”.
ANSI/IEC 60529-2020 *Edition 2.0*	Degrees of Protection Provided by Enclosures (IP Code)
ANSI/UL 50E-15 *Second Edition*	Enclosures for Electrical Equipment, Environmental Considerations
ANSI/UL 61010-1-2018 *Third Edition*	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements
ANSI/UL 60079-0:2019 *Seventh Edition*	Explosive atmospheres. Part 0: Equipment - General requirements.
ANSI/UL 60079-1:2015 *Seventh Edition*	Explosive atmospheres. Part 1: Equipment protection by flameproof enclosures “d”.
ANSI/UL 60079-7:2017 *Fifth Edition*	Explosive atmospheres. Part 7: Equipment protection by Increased Safety ‘e”.
ANSI/UL 60079-11:2018 *Sixth Edition*	Explosive atmospheres. Part 11: Equipment protection by Intrinsic Safety “i”.
ANSI/UL 60079-31:2015 *Second Edition*	Explosive atmospheres. Part 31: Equipment dust ignition protection by enclosure “t”.

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Date Issued: March 03, 2023

MARKINGS

The manufacturer is required to apply the following markings:

- Products shall be marked with the markings specified by the particular product standard.
- Products certified for Canada shall have all Caution and Warning markings in both English and French.

Additional bilingual markings not covered by the product standard(s) may be required by the Authorities Having Jurisdiction. It is the responsibility of the manufacturer to provide and apply these additional markings, where applicable, in accordance with the requirements of those authorities.

The products listed are eligible to bear the CSA Mark shown with adjacent indicators 'C' and 'US' for Canada and US (indicating that products have been manufactured to the requirements of both Canadian and U.S. Standards) or with adjacent indicator 'US' for US only or without either indicator for Canada only.

- Manufacturer's name: "Berthold Technologies GMBH & CO KG", or CSA Master Contract Number "215040", adjacent to the CSA Mark in lieu of manufacturer's name.
- Model designation: As specified in the PRODUCTS section, above.
- Electrical ratings: As specified in the PRODUCTS section, above.
- Ambient temperature rating: As specified in the PRODUCTS section, above.
- Manufacturing date in MMYY format, or serial number, traceable to year and month of manufacture.
- Enclosure IP ratings: As specified in the PRODUCTS section, above.
- The CSA Mark, with or without the "C" and "US" indicators, as shown on the Certificate of Conformity.
- The designation "CSA 15CA70009819X"
- Method of Protection markings (Ex -- markings): As specified in the PRODUCTS section, above. The word "Class" may be abbreviated "CL", the word "Zone" may be abbreviated "ZN".
- Models appearing in Class 2258 04/84 in the PRODUCTS section shall be marked: "INSTALL PER CONTROL DRAWING 45190VP10" or equivalent.
- The following bilingual cautions: (as applicable)

Variant	Bilingual cautions
all	ISO 3864 Symbol B.3.1 ⚠ or ISO 7000 symbol 0434 ⚠ (triangle with exclamation point): "SEE SAFETY MANUAL FOR FURTHER INFORMATION", and "VOIR LE MANUEL DE SÉCURITÉ POUR PLUS DE LES RENSEIGNEMENTS"
	ISO 3864 Symbol B.3.1 ⚠ or ISO 7000 symbol 0434 ⚠ (triangle with exclamation point): "NO NOT OPEN WHILE ENERGIZED – IN AN EXPLOSIVE ATMOSPHERE, DE-ENERGIZE AND WAIT 2 MINUTES BEFORE OPENING", and "NE PAS OUVRIR SOUS TENSION – EN PRESENCE D'UNE ATMOSPHÈRE EXPLOSIVES METTRE HORS TENSION ET ATTENDRE 2 MINUTES"
x1 LB 480 ab-cd-.e-*	ISO 3864 Symbol B.3.1 ⚠ or ISO 7000 symbol 0434 ⚠ (triangle with exclamation point): "SEAL WITHIN 50mm OF ENCLOSURE",

Certificate: 70009819 **Master Contract:** 215040
Project: 80137855 **Date Issued:** March 03, 2023

Where:	and
c = A, B, C, or D	"SCELLEMENT À MAXIMUM 50 mm DU BOÎTIER"

- The manufacturing location shall be identified if the equipment can be produced in more than one facility.
- ISO 60417, Symbol 5031 ⎓ adjacent to the DC input terminal rating.
- ISO 60417, Symbol 5032 ∼ adjacent to the AC input terminal rating.
- The equipment shall be marked with a specification that the field installed conductors shall be rated ≥ Ta +15 K.
- ISO 60417, Symbol 5019 ⏚ shall be permanently marked adjacent to the equipment ground (protective conductor) terminal.
- Terminals for field installed wiring shall be permanently marked on, or adjacent to, each terminal.
- The size and threadform of each wiring entry shall be permanently marked.

Notes:

Products certified under Class C225802 have been certified under CSA's ISO/IEC 17065 accreditation with the Standards Council of Canada (SCC). www.scc.ca

SCC Accredited CB-P/S OCPS Accrédité CCN TM

5.14 FM Certificates

5.14.1 US Certificate Of Conformity No: FM16US0282X

CERTIFICATE OF CONFORMITY

FM Approvals
Member of the FM Global Group

1. **HAZARDOUS (CLASSIFIED) LOCATION ELECTRICAL EQUIPMENT PER US REQUIREMENTS**
2. **Certificate No:** **FM16US0282X**
3. **Equipment: (Type Reference and Name)** **LB 480 Series Scintillation Measurement Equipment**
4. **Name of Listing Company:** **Berthold Technologies GmbH & Co. KG**
5. **Address of Listing Company:** **Calmbacher Strasse 22, 75323 Bad Wildbad, Germany**
6. The examination and test results are recorded in confidential report number:

   3054263 dated 22nd September 2016
7. FM Approvals LLC, certifies that the equipment described has been found to comply with the following Approval standards and other documents:

   Class 3600:2022, Class 3615:2022, Class 3616:2022,
   Class 3810:2005, ANSI/NEMA 250:1991
8. If the sign 'X' is placed after the certificate number, it indicates that the equipment is subject to specific conditions of use specified in the schedule to this certificate.
9. This certificate relates to the design, examination and testing of the products specified herein. The FM Approvals surveillance audit program has further determined that the manufacturing processes and quality control procedures in place are satisfactory to manufacture the product as examined, tested and Approved.
10. Equipment Ratings:

    Explosionproof for Class I, Division 1, Groups A, B, C and D; Dust-ignitionproof for Class II, Division 1, Groups E, F and G; and Class III, Division 1 hazardous (classified) locations, indoors and outdoors (Type 4X) with an ambient temperature rating of -40°C to +65°C (or +80°C).

Certificate issued by:

J. E. Marquedant
J. E. Marquedant
VP, Manager - Electrical Systems

18 January 2023
Date

To verify the availability of the Approved product, please refer to www.approvalguide.com

THIS CERTIFICATE MAY ONLY BE REPRODUCED IN ITS ENTIRETY AND WITHOUT CHANGE

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SCHEDULE

US Certificate Of Conformity No: FM16US0282X

11. The marking of the equipment shall include:

Class I Division 1, Groups A, B, C, D

Class II, III, Division 1, Groups E, F, G

T6, Ta = -40°C to +65

T5, Ta = -40°C to +80°C

Type 4X

12. **Description of Equipment:**

General - The LB 480 Series Scintillation Measurement Equipment is used as part of a measuring system for monitoring industrial processes. The equipment is used for continuously measuring the level or weight per unit area, in tanks or bins, of liquid, granular, viscous or encrustation-forming media and for measuring conveyor belt charges as well as the density of liquids, suspensions, slurries and bulk solids. The measurement principle is based on the absorption of gamma rays. The radiation source is not part of the measuring equipment and is not included in the product Approval.

Construction - The LB 480 Series Scintillation Measurement Equipment consists of a scintillation detector with associated electronics in an explosionproof/dust-ignitionproof enclosure with separate sensor and wiring compartments. The sensor and wiring compartments are separated by NRTL listed cemented feedthroughs. The sensor and housing (socket) are constructed of 304 or 316 stainless steel. The wiring compartment contains four ½-inch NPT entries and contains a threaded cover. The socket attaches to the sensor by cylindrical joint fastened with six bolts. The bolt holes terminate under the threaded cover inside the wiring compartment) and therefore contain six threaded plugs to form a valid flamepath. The equipment is available with an optional window which is cemented into the sensor.

Ratings - The equipment is rated for use in an ambient temperature of -40°C to +65°C (or +80°C). The equipment operates at 100-240 Vac (12 VA) or 24 Vdc (12 W).

LB 480-a-bA-cd-xe-0x0-x. Scintillation Measurement Equipment.
a = Sensor: 11, 12, 13, 14, 15, 16, 2A, 2B, 2E, 2F, 2I, 2J, 2K, 2L, 31, 32, 41, 42, 43 or 44.
b = Approval: F or G.
c = Signal output: 0, 1 or 2.
d = Power supply: 1 or 2.
e = Housing material: 1 or 3.
x = Options not affecting the equipment safety.

13. **Specific Conditions of Use:**

The ambient temperature range and T-code rating for the equipment is as follows:

Ambient Temperature	T-Code
-40°C to +65°C	T6
-40°C to +80°C	T5

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SCHEDULE

US Certificate Of Conformity No: FM16US0282X

14. **Test and Assessment Procedure and Conditions:**

    This Certificate has been issued in accordance with FM Approvals US Certification Requirements.

15. **Schedule Drawings**

    A copy of the technical documentation has been kept by FM Approvals.

16. **Certificate History**

    Details of the supplements to this certificate are described below:

Date	Description
22nd September 2016	Original Issue.
3rd August 2022	Supplement 1: Report Reference: RR233804 dated 3rd August 2022. Description of the Change: Minor documentation changes not affecting the equipment safety. Minor model code changes to add alternate terminal configuration and to remove variables with no influence on the protection method. Class 3600, 3615 and 3616 updated to the latest versions as changes between editions are non-technical.
18th January 2023	Supplement 2: Report Reference: PR460854 dated 18th January 2023. Description of the Change: Testing and examination of an alternate window cement material.

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5.14.2 Canadian Certificate Of Conformity No: FM16CA0144X

CERTIFICATE OF CONFORMITY

FM Approvals
Member of the FM Global Group

1. **HAZARDOUS LOCATION ELECTRICAL EQUIPMENT PER CANADIAN REQUIREMENTS**
2. **Certificate No:** **FM16CA0144X**
3. **Equipment:** **LB 480 Series Scintillation Measurement Equipment**
   (Type Reference and Name)
4. **Name of Listing Company:** **Berthold Technologies GmbH & Co. KG**
5. **Address of Listing Company:** **Calmbacher Strasse 22**
   75323 Bad Wildbad
   Germany
6. The examination and test results are recorded in confidential report number:

   3054263 dated 22nd September 2016
7. FM Approvals LLC, certifies that the equipment described has been found to comply with the following Approval standards and other documents:

   CAN/CSA-C22.2 No. 0.4:R2013, CSA-C22.2 No. 0.5:2016, CSA-C22.2 No. 25:R2014, CSA-C22.2 No. 30:R2016, CAN/CSA-C22.2 No. 94:R2011, CAN/CSA-C22.2 No. 61010-1-12:2012
8. If the sign 'X' is placed after the certificate number, it indicates that the equipment is subject to specific conditions of use specified in the schedule to this certificate.
9. This certificate relates to the design, examination and testing of the products specified herein. The FM Approvals surveillance audit program has further determined that the manufacturing processes and quality control procedures in place are satisfactory to manufacture the product as examined, tested and Approved.
10. Equipment Ratings:

    Explosionproof for Class I, Division 1, Groups B, C and D; Dust-ignitionproof for Class II, Division 1, Groups E, F and G; and Class III, Division 1 hazardous locations, indoors and outdoors (Type 4X) with an ambient temperature rating of -40°C to +65°C (or +80°C).

Certificate issued by:

J.E. Marquedant
VP, Manager - Electrical Systems

18 January 2023
Date

To verify the availability of the Approved product, please refer to www.approvalguide.com

THIS CERTIFICATE MAY ONLY BE REPRODUCED IN ITS ENTIRETY AND WITHOUT CHANGE

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SCHEDULE

Canadian Certificate Of Conformity No: FM16CA0144X

11. The marking of the equipment shall include:

Class I Division 1, Groups B, C, D

Class II, III, Division 1, Groups E, F, G

T6, Ta = -40°C to +65

T5, Ta = -40°C to +80°C

Type 4X

12. **Description of Equipment:**

General - The LB 480 Series Scintillation Measurement Equipment is used as part of a measuring system for monitoring industrial processes. The equipment is used for continuously measuring the level or weight per unit area, in tanks or bins, of liquid, granular, viscous or encrustation-forming media and for measuring conveyor belt charges as well as the density of liquids, suspensions, slurries and bulk solids. The measurement principle is based on the absorption of gamma rays. The radiation source is not part of the measuring equipment and is not included in the product Approval.

Construction - The LB 480 Series Scintillation Measurement Equipment consists of a scintillation detector with associated electronics in an explosionproof/dust-ignitionproof enclosure with separate sensor and wiring compartments. The sensor and wiring compartments are separated by NRTL listed cemented feedthroughs. The sensor and housing (socket) are constructed of 304 or 316 stainless steel. The wiring compartment contains four ½-inch NPT entries and contains a threaded cover. The socket attaches to the sensor by cylindrical joint fastened with six bolts. The bolt holes terminate under the threaded cover inside the wiring compartment) and therefore contain six threaded plugs to form a valid flamepath. The equipment is available with an optional window which is cemented into the sensor.

Ratings - The equipment is rated for use in an ambient temperature of -40°C to +65°C (or +80°C). The equipment operates at 100-240 Vac (12 VA) or 24 Vdc (12 W).

LB 480-a-bA-cd-xe-0x0-x. Scintillation Measurement Equipment.
a = Sensor: 11, 12, 13, 14, 15, 16, 2A, 2B, 2E, 2F, 2I, 2J, 2K, 2L, 31, 32, 41, 42, 43 or 44.
b = Approval: F or G.
c = Signal output: 0, 1 or 2.
d = Power supply: 1 or 2.
e = Housing material: 1 or 3.
x = Options not affecting the equipment safety.

13. **Specific Conditions of Use:**

The ambient temperature range and T-code rating for the equipment is as follows:

Ambient Temperature	T-Code
-40°C to +65°C	T6
-40°C to +80°C	T5

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SCHEDULE

Canadian Certificate Of Conformity No: FM16CA0144X

14. **Test and Assessment Procedure and Conditions:**

    This Certificate has been issued in accordance with FM Approvals Canadian Certification Scheme.

15. **Schedule Drawings**

    A copy of the technical documentation has been kept by FM Approvals.

16. **Certificate History**

    Details of the supplements to this certificate are described below:

Date	**Description**
22nd September 2016	Original Issue.
3rd August 2022	Supplement 1: Report Reference: RR233804 dated 3rd August 2022. Description of the Change: Minor documentation changes not affecting the equipment safety. Minor model code changes to add alternate terminal configuration and to remove variables with no influence on the protection method. C22.2 No. 30 updated to the latest reaffirmed date.
18th January 2023	Supplement 2: Report Reference: PR460854 dated 18th January 2023. Description of the Change: Testing and examination of an alternate window cement material.

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5.15 Inmetro Certificate – IEX 19.0182X

IEx	**CERTIFICADO DE CONFORMIDADE** *Certificate of Conformity*	Data de Emissão: 06/01/2020 *Issuing date*
		Data de Validade: 05/01/2029 *Validity date*
	Nº: IEx 19.0182X Página / *Page*: 1/5	Revisão / *Revision*
		Nº: 2 — Data: 06/01/2023 (*Date*)

Produto *Product*	**UNIDADE DE MEDIÇÃO DE CINTILAÇÃO** ***SCINTILLATION MEASURING UNIT***
Solicitante / Endereço: *Applicant / Address*	**BERTHOLD TECHNOLOGIES GmbH & Co. KG** Calmbacher Street 22 75323 - Bad Wildbad - Germany
Fabricante / Endereço: *Manufacturer / Address*	**BERTHOLD TECHNOLOGIES GmbH & Co. KG** Calmbacher Street 22 75323 - Bad Wildbad - Germany
Unidade (s) Fabril (is) / Endereço: *Production Site / Address*	**BERTHOLD TECHNOLOGIES GmbH & Co. KG** Calmbacher Street 22 75323 - Bad Wildbad - Germany
Modelo: *Model*	**LB 480**
Características Principais: *Ratings / Principal Characteristics*	Ver Descrição do Produto / ***See Product Description***
Marca / Código de barras: *Trademark / Bar Code*	**BERTHOLD**
Família de Produto: *Product's Family*	**Unidade de medição de cintilação para uso em atmosferas explosivas** ***Scintillation measuring unit for use in explosive atmospheres***
Número de Série / Lote: *Serial number / Batch number*	**N/A**
Marcação: *Marking*	Ver Descrição do Produto / ***See Product Description***
Normas Aplicáveis: *Aplicable Standards*	**ABNT NBR IEC 60079-0:2020 (corrigida 2022), ABNT NBR IEC 60079-1:2016 (corrigida 2020, ABNT NBR IEC 60079-7:2018 (corrigida 2022), ABNT NBR IEC 60079-11:2013 (corrigida 2017) & ABNT NBR IEC 60079-31:2022**
Modelo de Certificação: *Certification Model*	**Modelo 5, segundo ABNT NBR ISO/IEC 17067:2015 / Model 5**
Portaria Inmetro Nº / Escopo: *Inmetro Decree n° / Scope*	**115:2022 / Equipamentos Elétricos para Atmosferas Explosivas / Electrical Equipment for Explosive Atmospheres**
Concessão para: *Concession for*	**Uso do Selo de Identificação da Conformidade sobre o (s) produto (s) relacionado (s) neste Certificado / Use of the conformity identification seal on the product (s) listed in this certificate**

A **Associação IEx Certificações**, que é um Organismo de Certificação de Produto acreditado pela Coordenação Geral de Acreditação – Cgcre, sob o registro N° OCP-0064, confirma que o produto está em conformidade com a (s) Norma (s) e Portaria acima descritas.
Associação IEx Certificações, as a Product Certification Body accredited by Coordenação Geral de Acreditação – Cgcre, according to the register N° OCP-0064, confirms that the product (s) is (are) in compliance with the standards and Decree above mentioned.

MARCO ANTONIO BUCCIARELLI ROQUE:99815273868
MARCO ANTONIO BUCCIARELLI ROQUE:99815273868
Eu sou o autor deste documento
2023.01.16 14:41:56-03'00'
12.1.0

Marco A. Bucciarelli Roque
Signatário autorizado
Authorized signatory

Certificação do Produto — OCP 0064 — Produto certificado — IEx

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IEx-FR-005, Rev.12, 21/11/2017

	CERTIFICADO DE CONFORMIDADE *Certificate of Conformity*	Data de Emissão: 06/01/2020 *Issuing date*
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Representante Legal / Endereço: *Legal Representative / Address*	**INSTRUMENTOS LINCE LIMITADA** Rua Luiz Ferreira, 84 21042-210 - Rio de Janeiro - RJ - Brasil CNPJ: 29.359.171/0001-93

Marca *Trade mark*	Modelo *Model*	Descrição do produto *Product descripition*	Código de Barras *Bar Code*
BERTHOLD	LB 480	Unidade de medição de cintilação para uso em atmosferas explosivas para o monitoramento de processos industriais. U_N = 15 V; P = 5 W	N/A

Descrição do Produto / *Product Description*

A unidade de medição de cintilação da série LB 480 faz parte de um sistema de medição para monitoramento de processos industriais. É utilizado para medir continuamente o nível de tanques ou silos que contenham meios líquidos, granulares, viscosos ou formadores de incrustações, ou para medir as cargas da correia transportadora, a densidade de líquidos, suspensões, lamas e sólidos a granel.

A unidade consiste em um detector de cintilação com os componentes eletrônicos de análise necessários, que estão alojados em invólucro à prova de explosão.

A unidade de medição de cintilação da série LB 480 é estendida a versões de aparelhos elétricos associados para os sinais de saídas da entrada OC, PT100 e saída de corrente HART no tipo de proteção segurança intrínseca "i".

A fonte de alimentação e a interface RS485 foram projetadas como não intrinsecamente seguras.

A relação entre variação, tipo de proteção, classe de temperatura e temperatura ambiente é recodificada e está listada na tabela abaixo.

The scintillation measuring equipment series LB 480 is part of a measuring system for monitoring industrial processes. It is used for continuous measurement of the level in tanks or bins that contain liquid, granular, viscous or encrustation-forming media, and for measuring conveyor belt charges, as well as the density of liquids, suspensions, slurries and bulk solids.

The scintillation measuring equipment consists of a scintillation detector with associated electronics in a common housing in type of protection Flameproof Enclosure.

The series LB 480 of scintillation measuring equipment is extended to versions of associated electrical apparatus for the signal outputs OC-input, PT100 and HART current output in type of protection Intrinsic Safety "i".

The power supply and the interface RS485 are designed as non-intrinsically safe.

The relationship between variation, type of protection, temperature class and ambient temperature is re-codified and is listed in the table below.

ACESSÓRIOS E OPCIONAIS / *ACCESSORIES AND OPTIONALS*:

Proteção *Protection*	Classe de Temperatura *Temperature Class*	Variação *Variant*	Código *Type Code*	Temperatura Ambiente *Ambient Temperature*
Ex db IIC Gb Ex tb IIIC Db	T6 T75 °C	A1, B1, E1	LB 480-xx-AC-xx LB 480-xx-BC-xx	-40 °C ≤ Ta ≤ +60 °C
Ex db eb IIC Gb Ex tb IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-1C-xx LB 480-xx-2C-xx	-40 °C ≤ Ta ≤ +65 °C
Ex db eb IIC Gb Ex tb IIIC Db	T5 T95 °C	A2, B2	LB 480-1x-1C-xx LB 480-1x-2C-xx LB 480-2x-1C-xx LB 480-2x-2C-xx	-40 °C ≤ Ta ≤ +80 °C
Ex db [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A1, B1, E1	LB 480-xx-CC-xx LB 480-xx-DC-xx	-40 °C ≤ Ta ≤ +50 °C
Ex db eb [ia Ga] IIC Gb Ex tb [ia Da] IIIC Db	T6 T80 °C	A2, B2, E2	LB 480-xx-3C-xx LB 480-xx-4C-xx	-40 °C ≤ Ta ≤ +50 °C

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PARÂMETROS ELÉTRICOS / *ELECTRICAL DATA*

Alimentação / *Power supply* (Terminal 1, 2) (Terminal 3, 4)	max. 240 V, 50/60 Hz, max. 12 VA; ou/*or* max. 24 V (cc/*dc*), max. 12 W Um = 250 V
RS485 *Interface circuit* (Terminal 5, 6)	5 V (cc/*dc*), 20 mA Somente para conexão com circuitos de interface RS485 de outros instrumentos de cintilação LB 480 *Only for connection to RS485 interface circuits of other scintillation instruments LB 480*
(PT100) *Thermometer circuit* (Terminal 15, 16)	Tipo de proteção Ex ia IIB/IIC *type of protection Intrinsic Safety* Valores máximos / M*aximum values*: U_o = 14 V; I_o = 27.7 mA; P_o = 97 mW; C_i = 11 nF; L_i = desprezível / *negligible*

Valores externos máximos admissíveis para reatâncias efetivas comuns (Ci não é considerado).
Maximum permissible external values for common effective reactances (Ci is not considered).

L_o (mH)	IIB Co (µF)	IIC Co (µF)
0.1	4.6	0.73
0.5	4.0	0.71
1.0	3.3	0.59

O circuito RTD é eletricamente conectado ao circuito interno de alimentação e ao terra.
The RTD circuit is electrically connected to the internal supply circuit and the earth

Circuito coletor aberto / *Open collector circuit* (Terminal 11, 12)	Tipo de proteção Ex ia IIB/IIC *type of protection Intrinsic Safety* Valores máximos / M*aximum values*: U_i = 15 V; I_i = 26.6 mA; P_i = 100 mW; C_i = 11 nF; L_i = desprezível / *negligible*

O circuito coletor aberto é isolado eletricamente do terra e de todos os outros circuitos
The open collector circuit is safely electrically isolated from earth and all other circuits

Saída de corrente HART-current output (Source Mode) (Terminal 17, 18)	Tipo de proteção Ex ia IIB/IIC *type of protection Intrinsic Safety* Valores máximos / M*aximum values*: U_o = 25.2 V; I_o = 101 mA; P_o = 635 mW; C_i = 3 nF; L_i = 20 µH

Valores externos máximos admissíveis para reatâncias efetivas comuns (Ci não é considerado).
Maximum permissible external values for common effective reactances (Ci is not considered).

L_o (mH)	IIB Co (µF)	IIC Co (µF)
0.44	0.52	0.084
0.8	0.45	0.066
1.6	0.38	0.049
13.0	0.37	-

Reatâncias simples para a tabela A.2 e figura A.4 ou A.6 da NBR IEC 60079-11
Single reactances to table A.2 and figure A.4 or A.6 of IEC 60079-11

IIB		IIC	
L_o (mH)	C_o (µF)	L_o (mH)	C_o (µF)
17	0.820	4	0.107

Saída de corrente HART- *current output* (Sink Mode) (Terminal 17, 18)	Tipo de proteção Ex ia IIB/IIC *type of protection Intrinsic Safety* Somente para conexão a um circuito intrinsecamente seguro certificado / *Only for connection to a certified intrisically safe circuit.* Valores máximos / M*aximum values*: U_i = 30 V; I_i = 152 mA; P_i = 1,14 W, C_i = 3 nF; L_i = 20 µH

A saída de corrente HART (Modo *Source* ou Modo *Sink*) do módulo de saída de corrente é isolada eletricamente do terra e de todos os outros circuitos.
The HART current output (source mode or sink mode) of the current output module are safely electrically isolated from earth and all other circuits.

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Documentos / *Documents*			
Título / *Title*	**Número / *Number***	**Revisão / *Revision***	**Data / *Date***
Relatório de Avaliação da Conformidade	RACT-Ex 1166.218.19B	2	05/01/2023
Relatórios de Ensaios emitido por PTB	DE/PTB/ExTR12.0052/04	4	08/04/2022
Relatórios de Ensaios emitido por PTB	DE/PTB/ExTR12.0052/03	3	18/09/2020
Relatórios de Ensaios emitido por PTB	DE/PTB/ExTR12.0052/02	2	10/03/2020
Relatórios de Ensaios emitido por PTB	DE/PTB/ExTR12.0052/01	1	28/11/2013

Documentos / *Documents*:

Os documentos da Certificação estão listados no Relatório de Avaliação da Conformidade RACT-Ex 1166.218.19B.
The certification documents are listed in the Conformity Assessment Report RACT-Ex 1166.218.19B.

Observações / *Notes*

a) Os equipamentos fornecidos ao mercado brasileiro devem estar de acordo com a definição do produto e a documentação aprovada neste processo de certificação;
The equipment provided to the Brazilian Market shall be according to the product definition and to the documentation approved in this certification process;

b) Somente as unidades fabricadas durante a vigência deste Certificado estarão cobertas por esta certificação;
Only the units manufactured during the validity of this certificate will be covered by this certification;

c) A validade deste Certificado está atrelada à realização das avaliações de manutenção e tratamento de possíveis não conformidades de acordo com as orientações da Associação IEx Certificações e previstas no RAC específico da portaria N° 115:2022 / Equipamentos Elétricos para Atmosferas Explosivas.
Para verificação da condição atualizada de regularidade deste certificado de conformidade deve ser consultado o banco de dados do Inmetro, referente a produtos e serviços certificados;
The validity of this Certificate is linked to the performance of the surveillance audits and treatment of possible nonconformities according to the guidelines of the Associação IEx Certificações and foreseen in the specific RAC of the ordinance N° 115:2022 – Electrical Equipment for Explosive Atmospheres.
In order to verify the updated condition of the regularity of this certificate of conformity, the Inmetro database for certified products and services must be consulted;

d) O Selo de Identificação da Conformidade deve ser colocado na superfície externa do equipamento, em local facilmente visível;
The Conformity Identification Seal shall be placed on the outer surface of the equipment in an easily visible location;

e) Os produtos devem ser instalados em atendimento à norma de instalações elétricas para atmosferas explosivas (ABNT NBR IEC 60079-14);
The products must be installed in compliance with the standards of electrical installations for Explosive Atmospheres (ABNT NBR IEC 60079-14);

f) Esta certificação refere-se única e exclusivamente aos requisitos de avaliação da conformidade para equipamentos elétricos para atmosferas explosivas, não abrangendo outros regulamentos eventualmente aplicáveis ao produto;
This certification refers only and exclusively to the conformity assessment requirements for electrical equipment for explosive atmospheres, not covering any other regulation applicable to the product;

g) As atividades de instalação, inspeção, manutenção, reparo, revisão e recuperação dos equipamentos são de responsabilidade dos usuários e devem ser executadas de acordo com os requisitos das normas técnicas vigentes e com as recomendações do fabricante;
The activities of installation, inspection, maintenance, repair, revision and recuperation of equipment are the responsibility of the end users and shall be performed according to the applicable technical standards requirements and according to manufacturer recommendations;

h) A letra "**X**" após o número do certificado indica as seguintes condições especiais de uso seguro do equipamento:
The letter "X" in the Certificate Number refers to the following special conditions for safe use of the product:

- Consultar o fabricante para fins de reparos. O reparo de juntas à prova de explosão não é permitido de acordo com os valores da tabela 3 da ABNT NBR IEC 60079-1.
Consult manufacturer for repairs. Repair of flameproof joints is not allowed according to values of table 3 of IEC 60079-1.
- O circuito de interface RS485 serve exclusivamente para intercomunicação das sondas e não deve ser conectado a um circuito externo RS485.
The interface circuit RS485 serves exclusively for intercommunication of the probes and must not be connected to an external RS485 circuit.
- Em atmosferas de gases para a escolha do grupo IIB ou IIC dos circuitos intrinsecamente seguros, todos os circuitos intrinsecamente seguros e o medidor de cintilação série LB 480 devem ser totalmente operados no grupo selecionado IIB ou IIC.
In gas atmospheres for the choice of group IIB or IIC for the intrinsically safe circuits, all intrinsically safe circuits and the scintillation meter LB 480 series shall be fully operated in the selected group IIB or IIC either.

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Observações / *Notes*
- A sonda não deve ser instalada na zona 0 ou zona 20. O nível de proteção “ia” permite o uso seguro dos equipamentos de medição que podem ser utilizados na zona 0 ou zona 20. *The probe must not be installed in zone 0 or zone 20. The protection level “ia” allows the safe use of measuring equipment that may otherwise only be used in zone 0 or zone 20.*
i) Os produtos foram ensaiados com 1,5 vezes a sua pressão de referência, devendo ser submetidos ao ensaio de rotina de sobrepressão em 100% de sua produção. *The product was approved with 1.5 times the reference pressure and 100% of production shall be submitted to the overpressure routine test.*

Histórico de Revisões / *Revision History*

Revisão / *Revision*	**Data /** *Date*	**Descrição /** *Description*
0	06/01/2020	Emissão inicial / *Initial Issue*
1	30/03/2022	Atualização de Norma e Atualizações Menores / *Standard update and Minor Updates*
2	06/01/2023	Recertificação, Atualização de Normas e Atualização de Documentos e de Materiais *Recertification, Updating of Standards, Addition of Variants and Updating Documents and Materials*

Proposta / *Proposal:* **14.0.1166.218.19, 14.0.1166.101.22 & 14.0.1166.643.22**

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6 Electrical Installation

Electrical installations may be carried out only by a qualified electrician.

Electrical hazards

⚠ WARNING

Risk of fatal injury due to electric shock!

Open the housing only to perform installation, maintenance and repair work.

When the housing is open, you may come into contact with live parts if the power supply is connected. During installation and maintenance work on the hardware of the detector you have to switch off the measuring system and all the inputs and outputs in order to avoid contact with live parts.

Never modify the installation without having thoroughly read this User's Manual.

Cable glands, adapters and dummy plugs

The screwed fittings must be suitable for the intended use (ATEX or FM/CSA).

If the detector is not used in explosion hazardous areas, the screwed fittings, adapters and dummy plugs have to be tested in accordance with at least one of the following guidelines or standards:

- EN50262
- UL1565
- C22.2 No. 0.17.92
- ATEX

At ambient temperatures of -20 to +40°C, only metallic cable glands and metal adapters may be used to comply with the protection class IP 65. The material properties of the cable glands, adapters and dummy plugs used must be suitable for the ambient conditions existing at the measuring location.

At ambient temperatures above 40°C and below -20°C, only the cable glands tested and approved by Berthold may be used.

The tightening torques for the cable glands supplied by BERTHOLD TECHNOLOGIES are listed on *page 1-37*.

Please note that only one adapter per cable entry may be used. It is not permitted to screw together several adapters.

The total length of the cable glands, including any adapter must not exceed 10 cm.

Cable conduits that are not used must be closed by suitable, metallic dummy plugs.

Special cable glands are required for reinforced cables. The cable assembly is described in the installation instructions of the cable conduit used.

In case of doubt, we recommend using screw fittings, dummy plugs or adapters by BERTHOLD TECHNOLOGIES.

Cables and wires

Only use cables with diameters that are permitted for each cable gland. The cables must have the following wire cross-sections:

- Power cord: 1 mm^2 to 2.5 mm^2
- Signal lines: 0.5 mm^2 to 2.5 mm^2

The cables used must be suitable for at least a temperature which is 15°C above the maximum ambient temperature.

The cables must not be subjected to tensile stress, but have to be installed strain-relieved. We recommend creating a cable loop in front of the entry of the housing.

If there is a danger that the cable may be used as a stepladder, then the cables must be installed protected, for example in conduits. Also make sure that the cables that are connected to the detector are laid without abrasion or kinks.

Cable shielding Pt100

With SIL-certified detectors, shielded signal lines must be used for the PT100.

Stranded lead

The ends of multi-strand wires or fine wire lines (strands) may not be tinned or soldered. Permitted variations are ferrules and direct connection of the strand.

IMPORTANT

When installing fine wire lines in a terminal, individual wires often get stuck at the edge of the terminal, are then pushed back and in the worst case project over the insulated edge of the terminal. Therefore, make sure that all multi-wire or fine wire lines are covered by the terminal and are clamped inside the terminal.

Grounding conductor

The grounding conductor has to be connected to the terminals marked with PE. With interconnected detectors (multi-detector operation) the PE may not be looped from one detector to another. Therefore supply lines with PE have to be guided in a star-shaped pattern from one terminal box to the individual detectors.

Potential equalization

Connect the detector to a equipotential busbar on site. The line on this bar must be as short as possible.

Separator

A separator

- must be present (regulation according to EN 61010-1)
- must be easily accessible for maintenance personnel
- has to be included in the company's internal documentation

It can be installed in the form of a circuit breaker or as a switch and must meet the requirements of IEC 947-1 and IEC 947-3. If a fuse is used, it must trigger only at a current of greater than 4 amps per unit.

General points that are important for installation

IMPORTANT
Open the terminal compartment in dry ambient conditions, not in the rain.
Moisture in the terminal compartment can both cause a short circuit with other lines or cancel the explosion protection.

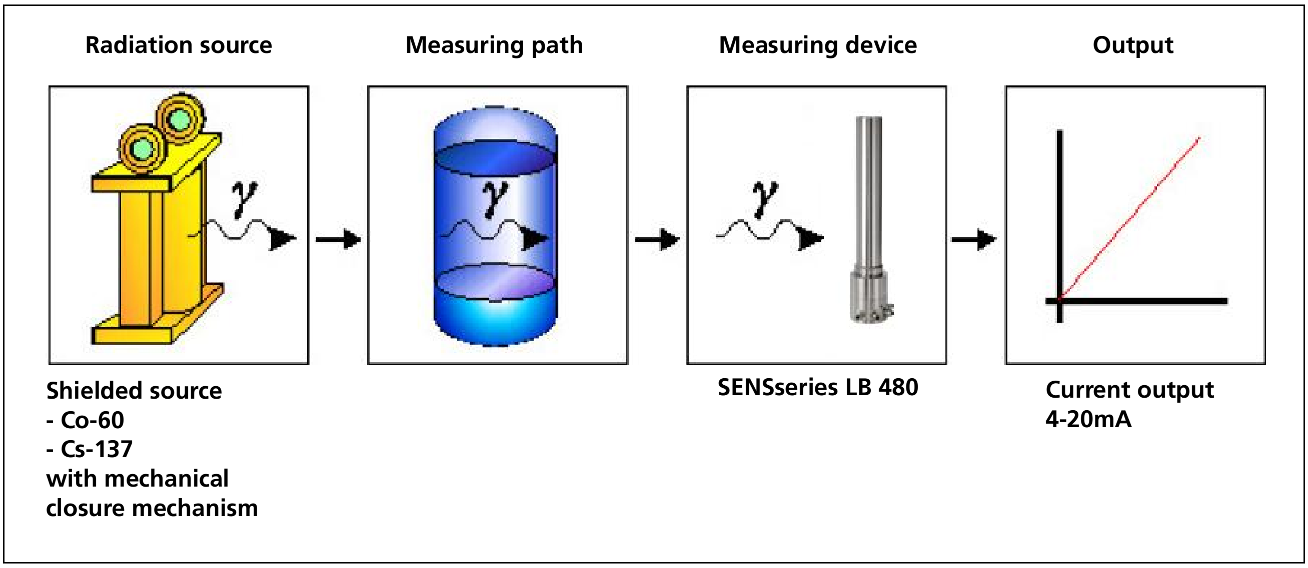
- Please follow the signs on the detectors.
- Connect the cables with special care.
- The connecting cable and its installation must comply with applicable regulations.
- When installing the cable, make sure that mechanical damage to the conductor insulation from sharp edges or moving metal parts will be ruled out.
- Install the connecting cables in the terminal compartment so that
  - dirt and moisture is avoided in the terminal compartment;
  - the wires are not damaged when stripping.
  - the conductor insulation or the collar of the ferrule extends into the housing of the terminal body;
  - bare conductive parts of the lines (e.g. small wires of a strand) do not protrude from the terminal body;
  - the length of the ferrule or the stripped wire can be 10 mm, so that the wire is securely held in the spring-type terminal;
  - if ferrules are used, the conductor insulation extends into the collar of the ferrule;
  - the minimum bending radii permitted for the respective cross-section are not fallen below;
  - install the cables strain-relieved and without abrasion.
- The SENSseries detectors may only be operated with fully closed housing.
- Cleaning corroded threads at the cable glands or cable conduits using abrasives or a wire brush is not allowed.
- The use of the detectors is not permitted if:
  - cable fittings are corroded or damaged;
  - threads on the housing are corroded or damaged;
  - dummy plugs are badly corroded or damaged;
  - the housing of the detector is badly corroded or damaged;
  - seals are damaged, show visible aging, or reduction.

7 Functional Safety

7.1 Scope

This safety manual applies for radiometric measurement systems consisting of a radiation source and the measuring system of the SENSseries LB 480. The measuring system can be used in the following applications:

- Level measurement (also cascaded in a master-slave arrangement)
- Level detection (as max and min limit switches)
- Density measurement



7.2 Use

The measuring device LB 480 may only be used as intended. Permissible measuring arrangements as well as the intended use are described in the operating manual.

For use in safety-related systems (Functional safety according to IEC 61508:2010 / 61511:2003) all information in this manual has to be considered.

The measuring device can be operated in the operating mode with low demand rate (low demand) or with high demand rate (high demand). For this purpose, the rules according to 7.4.5.3 of IEC 61508-2 regarding the demand rate must be observed specifically

- up to SIL 2 with one detector LB 480
- up to SIL 3 with two detectors LB 480

Any use beyond the information given in this manual shall be deemed as being not in conformity with the intended use and may result in serious injury or property damage. BERTHOLD TECHNOLOGIES GmbH & Co. KG shall not accept any liability for such injury or damage.

7.3 Other Applicable Documents and Records

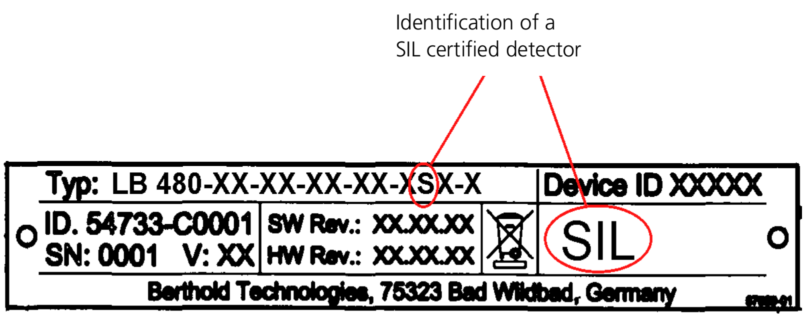
Depending on the design of the measuring system, the following documentation must be observed

Type	Operating manual
Level measurement	LB 480 Level measurement ID No. 54733-10BA1L German ID No. 54733-10BA2L English
Limit level measurement	LB 480 Limit level measurement ID No. 54733-20BA1S German ID No. 54733-20BA2S English
Density measurement	LB 480 Density measurement ID No. 54733-30BA1D German ID No. 54733-30BA2D English

The SIL conformity is certified in the attached certificate.

7.4 Detector Identification

SIL-certified detectors are marked on the nameplate with the designation "SIL" and in the LB number key in addition with an "S" (see figure below).



7.5 Project Planning

7.5.1 Safety Function

The measuring system SENSseries LB 480 is used for non-contact measurement of level, density or concentration. A gamma radiation source (Co-60 and Cs-137) generates a radiation field which is attenuated or absorbed by the product to be measured and is detected by the scintillation detector LB 480.

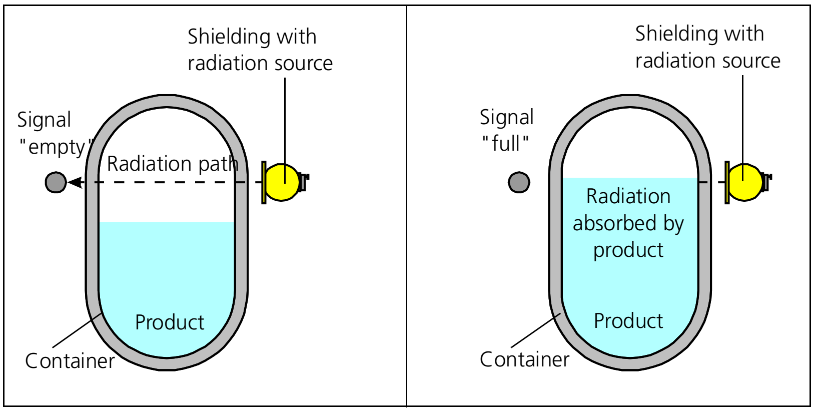
The following descriptions are exemplary for the respective application. The safety integrity, that is the non-detected measured value deviation is <2%. If TowerSENS detectors are used the deviation is <5%. Information on the accuracy of the measurement can be found in the technical data section of the operating manual.

7.5.1.1 Level detection

The measuring system consists of a detector and a radiation source. These are mechanically positioned on the filling level and trigger an alarm once this level is reached. The safety function is to monitor the fill level of the product to be monitored at a defined fill level. This can be both an overfill and underfill protection.

Principle of measurement

As long as the level is below the beam path, the detector receives radiation from the radiation source and the signals "Empty". If the level rises and reaches the height of the beam path, then the radiation is absorbed by the product. The significantly reduced radiation intensity evaluates the detector signal as a "Full" signal.



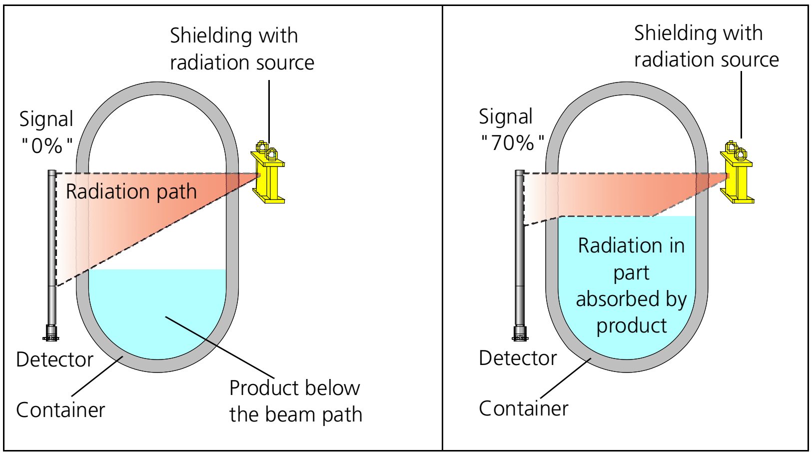
The "Empty" signal is displayed on the analog current output with 4 mA, the "Full" signal with 20mA.

7.5.1.2 Level measurement

The measuring system consists of a detector and a radiation source. Both the detector and the radiation source may be designed rod-shaped or point-shaped. These are mechanically positioned so that the desired measuring range can be covered. The safety function is to monitor the fill level of the product to be monitored within the measuring range.

Principle of measurement

As long as the level does not reach the area of the beam path, the radiation arrives unhindered at the detector. Once the level is within the measuring range, part of the radiation is absorbed. This reduced radiation intensity is indicated at the detector as rising level. The more the level rises, the more the radiation is reduced, which the detector signals as a continuous level increase from 0 to 100%.



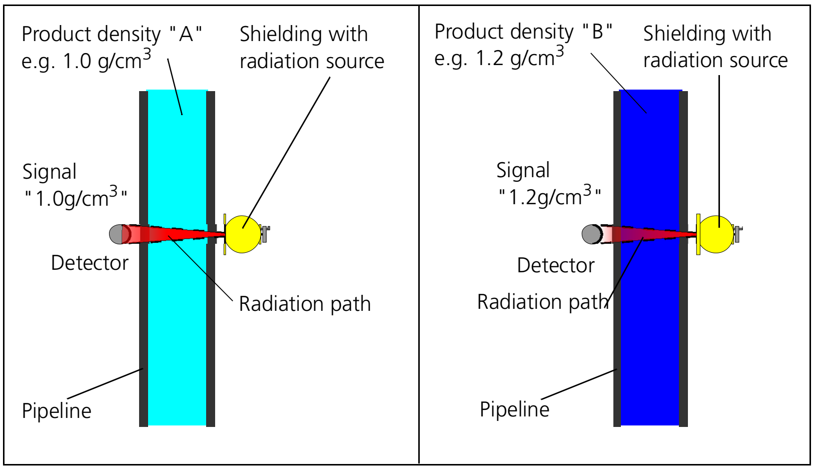
The level change from 0 ... 100% is represented by the analog current output 4 ... 20mA.

7.5.1.3 Density measurement

The measuring system consists of a detector and a radiation source. These are mechanically positioned such that the beam path runs through the product in order to detect the product density. The safety function is to monitor the fill level of the product to be monitored within a defined density measuring range.

Principle of measurement

A higher product density reduces the radiation intensity at the detector. A lower product density increases the radiation intensity at the detector. The change in radiation intensity is output in the detector as a continuous signal within the measurement range.



The detector signals the change in density via the analog current signal. The lower measuring range of the density corresponds to 4mA, the upper range corresponds to 20mA. The PT100 may be used for temperature compensation.

7.5.2 General Notes and Limitations

- The user-specific limits must be observed and the technical specifications must not be exceeded. See operating instructions.
- The container geometry on which the source-detector calculation is based must not differ from the one at the mounted measuring point. If there are any deviations, please contact BERTHOLD TECHNOLOGIES.
- Only the analog 4-20mA current output signal may be used for safety functions.
- The measuring signal may only be used by the control system when the Safety Mode is enabled.
- The RS485 interface must be used exclusively for the master-slave communication.
- The HART® multidrop mode is not allowed.
- If there are magnetic fields in the immediate vicinity of the measuring point, then you have to make sure through appropriate tests that the magnetic field intensity does not affect the measuring signal.
- Use only radiation sources with the isotope Co-60 or Cs-137.
- Only shieldings made by Berthold may be used.
- During operation, the source shielding may not be
  - closed
  - be changed in their position or removed
- It must be prevented that no additional absorber (e.g. steel plates) get into the beam path, which were not considered for commissioning.
- Any influence of adjacent radiometric measuring points should be avoided. If in doubt, the measuring point arrangement has to be discussed with BERTHOLD TECHNOLOGIES.
- Several detectors may be interconnected into a multi-detector system. In an interconnection, only one detector may be configured as a master detector.
- In a multi-detector system, the time constant must be > 2 seconds.
- The user is responsible for the validation of the safety function.
- The following types of detectors can only be used when all count rates within the measuring range are above 1000 cps.
  - LB 480-13 (CrystalSENS 40/35)
  - LB 480-14 (CrystalSENS 40/35 with water cooling)
  - LB 480-15 (CrystalSENS 25/25)
  - LB 480-16 (CrystalSENS 25/25 with water cooling)

  These detectors can be operated only with detector code "0".

- Detector code "1" has to be used for the following types of detectors: when count rates of less than 1000 cps may occur within the measuring range. In the other case detector code "0" can be used.
  - LB 480-11 (CrystalSENS 50/50)
  - LB 480-12 (CrystalSENS 50/50 with water cooling)
- The error current (Loop Alarm Type) has following setup options:
  - High: >21mA
  - Low: <3.6mA

7.5.3 Assumptions

The evaluation of the measuring device according to functional safety aspects is based on the following assumptions:

- The failure rates are constant over the lifetime.
- The environmental conditions correspond to an average industrial environment.
- The repair time (replacement of the measuring system) after an interference immune error is 72 hours. (MTTR[1]= 72h).
- The maximum operating time is limited by the average count rate and the scintillator used:

	maximum operating time	
average count rate	CrystalSENS (Point detectors with NaI crystal)	UniSENS (rod detectors) SuperSENS TowerSENS
40000 cps	10 years	10 years
80000 cps	5 years	10 years

- A temperature compensation can be used for a density measurement.

The following error cases are not considered:

- Closing or removing the source
- Failure rates of external power supplies
- Multiple errors

1. MTTR = Mean Time To Repair

7.5.3.1 Determination of the Failure Rates

The failure rates of the device were determined by an FMEDA according to IEC61508. The calculations are based on component failure rates according to SN29500. All numerical values refer to an average ambient temperature during the operating time of 40°C (104°F). For higher temperatures, the values should be corrected:

- Continuous operating temperature 50 … 60°C (122...140°F) by a factor of 1.3
- Continuous operating temperature 60 … 70°C (140...158°F) by a factor of 2.5
- Continuous operating temperature 70 … 80°C (158...176°F) by a factor of 4.5

Similar factors apply when frequent temperature fluctuations are expected.

7.6 Device Behavior during Operation

7.6.1 Device Behavior after Power On

After power on, a diagnosis phase of 15 seconds starts in which the measuring device is checked for errors. The current output changes to 24mA for 2 seconds and then to 0mA. During this time, no communication with the device is possible.

If an error is detected during the diagnosis phase, the device changes to fault current. In the other case, a current in the range between 3.8 ... 20.5 mA is output.

7.6.2 Behavior of the Current Output in Case of Error

If the measuring device detects a fault, the current output is brought to a safe condition.

Error >21mA or <3.6mA:

There is a hardware or software error.

Please refer to the operating manual for a detailed description of the error behavior.

7.6.3 Device Behavior in Case of Interference Radiation

The LB 480 is able to detect interference radiation caused, for example, by weld seam testing. If interference radiation is present, the measured value switches to fault current for the wait time set in the device. Overfilling or underfilling cannot be detected during this time. Even if the LB 480 is very sensitive when it comes to the detection of interference, one cannot rule out ultimately that specially low interference radiation influences may not be detected and the measured value is falsified. For this reason, it is generally necessary that the system operator is informed in advance and appropriate measures are taken to maintain the safe operation of the system.

7.7 Installation and Wiring

Installation and wiring is described in the relevant operating instructions.

If necessary, the following inputs can be connected and used:

- Pt100 for temperature compensation
- RS485 for cascading as a multi-detector system

The use of other inputs is not permitted in safety-related applications.

7.8 Commissioning

The following equipment may be used for commissioning:

- HART®-Communicator
- The PC-based control software LB 480-PC.

For commissioning, you should be familiar with the operating instructions (Level, Limit Level, or Density).

Carry out the following steps for commissioning:

1. Calibration (see User's Manual Volume 3, Chapter 5)
2. Enable Safety Mode

   Menu path: Device Config>Access>Safety ON

   With this setting, the security-compatible setting is checked and the detector LB 480 locked.

   The Safety Mode is maintained even if the device is turned off and then on again.
3. Check safety parameters and measured value

   Menu path: Diagnostic>Safety>Refresh Safety Status

   – First update Safety Stati.
     To do this, select parameter "Refresh Safety Status".
   – Then Safety Status 1, 2 and 3 have to show the value 0xFF.

   If not, the measurement cannot be used in a protection device. The measurement can be used in a protection device only when the settings are corrected so that 0xFF is displayed in the active "Safety Mode". If you need help, please see the brief explanation in the safety parameters in each menu of Safety Status 1, 2 and 3.

Please refer to *chapter 7.9 "Periodic Inspections"* so that the reference values for this test can be determined directly following the commissioning.

7.9 Periodic Inspections

The periodic performance test is used to check the safety function in order to detect possible non-recognizable dangerous errors and thus to test the operational capability of the measuring system at appropriate intervals. It is the responsibility of the operator to select the type of inspection.

The intervals depend on the PFD value used (see table in *chapter 7.11*).

The test has to be carried out so that the correct safety function can be established in the interaction of all components. The methods and procedures used in the tests must be stated and their suitability must be specified. The inspections have to be documented.

If the performance test is negative, the entire measuring system must be taken out of service and the process must be kept in a safe state by other measures.

The first test must be performed directly after the initial startup, so that the reference values and the general conditions are defined, and these are available in the following periodic inspections for reference.

IMPORTANT
During the test, the person performing the test must ensure the safety-related monitoring of the process by other technical and/or organizational measures.

7.9.1 Test Options

The options to test (proof-test) the measuring device as a component of the measuring system differ depending on the application the instrument is used for. The test options are listed below. Please note that this should be done under operating conditions, provided certain operating conditions have an impact on the measurement. For example, if there is a stirrer in the beam path, then the stirrer must be operated as under operating conditions. The same applies to a container under gas pressure, and to heating and cooling jackets, to name two further examples. It is the responsibility of the operator to select the type of inspection. The interval depends on the PFD used (see Table in *chapter 7.11*).

7.9.1.1 Limit Switch Application

The function in the Limit Switch application can be checked by controlling the response level in the course of a filling process. If filling is not feasible, the measuring system must be triggered to respond by an appropriate simulation of the level or the physical measuring effect.

7.9.1.2 Level Application

In the Level application, the function can be checked in the following manner:

1. Source open, container empty ⇒ it must be possible to check the zero point.
2. Source closed, container empty ⇒ measured value of the initial start-up must be reached under the same conditions.

7.9.1.3 Density Application

In the Density application, the function can be checked only by a reference liquid where we know the density. An example would be filling the measuring path with water. If this is not possible, a reference sample must be analyzed in the laboratory and its result has to be compared with the results of the measuring device.

In general, a 2-point tests leads to a higher safety level. A second point should have a fairly large distance from the first point. We recommend a difference between both points of >30% of the measuring range.

7.10 Repair

Repairs of the SENSseries LB 480 may be carried out at the manufacturer's works only.

7.10.1 Software Update

A software update must be carried out only by personnel authorized by BERTHOLD TECHNOLOGIES.

7.11 Functional Safety Data Sheet LB 480

7.11.1 SIL 2 in System Architecture 1oo1 (1-channel)

Parameter	Value
Protective function	- Limit level measurement - Level measurement - Density measurement
SIL	SIL 2 with one detector LB 480 (SIL2 SC3 FT0)
HFT	0
Device type	B
SFF	92%
MTTR, MRT	72h
λsd	0 FIT
λsu	0 FIT
λdd	2450 FIT
λdu	210 FIT
λtot	2660 FIT
PFDavg for T1 = 1 year	<1.12E-03
PFDavg for T1 = 2 years	<2.04E-03
PFDavg for T1 = 5 years	<4.79E-03
PFDavg for T1 = 10 years	<9.39E-03
PFH	<2.11E-07 1/h
MTBF	>42 years
Diagnostic test interval	<180s
Operating mode	Low Demand or High Demand
Maximale Demand Rate	= Diagnostic test interval * 100
DC	95%
Error response time*	0.5s

*) The error response time is the time between an error is detected until the moment the error current (<3.6mA or >21mA) is set.

In a cascade, the values for PFD and PFH must be multiplied with the number of detectors.

7.11.2 SIL 3 in System Architecture 1oo2 (2-channels)

Parameter	Value
Protective function	- Limit level measurement - Level measurement - Density measurement
SIL	SIL 3 with two detectors LB 480 (SIL3 SC3 FT1)
HFT	1
Device type	B
MTTR, MRT	72h
Beta	5%
PFDg for T1 = 1 year	<5.6E-05
PFDg for T1 = 2 years	<1.0E-04
PFDg for T1 = 5 years	<2.4E-04
PFDg for T1 = 10 years	<4.7E-04
PFH	<2.11E-07 1/h
MTBF	>19 years
Operating mode	Low Demand or High Demand
Response time	10sec
DC	95%

In a cascade, the values for PFD and PFH must be multiplied with the number of detectors.

7.12 Attachments

7.12.1 Test Log

Identification	
Company/Auditor	
Date	
Measuring point	
Product	
Order no.	
Isotope, source no., activity	
Detector type, detector size	
High voltage	
Date of last function test	

Device parameters of the safety function	
Operating mode	☐ Limit switch max
	☐ Limit switch min
	☐ Level
	☐ Density
lower measuring range (unit)	
upper measuring range (unit)	

Test	
Measured value 1 (unit)	
Measured value 2 (unit)	

Safety Status	
Safety Status 1	☐ 0xFF
Safety Status 2	☐ 0xFF
Safety Status 3	☐ 0xFF

Date: ________ Signature: ____________________

7.12.2 Definition of Terms

SIL	Safety Integrity Level
HFT	Hardware Fault Tolerance
SFF	Safe Failure Fraction
PFD_{AVG}	Average Probability of Dangerous Failure on Demand
PFH	Average Probability of Dangerous Failure on Demand
FMEDA	Failure Mode, Effects and Diagnostics Analysis
FIT	Failure in Time (1 FIT = 1 failure/109h)
λsd	Rate for safe detected failure
λsu	Rate for safe undetected failure
λs	λs = λsd + λsu
λdd	Rate for dangerous detected failure
λdu	Rate for dangerous undetected failure
DC	Diagnostic Coverage
T1	Proof Test Interval
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
IBN	Commissioning

7.13 Functional Safety Certificate

ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

TÜV SÜD Product Service

CERTIFICATE

No. Z10 047128 0002 Rev. 00

Holder of Certificate:	**Berthold Technologies GmbH & Co. KG** Calmbacher Str. 22 75323 Bad Wildbad GERMANY
Certification Mark:	TÜV SÜD Functional Safety
Product:	**Sensors** **Measuring System**
Model(s):	**SENSseries LB 480**
Parameters:	Architecture 1oo1: SIL2, SC3 Architecture 1oo2: SIL3, SC3 Degree of Protection: IP66 / IP68 The report to the certificate and the user documentation in the currently valid revision are mandatory parts of this certificate.
Tested according to:	IEC 61508-1:2010 IEC 61508-2:2010 IEC 61508-3:2010

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. This certificate is valid until the listed date, unless it is cancelled earlier. All applicable requirements of the testing and certification regulations of TÜV SÜD Group have to be complied. For details see: www.tuvsud.com/ps-cert

Test report no.: BB99553C

Valid until: 2028-09-10

Date, 2023-09-12

Peter G. Weiß

(Peter Weiß)

Page 1 of 1

TÜV SÜD Product Service GmbH • Certification Body • Ridlerstraße 65 • 80339 Munich • Germany

TÜV®

Zertifiziervertrag

Grundlage für die Zertifikatserteilung ist die Prüf- und Zertifizierordnung von TÜV SÜD Product Service.

Mit Erhalt des Zertifikates erkennt der Zertifikatsinhaber die jeweils gültige Fassung der Prüf- und Zertifizierordnung an (www.tuev-sued.de/ps_regulations) und wird somit Partner im Zertifiziersystem von TÜV SÜD Product Service.

Prinzipielle Voraussetzung für die Gültigkeit des Zertifikates:

– Gültigkeit der zitierten normativen Prüfgrundlage(n) ist gegeben

und zusätzlich bei Zertifikaten mit Berechtigung zur Verwendung eines Prüfzeichens bzw. bei Zertifikaten für QM-Systeme:

– Voraussetzungen für vorschriftsmäßige Fertigung werden eingehalten.

– Die Fertigungs- bzw. Betriebsstätten werden regelmäßig überwacht.

Certification contract

Certification is based on the TÜV SÜD Product Service Testing and Certification Regulations.

On receipt of the certificate the certificate holder agrees to the current version of the Testing and Certification Regulations (www.tuev-sued.de/ps_regulations) and thus becomes partner in the TÜV SÜD Product Service Certification System.

Requirements for the validity of the certificate in principle:

– Validity of the quoted test standard(s)

In addition for certificates with the right to use a certification mark and for QM certificates:

– Conditions for an adequate manufacturing are maintained

– Regular surveillance of the facility is performed

Akkreditierungen / Benennungen (Status 25.02.2010) /
Accreditations / notifications (as of 2010-02-25)

Deutschland / Germany

Geräte- und Produktsicherheitsgesetz (GPSG) /
Equipment and Product Safety Act (GPSG)

Europa / Europe

- Niederspannungsrichtlinie 2006/95/EG
- Spielzeugrichtlinie 2009/48/EG
- Richtlinie für aktive medizinische Implantate 90/385/EWG
- Richtlinie für Medizinprodukte 93/42/EWG
- Richtlinie für In-vitro-Diagnostika 98/79/EG
- Richtlinie für Gasverbrauchseinrichtungen 90/396/EWG
- Richtlinie für persönliche Schutzausrüstungen 89/686/EWG
- EMV-Richtlinie 2004/108/EG
- Richtlinie für Sportboote 94/25/EG + 2003/44/EG
- Richtlinie für Maschinen 2006/42/EG
- Richtlinie für Ex-Schutz Geräte 94/9/EG

- Low Voltage Directive 2006/95/EC
- Toys Directive 2009/48/EC
- Directive for Active Implantable Medical Devices 90/385/EEC
- Directive for Medical Devices 93/42/EEC
- Directive on In Vitro Diagnostic Medical Devices 98/79/EC
- Directive for Gas Appliances 90/396/EEC
- Directive for Personal Protective Equipment 89/686/EEC
- EMC Directive 2004/108/EC
- Directive for Recreational Craft 94/25/EC + 2003/44/EC
- Directive for Machinery 2006/42/EC
- Directive for Ex Safe Equipment 94/9/EC

- ENEC Agreement for luminaires and IT equipment

USA

- Nationally Recognized Testing Laboratory (NRTL) to 29 CFR 1910.7 by OSHA
- Accredited for FDA 510(k) Third Party Review
- Conformity Assessment Body to the MRA for Medical Devices; FDA QSReg Inspections, FDA 510(k) Third Party Review

Asien-Pazifik Region / Asia Pacific

- Recognized Certification Body to Electrical Products (Safety) Regulation; Hong Kong
- Konformitätsbewertungsstelle / Conformity Assessment Body to the MRA for Medical Devices; Australien / Australia
- Konformitätsbewertungsstelle / Conformity Assessment Body to the MRA for Medical Devices; Neuseeland / New Zealand

Weltweit / Worldwide

- NCB im CB-Scheme des IECEE / NCB in the CB Scheme of IECEE
- ExCB im IECEx-Scheme des IECEE / ExCB in the IECEx Scheme of IECEE
- TÜV SÜD Product Service Mark für Produkte / TÜV SÜD Product Service Mark for products DAP-ZE-1213.00
- Zertifizierung von QMS / Certification of QMS TGA-ZM-08-93-00
- Zertifizierung von QMS gemäß / Certification of QMS according to (DIN) EN ISO 13485 / ISO 13485

Zertifizierstelle für Produkte / Certification Body for Products • e-mail ps-zert@tuev-sued.de
Zertifizierstelle für Medizinprodukte / Certification Body for Medical Devices • e-mail ZASMAIL@tuev-sued.de
Kundenservice / Clients Services • Phone +49/89/50 08-42 61 • Fax +49/89/50 08-42 30 • e-mail ps-zert@tuev-sued.de

8 Visual Inspection

Regular visual inspections of the measuring system SENSseries have to be carried out, at least every three years. To do this, use the visual inspection plan on *page 1-55*. Take appropriate actions immediately if you detect damage in the course of the visual inspection; if necessary, disconnect the detector from power supply immediately.

To determine the inspection intervals for the visual inspection, take the following conditions into consideration:

- Ambient conditions (outdoor, rain, sunlight, heat and cold).
- Operating conditions (utilization of system, operating errors)
- Measuring system is operated within or outside of an explosion hazardous zone.

Carry out a visual inspection before first commissioning and after any repair that requires opening of the detector cover and check the terminal compartment. Please use the visual inspection plan (*Volume 1*) on *page 1-55* and the plan for checking the terminal compartment on *page 1-57*.

9 Radiation Protection

9.1 General Information and Guidelines

In order to prevent adverse health effects caused by working with radioactive substances, limits for the maximum permissible radiation exposure of operating personnel have been agreed upon on an international level. Appropriate measures in designing the shieldings and arranging the measuring system at the measuring site will ensure that the radiation exposure of the personnel will remain below the maximum permissible value of 1mSv (100mrem) per year.

To ensure safe operation and compliance with the legal regulations, the company has to appoint a Radiation Safety Manager who is responsible for all questions relating to radiation protection. The Radiation Safety Officer will monitor handling of 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. Radiation protection zones 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 actions in case of accidents – such as fire or explosion. Any special event has to be reported to the Radiation Safety Manager immediately. He will then investigate any damage and immediately take suitable precautions if he detects defects that may adversely affect the safe operation of the system.

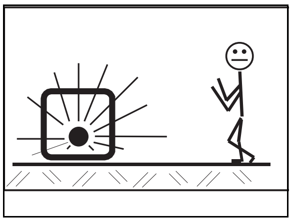
The Radiation Safety Manager has to make sure that the provisions of the Radiation Protection Regulations are observed. In particular, his duties include instructing the staff on the proper precautions when working in the vicinity of radioactive substances.

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, time and shielding.

Distance

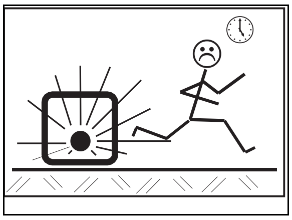


This means the distance between the radioactive source and the human body. The radiation intensity (dose rate) decreases – like light – in proportion to the square of the distance, i.e. doubling the distance to the source reduces the dose rate to one quarter.

Conclusion:

Maximum distance should be maintained when working in the vicinity of equipment containing radioactive material. This is especially true for persons that are not directly involved in this work.

Time

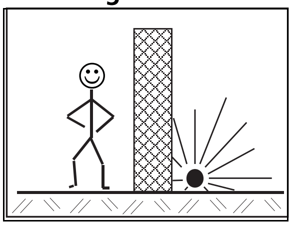


The total time a person stays in the vicinity of a radiometric measuring system and the body is exposed to radiation. The effect is cumulative and increases therefore with the duration of the radiation exposure.

Conclusion:

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

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 materials with a high specific weight are to be used for shielding purposes. The device designer usually calculates suitable dimensions.

Conclusion:

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

During use

Installation, dismantling, relocation, maintenance, testing involving the radioactive source and its shielding shall ONLY be performed under the supervision of the Radiation Safety Officer.

For more information please contact BERTHOLD TECHNOLOGIES.

9.2 Mounting the Shielding

9.2.1 Safety Instructions

The shielding container consists of a lead-filled, stable cast housing. To close the beam exit channel a rotating bezel is installed. Operation is carried out from behind by a T-handle, which is secured by a padlock in open as well as in closed position. The locking prevents that the radiation path can be closed or opened by unauthorized persons. Also is prevents that unauthorized persons can remove the source.

Radiation exposure during installation

To keep the radiation exposure of the assembling personnel as low as possible, only licensed personnel who have been trained on how to handle radioactive substances are allowed to assemble or disassemble the shielding with the source. The work is performed according to the instructions and under the supervision of the Radiation Safety Manager. It has to be ensured that the lock of the shielding is closed and secured, so that no unshielded radiation can exit. Make sure the shielding is not modified or damaged.

Vibrations

Constant vibrations can loosen the lead in the shielding and grind up lead in extreme cases. In this case, the shielding effect and the function of the shielding are no longer guaranteed. In the worst case, the radioactive substance may leak out. Also, constant vibrations can loosen the source holder or the source, which also would impair both the function and the shielding effect.

A corrosive atmosphere requires an additional protective covering made from a suitable material, such as stainless steel sheet, or the shielding itself must be made from a suitable stainless steel. Corresponding versions are available on request from BERTHOLD TECHNOLOGIES.

NOTICE

Depending on the operation conditions, the function check has to be repeated at appropriate intervals, at least once a year.

9.2.2 Radiation Exposure during Installation of the Shielding

The shieldings of measuring systems are usually designed such that the limit of the control area is in a given distance (in most cases less than one meter) around the shielding, and it does not matter whether point or rod sources are being used and how high their activity is. A simplified calculation of the radiation exposure during installation of the shielding is possible with sufficient accuracy using the dose rate data printed on the type plate, measured in 1 m distance from the shielding. The radiation exposure D can be calculated according to the following formula:

$$D = DR \times t \times 4$$

D = accumulated dose during assembly in Sv
DR = dose rate on the type plate of the shielding in µSv/h
t = time needed for the installation with shielding in h

If the work process is prepared well, you may expect a working time of less than 20 minutes to perform work such as installation of the shielding or operating the shutter.

Calculation example

DR = 3µSv
t = 20min (1/3h)

D = 3 x 1/3 x 4 = 4µSv/h

If we compare this dose with the permissible annual dose of 1 mSv for persons who are not exposed to radiation on their job, this work may be carried out 250 times per year by one and the same person.

9.2.3 Radiation Dose Calculations

When preparing work on radiometric measuring systems, it is important to pre-calculate the radiation exposure to be expected, since 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.

The radiation exposure to be expected for a shielded source is calculated as follows:

$$\text{Dose D} = \frac{A \times k \times T}{r^2 \times s}$$

A is the activity of the source and k the respective specific Gamma radiation constant (see table below). The distance from the measuring point to the source is r and the duration of stay at this point is T. s is the shielding factor of the shielding used, which is indicated on the information sheet of the shielding or which can be calculated. It is listed in the shielding brochure or can be calculated. s = 1 when calculating the dose rate for work with an unshielded source.

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

Calculation example

Calculate the dose in a distance of 50 cm from a Co-60 source with an activity of 350 MBq and a time of 30 minutes. The source is installed in a shielding with a shielding factor of 30:

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

9.3 Testing the Shutter Mechanism

The Radiation Protection Ordinance requires that regular functional testing and maintenance are carried out on the shielding and the inspection is documented. In establishing the testing interval for periodic functional testing and maintenance of the source shielding, the ambient and operating conditions of the measuring device, the legal regulations and the permit conditions must be considered. The functional checks and maintenance have to be carried out, however, at least once a year.

The functional test is to ensure that the locking mechanism is working properly. It must be ensured that:

- the closure moves easily and freely
- the locking mechanism does not get jammed at any point in the range of rotation
- the beam path can be closed completely

If you notice a failure or you have doubts, please contact the BERTHOLD TECHNOLOGIES service department.

9.4 Safety Measures

When designing the installation of radiometric measuring systems, the possibility that a fire breaks out must be considered. Flammable substances must not be stored in the proximity of radioactive substances. They should be covered and protected properly to prevent a possible spreading of the fire to the radioactive sources. It is mandatory to coordinate all preventive measures against fire with the local authorities, primarily with the fire department, which must be informed about the type, scope and place of application of the radioactive substances used, in order to be prepared in the event of fire.

When devising alarm plans, possible special features of the radiometric measuring system have to be mentioned; the Radiation Safety Manager to be notified in the event of an emergency has to be included in those plans as well, and also the address and phone number of the regulatory authority.

9.5 Protection against Theft

Radioactive substances or facilities containing radioactive substances must be secured against unauthorized use. Fixed installations are, by their nature, protected against unauthorized use.

If facilities working with radiometric measuring systems are taken out of service for a longer or indefinite period of time, the radioactive sources together with their shieldings should be dismantled and secured until the facility is taken into operation again.

Portable measuring systems, on the other hand, have to be protected by keeping them under constant supervision, or, if they are not in operation, by keeping them in a locked room or container which can be guarded against unauthorized access.

This is especially true for low activity test sources which are used, for example, to check the function of dose rate measuring instruments.

In the event that radioactive substances are lost, the Radiation Safety Manager and the regulatory authority have to be notified immediately.

In case of theft, the police must be informed as well.

9.6 Accidents, Loss, Damage, Fire, Theft

Remember the principles of health and safety in such situations: Time, distance, and shielding (see also *page 1-123*). In case of one of the above situations:

- Limit access to the area
- Report the incident to the authorities.
- Inform BERTHOLD TECHNOLOGIES.

Proper handling and disposal of possibly leaking radioactive sources or contaminated parts of the equipment must be coordinated with the supervisory authority.

9.6.1 Malfunctions and Accidents

The Radiation Protection Ordinance defines malfunction as an event which for safety reasons prohibits continuation of the operation of the facility.

Malfunction

Malfunction means, that a device necessary to guarantee safe operation of the facility, e.g. the seal of the active radiation beam of the shielding, no longer functions properly.

Accident

An accident is an event which could expose persons to a radiation dose which exceeds the permissible limits, or could cause contamination by radioactive substances.

In terms of safety, malfunctions and accidents are very serious events and appropriate steps must be taken immediately to prevent hazards to persons as well as facilities, or to reduce them as much as possible.

It is therefore important that the personnel is aware of preventive measures and is prepared for possible accidents or malfunctions of the facilities, so that dangerous consequences can be ruled out as far as possible by a proper reaction of the personnel.

In any case, the Radiation Safety Manager who checks the situation at site and takes all necessary steps to prevent unnecessary radiation exposure of the personnel must be notified immediately.

The Radiation Safety Manager will then take appropriate measures and will inform the official authority concerned, and, if necessary, get further information from the manufacturer.

IMPORTANT
The recovery of shieldings and sources after incidents and accidents may only be carried out in accordance with the instructions by the authorities.

The necessary steps should be taken in the following order:

- Locate source.
- Check function of shielding
- Check effectiveness of shielding by measuring the dose rate
- Guard and mark controlled areas.
- Secure source and shielding.
- Document the incident and assess possible radiation exposure of personnel.

In case the source capsule is damaged, the following points have to be considered:

- Avoid contamination.
- Handle source with tools (e.g. pincers or tweezers) and put both (source and tool) in a plastic bag.
- Stay behind auxiliary shielding (e.g. concrete, steel, or lead plate).
- Check if vicinity is free of contamination
- Secure radioactive waste properly (deposit at governmental collection site or return to manufacturer).

If the source is leaking and the dose rate might possibly be exceeded, the regulatory authority (e.g. trade board) has to be notified immediately.

In case of an accident or malfunction or any other event which affects the safety, the regulatory authority has to be informed and also, if necessary, the authority in charge of public safety. Please contact BERTHOLD TECHNOLOGIES if you need any further information.

9.7 Shielding and Source

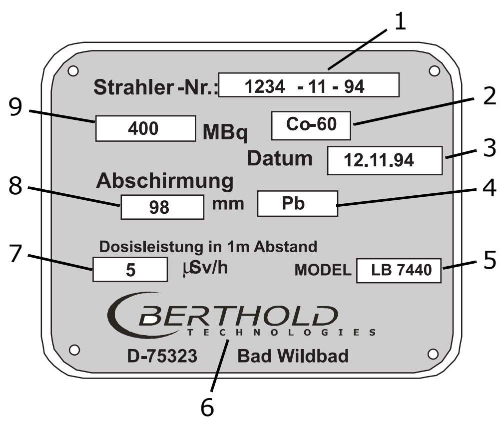
Shieldings do not include any wearing parts or mechanically moving parts that under normal operating conditions require maintenance. For safety reasons, however, it should be possible any time to lock the useful beam. A functional check has to be performed in appropriate intervals of max. one year (see *chapter 9.3*). The Radiation Safety Manager has to be informed immediately if any faults on the shielding or a sluggish locking mechanism are detected. If the problem cannot be solved simply by cleaning, you have to stop working with the system until it has been repaired.

As long as the shielding does not show any significant mechanical damage or strong corrosion, the built-in source will be protected. Please observe the radiation protection guidelines when checking or replacing the source.

The radioactive sources used and the function area of the measuring system typically permit a service life of more than 10 years. The useful life of radioactive sources should be based on the period of use recommended in the leak test certificate. A source may have to be replaced earlier if the statistical variations which increase in the course of time become intolerably high and any compensation by increasing the time constant is not acceptable any more, e.g. for control-engineering reasons.

IMPORTANT
Empty calibration has to be performed any time a source is replaced!

For information on the design of source and shielding please refer to the technical documentation and the identity plate (*Fig. 9-1*).



1 Source number
2 Isotope
3 Source manufacture date
4 Shielding material
5 Type of shielding
6 Shielding manufacturer
7 Dose rate in 1 m distance
8 Effective shielding thickness
9 Activity

Fig. 9-1 Identity plate

If the source has to be renewed, you have to include the source number of the original source in your new order. This number consists of three digits, for example:

1234 - 11 - 94

The first group is a consecutive number, the second group identifies the month (here: November) and the third the year the source was manufactured (here: 1994). It is included on the identity plate of the shielding and also on the leak test certificate that comes with every source.

9.8 Leak Test

Depending on the stipulations of the regulatory authority responsible for the sources employed in their territory, regularly recurring leak tests have to be carried out. These tests have to be carried out by approved experts, or in consultation with the regulatory authority, by the manufacturer. The appropriate documents on the source have to be provided in order to carry out this test.

9.8.1 Required Documents

- Inventory of the sources to be tested with information on the previous leak tests
- Source certificate including the following information:
  - Nuclide, activity, purchase date, physical-chemical form
  - Description of capsule and type of sealing
  - Resistance against mechanical and thermal influences or classification of the source design
- Information on location, intended use as well as on the typical operational maximum mechanical and thermal stress.
- If the sources are installed in an appliance, a drawing has to be enclosed which clearly shows the position of the source and of all parts that are essential for its protection against external influences. Proposals for the best test method should be available, e.g. through information on alternative test areas and, if necessary, the required manipulations, how the test can be carried out without adversely affecting the workability of the system or appliance.
- Certificate on an acceptance test by the manufacturer.

Alternative test areas

For point source shieldings LB 744X

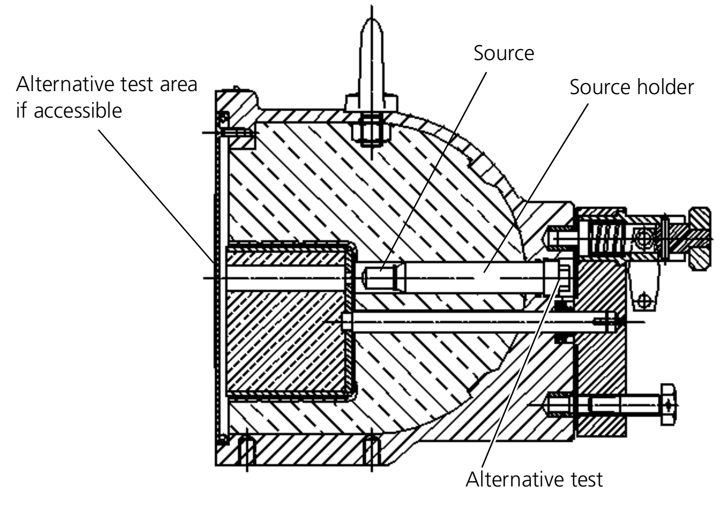


Fig. 9-2 Alternative test area on point source shieldings:

Turn lever to horizontal position for inspection.

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

10 Source Replacement

IMPORTANT
Radioactive sources may be replaced only by a competent firm that has a service license to handle radioactive materials.

10.1 Radiation Exposure during Source Replacement

It is important to calculate the possible radiation exposure even before mounting or dismantling point sources. An exact calculation is possible using the equation described in *chapter 9.2.3*.

The anticipated working hours should be split up in work in the direct vicinity of the shielding during mounting and dismantling the source holders and work with the unshielded source while fixing and dismantling the source and the source holder. The dose obtained while working in the vicinity of the shielding and the dose obtained while working with the unshielded source have to be calculated separately and added up.

A rather simplified estimation is possible, provided the work is prepared well. Based on the assumptions of a mean distance of 0.5 m for the whole body radiation and the time you are working with the unshielded source of 6 minutes (= 1/10 hour), the radiation exposure can be calculated for different activities (A) as follows:

Dose D = A x 0.15 for Co-60

Dose D = A x 0.04 for Cs-137

Enter the activity in MBq; the dose is calculated in μSv.

IMPORTANT
Using a pocket dosimeter with direct reading, measure the accurate radiation exposure during this work, even if the radiation exposure lies below the detection limit of dosimeters.

Calculation example

A point source with an activity of 400 MBq (approx. 11 mCi) has to be replaced. Using the above assumptions concerning distance and time and the above equation, we get the following result:

$$D = 400 \times 0.15 = 60\,\mu Sv$$

The radiation exposure in the vicinity of the shielding was previously calculated to be 10 µSv. The total radiation exposure including mounting and dismantling can then be estimated as being 70 µSv for a single part source.

If the above assumptions do no apply, the calculations have to be corrected accordingly. Actually, it can only be another working time which has a proportional effect on the result of the calculated dose rate.

10.2 Point Source Replacement on LB 744x Shieldings

In this chapter we will describe how to replace point sources on the following shieldings:

- LB 7440
- LB 7442
- LB 7444
- LB 7445
- LB 7446

The exchange of radioactive sources must be performed in accordance with applicable regulations under the supervision of the Radiation Safety Officer.

CAUTION

Health hazards due to radiation!

When replacing a source, you have to work with the unshielded source for a short time. An increased dose of radiation is harmful to health.

You have to carry a pocket dosimeter during work to measure the personal dose and to document the actual radiation exposure. Moreover, work has to be coordinated with the competent Radiation Safety Manager.

IMPORTANT

For Germany you have to keep in mind:
Source replacement by the customer is possible only if:
1) the appropriate technical qualification is guaranteed
2) the work to be done to replace the source has been approved explicitly by the regulatory authority. Your "License to Handle Radioactive Substances" states whether you are in possession of such a license.

Point sources have to be fixed on source holders which are then screwed into the shielding, positioning the source in the center of the shielding.

Prerequisite for this work is detailed knowledge of the design of the shielding; appropriate drawings must therefore be available.

Preparation

All necessary work has to be prepared well so that it can be carried out quickly to keep exposure to the unshielded source to a minimum. Using a drawing of the shielding, you should plan the best procedure and have the following tools handy:

- Allan keys in the required sizes.
- 2 pairs of pliers to take hold of source and source holder (e.g. a pair of combination pliers or multigrip pliers).

Cordon off an area consistent with the activity of the source. Prevent persons from approaching.

If sufficient space is available, the source can be replaced in the shielding installed at the measuring site. Move the new source in its transport shielding close to the installation site.

Prepare a suitable, clean space, if possible with an auxiliary shielding (shielding vessel, lead bricks, concrete stones, etc.) and place the source holder and the source there on a piece of paper to protect it against dirt.

Depending on the construction, you either have to open the lock on the shielding and turn the lever to center position between ON and OFF until the hexagon head bolt of the source holders becomes visible, or remove the locking plate, so that you can unscrew the source holder.

Source Replacement Procedure

- ▶ Open the lock (2) of the shielding (1).
- ▶ If necessary, pull out the locking screw (5) from the lever.
- ▶ Pull the knob (3) and turn the lever (4) by 90° to the right to the center position between OPEN and CLOSED

  Now the hex screw head of the source holder is visible.

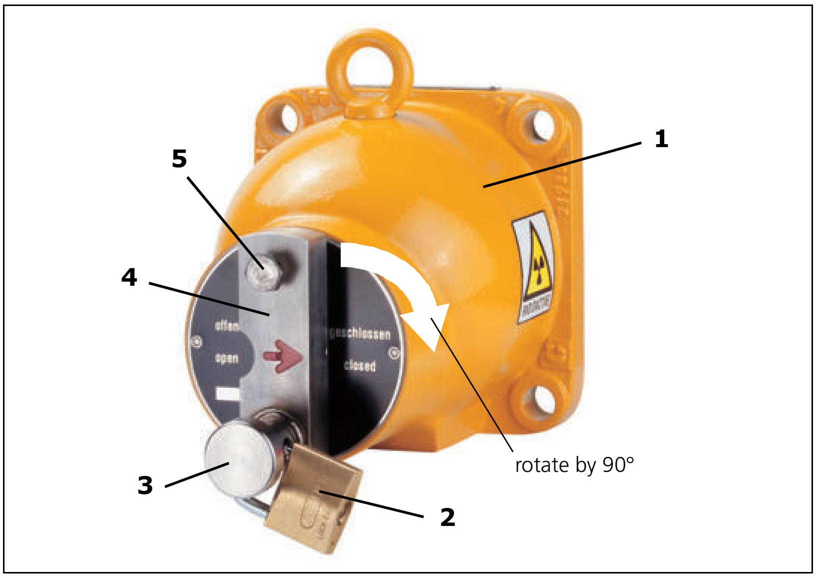


Fig. 10-1 Point source shielding, beam path closed

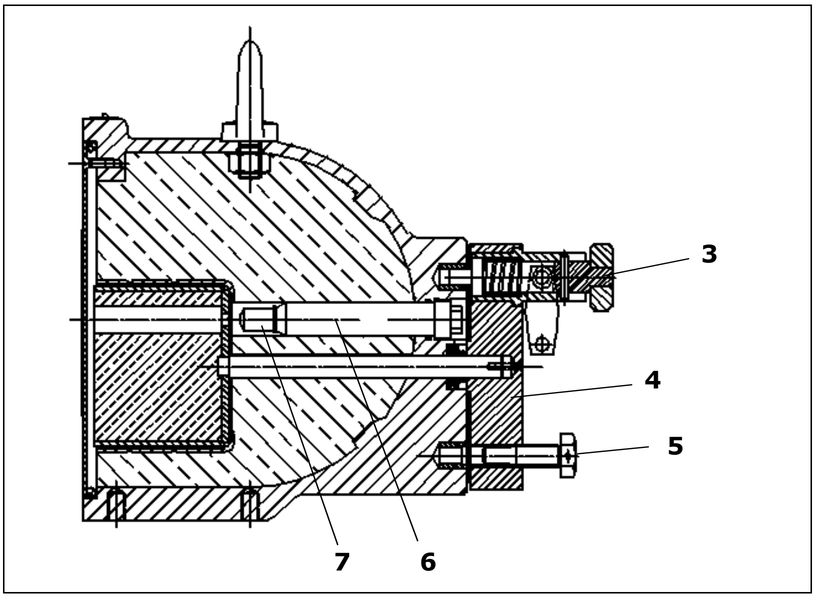


Fig. 10-2 Sectional drawing of source holder, beam path open

⚠ CAUTION

Health hazards due to radiation!

Do not remove the source from the shielding!

Do not touch the source to prevent a high partial body dose. Touch the source only with a tool that allows you to hold the source easily and safely. Keep the source far away from your body and set it down behind an auxiliary shielding.

- ▶ Screw the source holder (6) together with the source (7) using a socket wrench (size 12 mm).

Remove source from shielding

- ▶ Unscrew the source from the source holder using a socket wrench (size 10 mm). Hold the source holder using a second socket wrench (size 12 mm).

IMPORTANT
For this work, you should use the shielding housing as auxiliary shielding between source and body.

- ▶ Take hold of the source using a pair of pliers and immediately put it into the transport shielding or another shielding.

IMPORTANT
Make sure the source is not mixed up with the new or another source.

- ▶ If necessary, clean and grease the thread on the source holder and the shielding.

Install new source

- ▶ Using a pair of pliers, take the new source out of the transport shielding and firmly fix it onto the source holder together with the locking washer (torque: 3.5Nm).
- ▶ Put the source holder with the source again into the shielding and fix it using the socket wrench (torque: 44Nm).
- ▶ Check the proper ON/OFF function.
- ▶ Carefully close the transport shielding again, after you have put the old source into the transport shielding.

Replace the type label

- Replace the type label on the shielding or attach the new source number.
- Calibrate the system new (see *Volume 3*)

IMPORTANT
The special regulations regarding labeling and transport of the shielding back to the manufacturer have to be observed. If in doubt, please contact BERTHOLD TECHNOLOGIES's Source Transport Manager.

This completes the point source replacement.

11 Source Disposal

In general, each country has a collection site for radioactive material.

However, if you would like to return radioactive material to us for disposal, **the international regulations, ADR und GGVSE**, for transport, labeling and dose rates of the radioactive material have to be complied with, as well as the regulations of each country. It is the full responsibility of the sender to make sure these regulations are complied with.

Please keep in mind:

- Dose rate on the surface of the packing: <2000µSv/h.
- Dose rate in a distance of 1 m from the surface of the packing: <100µSv/h.
- Attach the UN number with the symbol for dangerous cargo on each package
- Shipping documents with correct description of the contents and accident procedures sheet in conformance with the ADR regulations are required.
- Packaging must comply with the valid ADR regulations.

For all questions on source transport or source return please contact our sales force, or our representative.

IMPORTANT

In many countries the transport of radioactive materials is subject to approval by the authorities. The source may be returned only after prior order confirmation and release confirmation by BERTHOLD TECHNOLOGIES.

Please keep in mind:

- Radioactive materials and their shieldings may not be damaged in any way and must have a valid seal test certificate. The seal test certificate may not be older than six months at the time of arrival in Germany. An exception is possible if a PTB certificate is available which confirms that the validity of the test dates has been extended.
- If you plan to return radioactive sources with isotope Am-241 or Cm-244, you have to include the *Special Form* certificate.
- It is indispensable that radioactive material that is returned to us is adequately labeled with your name and address.
  If you have received a quotation from us, please include our quotation number as well.
- Radioactive material can be returned only after you have received permission from BERTHOLD TECHNOLOGIES. We would be happy to send you a quotation on the costs to be expected for returning a source.
- The source return declaration and the seal test certificate have to be sent to BERTHOLD TECHNOLOGIES together with your order documents. You will get the form for the source return declaration from BERTHOLD TECHNOLOGIES on request.

Notes:

Subject to change in the course of further technical development.

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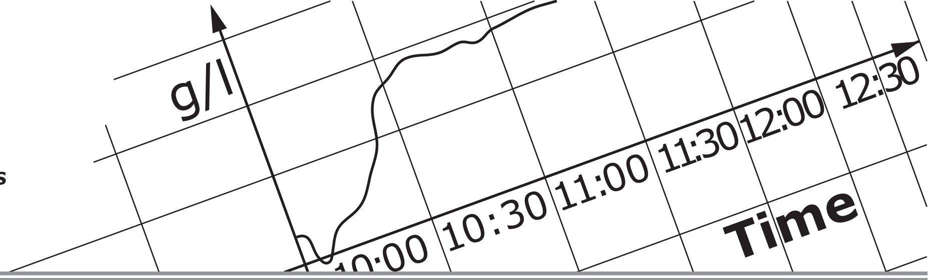


Volume 2 Installing SENSseries

1

System Description

1.1 Measuring System

1.1.1 Measuring Arrangements

The measuring system SENSseries LB 480 is a detector which, depending on its design, can be used for different measurement tasks:

- Level measurement
- Monitoring limit values
- Density measurement

The measuring system SENSseries LB 480 comes in the following versions:

- Point detector CrystalSENS (NaI 50/50)
- Point detector SuperSENS (scintillator 150/150)
- Rod detector UniSENS (length 0.5 to 2m in 50cm increments)
- Rod detector TowerSENS (length 3 to 8m in 1m increments)

The measuring system utilizes the radiometric measuring method, i.e. the absorption of Gamma radiation passing through the product being measured. In order to obtain an optimum measuring effect at minimal source activity, the ideal measuring geometry is calculated for each measuring site and the source is designed accordingly.

The measuring system SENSseries LB 480 is a compact detector, including the required components scintillation counters, power supply and the entire evaluation electronics, in one device.

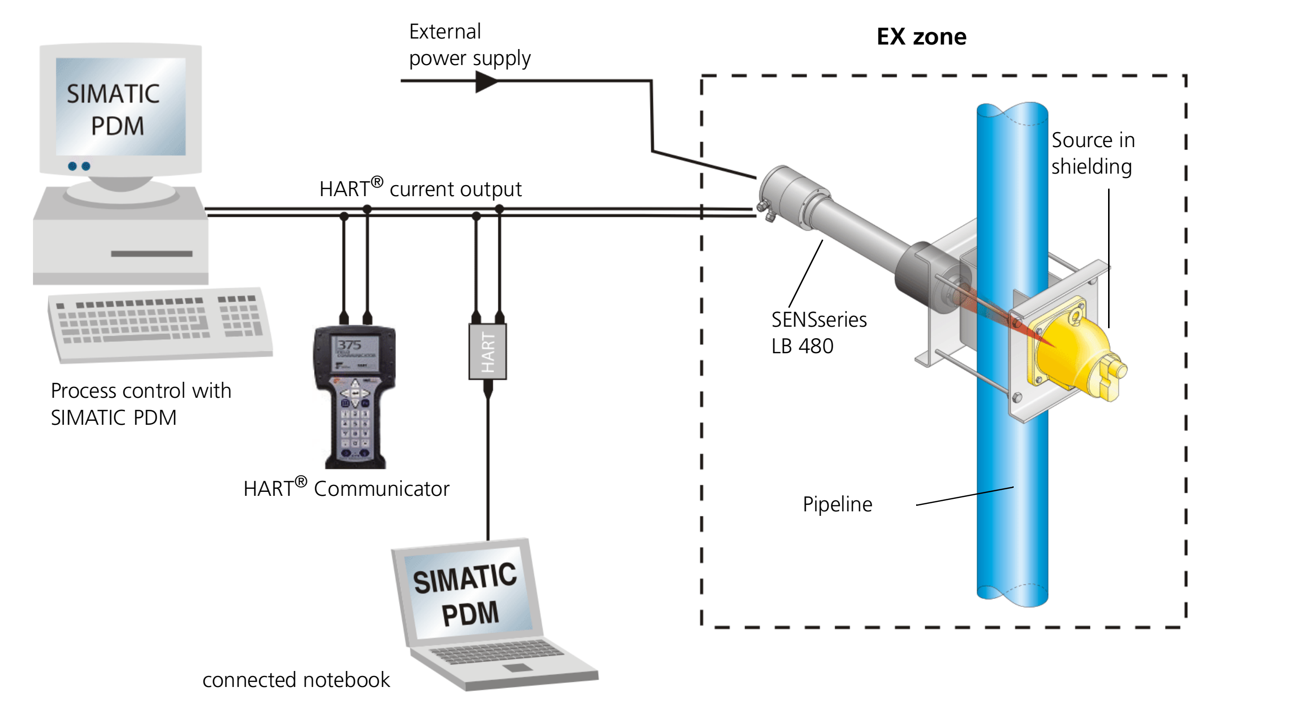


Fig. 1-1 Basic measuring configuration

1.1.2 Detector communication

Communication with the PCS[1]

The communication with display, evaluation and control devices takes place via a 2-wire HART® current interface with modulated digital current signal (FSK-modulation of the current signals according to the Standard Bell-202).

The density data are supplied as isolated 4-20 mA current signal to the process control system PCS.

Configuration and monitoring

Configuration, parameter setting and calibration of the detectors, as well as the output and display of the digital units of measure are carried out either:

- via a hand-held terminal, e.g. the 375 Field Communicator by Emerson Process Management GmbH & Co. OHG, or
- via PC and a suitable user interface for the detector, e.g. the SIMATIC PDM software.

Volume 3 describes the operation with HART® Communicator.

1. PCS = process control system

1.1.3 Measuring Geometries

The hardware and software of the measuring system SENSseries LB 480 allow for an easy adaptation of the system to different measuring geometries and measuring tasks. Therefore, the settings and parameters of the measuring device have to be defined with care during commissioning for the particular measuring task.

Commissioning log

Important parameters may not be changed during operation. The system must be taken into operation and settings changed only by persons who know how to work with the device. Therefore, all users should read these User's Manual carefully. BERTHOLD TECHNOLOGIES, therefore, recommends documenting all settings in a setup protocol.

Project planning

The best system configuration is selected for each measuring task in the planning stage. Therefore, the specific project documentation has to be observed and followed.

1.2 SENSseries Hardware

1.2.1 Detector

The measuring system SENSseries LB 480 comprises one detector and the evaluation unit, both accommodated in a sturdy stainless steel housing.

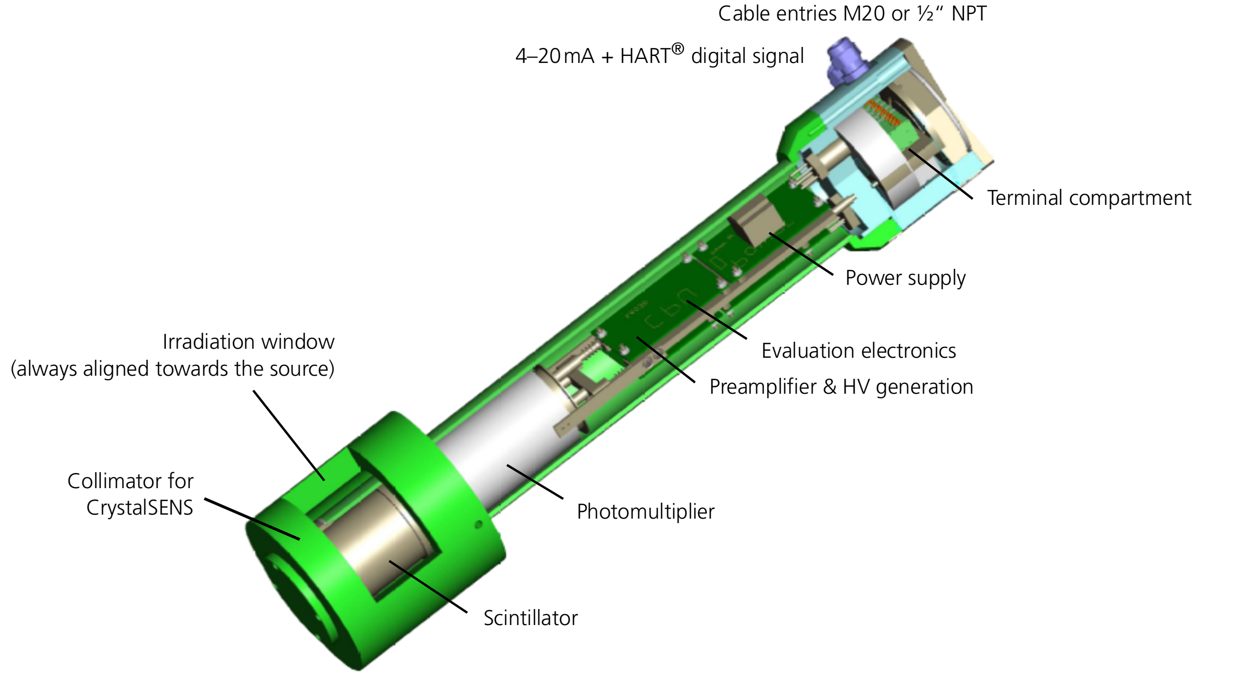


Fig. 1-2 Design of the SENSseries LB 480

Component	Description
Scintillator	Detecting Gamma radiation.
Photomultiplier, preamplifier, HV generation and evaluation electronics	Conversion of the flashes of light into electrical signals, conversion to liquid level, density or limit value.
Power supply	Power supply unit in two versions: 100V to 240V_{AC} 24V_{DC}
Terminal compartment	Includes all terminals which are necessary for the installation of the detector. For detailed information please see in *chapter 3* on *page 2-185*.
Thread of the cable entries	4 pcs M20 (ATEX) or 4 pcs ½" NPT (FM/CSA) for feedthrough of the connection cable.

Evaluation electronics

Control and processing of the signals are carried out by the evaluation electronics. The 4-20 mA measuring signal is passed through a 2-wire cable to the PCS (terminals 15 and 16).

Detector Communication

The measuring system SENSseries LB 480 uses the HART® protocol for communication. Configuration, parameter setting and calibration of the detectors, as well as the output and display of the digital units of measure are carried out either:

- via a hand-held terminal, e.g. the *375 Field Communicator* by Emerson Process Management GmbH & Co. OHG, or
- via PC with FDT frame application or
- via PC and the *SIMATIC PDM* software.

Access to electronics

At the top, the detector is closed by a detachable housing cover which can be removed by unscrewing the Allen screws.

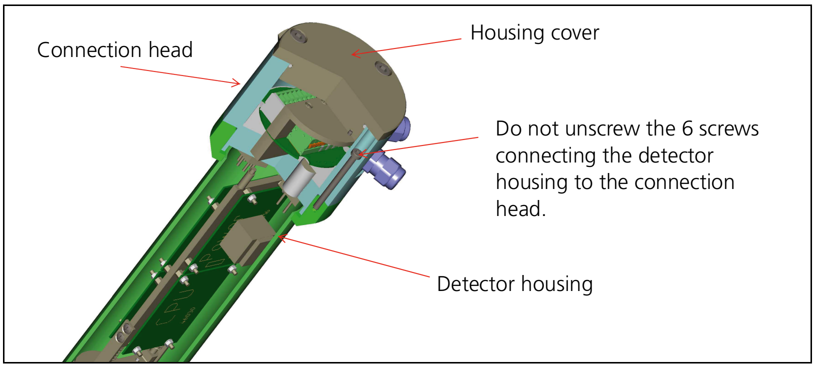


Fig. 1-3 Detector housing with connection head

Decay compensation

For automatic decay compensation, the detector is equipped with a capacitor-buffered real-time clock. The capacitor buffers the real-time clock for about one week. If the buffering is lost, the real-time clock starts with the last saved date the detector was supplied with power. A message informs you that the date has to be updated.

1.2.2 Sources

Sources are not part of the SENSseries LB 480 measuring system. They can be purchased separately through BERTHOLD TECHNOLOGIES together with the respective shieldings and holding devices.

Radioactive sources for industrial applications are always "encapsulated radioactive substances" which are tightly welded into a sturdy capsule made of titan or stainless steel, so that the radioactive substance cannot leak out. Contamination is therefore ruled out. Moreover, any activation of the product being measured by the sources used is not possible for physical reasons.

The following radiation sources are used for measurement:

- *Co-60* emits Gamma radiation with an energy of 1.17 or 1.33 MeV. It is available as rod or point-shaped source. The influence of interferences due to gas density fluctuations and varying wall deposits is lower than with Cs-137. The half-life period of Co-60 is 5.27 years.
- *Cs-137* emits Gamma radiation with an energy of 0.66 MeV. Typically, it is delivered as a point-shaped source, occasionally as a rod-shaped source. The half-life period of Cs-137 is about 30 years.

1.3 Measuring Principle

The principle of measurement is the irradiation method, utilizing the physical law of the absorption of radiation passing through matter. The resulting measuring effect is the ratio I/I_0 between the unattenuated radiation I_0 and the radiation I attenuated by the product being measured.

The mathematical correlation is as follows:

$$I = I_0 \times e^{-\mu \times \rho \times d}$$

The equation shows that with a given source and the respective mass attenuation coefficient μ the measuring effect is dependent only on the product density ρ and the measuring path d.

Since the measuring path is constant and possible product density changes at a certain measuring path due to exponential reasons do not have any effect any more, this measuring method is not affected by any chemical and virtually no physical properties of the product being measured. For this reason, the radiometric measuring principle ensures high reliability and low maintenance.

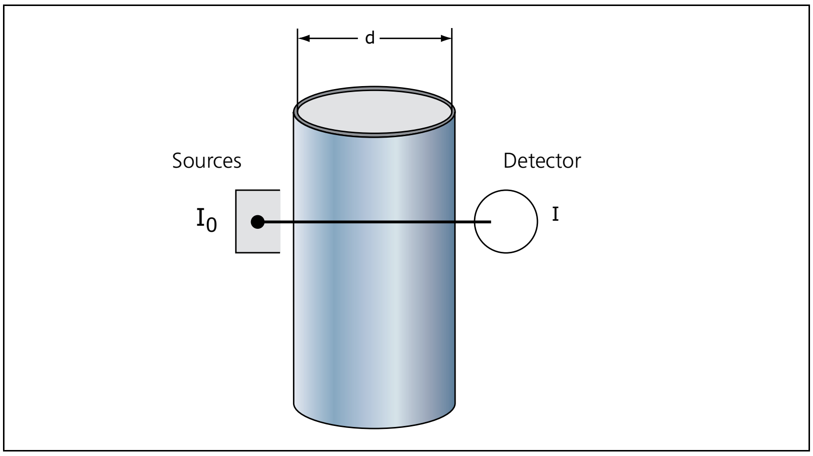


Fig. 1-4 Measuring Principle

1.4 Measuring Arrangements

The measuring arrangement for density, concentration and mass flow measurements usually comprises the following components:

- the radioactive source a)
- the shielding b)
- the SENSseries LB 480 c)
- the Pt100 resistance thermometer (optional) d)
- the mounting device e)
- the water cooling jacket for the detector (option)

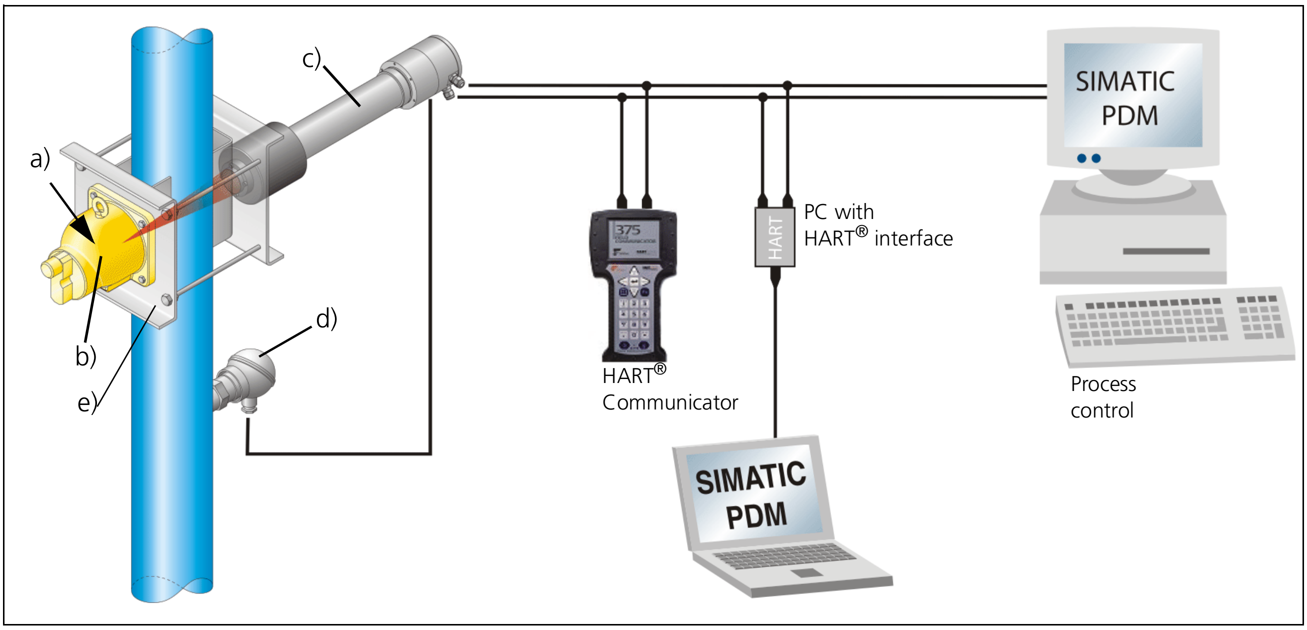


Fig. 1-5 Point source / Point detector arrangement

The supply voltage for the detector and the measurement signal from the detector to the evaluation unit are transmitted via the connecting cable between the detector and the evaluation unit.

Different arrangements and fixtures are required, depending on the measurement task and the characteristics of measuring product and containers. *Fig. 1-5* shows a schematic arrangement of a pipe with Pt100 resistance thermometer and a 90° mounting device for density, concentration, and mass flow measurement. 45° and 30° mounting devices are available to extend the measuring range. S- or U-shaped measuring sections can be used for smaller pipe diameters. A measurement in containers is also possible.

The respective selections are made during the planning stage and must be observed during assembly and commissioning.

1.5 Technical Data

If you are working under different operating conditions, please contact BERTHOLD TECHNOLOGIES.

Ambient temperature for "non-Ex" areas

	Operating temperature		Storage temperature
	uncooled	with water cooling	
CrystalSENS (Point detector)	-40 to +60°C	to +100°C	-40 to +60°C
UniSENS (Rod detector) SuperSENS	-40 to +60°C	to +100°C	-40 to +60°C

Ambient temperature in Ex areas

Limited temperature ranges can apply for use in explosion hazardous areas. Please note the maximum ambient temperature values for explosion protection in the Safety Manual.Keep devices in a dry (no condensation), dark (no direct sunlight), clean and lockable room. Stay within the temperature range for storage.

General ambient conditions for explosion protection to CSA

Pollution Degree: 2
Overvoltage Category: III
Altitude: up to 4000 m
Humidity: 90 % or less

The approvals listed on the type plate of the each detector are valid.

IP protection type

according to IEC 60529: IP66 and IP68
according to ISO 20653: IP69K
according to NEMA Standard Publ. 250: 4X and 6

Vibration, mechanical shock

Vibration: 1,9g
mechanical shock: 30g
according to DIN EN 60068-2-6 and 60068-2-27

EMC

Interference emission to EN 61326-1, Equipment Class A
Resistance to interference to EN 61326-1, NAMUR NE21 and EN 61326-3-1 (SIL)

Housing

Material stainless steel 1.4301/304; other stainless steels on request.

Weight

see *Volume 2*, *chapter 5*.

Water cooling

Stainless steel 1.4301/304; maximum 6 bar, hose connection R1/4" or 10 mm dia.

Current output

HART current output 4 ... 20 mA, floating

passive or active (Source, or Sink Mode)

Resolution better than 6µA

Impedance range active: 120 ohms to 500 ohms

Passive impedance range: up to 250 ohms at 12V, 500 ohms at 24V.

For safe HART® communication you need at least 250 ohms.

The maximum cable length of the HART® loop depends on the connected impedance as well as on the capacity and inductivity of the cable.

Max. cable length with BERTHOLD cable # 32024:

- 3300 m at 120 ohms
- 1600m at 250 ohms
- 800m at 500 ohms

The current output itself is monitored continuously and, in case of malfunction, signals 24 mA constantly via a redundant current path. The digital HART® communication remains in effect even on the redundant current path.

Current output		
passive	active	Signal output
LB 480-xx-0x	LB 480-xx-Zx	Non-ex
LB 480-xx-1x	LB 480-xx-2x	Ex e
LB 480-xx-3x	LB 480-xx-4x	intrinsically safe

For intrinsically safe signal output see *Volume 1, chapter 5 "Explosion Protection"*.

Power supply

Nominal voltages (depending on version):

100V to 240V_{AC}±10%, 50/60Hz, max. 8VA or
24V_{DC} (18 to 32V_{DC}), max 8W

Cable conduits

4 cable conduits with M20 (ATEX) or ½" NPT (FM/CSA) for process connection, closed with dummy plugs. The screwed fittings which are not needed for the installation must be closed with sealing plugs that are suitable for the type of protection, see *chapter "Assembly instructions for ID No. 56091"* on *page 2-240*.

Cable glands

Nickel-plated brass, 2 pieces for cable diameter 6 to 14 mm, TPE seal.

Optional: Cable glands made of stainless steel or EMC cable glands nickel-plated brass.

Cable cross-section

The cable cross-section is dependent on the cable glands used.

Wire cross-section for spring-type terminals

0.5mm^2 to 2.5mm^2; stripped length 10mm

Scintillators

Type	Scintillator	Dose Rate (typic) for CS-137 in µSv/h for 1000 lps	Tempera-ture stability	Weight in kg	Weight in kg with water cooling
CrystalSENS (Point detector)	NaI (Tl) 50*50mm NaI (Tl) 40*35mm NaI (Tl) 25*25mm NaI (Tl) 44*5mm	0,8µSv/h 1,6µSv/h 5,4µSv/h (Am-241)	≤0.002%/°C	11(w/o collim.) 20.5 (with collim.)	14.5 (w/o collim.) 24 (with collim.)
SuperSENS (Point detector)	Plastic scintillator 150*150mm	Cs-137: 0,14µSv/h Co-60: 0,2µSv/h	≤0.01%/°C	60	61

High voltage generation

Voltage range of control 300V to 1300V
(error message below 300V and above 1300V)

Voltage range external setting 300V to 1300V

Sensitivity changes due to temperature variation or due to ageing are automatically compensated for by an automatic high voltage control.

Counter

Rate max. 1,000,000 cps

Automatic decay compensation

For Cs-137, Co-60 and a universally configurable isotope

Digital output

Open Collector, electrically isolated; max. 100mA at 5 to 35V_{DC}; R_{max} 10kOhm; max. 2V voltage drop, leakage current in closed state <0,01mA; at inductive load a freewheeling diode is required

The output can be used either for:

- Error signal
- Stop signal
- Max. alarm
- Min. alarm
- Detector temperature
- Interfering radiation

For intrinsically safe signal output see *Volume 1, chapter 5 "Explosion Protection"*.

RS-485

For software updates

Detector temperature sensor

Two independent temperature sensors

Measurement deviation:
-25°C to 100°C: ±2K
-55°C to 125°C ±3K

Connection to PCS

Via current interface 4–20 mA with optional HART® protocol according to Standard BELL-202 FSK.

Pt100

- measurable temperature range -30°C ... 180°C
- monitored temperature limits
- accuracy: +/-0.2°C
- maximum connectable cable length: 30 m

1.6 Detector Codes

The detector codes are used for automatically adjusting the operating point of the high voltage and have already been set by the manufacturer. They only have to be checked or adapted when the electronics has been exchanged.

Detector type	LB no.	Scintillator	Detector code	Restrictions
CrystalSENS	LB 480-11 LB 480-12	50x50 NaI	0	for count rates in the range of >1000 cps
	LB 480-11 LB 480-12	50x50 NaI	1	for count rates in the range of >1000 cps
	LB 480-13 LB 480-14	40x35 NaI	0[1]	
	LB 480-15 LB 480-16	25x25 NaI	0[1]	
	LB 480-17 LB 480-18	44x5 NaI	2[1]	
UniSENS	LB 480-2A LB 480-2B	500	22	
	LB 480-2E LB 480-2F	1000	13	
	LB 480-2I LB 480-2J	1500	10	
	LB 480-2K LB 480-2L	2000	10	
SuperSENS	LB 480-31 LB 480-32	150x150	23	

1 The count rates in the measuring range must be greater than 1000cps.

1.7 Nomenclature of the SENSseries LB 480

LB480 - 1 1 - 1[ ] - 1 1 - r 1 - 0 0 0 - L

	Scintillator
1 1	CrystalSENS 50/50
1 2	CrystalSENS 50/50 + WC
1 3	CrystalSENS 40/35
1 4	CrystalSENS 40/35 + WC
1 5	CrystalSENS 25/25
1 6	CrystalSENS 25/25 + WC
1 7	CrystalSENS 44/5
2 A	UniSENS 500
2 B	UniSENS 500+ WC
2 E	UniSENS 1000
2 F	UniSENS 1000 + WC
2 I	UniSENS 1500
2 J	UniSENS 1500 + WC
2 K	UniSENS 2000
2 L	UniSENS 2000 + WC
3 1	SuperSENS 150x150
3 2	SuperSENS 150x150 + WC
4 1	TowerSENS 1000
4 2	TowerSENS 1000 + WC
4 3	TowerSENS 2000
4 4	TowerSENS 2000 + WC

[ ] = Ex-Revision A, B,...

	Approval; Supply/Signal
1[ ]	Zones (ATEX/IECEx/NEC/CEC) Ex-d/e/t; passive or slave
2[ ]	Zones (ATEX/IECEx/NEC/CEC) Ex-d/e/t; active
3[ ]	Zones (ATEX/IECEx/NEC/CEC) Ex-d/e/i/t; passive
4[ ]	Zones (ATEX/IECEx/NEC/CEC) Ex-d/e/i/t; active
A[ ]	Zones (ATEX/IECEx/NEC/CEC); Ex-d; passive or slave
B[ ]	Zones (ATEX/IECEx/NEC/CEC); Ex-d; active
C[ ]	Zones (ATEX/IECEx/NEC/CEC); Ex-dit; passive or slave
D[ ]	Zones (ATEX/IECEx/NEC/CEC); Ex-dit; active
F[ ]	Divisions (NEC/CEC); XP; passive or slave
G[ ]	Divisions (NEC/CEC); XP; active

LB480 - 1 1 - 1[ ] - 1 1 - r 1 - 0 0 0 - L

0 0		without Ex-approval, passive, M20 socket
Z 0		without Ex-approval, active, M20 socket
		Signal output
	0	Slave detector
	1	HART® (RS-485 terminated)
	2	HART® (RS-485 not terminated)
		Power supply
	1	$24V_{DC00}$
	2	100V to $240V_{AC}$
		Collimator
	0	without
	a	axial
	r	laterally positioned or laterally 66° for SuperSENS
	f	axial 316L
	s	lateral 316L
		Housing material
	1	1.4301 (Standard)
	3	316L

2

LB480 - 1 1 - 1[ ] - 1 1 - r 1 - 0 0 0 - L

Code	I/O extensions
0	without

Code	Special approvals
0	none
S	SIL

Code	Special version
0	none

Code	Application
0	Slave LK1
S	Switch LK1
T	Switch LK2
U	Switch LK3
V	Switch LK4
W	Switch LK5
L	Level LK2
M	Level LK3
N	Level LK4
O	Level LK5
D	Density LK3
E	Density LK4

(LK = license key)

IMPORTANT

In case of CrystalSENS and UniSENS:
An optional water cooling that is mounted on the detector at the factory, bears the following marking on an additional type plate: LB 480-AA-xx-xx-xx-xxx-x. The placeholder "AA" replaces the corresponding characters on the type plate on the detector.

2

Installation

Please pay attention to:

- the national safety and accident prevention regulations
- the national assembly and installation directions (for example, EN 60079)
- the generally accepted engineering rules
- the information on transport, assembly, operation, service, maintenance in this User's Manual
- the safety instructions and information in this User's Manual and the enclosed technical drawings and wiring diagrams
- the parameters, limit values and the information on operating and ambient conditions on the type labels and in the data sheets
- the labels on the device

CAUTION

Health hazards due to radiation!
Radiometric measurement devices use radioactive materials.

Danger due to radioactivity may occur if persons are exposed to radiation as a result of improper working with the measuring system.

Only persons who are trained in the handling of radioactive materials and possess the necessary know-how and skills are allowed to work with these measuring systems, see *Volume 1*, *chapter 3*, *"Qualification of the Personnel"*, *page 1-21*. Construction site personnel with experience in transporting heavy components may also be commissioned to carry out the installation. This construction site personnel, however, has to be guided by qualified persons; the Radiation Safety Officer has to be consulted for transportation and installation of the source.

Careful conformance to these regulations ensures that no hazard exists for persons using the devices.

Please be sure to comply with the Radiation Protection Guidelines applicable in your country and observe the Radiation Protection Instructions in *chapter 9*, *page 1-123*.

Storing the shieldings

The shielding with the radioactive source is delivered in a box in compliance with the regulations concerning the transportation of radioactive substances.

⚠ WARNING

Risk of injury!

The weight of the source shielding may be up to several 100kg, depending on the version.

Make sure that the mechanical stability of the mounting devices matches the weight of the shielding and that the operating staff is wearing hard hats and safety shoes whenever doing any work on the shielding.

Take the shielding out of the box just prior to installation. Up to that time, store the shielding with the radioactive source in a location that is guarded against unauthorized access, see *chapter 2.1.4* on *page 2-168*.

Detector

Damaged cable glands must be replaced immediately. Under no circumstances should the detector be operated with damaged cable glands. If moisture has penetrated, you have to dry the terminal compartment.

Detectors which are used in hazardous areas must not be put into operation again following a mechanical shock or drop, as the explosion protection is no longer guaranteed. If this happens, the detector must be examined by a person authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you have to replace the entire detector or return it to the manufacturer for inspection.

Corrosion resistance

The housing of the detector is made of stainless steel 1.4301 (304) and is therefore well protected from corrosion. The protection provided by stainless steels consists of a passive oxide layer on the surface, which is formed by oxidation with oxygen. However, if the surface gets damaged by unalloyed steel and particles of the unalloyed steel remain on the surface (ferrous contamination), then the surface may corrode at this contact point. Make sure, therefore, that neither during installation nor during operation other metal parts made of non-alloyed steel come into contact with the housing surface of the detector.

Mounting position

Size and position of the measuring range to be covered are determined in the projection phase for the measuring site and defined by drawings, sketches or details in writing. For assembly, these specifications have to be observed closely, since deviations may cause malfunctions of the measuring system.

Using the drawings of the shielding and taking into account the circumstances at the measuring site, carefully install the mounting brackets and fixtures.

2.1 Transport to the Installation Site

WARNING

Risk of injury!

– Never step under hovering loads while unloading heavy system parts!
– Only use tested lifting equipment matching the transport weights.
– Maintain adequate safety margin.
– Wear hard hat and safety shoes.

Transportation may also be carried out by construction site personnel with experience in transporting heavy components. However, this construction site personnel has to be guided by authorized persons; the Radiation Safety Officer has to be consulted for transportation of the source.

2.1.1 Transporting Detector and Evaluation Unit

NOTICE

Risk of damage!

System parts may get damaged during transport.

Transport the detector and evaluation unit in the original packaging and protect the parts from vibrations.

2.1.2 Transporting Shielding with Source

Please observe the Radiation Protection Guidelines. Radioactive substances may be transported on public traffic routes only by persons in possession of the proper transport license!

CAUTION

Hazards due to nuclear radiation!

A source may be transported only in its shielding. The shielding must be closed during transportation and installation.

The shielding with the source inside can be lifted onto a palette by a fork-lift and transported to its destination. If the system parts are provided with eyebolts for transportation, they have to be used for lifting, unless the system parts are transported in their original packaging.

2.1.3 Temporary Storage of Sources

The operator has to take suitable provisions for temporary storage of sources at the place of installation between the period from source delivery to the start of the installation work.

Sources will be stored in their shieldings. 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.

2.1.4 Installation Sites

WARNING

Risk of injury!

Heavy system parts may fall down if not installed properly.

The bearing capacity of the vessel walls or the brackets must be suitable for installation of the source with the 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.
- The electrical installation of the detector.
- Servicing and repair work, to install and dismantle parts.

The fixture for the assembled system components must not transfer any vibrations to the detector or the shielding. Likewise, it has to be ruled out that too high temperatures can be transferred to the system components.

The source with shielding and the detector are horizontally installed on the designated position on the outside of the vessel and outside a possibly installed heat insulation. The exact position for your system parts is stated on the calculation documents and the technical information prepared by BERTHOLD TECHNOLOGIES.

2.1.5 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.

2.2 Detector Protection

NOTICE

Risk of damage!

The detector may be damaged due to strong mechanical stress, vibrations and high temperatures.

Prevent heat transfer from the detector holder to the detector by using a suitable heat-insulation spacer.

2.2.1 Cooling

The ambient temperature must not exceed the values specified in the technical data (see *Volume 2*, *chapter 1.5*, *page 2-157*). If temperatures exceeding 50°C are expected, you have to use a detector with water cooling jacket (see *page 2-179*). The cooling water cycle has to remain in operation even when the detector is turned off, if the maximum operating temperature is likely to be exceeded.

NOTICE

Risk of overheating!

A failure of the water cooling or insufficient flow can overheat and thus destroy the detector.

The maximum ambient temperatures are listed in the technical data in *chapter 1.5*, *page 2-157*. In addition:

- To prevent freezing, the water cooling system must be drained.
- Polluted cooling water may clog the water cooling system, which may result in the detector getting overheated and destroyed. It is therefore essential to use clean cooling water.
- The water pressure in the cooling jacket must not exceed 6 bar.

Water cooling in Ex-areas

The information in the Safety Manual regarding the ambient temperature for explosion protection also apply to the operation of a water cooling on detectors that are used in hazardous areas.

Detector temperature monitoring

The detector includes an internal temperature measurement which can be used to trigger a pre-alarm if higher temperatures are measured. The temperature switching point can be adjusted. The alarm can be picked up at the digital output (see *Volume 3, chapter 2.27*). If you operate the water cooling so that the temperature at the detector remains below 40°C, you could switch off the detector on exceeding a temperature limit of e.g. 50°C prematurely to protect the detector against overtemperature.

Cooling water curves

The required amount of cooling water is dependent on the possible heat transmission, the cooling water temperature and the detector type. You find the cooling water curves and further information in the technical specifications on *page 2-217*.

Connecting the water cooling

Water is always supplied from the bottom to prevent air pockets that can drastically reduce the cooling effect. Therefore, the detector has to be aligned so that the water exits at the highest point (see illustration on *page 2-216*).

2.2.2 Sun Protection

If the detector is installed outdoors, it should be protected against exposure to direct sunlight by a weather protection roof.

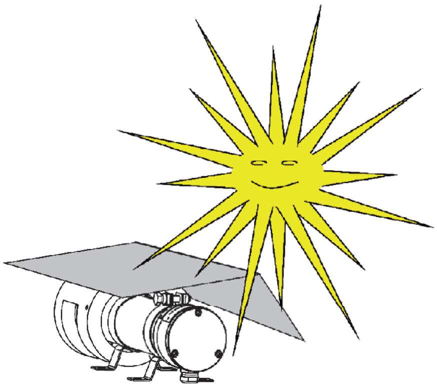


Fig. 2-1 Sun protection

2.2.3 Heavy-Duty Environments

When selecting the installation site, keep in mind that the detector should not be affected by mechanical stress or heavy vibrations, in order not to restrict its service life. If the measuring system is used in a heavy-duty environment, the detector and the shielding should be provided with an additional protective cover.

2.2.4 Precautions against Vibrations

Excessive vibrations or shocks on the detector shorten the service life. Mount the detector on a vibration-free support; you may also dampen possibly occurring vibrations or shocks using appropriate vibration absorbers.

2.2.5 Magnetic Fields

The detector is provided with an internal shielding that protects the photomultiplier against magnetic fields. Nevertheless, strong magnetic fields in close proximity to the detector may impair its function. In this case, the detector can be protected by an additional thick-walled steel tube, or the measuring point has to be relocated to another suitable position. In these cases BERTHOLD TECHNOLOGIES would be happy to help you.

2.2.6 Cleaning

Make sure not to damage the cable glands and the type plates by cleaning measures. The detector may be cleaned with water or gasoline. Remove coarse deposits with a wire brush. Grinding, filing or chipping away at deposits with the hammer is not permitted.

2.3 CrystalSENS (Point Detector)

Make sure that

– the detector or the source fixtures do not obstruct the beam path.

– there are no pipes, flanges, stirrers or other installations in the beam path.

Only installations that have already been taken into account in planning the measurement configuration are permitted. Otherwise, the curve is no longer linear; there may even be sections in the measurement range where the measured values do not change.

NOTICE

Function failure due to detector damage

The detector holder must not transfer any vibrations, shocks or heat on the detector, otherwise the detector is faulty or can fail completely.

Therefore, install the fixture on a vibration-free support or attenuate possible vibrations using vibration absorbers. Prevent heat transfer to the detector via the detector holder by using suitable insulating materials.

IMPORTANT

When installing the CrytsalSENS, please pay attention to the correct alignment relative to the source (see also page 2-173). The lateral opening (beam window) in the collimator releases the sensitive area of the detector and must be directed at the source.

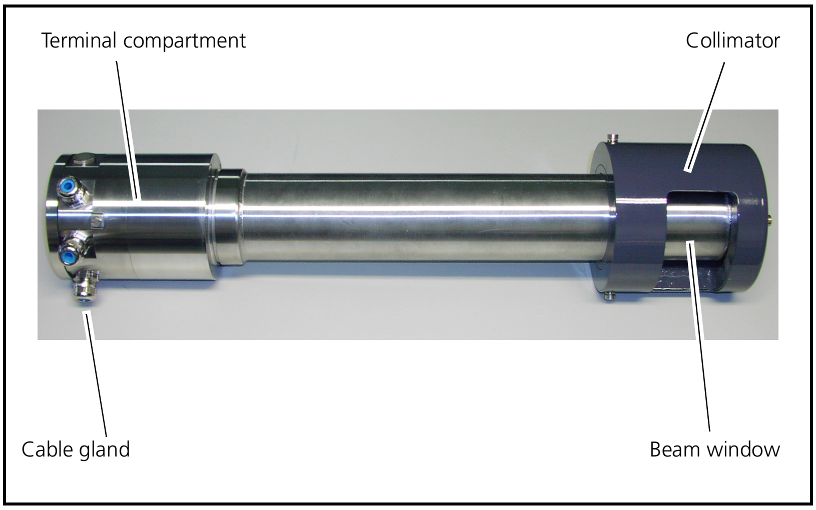


Fig. 2-2 CrystalSENS

2.3.1 Installation on Pipelines

Selection of the measurement site

When selecting the installation site, please keep in mind:

- Selection of measuring site: The pipeline must always be completely filled with the product being measured at the measuring site. If the pipeline is only partially filled, this may result in measurement errors.
- *Neither corrosion nor abrasion* or wall deposits must occur at the measuring site. This will result in incorrect measurements. That risk is lowest when the device is installed on vertical pipes.
- *Gas bubbles* in the product lead to measurement errors. The influence can be avoided or reduced by installing the measuring system at a location on the pipeline where the pressure is fairly high (installation in pressure pipes, at the foot of a standpipe). There must be no gas bubbles in the beam path.

  If no air bubbles are to be expected in the product, the *suction side of the pump* should preferably be used for installation to exclude air bubbles which might occur as a result of damaged pump seals.
- Measurements on *horizontal pipelines* should be performed using horizontal irradiation to reduce errors caused by deposit formation and gas bubbles. This will also help to avoid errors due to deposits or gas bubbles (see *Fig. 2-3*).

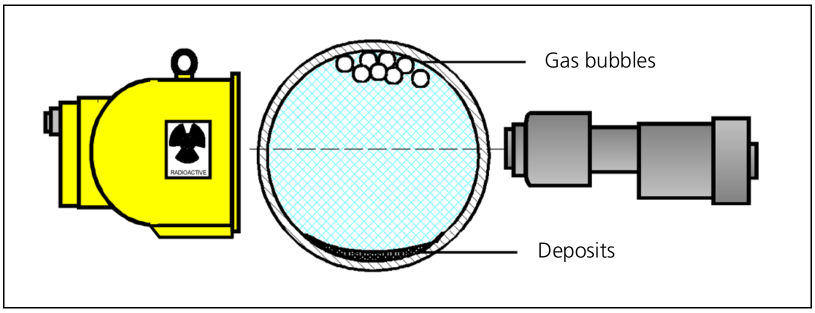


Fig. 2-3 Installation on a horizontal pipeline

- The pipeline should not be expanded. If it has to be done, it should be done only on vertical pipelines Pipelines may only be expanded at the measuring point if a continuous flow of the product over the entire pipeline cross-section will be ensured. Especially for products with high viscosity this is not always guaranteed; usually the product flows only in the center. Since the measurement covers the entire cross-section, it follows that the result will not be representative. In this case, the measurement result will not be representative.
- *Suspension measurements* must not be carried out directly at a pipe-bend, for there the material will not be distributed homogeneously. The distance from the bend must be the larger the higher the flow rate the bigger the difference between liquid density and solid density.

- On S or U-shaped measuring paths the shielding container with source has to be installed on top and the detector at the bottom (see *Fig. 2-4*).

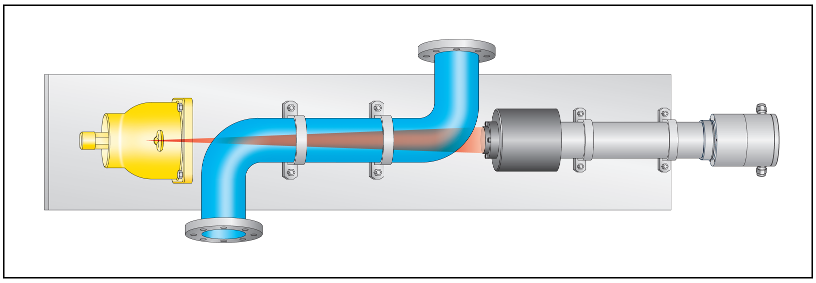


Fig. 2-4 Installation on S or U-shaped measuring path

- A thermal insulation consisting of glass or rock wool is unsuitable for installation, as it does not ensure safe installation of the measuring system. If, for technical reasons, thermal insulation at the measuring point is required, it must be made of a hard, non-hygroscopic material, i.e. aluminum silicate or it must not be installed directly on the pipeline, but on separate supports (see *Fig. 2-5*).

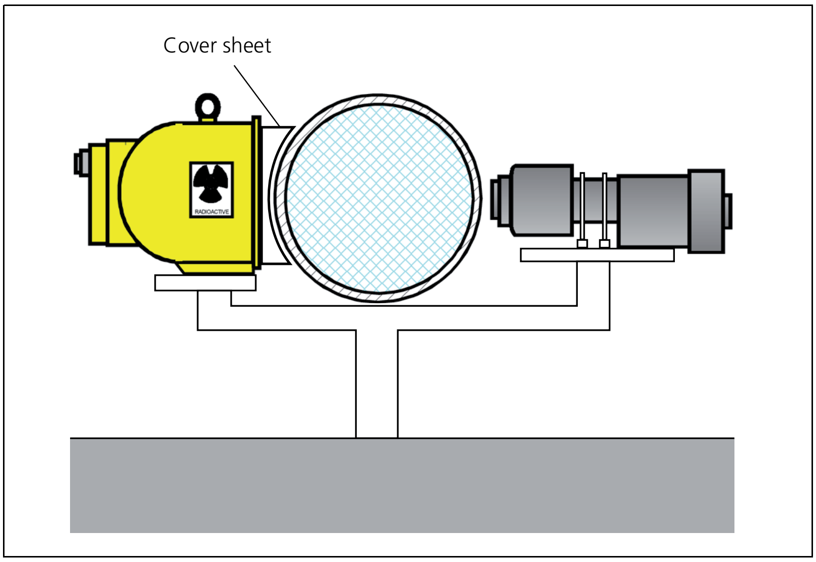


Fig. 2-5 External installation of shielding and detector

- According to the Radiation Protection Regulation areas where dose rates of > 3000 mSv/h (300 mrem/h) may be encountered are considered restricted areas. These areas must be protected by covers against unintentional reaching inside.
- The calibration of the measurement requires that samples of the product be taken. For this reason, a sampling point has to be provided near the measuring site.
- The product temperature for temperature compensation must be measured directly next to the density measurement.

2.3.2 Installation in a Container

The CrystalSENS is installed on the container using a fixture that is provided by the customer. The distance to the surface of the vessel or the surface of a thermal insulation should be about 100 mm. Clamps (see *page 2-177*) or an installation kit (see *page 2-177*) are used for installation of the detector on a bracket.

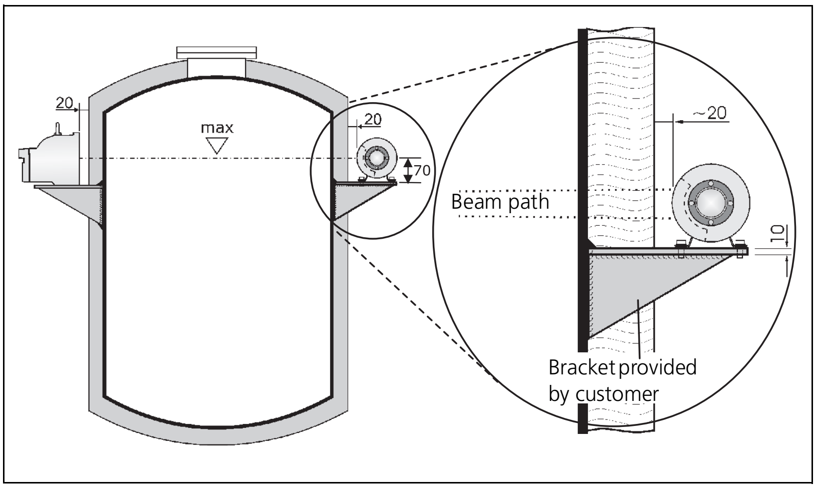


Fig. 2-6 Installing the CrystalSENS

If the bracket cannot be mounted on the container, then it has to be mounted on a support in the vicinity. *Fig. 2-7* shows three further alternative proposals (A, B, C) to mount the detector.

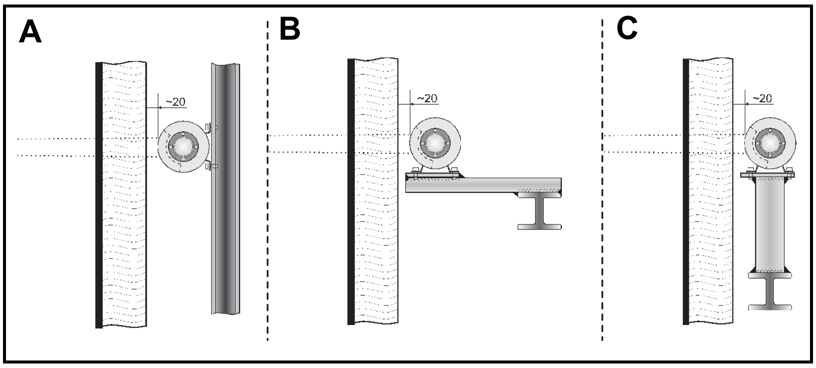
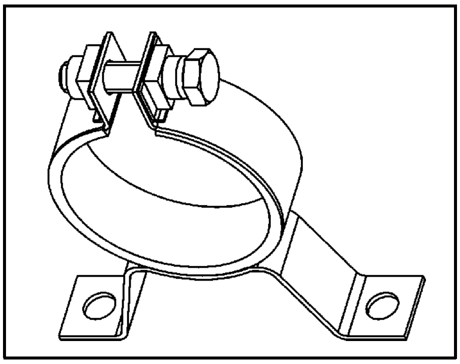


Fig. 2-7 Alternative installations

The technical drawings for CrystalSENS and its accessories can be found in *chapter "Technical Information" page 2-209* following.

Installation Procedure using Fastening Clamps

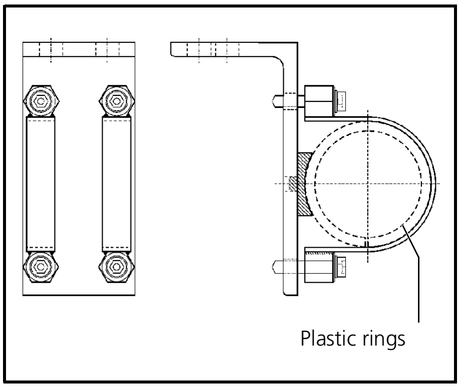


Stainless steel clamps are available for the installation of the detector.

Clamps for CrystalSENS without water cooling	Clamps for CrystalSENS with Water cooling
ID No. 31346 (1 set = 2 clamps)	ID No. 31347 (1 set = 2 clamps)

1. Make a suitable bracket for the container (*see chapter 5, "Technical Information"*).
2. Mount the bracket either directly on the container or on a stable support.
3. Mount the detector with the clamps on the bracket (see *chapter 5.1, "TI LB 480 Density"*).

Installation Procedure with Mounting Kit



A robust stainless steel holder is available instead of the clamps.

The holder consists of an angle on which two clamps are already mounted. You can bolt or weld the holder on a bracket.

For detectors without water cooling system you have to use the plastic rings shown with dashed lines in the drawing to the left for installation. They compensate for the difference in diameter between detectors with or without water cooling. Thus, the same bracket can be used for detectors with and without water cooling.

All metal parts of this holder are made of stainless steel. You find the technical drawing with dimensions in *chapter 5, "Technical Information"* ab *page 2-209*.

Mounting Kit for CrystalSENS
ID No. 39246

1. Make a suitable bracket for the container (*see chapter 5, "Technical Information"*).
2. Mount the bracket either directly on the container or on a stable support.
3. Mount the holder with the detector on the bracket.

2.4 Installation of Pt100

A temperature measurement must be carried out such that the measured temperature is fairly equal to the product temperature at the density measuring site. The resistance thermometer must not lie in the path of radiation.

If the resistance thermometer cannot be installed in the pipeline or the container, it may also be installed on the surface. This type of installation requires that the pipeline including the resistance thermometer must be provided with temperature insulation over a length of 1 - 2 m, ensuring that the surface temperature of the pipeline at the temperature measuring point is fairly equal to the product temperature. In a container, the area around the thermometer must be provided with insulation. Nevertheless, it may happen, particularly with plastic or coated pipelines or containers, that very rapid temperature changes in the product to be measured will lead to temperature-induced measurement errors. Density changes are detected by the measurement without time delay; however, the necessary temperature correction is delayed due to the inertia of the temperature measurement. Operating the measuring system with a rather large time constant may reduce this effect.

2.5 Water Cooling

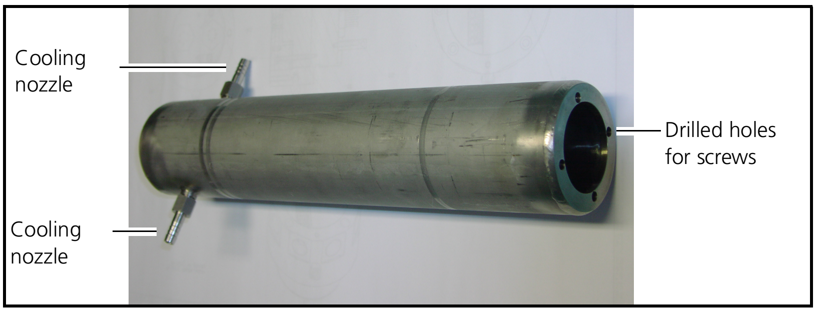


Fig. 2-8 Water cooling

If you have ordered the detector together with the water cooling, the water cooling is already mounted.

If you order the water cooling later, then you have to install it according to the following instructions.

Installing the water cooling

1. Remove the four front screws and pull the collimator from the detector.

NOTICE

To attach the collimator and the water cooling later to the detector again, you need four screws that are 5 mm longer than the original screws (not included).

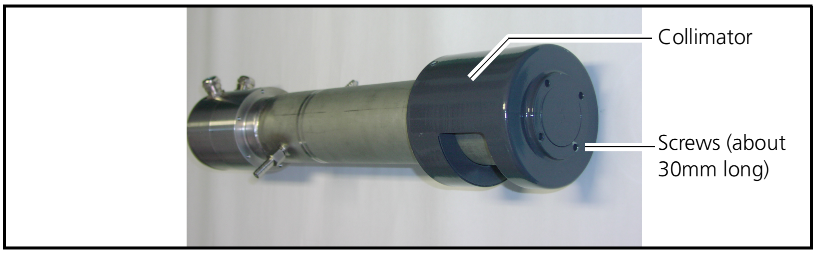


Fig. 2-9 Mounting screws for collimator

2. Slide the cooling jacket over the detector.

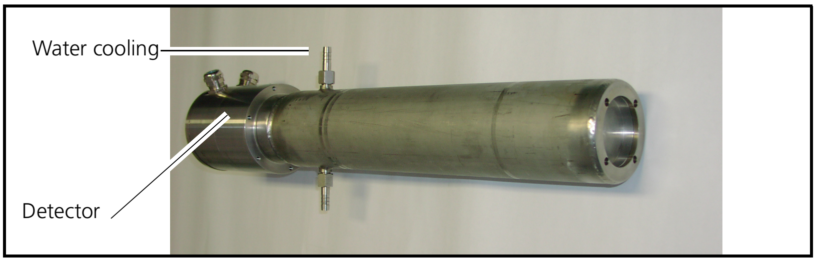


Fig. 2-10 Detector with water cooling

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

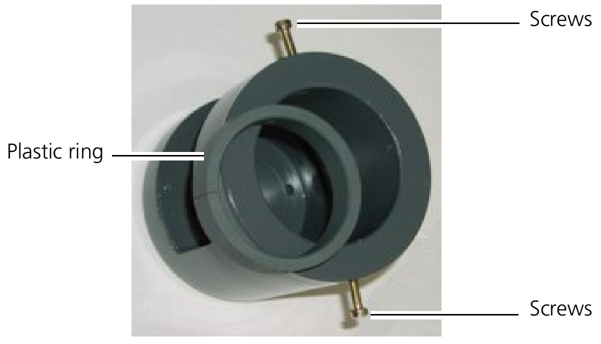


Fig. 2-11 Collimator for detector

4. Slide the collimator over the water cooling system, so that the beam window is facing the source. Position the collimator and water cooling relative to the pitch circle of the detector. Make sure that the position of the cooling nozzle is arranged so that later you have unhindered access to the installation of the water supply.

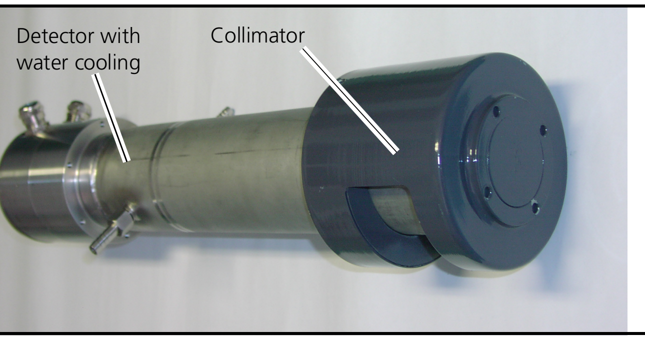


Fig. 2-12 Detector with water cooling and collimator

Please read the information on the water cooling on *page 2-170*.

2.6 Shielding

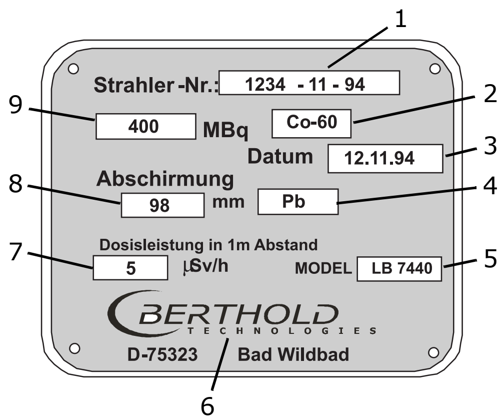
Shielding, source type, isotope and activity for each measurement configuration will be selected together with the customer to ensure compliance with the local dose rate limits. Co-60 or Cs-137 point sources are used which are tightly welded into a capsule made of titan or stainless steel. Therefore, no radioactive material can escape, provided the source is intact, and contaminations are ruled out.

For point source shieldings, the capsule with the source is fixed on a source holder and installed in the shielding. For rod source shieldings, a rod source is placed into the existing borehole of the shielding. The shielding matches the length of the source.

The distance from the source shieldings to the vessel surface is designed such that reaching into the beam channel with the hand is prevented (reference value approx. 20 mm). For shieldings with a rotary cylinder (vertically standing cylinder) make sure that the cylinder can be rotated on the vessel surface without friction.

Apart from a few exceptions, all shieldings are filled with lead to keep the dose rate on the surface with small construction sizes as low as possible. Therefore, the shieldings are quite heavy. The weights are listed in the technical drawings in *chapter 5* on *page 2-209*.

For information on the design of source and shielding please refer to the technical documentation and the type plate (*Fig. 2-13*).



1 Source number
2 Isotope
3 Source manufacture date
4 Shielding material
5 Type of shielding
6 Manufacturer of the shielding
7 Dose rate in 1m distance
8 Effective shielding thickness
9 Activity

Fig. 2-13 Type plate

Please observe the safety instructions in *Volume 1* on *page 1-123*. A source may be transported only in its shielding. Keep the source shielding closed during storage, transportation and installation.

The arrangement of the sources is defined during the planning stage and entered in a drawing or defined in writing. These details must be observed carefully to ensure correct linearization data. Detailed information about the design and function of each shielding being used can also be found in the drawings, which are included in the documentation.

2.6.1 Point Source Shielding LB744X

The radiation warning sign identifies the start of the controlled area, provided the controlled area is *outside* the shielding. If the controlled area is *inside* the shielding, then the radiation warning sign attached on the shielding suffices.

Fig. 2-14 Radiation warning sign

CAUTION

Increased radiation dose due to open beam channel!

A too high dose of radiation may be harmful to your health.

A source may be transported only in its shielding. The shielding must be closed during transportation and installation.

The radiation exit is cone shaped with an angle of about 10°. During installation, the shielding and thus the useful beam must be aligned such that they point exactly towards the detector.

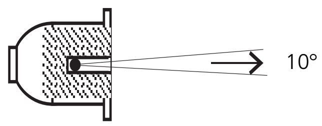


Fig. 2-15 Point source shielding

The shielding consists of a lead cylinder with source exit channel (7), surrounded by a steel jacket (*Fig. 2-16*). The locking core (6) is firmly connected with a lever (4). The "OPEN" and "CLOSED" positions are secured and the removal of the sources by unauthorized persons is prevented by a padlock (3).

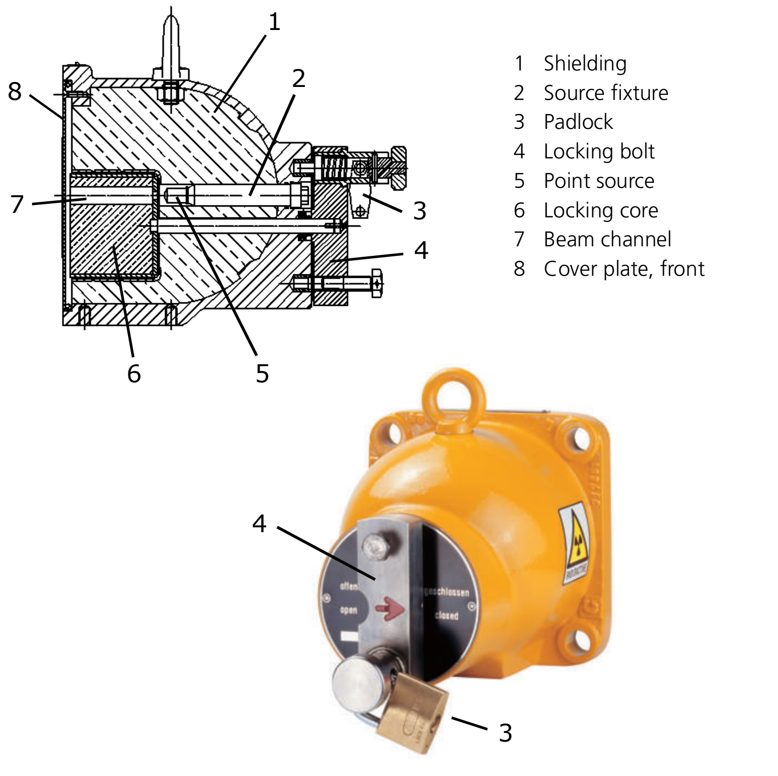


Fig. 2-16 Cross-section drawing and photo of the point source shielding, top: beam channel open, bottom: beam channel closed

Turning the lever (4) will also rotate the locking core and open the source exit channel towards the detector. The arrow on the lever is pointing to "OPEN".

The source exit channel must be closed during transportation, during installation and while carrying out work on the vessel. The arrow on the lever is pointing to "CLOSED". In the "OPEN" and "CLOSED" position, the lever or the locking core are protected by a padlock.

NOTICE

Function failure due to damage

The detector fixture must not transfer any vibrations or heat onto the shielding; otherwise the locking mechanism may be damaged and the shielding effectiveness may be adversely affected.

Therefore, install the fixture on a vibration-free support or attenuate possible vibrations using vibration absorbers. Prevent heat transfer by using suitable insulating materials.

Installing the shielding

The shielding can either be installed on a bracket or on a flange. Size and position of the measuring range to be covered are determined in the projection phase for the measuring site and defined by drawings, sketches or details in writing. For assembly, these specifications have to be observed closely, since deviations may cause malfunctions of the measuring system.

The mounting flange or mounting bracket for the shielding must take into account the angle foreseen when preparing the installation. Mounting parts such as adjustable angles allow adjustments or modifications later within certain limits.

3

Electrical Installation

Installation should only be performed by a qualified electrician (competent person).

The safe operation of the detector is only guaranteed you if follow the safety instructions described in *Volume 1*, *chapter 6*.

3.1 Cable Entries

Depending on the model, the detectors are provided either with M20 (ATEX) or with ½" NPT cable entries (FM/CSA), through which the electrical cables are be installed according to regulations. Conduits or cable glands can be screwed into the cable entries. They have to be licensed for the respective type of protection and have to be installed carefully in accordance with regulations! Cables and cable conduits have to be aligned such that water cannot flow into the bushing along the cable. Also make sure that all cables that are installed are not subject to abrasion, strain or kinks.

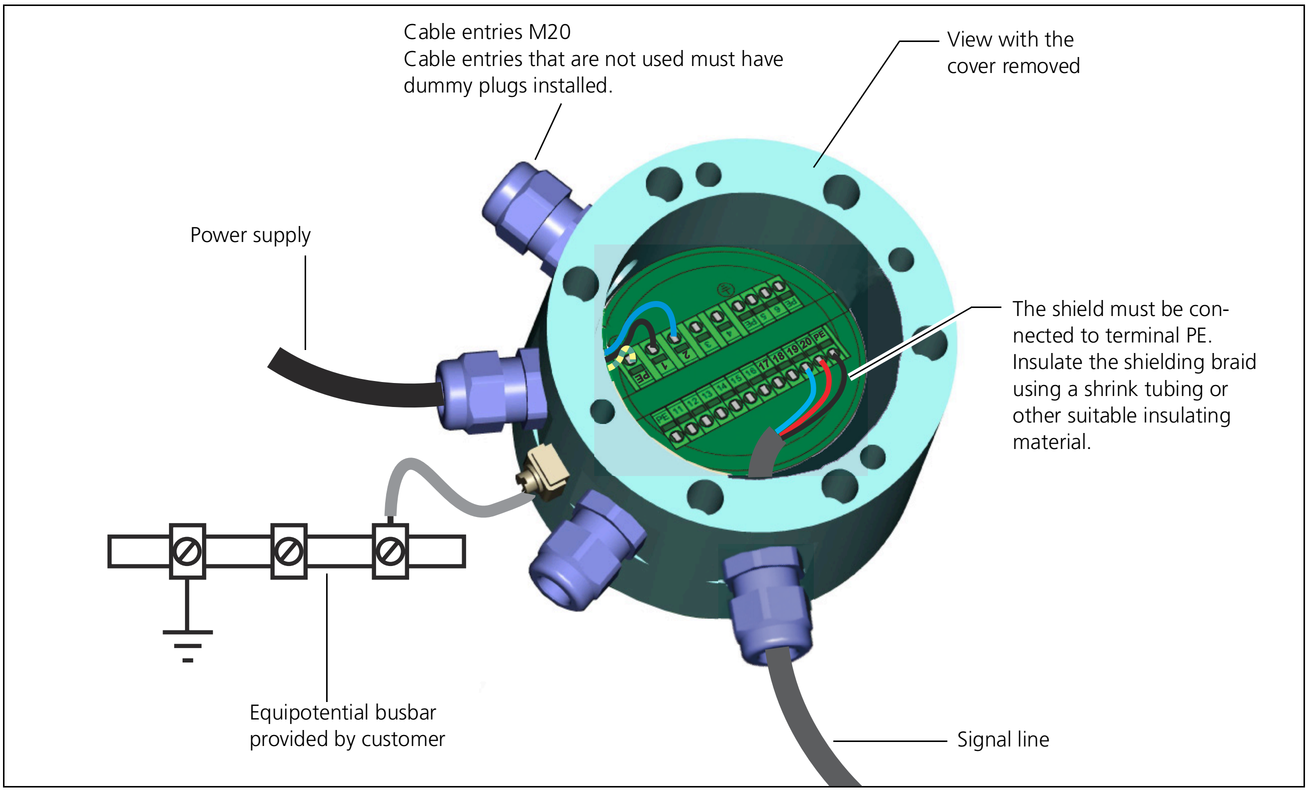


Fig. 3-1 Detector housing open - top view

Cable entries that are not used must have dummy plugs installed.

3.1.1 Multi-detector Operation

Refer to the connection diagrams in the *document "Technical Information"*

3.1.2 ATEX Connection Type

Follow the safety instructions in *chapter 5*, *"Explosion Protection", Volume 1*.

3.1.3 FM/CSA Connection Type

A stopping box (conduit seal) has to be installed on each cable entry used directly behind the detector housing.

3.1.4 Replacing a Detector or Using it at another Measuring Point

Detectors which are used in non-hazardous areas are not subject to the supervision and maintenance of Ex-protection experts; therefore, it is not guaranteed that, for example, for repair or assembly, the necessary care is taken which is required for the detectors in Ex-areas. The Ex-protection safety is therefore no longer guaranteed. The same applies to the intrinsic safety of detectors. Therefore:

- Detectors that are used in the non-Ex area may not be used in an Ex area.
- Intrinsically safe detectors, whose intrinsically safe signals are connected to non-intrinsically safe circuits must not be connected to intrinsically safe circuits any more.

3.2 Terminals

3.2.1 Master Terminal Compartment

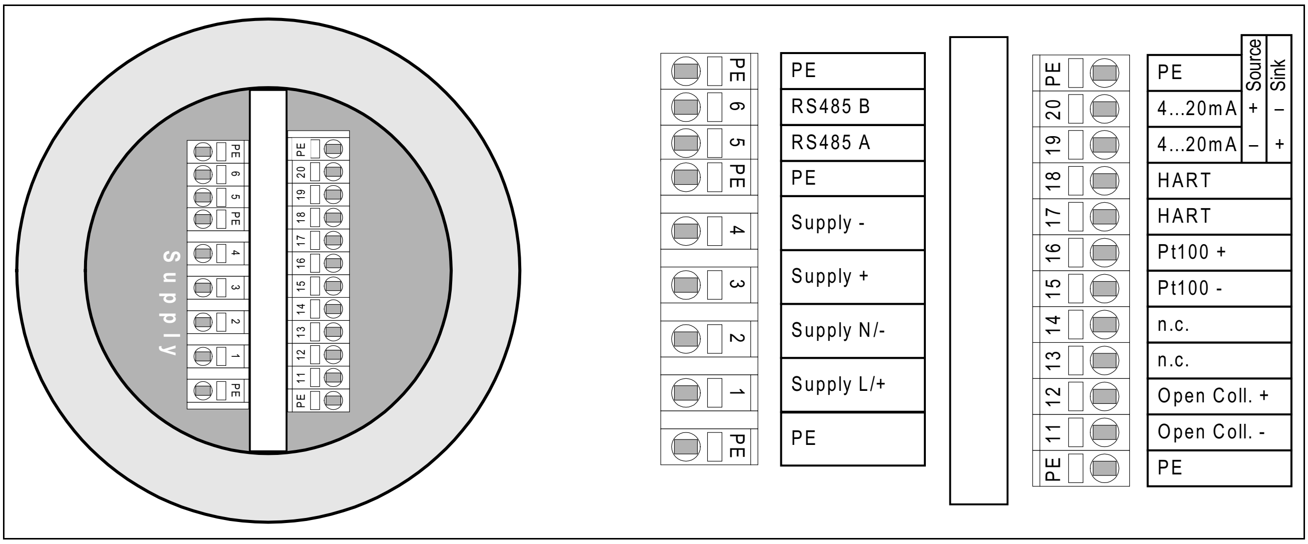


Fig. 3-2 Master Terminal Compartment

Permissible conductor cross-section for terminals:

- with ferrules 0.5 - 1.5 mm² (AWG 21 - 16 flexible)
- without ferrule 0.5 - 2.5 mm² (AWG 21 - 14 flexible or solid)

Terminal description

Terminals	Master
	HART®
PE (5 x)	Ground connection and screen
1 - 2	Power supply: 100V to 240V_{AC} or 24V_{DC}, depending on version
3 - 4	Like terminals 1 - 2: additional terminal pair for transmission (loop through) the supply voltage to the next slave (only permitted for supply of 24 V_{DC})
5 - 6	RS-485: for multidetector operation, connection for slave detector, service interface and software update
11 - 12	Open collector signal output with reverse voltage protection ALARM: no current flowing NORMAL: Current flowing The supply voltage for the open collector must be between 5 and 36V. The maximum current that may flow through the open collector is 100mA. Depending on the supply voltage, this leads to the following resistance values which must be connected: 5V: ≥30Ω 12V: ≥100Ω 24V: ≥220Ω 36V: ≥340Ω If the resistance value is not reached, the open collector may be damaged.
13 - 14	Reserved for optional I/Os
15 - 16	Pt100 for temperature compensation, only for density measurement
17 - 18	Like terminal 19 - 20: additional terminal pair for parallel connection of a HART® Communicator

<table>
<tr><th rowspan="2">Terminals</th><th>Master</th></tr>
<tr><th>HART®</th></tr>
<tr><td>19 - 20</td><td>HART® current output: 4-20 mA current output for measured value output and parameterization. This current output is used for the continuous transfer of the measured value and for display of the error status via the adjustable fault current:
– 4–20 mA for current measured value.
– Adjustable fault current from 3.5 to 24 mA in case of error.
The current output is continuously monitored and in case of failure signals the fault current set via the software through a redundant current path. The digital HART® communication remains in effect even on the redundant current path.
– Max. cable length with BERTHOLD cable # 32024:
– 1600 m at 250Ω
– 800 m at 500Ω
– Depending on the type, the current output is operated in the Sink or Source mode.
Source mode (active current output)
– Impedance range: 250 ... 500Ω
Sink mode (passive current output)
– Supply voltage: 18 ... 32V_{DC}
max. impedance: 500Ω</td></tr>
</table>

Signal cable with shielding

We recommend using a screened cable for the signal lines. The screen has to be connected to the detector on the PE terminal in the terminal compartment of the detector, or better, to suitable EMC cable glands.

3.3 Connecting the Detector

If lines are already connected to the detector, keep in mind:

WARNING

Explosion hazard!

As long as the detector is supplied with power, do not open the terminal compartment cover if there is a potentially explosive atmosphere.

WARNING

Risk of fatal injury due to electric shock!

If the terminal compartment cover is open, you are at risk of getting an electric shock when you touch the terminals. Do not connect or disconnect any wires as long as the device is supplied with line voltage.

Depending on the type of detector, the detector is supplied with 110/230 V_{AC} or 24 V_{DC}. With the version with 110/230 V_{AC} and with the line voltage switched, please pay attention to adequate protection against accidental contact.

Always follow the safety instructions for "Electrical Installation" on *page 2-185* and if applicable for *"Explosion Protection"* on *page 1-25*.

IMPORTANT

Open the terminal compartment only in dry ambient conditions, never in the rain.
Moisture in the terminal compartment can both cause a short circuit with other lines or cancel the explosion protection.

Hereinafter, it is assumed that no cables have been connected yet. Otherwise, make sure that the detector is not live.

As the intensity of electromagnetic interference on the cables is very different in the systems, we recommend using a shielded cable. Signal cables must not be laid parallel to power lines. This is especially important for master lines and lines with high current load: Keep a minimum distance of 50 cm.

Cable shields can be placed on the terminals marked with PE. If EMC cable glands are used, the shield must be placed directly in the cable gland. Screened cables must be connected at one end to the detector. Even with a multi-detector application, put on the shield of the RS-485 connection cable on one side only.

For the following activities, use the checklists in *chapter 5.9.1* on *page 1-55* and *chapter 5.9.2* on *page 1-57*, to document the accuracy and completeness of your work.

For detectors that are used in hazardous areas, the detector housing (*Fig. 3-3*) and thus the pressure-proof enclosure of the electronics may be opened only by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES.

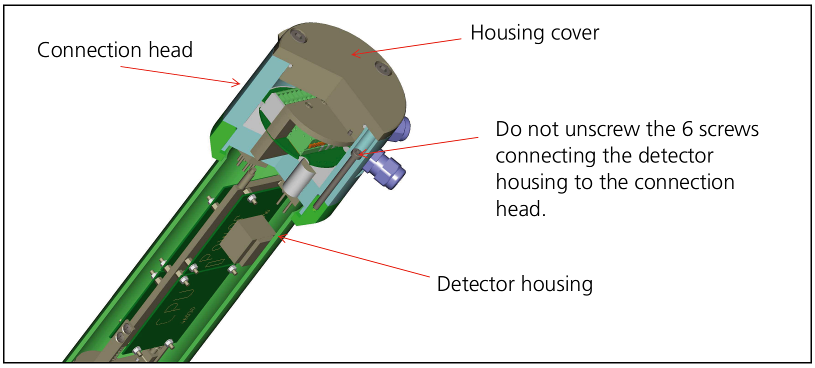


Fig. 3-3 Detector housing with connection head

Connecting cables

- Unscrew the housing cover (M5 and M8 Allen wrench).
- Remove the sealing plug on the bushings that you need for your cable entry.
- Install the screwed cable gland or for FM/CSA a conduit system with a conduit seal before the cable entry into the terminal compartment.

IMPORTANT

In Ex-protected areas, use only cable glands that are approved for your explosion protection.

- Pull the connection cables with the complete external insulation through the cable entry into the terminal compartment.

  Make sure that the cable diameter of the cable used is suitable for the screw connection.
- Make sure when installing the cables that mechanical damage to the conductor insulation from sharp edges or moving metal parts will be ruled out.
- Keep the cable length long enough to create a cable loop for strain relief before the housing inlet.

- Install the connecting cables in the terminal strip so that
  - dirt and moisture is avoided in the terminal compartment;
  - the wires are not damaged when stripping;
  - the conductor insulation extends into the terminals when stripping;
  - the minimum bending radii permitted for the respective conductor cross-section are not fallen below.
- Stranded leads have to be stripped 10 mm, and may be introduced only when the spring-type terminal was opened by a suitable tool (screwdriver with a blade width of about 3 mm). Make sure that all wires of the stranded lead are completely trapped and no small wires project from the terminal. The insulation of the wire must extend into the terminal insertion opening.
- Connect the wires according to the wiring diagram in *chapter 3.1* and *chapter 3.2* to the terminal strip of the detector. Use at least the following terminals:
  - Signal output: Terminals 19 and 20
  - Power supply: Terminals 2 and 3 and the PE terminal for the grounding conductor connection.
- Place the cable shields on the terminals marked with PE. Place the cable shield directly inside the screw fitting, if you are using EMC screw fittings.
- Make sure that the wires sit securely in the terminals.
- Connect the terminal for potential equalization to the outside of the detector housing using the equipotential busbar.
- With cable glands: Tighten the hexagon nuts of the cable entries so much that the tightness of the terminal compartment and the strain relief protection of the connection points are secured. The tightening torques can be found on *page 1-37*.
- Remove any loose metal particles, dirt and traces of moisture from the terminal compartment.
- Only with Ex-protection FM/CSA: When installing pipework in a hazardous area, encapsulate the conduit seal using a suitable filler.
- Make sure that the cover seal is undamaged and the snap rings or Nordlock discs are placed on all the cover screws.
- Close the housing carefully with the cover seal and the housing cover. To do this, put the housing cover with the sealing on the housing and tighten the Allen screws using the specified torque: depending on the version, M5 with 4 Nm or M8 with 17 Nm (standard values).

- Create cable loops with the connected lines in front of the housing entrance and provide for an appropriate strain relief of the connected cables. If there is a danger that the cable may be used as a stepladder, then the cables must be installed protected, for example in conduits.
- Now you may turn on the line voltage.

After completing work, use the *"Plan for Inspection of the Terminal Compartment"* on *page 1-57*.

4

Repair, Maintenance and Upkeep

IMPORTANT

Spare parts for detectors used in the Ex-area must be mounted solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

For devices that are *NOT* used in an Ex-area, the following parts may be replaced at your own risk and taking into account a loss of any existing warranty by BERTHOLD TECHNOLOGIES:

- the complete detector electronics
- the complete connection head
- the crystal at the CrystalSENS
- the multiplier (PMT)
- the multiplier crystal combination
- the detector housing

BERTHOLD TECHNOLOGIES recommends to have detectors repaired solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES.

Only original spare parts by BERTHOLD TECHNOLOGIES may be used.

Please follow the instructions in the Safety Manual (*Volume 1*) and the instructions in *chapter 3*, *"Electrical Installation" page 2-185*.

After every repair, maintenance or upkeep, please use the checklists on *page 1-55* and *page 1-57*.

4.1 Safety Instructions

Observe the legal provisions that apply in your country!

Repair and maintenance work on the detectors must be performed by competent personnel, see *Volume 1*, *chapter 3*, *"Qualification of the Personnel", page 1-21*. If in doubt, return the entire detector for repair to BERTHOLD TECHNOLOGIES.

Also note the following points:

- Repairs to electronic circuits on the board of your SENSseries detector must be carried out exclusively by the manufacturer.
- Any time you are working on electrical components, you have to observe the relevant safety regulations. Please refer to the safety instructions at the beginning of this User’s Manual. Turn off the detector and disconnect all inputs and outputs.

CAUTION

Danger due to radiation!
Radiometric measurement devices use radioactive materials.

The source emits radiation through the source exit channel. There may be a danger arising from radioactivity when people are exposed to this radiation.

Always keep the source exit channel of the shielding closed during assembly work.

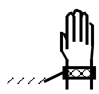
Any work in the direct vicinity of the shieldings containing the radioactive source may be performed only following proper training and under professional guidance, see *Volume 1*, *chapter 3*, *"Qualification of the Personnel"*. Repairs performed by untrained persons may result in the loss of explosion protection.

Corrosion protection

If non-alloyed steel comes into contact with a stainless steel surface, the surface can corrode at this point. Make sure, therefore, that neither during installation nor during operation other metal parts made of non-alloyed steel come into contact with the housing surface of the detector.

ESD protective measures

The electronics of this measuring system contains electrostatic highly sensitive components. We recommend that you wear an ESD wrist strap during installation or repair work. Connect this wrist strap to the ground conductor.



4.2 Replacing the Complete Detector

Reuse of detectors

Detectors that are used in the non-Ex area may not be used in an Ex area.

Intrinsically safe detectors, whose the intrinsically safe signals are connected to non-intrinsically safe circuits must not be connected to intrinsically safe circuits any more.

Explanation:

Detectors which are used in non-hazardous areas are not subject to the supervision and maintenance of Ex-protection experts; therefore, it is not guaranteed that, for example, for repair or assembly, the necessary care is taken which is required for the detectors in Ex-areas. The Ex-protection safety is therefore no longer guaranteed. The same applies to the intrinsic safety of detectors.

Replacing the detector

Proceed as follows to replace the detector:

- ▶ Write down all software parameters of the installed detector.
- ▶ Disconnect the detector from power.
- ▶ Turn off any peripherals connected and all inputs and outputs.
- ▶ Unscrew the housing cover (M5 and M8 Allen wrench).
- ▶ Open wiring on digital board and on the terminals.

Tip

If the wires are not marked, we recommend marking the individual wires before disconnecting them.

NOTICE

After you have disconnected the wires and cables, reattach the housing cover with sealing immediately, so that the parts cannot be damaged during the mechanical removal.

- ▶ Dismantle the old detector from the fixture.
- ▶ Mount the new detector onto the fixture.
- ▶ Unscrew housing cover of the old detector.
- ▶ Connect the wires.
- ▶ Close the housing carefully with the housing cover. To do this, put the housing cover with the sealing on the housing and tighten the Allen screws using the specified torque: depending on the version, M5 with 4 Nm or M8 with 17 Nm (standard values).
- ▶ Turn on power.

- Enter the previously documented parameters of the detector *with the exception of the parameter HV-Default* via the HART® Communicator or an alternative user interface.
- Perform a new calibration (see *Volume 3, chapter 5*).

Now the detector is ready for operation again.

4.3 Replacing the Electronics Module

WARNING

Explosion hazard!

For detectors used in the Ex-area, the electronics module must be replaced solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

2

IMPORTANT

Removal and installation of parts of the SENSseries detector should be carried out in a clean workshop environment.

The electronics module has to be dismantled if one of the following parts has to be exchanged:

- Electronics module (see *page 2-199*)
- Crystal-multiplier combination for CrystalSENS (see *page 2-202*)

The electronics in the CrystalSENS is dismantled together with the crystal-multiplier assembly. In the SuperSENS the electronics is dismantled together with the multiplier.

4.3.1 Dismantling the Electronics Module

IMPORTANT

Since all detector parameters are stored on the electronics module, you have to enter all the parameters again after you have exchanged the electronics. If you still have access to the detector parameters before the exchange, write them down so you can then enter them into the new electronics. Otherwise, you have to re-configure and re-calibrate the detector again. Please see the appropriate volume for instructions.

To replace the electronics module, you have to dismantle the detector housing tube from the connection head.

You may carry out the activities described below only if the detector is not used in an Ex-area.

- ▶ Write down all software parameters of the installed detector.
- ▶ Disconnect the detector from the power and switch off the detector and any connected peripherals.

WARNING

Risk of fatal injury due to electric shock!

If the housing is open you may come into contact with live parts if the power supply is connected.

Make sure when you open the cover that no supply voltage is applied to the terminals. Use a voltmeter.

- Unscrew the housing cover (M5 and M8 Allen wrench).
- Unscrew the six screws that connect the detector housing to the connection head (Torx T25).

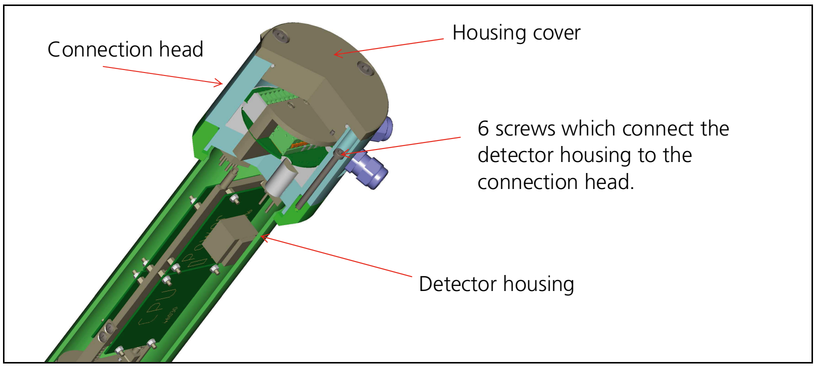


Fig. 4-1 Dismantling the detector electronics

- Carefully pull out the electronics module together with the crystal-multiplier assembly.
- Remove the overtube with the multiplier (SuperSENS) or the crystal-multiplier assembly (CrystalSENS) from the electronics.
- Loosen the connecting wires between connection head and electronics.
- Remove the electronics from the connection head by opening the four stud screws on the side of the metal plate of the PCB holder.
- Now you can replace the entire electronics module.

4.3.2 Installing the Electronics Module

Reassemble the electronics module in reverse order.

- Connect the wires between connection head and electronics correctly.
- Check that the wires sit firmly in the terminals.
- Replace the O-ring that seals the housing.
- Make sure that neither moisture nor metal chips are present in the connection box.
- Carefully insert electronics module with the crystal-multiplier assembly again into the housing.
- Attach the connection head to the detector housing again. Tighten screws evenly and alternating between screws.
- Close the housing carefully with the housing cover. To do this, put the housing cover with the sealing on the housing and tighten the Allen screws using the specified torque: depending on the version, M5 with 4 Nm or M8 with 17 Nm (standard values).

If you have installed a new electronics module:

- Place the supplied sticker over the number of the Dev. ID on the type plate.
- Turn on the power supply of the detector again.
- Set the software parameters again using the list you have noted down at the beginning. See also *Volume 3* on *page 3-249*.

  Separate User’s Manuals are available for user interfaces such as SIMATIC PDM or FOUNDATION™ Fieldbus.

This completes the replacement of the electronics module.

4.4 Replacing the Crystal-Multiplier Assembly (for CrystalSENS)

WARNING

Explosion hazard!

For detectors used in the Ex-area, the crystal-multiplier assembly must be replaced solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

Replacing the crystal-multiplier assembly can cause a change in sensitivity of the detector for gamma radiation. Therefore, check the calibration after the replacement and possibly perform a new calibration.

You may carry out the activities described below only if the detector is not used in an Ex-area.

- Remove the electronics module as described on *page 2-199*.
- Dismantle the crystal: loosen and remove the sleeve nut on top of the overtube of the multiplier tube (PMT). Then pull the crystal off the multiplier.
- Remove the PMT overtube from the PCB holder.
- Pull the multiplier from the base of the electronics.
- Plug the new multiplier into the socket. Please observe the encoding nose.
- Install the electronics module into the detector as described on *page 2-201*.

IMPORTANT

The replacement of the multiplier requires a readjustment of detector code and HV parameters. Please read also Volume 2, chapter 1.6, "Detector Codes", page 2-161, and Volume 3, chapter 2.40, "Plateau MeasurementPlateau Measurement", page 3-312.

- Check the function of the measurement. If you detect any deviations, carry out a new calibration, see *Volume 3*, *chapter 5*, on *page 3-333*.

  Separate User's Manuals are available for user interfaces such as SIMATIC PDM or FOUNDATION™ Fieldbus.

This completes the exchange of the crystal-multiplier assembly.

4.5 Checking the Detector

Scintillation counters do not include any wearing parts and their service life is not limited, provided they are used under normal operating conditions. Malfunctions or aging in the scintillation detector can only be caused by excessive mechanical or thermal stress.

Scintillation counters are used as detectors, since only these detector systems provide the required high sensitivity to Gamma radiation and their service life is independent of the intensity of the radiation field.

The number of light flashes per time unit is a measure of the intensity of the radiation field. The individual flashes of light are very short, so that a high resolution is obtained; this detector can be employed for high count rates.

The flashes of light are converted into electrical signals in a *photomultiplier* (PMT), which is optically coupled to the detector.

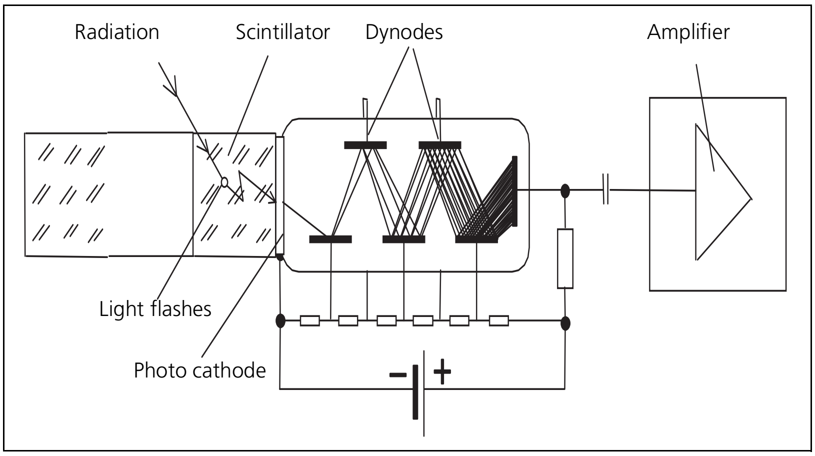


Fig. 4-2 Scintillation detector

The *point detector* CrystalSENS uses a 50/50 NaI crystal as a scintillator, the SuperSENS detector uses a 150/150 scintillator.

4.5.1 Checking the NaI Point Detector (CrystalSENS)

Malfunctions of the scintillation counter are not always indicated by a missing pulse rate; it is also possible that the specific Gamma sensitivity appears to have changed or obvious instabilities are apparent. These errors can be detected only by means of a plateau check. The detectors of the SENSseries include a function for automatic plateau recording. The check can be performed using the source at the measuring site or better a test source. Plot the measurement results in a curve (*Fig. 4-3*). The detector works perfect when you get a clearly visible plateau; the position of the plateau within the high voltage range does not matter. The plateau is recorded automatically. See also *page 3-367*.

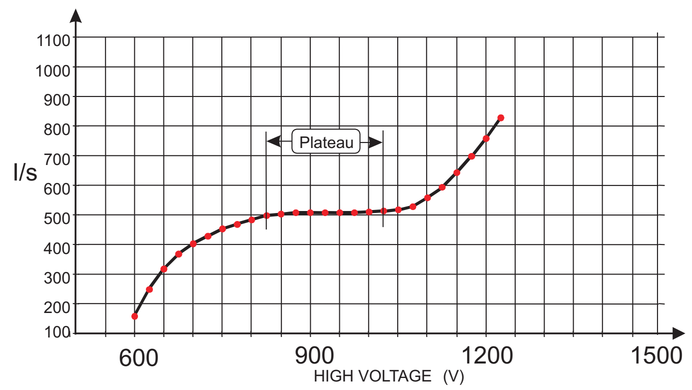


Fig. 4-3 Plateau curve of NaI detector

If the count rate changes by more than 5% per 100 V high voltage, or if the plateau is shorter than 50V, the scintillation counter will be unstable. In this case the complete detector or the crystal-multiplier assembly should be replaced.

IMPORTANT

The radiation conditions must be constant while recording the plateau!

4.5.2 Checking the Crystal-Multiplier Assembly

The plateau becoming too small or too steep indicates faults in the crystal-multiplier assembly. They can often be detected through visual inspection. To do this, take the crystal-multiplier assembly apart. To separate both parts, remove the Mu metal shielding and carefully detach the crystal from the multiplier window by gently sliding the crystal sideways. Wipe silicon oil traces off the mating faces of crystal and multiplier using a soft cloth. While you are doing this, make sure that the multiplier is not exposed to bright sunlight.

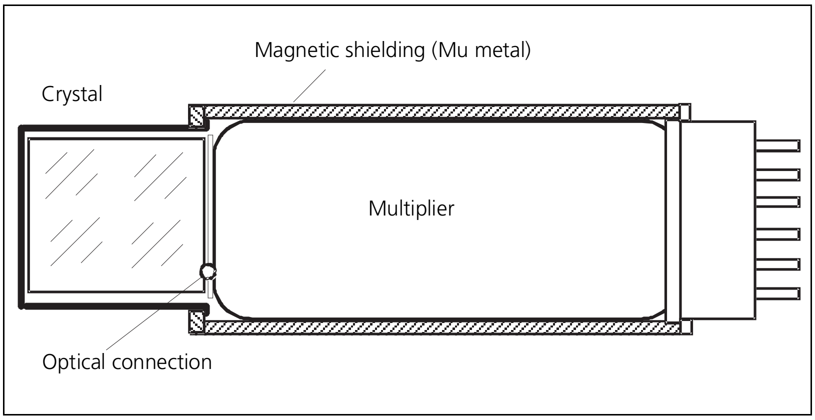


Fig. 4-4 Crystal-multiplier assembly

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

The multiplier window is coated with a vapor-deposited layer acting as photo cathode. This layer gives the window a brownish tint similar to smoked glass. If this layer is no longer present or if it is stained, then the photo-cathode has been destroyed (e.g. by overheating, glass breakage, or incident light). The multiplier must be replaced. Faults caused by damage to the dynode systems (e.g. by excessive vibration) cannot be identified by appearance. If in doubt, replace the multiplier.

Before re-assembly, apply a drop of pure silicon oil (Berthold Id.-Nr. 18844) between crystal and multiplier, and distribute it evenly by gentle rubbing to ensure a sound optical connection between the two components. Using the adhesive tape, replace the Mu-metal screen, making sure that it is only under light tension.

4.6 Customer Service

Customer service for BERTHOLD TECHNOLOGIES measuring systems is available in many countries outside Germany. For further information please visit our website www.Berthold.com.

If you do not know the phone number of your local service engineer, please call one of the following numbers at BERTHOLD TECHNOLOGIES:

+49 (0) 7081 177-111 (phone)
+49 (0) 7081 177-339 (fax)
+49 (0) 7081 177-0 (switchboard))

e-mail: Service@Berthold.com

To get efficient help you have to provide the following information:

- Detector type or "LB" number, e.g. LB 480
- Information on the error
- Information on the application
  - Product being measured
  - Installation situation
  - Measuring system, e.g. limit switch, point source with CrystalSENS
- Parameter listing
- Source number and/or BERTHOLD TECHNOLOGIES commission number
- Contact person and phone number

4.7 Repair, Return Shipping

4.7.1 Electronics, Detector

If you intend to return parts or complete detectors for repair, please provide the following information:

- Detector type or "LB" number, e.g. LB 480
- Information on the error
- Delivery address
- Billing address
- Your order number (if necessary)
- Preferred mode of transportation (if necessary)
- Customs value (for cross-border shipment)

Delivery address of BERTHOLD TECHNOLOGIES:

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Service department
Calmbacher Str. 22
D-75323 Bad Wildbad

4.7.2 Source and Shielding

If source and/or shieldings have to be returned for repair, please contact the Supervisor of Transportation at BERTHOLD TECHNOLOGIES to clarify details:

+49 (0) 7081 177-219 (phone)

Please provide the following information:

- Name, address and telephone number of the Radiation Safety Officer
- Number of sources
- Source number(s)
- Isotope and activity
- Date of the last leak test
- State of the source(s) and the shielding(s)
- Information on the type of shielding, with which the source is to be transported (if available)
- Proforma invoice for the source and the shielding in which the source is returned (for customs purposes and only for cross-border transport)

The shipment is carried out either by a forwarder trained specifically for source transport or by air freight.

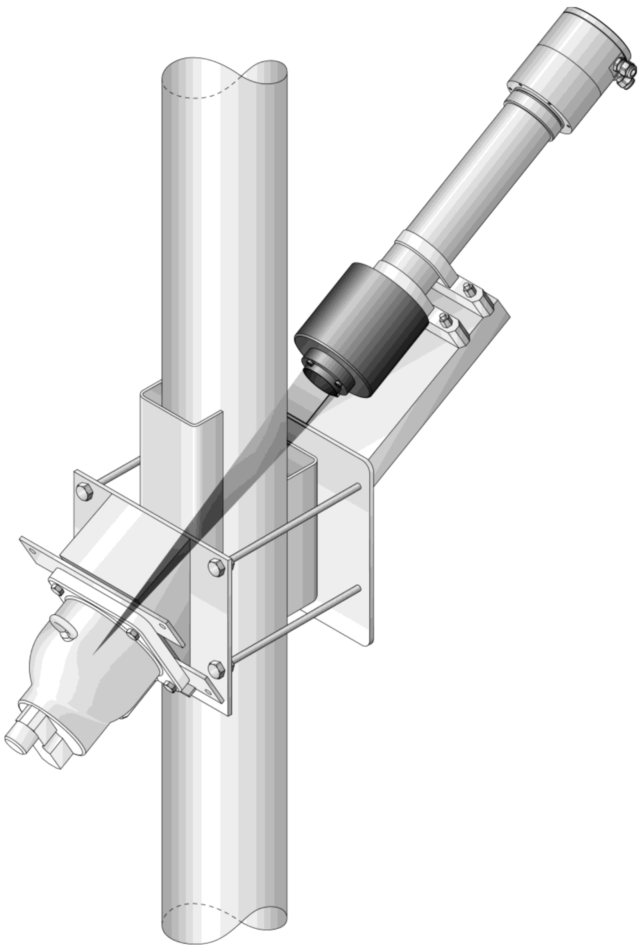
5 Technical Information

5.1 TI LB 480 Density

Technical Information
Density LB 480

Density Gauge
Dichte Messung

Field mounted components
Messstellen-Komponenten



54733-30BA2D
09.2023

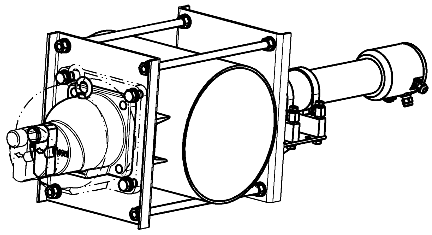
2

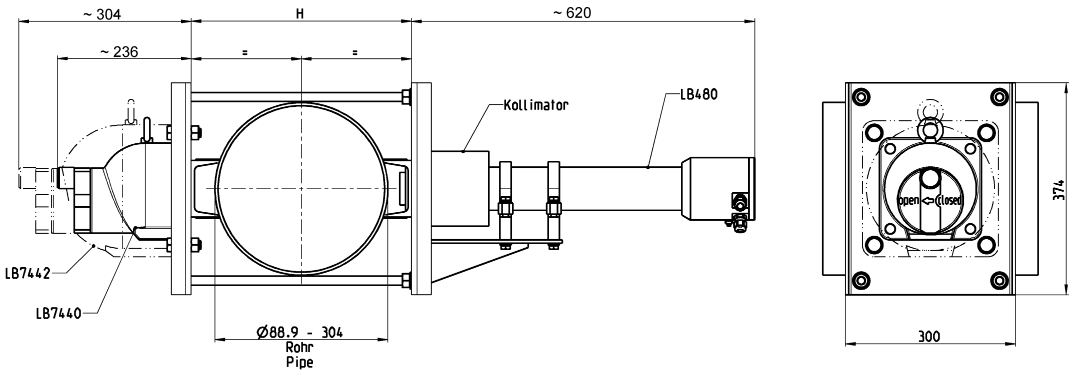
LB 480

Dimensions in mm
Abmessungen in mm

1.0 Clamping Device 90° for Pipe Diameter 88.9 … 304 mm
Montagevorrichtung 90° für Rohrdurchmesser 88.9 … 304 mm

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





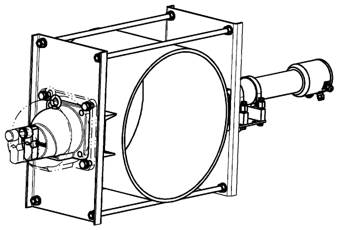
Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
80795	88.9 101.6 114.3 141.3 168.3 219.1 273.0 304.0	120 156 180 218 250 310 368 402	23 kg

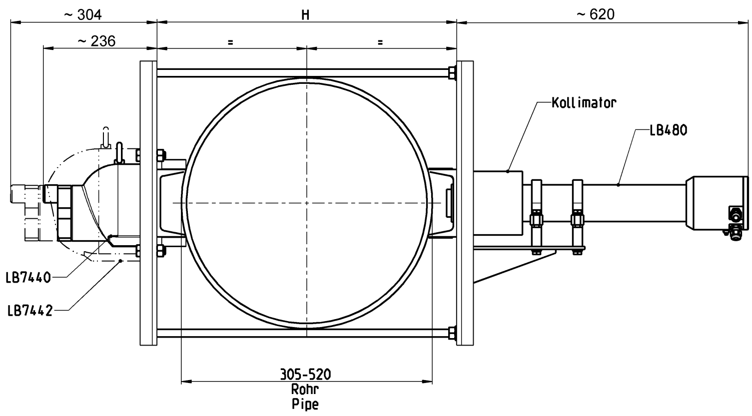
LB 480

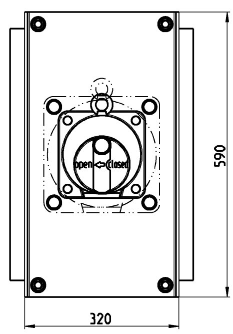
Dimensions in mm
Abmessungen in mm

1.1 Clamping Device 90° for Pipe Diameter 305 … 521 mm
Montagevorrichtung 90° für Rohrdurchmesser 305 … 521 mm

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau







Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
80796	305.0 318.0 323.8 355.6 406.4 457.2 508.0 521.0	400 413 419 451 501 552 603 616	34 kg

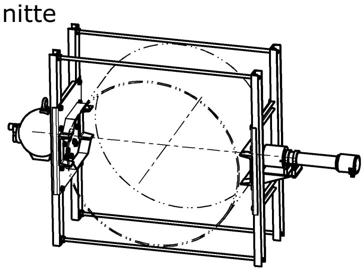
BERTHOLD

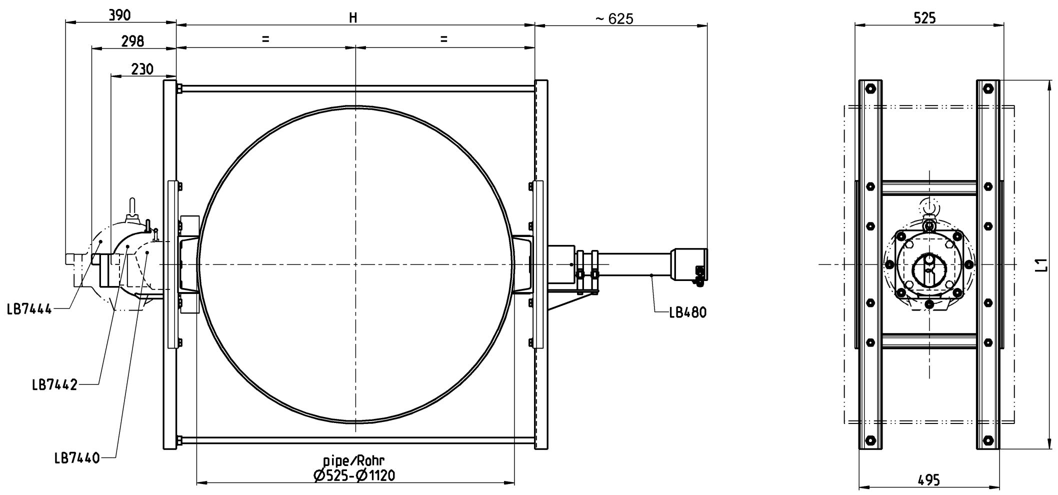
LB 480

Dimensions in mm
Abmessungen in mm

1.2 Clamping Device 90° for Large Pipe Diameters
Montagevorrichtung 90° für große Rohrleitungsquerschnitte

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





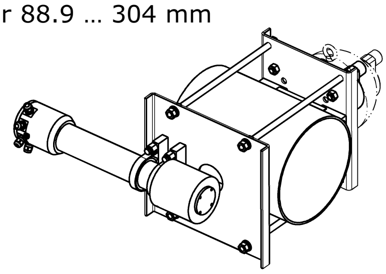
Part No. Id. Nr.	Pipe Ø Range Rohr Ø Bereich	H	Length of the thread bars Länge der Gewindestangen	L1	Weight of Clamp. Device Gewicht der Montagevorrichtung
51872-01	**400 … 519**	643	735	680	76 kg
51872-02	**520 … 559**	686	790	680	77 kg
51872-03	**560 … 659**	792	890	740	79 kg
51872-04	**660 … 759**	896	990	840	84 kg
51872-05	**760 … 869**	1009	1100	950	89 kg
51872-06	**870 …1020**	1163	1250	1200	98 kg
51872-07	**1020 …1120**	1265	1350	1300	103 kg

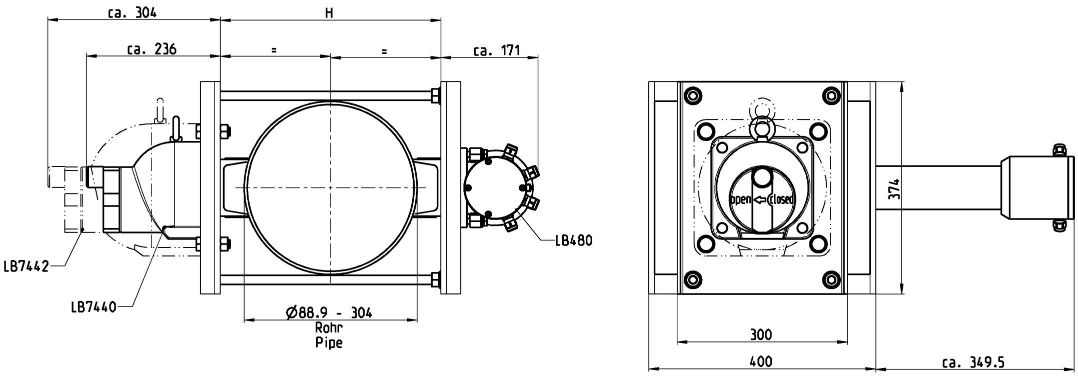
LB 480

Dimensions in mm
Abmessungen in mm

2.0 Parallel Clamping Device 90° for Pipe Diameter 88.9 … 304 mm
Parallele Montagevorrichtung 90° für Rohrdurchmesser 88.9 … 304 mm

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
59296	88.9 101.6 114.3 141.3 168.3 219.1 273.0 304.0	120 156 180 218 250 310 368 402	22 kg

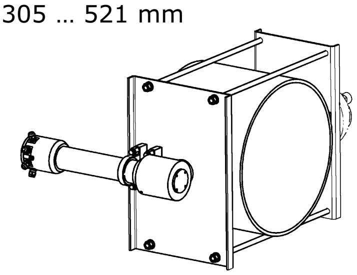
BERTHOLD

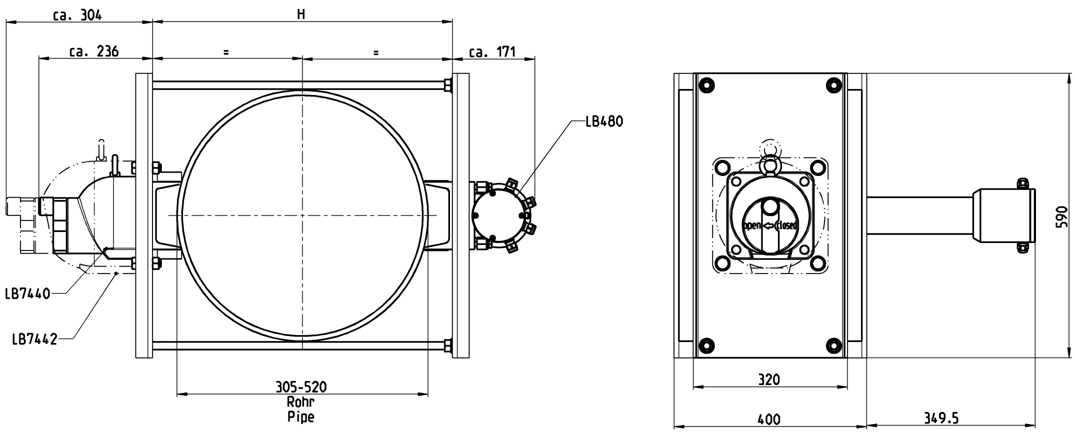
LB 480

Dimensions in mm
Abmessungen in mm

2.1 Parallel Clamping Device 90° for Pipe Diameter 305 ... 521 mm
Parallele Montagevorrichtung 90° für Rohrdurchmesser 305 ... 521 mm

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





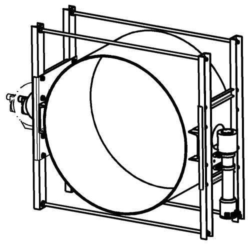
Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
59293	305.0 318.0 323.8 355.6 406.4 457.2 508.0 521.0	400 413 419 451 501 552 603 616	34 kg

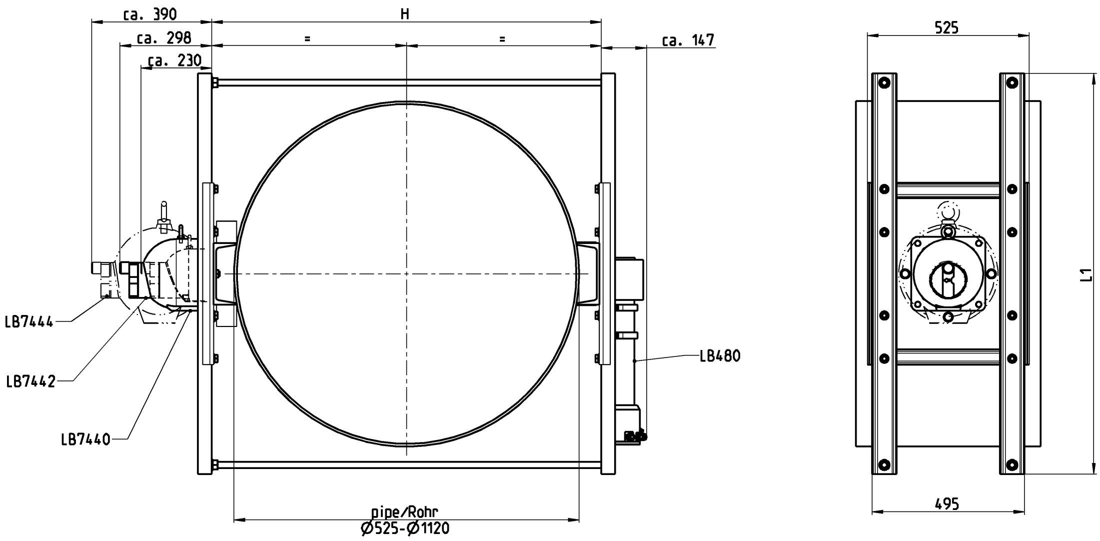
LB 480

Dimensions in mm
Abmessungen in mm

2.2 Clamping Device 90° for Large Pipe Diameters
Montagevorrichtung 90° für große Rohrleitungsquerschnitte

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





Part No. Id. Nr.	Pipe Ø Range Rohr Ø Bereich	H	Length of the thread bars Länge der Gewindestangen	L1	Weight of Clamp. Device Gewicht der Montagevorrichtung
	400 … 519	643	735	680	73kg
	520 … 559	686	790	680	74 kg
	560 … 659	792	890	740	76 kg
81491	**660 … 759**	896	990	840	79 kg
	760 … 869	1009	1100	950	86 kg
	870 …1020	1163	1250	1200	95 kg
	1020 …1120	1265	1350	1300	100 kg

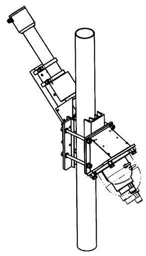
BERTHOLD

LB 480

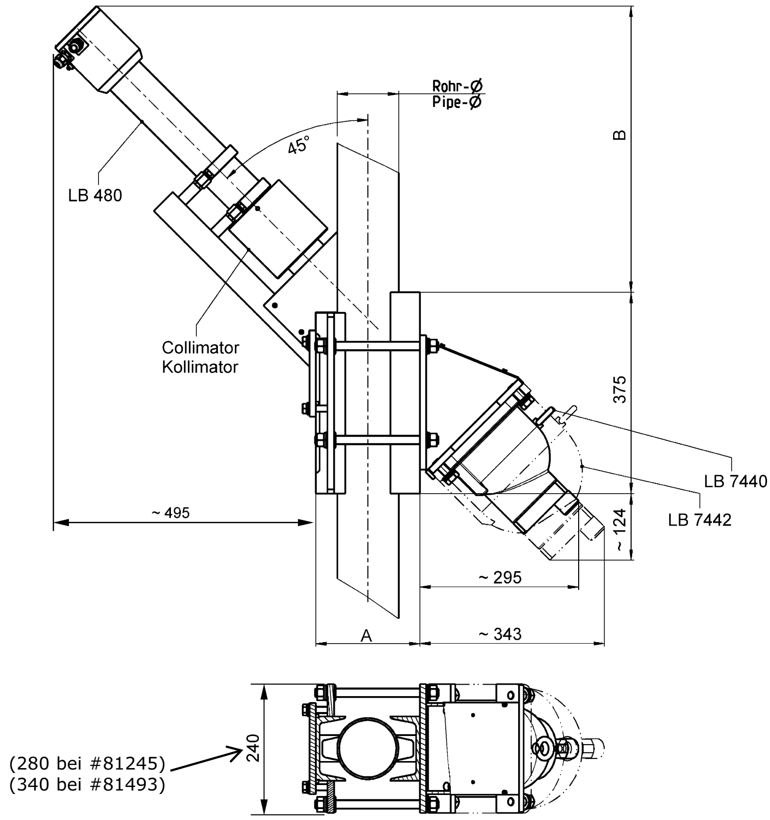
Dimensions in mm
Abmessungen in mm

3.0 Clamping Device 45°
Montagevorrichtung 45°

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau



2



Part No. Id. Nr.	Pipe Ø	A	B	Weight approx Gewicht ca		Part No. Id. Nr.	Pipe Ø	A	B	Weight approx Gewicht ca.
27249	**48.3**	128	480	31 kg		80793	**127.0**	165	523	30 kg
27248	**60.3**	128	480			26997	**133.0**	177	534	
27250	**63.5**	133	485			26998	**139.7**	189	545	
27251	**70.0**	142	494			26999	**146.0**	199	555	
27252	**76.1**	149	500			27000	**152.4**	209	563	
27253	**82.5**	157	508			27001	**159.0**	219	573	
27254	**88.9**	165	516			27002	**165.1**	227	581	
27255	**95.0**	172	522			27003	**168.3**	232	585	
27256	**101.6**	179	529			27004	**171.0**	235	589	
27257	**108.0**	187	536			27005	**177.8**	244	598	
27258	**114.3**	194	543			27006	**191.0**	261	614	
80794	**121.0**	201	550			81245	**220.0**	296	646	
						81493	**273.0**	356	706	

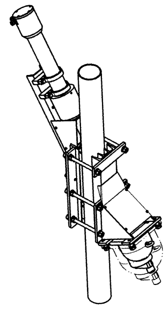
BERTHOLD

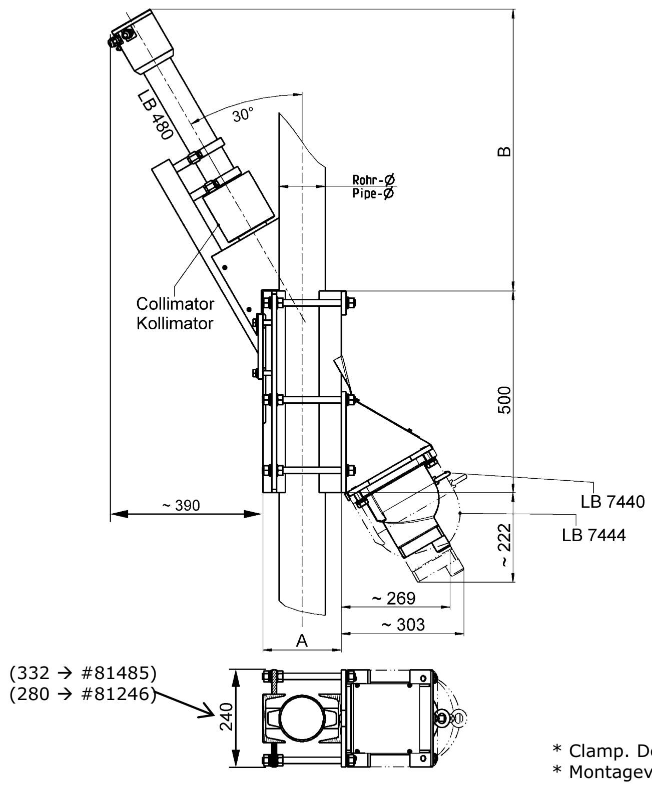
LB 480

Dimensions in mm
Abmessungen in mm

3.1 Clamping Device 30°
Montagevorrichtung 30°

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





* Clamp. Device Weight (kg)
* Montagevorrichtung Gewicht (kg)

Part No. Id. Nr.	Pipe Ø	A	B	Weight* Gewicht*
25964	**48.3**	128	602	39 kg
80792	**60.3**	128	602	
25971	**63.5**	133	610	
25972	**70.0**	142	625	
25973	**76.1**	149	636	
25974	**82.5**	157	650	
25975	**88.9**	165	663	
25976	**95.0**	172	674	
25977	**101.6**	179	686	
25978	**108.0**	187	698	
25979	**114.3**	194	710	
25980	**121.0**	201	723	

Part No. Id. Nr.	Pipe Ø	A	B	Weight* Gewicht*
80791	**127.0**	165	674	39 kg
26655	**133.0**	177	692	
26656	**139.7**	189	712	
26657	**146.0**	199	728	
26658	**152.4**	209	741	
26659	**159.0**	219	759	
26660	**165.1**	227	773	
26661	**168.3**	232	780	
26662	**171.0**	235	787	
26663	**177.8**	244	803	
26664	**191.0**	261	830	
81246	**220.0**	296	884	40 kg
81485	**273.0**	356	988	

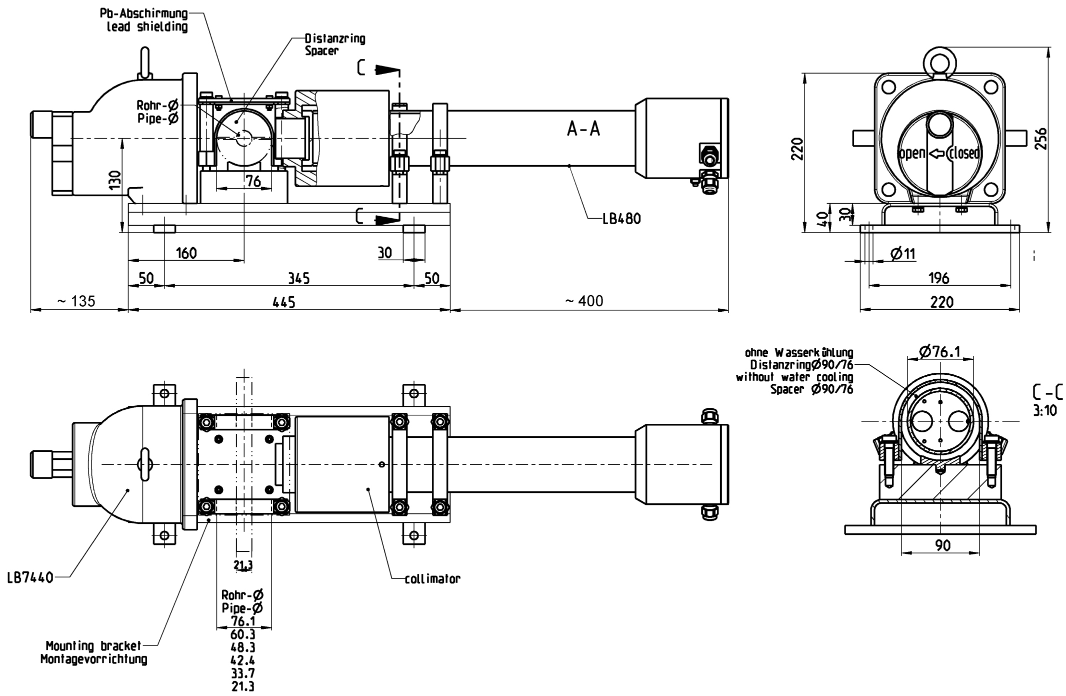
BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

4.0 Clamping Device 90° for Small Pipe Diameters
Montagevorrichtung 90° für kleine Rohrleitungsquerschnitte

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau



Part No. Id. Nr.	Pipe Ø	Weight of Clamp. Device Gewicht der Montagevorrichtung
47292-01	**21.3**	70 kg
47292-02	**33.7**	
47292-03	**42.4**	
47292-04	**48.3**	
47292-05	**60.3**	
47292-06	**76.1**	

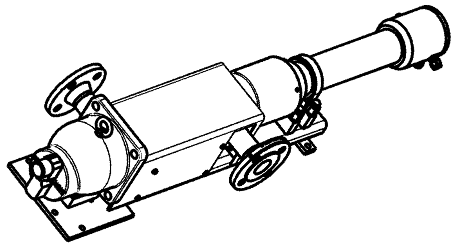
BERTHOLD

LB 480

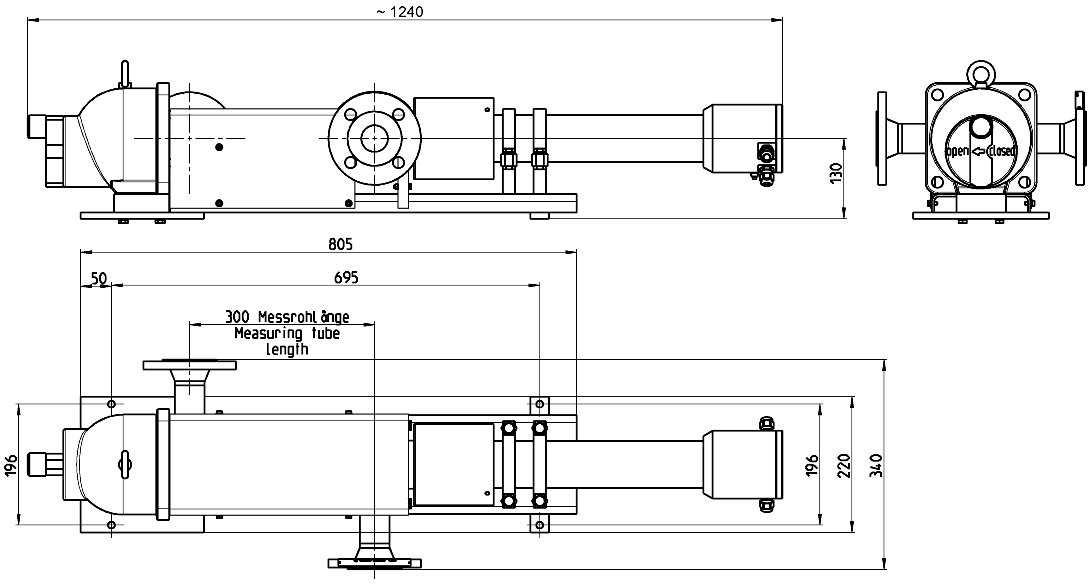
Dimensions in mm
Abmessungen in mm

4.1 S + U Pipe Clamping Device
S + U förmige Montagevorrichtung

Material	Carbon Steel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau



Part No. / Id. Nr. 21087



Verschiedene Versionen erhältlich. Obige beispielhafte Abbildung zeigt die Messstrecke in: - S-Form - DN40 - Messrohrlänge 300 - PN16 - ohne Temp.-Fühler	**Various versions available.** The drawing above shows exemplarily a clamping device with: - S-shaped - DN40 - pipe length 300 - PN16 - without temp.-sensor

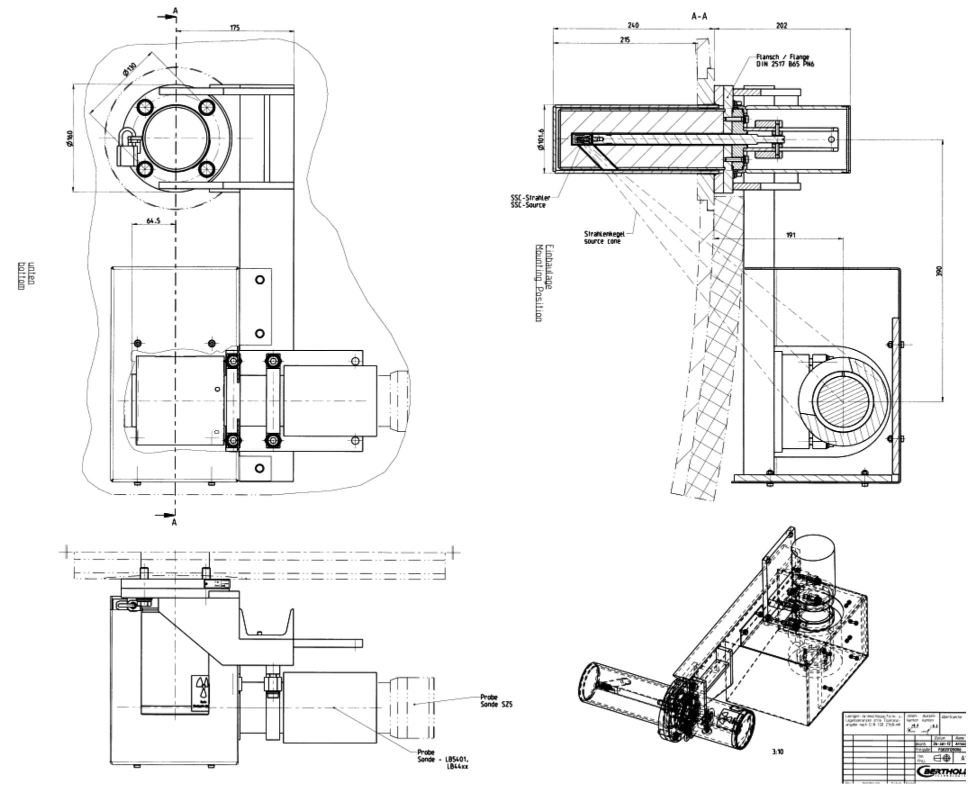
BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

5.0 Immersion Shielding
Tauchabschirmung

Material Dip Pipe Material Tauchrohr	Stainless Steel AISI 316Ti 1.4571
Painting Lackierung	Polyurethane, gray Polyurethan, grau



Part No. Id. Nr.	Measuring Range Messbereich
58959-01	depending on der vessel diameter

BERTHOLD

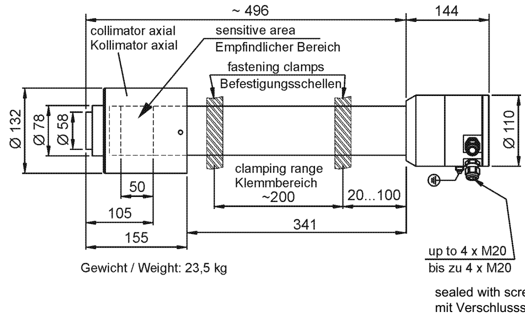
LB 480

Dimensions in mm
Abmessungen in mm

6.0 CrystalSENS (Version f. Zone 1/2)

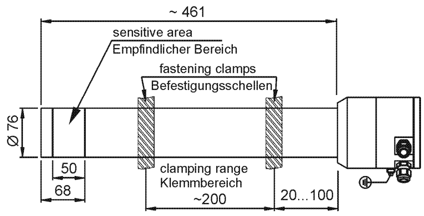
LB 480-1.-0.
LB 480-1.-1.
LB 480-1.-2.
LB 480-1.-Z.

LB 480-1.-.. -..-r.-



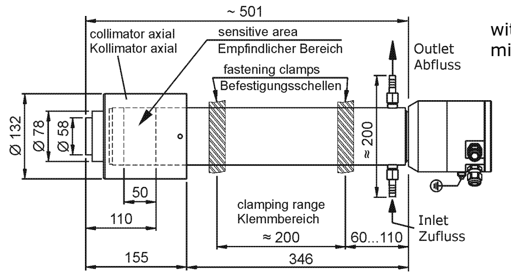
Gewicht / Weight: 23,5 kg

LB 480-1.-.. -..-0.-

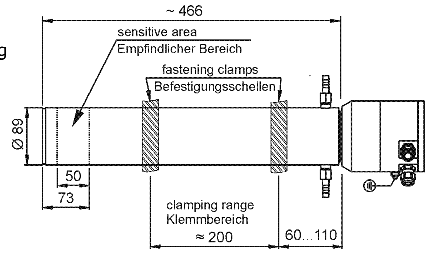


Gewicht / Weight: 12,5 kg

with water cooling
mit Wasserkühlung



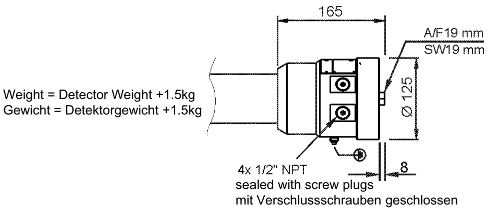
Gewicht / Weight: 27,5 kg



Gewicht / Weight: 16,5 kg

6.1 CrystalSENS (Version f. Divisions 1/2)

LB 480-1.-F.
LB 480-1.-G.



The detector version for divisions (NEC/CEC) differs only in the terminal housing, compared to the standard version illustrated above. The dimensions of this terminal housing are illustrated in this drawing.

Die Detektor-Version mit Ex-Zulassung für Divisions (NEC/CEC) unterscheidet sich ausschließlich im Anschlusskopf, verglichen mit der oben aufgeführten Standardvariante. Die Abmessungen für den Anschlusskopf sind aus dieser Zeichnung zu entnehmen.

6.2 CrystalSENS Scintillator Size / Szintillatorgröße

Type **Typ**	**Scintillator Size (Ø/h)** **Szintillatorgröße**	**Water cooling** **Wasserkühlung**
LB 480-11	50/50	-
LB 480-12	50/50	✓
LB 480-13	40/35	-
LB 480-14	40/35	✓
LB 480-15	25/25	-
LB 480-16	25/25	✓

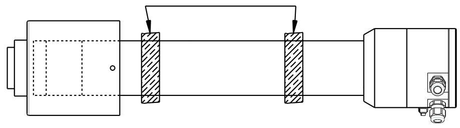
BERTHOLD

2

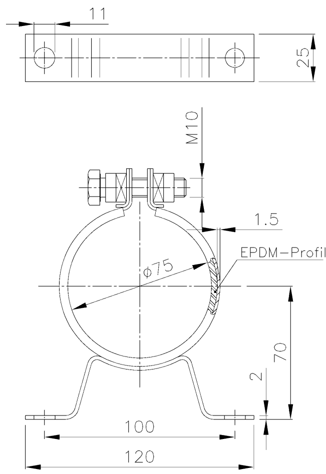
LB 480

Dimensions in mm
Abmessungen in mm

6.3 Mounting Clamps for Detector
Befestigungsschellen für Detektor



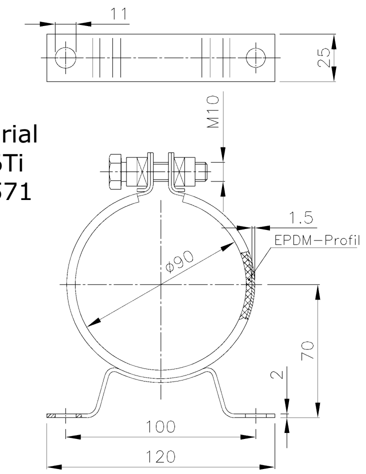
for Detectors without water cooling
für Detektoren ohne Wasserkühlung



Id. Nr. 31346 (1 set = 2 clamps)
Id. Nr. 31345 (single clamp)

Material
316Ti
1.4571

for Detectors with water cooling
für Detektoren mit Wasserkühlung



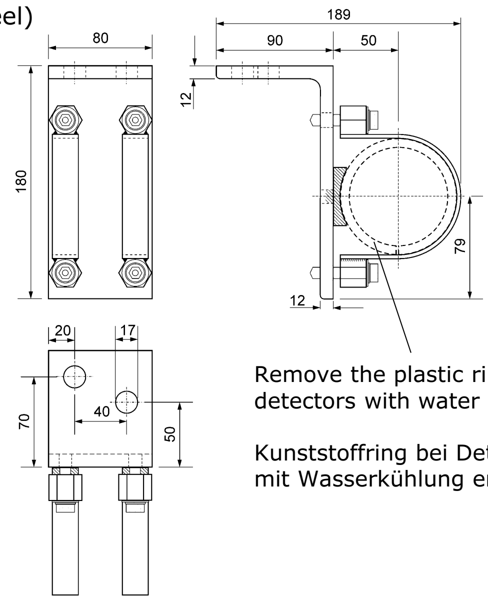
Id. Nr. 31347 (1 set = 2 clamps)
Id. Nr. 31344 (single clamp)

position for the clamps, see detector drawing
Position für die Schellen-Befestigung siehe Detektor-Zeichnung

---

Heavy Duty Detector Holder (stainless steel)
Robuste Detektor Halterung (Edelstahl)

Part No. Id. Nr.	for Detector für Detektor
39246	without water cooling ohne Wasserkühlung
39247	with water cooling mit Wasserkühlung



Remove the plastic ring for detectors with water cooling.

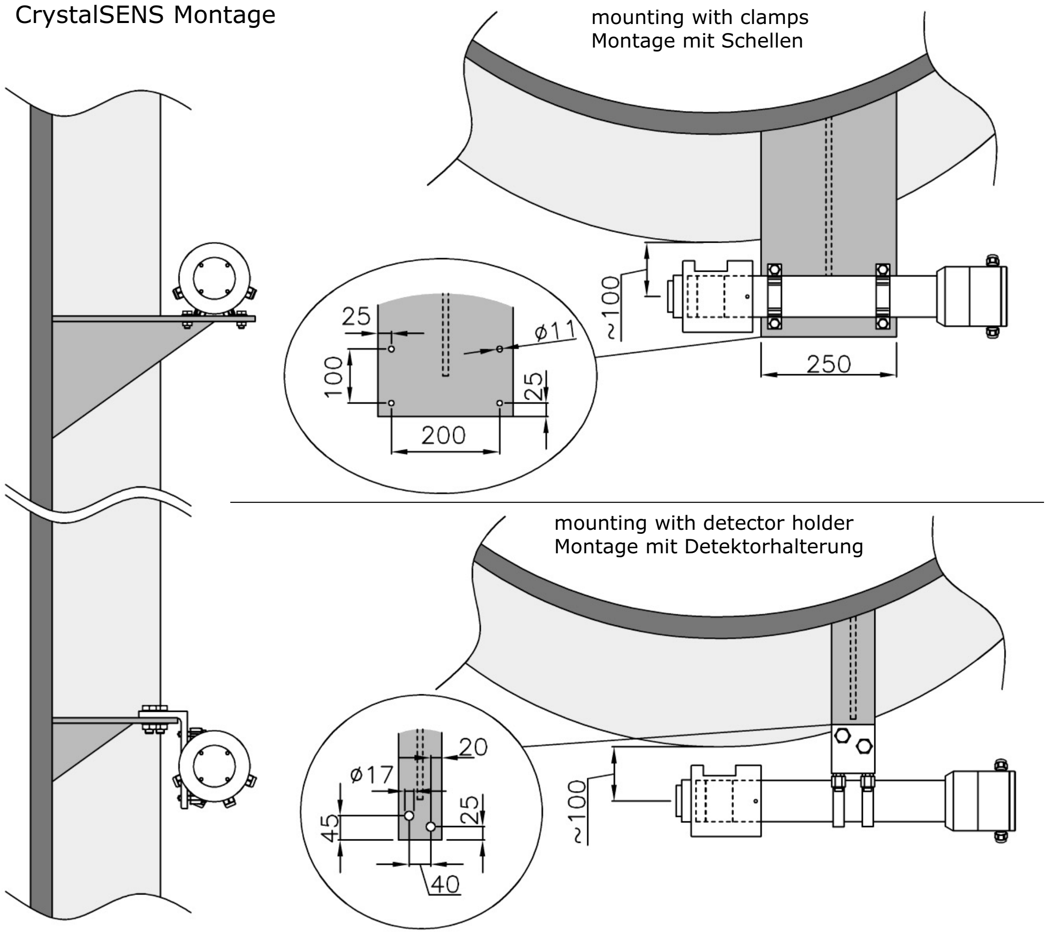
Kunststoffring bei Detektoren mit Wasserkühlung entfernen.

BERTHOLD

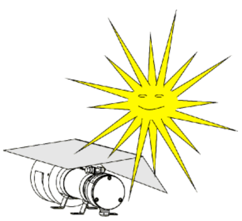
LB 480

Dimensions in mm
Abmessungen in mm

6.4 CrystalSENS Mounting
CrystalSENS Montage



6.5 Sun Roof against Strong Sun Radiation
Sonnendach gegen starke Sonneneinstrahlung



Direct sun radiation can overheat the detector. If the detector temperature can reach more than 50°C, a suitable sun roof must be installed.
The heating of the detector by thermal radiation from the vessel can also be moderated by a thermal sheet, e.g. by a thin metal plate.
For each detector a water cooling (option) is available.

Wird durch Sonneneinstrahlung eine Detektortemperatur von über 50°C erreicht, so ist ein geeigneter Sonnenschutz zu montieren.
Auch die Aufheizung des Detektors durch Wärmeabstrahlung vom Behälter kann durch ein dünnes Wärmeableitblech gemildert werden.
Für jeden Detektor steht auch eine geeignete Wasserkühlung (Option) zur Verfügung.

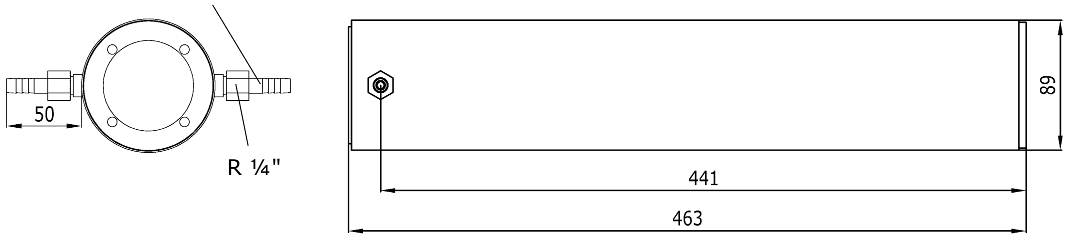
BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

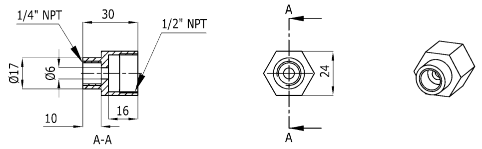
6.6 CrystalSENS Water Cooling Jacket and Adaptor Fittings
CrystalSENS Wasserkühlung und Adapter Anschlussstücke

pipe connection diameter 10
Schlauchanschluss Ø 10



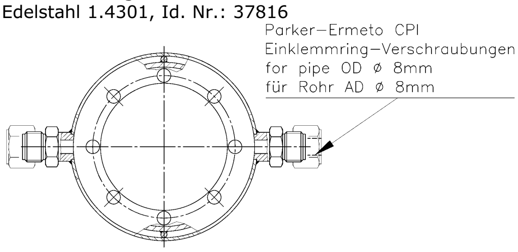
Fitting adaptor for standard water cooling Rp ¼" → ½" NPT
stainless steel 304, part no: 47189

Adapter für Standard Wasserkühlung Rp ¼"→ ½" NPT
Edelstahl 1.4301, Id. Nr.: 47189



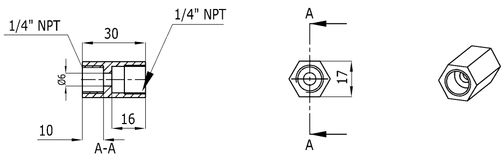
Water cooling jacket with Parker Ermeto Fittings
stainless steel 304, part no: 37816

Wasserkühlung mit Parker Ermeto Anschlüssen
Edelstahl 1.4301, Id. Nr.: 37816



Fitting adaptor for standard water cooling Rp ¼> ¼" NPT
stainless steel 304, part no: 46743

Adapter für Standard Wasserkühlung Rp ¼> ¼" NPT
Edelstahl 1.4301, Id. Nr.: 46743



Further fitting adaptors for standard water cooling jacket:
Rp ¼"> ½" NPT male, stainless steel 304, part no: 06352
Rp ¼"> ¼" NPT male, stainless steel 304, part no: 06349
Weitere Adapter für die Standard-Wasserkühlung:
Rp ¼"> ½" NPT Außengewinde, 1.4301, Id. Nr.: 06352
Rp ¼"> ¼" NPT Außengewinde, 1.4301, Id. Nr.: 06349

The above mentioned water cooling jackets and adaptor fittings offers following connection versions:
Die oben aufgeführten Wasserkühlungen und Adapter ermöglichen folgende Anschlussvarianten:

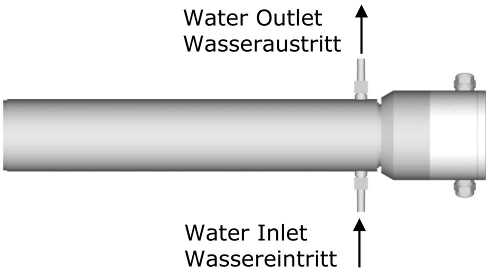
Fitting Connection	**Anschluss-Stutzen**	**part no. (material)** **Id.Nr. (Werkstoff)**
R ¼" pipe connection, male European standard Whitworth pipe thread	R ¼" Außengewinde für Rohrverschraubung europäisches Standard Whitworth-Rohrgewinde	21326 (304/1.4301) 38055 (Carbon Steel St37)
10 mm hose connection for water hose connection ID 10 mm	Schlauchstutzen für Schlauch- Innendurchmesser 10 mm	21326 (304/1.4301) 38055 (Carbon Steel St37)
fitting adaptor ½" NPT female	Adapter mit ½" NPT Innengewinde	47189 (304/1.4301)
fitting adaptor ¼" NPT female	Adapter mit ¼" NPT Innengewinde	46743 (304/1.4301)
fitting adaptor ½" NPT male	Adapter mit ½" NPT Außengewinde	06352 (304/1.4301)
fitting adaptor ¼" NPT male	Adapter mit ¼" NPT Außengewinde	06349 (304/1.4301)

LB 480

Dimensions in mm
Abmessungen in mm

6.7 Water Cooling Installation Instruction
Anweisung zur Installation der Wasserkühlung

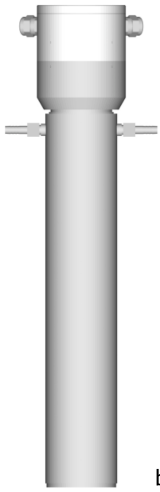
Horizontal Detector Installation
Horizontale Detektor Installation



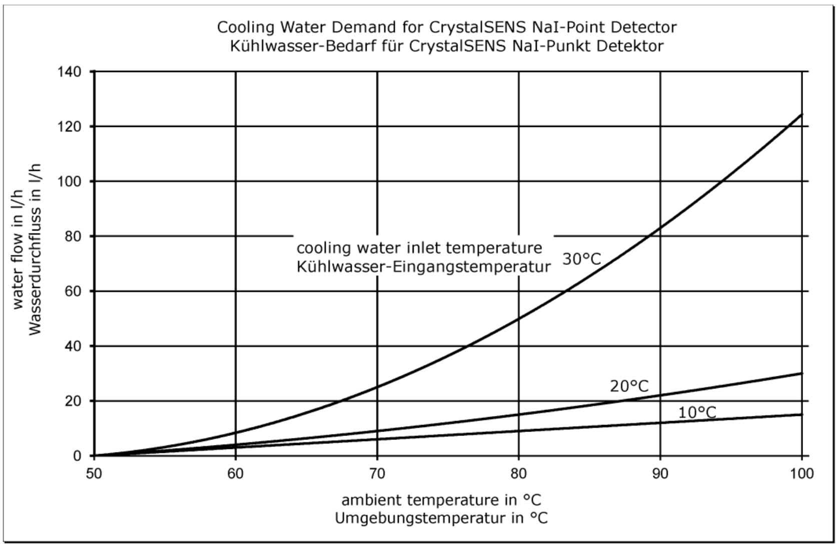
In order to fill the entire water cooling jacket, incoming water must enter from the bottom.
Damit sich die Wasserkuhlung vollständig mit Wasser füllt, muss der Wasserzufluss von unten erfolgen.

Vertical Detector Installation
Vertikale Detektor Installation

Install the Detector with the connection at the top.
Installieren Sie den Detektor mit dem Anschlussgehäuse oben.



6.8 Detector Cooling Water Demand
Detektor Kühlwasserbedarf



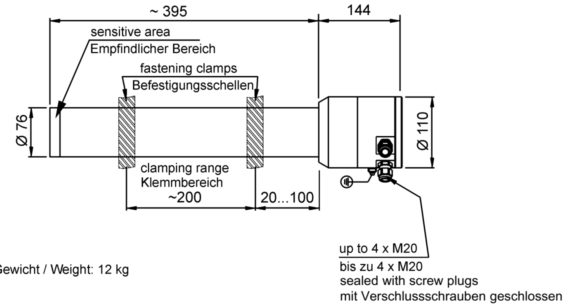
BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

7.8 CrystalSENS 44/5 f. Am-241
(none Ex, nicht-Ex)

LB 480-17-00 -..-0.-
LB 480-17-Z0 -..-0.-



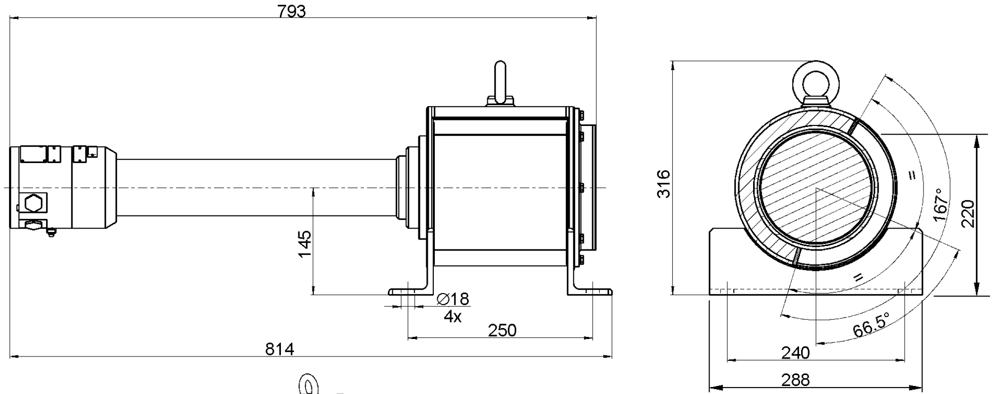
Gewicht / Weight: 12 kg

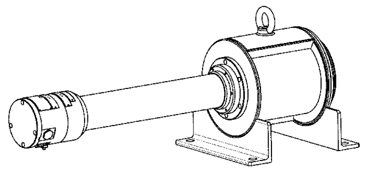
LB 480

Dimensions in mm
Abmessungen in mm

7. SuperSENS

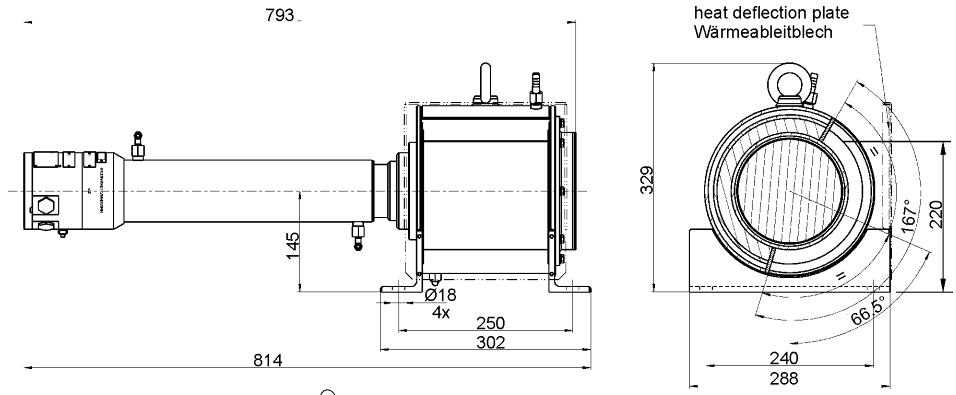
7.1 with Side Irradiation
mit seitlicher Einstrahlung
LB 480-31-..-..-r.

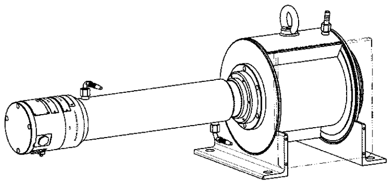




Weight/Gewicht 52 kg

7.2 with Side Irradiation and Water Cooling
mit seitlicher Einstrahlung und Wasserkühlung
LB 480-32-..-..-r.





Weight/Gewicht 59 kg

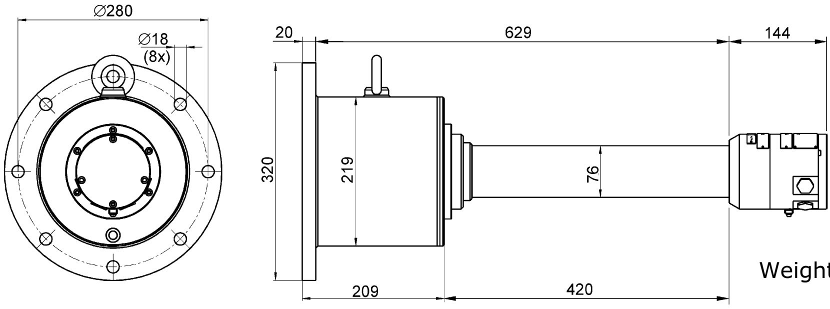
BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

7.3 with Axial Irradiation
mit frontaler Einstrahlung

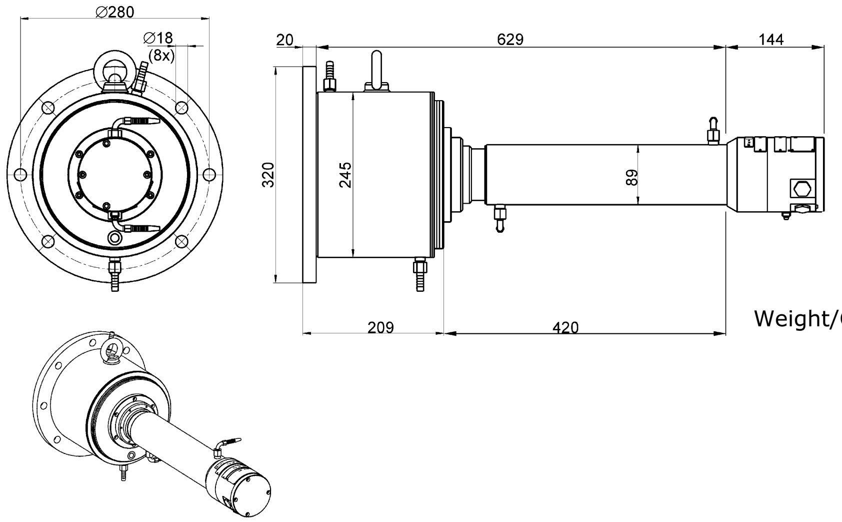
LB 480-31-..-..-a.



Weight/Gewicht 62 kg

7.4 with Axial Irradiation and Water Cooling
mit frontaler Einstrahlung und Wasserkühlung

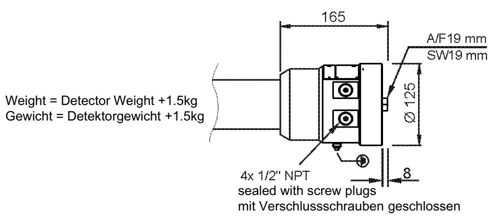
LB 480-32-..-..-a.



Weight/Gewicht 69 kg

7.5 SuperSENS (Version f. Divisons 1 + 2)

LB 480-3.-F.
LB 480-3.-G.



The detector version for divisions (NEC/CEC) differs only in the terminal housing, compared to the standard version illustrated above. The dimensions of this terminal housing are illustrated in this drawing.

Die Detektor-Version mit Ex-Zulassung für Divisions (NEC/CEC) unterscheidet sich ausschließlich im Anschlusskopf, verglichen mit der oben aufgeführten Standardvariante. Die Abmessungen für den Anschlusskopf sind aus dieser Zeichnung zu entnehmen.

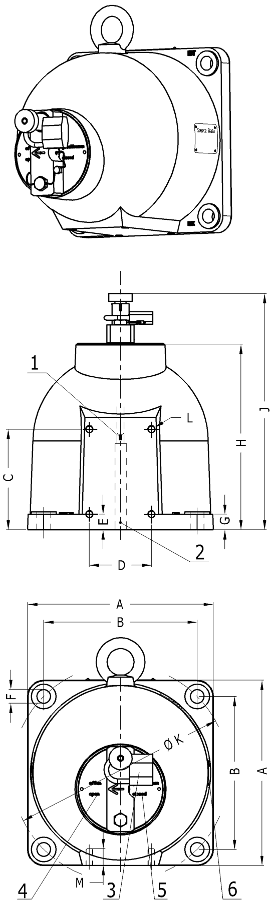
BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

8.0 Point Source Shielding LB 744x
Punktstrahler-Abschirmbehälter LB 744x

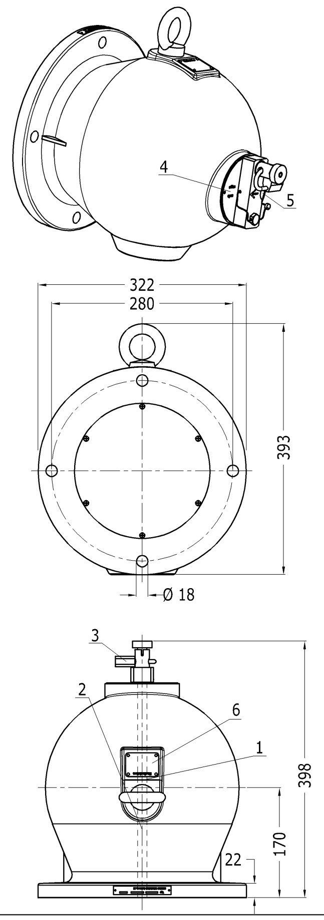
LB 7440 / 7442 / 7445 / 7446



1 Strahler
2 Strahlenausgang
3 Schloss
4 Position **Offen**
5 Position **Geschlossen**
6 Typenschild

1 Point Source
2 Radiation Exit
3 Lock
4 Position **Open**
5 Position **Closed**
6 Type Label

LB 7444



Housing Gehäuse	**Type Typ**	**A**	**B**	**C**	**D**	**E**	**FØ**	**G**	**H**	**J**	**KØ**	**L**	**M**	**Flange Flansch**		**kg**
Carbon Steel St 37	LB 7440-D-CR LB 7445-D-CR	180	142	75	60	15	18	20	173	238	200	M8	12	ND 125 PN 6	11°	31
Super Duplex UNS 32750 SAF 2507 1.4410	LB 7440-DE-CR LB 7445-DE-CR															
	LB 7442-DE-CR	240	198	130	80	20	18	20	242	306	280	M10	14	ND 200 PN 6	7°	81
Carbon Steel St 37	LB 7442-D-CR LB 7446-D-CR															
	LB 7444-CR	Dimensions in drawing / Abmessungen in Zeichnung												ND 200 PN 6	6°	170

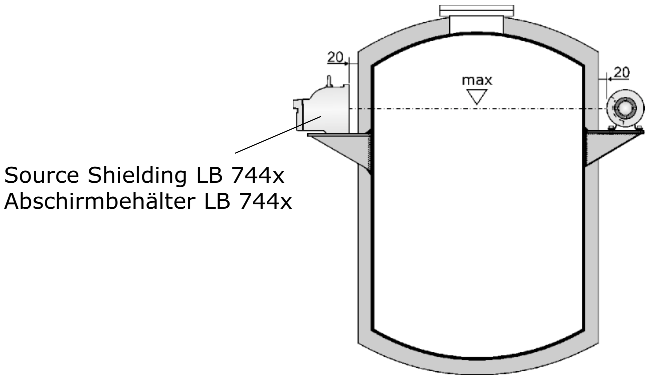
Radiation Angle of the Shielding / Abstrahlwinkel der Abschirmung

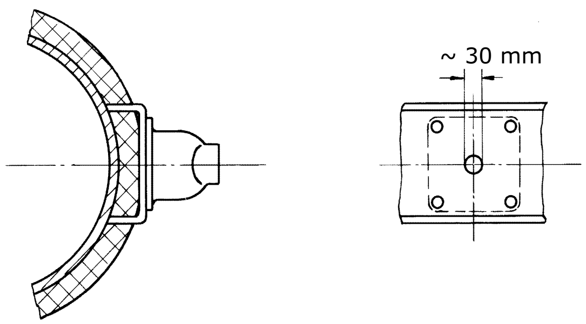
BERTHOLD

LB 480

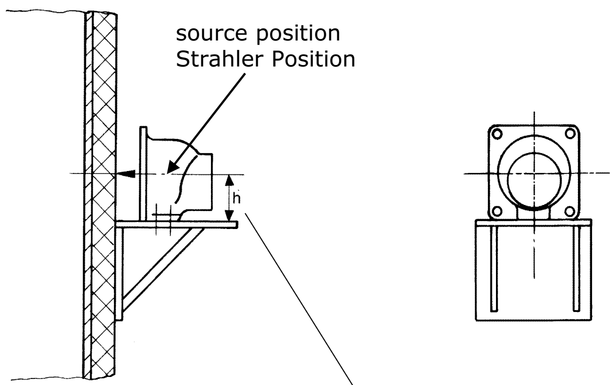
Dimensions in mm
Abmessungen in mm

8.1 Mounting Proposal for Source Shielding LB 744x
Montagevorschlag für Abschirmbehälter LB 744x





Flange Installation
Flanschinstallation



Pedestal Installation
Sockelinstallation

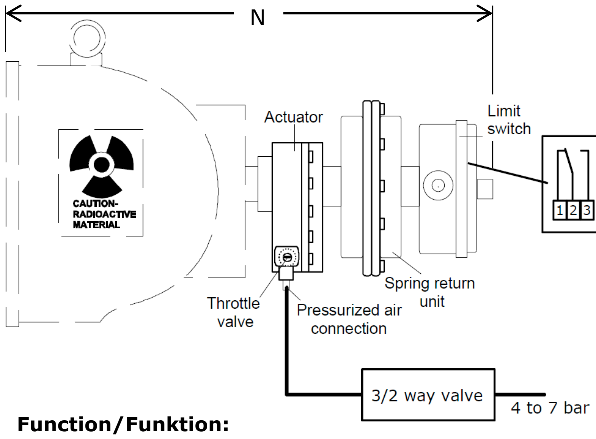
	LB 7440 LB 7445	LB 7442 LB 7446	LB 7444
h	90	120	161

BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

8.2 Pneumatic Actuator for Source Shielding LB 744x
Pneumatischer Verschlussantrieb für Abschirmbehälter LB 744x



N approx N ca.	Type / Typ
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

Function/Funktion:
The pressurized air moves the shutter to the OPEN position. If the pressurized air is turned off or in case of failure the moveable shutter is turned back to the CLOSED position by the spring return unit.
Die Druckluft bewegt den Verschlusskern in die Position AUF. Wenn der Druck abfällt, bewegt sich der Verschlusskern, mit Hilfe der Rückzugfeder, zurück in die Position ZU (Fail Save).

Protection Schutz	Part No. Ident.	Description Beschreibung
IP 65	36119	Pneumatic Actuator with Limit Switch Pneumatischer Verschlussantrieb mit Endschalter
Ex de IIC T6	80919	Pneumatic Actuator with Limit Switch with ATEX Pneumatischer Verschlussantrieb mit Endschalter with ATEX

Technical Data for Pneumatic Actuator Technische Daten für pneumatischen Verschlussantrieb	
Compressed Air Druckluft	min. 4 x 10^5 Pa (4 bar) max. 7 x 10^5 Pa (7 bar) Connection / Anschluss: G 1/8
Air Quality Luftqualität:	clean as usual for air compressed tools, oil free Sauber wie für Druckluft-Werkzeuge üblich, ölfrei
Temperature Range Temperaturbereich:	-20°C … +80°C

Limit Switch, Option for Signaling OPEN/CLOSED Endschaltereinheit, Optionen für Signalisierung AUF / ZU	
Option I:	IP 65, 2 contacts (OPEN/CLOSED) IP 65, 2 Kontakte (AUF/ZU)
Option II:	2 contacts (OPEN/CLOSED) Protection for internal micro switches: EEx d IIC T6 Housing protection: EEx e II T6 2 Kontakte (AUF/ZU) Schutzart der Microeinbautaster: EEx d IIC T6 Gehäuseschutzart: EEx e II T6
Option III:	2 Proximity switches for intrinsically safe power supply 2 Näherungsinitiatoren für Eigensichere Speisung

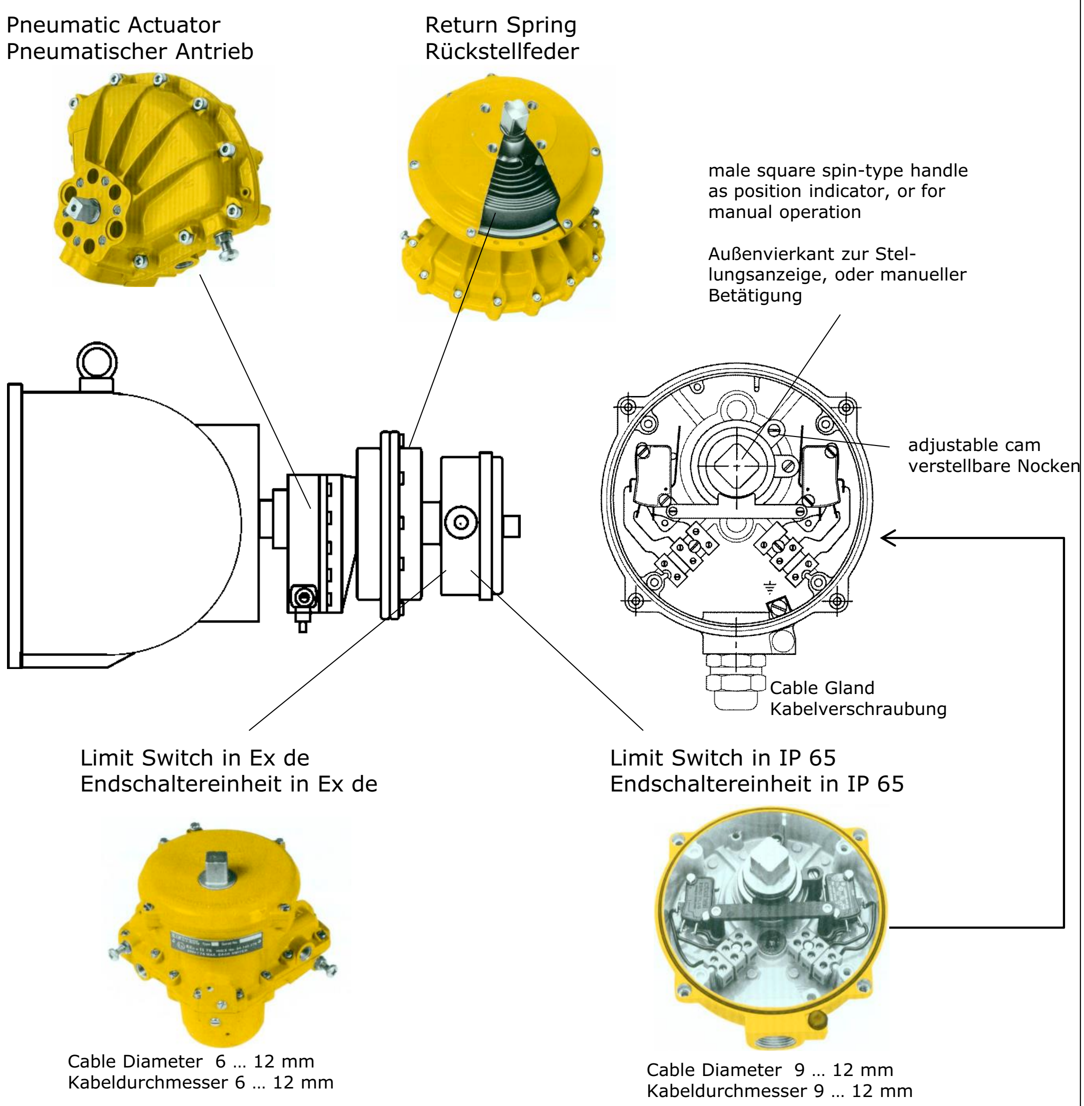
The pneumatic actuator is equipped with a throttle valve. The factory setting of the valve is set such that the shield opening and closing process takes at least 2 s; otherwise the shield may get damaged!
Der pneumatische Antrieb hat ein Drosselventil. Diese Ventil ist werksseitig so eingestellt, dass die Bewegung für AUF/ZU mindestens 2 s dauert. Im anderen Fall könnte die Abschirmung beschädigt werden.

BERTHOLD

LB 480

Dimensions in mm
Abmessungen in mm

8.3 Components for Pneumatic Actuator
Einzelteile für Pneumatischen Verschlussantrieb



Contact Rating
Kontaktbelastbarkeit

Volt		Load / Last (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

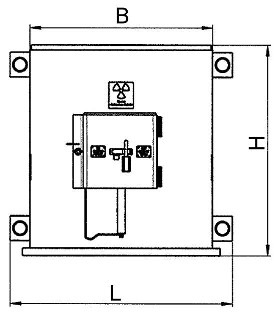
Contact Rating
Kontaktbelastbarkeit

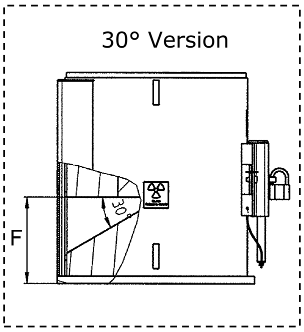
Volt		Load / Last (A)		
AC	DC	R	L	Lamp / Lampe
250		15	3	1,5
125		15	3	1,5
	12	15	3	1,5
	24	10	2	1
	48	3	0,6	0,3
	250	0,25	0,05	0,025

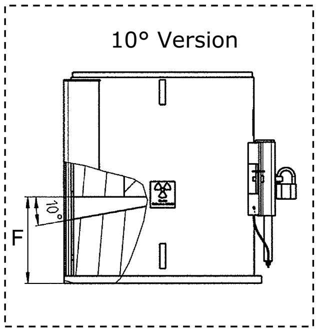
LB 480

Dimensions in mm
Abmessungen in mm

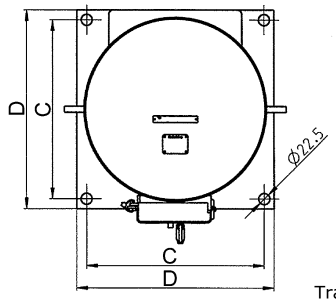
8.4 Point Source Shielding LB 8030/8040
Punktstrahler-Abschirmbehälter LB 8030/8040



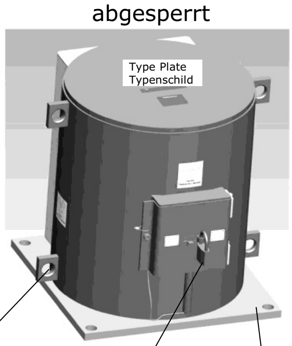




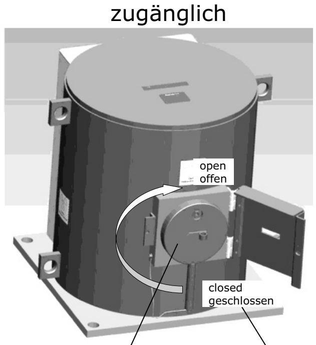
Radiation Exit
Strahlenaustritt



Shutter mechanism locked
Strahlermechanismus abgesperrt



Shutter mechanism accessible
Strahlermechanismus zugänglich



Transport Lug
Transportöse

Pad Lock
Vorhängeschloss

Mounting Flange
Montageflansch

Source Locking Mechanism
Strahlerverschluss-mechanismus

Source Position
Strahler Position

Material Material	Stainless Steel 304 Edelstahl 1.4301
Painting Lackierung	Polyurethane, yellow Polyurethan, gelb

Type **Typ**	**B**	**C**	**D**	**F**	**H**	**L**	∢	**kg**
LB 8030-01	370	360	400	174	425	450	30°	516
LB 8030-02							10°	
LB 8040-01	456	460	500	305	567	536	30°	1014
LB 8040-02							10°	

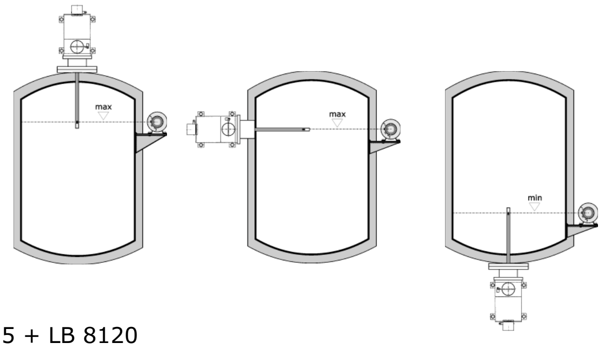
∢ Radiation Angle of the Shielding / Abstrahlwinkel der Abschirmung

BERTHOLD

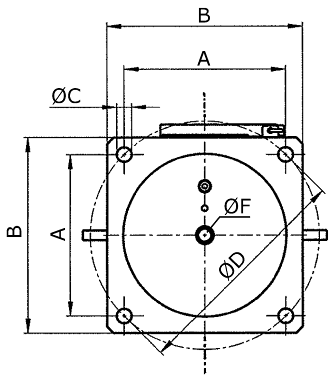
LB 480

Dimensions in mm
Abmessungen in mm

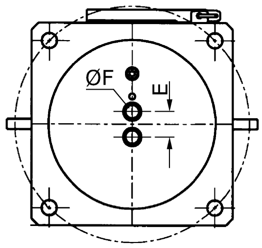
8.5 Point Source Flange Shielding LB 81xx for Dip Pipe Installations
Punktstrahler-Flansch-Abschirmbehälter LB 81xx für Tauchrohr-Applikationen

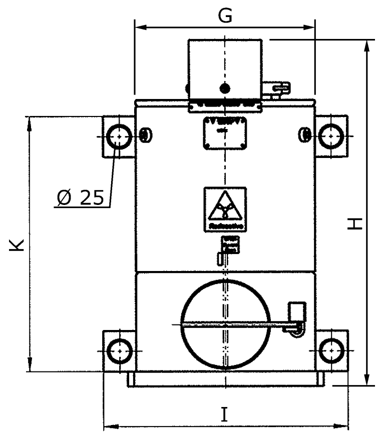


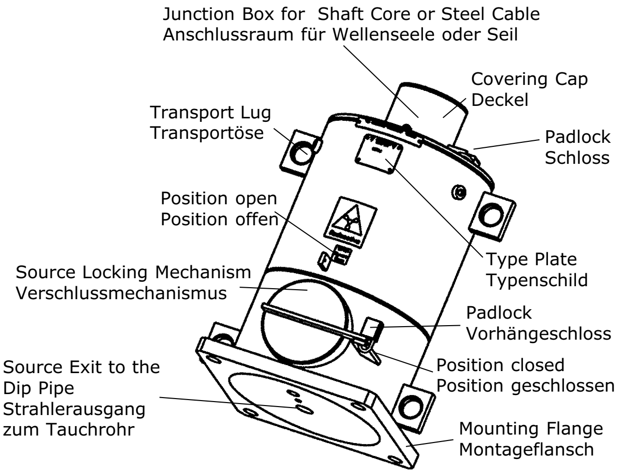
Type/Typ LB 8115 + LB 8120



Version for 2 Sources LB 81xx-20
Version für 2 Strahler LB 81xx-20





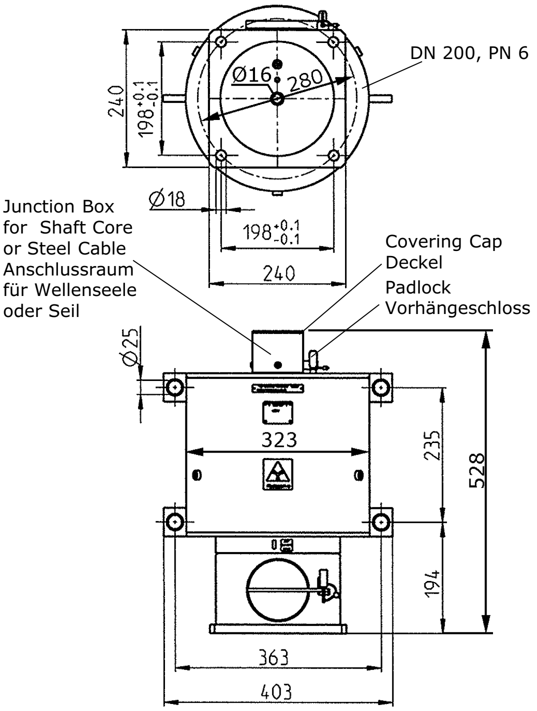


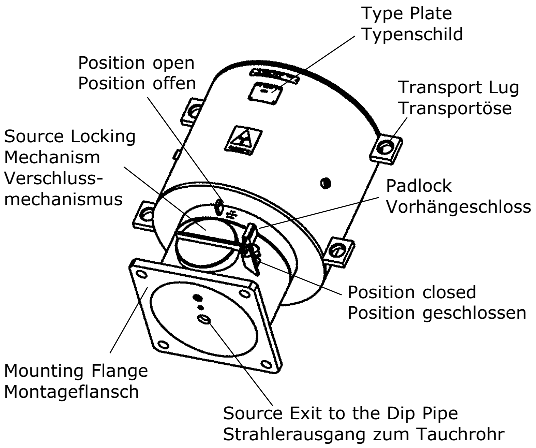
Type Typ	A	B	ØC	ØD	E	ØF	G	H	I	K	kg
LB 8115-01 LB 8115-20	141,5	180	18	200	- 30	16	159	350	239	237	60 kg
LB 8120-01 LB 8120-20	198	240	18	280	- 30	16	219	425 429	300	313	137 kg

LB 480

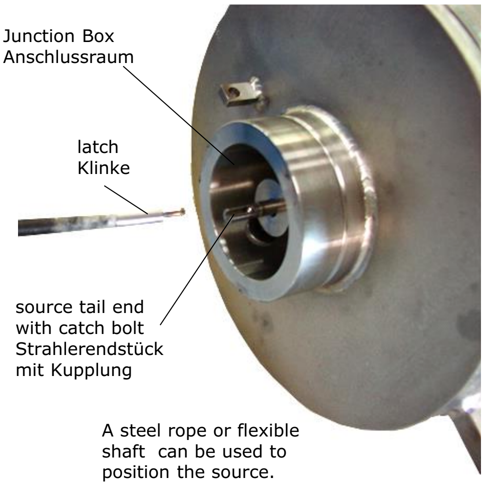
Dimensions in mm
Abmessungen in mm

Type/Typ LB 8125-01





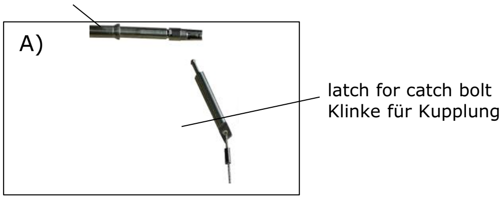
8.6 Operation of Flange Shielding
Bedienung der Flanschabschirmung



A steel rope or flexible shaft can be used to position the source.

Zur Positionierung kann ein Stahlseil oder eine Wellenseele genutzt werden.

source tail end with catch bolt
Strahlerendstück mit Kupplung



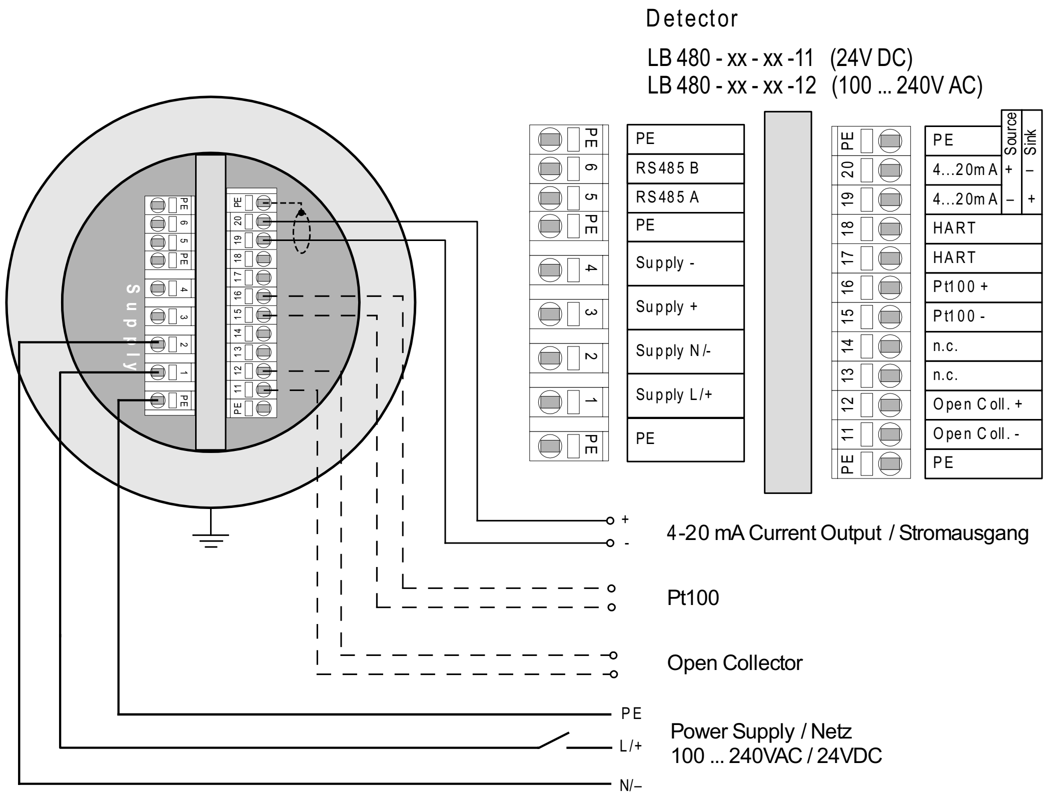
plug the latch into the catch bolt
Klinke in Kupplung einklinken

latch plugged into the catch bolt
Klinke in Kupplung einklinken

LB 480

Dimensions in mm
Abmessungen in mm

9.0 Terminal Connection
Elektrischer Anschlussplan



6

Accessories

6.1 Cable glands

The sealing of the screwed fittings on the cable can be made of several sealing rings, depending on the screwed fitting, which have to be adapted to the diameter of the cable. The sealing rings inserted into the screwed fittings allow a relatively large cable clamping area. Remove the sealing rings from the screwed fitting to adapt them to the cable diameter used. A list of screwed fittings available from BERTHOLD TECHNOLOGIES can be found in the manual for explosion protection on *page 1-51*.

The following is an example for a M20 cable gland with additional sealing ring for small cable diameters, that must be removed for cables with larger diameter.

Assembly instructions for ID No. 55412 and 56086

blueglobe® – Montage
*blue*globe® – *Installation*

blueglobe® mit kleinem Kabeldurchmesser
Bei IP 68 Installationen globemarker® außenliegend

blueglobe® with small cable diameter
With IP 68 installations globemarker® on the outside

Abb. 1
Fig. 1

blueglobe® mit kleinem Kabeldurchmesser
oder globemarker® entfernen

blueglobe® with small cable diameter
or removing globemarker®

Abb. 2
Fig. 2

blueglobe® mit großem Kabeldurchmesser
Bei großem Kabeldurchmesser Inlet entfernen: Schraubendreher senkrecht in Trennnaht einstechen

blueglobe® with large cable diameter
With a large cable diameter – remove inlet. Insert screwdriver vertically into separating seam

Abb. 3
Fig. 3

blueglobe® mit großem Kabeldurchmesser
Inlet aushebeln

blueglobe® with large cable diameter
Lift out the inlet

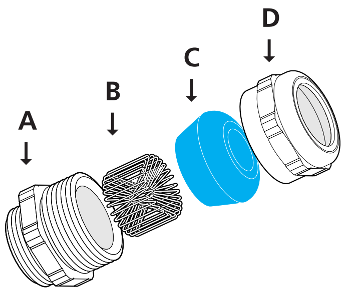
Abb. 4
Fig. 4

Assembly instructions for ID No. 56091

*blue*globe TRI® – Montageanleitung
blueglobe TRI® – Assembly Instruction

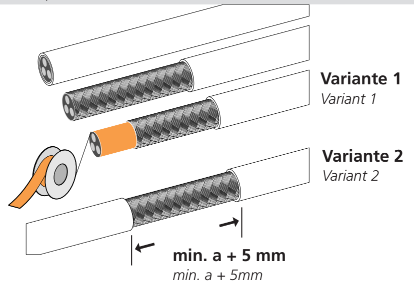
Übersicht Bestandteile
Overview components

Doppelnippel (A), Feder (B), Globe-Dichteinsatz (C), Druckschraube (D)
Double nipple (A), spring (B), globe-sealing insert (C), pressure screw (D)



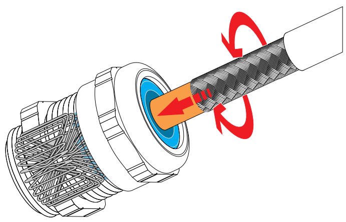
Schritt 1 – Vorbereitung der Montage
Step 1 – Prepare installation

Leitung abmanteln, Geflecht mit Isolierband schützen
Dismantle wire, protect braid



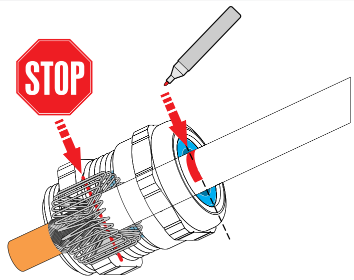
Schritt 2 – Montage
Step 2 – Installation

Kabel mit leichter Drehung einführen
Install cable with slight turn



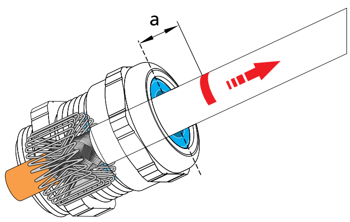
Schritt 3 – Montage
Step 3 – Installation

Markieren, wenn der Kabelmantel die Feder berührt
Mark when cable sheath touches spring



Schritt 4 – Montage
Step 4 – Installation

Kabel gemäß Maß a zurückziehen (siehe Tabelle unten)
Withdraw cable acc. size a (see table)



Schritt 5 – Montage
Step 5 – Installation

Druckschraube mit Drehmoment festziehen (siehe Tabelle unten)
Fix pressure screw with nominal torque (see table)

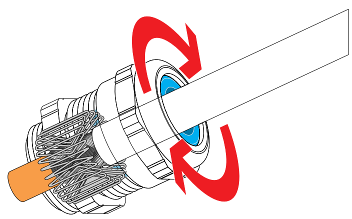


Tabelle
Table

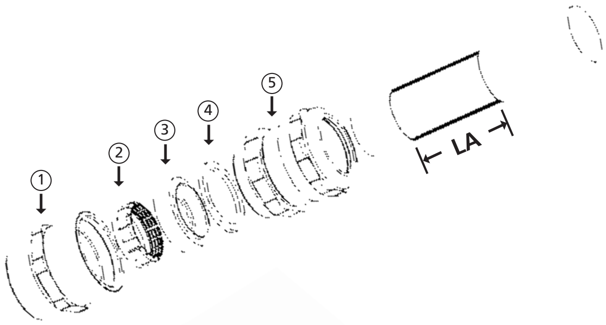
Artikel *Article*	**a/mm** *a/mm*	**Nenndrehmoment/Nm** *Nominal torque/Nm*
bg 212mstri	7	5
bg 216mstri	8	8
bg 220mstri	9	10
bg 225mstri	10	15
bg 232mstri	11	15
bg 240mstri	13	20
bg 250mstri	15	30
bg 263mstri	15	35
bg 275mstri	15	80
bg 285mstri	15	100

Assembly instructions for ID No. 56088 and 56103

blueglobe® AC – Montageanleitung
blueglobe® AC – *Assembly Instruction*

Übersicht Bestandteile
Overview components

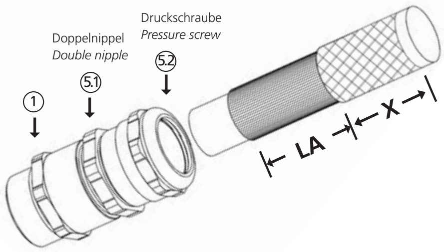
Adapter mit O-Ring ①, Klemmring ②, Druckring ③, Dichtung ④ und Standard - blueglobe® ⑤
Adapter with O-Ring ①, Clamping ring ②, Pressure ring ③, scaling ④, and Standard - blueglobe® ⑤



Schritt 1 – Vorbereitung der Montage
Step 1 – Prepare installation

1. Leitung abmanteln, Armierung kürzen gemäß Tabelle (siehe unten)
1. Dismantle wire, cut armour according table 1 (see below)

2. Adapter ① mit Nenndrehmoment 1 gemäß Tabelle (siehe unten) einschrauben (Komplettverschraubung AC nicht öffnen)
2. Fix adapter ① with torque 1 according table (see below) (do not open complete AC gland)



Schritt 2 – Montage
Step 2 – Installation

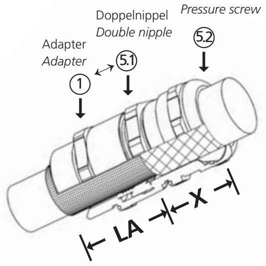
1. Kabel mit Länge X einführen, gemäß Tabelle (siehe unten)
1. Install cable with length X according table (see below)

2. Doppelnippel 5.1 mit Nenndrehmoment 1 gemäß Tabelle (siehe unten) anziehen zum Kontaktieren
2. Fix double nipple 5.1 with torque according table (see below) for contact

3. Druckschraube 5.2 mit Nenndrehmoment 2 gemäß Tabelle (siehe unten) anziehen zur Abdichtung
3. Fix pressure screw 5.2 with torque 2 according table (see below) for tightness

Tabelle
Table

Artikel *Article*	**LA/mm** *LA/mm* [min]	**X/mm** *X/mm*	**Drehmoment 1/Nm** *Torque 1/Nm* für/for ① + 5.1	**Drehmoment 2/Nm** *Torque 2/Nm* für/for 5.2
220bg220msAC13	20	35	15	10
220bg225msAC15	22	37	15	15
225bg225msAC17	22	37	15	15
232bg232msAC23	26	40	25	15
232bg240msAC27	28	43	40	15
240bg240msAC31	28	43	20	20
250bg250msAC36	32	49	50	30
250bg250msAC40	32	49	50	30
263bg263msAC46	32	50	50	35
263bg263msAC51	32	50	50	35
275bg275msAC61	36	62	80	80
285bg285msAC70	38	64	100	100
285bg285msAC78	38	64	100	100

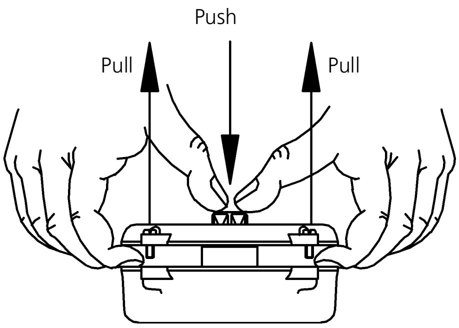


6.2 Limit Switches for Pneumatics

Installation and setup instructions for limit-switch box by KINETROL … -003U Ex ed IIC T6 and … -004U

IMPORTANT
If the limit-switch box … -003U is delivered separately, it has to be stored in a plastic bag until it will be installed.
The certification will keep its validity only if the limit-switch box has been installed correctly on the swivel drive.

For indirect installation, the limit-switch box can be supplied, on customer's request, with installation dimensions according to VDI/ VDE 3845 or according to KINETROL's factory norm (see below).



Direct installation

- Unscrew the cover of the supplied limit-switch box and pull it off, as shown in the illustration, while pushing down the limit-switch shaft. Caution: Do not lose the cover sealing!
- Remove shaft mounting bracket by opening the screws and take off the limit-switch shaft.
- Clamp swivel drive in vise (use soft jaws)
- Apply LOCTITE (or a similar adhesive) on mounting thread, put on the supplied cork sealing and attach the bottom part of the limit-switch box. Fix it using the screws supplied.
- The two trip cams on the limit-switch shaft are fixed by one screw each. Untighten these screws.
- Place limit-switch shaft with the Allen key onto the upper four cornered shaft of the drive or the spring lock unit. DO NOT HAMMER – DO NOT APPLY FORCE!
- Install shaft mounting bracket again.

Adjusting the trip cams

- Set revolving wings of the swivel drive to the initial position. Caution: The mechanical end stops of the swivel drive should have been set already to make subsequent correction of the trip cams superfluous.
- Move the respective trip cams on the guide ring until a soft click indicates that the contact of the micro push-button (… -3U) or micro push-button (… -4U) has switched. To be on the safe side, move the trip cams by about 2-3 degrees further and tighten the clamping screw.
- Move revolving wings to the opposite stop position. Compressed air is needed for single-acting swivel drives with spring lock unit.
- Proceed accordingly with the second trip cam.

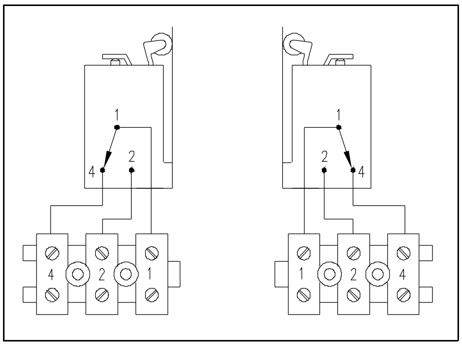
Technical Specification / Electrical Wiring

... **-3U**

2 micro push-buttons

BARTEC 07-1501-6120-63 (closer) for drive size 02/03

BARTEC 07-1501-6130-63 (changer) for drive size 05-14

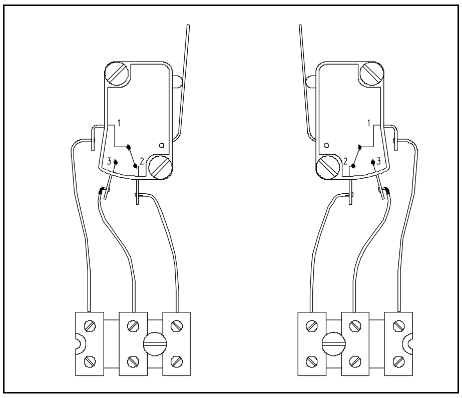


Volt		Load (A)	
AC	DC	Resistor	inductive (max.)
250		7	5
125		7	5
	up to 12	7	5
	up to 24	1	1
	up to 48	0.5	0.06
	up to 250	0.3	0.03

... **-4U**

2 micro push-buttons

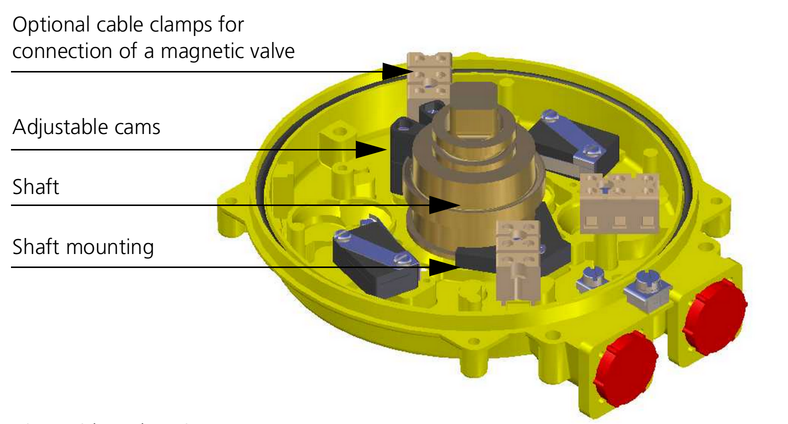
Standard dimensions according to DIN41635



Volt		Load (A)		
AC	DC	Resistor	inductive (max.)	Lamps
250		15	5	1.5
125		15	5	1.5
	up to 12	15	5	1.5
	up to 24	10	1	1
	up to 48	3	0.06	0.3
	up to 250	0.25	0.03	0.025

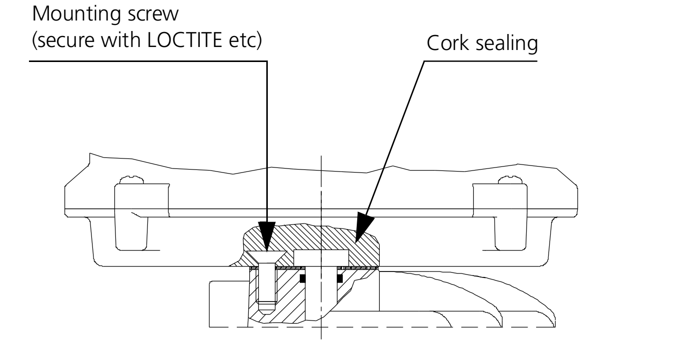
Material: … **-3U and** … **-4U**

	KINETROL …-3U	KINETROL …-4U
Housing	Zinc die casting	
Coating	Epoxy resin, burned in	
Sealing	O-rings (Nitril)	
Temperature range	-25°C to +60°C	-20°C to +80°C
Weight	1.4 kg	
Cable inputs	M20x1.5	M20x1,5; PG13,5; ½" NPT; 4-pole connector (DIN 43650A)
Cable clamp	Terminal cross-section 2.5 mm², grounded conductor terminal 2.5 mm², earthed conductor clamp 4.0 mm²	
Protection type	IP54–65	

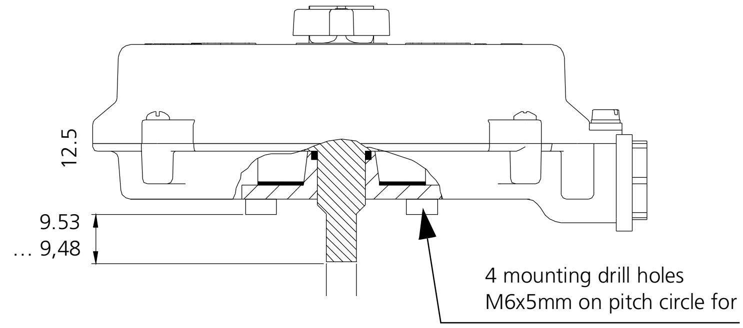


View without housing cover

Technical Specification / Electrical Wiring



Direct installation



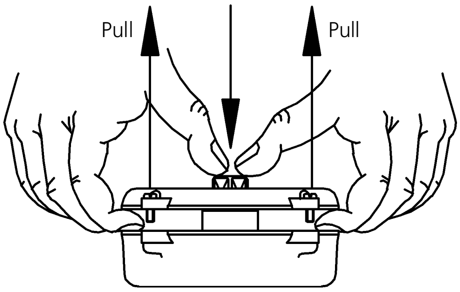
Installation according to factory

After connecting, tighten the stuffing box fitting.

IMPORTANT
Make sure that the cover sealing is inserted in its groove!

Slightly grease the housing cover in the shaft duct with MoS_2 grease, attach it and tighten cover screws.

Correction of the switching points for drive with pre-assembled limit-switch box



Direct installation

- Unscrew the cover of the supplied limit-switch box and pull it off, as shown in the illustration, while pushing down the limit-switch shaft. Caution: Do not lose the cover sealing!
- Remove shaft mounting bracket by opening the screws and take off the limit-switch shaft.
- Apply LOCTITE (or a similar adhesive) on mounting thread, put on the supplied cork sealing and attach the bottom part of the limit-switch box. Fix it using the screws supplied.
- The two trip cams on the limit-switch shaft are fixed by one screw each. Untighten these screws.

See further steps *"Adjusting the trip cams"* on *page 2-242* and Technical Specification / Electrical Wiring on *page 2-243*

Notes:

Subject to change in the course of further technical development.

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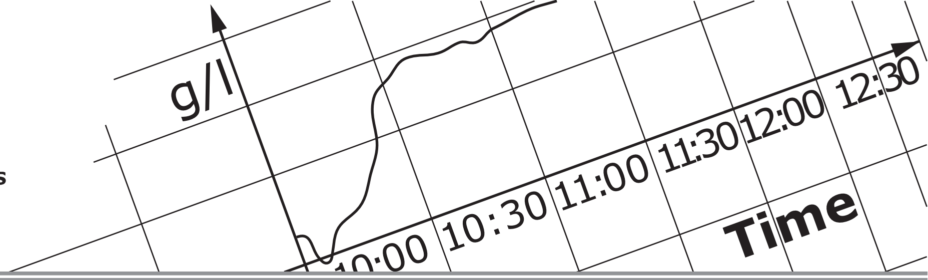


Volume 3 Operation with HART® Communicator

1 HART® Communication

HART® REGISTERED

Certificate of Registration
FieldComm Group Verified

Berthold Technologies GmbH & Co. KG	LB480 Density
Manufacturer	Product Name
00A1	A179
Manufacturer ID (Hex)	Expanded Device Type (Hex)
7	01
HART Protocol Revision	Device Revision (Hex)
01	05
Hardware Revision (Hex)	Software Revision (Hex)
8/20/2014	FieldComm Group
Test Date	Verification Method

The above product has successfully completed the validation process and meets the requirements to be "HART REGISTERED".

"HART REGISTERED" products conform to GB/T 29910.1-6-2013 and IEC 61158 standards.

Registration Number: L2-06-1000-384 Registration Issue Date: 4/16/2015 Approval: T. J. Masters

FieldComm Group™
Connecting the World of Process Automation

HART® is a registered trademark of FieldComm Group

3

The LB 480 can be operated with the following hosts:

- HART® Communicator (375/475) by Emerson Process
- Siemens Simatic PDM
- AMS DeltaV by Emerson Process

1.1 HART® Protocol

The density measured value is transferred in the process variable PV.

The measured values are transmitted via the following HART® variables:

- PV - Process value (for level %, for density the selected unit)

From software version 01.01.00 on additional variables available:

- SV - CPS live
- TV - CPS average (depending on the time constant)
- QV - Detector temperature

The SENSseries LB 480 is HART®-7 compatible, see certificate.

Download the Device Descriptions (DD) from the homepage of HCF:

https://fieldcommgroup.org/registered-products/

1.2 General Information on the HART® Communicator

IMPORTANT

Changes in the parameters affect the behavior of any connected controller and can lead to undesirable operating conditions. Never change the parameter settings without a full knowledge of this User’s Manual as well as a full knowledge of the behavior of the connected controller and the possible influence on the operating process to be controlled.

The measuring system SENSseries LB 480 is compatible with the HART® Communicator Model 375 with firmware 3.0 and the Model 475 (HART® Communicator, HART = Highway Addressable Remote Transducer) by Emerson Process Management GmbH & Co. OHG. Other HART® compatible communicators may also be used, provided they support Enhancements. The HART® Communicator uses the Bell 202 Frequency Shift Keying technique to superimpose high-frequency digital communication signals on the standard 420mA current loop. The minimum load resistance on the 420 mA loop has to be 250 ohms.

Refer to the instruction manual for the HART® Communicator for information on key usage, data entry and equipment interface.

1.3 Connection, Power On and Power Off of the HART® Communicator

WARNING

Risk of explosion!

In hazardous areas, a HART® Communicator may be connected only under the following conditions:

- the current output of the measuring system SENSseries LB 480 is intrinsically safe
- the HART® Communicator is intrinsically safe
- the HART® Communicator has previously never be connected to non-intrinsically safe live electric cables.

The communicator may be switched on only after it has been connected to the HART® current output. Otherwise, communication with the detector is not established.

For safe HART® communication you need an impedance of at least 250 to maximum 500 ohms at the current output.

The Start menu appears as soon as the detector and the Communicator have been connected and commissioned properly (see page *page 3-265*).

From this menu you may directly select the item **Live Display** for online display of the measured values. The measured data are only valid when the probe was calibrated and configured.

The Communicator may be turned off or disconnected only after completion of a possible parameter change of the detector.

1.4 Working with the HART® Communicator

The Communicator is easy to use:

- Use the arrow keys to select a menu item and then press the button with the right arrow key or the ***ENTER*** key. Alternatively, you can press the number listed in front of most menu items on the numeric keypad; then the menu item is called immediately.
- To change information or data, use the softkeys on which the valid function is depicted, e.g. ***SAVE, ABORT, OK, ENTER*** or ***SEND***. Push ***HOME*** to return to the Start menu (see *chapter 2.3, "Start Menu", page 3-265*).
- Use the numeric keypad to enter numbers. With these keys you can also enter text for some menu items by pressing the appropriate number key repeatedly.

1.5 Archiving Parameter Sets

Parameter sets can be archived from the LB 480 to a PC via these hosts:

- HART® Communicator Model 375/475
- Siemens Simatic PDM
- AMS DeltaV, Emerson Process
- LB 480-PC (BERTHOLD TECHNOLOGIES specific program for the RS485 interface)

IMPORTANT
Depending on the HOST system, it may happen that certain parameters are not stored correctly.
Therefore, verify the data stored after each archiving step.
Even if you restore the saved data to the LB 480, you have to check the calibration setting afterwards.

3

1.5.1 HART® Communicator

The HART® Communicator Model 375/475 allows you to archive parameters sets. For this purpose, the parameter set first has to be saved using the software button **SAVE** from the detector to the SD card of the HART® Communicator. The stored data can then be archived to a PC via SD card or via infrared interface. First, preparatory actions have to be performed in the Online menu. The following sequence shows how the parameter set can be transferred from the detector to a PC via SD card.

1. Enter the file name of the parameter set for archiving in the Tag parameter.

   Command: **Tag**

   Execution:
   Online via the HART® Communicator in the **Identification** menu, select the **Tag** parameter and enter a name. Up to 8 characters.

2. Load current measurement parameters to the calibration parameters.

   Command: **Recall**

   Execution:
   Online via the HART® Communicator in the **Cal Parameter** menu, select the command **Recall**.

3. Save parameter set to the HART® Communicator.

   Command: **SAVE**

   Execution:
   Online via the HART® Communicator, push the software button **SAVE** on the display.

   Info:
   The parameter set is now also available offline on the HART® Communicator.

4. Transfer parameter set to PC.

   You need the program "Easy Upgrade Utility" for this step. This program must be installed earlier on the PC.

   Execution:

   – Remove SD card from 475 and insert it into the SD card reader of your PC.
   – Start Easy Upgrade Utility.

   The following steps describe the sequence in "Easy Upgrade Utility":

   – ("Update PC" recommended)
   – Connection type: Card Reader
   – "Connect"
   – Select "More options ...".
   – Select "HART configuration" tab.
   – Select a file in the right box and upload it to the PC database in the left box.

   The parameter set can now be displayed, or printed, by double-clicking.

   For more information about "Easy Upgrade Utility" please refer to the Online help.

To transfer already archived files to the detector:

1. Transfer the file from PC to SD card using "Easy Upgrade Utility".
2. Insert SD card again in the HART® Communicator.
3. Select the parameter set in the offline mode of the HART® Communicator and transfer it to the detector with the **Send** command.

   The detector is now ready for measurement.

To update the data, you have to restart the HART® Communicator.

For archiving with other hosts please see the following chapter.

1.5.2 PDM (Siemens Simatic PDM)

The PDM can also store data in the offline menu. Again, you have to select **Recall** on the **Cal Parameter** menu.

When restoring the data to the detector, it is necessary to transfer the data twice to the detector. This ensures that the data will be properly enabled in the detector.

1.5.3 AMS (DeltaV Emerson Process)

The AMS can save data in the offline menu only from version 10 and above. Again, you have to select **Recall** on the **Cal Parameter** menu.

However, safe transfer of data from the offline menu to the detector can only be guaranteed by transmitting each parameter individually. You have to check whether the corresponding value has actually been transmitted properly. Then in addition you have to select **Restore** in the **Cal Parameter** menu to transfer the calibration values into the measurement parameters.

2

Menu Structure

2.1 Information on the Menu Structure

The menu structure on the following pages provides an overview over all functions of the SENSseries detectors. Using the page numbers indicated you can look up explanations on the function of each menu item.

First *ENTER* then *SEND*

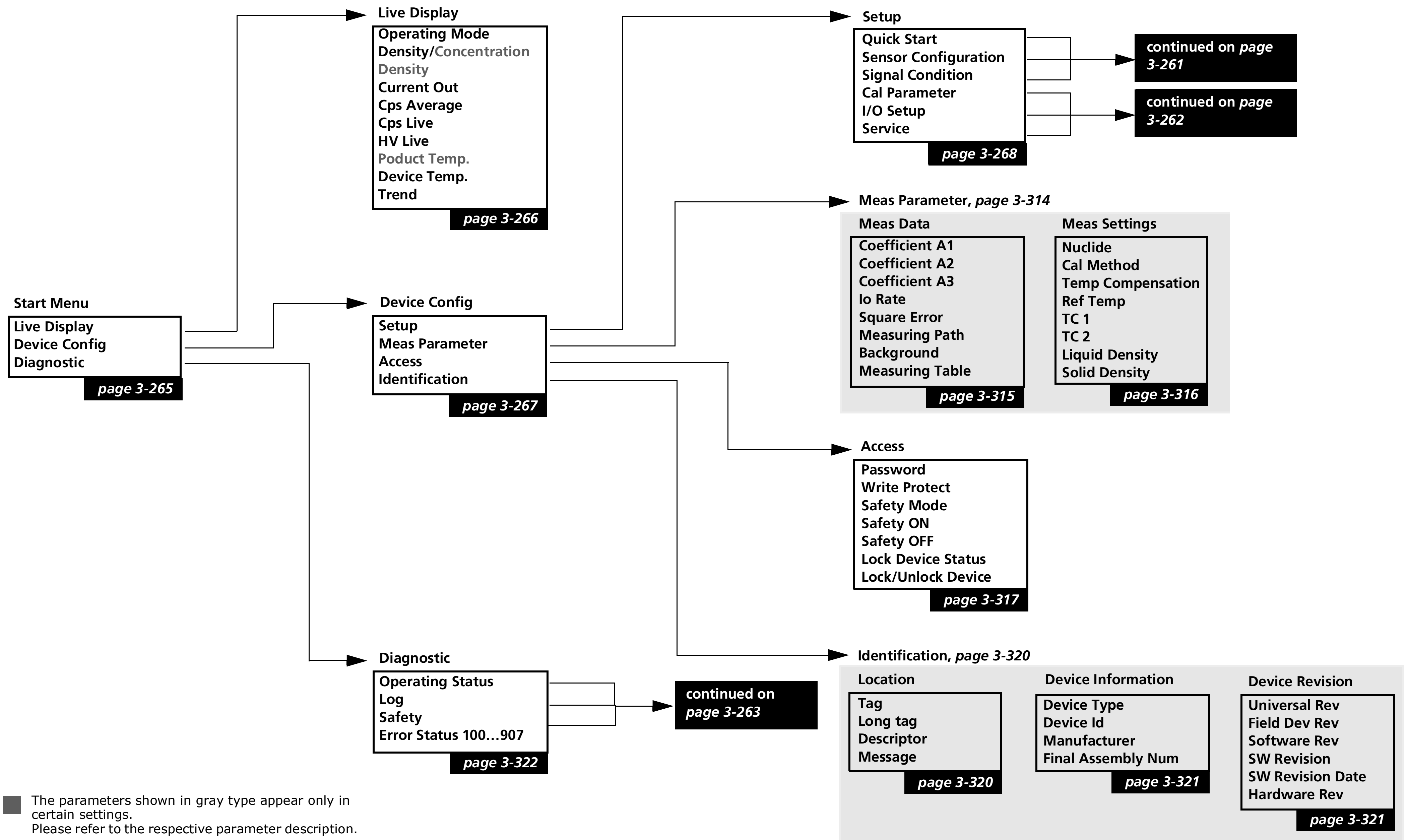
To rule out incorrect entries, you always have to push the ***SEND*** softkey immediately after you have entered a value via the ***ENTER*** button. The ***SEND*** softkey is only visible after values have been changed.

- Push ***ENTER*** to save edited values and parameters in the Communicator.
- Push ***SEND*** to transfer all modified values from the Communicator to the detector.

The following sections assume that you:

- know how to work with the Communicator
- *Volume 2* have read and understood this User's Manual.

2.1 Menu Overview



The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.

Setup

- Quick Start
- Sensor Configuration
- Signal Condition
- ...
- ...
- ...

page 3-268

Quick Start, *page 3-269*

Step 1, Date

- Date
- Time

page 3-269

Step 2, Setup

- Time Constant
- Nuclide
- Half Life Time
- Measuring Path
- ReadIn Time

page 3-270

Step 3, Range

- Unit Family
- Unit
- Lower Range Limit
- Upper Range Limit
- Liquid Density
- Solid Density

page 3-271

Step 4, 1-Point Calibration

- Read In
- Cal Density
- Cal Rate
- Coefficient A1
- Calibrate + Preset

page 3-273

Sensor Configuration *page 3-275*

Date & Time

- Date
- Time

page 3-276

Sensor Settings

- Error Code
- Detector Code
- HV Mode
- HV Live
- HV Average
- HV Manual
- HV Default
- Cps Single Detector

page 3-277

The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.

Signal Condition *page 3-279*

Signal Parameter

- Time Const
- Error Handling
- Signal Unlocked

page 3-279

Reading Range

- Lower Range Value
- Upper Range Value
- % Meas Range
- Factor
- Offset

page 3-281

Signal Dependency

- Response Mode
- Io Factor
- RI Sigma
- Waiting Time
- Meas Delay Time
- RS Sigma
- Cps Upper Limit
- Cps Lower Limit

page 3-282

Source Exchange

- Selection
- Warning Date

page 3-286

Setup
- ...
- ...
- ...
- Cal Parameter
- I/O Setup
- Service

page 3-268

Cal Parameter, *page 3-287*

Cal Points
- ReadIn
- Background
- Cal Point No.
- Cal Concentration
- Cal Density
- Cal Density TC
- Cal Rate
- Cal Temp
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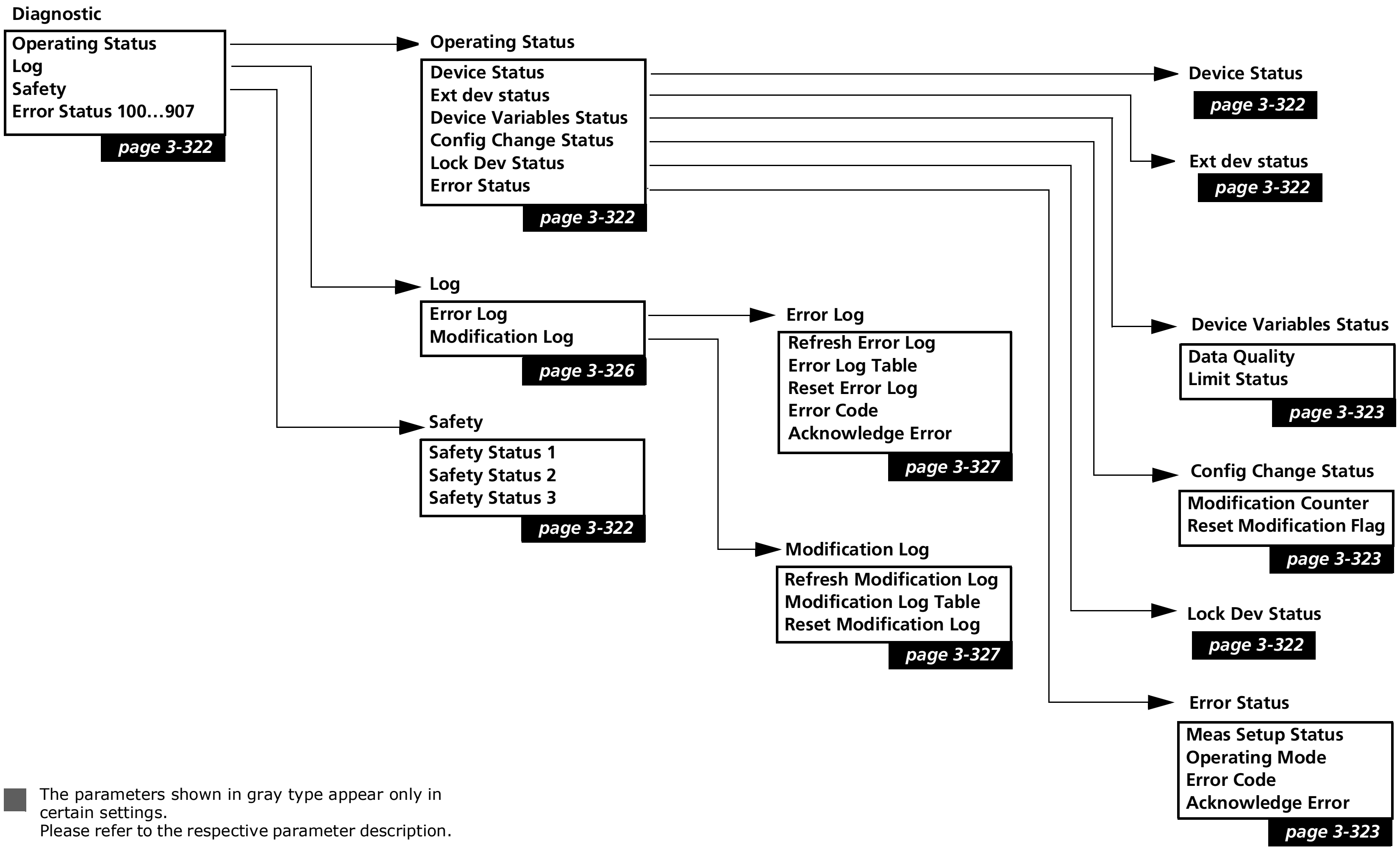
continued on *page 3-264*

The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.



The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.

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The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.

2.1 Start Menu

The Start menu is the first and highest level for communication with the SENSseries. From the Start menu you have access to all other menu items.

The Start menu appears if you...

- switch on the connected HART® Communicator or
- push the ***HOME*** softkey anywhere in the menu.

1 Live Display

Shows the menu with the currently measured values. (*page 3-266*).

2 Device Config

Leads to the menu for setting the detector parameters. (*page 3-267*).

3 Diagnostic

Opens the menu displaying status and error information and the protocols for errors and parameter changes (*page 3-322*).

2.2 Live Display

1 Operating Mode

Shows the current operating status.

The following states may occur:

- ***RUN***

  The measurement is in the normal measurement mode.

- ***WARNING***

  An error category **2** warning is displayed.

  If the error is no longer displayed in **Active Error**, you can view it in the error log (**Diagnostic ▶ Log**, *page 3-326*). In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

- ***ERROR***

  An error category **1** error is displayed.

  If the error is no longer displayed in **Active Error**, you can view it in the error log (**Diagnostic ▶ Log**, *page 3-326*). In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

- ***SHUTDOWN***

  A serious error category **0** error is displayed.

  If the error is no longer displayed in **Active Error**, you can view it in the error log (**Diagnostic ▶ Log**, *page 3-326*).

  In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures. If the error does not disappear after restart (power off and then on, or software reset, *page 3-305*), then the detector must be replaced.

- ***HOLD***

  The measurement is in the hold state, which means that the measured value and the current output signal is frozen. This status can occur under the following conditions:

  - the plateau recording is running
  - interference radiation was detected
  - the digital input is on Hold

- ***TEST***

  A test value is enabled, see *chapter 2.37*, *page 3-307*.

2 Density / Concentration

Displays the current measured value.

3 Density

Displays the current density. The parameter is displayed only if the calibration was performed as a suspension measurement.

4 Current Out

Displays the actual output current at the analog output in mA.

5 Cps Average

Shows the current count rate averaged over the time constant.

6 Cps Live

Shows the current non-averaged count rate.

7 HV Live

Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

8 Product Temp.

⇒ Visible only with temperature compensation enabled.

Shows the product temperature, for example, the liquid temperature in the tube, the density of which is to be measured.

9 Device Temp.

Displays the temperature inside the detector.

10 Trend

Displays the trend of important measured values such as density, count rate and temperature.

2.3 Device Config

1 Setup

Opens the Setup menu. If ***Setup !locked!*** appears here, then the access has to be enabled via **Access** (*page 3-268*).

2 Meas Parameter

Leads to the menu displaying the currently valid measurement parameters that are used to determine the measured value (*page 3-314*).

Each calibration with **Calibrate** overwrites these values again. These readings help the user to check his calibration.

3 Access

Opens the menu for entering the password, the options to prevent configuration changes and to activate the safety mode (*page 3-317*).

4 Identification

Opens the menu displaying various detector parameters, such as model, device ID, software and hardware revision (*page 3-320*).

2.4 Setup

Menu path: **Device Config ▶ Setup**.

These menus allow you to make changes to the settings and the calibration of the detector. Upon delivery of the instrument, access to all menu items is possible without password. If a password has been entered and activated, you must enter it again to allow access (see *chapter 2.46*, *page 3-317*).

Use **Recall** (**Device Config ▶ Setup ▶ Cal Parameter ▶ Recall**, *page 3-287*) if you only want to change a few settings. This will copy the current settings in the menus for the setup and you can make changes to individual settings.

Enable the changes with **Calibrate** (**Device Config ▶ Setup ▶ Cal Parameter ▶ Calibrate**), see *chapter 2.20*, *page 3-287*.

1 Quick Start
Opens a menu that enables fast user-guided, initial configuration of the detector (*page 3-269*).

2 Sensor Configuration
Opens the menu for the sensor settings (*page 3-275*).

3 Signal Condition
Opens the menu for the signal processing settings (*page 3-279*).

4 Cal Parameter
Opens the menu for the calibration (*page 3-287*).

5 I/O Setup
Opens the menu for the I/O functions (*page 3-297*).

6 Service
Opens the menu for testing and service functions as well as for the plateau measurement and display of the plateau values (*page 3-305*).

2.5 Quick Start

Menu path: **Device Config ▶ Setup ▶ QuickStart**.

QuickStart allows you to quickly take the detector into operation, without having to deal with the complete menu. Additional functions can be enabled any time on the main menu.

IMPORTANT
Changes in the ***Quick Start*** *menu must finally be enabled with* ***Calibrate + Preset*** *(in Step 4).*

2.6 Quick Start, Step 1: Date

Enter the current date and time.

The correct date is important for the automatic decay compensation of the isotope. Since the activity of the source diminishes with time, the calibration count rates will be compensated automatically through the date. The decay compensation takes place daily at 09:01 h

1 Date

Current date. The date is specified in the following format:

- MM/DD/YYYY.

If the detector detects that the date deviates, a date error is indicated.

The response of the signal output depends on the setting in **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**, *page 3-279*):

- ***NORMAL***

  The measurement continues with the last saved date.
- ***SENSITIVE***

  The measurement goes to the safe condition and the current output goes to fault current.

2 Time

Current time. The time is specified in the following format:

- hh:mm:ss

Differences in time have virtually no effect on the correction of the decrease in activity. However, the correct time is helpful to check the detector function: If an error occurs, you can see in the error log (**Diagnostic ▶ Log**, *page 3-326*) when exactly the error occurred.

2.7 Quick Start, Step 2: Setup

1 Time Constant

The time constant smoothes the output signal. Essentially, statistical fluctuations will be smoothed. A time constant of 30 s to 60 s is usually reasonable.

2 Nuclide

▶ Enter here the isotope (nuclide) that is used in your source:

- ***Co-60***
- ***Cs-137***
- ***USER DEFINED***

This entry controls the automatic decay compensation. The correct entry is also important in a one-point calibration and for gas density compensation. The isotope used is listed on the type plate of the shielding and on your delivery documents. The item ***USER DEFINED*** allows you to use any isotope you want. In this case, the parameter **Half Life Time** is queried in addition.

What happens when you have selected the wrong isotope?

As a result of the wrong decay compensation, you will get a deviating display only after several weeks or months, with the deviation increasing over time.

3 Half Life Time

⇒ Visible only if **Compensation Mode** is set to ***MANUAL GDA***.

Required only for special applications.

Enter the half-life in years.

4 Measuring Path

Enter the measuring path of the beam path through the product to be measured.

Generally it corresponds to the inner diameter of the pipe. Especially with the one-point calibration, you must enter this value exactly to the millimeter.

5 ReadIn Time

Define here the period of time over which the count rate is to be read-in with **ReadIn** for each calibration point.

The statistical variation of the count rate is averaged over this time period. The longer it is, the better the mean value. A time period of 30 s (default setting) is usually reasonable.

2.8 Quick Start, Step 3: Range

Define the measuring range and the unit of measurement.

1 Unit Family

Select the unit family for the measurement. Depending on this entry, the relevant units are available for selection under **Unit**, such as:

- ***DENSITY*** (g/cm^3, kg/m^3, g/l, ...)
- ***LENGTH*** (m, mm, yard, ...)
- ***SUSPENSION*** (%sol-wt, g/l, °Be)

Please note: When selecting ***SUSPENSION***, the measurement operates in a mode in which the concentration level of a substance is measured, for example, the proportion of the solid in a carrier liquid (%sol-wt). Additional inputs for **Liquid Density** and **Solid Density** are required.

*Information on **SUSPENSION** (suspension measurement):*

Since the concentration is not proportional to the density, the concentration is internally converted into g/cm^3. This conversion allows a linear calibration curve and with a one-point calibration the use of the standard coefficients for A1. To convert concentration values into g/cm^3, the entries for **Liquid Density** and **Solid Density** are required.

2 Unit

⇒ You will find all selectable units of the LB 480 in *chapter 9, page 3-403.*

Select the unit in which the measured value is to be displayed. To select units that are not included in the list, you may need to change the **Unit Family**.

3 Lower Range Limit

Enter the lower limit of the measuring range where 4 mA is to be output.

4 Upper Range Limit

Enter the upper limit of the measuring range where 20mA is to be output.

5 Liquid Density

⇒ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. In water, for example $1.00 g/cm^3$. For solutions, you have to enter the density of the main component.

6 Solid Density

⇒ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. For solutions, you have to enter the density of the main component.

Enter the density (g/cm^3) of the solid, and for solutions the density of the second component.

Example with sand as a solid:

With sand, the value to be entered corresponds to the average density of each individual grain of sand. This value is approximately $2.65 g/cm^3$.

2.9 Quick Start, Step 4: 1-Point Calibration

This menu allows you to determine the calibration date and then calibrate the instrument. When you calibrate, these data are transferred to the **Measurement Data** menu and thus activated for the measurement.

1 Read In

Start reading-in the count rates. While the count rate is read in, the average is calculated and displayed continuously.

The read-in period is defined under **ReadIn Time** *(chapter 2.9, "Quick Start, Step 2: Setup", page 3-270)*.

Enter the averaged count rate in **Cal Rate**.

When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the measured count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

2 Cal Density

Density for the calibration point.

Enter the density or concentration of the analyzed sample value.

3 Cal Rate

Count rate for the calibration point.

Select ReadIn to read in the count rate. If you already know the value, you can enter it here.

When reading in the count rate, you have to take the lab sample at the same time, or at least within a narrow time frame.

4 Coefficient A1

Absorption coefficient.

Determines the slope and thus the sensitivity of the measurement.

For the following units, the standard value -0.066 can be entered, provided Cs-137 is used as a radiation source:

– g/cm^3 (density) also for all other "density units"
– Wt% (concentration)
– g/l (concentration)
– °Be (concentration)
– °Bx (concentration)

If Co-60 is used as a radiation sources, then enter -0.044.

Other units, e.g. the length or volume units, require a multi-point calibration, which is only possible in the Cal Parameter menu.

The absorption coefficient can be entered in two different ways.

Example with input value -0.066:

- -0.066
- -66e-3

Entering the value as a power of ten allows you to enter very small coefficients without any problems.

3

5 Calibrate + Preset

With this menu item you enable the calibration data determined during the measurements. The calibration data are transferred to the parameter set Meas Parameter. Thus, the detector will get a new calibration which in the future will be used to determine the measured values.

After the calibration, a status message is displayed, indicating if the activation of the calibration data has been carried out successfully. If not, the measurement parameters are unchanged. Possible status messages are:

- ***0-OK***: The calibration carried out is OK.
- ***1-ERROR BACKGROUND***:
  The count rate for the background radiation (background) is higher than the count rates in the measuring range.
- ***2-MISSING CALIBRATION POINT***:
  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:
  - ***DIRECT ENTRY***: none
  - ***1-POINT***: one
  - ***LINEAR***: two
  - ***SQUARE***: three
  - ***CUBIC***: four
- ***3-ERROR NOT MONOTONOUS***:
  The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

⇒ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-COMPENSATION ERROR***:
  A water temperature compensation is only possible if suspension measurement has been selected.
- ***5-DATE ERROR***:
  A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.
- ***6-CHECK ERROR***:
  The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

The following settings are made automatically at **Calibrate** + **Preset**:

- **Temp Compensation** = ***OFF***
- **Calibration Method** = ***1-Point***
- **Background** = ***0***
- **Factor = 1**
- **Offset = 0**

2.10 Sensor Configuration

Menu path: **Device Config ▶ Setup ▶ Sensor Configuration**.

The **Sensor Settings** are preset at the factory.

1 Date & Time

Opens the menu for the date and time (*page 3-276*).

2 Sensor Settings

Opens the menu for the detector code and HV settings (*page 3-277*).

2.11 Date & Time

Menu path: **Device Config ▶ Setup ▶ Sensor Configuration ▶ Date & Time**.

The correct date is important for the automatic decay compensation of the isotope. Since the activity of the source diminishes with time, the calibration count rates will be compensated automatically in the **Meas Data** menu through the date. The decay compensation takes place daily at 09:01 h. A capacitor ensures that the date and time continue to run for about a month even when the detector is turned off and even if the power supply is switched off. If the detector has not been supplied with power for a longer period of time (several weeks), then the capacitor may be empty. If the power supply is switched on again, then the clock starts with the last saved date and an error message "Real time clock not valid" indicates that the date must be updated.

1 Date

Current date. The date is specified in the following format:

- MM/DD/YYYY.

If the detector detects that the date deviates, a date error is indicated. The response of the signal output depends on the setting in **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**, *page 3-279*):

- ***NORMAL***

  The measurement continues with the last saved date.

- ***SENSITIVE***

  The measurement goes to the safe condition and the current output goes to fault current.

2 Time

Current time. The time is specified in the following format:

- hh:mm:ss

Differences in time have virtually no effect on the correction of the decrease in activity. However, the correct time is helpful to check the detector function: If an error occurs, you can see in the error log (**Diagnostic ▶ Log**, *page 3-326*) when exactly the error occurred.

2.12 Sensor Settings

Menu path: **Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings**.

1 Error Code

Indicates if an error is present in the active detector.

If no error is present, then ***0*** is displayed here.

An error message is displayed with a three digit number. The cause of the error and suggestions for correcting the error are described in *chapter 8*, *"Error Handling"*.

2 Detector Code

The currently selected detector code is displayed.

The detector code is crucial for the proper function of the automatic HV control (high voltage control).

- Point detector NaI 50/50 = ***0***
- SuperSENS 150/150 = ***23***

3 HV Mode

The HV-mode (high-voltage control) provides the following options:

- ***AUTO***

  Automatic HV control. Select this mode in normal measurement mode. It enables a temperature-stable operation of the detector.

- ***MANUAL***

  Automatic HV control. This setting is used for testing purposes; you can also provisionally set the operating point of the detector. The specified voltage must, however, lie in the plateau.

  If you select ***Manual***, the automatic HV control is switched off. The HV is then set to the value that was set in the menu item **HV Manual** (6).

- ***PLATEAU***

  Starts the plateau measurement. If you select ***PLATEAU***, the measurement mode is exited and the plateau of the multiplier measured, which is used in the detector. The plateau is measured using the settings in the menu **Device Config ▶ Setup ▶ Service ▶ Plateau**.

  At the end of the plateau measurement the detector automatically switches back to **HV Mode**: ***AUTO*** or ***MANUAL*** depending on which mode was last set.

4 HV Live

Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

5 HV Average

Shows the average HV (high voltage) of the last 10 days.

Significant deviations from **HV Live** to **HV Average** are considered and reported as errors.

If you change **HV Default**, **HV Average** automatically takes over the value from **HV Default**.

6 HV Manual

You can enter a fixed HV value. The value becomes active when you select ***MANUAL*** at **HV-Mode**.

7 HV Default

HV Default causes:

– A quick operation point control after power failure

  After a power failure, the HV starts at the last **HV Average** value which results from the **HV Default**. This will significantly reduce the start-up phase after power failure.

– Error detection in case of HV-drift

  If the HV deviates too far (+40%, -20%) from the HV Default or if the HV reaches the limits of the range of 300 V or 1300 V, this is reported as an error.

– Special feature: 0V

  For maintenance purposes, the **HV Default** can be set to 0V. In this case, the mechanisms described above are suspended; after a power failure, the measurement begins to get adjusted at 800 V.

HV Default has already been determined and set by BERTHOLD TECHNOLOGIES. If this value deviates during the *first commissioning* by more than 5% from **HV Live**, then you have to adjust **HV Default** new.

▶ Set **HV Default** to 0.

▶ Read off the value in **HV Live** 30 minutes later.

▶ Enter the value read in **HV Default**.

With the CrystalSENS, please note that the count rate during this process is above 300 cps to allow the HV to adjust itself.

Tip

The operating point in new detectors is usually between 400 to 900 V. If you get a different value, please contact BERTHOLD TECHNOLOGIES or your local representative.

8 Cps Single Detector

Shows the count rate of the active detector normalized to one second.

2.13 Signal Condition

Menu path: **Device Config ▶ Setup ▶ Signal Condition**.

This menu contains some special features which have a direct impact on the signals of the measurement:

- the way of signaling
- general warning and error messages
- special warning signs for early detection of functional limitations

An important issue are the settings in the menu item **Error Handling** in the **Signal Parameter** menu.

1 Signal Parameter

Opens the menu for error handling and the signal output settings (see below).

2 Reading Range

The measuring range can be specified in this menu.

3 Signal Dependency

Opens the menu in which the interference radiation detection or the rapid switchover can be enabled.

4 Source Exchange

Opens the menu in which the early warning for the source replacement can be set.

2.14 Signal Parameter

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**.

1 Time Constant

The time constant smoothes the output signal. Statistical fluctuations and density fluctuations due to the process can be smoothed. A time constant of 30 s to 60 s is usually reasonable.

2 Error Handling

Here you can set a different weighting of errors and error handling:

- ***SENSITIVE***

  All faults cause the current output to report a *Fault current*. To get warning messages, you must also evaluate the messages via the HART® signal or the digital output.

  The setting ***SENSITIVE*** is automatically enabled when the **Safety Mode** is selected.

- ***NORMAL***

  Only fatal errors are reported as a fault current. Thus, the measured value via the current signal will fail only if the measurement can no longer be used.

  To also get minor error and warning messages, you must also evaluate the messages via the HART® signal or the digital output.

IMPORTANT

*You may select the **NORMAL** setting only if hazards to persons or damage to property a as a result of a faulty measured value can be ruled out.*

Select ***SENSITIVE*** if system safety is an important issue. Use ***NORMAL*** if a failure of the measurement is non-critical for human health and the environment and production safety is an important issue.

To use the digital output for the above mentioned messages, you need to use the setting ***WARNING + ERROR*** in the menu **Digital Out Function** (⇆⇨◁↓⇨⇨ ⬎⇕⇔←↓→ ▶ **Setup** ▶ **I/O Setup** ▶ **Digital Output** ▶ **Digital Out Function**, *page 3-299*).

Tip

Error handling is described in detail in *chapter 8* starting on *page 3-391*.

3 Signal Unlocked

You will get alerted when the device is unlocked with a password. The warning message 901 is output. Choose ***WARNING*** only if the control system is to be alerted when the device was unlocked with the password.

- ***OFF***

  The function is switched off.

- ***WARNING***

  Once the detector is unlocked with a password, a warning is issued. If **Error Handling** is set to ***SENSITIVE***, then a fault current is output in addition to the alarm.

The reaction can be identified based on the list in *chapter 8.2* on *page 3-392*.

2.15 Reading Range

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Reading Range**.

1 Lower Range Value

Allows you to change the measuring range even after the calibration.

For the calibration characteristics ***SQUARE*** and ***CUBIC*** which are used in special cases, the measuring range must be set only in the **Calibrate** menu, since there a check regarding the monotony of the calibration measurement is carried out.

2 Upper Range Value

Allows you to change the measuring range even after the calibration.

For the calibration characteristics ***SQUARE*** and ***CUBIC*** which are used in special cases, the measuring range must be set only in the **Calibrate** menu, since there a check regarding the monotony of the calibration measurement is carried out.

3 % Meas Range

Displays the current percentage value within the measuring range. It depends on the current measured value and the measuring range.

4 Factor

Factor with which the measured value is multiplied. Deviations in the calibration can be corrected with this factor. This allows you to adapt the system to changing operating conditions, such as build up of crusts or abrasion on the pipe wall, without having to carry out a recalibration.

The default value is ***1***.

The Offset and Factor corrected reading is calculated as follows:

Display = measured value x factor + offset

IMPORTANT
Changes have a direct effect on the measured value.

5 Offset

With this function you can adjust the calibration curve by entering an offset (parallel shift of the calibration curve). This allows you to adapt the system to changing operating conditions, such as build up of crusts or abrasion on the pipe wall, without having to carry out a recalibration.

The default value is ***0***.

The Offset and Factor corrected reading is calculated as follows:

Display = measured value x factor + offset

IMPORTANT
Changes have a direct effect on the measured value.

2.16 Signal Dependency

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Signal Dependency**.

On this menu you can enable one of the following functions:

- **RAD. INTERFERENCE**
- **RAPID SWITCH**
- **PULSE LIMIT**

1 Response Mode

Additional parameters are displayed, depending on which function you select.

Select the detection mode:

- ***DISABLED***

  Interference radiation detection, rapid switchover and count rate limits are disabled.

- ***RAD. INTERFERENCE***

  Interference radiation detection is enabled.

  Use this function, for example, to detect external radiation from weld inspections, or short-term use of other sources in the vicinity of the detector.

  Function description:

  If the current count rate exceeds the threshold set in **Io Factor** or in **RI Sigma**, the interference radiation warning will be issued. In this case:

  – the measured value is frozen and

  – the current output holds the last measured value

  The measurement remains frozen as long as the external radiation is present, plus the waiting time that has been set in **Waiting Time**.

  To get the warning messages, you have to evaluate the messages via the HART® signal or the digital output.

IMPORTANT

If interference radiation detection is enabled, the measured values are output with a delay. The delay is adjustable from 0 ... 5 seconds. The delay is required so that at the moment of detection the measured value remains unaffected, even though in this case, increased count rates are already present. For this reason, while interference radiation detection is active, no applications can be run where the reaction time must be below the set delay.

For detailed information please refer to the section Interference Radiation Detection (*chapter 7.2, page 3-372*).

If the source is closed often, or even regularly, then you should keep in mind that in such cases the measurement takes a longer time to return the measured value, because the sigma detection responds when the source is opened. The longer the time selected in **Waiting Time**, the longer the warm-up time.

- ***RAPID SWITCH***

  Rapid switchover is enabled.

  We recommend using the function ***RAPID SWITCH*** only for special applications where the output signal has to adapt rapidly to the new value, e.g. if sudden, strong changes in product density occur.

IMPORTANT

*The function **RAPID SWITCH** should not be enabled when the measurement is installed into a control loop, since this function operates with two different time constants.*

- ***PULSE LIMIT***

  Use this setting if the measurement is to start again without delay with the following conditions:

  – with the pipe running empty

  – with closed source shielding

  By entering count rate limits, the measurement can be stopped automatically and frozen until the count rate is back to normal. The measurement is therefore automatically stopped in the above situations until the pipeline is filled again, and the source shielding is open.

2 Io Factor

⇒ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

Io Factor defines the threshold where the interference radiation detection responds.

With the default value of 1.5, the threshold is 1.5 times the count rate obtained at the lower measuring range limit.

If the current count rate exceeds the threshold set in **Io Factor**, the interference radiation warning will be output. In this case:

– the measured value is frozen and

– the current output holds the last measured value

The factor for the threshold can be chosen as needed. Increasing the factor decreases the sensitivity. Factor ***1.5*** is suitable for most applications.

3 RI Sigma

⇒ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

RI Sigma must be set correctly to detect changes caused by interference radiation within the measuring range. This value is the threshold where the interference radiation detection responds if a sudden increase in radiation occurs. The default value of ***10*** is suitable for most applications. The response becomes less sensitive if you increase the value. You can enter the number ***0*** to turn the Sigma function off.

4 Waiting Time

⇒ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

If interference radiation is detected, the measurement is "frozen" and will be released at the earliest after the waiting period is over. The value must be entered in seconds and should be at least 3 times the time constant. If it is smaller and interference radiation is detected in quick succession, then it may happen that the interference radiation detection does not respond the second time, or only delayed.

To get the warning messages for "Radiation Interference", you have to evaluate the messages via the HART® signal or the digital output.

5 Meas Delay Time

⇒ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

If interference radiation detection is enabled, the measured values are output with a delay. **Meas Delay Time** is adjustable from 0 to 5 seconds.

The delay is required so that at the moment of detection the measured value remains unaffected, because in this case, increased count rates are already present which may distort the measured value. For this reason, while interference radiation detection is active, no applications can be run where the reaction time must be below the set delay.

6 RS Sigma

⇒ Displayed only when **Response Mode** = ***RAPID SWITCH***.

This value is the threshold where the rapid switchover responds. The higher the value, the higher the threshold and the less likely the response to interference radiation.

The default value of ***10*** is suitable for most applications.

The response becomes less sensitive if you increase the value.

7 Cps Upper Limit

⇒ Displayed only when **Response Mode** = ***PULSE RATE LIMITS*** .

Use this function for example to freeze the measured value when the pipeline is running empty. If the pipeline fills up again, then the time until the measured value becomes stable again is reduced.

Enter a value greater than zero to enable the upper count rate threshold. If the current count rate threshold exceeds the upper threshold, the measurement will be stopped until the measured value has fallen below the count rate threshold again. When the measurement is stopped, the measured value and the current output are "frozen".

8 Cps LowerLimit

⇒ Displayed only when **Response Mode** = ***PULSE RATE LIMITS*** .

Use this function for example to freeze the measured value when closing the shielding. If the shielding is opened again, then the time until the measured value becomes stable again is reduced.

Enter a value greater than zero to enable the lower count rate threshold. If the current count rate threshold falls below the lower threshold, the measurement will be stopped until the count rate threshold is exceeded again. When the measurement is stopped, the measured value and the current output are "frozen".

2.17 Source Exchange

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Source Exchange**.

Often, it is not apparent to the user when a source must be replaced. Activate the message "Source Exchange" if you want to be warned in time that the source has to be replaced. Reasons for a source replacement may be to ensure the measurement function, or, for radiation protection reasons, a maximum service life of the source.

To get the warning messages, you have to evaluate the messages via the HART® signal or the digital output.

IMPORTANT
Usually, the manufacturer recommends a service life of the source of about 10 years. A longer service life of the source has to be clarified with the Radiation Safety Officer in charge who is familiar with the local radiation protection requirements.
*The service life approved by the Radiation Safety Officer limits the maximum period of use, even if a longer technical service life is displayed under **Warning Date**. In this case, select **DATE** at **Selection** and enter the source exchange date specified by the Radiation Safety Officer.*

1 Selection

- ***OFF***

  No message is output.
- ***DATE***

  The message Source Exchange is output on a specific date. Enter the date in **Warning Date**.

2 Warning Date

If you have selected ***DATE*** at **Selection**, you have to enter the date when you want to get the Source Exchange warning (format: MM/DD/YYYY.

2.18 Cal Parameter

Menu path: **Device Config ▶ Setup ▶ Cal Parameter**.

In this menu you can calibrate and adjust the measuring system and set the parameters needed to perform the measurement.

Readjustment of an already calibrated measurement:

The count rates in this menu and the submenus are not decay compensated[1]. For this reason, after several weeks the calibration characteristic curve cannot be changed using data from **Cal Parameter**; rather, it must be changed using the values from **Meas Parameter**. These values correspond to the data the LB 480 is currently using to run measurements. The data in **Meas Parameter** also include the decay compensated count rates of the calibration points which were used last to calibrate the LB 480. Select **Recall** to obtain the decay compensated values. The current values from **Meas Parameter** (**Device Config ▶ Meas Parameter**) are copied back here.

IMPORTANT
*Changes in these parameters have an influence on the measurement only when you select the **Calibrate** command.*

Explanation "decay compensation":

Each source loses activity with time and becomes weaker. This is known as source decay. For this reason, the count rate measured at the detector decreases in the course of time. This process is mathematically reproducible and is automatically compensated - decay compensated - in this device.

1 Cal Points

This menu is used to determine the calibration points. The count rates for each calibration point are read in along with the current temperature (if a Pt100 is connected).

The type and manner of the calibration is selected from the **Cal Settings** menu under **Calibration Method**.

Only those parameters will be displayed that are required for each calibration method (**Calibration Method**).

2 Cal Settings

On this menu you enter the basic detector-specific parameters that need to be set before calibration.

3 Product Conditions

On this menu you enter the basic product-specific parameters that need to be set before calibration.

4 Adapt Calibration

The menu contains functions to take over older calibration data.

1. Each source will lose activity over time and become weaker; this is called source decay. For this reason, the count rate measured at the detector decreases in the course of time. The process can be calculated using a mathematical function and is automatically compensated for by the SENSseries detectors.

5 Calibrate

With this menu item you enable the calibration data determined during the measurements. In this case, the calibration data are transferred from **Cal Parameter** to **Meas Parameter**. Thus, the detector will get a new calibration which in the future will be used to determine the measured values.

After the calibration, a status message is displayed, indicating if the activation of the calibration data has been carried out successfully. If not, the measurement parameters are unchanged. Possible status messages are:

- ***0-OK***

  The calibration carried out is OK.

- ***1-ERROR BACKGROUND***

  The count rate for the background radiation (background) is higher than the count rates in the measuring range.

- ***2-ERROR MISSING CALIBRATION POINT***

  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:

  - ***DIRECT ENTRY***: none
  - ***1-POINT***: one
  - ***LINEAR***: two
  - ***SQUARE***: three
  - ***CUBIC***: four

- ***3-ERROR NOT MONOTONOUS***

⇒ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

  The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

  Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-COMPENSATION ERROR***

  A water temperature compensation is only possible if suspension measurement has been selected.

- ***5-DATE ERROR***

  A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.

- ***6-CHECK ERROR***

  The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

Please keep in mind that the parameters **Factor** and **Offset** are automatically reset at **Calibrate**.

5 Recall

Allows you to copy the current data set from **Meas Parameter** to **Cal Parameter**. This allows you to edit the valid parameters or read them in again, without this having an impact on the measurement and without having to read in all parameters again. After you have finished editing, you can activate the changed settings with **Calibrate**.

The use of **Recall** is also necessary because the count rates in the calibration parameters (**Cal Parameter**) are not decay compensated, unlike the count rates of the measuring parameters (**Meas Parameter**).

i ***IMPORTANT***

Recall *overwrites all settings of the* ***Cal Parameter*** *menu.*

2.19 Cal Points

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Points**.

i ***IMPORTANT***

Changes in this parameter group have an effect only when you call ***Calibrate*** *(****Device Config ▶ Setup ▶ Cal Parameter ▶ Calibrate****, page 3-287).*

This menu allows you to adjust the measuring system.

1 ReadIn

Start reading-in the count rates. While the count rate is read in, the average is calculated and displayed continuously. Under **ReadIn Time** (**Cal Settings**) you define the read-in period.

First choose which calibration point you want to read in:

- ***BACKGROUND***

⇒ Not required for CrystalSENS (50/50).

With SuperSENS and UniSENS you have to measure the background (**Background**) to enable the detector to correctly compensate for the decay of the radiation source.

Before taking measurements, make sure you do not measure any radiation from the radiation source

The easiest way to ensure this is if the source is not yet mounted. Otherwise, close the beam path and in addition fill the container or the pipeline.

- ***ACTIVE POINT***

  The count rate for the calibration point displayed under **Point No. Cal.** is read in.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

2 Background

⇒ Only important for large-volume detectors such as SuperSENS or UniSENS (rod detectors).

The term background refers to the background radiation which is present in the environment. The background radiation has to be measured so that the detector can correctly compensate for the decay of the radiation source.

Select ***ReadIn*** to read in the count rate for the background radiation. If you already know the value, you can enter it here.

3 Cal Point No.

Indicates to which calibration point the parameters below refer, such as **Cal Density** and **Cal Rate**.

4 Cal Concentration

⇒ The parameter appears only when suspension measurement is selected.

Enter here the analysis value of the concentration for the calibration point.

5 Cal Density

Enter here the analysis value for the calibration point.

If suspension measurement is selected, then this parameter indicates the density value converted from the concentration.

6 Cal Density TC

⇒ Visible only when **Temp. Comp** = ***ON***.

Shows the compensated density value.

Depending on the temperature value measured while reading in the counting rate and the settings under **Product Conditions** the temperature-compensated density or concentration value is automatically determined here.

7 Cal Rate

Calibration count rate.

Select **ReadIn** to read in the count rate. If you already know the value, you can enter it here.

8 Cal Temp

⇒ Visible only when **Temp. Comp** = ***ON***.

Saves the temperature measured during the reading in of the count rate.

9 Calibration Chart

Allows a clear presentation of the calibration points.

- **Max Nbr Cal Points**

  Displays the maximum possible number of calibration points.

- **Refresh Cal Table**

  Updates the calibration points in **Cal Table**.

- **Cal Table**

  Shows all calibration points in a table. You can edit the calibration points in this table.

- **Clear Table**

  Clears all calibration points in a table.

- **Calibration Curve**

  Shows all calibration points in a calibration curve.

10 Io Rate

⇒ Displayed only when **Calibration Method** = ***DIRECT ENTRY***.

Io is the count rate at zero density. It is a theoretical value which is calculated from a calibration with one or several calibration points. If this value is already known, it can be entered here. The calibration can then be performed together with **A1**. Calibration points and lab analyses are not required here.

11 Coefficient A1

⇒ Displayed only when **Calibration Method** = ***1-POINT*** or ***DIRECT ENTRY***

The absorption coefficient determines the sensitivity of the measurement.

– ***DIRECT ENTRY:***

  A1 has to be known and to be entered manually.

– ***1-POINT***:

  For density and suspension measurements, -0.066 can be used as default value for Cs-137 and -0.044 for Co-60 radiation sources, unless other values are known.

  These standard coefficients cannot be used with the unit % and length.

The absorption coefficient can be entered in two different ways.

Example with input value -0.066:

- -0.066
- -66e-3

Entering the value as a power of ten allows you to enter very small coefficients without any problems.

2.20 Cal Settings

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**.

All parameters defining basic settings before calibration can be entered on this menu.

1 Nuclide

Enter here the isotope (nuclide) that is used in your source:

- ***Co-60***
- ***Cs-137***
- ***USER DEFINED***

This entry controls the automatic decay compensation. The correct entry is also important for a one-point calibration. The isotope used is listed on the type plate of the shielding and on your delivery documents. The item ***USER DEFINED*** allows you to use any isotope you want. In this case, the parameter **Half Life Time** is queried in addition.

What happens when you have selected the wrong isotope?

As a result of the wrong decay compensation, you will get a deviating display only after several weeks or months, with the deviation increasing over time.

2 Half Life Time

⇒ Visible only when **Nuclide** = ***USER DEFINED***.

See **Nuclide**.

3 Calibration Method

Five different calibration methods are available. A selection guide can be found in chapter *chapter 5.3*.

- ***DIRECT ENTRY***

  Allows you to easily enter the characteristic curve parameters **A1** and **Io**, provided these are already known or have already been calculated. Calibration points are not needed here.

- ***1-POINT***

  One calibration point is enough (count rate and lab analysis) when for the user the density lies in the normal operating range. In addition to this calibration point and depending on the source, you also have to enter the standard absorption coefficient **A1**:

  - 0.066 for Cs-137
  - 0.048 for Co-60

- ***LINEAR***

  You can enter up to 11 calibration points for calibration. These should also be fairly different in their density varies, but they should also lie within the measuring range.

  With **Calibrate** the LB 480 draws a linear curve through the calibration points and calculates the characteristic curves in the form of a zero count rate and a linear (A1) calibration coefficient.

- ***SQUARE***

  At least 3 calibration points are required for this type of calibration.

  With **Calibrate** the LB 480 draws a square curve through the calibration points and calculates the characteristic curves in the form of a zero count rate, a linear (A1) and a square (A2) calibration coefficient.

- ***CUBIC***

  At least 4 calibration points are required for this type of calibration.

  With **Calibrate** the LB 480 draws a cubic curve through the calibration points and calculates the characteristic curves in the form of a zero count rate, a linear (A1), a square (A2) and a cubic (A3) calibration coefficient.

4 Measuring Path

The value to be entered is the length of the beam path through the measured product. With a 90° measuring path, this corresponds to the inner diameter of the pipe. Especially with the calibration ***1-POINT***, you have to enter this value accurate to the millimeter.

5 Unit Family

Select the unit family for the measurement. Depending on this entry, the relevant units are available for selection under **Unit**, such as:

- ***DENSITY*** (g/cm^3, kg/m^3, g/l, ...)
- ***LENGTH*** (m, mm, yard, ...)
- ***SUSPENSION*** (%sol-wt, g/l, °Be)

Please note: When selecting ***SUSPENSION***, the measurement operates in a mode in which the concentration level of a substance is measured, for example, the proportion of the solid in a carrier liquid (%sol-wt). Additional inputs for **Liquid Density** and **Solid Density** are required.

6 Unit

Select the unit in which the measured value is to be displayed. To select units that are not included in the list, you may need to change the **Unit Family**.

7 Lower Range Limit

Enter the lower limit of the measuring range where 4 mA is to be output.

8 Upper Range Limit

Enter the upper limit of the measuring range where 20mA is to be output.

9 ReadIn Time

Define here the period of time over which the count rate is to be read-in with **ReadIn** for each calibration point.

The statistical variation of the count rate is averaged over this time period. The longer it is, the better the mean value. A time period of 30 s (default setting) is usually reasonable.

2.21 Product Conditions

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Product Conditions**.

On this menu you enter the basic product-specific parameters that need to be set before calibration.

1 Temp Compensation

To make sure that temperature fluctuations in the product do not have any effect on the measured value, the measured density value has to be compensated using the current product temperature. First, you have to enter a reference temperature.

For a standard density measurement you now have to enter the values for **TC1** in g/cm3/°C or in g/cm3/°F. For concentration measurements where water is the carrier fluid, you can also enable the function ***WATER TC***.

For more information please see the section on temperature compensation on *page 3-356*.

The following parameters can be set:

- ***OFF***

  The temperature compensation is switched off.
- ***STANDARD TC***

  The standard temperature compensation is enabled. Enter the values for Ref Temp and TC1.
- ***WATER TC***

⇒ Displayed only if ***SUSPENSION*** is selected. Can only be used when water is the carrier fluid for the solid.

An internally stored density temperature curve then allows the temperature to be compensated without requiring any further input.

2 Ref Temp

An entry is required if the **Temp Compensation** is enabled, i.e. ***STANDARD TC*** was selected under **Temp Compensation**.

Enter the mean product temperature over the year in °C or in °F.

3 TC 1

An entry is only required if ***STANDARD TC*** is selected at **Temp Compensation**.

TC 1 the linear temperature coefficient. It is entered in g/cm^3/°C or in g/cm^3/°F. Exceptions are the units of length and the unit percent (density 3) where the temperature coefficient does not relate to g/cm^3 but directly to the respective unit.

A value of zero means that the compensation is turned off with **TC 1**.

IMPORTANT
The coefficient has to be entered as a positive value, i.e. without a negative algebraic sign if the density of the product decreases with rising temperature. Furthermore, TC1 has to be entered multiplied by 1000.

4 TC 2

An entry is only required if ***STANDARD TC*** is selected at **Temp Compensation** and a square coefficient (TC 2) needs to be added to the linear temperature coefficient **TC 1**.

A value of zero means that the compensation is disabled with **TC 2**.

IMPORTANT
TC2 has to be entered multiplied by 1,000,000.

5 Temp Unit

Unit for the detector temperature.

6 Liquid Density

⇒ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. In water, for example 1.00g/cm^3. For solutions, you have to enter the density of the main component.

7 Solid Density

⇒ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. For solutions, you have to enter the density of the main component.

Enter the density (g/cm^3) of the solid, and for solutions the density of the second component.

Example with sand as a solid:

With sand, the value to be entered corresponds to the average density of each individual grain of sand. This value is approximately 2.65g/cm^3.

2.22 Adapt Calibration

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Adapt Calibration**.

The menu contains functions to take over older calibration data.

1 Restore Upload

This feature helps you to use old calibration data again, for example, if the electronics had to be replaced and the old data is available.

The calibration data can then be entered manually or transferred as a file. Under **Restore Date** you have to enter the date of the old calibration data. You need to enable **Restore Upload** to transfer the data to the measuring parameters. The count rates are automatically decay-compensated.

IMPORTANT
Do not enable Calibrate, otherwise the old data will be transferred to the measuring parameters. You can enable Recall to update the calibration data again.

2 Restore Date

Works together with **Restore Upload**.

To transfer old calibration data decay-compensated to the measuring parameters, you must enter the date of the old data.

Then you have to transfer the calibration data to the measuring parameters with **Restore Upload**.

2.23 I/O Setup

Menu path: **Device Config ▶ Setup ▶ I/O Setup**.

This menu allows you to set the analog and digital inputs and outputs and the interfaces.

1 Current Output

Opens the menu with the settings for the current output (*page 3-297*).

2 Digital Output

Opens the menu with the settings for the digital output (*page 3-299*).

3 Pt 100

Opens the menu in which the Pt100 input can be adjusted

4 Digital Input

Opens the menu with the settings for the digital input (*page 3-303*).

5 HART Interface

Opens the menu with the settings for the HART® interface *(page 3-304)*.

2.24 Current Output

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Current Output**.

1 Current Loop Monitoring

Enable or disable the monitoring of the
4-20 mA current signal. Monitoring checks whether the set current is actually flowing in the current loop, and signals an error if any deviation is detected.

You have the following setting options:

- ***ENABLED***

  Monitoring is enabled. (Factory setting)

  Unless there are compelling reasons, you should keep this setting. If you enable the **Safety Mode**, ***ENABLED*** is set here automatically.

- ***DISABLED***

  Monitoring is disabled. The HART® Communicator outputs a corresponding message.

Tip

In case of a gross deviation or loose contact, monitoring may have the effect that the fault condition can only be reset by a software reset. The software reset can be done in the menu **Service** (**Device Config ▶ Setup ▶ Service ▶ Reset Device**, *page 3-305*) or by turning the power supply off and then on again.

2 Loop Alarm Type

Here you specify the fault current, i.e. the current that is to be output in case of error.

> **i** ***IMPORTANT***
> *In Safety Mode, only the values "High" and "Low" are possible.*

You have the following setting options:

- ***High***

  In case of error the current output is set to >21mA.
- ***Low***

  In case of error the current output is set to <3.6mA.
- ***Hold Last Value***

  In case of error the current output holds the last measured value.
- ***Value***

  In case of error, the current output is set to the current value, which is set in **Error Current Value**.

3 Error Current Value

Here you define the fault current in mA if you have selected ***Value*** in the **Loop Alarm Type** parameter.

If you have selected ***High*** or ***Low***, then the appropriate current value is displayed here (>21mA/<3.6mA).

4 Current Lower Limit

Lower limit of the current range for the 4-20 mA current output.

For adjustment purposes or to safely identify an over or under measuring range condition, the current range available for the measurement signal is extended beyond the standard range of 4 mA and 20mA.

According to the Namur specifications (NE 43), the lower current value must not be less than 3.8 mA. The limits can be set within the range from 3.8 mA to 4 mA.

5 Current Upper Limit

Upper limit of the current range for the 4-20 mA current output.

For adjustment purposes or to safely identify an over or under measuring range condition, the current range available for the measurement signal is extended beyond the standard range of 4 mA and 20mA.

According to Namur specifications (NE 43), the upper current value must not be higher than 20.5mA. The limits can be set within the range from 20 mA to 20.5 mA.

6 D/A trim

Allows you to adjust the current output. You will need a current meter which has to be connected to the current loop. A method will take you through the adjustment.

2.25 Digital Output

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output**.

The digital output provides a wiring for different signals. Without additional I/O cards the digital output is an open collector which is switched fail safe. This means that the transistor is conductive, as long as no alarm is reported and is blocked if an alarm is signaled. For more information on the digital output, see *Volume 2* in *chapter 3, "Electrical Installation", page 2-185*.

IMPORTANT

*If you use the setting **NORMAL** in the menu **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter ▶ Error Handling**), only errors are reported via the current output. Alerts can then be received only through one of the following signal outputs:*
- *via the digital output as a binary signal*
- *via the HART® signal as a text message*

3

1 Digital Out Function

The digital output provides a wiring for different signals. Without additional I/O cards the digital output is an open collector which is switched fail safe. This means that the transistor is conductive, as long as no alarm is reported and is blocked if an alarm is signaled. For more information on the digital output, see *Volume 2* in *chapter 3, "Electrical Installation", page 2-185*.

IMPORTANT

*If you use the setting **NORMAL** in the menu **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter ▶ Error Handling**), only errors are reported via the current output. Alerts can then be received only through one of the following signal outputs:*
- *via the digital output as a binary signal*
- *via the HART® signal as a text message*

You have the following setting options:

- ***ALARM***

  The alarm is triggered when the limit value is exceeded or fallen below, i.e. it responds in parallel with the current output. The switching behavior depends on the selected output function min/max, as described in **Switch Function**.

- ***DET. TEMP***

  The alarm is triggered when the detector temperature is below or above the permissible temperature range. The temperature range is defined in **Sensor Temperature (Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Temp. Threshold Settings,** *page 3-301***)**.

- ***HOLD***

  The alarm is triggered when the measurement is on hold, i.e. the measured value is frozen. This can be caused, for example, by the digital input or by RID.

- ***WARNING + ERROR***

  The alarm is triggered when the detector signals an error or reports a warning. In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

- ***RAD. INTERF.***

  An alarm is triggered as soon as interference radiation is detected.

  See under **Rad. Interf.** in the menu **Signal Condition ▶ Signal Dependency** (see *page 3-282*).

2 Digital Out State

Displays the current value of the digital output. If the test mode is active, then the test value is displayed. The following functions can be displayed:

– ***Normal***

– ***Alarm***

3 Threshold Settings

Opens the menu in which you can set alarm limit values for the density.

4 Temp. Threshold Settings

Opens the menu for the temperature-related settings *(page 3-301)*.

2.26 Threshold Settings

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Threshold Settings**.

1 Switch Function

Here you define whether the switching function for the digital output (open collector) is used as a High Alarm or Low Alarm. The switching direction ensures the fail-safe function of the digital output (open collector).

You have the following setting options:

- ***MAX***

  Alarm is triggered if the limit value is exceeded (high alarm).
- ***MIN***

  Alarm is triggered if the limit value is not reached (low alarm).

2 Threshold

Enter the limit value of the selected unit for the density or concentration where the alarm is to be triggered.

3 Hysteresis

The hysteresis prevents switching back and forth caused by statistical fluctuations of the measured values.

2.27 Temp. Threshold Settings

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Temp. Threshold Settings**.

1 Temp. Upper Limit

Upper limit value for the detector temperature.

An alarm may be signaled via the digital output if this temperature is exceeded. To do this, set the digital output to the function ***DET. TEMP***. The alarm is also signaled when the minimum detector temperature (**Temp. Lower Limit**) is not reached.

Tip

You can use this feature, for example, as a pre-alarm, for the detection of an over-temperature, or to control the cooling water cycle of the detector so that the cooling water flow is started at elevated temperature.

2 Temp. Lower Limit

Lower limit value for the detector temperature.

An alarm may be signaled via the digital output if this temperature is not reached. To do this, set the digital output to the function ***DET. TEMP***. The alarm is also signaled when the maximum detector temperature (**Temp. Lower Limit**) is exceeded.

Tip

You can use this function as a pre-alarm for under-temperature, so that a possibly connected cooling water system does not freeze, or a heater is turned on.

3 Temp. Hysteresis

Hysteresis for the temperature limit values.

4 Device Temp.

Displays the temperature inside the detector.

2.28 Pt100

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Pt100**.

1 Pt100 Temp

Shows the current Pt100 temperature.

2 Pt100 Adjustment

Allows you to adjust the Pt100 input new. The adjustment has already been made at the factory. If an adjustment should be required, then this must take place at a resistance of 100 Ω (max. ±1 Ω).

3 Pt100 Fine Tuning

Allows a fine adjustment after **Pt100 Adjustment** was performed, when the temperatures in the upper temperature range cannot be displayed with sufficient accuracy. For this purpose, the current actual temperature can be entered. Alternatively, you can also use a known resistance (max. ±1 % tolerance) to adjust the resulting temperature. In order to minimize calibration errors, the fine tuning should be carried out, if possible, using the maximum temperature possible during operation, but at least at more than 50°C.

2.29 Digital Input

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Input**.

The digital input can be controlled by the process control system. The reaction occurs when a short circuit of the input takes place; the signal must be bounce-free.

IMPORTANT
*If **Safety Mode** is enabled, the digital input is disabled automatically.*

The digital input is only available as an option. It is available for versions with HART® signal, but not for detectors with fail-safe signal output.

1 Digital In Function

Here you can define the switching function of the digital input. You have the following setting options:

- ***OFF***

  The digital input is disabled.

- ***HOLD***

  The measurement is frozen (hold mode) as long as the contact is closed.

IMPORTANT
The digital input is optional and can be used only when the detector has been prepared accordingly.

2 Digital In State

Indicates whether the input is open or closed.

2.30 HART Interface

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ HART Interface**.

1 Poll Addr

Shows the current polling address. The address can be set with **Set Poll Address**.

2 Set Poll Address

Allows you to set the polling address for multidrop operation.

Enter only a polling address > 0 if the multidrop mode is used to operate several HART® devices at one current loop. Otherwise, leave the value at 0, since with a polling address > 0 the current output has no function anymore.

To use the multi-drop mode the current output must be passive (sink mode).

Multidrop mode

The host terminal uses the multidrop mode to identify the field device if more than one HART® device is connected to the same HART® loop. From HART® 6, up to 63 HART® devices can be interconnected in one HART® loop. Each device must have a different polling address between 1 and 63.

If an address is set which is higher than 0, the Multidrop Mode is selected automatically and the current output is switched to a fixed current value of 4 mA. Then only the digital HART® communication will be available.

IMPORTANT

For safe HART® communication, the current output must have a minimum impedance of 250ohms and a maximum impedance of 500ohms.

3 Num Req Preams

Display of the requested preambles during communication between detector and communicator to initiate the start of communication.

The value is set to 3 and cannot be changed.

4 Num Resp Preams

Number of returned preambles during communication between detector and communicator to initiate the start of communication.

The default value is 5. At a higher number, the communication is slowed down slightly. The setting range is 5 to 20.

2.31 Service

Menu path: **Device Config ▶ Setup ▶ Service**.

This menu allows you to access various test functions, enter the license key and perform a detector reset.

1 PMT

Opens the menu showing the anode current of the photomultiplier (PMT) *(page 3-306)*.

2 Sensor Temperature

Opens the menu showing the various detector temperatures *(page 3-306)*.

3 Test

Opens the menu with the various test functions *(page 3-307)*.

4 Plateau

Opens the menu for the plateau measurement and display of the plateau values *(page 3-312)*.

5 License Key

The license key allows you to enable the detector for other applications (level, density). You can get a license key through your sales partner or directly from BERTHOLD TECHNOLOGIES GmbH & Co. KG.

6 Reset Device

The menu offers you several ways to reset the detector or certain functions:

- ***MODIFICATION LOG RESET***

  Deletes all entries in the **Modification Log**.
- ***ERROR LOG RESET***

  Deletes all entries in the **Error Log**.
- ***SW RESET*** (Software Reset)

  Starts the detector new. The function corresponds to the switching off and on of the supply voltage.
- ***FACTORY RESET***

  Resets most settings to factory default. Some settings, such as the adjustment of current output and the license key will be preserved.

2.32 PMT

Menu path: **Device Config ▶ Setup ▶ Service ▶ PMT**.

This menu allows the qualification of the photomultiplier (PMT) after consultation with BERTHOLD TECHNOLOGIES. Increased current values at the multiplier indicate a strong radiation levels (caused, for example, by weld testing), or a defect at the PMT, or the HV control.

1 HV Live

Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

2 HV Feedback

Display of the read back HV value which is actually present at the multiplier. The display is used to control the HV.

3 Meas CH CPS

Count rate in the measuring channel.

4 Control CH CPS

Count rate in the control channel.

5 Auxiliary CH CPS

Count rate in the auxiliary channel.

6 PMT Current

Displays the current anode current.

7 PMT Current Max

Display of the stored maximum value for the multiplier tube current (**PMT Current**).

8 Reset Current Extrema

Clears the maximum value of the multiplier tube current (**PMT Current Max**).

2.33 Sensor Temperature

Menu path: **Device Config ▶ Setup ▶ Service ▶ Sensor Temperature**.

On this menu you can view the various detector temperatures.

1 Device Temp.

Displays the current detector temperature. The temperature is measured in the electronics of the detector.

2 Device Temp. Min

Display of the lowest temperature measured.

3 Device Temp. Max

Display of the highest temperature measured.

4 Reset Temp Extrema

Clears the stored values in **Device Temp. Min** and **Device Temp. Max**.

2.34 Test

Menu path: **Device Config ▶ Setup ▶ Service ▶ Test**.

These menus allow you to perform various tests on the detector. All tests have a direct influence and are not delayed by the time constant.

If you lock the device with the password or if the Safety Mode is enabled, all test settings will be disabled automatically.

1 Test Settings

Opens the menu offering various test options for the detector *(page 3-307)*.

2 I/O Test Settings

Opens to the menu offering various test options for the digital inputs and outputs *(page 3-310)*.

2.35 Test Settings

Menu path: **Device Config ▶ Setup ▶ Service ▶ Test ▶ Test Settings**.

This menu allows you to check your calibration setting by simulating the measurement signal.

1 Meas Mode

Here you can check if the process value is correctly transmitted from the field device to the process control system.

To simulate a density reading, you have to:

1. Enter a value in **Density** (concentration).
2. Select ***FIXED VALUE*** at **Meas Mode**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise your measurement signal will remain frozen at this value.*

2 Density

Enter the value to be simulated.

To enable the simulation, you must set ***FIXED VALUE*** at **Meas Mode**.

3 Cps Average Mode

This item allows you to check whether your calibration is correct. Enter a count rate and then check the simulated density reading.

To simulate a density reading via a count rate, you have to:

- Enter a count rate at **Cps Average Test**.
- Select ***FIXED VALUE*** at **Cps Average Mode**.

IMPORTANT

*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise your measurement signal will remain frozen at this value.*

4 Cps Average Test

Enter the value to be simulated.

To enable the simulation, you must set ***FIXED VALUE*** at **Cps Average Mode**.

5 Product Temp. Mode

This makes it possible to simulate temperature compensated calibration values. In addition to the count rate, the temperature can be entered here in addition at which the count rate was recorded. As a result, the laboratory density has to be displayed. In a multipoint calibration, deviations may occur due to the regression of the calibration curve.

To enter a test temperature, you have to:

- Enter a temperature value in **Product Temp. Test**.
- Select ***FIXED VALUE*** at **Product Temp. Mode**.

IMPORTANT

*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise the temperature signal will remain frozen at this test value.*

6 Product Temp. Test

Enter a temperature value in order to test the digital output as a signal output for over- or under-temperature.

To enable the simulation, you must set ***FIXED VALUE*** at **Product Temp. Mode**.

7 Device Temp. Mode

Allows you to verify if over- or under-temperature is signaled via the digital output. Enter a test temperature and then check the signal at the digital output.

To check the digital output as a temperature output, you have to:

- set the digital output to ***DET. TEMP***,
- enter a count rate in **Cps Average Test**,
- select ***FIXED VALUE*** in **Cps Average Mode**.

IMPORTANT

*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise the temperature signaling will be kept.*

8 Device Temp. Test

Enter a temperature value in order to test the digital output as a signal output for over- or under-temperature.

To enable the simulation, you have to set **Device Temp. Mode** to ***FIXED VALUE***.

2.36 I/O Test Settings

Menu path: **Device Config ▶ Setup ▶ Service ▶ Test ▶ I/O Test Settings**.

This menu allows you to perform various tests on the analog and the digital inputs and outputs.

1 Digital Out Mode

This allows you to check whether the signal from the digital output is correctly transmitted to the control system.

To enable the test, you have to:

▶ Select ***FIXED VALUE*** at **Digital Out Mode**.

▶ Enter ***CLOSED*** or ***OPEN*** at **Digital Out Test State**.

2 Digital Out Test State

Choose ***OPEN*** or ***CLOSED*** to check the appropriate reaction at the digital output.

To enable the simulation, you have to set **Digital Out Mode** to ***FIXED VALUE***.

3 Digital In Mode

Allows you to simulate a signal at the digital input and examine its impact on the detector.

To enable the test, you have to:

▶ Set a function for the digital input via **Digital In Function** (**Device Config ▶ Setup ▶ I/O Setup ▶ Digital Input ▶ Digital In Function**, *page 3-303*).

▶ Select ***FIXED VALUE*** at **Digital In Mode**.

▶ Enter ***CLOSED*** or ***OPEN*** at **Digital In Test State**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise the signaling will be kept.*

4 Digital In Test State

Choose ***OPEN*** or ***CLOSED*** to check the appropriate reaction of the detector.

To enable the simulation, you must set ***FIXED VALUE*** at **Digital In Mode**.

5 Loop Current Mode

Indicates whether the current output is active or frozen. The following displays are possible:

- ***ENABLED***

  The current output is active.
- ***DISABLED***

  The current output is frozen.

The current output is frozen in the following cases:

- if it is set to fault current
- in multi-drop mode (**Set Poll Address**, see *page 3-304*)
- in test mode

6 Loop test

Allows you to selectively output current values at the current output. Thus you can check the correct function of the current output and the display value in the process control system. Enter the desired value in mA.

2.37 Plateau

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau**.

This menu leads to the plateau measurement and to the display of the plateau values.

1 Plateau Measurement

Leads to the plateau measurement (*page 3-312*).

2 Plateau View

Enables the display of the plateau data in a table or as a plateau curve *(page 3-313)*.

3 Plateau Information

General information on the plateau measurement *(page 3-314)*.

2.38 Plateau Measurement

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau Measurement**.

These parameters determine how the plateau measurement is to be performed.

For information on how to perform a plateau measurement please refer to *chapter 6.1*, *page 3-367*.

1 HV Start

Enter the HV start value in volts.

2 HV Stop

Enter the HV stop value (end value of the measurement) in volts.

3 HV Step

Enter the step size in volts, which should lie between the measuring points.

4 Meas. Time

Enter the length of time over which each measuring point should be averaged, for example 20 s.

5 HV Mode

The menu item offers the following options:

- ***AUTO***

  Enables the automatic HV control. Set this operating mode for the normal measurement mode. This enables a temperature-stable operation of the detector.

- ***MANUAL***

  This setting is typically used for testing purposes only. You can specify, for example, the provisional operating point of the detector. The specified voltage must, however, lie in the plateau.

  As soon as you enable ***Manual***, the automatic HV control is switched off. The HV is then set to the value specified in **HV Manual**.

- ***PLATEAU***

  Starts the plateau measurement. The measurement mode is exited and the plateau of the multiplier which is used in the detector is measured. The measurement is done with the settings defined in the menu items **HV Start**, **HV Stop**, **HV Step** and **Meas. Time**.

  At the end of the plateau measurement the detector automatically switches back to **HV Mode**:

6 HV Live

Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

7 Cps Live

Shows the current non-averaged count rate.

2.39 Plateau View

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau View**.

This menu allows you to display the plateau data in a table or as a plateau curve.

1 Refresh Plateau

Updates the plateau table by loading the data from the detector.

2 Plateau Table

Shows the plateau data points in a table.

3 Plateau Curve

Shows the plateau data points in a curve.

2.40 Plateau Information

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau Information**.

General information on the plateau measurement.

1 Plateau Date

Shows the date of the last plateau recording.

No plateau recording exists, if the date 01/01/2000 is displayed.

2 Plateau Tab Entries

Displays the number of data points for the plateau measurement.

2.41 Meas Parameter

Menu path: **Device Config ▶ Meas Parameter**.

These menus show the currently valid measurement parameters.

1 Meas Data

Opens the menu showing the currently measured values *(page 3-315)*.

2 Meas Settings

Opens the menu showing the most important detector settings *(page 3-316)*.

2.42 Meas Data

Menu path: **Device Config ▶ Meas Parameter ▶ Meas Data**.

Shows the calibration curve and the calibration points used by the measurement. The values were calculated from the **Cal Parameter** menu with ***Calibrate*** and taken over.

1 Coefficient A1

Absorption coefficient 1.

Determines the slope and thus the sensitivity of the measurement.

2 Coefficient A2

Absorption coefficient 2.

Is calculated only for the calibration modes ***SQUARE*** and ***CUBIC***.

3 Coefficient A3

Absorption coefficient 3.

Is calculated only for the calibration mode ***CUBIC***.

3 Io Rate

Count rate calculated at density = 0.

4 Square Error

Shows the least squares for the current calibration with multi-point calibrations (at least three pairs of values are required).

The smaller the numerical value, the better the curve fitting. For values greater than 0.002, you should check your calibration for input errors; values below 0.0005 are very good.

5 Measuring Path

Enter the length of the absorption path (measuring path in the medium). Generally it corresponds to the inner diameter of the pipe. Especially with the calibration ***1-POINT***, you have to enter this value exactly to the millimeter.

6 Background

Shows the calibration value of the background radiation.

7 Measuring Table

After calibration, the calibration points are displayed here in a table.

3

2.43 Meas Settings

Menu path: **Device Config ▶ Meas Parameter ▶ Meas Settings**.

1 Nuclide

Display of the isotope (nuclide) selected for the calibration. It must be the same as the source which is used at the measuring site.

2 Cal Method

Indicates which type of calibration was last performed.

3 Temp Compensation

Shows which temperature compensation is used for compensation.

- ***OFF***

  The temperature compensation is disabled.

- ***STANDARD TC***

  The standard temperature compensation is enabled. The following settings are active:
  - Ref Temp
  - TC 1
  - TC 2

- ***WATER TC***

  The temperature compensation with water TC is enabled.

4 Ref Temp

Mean product temperature entered by the user.

5 TC 1

Linear temperature coefficient used to compensate the measurement, provided ***STANDARD TC*** has been selected.

A value of zero means that the compensation with **TC 1** is turned off.

6 TC 2

Square temperature coefficient used to compensate the measurement, provided ***STANDARD TC*** has been selected.

A value of zero means that the compensation with **TC 2** is turned off.

7 Liquid Density

Enter the density of the carrier fluid in g/cm^3. The value is only relevant if suspension measurement is enabled.

8 Solid Density

Enter the density of the solids in g/cm^3. The value is only relevant if suspension measurement is enabled.

2.44 Access

Menu path: **Device Config ▶ Access**.

On this menu you can enter the password, enable write protection to prevent configuration changes and activate the safety mode.

1 Password

Enter a password to protect the detector against unauthorized access. Then access to editable parameters is disabled. To undo the protection again, you must enter the password again.

You can choose any password you want; it may comprise a maximum of 8 characters or digits.

Tip
Write down your password to be able to unlock the detector later. Please contact BERTHOLD TECHNOLOGIES if you lose your password.

2 Write Protect

Indicates whether the detector is protected against changes in the settings (parameters).

- ***NO***

  The detector is not write protected, so that the settings can be edited.
- ***YES***

  The detector is write protected; settings cannot be edited, but they can still be displayed.

3 Safety Mode

Indicates whether the safety mode is enabled:

- ***ON***

  Safety mode is enabled.
- ***OFF***

  Safety mode is disabled.

4 Safety ON

The safety mode has to be enabled for safety-relevant applications.

IMPORTANT
*Activation of the Safety Mode does not automatically turn a detector into a device that can be used in a SIL safety circuit. Only a system marked SIL on the type plate can be used with the SIL data in the safety manual in a safety circuit. SIL-certified detectors are marked with an "S" in the LB number key: LB 480-xx-xx-xx-xx-x**S**x-x.*

In safety mode, safety-limiting values are set to a safety-compatible setting. In addition, you will be prompted to protect the detector with a password.

The following settings must be set to enable the **Safety Mode**:

- Current Loop Monitoring = ***ENABLED***
- High voltage control = ***AUTO***
- Test Settings = ***NORMAL***
- Digital inputs: Digital In Function = ***OFF***
- Multidrop: Poll Addr = ***0***

When enabling the **Safety Mode**, the parameter **Error Handling** is automatically set to ***SENSITIVE***.

During multi-detector operation, all connected slave detectors are also set to **Safety Mode** as soon as the Master is set to **Safety *ON***.

IMPORTANT
***HV default** must have the correct value (operating point).*

If you have changed the factory-set HV value, you have to determine it again. Determine the operating point and enter this value at **HV Default** (**Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings ▶ HV Default**, *page 3-278*). See also *chapter 6.1*, *page 3-367*.

Tip
The operating point in new detectors is usually between 400 to 900 V. If you get a different value, please contact BERTHOLD TECHNOLOGIES or your local representative.

5 Safety OFF

Disables the safety mode. Keep the password handy in case you want to make changes, because you will need any time you make changes.

If you disable the safety mode, the following settings are made automatically:

- the detector is unlocked, i.e. **Write Protect** is set to ***OFF***.
- **Error Handling** is set to ***NORMAL*** *(page 3-279).*
- **Response Mode** is set to ***DISABLED*** *(page 3-287)*

6 Lock Device Status

Indicates whether the detector is enabled or disabled for access to the HART® interface by other users.

7 Lock/Unlock Device

Locks or unlocks the detector to prevent access by other users to the HART® interface.

2.45 Identification

Menu path: **Device Config ▶ Identification**.

This menu shows various detector parameters, such as model, device ID, software and hardware revision.

1 Location
Opens the menu showing information about the tag *(page 3-320)*.

2 Device Information
Opens the menu showing information about the detector *(page 3-321)*.

3 Device Revision
Opens the menu showing the hardware and software revisions *(page 3-321)*.

2.46 Location

Menu path: **Device Config ▶ Identification ▶ Location**.

This menu shows information about the tag.

1 Tag
Shows the tag number. You can edit information, any text is possible. Up to 8 characters.

2 Long tag
Shows the tag number. You can edit information, any text is possible. Up to 32 characters.

3 Descriptor
Shows a tag description. You can edit information, any text is possible.

4 Message
Shows a message. You can edit information, any text is possible.

2.47 Device Information

Menu path: **Device Config ▶ Identification ▶ Device Information**.

This menu shows information about the detectors.

1 Device Type

Shows the model name of the SENSseries. This information cannot be edited by the user.

2 Device Id

Identification number of the detector. It shows the specific HART® device number. This information is set up by BERTHOLD TECHNOLOGIES and edited be changed by the user.

3 Manufacturer

Shows the manufacturer's name. This information cannot be edited by the user.

4 Final Assembly Num

Number for identification of the detector.

2.48 Device Revision

Menu path: **Device Config ▶ Identification ▶ Device Revision**.

This menu shows the hardware and software revisions.

1 Universal Rev

Shows the revision of the specific universal HART® command set.

For the SENSseries you need the Universal Commands for HART® 6 or higher. This requires that the 375 Field Communicator of the Emerson Process Management GmbH & Co. OHG or a compatible model is used which supports enhancements.

If the Communicator has a lower version than HART® 6, then the so-called *Generic DD* will be started. The Generic DD does have a HART®-specific command set, but this does not sufficient for the SENSseries.

2 Field Dev Rev

Shows the compatibility of the detector with DD on the Communicator. This number, e.g. 2, indicates that DD Revision 2 is necessary which supports the full functional range of the detector. See also *chapter 7.6*, *page 3-386*.

3 Software Rev

Displays the software revision (embedded software). This information depends on the currently installed firmware and cannot be changed.

4 SW Revision

Software revision with presentation according to NAMUR.

5 SW Revision Date

Date of the software revision.

6 Hardware Rev

Shows the hardware revision. This information is set up by BERTHOLD TECHNOLOGIES and edited be changed by the user.

2.49 Diagnostic

This menu provides status and error information and allows you to view the error logs and setting changes logs (parameter changes).

Tip
In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

1 Operating Status

Opens the menu showing the operating status *(page 3-322)*.

2 Log

Opens the menu showing the logs for error and setting changes *(page 3-326)*.

3 Safety

The status of all settings listed here must be ***OFF***, when you have enabled **Safety ON** (**Device Config ▶ Access**, *page 3-317*).

4 Error Status 100 … 907

Here you can check the status of all error messages that are possible in the detector.

- ***OFF*** = error free
- ***ON*** = an error is indicated

2.50 Operating Status

Menu path: **Diagnostic ▶ Operating Status**.

1 Device Status

Displays the current device status (standard HART® command).

2 Ext dev status

Shows the extended device status (standard HART® command).

3 Device Variables Status

Opens the menu showing the status of the detector variable (standard HART® command, *page 3-323*).

4 Config Change Status

Opens the menu showing the status of the detector variable (standard HART® command, *page 3-323*).

5 Lock Dev Status

Indicates to what extent the device is locked against access to the HART® interface.

– ***Device is Locked***
– ***Lock is Permanent***
– ***Locked by Primary Master***

6 Error Status

Opens the menu showing the status of the detector variable (standard HART® command, *page 3-323*).

2.51 Device Variables Status

Menu path: **Diagnostic ▶ Operating Status ▶ Device Variables Status**.

1 Data Quality

Indicates the quality of the main variables (standard HART® command).

2 Limit Status

Indicates whether the limits of the main variables were reached (standard HART® command).

2.52 Config Change Status

Menu path: **Diagnostic ▶ Operating Status ▶ Config Change Status**.

1 Modification Counter

Shows the number of parameter changes carried out since the last reset with **Reset Modification Flag**.

2 Reset Modification Flag

Sets the Modification Counter to 0.

2.53 Error Status

Menu path: **Device Config ▶ Diagnostic ▶ Operating Status ▶ Error Status**.

1 Meas Setup Status

Displays the status of the calibration parameters. The status is updated after each decay compensation (at 09:01 h) and after each date change. It informs you that the measurement is still working safely. One of the following status messages is displayed:

One of the following status messages is displayed:

- ***0-OK***

  The calibration carried out is OK.

- ***1-ERROR BACKGROUND***

  The count rate of the background radiation is higher than that for the calibration points for empty or full (**Cal Point 0%** or **Cal Point 100%**).

- ***2-ERROR MISSING CALIBRATION POINT***

  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:
  - ***DIRECT ENTRY***: none
  - ***1-POINT***: one
  - ***LINEAR***: two
  - ***SQUARE***: three
  - ***CUBIC***: four

3

- ***3-ERROR NOT MONOTONOUS***

⇒ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-DATE ERROR***

A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.

- ***5-CHECK ERROR***

The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

2 Operating Mode

Displays the operating status of the measurement. One of the following status messages is displayed:

- ***RUN***

  The measurement is in the normal measurement mode.

- ***WARNING***

  A warning of error category **2** is displayed and the following steps are carried out:

  - entry in the error log (the error is stored in the error memory)
  - the error will be reported digitally via HART®
  - the error is reported binary via the digital output (Digital Out) if this output has been set to ***WARNING + ERROR*** (see *chapter 2.27*, *page 3-299*)

  If the error is no longer displayed in **Active Error**, you can check the error log (**Device Config ▶ Diagnostic ▶ Log**, *page 3-326*). In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

- ***ERROR***

  An error of error category **1** is displayed and the following steps are carried out:

  - entry in the error log (the error is stored in the error memory)
  - the error will be reported digitally via HART®
  - the error is reported binary via the digital output (Digital Out) if this output has been set to ***WARNING + ERROR*** (see *chapter 2.27*, *page 3-299*)
  - the fault current goes to >21mA

  If the error is no longer displayed in **Active Error**, you can check the error log (**Device Config ▶ Diagnostic ▶ Log**, *page 3-326*). In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

- ***SHUTDOWN***

  A serious error of error category **0** is displayed and the following steps are carried out:

  - entry in the error log (the error is stored in the error memory)
  - the error will be reported digitally via HART®
  - the error is reported binary via the digital output (Digital Out) if this output has been set to ***WARNING + ERROR*** (see *chapter 2.27*, *page 3-299*)
  - the fault current goes to >21mA
  - the measurement is stopped.

  The error remains active until it is eliminated and a reboot or software reset has been carried out. If the error does not disappear after restart (power off and then on, or software reset, *page 3-305*), then the detector must be replaced.

- ***HOLD***

  The measurement is in the hold state, which means that the measured value and the current output signal are frozen. This status can occur under the following conditions:

  - the plateau recording is running
  - interference radiation is detected
  - the digital input (option) is shorted

- ***TEST***

- A test value has been enabled in the menu **Service▶ Test** (*page 3-305*).

3 Error Code

Indicates if an error message is present.

If no error is present, then ***0*** is displayed here.

An error message is displayed with a three digit number.

The cause of the error and suggestions for correcting the error are described in *chapter 8*, *"Error Handling"*.

4 Acknowledge Error

Acknowledges the currently pending error.

2.54 Log

Menu path: **Device Config ▶ Diagnostic ▶ Log**.

This menu provides information about the history of the error messages and parameter changes. Up to 25 events can be entered.

1 Error Log

Opens the menu displaying the errors that have occurred.

2 Modification Log

Opens the menu showing the history of the settings made.

2.55 Error Log

Menu path: **Device Config ▶ Diagnostic ▶ Log ▶ Error Log**.

Update the error log by selecting **Refresh Error Log** before you select one of the following menu items. Otherwise, no or only old entries may be displayed.

Tip
In *chapter 8* on *page 3-391* you find a list of possible causes and troubleshooting procedures.

1 Refresh Error Log
Updates entries in the error log table.

2 Error Log Table
The last 25 errors are displayed in a table. The table contains the error code and the time the error occurred. The prerequisite is that the date and time were set correctly.

3 Reset Error Log
Deletes all entries in the error log.

4 Error Code
Indicates if an error message is present.

If no error is present, then ***0*** is displayed here.

An error message is displayed with a three digit number. The cause of the error and suggestions for correcting the error are described in *chapter 8*, *Error Handling*.

5 Acknowledge Error
Acknowledges the currently pending error.

2.56 Modification Log

Menu path: **Device Config ▶ Diagnostic ▶ Log ▶ Modification Log**.

Update the modification log by selecting **Refresh Modification Log** before you select one of the following menu items. Otherwise, no or only old entries may be displayed.

1 Refresh Modification Log
Updates the modification log.

2 Modification Log Table
The last 25 modifications are displayed in a table. The table includes the old and the new parameter value and the time the change was made. The prerequisite is that the date and time were set correctly.

3 Reset Modification Log
Deletes all entries in the modification log.

3

Getting Started via the HART® Communicator

The measuring system SENSseries LB 480 is compatible with the 375 Field Communicator (HART® Communicator, HART = Highway Addressable Remote Transducer) by Emerson Process Management GmbH & Co. OHG. Other HART® compatible communicators may also be used, provided they support Enhancements. The HART® Communicator Model 275 by Emerson Process Management GmbH & Co. OHG *cannot* be used.

⚠ WARNING

Make sure before commissioning that

- the detector is not damaged,
- the detector is properly installed,
- the connections have been carried out properly,
- the cables are properly inserted,
- unused cable entries are sealed with plugs certified according to Directive 2014/34/EU,
- the cover is tight,
- the dummy plugs and cable glands or conduits are tight.

The measuring system can be taken into operation either via the *HART® Communicator* or via a *PC and the SIMATIC PDM* software.

Basically, the procedure for getting started is nearly identical for both versions. The difference is only the interface through which the measuring system communicates.

This chapter describes how to take the measuring system into operation via the *HART® Communicator*. Previous knowledge of the functionality of the *HART®* Communicator used is assumed.

3.1 Steps for Getting Started

Step	Activity	Page
1	Check if the Device Description is installed on the HART® Communicator (see HART® Communicator User's Manual); if necessary, have it installed by the manufacturer.	–
2	Connect HART® Communicator.	*3–254*
3	Turn HART® Communicator on (see HART® Communicator User's Manual).	–
4	Calibrate measuring system.	*3–333*
5	Create setup protocol.	*3–409*

4 Quick Guide to Calibration

Prerequisites

- The detector is installed and is supplied from the mains.
- The factory setting of parameters have not been changed yet. Otherwise, perform a factory reset (see *chapter 5.1.1*).
- The user is familiar with the basic calibration of a radiometric measurement.
- The user is aware of the risks of incorrect calibration.
- Communication with the HART® Communicator is established.
- Under **Unit Family** in Step 3, select ***DENSITY 1*** or ***SUSPENSION 1***.

The following calibration is based on a one-point calibration, which requires only one calibration point.

Tip
Set the date and time when the error message 105 appears.

▶ Select the menu item **Quick Start**: **Device Config ▶ Setup ▶ QuickStart**.

QuickStart Menu

Step 1, Date	Step 2, Setup	Step 3, Range	Step 4, 1-Point Calibration
Date	Time Constant	Unit Family	Read In
Time	Nuclide	Unit	Cal Density
	Half Life Time	Lower Range Limit	Cal Rate
	Measuring Path	Upper Range Limit	Coefficient A1
	ReadIn Time	Liquid Density	Calibrate + Preset
		Solid Density	
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Step 1 - Date/Time

▶ Check and update the date.

▶ Check and update the time.

Step 2 - Setup

▶ Select **Nuclide**: ***Cs-137*** or ***Co-60*** (see type plate of the source shielding).

▶ Enter the measuring path in the product in **Measuring Path**.

Step 3 - Range

- Under **Unit Family**, select ***DENSITY 1*** or ***SUSPENSION 1***. If you have selected ***SUPENSION 1***, you also have to enter the liquid and solid density.
- Select the unit you need in **Unit**.
- Enter the lower measuring range in **Lower Range Limit**.
- Enter the upper measuring range in **Upper Range Limit**.

Step 4 - Calibration Points

Adjust calibration point

Source is mounted and beam path is open. The current density or concentration is at a normal value, or in the middle measuring range.

- Select **ReadIn** and wait until the measurement time is over.

Enter density value

Take a lab sample at the same time to adjust the calibration point.

- Select **Cal Density** and enter the lab value.

Enter calibration coefficient

- Depending on the nuclide, enter here one of the following coefficients:
  - 0.066 (for Cs-137)
  - 0.048 (for Co-60)

Calibration

- Select **Calibrate + Preset**.

The message ***0-OK*** must be displayed, otherwise correct the calibration error as per the error message and reselect **Calibrate + Preset**.

On the following pages you can find detailed calibration instructions.

Tip
Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the detector is set correctly (see *chapter 2.37*, *page 3-307*, **Cps Average Mode** and **Cps Average Test**).

5 Calibration

NOTICE

Errors in the calibration or in the parameter setting can lead to false results. This may possibly lead to loss of production, or to damage in the system.

For testing, we recommend using the test settings in the Service menu to simulate the calibration points.

Basically we recommend to have commissioning carried out by the BERTHOLD TECHNOLOGIES service.

Prerequisites for calibration with the HART® Communicator

– The detector is installed correctly and is powered from the mains (see *Volume 2*, *chapter 2* and *chapter 3*).

– The HART® Communicator is connected to the current loop.

5.1 Preparing Calibration

For correct calibration of the measuring system, you have to ensure that the detector and basic settings are correct.

▶ Turn the HART® Communicator on.

After power on, the Start menu appears.

Tip

Push ***HOME*** to return from any level back to the Start menu.

If the detector has been in stock for a long time, it may happen that the internal timer no longer displays the current date. In this case, the error message *105 Real time clock not valid* is displayed. Update the date and time to reset the error message (see *chapter 2.13*, *page 3-276*).

If you are sure that the detector and basic configuration are correct, you can start with the calibration of the measuring system immediately as described in *chapter 5.2*.

Otherwise proceed as follows:

▶ If the device is still locked with a password, undo the password protection (see *page 3-317*).

▶ Reset the detector to factory defaults (see *chapter 5.1.2*)

▶ Adjust the value for HV default (see *page 3-334*). This is usually not necessary, since the detector is factory-calibrated.

5.1.1 SENSseries Reset to Factory Settings

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Service ▶ Reset Device**.

▶ Select ***FACTORY RESET*** and confirm the security prompt.

After successful reset, the message *Device is reset!* appears.

▶ Now turn the HART HART® Communicator OFF and ON again.

The parameters in the detector are now again identical with the factory setting (delivery state).

5.1.2 Adjust HV Default

HV Default has already been determined and set by BERTHOLD TECHNOLOGIES. If this value deviates during the *first commissioning* by more than 5% from **HV Live**, then you have to adjust **HV Default** new.

The adjustment of **HV Default** is only successful if the current count rate in the
CrystalSENS is at least at 200 cps. With SuperSENS and UniSENS the count rate is irrelevant.

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Sensor Configuration ▶ Plateau ▶ Sensor Settings**.

▶ Select **HV Mode *AUTO***, if this is not already set.

▶ Save the changes with ***SEND***.

▶ Wait until the HV value (**HV Live**) has been adjusted.

This takes about 2 minutes in the CrystalSENS and 30 minutes in the SuperSENS and UniSENS.

▶ Read off the value **HV Live**.

▶ Enter the value read-off at **HV Default**.

▶ Save the changes with ***SEND***.

This completes the adjustment of the HV Default value.

5.1.3 Detector Code

Set the detector code using the table in *Volume 2, chapter 1.6, "Detector Codes"*.

5.2 Calibration with Quick Start

QuickStart allows you to quickly take the detector in operation, without having to deal with the complete menu. Additional functions can be enabled any time on the main menu after the calibration.

For calibration in the **Quick Start** menu, you have to set the required values in the 4 Quick Start menus and then complete the calibration with **Calibrate + Preset**.

Please note that the function **Calibrate + Preset** in the **Quick Start** menu will automatically set the following parameters:

- Temp Compensation = OFF
- Calibration Method = 1-Point
- Background = 0
- Factor = 1
- Offset = 0

If other settings are required, the calibration has to be carried out in the **Cal Parameter** menu.

This chapter describes the calibration in the **Quick Start** menu in detail. A quick reference guide can be found in *chapter 4*.

The **Quick Start** menu supports a one-point calibration which requires only one calibration point.

In many cases, a one-point calibration suffices, especially if the measurement is integrated into a control system designed to hold the process value. In other cases, it quickly leads to a display of the measured value and makes it easy to quickly get familiar with the operation of the system. Advanced options are available on the **Cal Parameter** menu.

The following reasons could make it necessary that you carry out the calibration on the main menu under **Cal Parameter** rather than in **Quick Start**, e.g.:

- because the calibration coefficient is unknown
- because the reading must not only be reproducible over the entire measuring range, but also accurate, so that a multi-point calibration is required
- because individual laboratory values cannot be determined with sufficient accuracy, so that several laboratory analyses are required to obtain a sufficient accuracy
- because the calibration curve is not linear, i.e. more than one calibration coefficient is required
- because a temperature compensation measurement is required
- because you want to enter a known calibration curve based on the zero count rate and the absorption coefficient
- because a SuperSENS detector is used for the density measurement and the background has to be entered for optimal long-term stability of the measurement. We will advise you if you have any doubts as to the correct procedure.

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

▶ Select **Device Config** ▶ **Setup** ▶ **Quick Start**.

QuickStart Menu

Step 1, Date	Step 2, Setup	Step 3, Range	Step 4, 1-Point Calibration
Date	Time Constant	Unit Family	Read In
Time	Nuclide	Unit	Cal Density
	Half Life Time	Lower Range Limit	Cal Rate
	Measuring Path	Upper Range Limit	Coefficient A1
	ReadIn Time	Liquid Density	Calibrate + Preset
		Solid Density	
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This menu contains four steps (**Step 1** to **Step 4**) with the corresponding submenus. Go through the individual steps menu item for menu item.

5.2.1 Step 1

▶ Enter the current date (**Date**) and time (**Time**). The Date is specified in the format MM/DD/YYYY, the Time in the format hh:mm:ss.

The correct date is important for the automatic decay compensation of the isotope. Since the activity of the source diminishes with time, the calibration count rates will be compensated automatically through the date. The decay compensation takes place daily at 09:01 h. Time differences have no impact on the correction of the decline in activity. However, the correct time is helpful to check the detector function: In case of error, you can see in the error log when the error occurred.

5.2.2 Step 2

Time Constant

▶ Enter the desired time constant.

The time constant smoothes the output signal. Statistical fluctuations and process-related fluctuations can be smoothed. A time constant of 60 s is usually reasonable.

Nuclide

▶ Enter here the isotope (nuclide) that is used in your source:

- ***Co-60***
- ***Cs-137***
- ***USER DEFINED***

This entry controls the automatic decay compensation. The correct entry is also important in a one-point calibration and for gas density compensation. The isotope used is listed on the type plate of the shielding and on your delivery documents. The item ***USER DEFINED*** allows you to use any isotope you want. In this case you must enter the half-life of the nuclide used in **Half Life Time**.

What happens when you have selected the wrong isotope?
As a result of the wrong decay compensation, you will get a deviating display only after several weeks or months, with the deviation increasing over time.

Measuring Path

▶ Enter the measuring path in the product. With a standard 90° measuring path on a pipe that would be, for example, the inner diameter of the pipe.

ReadIn Time

▶ Define here the period of time over which the count rate is to be read-in for each calibration point.

The statistical variation of the count rate is averaged over this time period. The longer it is, the better the mean value. A time period of 180 s (default setting) is usually reasonable.

5.2.3 Step 3

Unit

- Select the unit you need in **Unit**.
  If you do not find the required unit in the selection list, you can switch to another **Unit Family** to select other units.

Lower Range Limit

- Enter the lower measuring range in **Lower Range Limit**.

Upper Range Limit

- Enter the upper measuring range in **Upper Range Limit**.

If you have selected ***SUPENSION*** in **Unit Family**, you also have to enter the liquid and solid density.

When will the unit family SUSPENSION be used?

- If you have a mixture of one solid and one liquid, and the measured value is to be output as concentration value (%, g/l, Brix).
- To allow for the non-linear relationship between density and concentration with only one absorption coefficient.
- To calibrate a concentration measurement with a one-point calibration.

5.2.4 Step 4

The current density or concentration is at a normal value, or in the middle measuring range.

ReadIn

- Start reading-in the count rates with **ReadIn**. While the count rate is read in, the average is calculated and displayed continuously. Under **ReadIn Time** (*Quick Start, Step 2: Setup*) you define the read-in period.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.
- As you read in the count rate, you also need to take a sample of the product in order to determine the density or the concentration in the laboratory. The sample must be representative, i.e.:
  - it must be taken in the immediate vicinity of the measuring point
  - it must be taken promptly after the reading-in of the count rate
  - the product density must not fluctuate during this period but must be constant

Depending on the sampling site, it is best to let a sufficient amount initially run into another container before taking the actual sample. This prevents that a product located in a branch line may possibly distort the lab sample.

Depending on the laboratory facilities, it is advisable to take duplicate samples and to have them analyzed in the lab at different times.

Cal Density

▶ Enter the lab value.

Cal Coefficient A1

▶ If you have selected ***DENSITY 1*** (or ***SUSPENSION 1***) under **Unit Family**, you can enter the following standard coefficients:

- 0.066 (for the nuclide Cs-137)
- 0.048 (for the nuclide Co-60)

In the other case, and if you do not know the coefficient, you need to perform a two- or multi-point calibration under **Cal Parameter**.

Calibrate + Preset

With this menu item you enable the calibration data determined during the measurements. The calibration data are transferred to the parameter set **Meas Parameter**. Thus, the detector will get a new calibration which in the future will be used to determine the measured values.

After the calibration, a status message is displayed, indicating if the activation of the calibration data has been carried out successfully. If not, the measurement parameters are unchanged. Possible status messages are:

- ***0-OK***: The calibration carried out is OK.
- ***1-ERROR BACKGROUND***:
  The count rate of the background radiation is higher than that for the calibration points for empty or full (Cal Point 0% or Cal Point 100%).
- ***2-MISSING CALIBRATION POINT***:
  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:
  - ***DIRECT ENTRY***: none
  - ***1-POINT***: one
  - ***LINEAR***: two
  - ***SQUARE***: three
  - ***CUBIC***: four
- ***3-ERROR NOT MONOTONOUS***:
  The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

⇒ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

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- ***4-DATE ERROR***:
  A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.
- ***5-CHECK ERROR***:
  The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

The following settings are made automatically at **Calibrate** + **Preset**:

\- **Temp Compensation** = ***OFF***
\- **Calibration Method** = ***1-Point***
\- **Background** = ***0***
- Factor = 1
- Offset = 0

▶ At the end, fill out the commissioning log, see *chapter 10*, *page 3-409*.

Tip
Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the detector is set correctly (see *chapter 2.37*, *page 3-307*, **Cps Average Mode** and **Cps Average Test**).

- This completes the calibration.

5.3 Calibration in the Cal Parameter Menu

Advanced functions

In addition to calibration with **Quick Start**, you can also calibrate using the **Cal Parameter** menu. Further options are offer there, such as:

- various types of calibration

- Temperature compensation

You can enable additional signals and messages in the menu **Signal Condition**.

Via **I/O Setup** you can use existing or optional I/Os to output or process signals.

In order to avoid the risk that the device supplies faulty signals, it is imperative that you familiarize yourself with these additional features before you use them.

The calibration can be carried out as soon as the basic configuration has been set. Three types of calibration are possible:

- Two- or multi-point calibration
- One-point calibration
- Suspension calibration

5.3.1 Calibration Methods

The SENSseries LB 480 offers five calibration methods:

1. 1-POINT (one-point calibration)

   This type of calibration can be used in many applications. The absorption coefficient, the length of the absorption path and one calibration point are entered or measured. This calibration method should be used when

   – to keep a certain product density constant for the process during operation
   – when only one calibration point (value pair with count rate and density or concentration value) is available
   – to perform a pre-calibration only.

2. LINEAR (two- or multi-point calibration with linear coefficients)

   Linear curve fitting is the most frequently used calibration method.

   Here, the product density for two or more calibration points is measured or entered (two-point or multi-point calibration). This calibration method should be used when

   – accuracy is desired over the entire measuring range
   – only two calibration points are available.

   You should choose this calibration method also over a quadratic or cubic curve when

   – multiple calibration points are available, but these are very close together, so that not the entire range is covered by samples. Even minor errors in sampling or in the laboratory then distort the calibration curve significantly. It this case it may even be better to run only a one-point calibration.
   – sampling may be carried out only very inaccurately, so that the samples are subject to errors.

3. SQUARE (multi-point calibration with linear and quadratic coefficients)

   This type of calibration is used very rarely and requires visual assessment of the calibration points on y(x)-graph, as shown in *Fig. 5-1*.

   With this calibration method, the product density is measured or entered for at least three calibration points. This calibration method should be used only when

   – the entire measuring range is covered evenly with several calibration points
   – the measurement is carried out in % concentration, °Bx or another measured variable measurement, which is not in a linear relationship with the density.

4. CUBIC (multi-point calibration with linear, quadratic and cubic coefficients)

   This type of calibration is used only in exceptional cases and requires not only a thorough visual inspection of the calibration points on y(x)-graph, as shown in Fig. 5-1, but also a subsequent precise control of the measured value display using a test generator!

   With this calibration method, the product density is measured or entered for at least four calibration points. You should use this calibration method if a sufficient number of calibration points is available (approx. > 8), and the curve can clearly be fitted better to the calibration points with CUBIC than with LINEAR or SQUARE. We recommend to discuss the use of the calibration method CUBIC with BERTHOLD TECHNOLOGIES.

5. DIRECT ENTRY

   Direct entry means that you can enter an already known characteristic curve directly into the device, without requiring any calibration data or laboratory analysis data. The entry of the characteristic curve comprises the background, the absorption coefficient A1 and the measuring path.

   Direct entry of quadratic and cubic curves is not possible.

5.3.2 Operation Modes for Calibration

▶ If the Start menu is not already displayed, press **HOME** to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**.

▶ Select the calibration method under **Calibration Method**:
   - ***DIRECT ENTRY*** for direct entry of a known calibration curve
   - ***1-POINT*** for one-point calibration
   - ***LINEAR*** for standard multi-point calibration
   - ***SQUARE*** for a quadratic curve with at least 3 calibration points
   - ***CUBIC*** for a cubic curve with at least 4 calibration points

- This completes the setting of the operating mode for the calibration.

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5.4 Two and Multi-Point Calibration

Multi-point calibration can be based on a one-point calibration or started new. For calibration, several samples have to be taken and the product densities and concentrations are measured in the laboratory. The individual calibration points can be connected either by a straight line (two-point calibration) or by using multiple calibration points and calculating the characteristic curve using a linear, quadratic or cubic curve fit.

5.4.1 Basics

The gradient of the calibration curve can be determined accurately by two-point calibration. Multi-point calibration helps to exclude errors made during sampling and analysis. Furthermore, the output signal is in linear proportion to the concentration, even though the density is not linear to the concentration.

For multi-point calibration, measure the count rates obtained at different density values and enter the corresponding density or concentration value determined in the lab. In determining the density values, you need not observe a rising or falling order.

IMPORTANT
However, correct correlation of measured count rate and density value from the lab measurement is important.

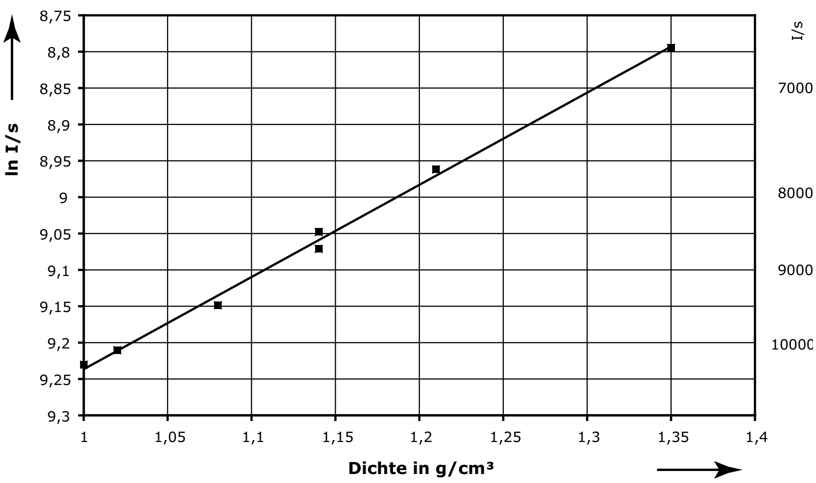

Fig. 5-1 Example of a multi-point calibration

The values have to be available in pairs. If the associated density or concentration value is missing, the count rate is automatically given the density or concentration value *0*. You can correct the data entered as often as needed, since the calibration process takes place only after selecting the menu item **CALIBRATE**. The following steps are carried out for a multi-point calibration:

1. Calculation of curve function

   The curve function is calculated using the selected calibration mode from the value pairs measured or entered in accordance with the lab values.

2. Calculation of square error of curve fit

   The quality of the calibration curve is calculated from the differences between the calculated calibration curve and the value pairs entered. Ideally, all points exactly match the calculated curve. The square error becomes zero.

3. Check of calibration curve for turning points

The system checks the curve for a clearly rising or falling trend. If this is not the case, the error message "Curve not clear" will be displayed.

5.4.2 Calibration

Linear two- or multi-point calibration is carried out in several steps:

1. Select operating mode ***LINEAR***.
2. Calibration at product density 1.
3. Calibration at product density 2.
4. Calibration at product density 3 and other product densities, if a multi-point calibration is performed.
5. Check calibration.

The individual steps are described in detail below. Further explanation of each function can be found in the parameter description in *Chapter 2*.

▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.

▶ Select **Device Config** ▶ **Setup** ▶ **Cal Parameter** ▶ **Cal Settings**

Cal Settings

- Under **Nuclides**, select the isotope of your source. If in doubt, see type plate on the shielding.
- Under **Calibration Method**, select ***LINEAR***.
  If absolutely necessary, you may alternatively select ***SQUARE*** or **CUBIC**. For ***SQUARE*** at least 3 and for ***CUBIC*** at least 4 calibration points are required.
- Enter the measuring path in the product in **Measuring Path**.

  Example: With a standard 90° measuring path on a pipe that would be the inner diameter of the pipe.
- Select the required unit in **Unit** to display your measured value. If you do not find the required unit in the selection list, you can switch with **Unit Family** to another unit family (***DENSITY 1***, ***2***, ***3***, or ***LENGTH***).
  If the unit family ***SUSPENSION 1*** or ***2*** is required, enable the suspension measurement as described in *chapter 5.6*.
- Enter the lower measuring range in **Lower Range Limit**.
- Enter the upper measuring range in **Upper Range Limit**.
- Enter 180s in **ReadIn Time**. This defines the average time for reading-in the count rate of each calibration point.
- Go back to the menu **Cal Parameter**.
- Select **Product Conditions**.

Product Conditions

If the temperature compensation is needed, then proceed as described on *page 3-356*. In the other case, disable the temperature compensation:

- Under **Temp Compensation**, select ***OFF***.
- Go back to the menu **Cal Parameter**.
- Select **Cal Points**.

Cal Points

The background needs to be determined only when using a SuperSENS instead of a CrystalSENS. Proceed as follows to determine the background:

- Close the shielding with a filled pipe, or better dismantle the shielding from the fixture and put it down in a distance of at least 10m from the detector, so that no effective radiation arrives at the detector which may distort the background. See also chapter Background on *page 3-371*.
- Select **ReadIn *BACKGROUND***.
- Wait until the remaining time until the end of the operation has run down.

Record calibration points

- Under **Cal Point No.** select calibration point 1.
- Select **ReadIn *ACTIVE POINT***.
  This starts the reading-in of the count rates. While the count rate is read in, the average is calculated and displayed continuously.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

  As you read in the count rate, or directly after this step, you also need to take a sample of the product in order to determine the density or the concentration in the laboratory. The sample must be representative, i.e.:
  - it must be taken in the immediate vicinity of the measuring point
  - it must be taken promptly after the reading-in of the count rate
  - the product density must not fluctuate during this period but must be constant

  Depending on the sampling site, it is best to let a sufficient amount initially run into another container before taking the actual sample. This prevents that a product located in a branch line may possibly distort the lab sample.

  Depending on the laboratory facilities, it is advisable to take duplicate samples and to have them analyzed in the lab at different times.
- Enter the density value of the sample analyzed in the laboratory in **Cal Density**.

Second calibration point

The density must be significantly higher or lower than that of the first calibration point.

- Under **Cal Point No.** select calibration point 2.
- Select **ReadIn *ACTIVE POINT***.
- Continue as with the first calibration point.

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Additional calibration points

Each additional calibration point must clearly differ in its density from the previously recorded calibration points.

- Under **Cal Point No.** select the next free calibration point.
- Select **ReadIn *ACTIVE POINT***.
- Continue as with the first calibration point.

Tip

You can improve the quality of the calibration by distributing all recorded calibration points evenly over the entire measuring range. On the other hand, the calibration will be the worse the closer the density values of the individual calibration points lie next to each another.

Tip

Under **Cal Points u Calibration Chart** you can view, edit or delete the calibration table.

- Go back to the menu **Cal Parameter**.
- Select **Calibrate** and press ***OK***.
- This completes the multi-point calibration.

Checking a multi-point calibration

The absorption coefficients and thus the curve function can be calculated based on the entered value pairs. The square error indicates how well the calculated curve could be approximated to the entered or measured values. However, you cannot use the square error as a criterion for the selection of a particular waveform (quadratic, cubic). View the following data in the menu **Meas Data** and in the menu **Reading Range** and if you find any deviations check the calibration:

Display	Value	
Meas Coefficient A2	calculated coefficient (with calibration method LINEAR = 0)	
Meas Coefficient A2	calculated coefficient (with calibration method LINEAR + SQUARE = 0)	
Factor	1	
Offset	0	
Square Error	<0.0005	very good calibration
	<0.0019	good calibration
	<0,002	still usable

We get a **Square Error** unequal to zero only when at least one calibration point more is available than is required as a minimum.

Tip
Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the device is set up correctly (see *chapter 2.36* **Cps Average Mode** and **Cps Average Test**).

5.5 One-point calibration

The one-point calibration has already been explained in the **Quick Start** section. It is also accessible on **Cal Parameter** and can there be combined with other functions, such as the temperature compensation.

One-point calibration is used when a calibration is possible with only one density value.

5.5.1 Basics

For one-point calibration you must enter or measure a value pair (count rate and density or concentration value), the absorption coefficient and the absorption path length. You can take the absorption coefficient for the current products from the table in *chapter 9.1* on *page 3-403*.

For products not listed in this table, enter the following values for the unit g/cm^3.

Cs-137

	Frontal (axial) irradiation	Lateral irradiation
Absorption coefficient μ	-0.0664	-0.057

Co-60

	Frontal (axial) irradiation	Lateral irradiation
Absorption coefficient μ	-0.0478	-0.0403

For other units, and if you are not using the unit family ***SUSPENSION***, you have to convert the absorption coefficients:

$$\mu_x = \mu \cdot \frac{\Delta\rho}{\Delta C} = \mu \cdot \frac{\rho_{max} - \rho_{min}}{C_{max} - C_{min}}$$

Example

$\rho_{max} = 0.95\,g/cm^3 : C_{\rho max} = 30\,\%$

$\rho_{min} = 0.91\,g/cm^3 : C_{\rho min} = 50\,\%$

$$\mu_x = -0.0664 \cdot \frac{0.95 - 0.91}{0.30 - 0.50} = 0.0133$$

In this case, enter *1.33e-02*.

Influence of a faulty absorption coefficient

The curve obtained with one-point calibration always passes through the calibration point. The gradient of the curve is determined by the entered absorption coefficient and may therefore be somewhat inaccurate. *Fig. 5-2* illustrates how an accurate coefficient can affect the calibration. Assuming that the characteristic curve a) shows the correct course of the characteristic curve, the characteristic curves b) and c) show how the characteristic curve changes when the entered coefficient is too large or too small.

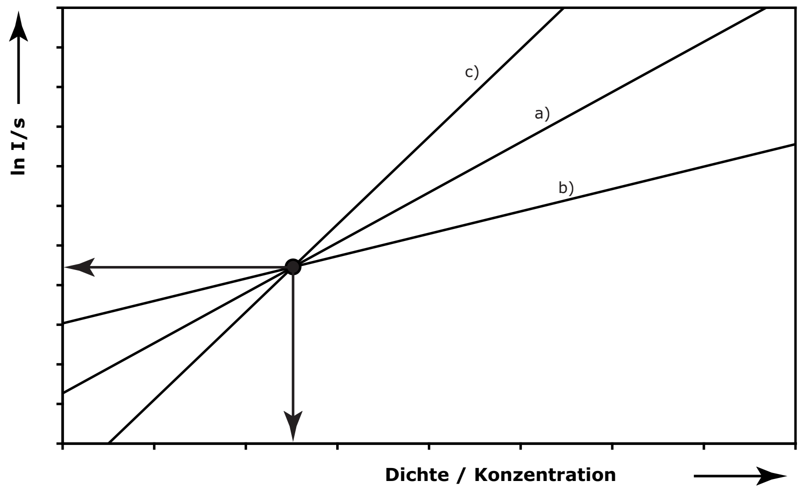


Fig. 5-2 Influence of the absorption coefficient

An error in the calibration can have a more important effect, the more the measured value deviates from the calibration point.

You may later add further calibration points to improve the calibration.

5.5.2 Calibration

One-point calibration is performed in five steps:

1. Select operating mode one-point calibration.
2. Enter the absorption coefficient
3. Enter length of the absorption path
4. Record calibration point
5. Check calibration

The individual steps are described in detail below.

Prerequisite for one-point calibration:

- the current density or concentration is at a normal value, or in the middle measuring range.
- the absorption coefficient is known.

▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.

▶ Select **Device Config** ▶ **Setup** ▶ **Cal Parameter** ▶ **Cal Settings**

Cal Settings

▶ Under **Nuclides**, select the isotope of your source. If in doubt, see type plate on the shielding.

▶ Under **Calibration Method**, select ***1-POINT***.

▶ Enter the measuring path in the product in **Measuring Path**.

Example: With a standard 90° measuring path on a pipe that would be the inner diameter of the pipe.

(pay attention that your entries are accurate to the millimeter)

▶ Select the required unit in **Unit** to display your measured value. If you do not find the required unit in the selection list, you can switch with Unit Family to another unit family (***DENSITY 1***, ***2***, ***3***, or ***LENGTH***).
If the unit family ***SUSPENSION 1*** or ***2*** is required, enable the suspension measurement as described in *chapter 5.6*.

▶ Enter the lower measuring range in **Lower Range Limit**.

▶ Enter the upper measuring range in **Upper Range Limit**.

▶ Enter 180s in **ReadIn Time**. This defines the average time for reading-in the count rate of each calibration point.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Product Conditions**.

Product Conditions

If the temperature compensation is needed, then proceed as described on *page 3-356*. In the other case, disable the temperature compensation:

- Under **Temp Compensation**, select ***OFF***.
- Go back to the menu **Cal Parameter**.
- Select **Cal Points**.

Cal Points

The background needs to be determined only when using a SuperSENS instead of a CrystalSENS. Proceed as follows to determine the background:

- Close the shielding with a filled pipe, or better dismantle the shielding from the fixture and put it down in a distance of at least 10m from the detector, so that no effective radiation arrives at the detector which may distort the background. See also chapter Background on *page 3-371*.
- Select **ReadIn *BACKGROUND***.
- Wait until the remaining time until the end of the operation has run down.

Record calibration point

- Under **Cal Point No.** select calibration point 1.
- Select **ReadIn *ACTIVE POINT***.
  This starts the reading-in of the count rates. While the count rate is read in, the average is calculated and displayed continuously.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

  As you read in the count rate, or directly after this step, you also need to take a sample of the product in order to determine the density or the concentration in the laboratory. The sample must be representative, i.e.:

  – it must be taken in the immediate vicinity of the measuring point
  – it must be taken promptly after the reading-in of the count rate
  – the product density must not fluctuate during this period but must be constant

  Depending on the sampling site, it is best to let a sufficient amount initially run into another container before taking the actual sample. This prevents that a product located in a branch line may possibly distort the lab sample.

  Depending on the laboratory facilities, it is advisable to take duplicate samples and to have them analyzed in the lab at different times.

- Enter the density value of the sample analyzed in the laboratory in **Cal Density**.
- Under **Cal Coefficient A1**, enter the absorption coefficient as described in *chapter 5.5.1*.

Tip
Under **Cal Points u Calibration Chart** you can view, edit or delete the calibration table.

- Go back to the menu **Cal Parameter**.
- Select **Calibrate** and press ***OK***.
- This completes the one-point calibration.

Checking a one-point calibration

The entered absorption coefficient must be unchanged. Also view the following information and if you detect any deviations check the calibration:

Display	Value
Meas Coefficient A2	0
Meas Coefficient A3	0
Factor	1
Offset	0
Square Error	0

Tip
Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the device is set up correctly (see *chapter 2.36* **Cps Average Mode** and **Cps Average Test**).

5.6 Enabling the Suspension Measurement

A suspension measurement is used to determine the amount of the solid in a mixture. If the measured value is determined, for example, in weight per volume, then a measured value of 200 g/L means that one liter of mixture contains 200g solid. If the measured value is displayed in weight percent, then a measured value of 10% means that in 100% of the mass of a mixture there is a share of 10% of solid mass.

The suspension measurement has to be enabled when:

- the measured value is to be output as the concentration
- the concentration differences result from the ratio of maximum two components
- the two components are known and have constant densities

If the suspension measurement is to be used, it must be enabled before recording the calibration points.

For more information on suspension measurements see *chapter 7.3*.

3

▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.

▶ Select **Device Config** ▶ **Setup** ▶ **Cal Parameter** ▶ **Cal Settings**

Cal Settings

▶ In **Unit Family** select ***SUSPENSION 1*** (g/L, g/cm3, ...), or ***SUSPENSION 2*** (Brix, % sol-wt)

▶ Select the required unit in **Unit** to display your measured value.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Product Conditions**.

Product Conditions

▶ In **Liquid Density**, enter the value of the liquid density in g/cm3.

▶ In **Solid Density**, enter the value of the solids density in g/cm3.

- The suspension measurement is enabled.

5.7 Temperature Compensation

Temperature fluctuations in the product to be measured are usually associated with density fluctuations. This means that a changed density value is displayed, although the concentration of the product has not changed. To avoid this, you can use the temperature compensation.

If the temperature measurement is to be used, it must be enabled before recording the calibration points.

Temperature measurement

The product temperature is measured by a Pt100 resistance thermometer that is mounted by the customer on the pipe in close proximity to the measurement site.

The Pt100 has to be connected to terminal 15 and 16.

While the count rate for the calibration point is being read in, the temperature is also read in automatically.

Monitoring the temperature signal

If the temperature compensation is enabled, the temperature signal is monitored and an error message is output:

- Pt100, at >180°C, e.g. if no Pt100 is connected
- Pt100, at <-30°C, e.g. if the Pt100 input is short-circuited

For the error messages to be triggered correctly:

- the tolerance of the compensating resistor must not exceed 1%.
- the line resistance must not exceed 8 Ω.

Reference temperature

Linear temperature coefficient (TK_1):

The average product temperature (not the lab temperature) is entered as reference temperature. A correction value (ϑ_ρ - ϑ_{Ref})*TK_1 is added to the measured value. A slightly incorrectly entered value TC_1 will then have a more significant effect, the larger the difference ϑ_ρ- ϑ_{Ref}.

If you assign the density values determined at a constant lab temperature to the count rate read in at operating temperature, the display is always equal to the density value calculated relative to the lab temperature.

Example: If the temperature varies over the year between 10 and 30°C, then you have to enter a temperature of 20°C.

Square temperature coefficient (TC_1 and TC_2):

The lowest temperature used for the calculation of the temperature coefficients is entered as the reference temperature.

Example: If the temperature varies over the year between 10 and 30°C, then you have to enter a temperature of 10°C.

3

Enable standard temperature compensation

- ▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.
- ▶ Select **Device Config** ▶ **Setup** ▶ **Cal Parameter** ▶ **Product Conditions**
- ▶ Under **Temp Compensation**, select ***STANDARD TC***.
- ▶ Under **Temp. Unit**, select the unit for the temperature (***degC*** or ***degF***).
- ▶ Enter the reference temperature in **Ref Temp**.
- ▶ In **TC 1**, enter the linear temperature coefficient (see *chapter 7.5*).
- ▶ If required, in **TC 2**, enter the square temperature coefficient (see *chapter 7.5*).
- • The standard temperature compensation is enabled.

Enabling the water temperature compensation

The temperature characteristic of water is already stored for suspension measurements using water as a carrier liquid. Therefore, no data has to be entered for the temperature coefficient and the reference temperature.

- ▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.
- ▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**
- ▶ Under **Temp Compensation**, select ***WATER TC***.
- ▶ Under **Temp. Unit**, select the unit for the temperature (***degC*** or ***degF***).
- • The water temperature compensation is enabled.

5.7.1 Correction of the Lab Values

The count rates measured during the calibration are dependent on the density of the product during the measurement. The density of the sample is usually determined in the laboratory at a fixed temperature. With constant concentrations but different temperature between the count rate measurement and the measurement in the laboratory we would then get incorrect characteristic values. To avoid such calibration errors, the product temperature is also stored in the SENSseries LB 480 when measuring. When calculating the calibration curve, the entered laboratory value is corrected by means of the temperature coefficient.

This correction is carried out only when:

- Temp Compensation is specified in the device configuration (see *chapter 2.23* on *page 3-294*)
- at least one temperature coefficient is entered (see *chapter 2.23* on *page 3-294*).

The corrected lab values from which the calibration curve is calculated are displayed after the coefficients and the square error, provided the temperature compensation was enabled during calibration. Otherwise, the lab value already entered is displayed.

For concentration measurements the temperature compensation always has to be enabled prior to performing calibration. The following section is relevant only for density measurements:

- No correction is required if the density has been determined at exactly the same temperature at which the count rate was read in (e.g. spindles on site). Enter the density value directly and enable the temperature compensation only after the calibration.
- Manual correction of the sample values is required only if the measurement was run in g/cm^3, and the density of the samples was determined in the laboratory at various temperatures. Carry out the following corrections:

$$\rho_K = \rho_M - (\vartheta_\rho - \vartheta_M) \cdot TC_1$$

ρ_K	=	corrected input value
ρ_M	=	measured density value
ϑ_ρ	=	product temperature during the density measurement
ϑ_M	=	reference temperature relative to which the density was calculated
TK_1	=	Temperature coefficient

The display always relates to ρ_M.

Example with manual correction

Temperature coefficient = $0.5*10^{-3}$

ρ_M in g/cm^3	ϑ_ρ in °C	ϑ_M in °C	ρ_K in g/cm^3
1.30	75	70	1.2975
1.32	70	70	1.3200
1.35	65	70	1.3750

Since in this case correction has already been done manually, the temperature compensation must be turned off and then on again.

5.8 Correction of the Measured Values

Addition and multiplication functions are available for the correction of the measured values. However, these are no substitute for a careful calibration; they should only be used for minor corrections. Otherwise we recommend doing a re-calibration.

5.8.1 Correction with Factor and Offset

- ▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.
- ▶ Select **Device Config** ▶ **Setup** ▶ **Signal Condition** ▶ **Reading Range**
- ▶ In **Factor**, enter the value for the multiplicative factor.
- ▶ In **Offset**, enter the value for the additive constant.
- ▶ Then check if your measured value is output properly corrected.

3

Additive constant

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

Example additive constant:

Measuring range 1.1 – 1.3g/cm^3

It is found that the measuring values are too low by 0.05g/cm^3.

Remedy: Enter *0.05* at Offset. All measured values will be raised by 0.05g/cm^3, i.e. instead of 1.1g/cm^3 1.15g/cm^3 is now displayed and instead of 1.3g/cm^3 1.35g/cm^3 is displayed.

If the measured values are too high by 0.05g/cm^3, you have to enter *-0.05*.

Multiplicative factor

Each measured value is multiplied by the value specified in **FACTOR**. This allows you to change the gradient of the calibration curve.

Example multiplicative factor:

Measuring range 1.1 –1.3g/cm^3

If you enter 1.1 at Factor, 1.21g/cm^3 will be displayed instead of 1.1g/cm^3. Instead of 1.3g/cm^3, the value 1.43g/cm^3 is now displayed.

Correction with Factor and Offset

When using a multiplicative factor only, however, the lower point of the measuring range is increased as well, provided it is not at 0. For this reason, the Factor may normally not be used alone for the correction, but must be calculated in combination with the Offset. It is necessary to determine the ACTUAL and TARGET values at two points each. The two points should be fairly far away from each other so that the curve is corrected as accurately as possible.

The formula used for the automatic correction is:

$A_k = A_i \times F + K$

A_k: corrected measured value

A_i:current measured value

F: Factor

K: Offset

Two examples for the calculation of Factor and Offset.

Example 1:

At 1.1g/cm^3 the displayed value is correct, instead of 1.2g/cm^3, however, 1.25g/cm^3 should be displayed.

Calculation of the Factor:

$$F = \frac{H_{soll} - L_{soll}}{H_{ist} - L_{ist}} = \frac{1.25 - 1.1}{1.2 - 1.1} = 1.5$$

Calculation of the Offset:

$$K = L_{soll} - (L_{ist} \cdot F) = 1.1 - (1.1 \cdot 1.5) = -0.55$$

with

H_{actual}	=	upper display value
H_{target}	=	Lab value of the density when H_{actual} is displayed
L_{actual}	=	lower display value
L_{target}	=	Lab value of the density when L_{actual} is displayed

Example 2:

L_{actual}	=	$1.12 g/cm^3$
L_{target}	=	$1.15 g/cm^3$
H_{actual}	=	$1.25 g/cm^3$
H_{target}	=	$1.3 g/cm^3$

This results in:

$$F = \frac{H_{soll} - L_{soll}}{H_{ist} - L_{ist}} = \frac{1.3 - 1.15}{1.25 - 1.12} = 1.1538$$

and

$$K = L_{soll} - (L_{ist} \cdot F) = 1.15 - (1.12 \cdot 1.1538)$$
$$= -0.1423$$

Enabling Factor and Offset

▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.

▶ Select **Device Config** ▶ **Setup** ▶ **Signal Condition** ▶ **Reading Range**

▶ In **Factor**, enter the value for the multiplicative factor.

▶ In **Offset**, enter the value for the additive constant.

• Factor and offset are now enabled.

▶ Then check if your measured value is output properly corrected.

Please note that after each calibration with **Calibrate**, **Factor** and **Offset** will be reset automatically.

To disable factor and offset manually:

▶ In **Factor**, enter the value ***1***.

▶ In **Offset**, enter the value ***0***.

5.9 Ensuring the Function of the Measurement

Please proceed as follows to ensure that the measurement is working correctly after calibration or parameter change:

- Check the live display
- Compare the measured values with the control system
- Simulate measured values with test generator
- Perform test run with product
- Archive the calibration data

5.9.1 Simulating Measured Values with a Test Generator

The measuring system has an internal test generator to generate counts that can be used to check the calibration and thus the measured value display accurately.

For this purpose the counting rates of the calibration values may be used.

▶ Select **Device Config ▶ Setup ▶ Service ▶ Test ▶ Test Settings**.

▶ Set **Cps Average Mode** to ***FIXED VALUE***.

▶ Enter the calibration count rate for **Cps Average Test**.

▶ Read off the expected measured value at **Level** or **Density**.

In addition to the calibration count rates, you may also enter intermediate values, if necessary, to check the measured value display.

At the same time, you can also compare the measured value display in the control system for every single count rate with the measured value displayed in the LB 480 to ensure the correct transfer of the measurement signal.

After this simulation has been completed, you have to switch the parameter **Cps Average Mode** back to ***NORMAL***. If you forget this, the measurement remains frozen. As a reminder, the Communicator cyclically outputs error message 106 and the **Operating Status** of the measurement shows ***TEST*** (instead of ***RUN***).

5.9.2 Checking the Live Display

Check the live display to make sure no error is displayed and the measurement is in the normal measurement mode. You can also see whether the measured values are plausible and are output correctly.

▶ Select **Live Display**.

- The **Operating Mode** must show ***RUN***.
- At **Level** or **Density**, the current target value must be displayed and must be alive *

– At **Current OUT**, the current target value must be displayed and must be alive *

*) Alive = the display must fluctuate around a mean

5.9.3 Test Run with Product

This test will give you the highest level of security, as it is performed under real conditions. The test should be performed under operating conditions, if possible; i.e. any existing stirrer should run and a gas pressure existing during operation should also be present during the test. However, often this involves a lot of effort, so that the options on site and the need have to be clarified first. In many cases, water rather than product may be used for a test run and a possible gas pressure can often be simulated with nitrogen. The differing density between the product and the substitute product used for the test has to be taken into account.

Level

- ▶ Fill the container. Move the container under operating conditions from empty to full.
- ▶ Record the measurement signal and verify it.

Substitute procedures such as closing the source when the container is empty can be used only to a limited extent as a functional test.

If substitute procedures are chosen, the restrictive conditions must be carefully evaluated.

Limit switch

- ▶ Control the limit level under operating conditions.
- ▶ Record the response of the measurement and verify it.

Substitute procedures such as closing the source when the container is empty can be used only to a limited extent as a functional test.

If substitute procedures are chosen, the restrictive conditions must be carefully evaluated.

Density measurement

A density measurement is best tested using sample values. To this end, samples distributed over the measuring range should be taken and these should be compared with the display value.

If the measuring area also covers the density of 1 g/cm^3, then water may also be used for the test. If it is not possible to control different densities within the measuring range, a one-point calibration can alternatively be performed. Since only one point within the measuring range is tested, it must be clarified whether this test is sufficient for the application.

If in doubt, please ask the BERTHOLD TECHNOLOGIES Service for support.

5.9.4 Archiving Calibration Data

We generally recommend to archive both the calibration and all other settings. This greatly simplifies and accelerates any necessary exchange of the measuring system. Also, incorrect operation may cause data loss and in this case archived data may be very helpful.

There are several ways to archive data.

- Fill out the parameter protocol in the Appendix to the operating instructions
- Digital storage of data

Several options are available for digital storage, depending on the communication interface and host used:

- LB 480-PC (Berthold specific program for the RS485 interface)
- HART® Communicator
- Siemens Simatic PDM
- AMS Emerson Process

See also *Volume 3*, *chapter 1.5*.

6

Functional Processes

The following chapter describes the major functional processes that occur when working with the SENSseries.

6.1 Plateau Measurement

Below we will describe how to perform a plateau measurement. The plateau measurement checks the function of the detector.

IMPORTANT
The radiation conditions must be constant while recording the plateau!

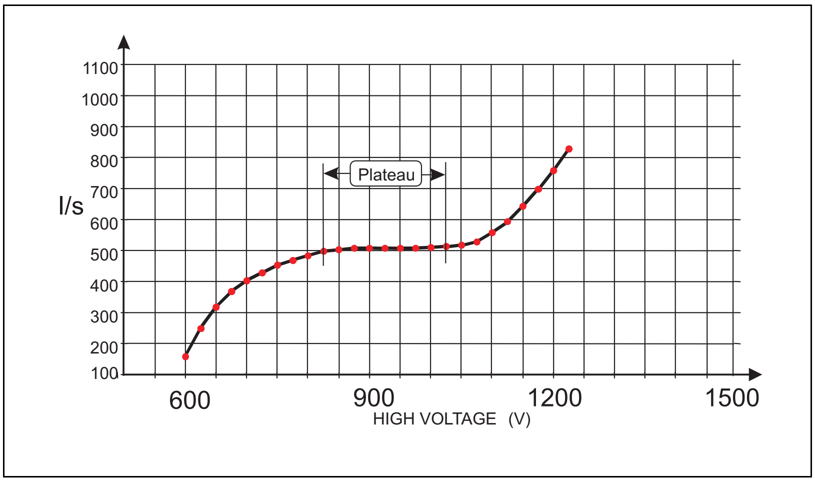


Fig. 6-1 Result of a plateau measurement

The plateau is the flat section of the curve and it is typically approx. 200V long (see also *Volume 2*, *chapter 4.5*). Please note that the above characteristic curve and the following information is only valid for a NaI detector. With a plastic scintillator the plateau is steeper and may have to be qualified by a BERTHOLD service technician.

The crystal-multiplier assembly or the complete detector has to be replaced if:

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

IMPORTANT
During the plateau measurement the density measurement is held at the last measured value.

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

▶ Select **Device Config** ▶ **Setup** ▶ **Service** ▶ **Plateau** ▶ **Plateau Measurement**.

▶ At **HV Start** enter the high voltage (e.g. 500V, minimal 300V), where the plateau measurement should start and confirm the input with ***ENTER***.

▶ At **HV Stop** enter the high voltage (1000V, maximal 1300V), where the plateau measurement should stop and confirm the input with ***ENTER***.

▶ At **HV Step** enter the step size between the measurement points (e.g. 50V) and confirm by pressing ***ENTER***.

The step width determines the number of value pairs. The larger the step width, the lower the number of the value pairs!

▶ At **Meas. Time** enter the time how long a measurement point should be recorded or the count rate is to be averaged (e.g. 20 s) and confirm the entry with ***ENTER***.

▶ Transfer the entries with ***SEND***.

▶ Select ***PLATEAU*** at **HV Mode** to start the plateau measurement.

The plateau measurement is started. For this purpose, the measuring mode is exited and the plateau of the multiplier which is used in the detector is measured.

During the plateau measurement the values of the following parameters are updated continuously:

- **HV Live**: HV value of the voltage at which the count rate is being measured.
- **Cps Single Detector:** Count rate of the selected detector.
- **Cps Live**: Total count rate of all detectors.

At the end of the plateau measurement the detector automatically switches back to **HV Mode**: ***AUTO*** or ***MANUAL*** depending on which mode was last set.

The plateau measurement is now complete and can be viewed and reviewed under **Plateau View** as a table or plateau curve.

6.2 Master Reset

Besides the options described in **Device Config ▶ Setup ▶ Service ▶ Reset Device** on *page 3-305* to reset the detector or certain functions, there is the *Master Reset*, which deletes *all* parameters. You have to open the housing to perform the Master Reset.

IMPORTANT

Perform a Master Reset only if a previous ***SW Reset*** *or even a* ***Factory Reset*** *was not successful.*

Please keep in mind that after a ***Master Reset****:*
– the previously set parameters will be lost
– the license key must be entered again
– current output and HV default have to be adjusted
– the measurement needs to be calibrated

If in doubt, have this work carried out by the BERTHOLD TECHNOLOGIES service.

WARNING

EX

Risk of explosion!

For detectors that are used in hazardous areas, the housing must only be replaced by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

For non-Ex devices, you can proceed as described below.

Preparing for Master Reset

You will need:

- M5 and M8 Allen wrenches to open the housing.
- Jumpers to bridge two pins.
- Your original license key from your code listing or from the Service menu.
- Multimeter to adjust the current output.
- The current value for **HV Default** (*chapter 2.14*, *page 3-277*).
- Clean working environment, so that no debris or dirt can get into the electronics.

⚠ WARNING

Danger, electric shock!

If the housing is open you may come into contact with live parts if the power supply is connected.

The Master Reset has to be carried out with open housing cover and the power supply turned on. Power supply is applied to the terminals 1 to 4.

Furthermore, high voltage is present in the area of the base of the board for the photomultiplier.

Perform Master Reset

1. Disconnect detector from mains.
2. Open housing.
3. Plug bridge on connector "F" (the connector is located on the CPU board next to the large capacitor).
4. Turn detector on and wait 10 seconds until the LED flashes.
5. Turn detector off again.
6. Pull bridge off connector "F".
7. Turn detector on and wait 10 seconds until the LED flashes.
8. Turn detector off again.
9. Connect HART® Communicator to the current output in the terminal compartment.
10. Turn detector on again and wait 10 seconds until the LED flashes.
11. Acknowledge error message on HART® Communicator.
12. Enter License Key new, menu **Device Config ▶ Setup ▶ Service ▶ License Key**, see *chapter 2.33*, *page 3-305*.
13. Adjust current output with multimeter, menu **Device Config ▶ Setup ▶ I/O Setup ▶ Current Out ▶ D/A trim**, see *chapter 2.26*, *page 3-297*.

IMPORTANT
The adjustment is absolutely essential, even if the current output appears to be OK.

14. Enable monitoring of the 4-20 mA current signal (set to ***ENABLED***), menu **Device Config ▶ Setup ▶ I/O Setup ▶ Current Out ▶ Current Loop Monitoring**
15. Set Detector Code, menu **Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings ▶ Detector Code**, *see page 2-161.*
16. Set **HV Default**, see *chapter 5.1.2*, *page 3-334*.

This completes the reset, the detector is now ready for calibration.

7 Explanations

7.1 Background

The term "background" refers to the count rate resulting from the natural environmental radiation. The background level is largely dependent on the scintillator volume. The background is not accounted for by the decay compensation as it is regarded as a constant.

An error when recording the background may later lead to drift effects in the measurement. Influences from neighboring radiation sources must be avoided.

The background has to be recorded only for the SuperSENS. The background need not be recorded for the CrystalSENS.

To measure the background, the shielding with the source must not be mounted and must be at least 20 m away from the measuring point. If the shielding is dismantled for this purpose, it must first be closed.

The background should always be measured with a filled product line, or a filled container.

7.2 Radiation Interference Detection

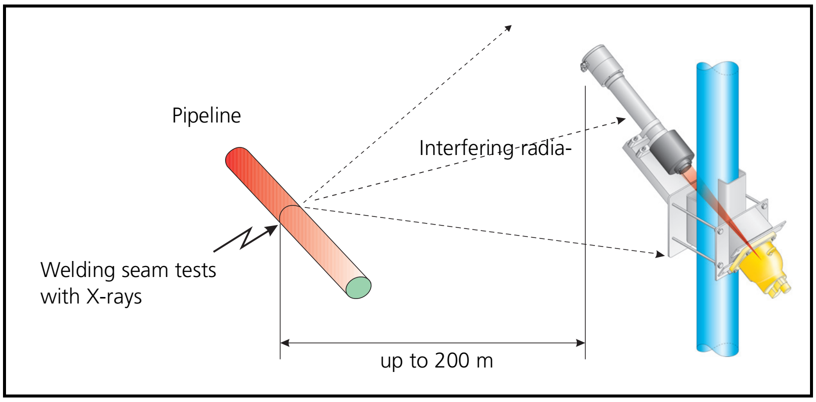


Fig. 7-1 Interference radiation

7.2.1 Detecting Interference Radiation

The high Gamma sensitivity of scintillation detectors may cause a false reading. To detect interfering radiation, a double plausibility check can be enabled.

The alarm is triggered by:

Scenario A:

Maximum possible count rate (empty calibration)

Is > Io * 1.5

Is = current count rate in cps integrated over one second
Io = maximum count rate at empty calibration

Scenario B:

Mean value of current count rate monitored.

The system sensitivity, i.e. the distance of the alarm thresholds is defined as the multiple of the mean statistical variations and can be entered as Sigma value as needed. The time constant is one second.

When reaching the alarm threshold, a message is signalized via HART. This signal can also be output via the digital output and as a failure current.

Is > Im + n * Sigma

Im = current count rate integrated over one second

n = multiple value of Sigma

Further information on scenario A:

A relative limit value is monitored, i.e. the alarm threshold is reached when exceeding a maximum dose rate (calibration value at empty vessel) at the detector.

False alarms due to operative factors are not possible. However, only stronger interfering radiation is detected.

Further information on scenario B:

A differential limit value is monitored, i.e. each fast rise of the dose rate triggers an alarm.

Even minor outside radiation is detected, when it occurs erratically. Operative factors such as fast emptying of the vessel or opening the shielding container may trigger false alarms.

To rule out false alarms with sufficient statistical safety, you should enter n > 5. The mathematical correlation shows that the distance of the alarm threshold is dependent upon the respective mean count rate In.

For calculation it holds:

$$\text{Sigma} = \sqrt{\text{Ips}}$$

Example

Count rate Im = 300 cps, n = 6

$$\text{Is} = \text{Im} + n \times \sqrt{\text{In}}$$

$$\text{Is} = 300 + 6 \times \sqrt{300} = 404 \text{ Ips}$$

Thus, an alarm is signaled as soon as IS exceeds 404 cps.

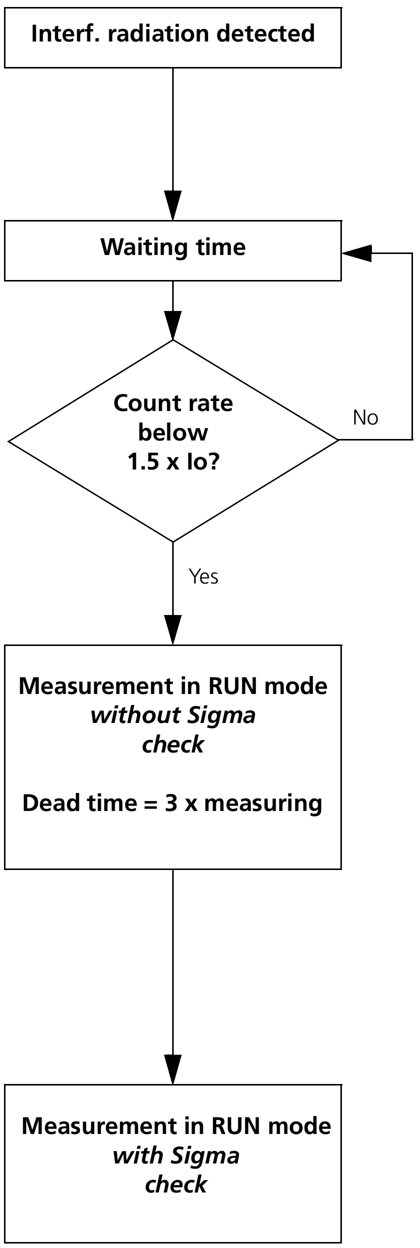
IMPORTANT

Due to the dynamic behavior of the interference radiation detection, a quick increase of the pulse rate due to operational factors (e.g. empty running pipeline) can be interpreted as interfering radiation. By setting the parameters for the interference radiation detection accordingly, erroneous activation by these operating conditions can be suppressed. However, the radiation interference detection also becomes less sensitive.

For example, opening the useful beam channel on the shielding can also cause a quick increase of the count rate. You have to reset the alarm that is then triggered, or better, do not enable the interfering radiation detection at first. However, it would be better not to enable the interfering radiation detection at first. Enable the interfering radiation detection only after calibration.

3

7.2.2 Interference Radiation Detection Flow Chart



If radiation interference is detected, following will happen:

If interference radiation is detected, the measurement switches to the HALT mode.

- Measured value and current output are "held".

The measurement is "held" up to the end of the defined waiting time.

At the end of the waiting time the system checks if the arriving count rate is smaller than 1.5-times the calibrated empty count rate (Io) (see scenario A). If not, the waiting time starts again.

If the count rate is below 1.5-times the empty count rate, the measurement automatically switches to the RUN mode. Sigma detection (see scenario B) is disabled for 3 x measuring time (= dead time).

Example:

If the measurement time is 20s, the dead time is 60s. This time is needed for the measurement to adjust to a possibly changed density, without triggering interference radiation detection. During this time, interference radiation is detected only when the count rate has increased to 1.5-times the empty count rate.

At the end of the dead time the Sigma detection is active again.

7.3 Measurement of Suspensions

Clear correlation of density and concentration is possible only when

- liquid density

  and

- solid density

are constant.

Concentration measurements of suspensions can be carried out in these units:

1. Concentration in weight per volume (g/L, g/cm^3, kg/m^3, ...)
2. Concentration in degBrix
3. Concentration in percent by weight (% sol-wt)
4. °Be

Data input, calibration and display are carried out in the selected unit of measure. The calibration curve, however, is calculated in g/cm^3, i.e. for the units in items 1 to 4 the values are internally converted into g/cm^3 in order to detect the curvature of the characteristic curve. Through conversion, a correct characteristic line can be obtained for suspensions already with one or two calibration points.

Both the solid density and the liquid density can be entered for the conversion. If you do not know the solid density, you can determine it as follows:

1. Determine the weight of the dry solid
2. Determine the volume, e.g. by displacement of water
3. Dividing weight by volume in the unit g/cm^3

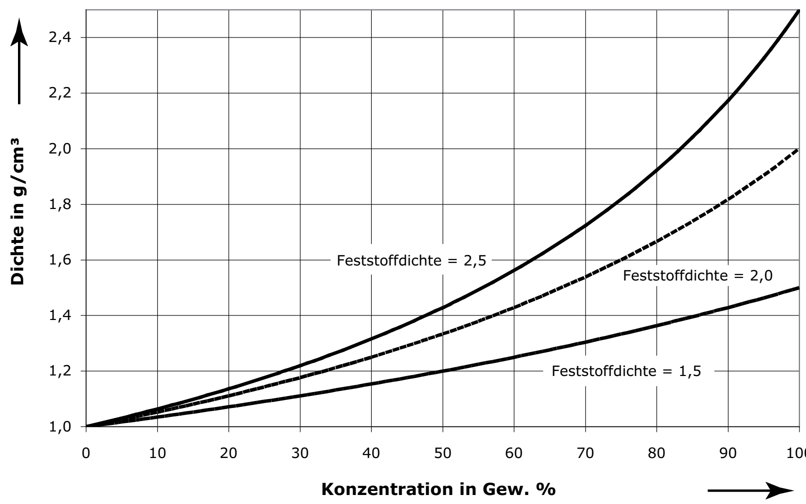


Fig. 7-2 Density of suspensions

The conversion is carried out according to the formulas.

Conversion concentrations in g/l

$$\rho = \left(1 - \frac{S}{\rho_S \cdot 1000}\right) \cdot \rho_L + \frac{S}{1000}$$

ρ	=	density of suspension in g/cm^3
ρ_S	=	solids density in g/cm^3
S	=	solids content in g/l
P_L	=	liquid density in g/cm^3

Conversion concentrations in %

$$\rho = \rho \cdot \frac{\rho_L}{\frac{C' \cdot \rho_L}{\rho_S} + 1 - C'} = \frac{\rho_L \cdot \rho_S}{C' \cdot (\rho_L - \rho_S) + \rho_S}$$

ρ	=	density of suspension in g/cm^3
ρ_S	=	solids density in g/cm^3
S	=	solids content in g/l
P_L	=	liquid density in g/cm^3
C'	=	concentration in percentage by weight/100

Conversion concentrations in °Be

For $\rho < 1$:

$$\rho = \frac{144.3}{144.3 - n}$$

For $\rho > 1$:

$$\rho = \frac{144.3}{144.3 + n}$$

n	=	°Be

Strictly speaking, the formulas for g/l and concentration in % apply only to suspensions. For solutions or liquid mixtures, large deviations may occur when the measurement involves larger ranges.

The diagram in *Fig. 7-3* shows how to convert the units for calibration.

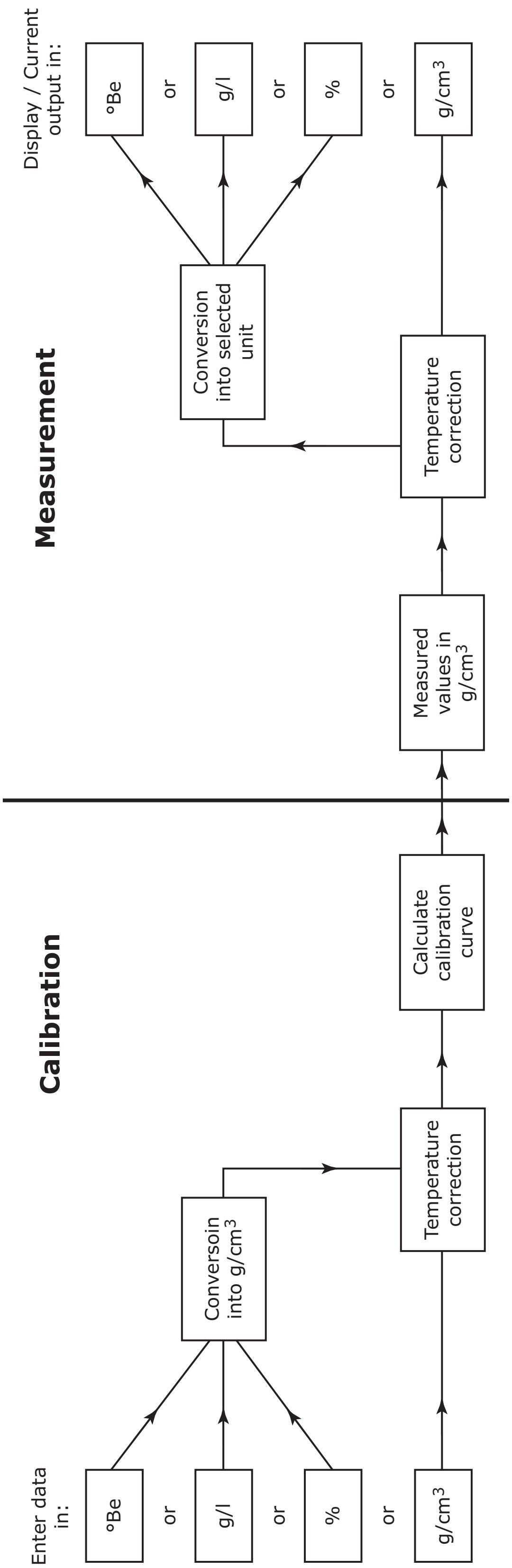


Fig. 7-3 Calculation of suspensions

7.3.1 Calculating the Density of Individual Components

With suspensions one can usually assume that liquid and solid density are constant. This is not the case when the liquid contains dissolved substances in different concentrations.

With solutions, one can use the suspension formula to allow simple calibration. However, it is better to use multi-point calibration without the suspension formulas since with solutions the density of both components is not constant due to the mixing ratio. With suspensions the solid density is usually known and water can be used as carrier liquid; with solutions, on the other hand, the density of the relevant components has to be calculated from table values.

Enter the density of the carrier liquid or the density of the attendant component (mostly water) at average temperature (reference temperature) as liquid density.

Table values are available as % concentration/density

In this case:

$$\rho_S = \frac{C' \cdot \rho_L}{\frac{\rho_L}{\rho} - 1 + C'}$$

ρ = density of the mixture g/cm^3 at medium concentration

ρ_S = density of the component to be measured (solid density)

P_L = density of the attendant component (liquid density) in g/cm^3

C' = concentration in percentage by weight/100

Example

Product	HCl – H_2O
Measuring range: Concentration	10 ... 30% HCl
Average product temperature	20°C
Density ρ at 20°C and 20% concentration	1.0980g/cm^3
Density H_2O (ρ_L) at 20°C	0.99823g/cm^3

$$\rho_S = \frac{0.2 \cdot 0.99823}{\frac{0.99823}{1.0980} - 1 + 0.2} = 1.8294$$

Input liquid density	0.99823
Input solid density	1.8294

Table values of the example are available as concentration in g/l

In this case:

$$\rho_S = \frac{S \cdot \rho_L}{\rho_L - \rho + S}$$

ρ = density of the mixture in g/cm^3 at medium concentration

ρ_S = density of the component to be measured (solid density)

P_L = density of the attendant component (liquid density) in g/cm^3

S = Concentration in g/l/1000

Example

Concentration	219.6g/l
Concentration S	0.2196
Density ρ	1.0980g/cm^3
Density H_2O (ρ_L)	0.99823g/cm^3

$$\rho_S = \frac{0.2196 \cdot 0.99823}{0.99823 - 1.0980 + 0.2196} = 1.8294$$

Input liquid density	0.99823
Input solid density	1.8294

7.4 Time Constant

The time constant is calculated automatically (factory setting), but can also be set manually to a fixed value. The time constant smoothes the output signal. Statistical fluctuations as well as process-related fluctuations in density, e.g. caused by agitators, can be smoothed.

The measured data supplied by the detector is averaged with the time constant.

A so-called RC-averaging is carried out:

nM = aM + ((AZR - aM) * (1 - e(-t/τ)

nM = new mean value

aM = old mean value

AZR = current, non-averaged count rate
(current display count rate)

t = time interval between the measurements in seconds

τ = time constant in seconds

Fig. 7-4 shows the reaction of the output signal in case of erratic filling of the container (input change) from 0 to 100%.

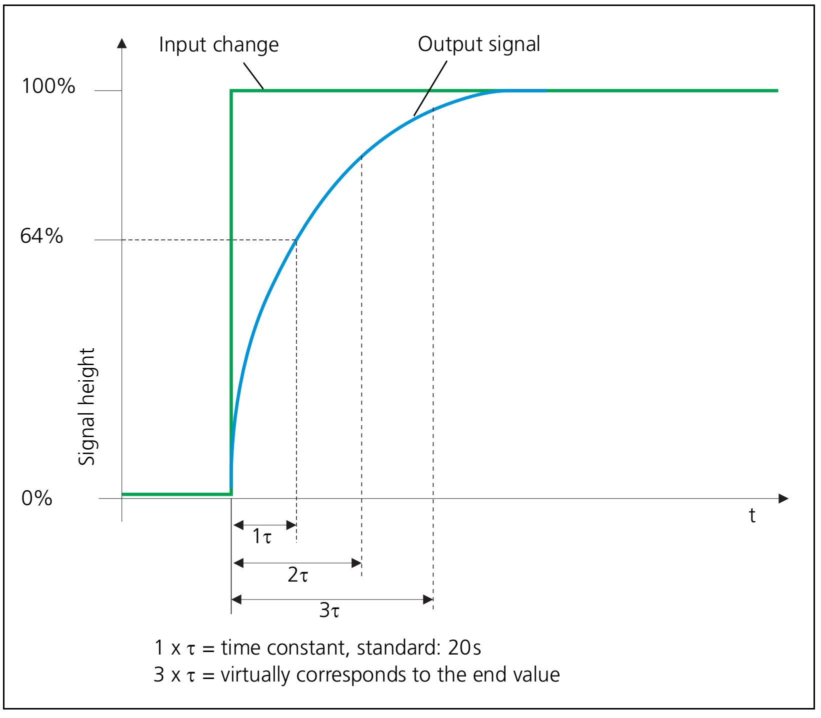


Fig. 7-4 Time constant

7.5 Temperature Compensation in Detail

Function of temperature compensation

The temperature coefficient of a liquid is not constant over a large temperature range, but usually it increases with rising temperatures. Temperature compensation is carried out according to the following formula:

$$\rho_{Ref} = \rho_M + (\vartheta_\rho - \vartheta_{Ref}) \cdot TK_1 + (\vartheta_\rho - \vartheta_{Ref})^2 \cdot TK_2$$

with:

ρ_{Ref}	=	density value compensated relative to reference temperature
TC_1	=	linear temperature coefficient TC_1
TK_2	=	square temperature coefficient TC_2
ρ_M	=	measured density value
ϑ_r	=	product temperature
ϑ_{Ref}	=	reference temperature

With minor temperature changes (approx. ± 20°C) it suffices, in most cases, to enter the linear coefficient (TC_1).

Calculation of the linear temperature coefficient

Example:

Product:	HCl water mixture
Measuring range:	20 … 40 wt % HCl
Temperature range:	10 … 30°C
Unit of measure:	g/cm^3

The temperature coefficient at average concentration (30%) is calculated as follows:

$$TK = -\frac{\rho_1 - \rho_2}{\vartheta_1 - \vartheta_2} = -\frac{1.1551 - 1.1433}{10 - 30} = 0.00059$$

with

ρ_1	=	Density in g/cm^3 at ϑ_1
ρ_2	=	Density in g/cm^3 at ϑ_2

The input value is therefore *5,9 e-04*.

For other units of measure (e.g. °Bx,% concentration, g/l, etc.), the temperature coefficients have to be converted accordingly. To do this, one first has to calculate the density change/unit of measure obtained for the measuring range (e.g. %):

$$\frac{\text{Density change}}{\text{Concentration change}} = \frac{\Delta\rho}{\Delta C} = \frac{\rho_{C1} - \rho_{C2}}{C_1 - C_2}$$

with

ρ_{C1} = Density at average temperature and minimum concentration in measuring range

ρ_{C2} = Density at average temperature and maximum concentration in measuring range

Example:

ρ_{C1} at 20°C and 20% HCl = 1.0979g/cm^3

ρ_{C2} at 20°C and 30% HCl = 1.1493g/cm^3

$$\frac{\Delta\rho}{\Delta C} = \frac{1.0979 - 1.1493}{20\% - 30\%} = 0.00514\frac{g}{cm^3 \cdot \%}$$

The temperature coefficient TC' for the unit % is calculated as follows:

$$TK' = \frac{TK_1}{\frac{\Delta\rho}{\Delta C}} = \frac{0.00059}{0.00514} = 0.11478$$

The input value is therefore *1.1478 e-01*.

Calculating the square temperature coefficient

If significant temperature variations are likely to occur in the product (approx. > ± 20°C), it is advisable to enter the square temperature coefficient as well.

Procedure:

1. Calculate TC_1 (see above).
2. With TC_1 calculate nominal value ρ_2' at higher temperature:

$$\rho_2' = \rho_1 + (\vartheta_1 - \vartheta_2) \cdot TK_1$$

3. Take actual density value ρ_2 from table.
4. Calculate TC_2:

$$TK_2 = \frac{\rho_2' - \rho_2}{(\vartheta_1 - \vartheta_2)^2}$$

Enter calculated value as temperature coefficient TC_2.

Example:

Ethanol, concentration 30 %, reading in g/cm³, relative to 10°C.

1. Temperature coefficient in range 10 ... 20°C:

$$TK_1 = -\frac{0.9599 - 0.9540}{10 - 20} = 0.00059$$

   Input value TC_1: 5.9 e -04
2. Calculate nominal value ρ_2' of density using the calculated TC_1 at 100°C:

$$\rho_2' = 0.9599 + (10 - 100) \cdot 0.59 \cdot 10^{-3}$$

3. Table value of ρ_2: 0,8936
4. This yields TC_2:

$$TK_2 = \frac{0.9068 - 0.8963}{(10 - 100)^2} = 1.2962 \cdot 10^{-6}$$

The input value for TC_2 is therefore *1.2962 e-06*.

3

Calculation of the temperature coefficient without table values

Linear temperature coefficient (only TC_1):

If you do not know the temperature coefficient of the product to be measured, you can calculate it using the method described below. The only prerequisite is that the measurement device is calibrated at reference temperature using at least two value pairs.

Procedure:

1. Fill measuring path with the product to be measured. The density should be about the average value of the requested measuring range.
2. Disable temperature compensation (instrument configuration without TC).
3. Start measurement and wait for a short time until the reading shows the value of the product in the measuring path.
4. Read off and write down the density or concentration value ρ_1.
5. Read off product temperature ϑ_1, write it down and enter it in reference temperature.
6. Change temperature of product in the measuring path through heating or cooling by approx. 10 to 15°C.
7. Write down the displayed density or concentration value ρ_2 and the displayed temperature ϑ_2.
8. Calculate the temperature coefficient as follows:

$$\mathrm{TK} = -\frac{\rho_1 - \rho_2}{\vartheta_1 - \vartheta_2}$$

9. Enter the calculated temperature coefficient in TC_1. TC_2 must contain "0".
10. Enable temperature compensation in the device configuration. The same density or concentration value as noted under 4. must now be available again.

Square Temperature Coefficient (TC_1 and TC_2):

To calculate the square coefficient one first has to calculate the linear coefficient, starting from the reference temperature (here: lowest temperature), as described above. The initial temperature should equal the lowest product temperature.

After calculation of the linear coefficient with temperature compensation enabled, increase the product temperature by at least 40 to 50°C. From the resulting change in reading and the associated temperature change one then calculates the square coefficient TC_2:

$$TK_2 = \frac{\rho_{soll} - \rho_A}{(\vartheta_1 - \vartheta_2)^2}$$

with

ρ_{target}	=	actual density value (table value or lab value at this temperature)
ρ_A	=	displayed density value
ϑ_1	=	original temperature
ϑ_2	=	temperature at ρ_A

Enter the calculated value at TC_2. Now the originally noted density or concentration value must be obtained again.

7.6 Software Versions

Two programs are needed to operate the SENSseries:

- *Embedded Software:* It is stored in the SENSseries (hardware).
- *Device Description (DD):* It is stored on the HART® Communicator.

To ensure that operation works smoothly, the DD version has to correspond to the embedded software on the SENSseries.

Proceed as follows to find the revision of the Device Description (DD) LB 480. The Device Description is the user interface the HART® Communicator requires to operate the respective device, e.g. the SENSseries LB 480. Each device requires its own DD.

7.6.1 Software Management

Show software versions

If the Start menu is not displayed, push ***HOME*** to go to the Start menu.

▶ Exit the Start menu by selecting the button "to the left".

▶ Select **UTILITY**.

▶ Select **SIMULATION**.

▶ Select **BERTHOLD TECHNOLOGIES**.

▶ Select LB 480.

Here you can read the revision of the Device Revision (Dev vX) and the Device Description (DD vX).

Type of modifications

HART® distinguishes two different types of software modifications:

- Modifications affecting functions and thus the DD and the embedded software.

  This type of modification will affect the compatibility to previous software versions.

- Modifications which only affect the DD or only the embedded software.

  These modifications do not affect the compatibility to the previous software version.

Example:

If a new function is added which allows you to enable or disable the digital input of the SENSseries then the embedded software has to be changed.

Likewise, a selection option has to be provided in the DD. Since this function was not yet implemented in previous versions, this will lead to incompatibilities with older software versions.

Two version numbers each

HART® has therefore introduced a system for identification which, at the same time, also describes the compatibility of the DD with the embedded software. Therefore, there are two HART®-specific version numbers for each software modification.

- A number that is incremented for *each* modification:
  - Software rev for the embedded software
  - DD v for the Device Description
- A number that is incremented only *if compatibility with the previous software is no longer given:*
  - Fld dev rev for the embedded software
  - Dev v for the Device Description

The table below shows the software versions of the SENSseries LB 480 for the version with HART® Communicator:

Embedded software version in the SENSseries			Device Description	
	Software versions (indicated on the HART® Communicator			
	under ... ▸ **review**		under ... ▸ **simulation**	
Software version	Software rev	Fld dev rev	Dev v	DDv
1.00.00	1	1	1	1
1.00.01	2	1	1	1
1.00.02	3	1	1	1
1.00.03	4	1	1	1
1.00.04	5	1	1	1

3

Explanations

Software release in the SENSseries (embedded software)

The software release of the embedded software in the SENSseries is described by the following three identifications:

- *Software version:* Berthold internal version number, e.g. 1.20
  - It is needed when the embedded software of the SENS-series is to be updated. The version appears in the file name, e.g. "LB480_V120.run".
- *Software rev:* ongoing revision number, e.g. 12
  - It is incremented with each embedded software modification.
  - Display of the *Software rev* see *page 3-386*.
- *Fld dev rev:* Field Device Revision, e.g. 3
  - This number will be incremented only when new commands have been implemented which create an incompatibility to previous DD versions.
  - It is stored in the embedded software of the SENSseries.
  - It shows which DD is required to utilize the full range of functions.
  - It is checked for compatibility by the DD (Dev v).
  - Display of the *Fld dev rev*, see *page 3-386*.

Software release of the DD (Device Description)

The software release of the DD on the HART® Communicator is identified by two version numbers:

- *Dev v:* Device Version, e.g. 3

  Revision number of the DD on the Communicator.
  - It is incremented only for modifications where new commands have been implemented that create an incompatibility with previous versions.
  - It is checked for compatibility with the *Field Device Revision* (see above).
  - Display of the *Dev v* see *page 3-386*.
- *DD v:* DD Version, e.g. 3

  Consecutive number of the DD on the Communicator.
  - It is incremented for any DD modification.
  - If may be higher than the *Dev v*.
  - Display of the *DD v*, see *page 3-386*.

Compatibility

You can load several different revisions onto the HART® Communicator. The Communicator compares the *Field Device Revision* of the SENSseries with the *Device Version* of the DD. The compatible DD version is started automatically.

8

Error Handling

Errors are indicated by the digital output and/or via fault current. Error messages are displayed on the HART® Communicator. All error messages are stored in the error log together with date and time. To view the error log, select **Device Config ▶ Diagnostic ▶ Log ▶ Error Log**.

8.1 Error Handling Modes

The behavior in case of errors is dependent on the weighting set in Error Handling (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**, *chapter 2.16*, *page 3-279*): ***NORMAL*** or ***SENSITIVE***.

Both operation modes behave as follows:

- ***SENSITIVE***

  All faults cause the current output to report a *Fault current*. To also get warning messages, you must also evaluate the messages via the HART® signal or the digital output.

  The setting ***SENSITIVE*** is automatically enabled when the Safety Mode is selected.

- ***NORMAL***

  Only fatal errors are reported as a fault current. Thus, the measured value via the current signal will fail only if the measurement can no longer be used.

  To also get minor error and warning messages, you must also evaluate the messages via the HART® signal or the digital output.

i ***IMPORTANT***

*You may select the **NORMAL** setting only if hazards to persons or damage to property a as a result of a faulty measured value can be ruled out.*

Select ***SENSITIVE*** if system safety is an important issue. Use ***NORMAL*** if a failure of the measurement is non-critical for human health and the environment and production safety is an important issue.

To use the digital output for the above mentioned messages, select on the menu **Digital Out Function** the setting ***WARNING + ERROR*** (**Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Digital Out Function**, see *chapter 2.27*, *page 3-299*).

8.2 Device Response to Errors

The following tables provide a description of the error codes, error and warning messages, information about the reason for the error and how to remedy the error. To keep the list clearer, we have created two separate lists for ***SENSITIVE*** and ***NORMAL***.

The list is so detailed as to cover and diagnose all possible error sources in such a radiometric measuring system. Thus, it is possible to offer the user a high level of safety and diagnostic options.

Meaning of the individual columns:

Identification	Meaning
x	An error message is issued.
–	*No* error message is output.
Error Log	The error that occurred is written to the error log.
HART®	An error telegram is digitally output via the HART® to the process control system. The control system must evaluate the HART® signal.
Digital Out	The digital output of the detector is actuated. In the standard version, this is an open collector.
Fault current	The current output switches to fault current. The 4-20 mA measurement signal is no longer available. The measurement signal is then available only via the digital HART® protocol.
SHUTDOWN	The current output switches to fault current, the HV (high voltage on the photomultiplier) goes to 0V. The measurement stops and can only be restarted by a restart of the detector or a software reset after the problem is solved.
Self-repairing	If the error disappears, then the fault condition is removed automatically. If the error is not self-repairing, then you need to reset the error state by rebooting or software reset.
Quality of measurement value for Master and Slave (only HART®)[1]	
g	Measured value is good
u	Measured value is doubtful
f	Measured value is frozen
b	Measured value is bad

1. The digital HART® protocol conveys the measured value as well as its quality.

8.2.1 Error Signaling

Code	Error message	Error Handling N=Normal S=Sensitive	Error Log	HART®	Digital Out	Fault current	SHUTDOWN	Slave Status	Master Status	Self-repairing
101	HW module missing or not tested	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	b	b	–	x
102	Device data-set error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
103	RAM Error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
104	Device Error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
105	Real time clock not valid	N	x	x	x			u	u	–
		S	x	x	x	x		b	b	–
106	Test mode active	N						g	u	–
		S						g	u	–
107	Watchdog reset	N	x					g	g	x
		S	x	x	x	x	x	b	b	–
108	Safety parameter invalid	N						g	g	–
		S	x	x	x	x		b	b	x
200	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
201	Error by analog input calibration	N	x	x	x			u	u	–
		S	x	x	x	x		u	u	x
202	Clock signal deviation	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
300	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
301	Error by ADC calibration	N	x	x	x			u	u	–
		S	x	x	x	x		u	u	–
302	Error by DAC calibration	N	x	x	x			u	u	–
		S	x	x	x	x		u	u	–
303	Supply 5.0V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
304	Reference 2.0V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
305	Reference 2.5V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
306	ERROR GND CPU ST9	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
307	No impulses in measuring channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
308	No impulses in control channel	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
309	No impulses in auxiliary channel	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
310	Impulse difference measuring channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
311	Impulse difference control channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
312	Impulse difference auxiliary channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
313	Instable pulse rate	N						g	g	x
		S						g	g	x
314	Threshold of measurement channel 1	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
315	Threshold of measurement channel 2	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
316	Threshold of control channel 1	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
317	Threshold of control channel 2	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
318	Threshold of auxiliary channel 1	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
319	Threshold of auxiliary channel 2	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
320	HV voltage	N	x	x	x			u	u	x
		S	x	x	x	x	x	b	b	–
321	Generated HV voltage	N	x	x	x	x		b	b	x
		S	x	x	x	x	x	b	b	–
322	HV reached its limit value	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
323	HV average is 20% lower than default HV	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
324	HV average is 40% higher than default HV	N	x	x	x			g	g	x
		S	x	x	x	x		u	u	x
325	Lower PMT current limit is exceeded	N	x					u	u	x
		S	x					u	u	x
326	Upper PMT current limit is exceeded	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
327	Temperature sensor deviation	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x

3

Code	Error message	Error Handling N=Normal S=Sensitive	Error Log	HART®	Digital Out	Fault current	SHUTDOWN	Slave Status	Master Status	Self-repairing
328	Temperature warning	N	x	x	x			g	g	x
		S	x	x	x	x		b	b	x
329	Temperature out of allowed limits	N	x	x	x	x		b	b	x
		S	x	x	x	x	x	b	b	–
330	Detector malfunction	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
400	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
401	Supply 11V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
402	Supply 5V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
403	Supply 5VM	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
404	Supply 3.3V	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
405	RS-485 Communication error	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
406	Remote device warning	N	x	x	x			u	u	x
		S	x	x	x			u	u	x
407	Remote device error	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
500	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
502	Digital input malfunction	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x
503	Digital output malfunction	N	x	x	x	x		g	g	x
		S	x	x	x	x		g	g	x
504	Pt100 Temperature	N	x	x	x	x		g	u	x
		S	x	x	x	x		g	u	x
600	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
601	License Key Error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
603	Measuring Error check <Error Status>	N	x	x	x			g	u	–
		S	x	x	x	x		g	b	–
604	Decay Compensation Error	N	x	x	x			g	u	–
		S	x	x	x	x		g	b	–
605	Source Exchange	N	x	x	x			g	g	x
		S	x	x	x			g	u	x
606	Radiation Interference	N	x	x	x			g	f	x
		S	x	x	x	x		g	f	x
607	RID Interference	N	x	x	x			g	g	x
		S	x	x	x			g	g	x
608	Inherited Message	N	x					g	g	x
		S	x					g	g	x
609	Inherited Message	N	x					g	g	x
		S	x					g	g	x
610	Pulse Rate Limit Min	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x
611	Pulse Rate Limit Max	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x
612	Pt100 missing	N	x	x	x			g	b	x
		S	x	x	x	x		g	b	x
613	Pt100 faulty	N	x	x	x			g	b	x
		S	x	x	x	x		g	b	x
700	Data flow	N	x	x	x	x	x	b	b	x
		S	x	x	x	x	x	b	b	–
701	Impulse difference	N	x	x	x	x		g	g	x
		S	x	x	x	x		g	g	x
702	Current loop malfunction	N	x	x	x	x		g	g	–
		S	x	x	x	x		g	g	–
703	CLoop Monitoring Disabled	N	x					g	g	x
		S	x					g	g	x
704	ERROR GND CPU ST6	N	x	x	x			g	g	x
		S	x	x	x	x		g	g	x
900	Data Flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
901	Signal Unlocked	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x

8.2.2 Error Handling

Code	Error message	Error reason	Error Handling
101	HW module missing or not tested		
102	Device data-set error		
103	RAM Error		
104	Device Error		
108	Safety parameter invalid		
200	Data flow		
201	Error by analog input calibration		
202	Clock signal deviation		
300	Data flow		
301	Error by ADC calibration		
302	Error by DAC calibration		
303	Supply 5.0V		
304	Reference 2.0V		
305	Reference 2.5V		
306	ERROR GND CPU ST9		
307	No impulses in measuring channel		
308	No impulses in control channel		
309	No impulses in auxiliary channel		
310	Impulse difference measuring channel		
311	Impulse difference control channel		
312	Impulse difference auxiliary channel		
313	Instable pulse rate	Hardware error	The error can be eliminated only by replacing the detector or the detector electronics.
314	Threshold of measurement channel 1		
315	Threshold of measurement channel 2		
316	Threshold of control channel 1		
317	Threshold of control channel 2		
318	Threshold of auxiliary channel 1		
319	Threshold of auxiliary channel 2		
330	Detector malfunction		
400	Data flow		
401	Supply 11V		
402	Supply 5V		
403	Supply 5VM		
404	Supply 3.3V		
500	Data flow		
502	Digital input malfunction		
503	Digital output malfunction		
504	Pt100 Temperature		
600	Data flow		
700	Data flow		
701	Impulse difference		
704	ERROR GND CPU ST6		
900	Data Flow		

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Code	Error message	Error reason	Error Handling
105	Real time clock not valid	Date invalid	If the device was turned off, check or update the date and time. If the unit was in operation when the error occurred, then there is a defect in the hardware. The error can be eliminated only by replacing the detector electronics.
106	Test mode active	A safety parameter could not be set.	Check or reset all test settings in the Service menu.
107	Watchdog reset	A line failure has triggered an error in the program flow and the device has been restarted automatically.	If the error occurs again, the detector electronics has to be replaced. If the exchange is unsuccessful, search for electromagnetic interference.
108	Safety Parameter invalid	Safety parameter invalid	Check in the Diagnostics menu which of the safety parameters could not be set and why.
320	HV voltage	A faulty measurement was detected in the high voltage.	The error can be eliminated only by replacing the detector electronics or the photomultiplier.
321	Generated HV voltage		
322	HV reached its limit value		
323	HV average is 20% lower than default HV		
324	HV average is 40% higher than default HV		
325	Lower PMT current limit is exceeded	The PMT current is >50µA.	Either there is strong radiation interference, or the photomultiplier (PMT) is defective and therefore has to be exchanged.
326	Upper PMT current limit is exceeded	The PMT current is >100µA.	
327	Temperature sensor deviation	The redundantly measured electronics temperatures differ more than 10 °C from each other.	The error can be eliminated only by replacing the detector electronics.
328	Temperature warning	The temperature in the detector has exceeded 75°C, or fell below -35°C.	Assemble water cooling, respectively assemble a trace heating system.
329	Temperature out of allowed limits	The temperature in the detector has exceeded 80°C, or fell below -40°C.	We recommend to return the detector for repair to the manufacturer, even if the detector appears to be functioning still.
405	RS-485 Communication error	Master-slave communication disturbed.	Check the wiring between master and slave, the detector address and the supply voltage.
406	Remote device warning	A slave returns a warning message.	Go to the Diagnostics menu and check in the local slave table which warning message is indicated for which slave.
407	Remote device error	A slave returns an error message.	Go to the Diagnostics menu and check in the local slave table which error message is indicated for which slave.
504	Inherited Message	A new software application has been installed and a previously stored fault is not existent in the new application.	Clear the fault memory with **Reset Error Log**.
601	License Key Error	The license key is invalid or does not match the application.	Check and correct license key. If necessary, consult BERTHOLD TECHNOLOGIES.

Code	Error message	Error reason	Error Handling
603	Measuring Error check <Error Status>	During decay compensation, an error was detected in the measurement parameters.	For more information on the cause of the error please go to the Diagnostics menu under **Error Status**.
604	Decay Compensation Error	The decay compensation could not be performed.	The error can be eliminated only by replacing the detector electronics.
605	Source Exchange	Based on the criteria entered, it was found that the source is too weak.	Replace source at the next opportunity. Please contact the manufacturer.
606	Radiation Interference	Based on the criteria entered radiation interference was detected.	Check whether welding seam tests were performed, or whether the criteria are set incorrectly or not optimally.
607	RID Interference	Message in this software is not active.	
608 609	Inherited Message	A new software application has been installed and a previously stored fault is not existent in the new application.	Clear the fault memory with **Reset Error Log**.
610	Pulse Rate Limit Min	The count rate entered in the parameter the Cps Lower Limit has been exceeded.	The message is dependent on the setting on the device. Unless the message is not displayed or incorrectly, you have to check the corresponding threshold setting in the menu.
611	Pulse Rate Limit Max	The count rate entered in the parameter the Cps Upper Limit has been exceeded.	
612	Pt100 missing	The Pt100 input is open, or the measured Pt100 temperature has exceeded 180°C.	Check wiring and Pt100, if necessary.
613	Pt100 faulty	The Pt100 input is open, or the measured Pt100 temperature has exceeded -30°C.	Check wiring and Pt100, if necessary.

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Code	Error message	Error reason	Error Handling
702	Cloop Malfunction	– Loose connection in the current loop. – Impedance in the current loop. >500Ω – Fault in the power output of the LB 480	If a loose connection or a too high impedance can be ruled out, the probe must be returned to the factory for repair.
703	CLoop Monitoring Disabled	The monitoring of the current output is turned off. Message always appears when restarting.	Enable the monitoring on the I/O Setup menu, unless there are reasons to keep the monitoring switched off.
901	Signal Unlocked	The detector has been unlocked with the password.	The warning message was generated as a result of the setting in **Signal Unlocked**, see *chapter 2.16*, *page 3-279*.

8.3 Trouble Shooting

Problem	Cause	Solution
No signal	System does not work	Check power supply
Count rate too low	Shielding not open or not open correctly.	Check lock and secure it in position OPEN
	Alignment of the effective radiation towards the detector is incorrect	Correct and optimize alignment
	Container installations in the beam path	Offset irradiation plane
	Wall deposits in the container	Remove wall deposits or perform new calibration if wall deposits cannot be removed.
	Source has reached the end of its service life	Replace source
No or incorrect density reading	Entry of final density values incorrect	Check calibration values and density reading
Density reading fluctuates strongly	Time constant too small	Increase time constant in the Parameter menu (min. 20s)
	Wrong calibration	Check calibration values
	Rapid switchover with too small Sigma value	Increase Sigma value or disable automatic time switch
	Count rate too low (see above)	Check age of source and irradiation level; replace detector
Density reading drifts	Detector stabilization faulty	Replace detector
	Multiplier faulty	Exchange multiplier
Current output at 24mA	Current output faulty or defective.	Recalibrate current output. Then restart detector by **Software Reset** or by turning the power supply off/on. If the current output cannot be calibrated, the detector needs to be repaired.

8.4 Reset

The SENSseries detectors can be reset in various ways. Use the menu **Device Config ▶ Setup ▶ Service** to perform a software reset or reset all settings to factory default.

1. Software reset: ***SW RESET***

   Starts the new detector, the parameters remain unchanged. The function corresponds to the switching off and on of the supply voltage.

2. Factory reset: ***FACTORY RESET***

   Resets most settings to factory default. Some settings, such as the adjustment of current output and the license key will be preserved. Turn the HART® Communicator off and on again after you have initiated the reset.

Switching the supply voltage off/on also causes a reset similar to the software reset, but in this case possible "hardware blocks" will also be fixed. The parameters remain unchanged.

See also *chapter 6.2*, *"Master Reset", page 3-369*.

8.5 Operation Modes during Measurement

Select **Operating Mode** (menu **Live Display**, *page 3-266*), to view the current operating status:

- The measurement is in the normal measurement mode or in the halt mode.
- A warning or an error is indicated.
- A test value is enabled.

See also *chapter 2.55*, **Operating Mode**, *page 3-323*, and the error lists in the previous chapter.

8.6 Error Reset

If an error or a warning is identified, an error message is displayed. This error message must be reset. If the error still occurs after resetting, it will be indicated again on the display.

If the error is corrected, but the error message is still displayed, the error can be acknowledged as follows:

- with **Acknowledge Error** under **Diagnostic ▶ Operating Status**
- with **Software Reset** under **Device Config ▶ Setup ▶ Service ▶ Reset Device**
- by switching the supply voltage off and on at the detector

8.7 Fault Current

There are four different ways of how the current output should respond to errors:

- *High:* Hold at >21mA.
- *Low:* Hold at <3.6mA.
- *Hold:* Hold last measured value.
- *Value:* Hold at a selected value between 2 and 22mA. The corresponding value must be defined in **Error Current Value** (see *page 3-297*).

Example for *High*

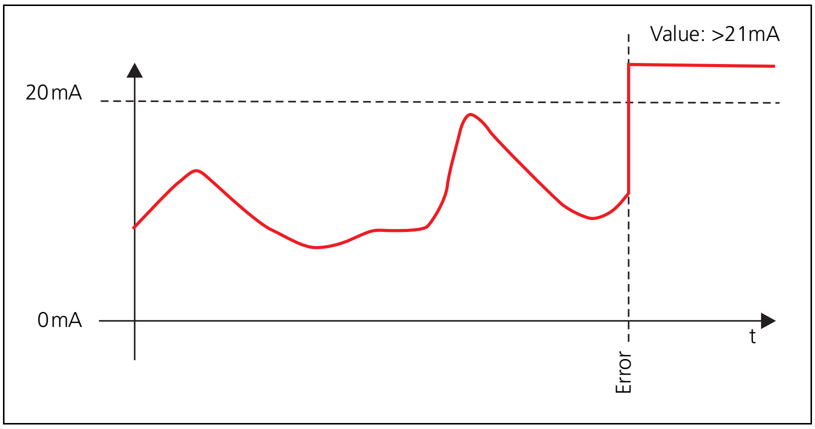

Fig. 8-1 Example for High

Example for *Hold*

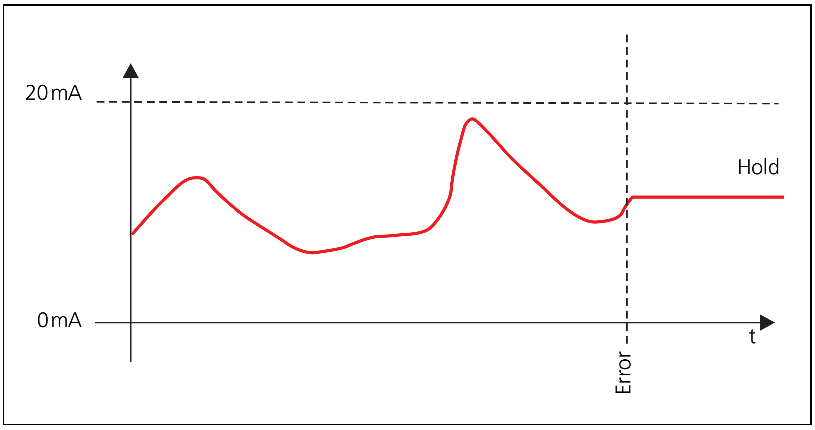

Fig. 8-2 Example for Hold

9 Tables

9.1 Absorption Coefficients

The absorption coefficients were calculated for average concentrations. Depending on the resolution behavior, these values may differ with other concentrations.

Product	Unit of measurement		
	g/cm^3	% concentration	Conc. in g/l
Whole milk	-0.0737	-0.00018	-0.000017
Skim milk	-0.0737	-0.000027	-0.000295
Whey	-0.0737	-0.000294	-0.0000254
Sugar solution	-0.0657	-0.00044	-0.000021
Hydrochloric acid (HCl) - H_2O	-0.0608	-0.0003	-0.000025
Sulfuric acid (H_2SO_4) - H_2O	-0.0623	-0.0005	-0.000036
Nitric acid (HNO_3) - H_2O	-0.0576	-0.00036	-0.000027
Sodium hydroxide (NaOH) - H_2O	-0.0664	-0.00069	-0.000049
Ethanol (C_2H_6O) - H_2O	-0.0677	0.00014	0.000018
Propyl alcohol (C_3H_8O) - H_2O	-0.0673	0.00015	0.0000186
Glycerin ($C_3H_5(OH_3)$) - H_2O	-0.0667	-0.00017	-0.000015

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9.2 Temperature Coefficients

Water temperature coefficient can be used for many low concentration products such as milk, beer, whey, starch suspensions, etc. For concentrated milk, whey, cottage cheese, etc., the values given for the sugar solution can be used with good approximation.

Temperature coefficients for water

Temperature in °C	Input value at g/cm^3
10	1.5000E-04
20	2.0300E-04
30	2.9900E-04
40	3.8000E-04
50	4.5700E-04
60	5.1300E-04
70	5.7100E-04
80	6.2350E-04
90	6.7000E-04

Temperature coefficient for sugar solution

Concentration in weight %	Aver. temp in °C	Input value at			
		g/cm^3	g/l	%	°Be
10	20	0.0002377	0.621	0.05748	0.000823
30	20	0.000341	0.908	0.07144	0.001245
50	20	0.000436	1.196	0.0794	0.001488
70	20	0.000518	1.457	0.0855	0.00355
10	50	0.000472	1.247	0.1167	0.00339
30	50	0.000582	1.395	0.1111	0.00302
50	50	0.000559	1.536	0.1033	0.00254
70	50	0.000588	1.654	0.0983	0.00475
10	70	0.000582	1.538	0.145	0.00531
30	70	0.000608	1.631	0.131	0.00426
50	70	0.000627	1.718	0.117	0.00328
70	70	0.000632	1.768	0.106	0.00561
10	80	0.000632	1.665	0.1583	0.00636
30	80	0.000649	1.173	0.1401	0.00491
50	80	0.000658	1.794	0.1223	0.00365
70	80	0.000641	1.785	0.1072	0.00582

Temperature coefficients for H_2O - H_2SO_4

Concentration in weight %	Aver. temp in °C	Input value at			
		g/cm^3	g/l	%	°Be
20	30	5.9500E-04	1.0220E+00	8.0000E-02	5.3100E-03
50	30	6.9500E-04	1.9320E+00	1.0300E-01	7.7300E-03
80	30	1.0150E-03	2.5190E+00	1.0000E-01	4.9900E-03
20	60	6.3500E-04	1.1070E+00	8.8000E-02	1.2920E-02

Temperature coefficients for H_2O - HCl

Concentration in weight %	Aver. temp in °C	Input value at			
		g/cm^3	g/l	%	°Be
10	25	3.3000E-04	7.3600E-01	6.7200E-02	2.9300E-03
30	25	6.0000E-04	1.5720E+00	1.2150E-01	8.0000E-03
10	75	5.3800E-04	1.1960E+00	1.1160E-01	4.1450E-02
30	75	5.7600E-04	1.6610E+00	1.3330E-01	4.4380E-02

Temperature coefficients for H_2O - NaOH

Concentration in weight %	Aver. temp in °C	Input value at			
		g/cm^3	g/l	%	°Be
10	30	0.00047	0.528	0.04315	0.00436
30	30	0.00062	0.974	0.05964	0.00308
50	30	0.00072	1.44	0.0759	0.00684
10	60	0.00055	0.628	0.0521	0.0064
30	60	0.00065	1.02	0.0634	0.00353
50	60	0.0007	1.404	0.075	0.00681

9.3 Density of Water as a Function of the Temperature

Temp in °C	Density in g/cm^3	Temp in °C	Density in g/cm^3	Temp in °C	Density in g/cm^3
10	0.99973	40	0.99224	70	0.97781
11	0.99963	41	0.99185	71	0.97723
12	0.99951	42	0.99146	72	0.97665
13	0.99939	43	0.99106	73	0.97607
14	0.99926	44	0.99065	74	0.97548
15	0.99911	45	0.99024	75	0.97488
16	0.99896	46	0.98982	76	0.97428
17	0.99879	47	0.98939	77	0.97368
18	0.99861	48	0.98896	78	0.97307
19	0.99843	49	0.98852	79	0.97425
20	0.99823	50	0.98807	80	0.97183
21	0.99801	51	0.98761	81	0.97120
22	0.99779	52	0.98715	82	0.97057
23	0.99755	53	0.98668	83	0.96993
24	0.99731	54	0.98621	84	0.96929
25	0.99706	55	0.98673	85	0.96864
26	0.99680	56	0.98524	86	0.96799
27	0.99653	57	0.98475	87	0.96734
28	0.99625	58	0.98425	88	0.96668
29	0.99597	59	0.98375	89	0.96601
30	0.99567	60	0.98324	90	0.96534
31	0.99536	61	0.98272	91	0.96467
32	0.99504	62	0.98220	92	0.96399
33	0.99472	63	0.98167	93	0.96330
34	0.99439	64	0.98113	94	0.96261
35	0.99405	65	0.98059	95	0.96192
36	0.99370	66	0.98005	96	0.96122
37	0.99335	67	0.97950	97	0.96052
38	0.99299	68	0.97894	98	0.95981
39	0.99262	69	0.97838	99	0.95910

9.4 List of the units

The following units can be selected in the LB 480 as measuring units.

	Density			Length	Suspension (Concentration)	
Unit Family	DENSITY 1	DENSITY 2	DENSITY 3	LENGTH	SUSPENSION 1	SUSPENSION 2
Unit	SGU	degBrix	%	ft	SGU	degBrix
	g/Cucm			m	g/Cucm	% sol-wtt
	kg/Cum			in	kg/Cum	
	LB/gal			cm	LB/gal	
	lb/Cuft			mm	lb/Cuft	
	g/ml				g/ml	
	kg/l				kg/l	
	lb/Cuin				lb/Cuin	
	STon/Cuyd				STon/Cuyd	
	degTwad				degTwad	
	degBaum hv				degBaum hv	
	degBaum lt				degBaum lt	
	degAPI				degAPI	
	ug/L				ug/L	
	ug/Cum				ug/Cum	

3

10 Setup Protocol

For reasons of clarity, only those parameters are listed in the following list which have a decisive influence on the measured signal.

As an alternative to completing the list below, you can also transfer and print the data digitally, via the HART® signal. See also *chapter 1.5, "Archiving Parameter Sets", page 3-255*.

▶ After commissioning, enter the parameters in the following parameter list in order to document the start-up.

TAG No.		**Date**	
Isotope		**Activity**	
Source no.		**Detector**	
Product		**HV**	

Path	Parameters	Unit	Standard	Setup
Device Config ▶ Setup ▶ Cal Parameter ▶ Product Conditions				
	Temp Compensation	OFF / STANDARD TC	OFF	
	Ref Temp	degC	0	
	TC 1		0	
	TC 2		0	
	Temp. Unit	degC / degF	degC	
Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings				
	Nuclide		Cs-137	
	Calibration Method	DIRECT ENTRY 1-POINT LINEAR SQUARE CUBIC	LINEAR	
	Measuring Path	cm	10	
	Unit Family	DENSITY 1 DENSITY 2 DENSITY 3 LENGTH SUSPENSION 1 SUSPENSION 2	DENSITY 1	
	Unit		g/cm3	
	Lower Range Limit		1	
	Upper Range Limit		1.2	
	ReadIn Time	s	180	

Path	Parameters	Unit	Standard	Setup
Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Points				
	Background	cps	0	
	Cal Coefficient A1			
Cal Point	Cal Density	Cal Density TC	Cal Rate	Cal Temperature (degC)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter				
	Time Constant	s	30	
	Error Handling	SENSITIVE / NORMAL	NORMAL	
	Signal Unlocked	OFF / WARNING	OFF	
Device Config ▶ Setup ▶ Signal Condition ▶ Reading Range				
	Lower Range Value		1	
	Upper Range Value		1.2	
	Factor		1	
	Offset		0	

Path	Parameters	Unit	Standard	Setup
Device Config ▶ Setup ▶ Signal Condition ▶ Signal Dependency				
	Response Mode	DISABLED RAD.INTERFERENCE RAPID SWITCH PULSE LIMIT	DISABLED	
	Io Factor		1.5	
	Waiting Time	S	60s	
	RI Sigma	sigma	10	
	Meas Delay Time	s	4	
	RS Sigma	Sigma	4	
	Cps Upper Limit	Cps	0	
	Cps Lower Limit	Cps	0	
Device Config ▶ Setup ▶ Signal Condition ▶ Source Exchange				
	Selection	OFF / DATE	OFF	
	Warning Date			
Device Config ▶ Setup ▶ Sensor Configuration ▶ Date - Time				
	Date	MM/DD/YYYY		
	Time	hh:mm:ss		
Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings				
	Detector Code	0 … 50	0	
	HV Mode	AUTO / MANUAL	AUTO	
	HV Live	V		
	HV Average	V		
	HV Manual	V		
	HV Default	V		

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Path	Parameters	Unit	Standard	Setup
Device Config ▶ Meas Parameter ▶ Meas Data				
	Meas Coefficient A1			
	Meas Coefficient A2			
	Meas Coefficient A3			
	Io Rate	cps		
	Square Error			
	Measuring Path	cps		
	Background	cps		
Device Config ▶ Meas Parameter ▶ Meas Data ▶ Meas Table				
Point	Value	Rate	Temperature	Density (TC)
Device Config ▶ Meas Parameter ▶ Meas Settings				
	Nuclide			
	Calibration Method			
	Temp Compensation			
	Ref Temp			
	TC 1			
	TC 2			

Notes:

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