EPHY MESS
Gesellschaft für Elektro-Physikalische Meßgeräte mbH

Manual
Temperature sensor PR-SPA-EX-LTH

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Manual

Temperature sensor PR-SPA-EX-LTH

1. Manufacturer and distributor

EPHY-MESS GmbH
Berta-Cramer-Ring 1
65205 Wiesbaden
Germany

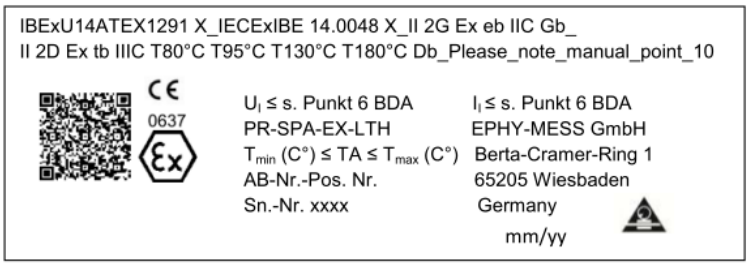
phone: +49 6122 9228-0
fax: +49 6122 9228-99
email: info@ephy-mess.de

2. Applied standards

- DIN EN 60079-0:2012 + A11:2013 (IEC 60079-0:2011, modified + Cor.: 2012 + Cor.: 2013)
- DIN EN 60079-7:2015 (IEC 60079-7:2015)
- DIN EN 60079-11:2012 (IEC 60079-11:2011 + Cor.:2012)
- DIN EN 60079-31:2014 (IEC 60079-31:2013)

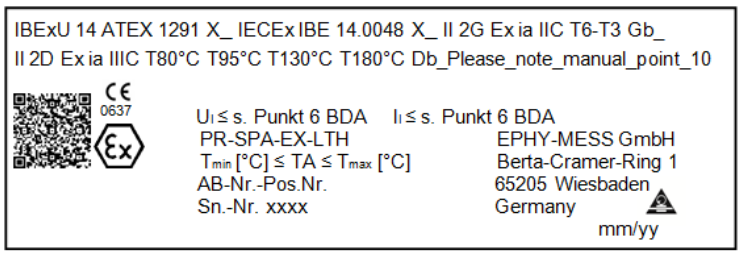
3. Labeling

3.1 Equipment protection by increased safety



Labeling according to manual
**not for bimetallic switches*

3.2 Equipment protection by intrinsic safety



Labeling according to manual

4. Assembly and commissioning

4.1 Installation in the blind hole drillings

- Temperature sensors of type PR-SPA-EX-LTH are especially designed for the installation into blind hole drillings in electrical motors, generators or other electrical machinery.
- The angular cable exit enables an installation of the temperature sensor very close to the machine housing and a tensile free cable installation on the housing surface.

- The PR-SPA-EX-LTH sensor installation / mounting must be accomplished with a special moveable fitting with brass or steel clamp/cutting ring, which is adapted to the protective tube diameter.
- The potential equalization is ensured by the screw connection.
- For insulated protection pipes only fittings with Teflon clamp rings are allowed to be used. In this case, the thermometer does not need to be grounded.
- By using moveable fittings the installation angle (cable exit) can be adapted exactly to the local requirements.
- The fore mentioned restrictions for the moveable fitting installation are not valid for sensor versions with rigid (non moveable) fittings.
- The protection tube of the thermometer must be installed, protected in full length (for example in a blind hole drilling or through bore).
- During installation of the thermometer one has to consider that no damage of cable and insulation occurs.
- High bending loads (flexing) as well as mechanical point loads on the temperature sensor (protection pipe and cable exit) during installation and operation must be avoided.
- The supply lines (connecting wires) have to be installed strain-relieved.
- The installation of the component must be defined in the EC-Type Examination Certificate for the particular electrical device.
- The sensor shall be mounted with mechanical protection only.
- When using cable screw connections one has to use a sealing compound in the region of the screw thread.

4.2 Usage outside the blind hole drillings

At this type of use, wherein the sensor is in direct contact with the explosive atmosphere are the self-heating and the resultant increase of the surface temperature be observed.

Temperature class	Maximum surface temperature of the equipment	Ignition temperature of the flammable materials
T1	450°C	> 450°C
T2	300°C	> 300°C < 450°C
T3	200°C	> 200°C < 300°C
T4	135°C	> 135°C < 200°C
T5	100°C	> 100°C < 135°C
T6	85°C	> 85°C < 100°C

4.3 Self-heating

When measuring the electrical resistance value, the current flows through the temperature sensor. Depending on the external influences, this causes power dissipation and thus a self-heating of the temperature sensor. Since a measuring current of 1 mA is generally not exceeded, the power dissipation of a Pt100 is in the range of a few tenths of a milliwatt and normally does not produce any significant measuring error. Otherwise, the self-heating must be observed so that the permissible maximum temperature is not exceeded and measurement errors are avoided.

Sample calculation for the self-heating, which the end user has to consider in his application:

Ohm's law:

1] $U = R \times I \rightarrow I = \frac{U}{R}$

[2] $P = U \times I$

[3] $P = R \times I^2$

P = electrical power / W
R = sensor resistance / Ω
I = measuring current / A
U = voltage / V

[4] $R(t) = R_0 \times (1 + A \times t + B \times t^2)$

R(t) = resistance at temperature t / Ω
T = temperature / °C
R_0 = nominal resistance at 0 °C / Ω
A = $3.90802E^{-3}$ x°C^{-1}
B = $-5.802E^{-7}$ x °C^{-2}

[5] $\Delta T = E \times P = E \times \frac{U^2}{R} = E \times R \times I^2$

E = self-heating coefficient, K/mW^{-1} = 0.4 KmW^{-1} *
ΔT = self-heating
T = permissible surface or ambient temperature

R (180°C) = 100 Ω x (1+ $3.90802E^{-3}$ x°C^{-1}x180°C+(-$5.802E^{-7}$ x °C^{-2} x (180°C)²) = 168.48 Ω

P (180°C) = 168.48 Ω x (0.001 A)² ** = 0.00016848 W → 0.16848 mW

ΔT = 0.4 K/mW x 0.16848 mW = 0.067392 K

T = 180°C – 0.067392°C = 179.932608°C

R (100°C)*** = 100 Ω x (1+ $3.90802E^{-3}$ x°C^{-1}x100°C+(-$5.802E^{-7}$ x °C^{-2} x (100°C)²) = 138.51 Ω

P (100°C) = 138.51 Ω x (0.001 A)² = 0.00013851 W → 0.13851 mW

ΔT = 0.4 K/mW x 0.13851 mW = 0.55404 K

T = 180°C – 0.55404 °C = 179.944596°C

* This calculation is applicable to one measuring circuit. If several (n) measuring circuits are included in a sensor, k must be replaced by n x k in the formulae.
** As an example we take 1 mA, because generally a measuring current of 1 mA is not exceeded.
*** Permissible ambient temperature of the connection head: T = 100 ° C

4.4 Self-heating coefficients

Sensor/Variant	Self-heating coefficients
Pt/Ni/Cuxxxxx	0.4 K/mW
TE	0 K/mW
KTYxx	0.4 K/mW
PTC-NATxxx	Not relevant because of characteristic curve
BIS	Not applicable*

**only under observation of max. switching currents, see Technical data, p. 6*

4.5 Electrical data

Characteristic values		Gas / Dust	
		Ex e	Ex i
Max. voltage U_I	*Chip, Class A*	DC 17 V	DC 17 V
	Chip, Class B	DC 25 V	DC 25 V
Max. current I_I	*Chip, Class A*	55 mA	55 mA
	Chip, Class B	80 mA	80 mA
Max. power P_I	*Chip, Class A*	1 W	1 W
	Chip, Class B	2 W	2 W
Permissible surface/ ambient temperature		T_{max} – self-heating	T_{max} - self-heating
Capacity C_I		*negligible*	*negligible*
Inductivity L_I		*negligible*	*negligible*

For the error analysis acc. to DIN EN 60079-ff. the permissible electrical values must be considered carefully. The maximum permissible ambient temperatures must be calculated and ensured under consideration of the self-heating.
The equipment operators must ensure that these values will not be exceeded.

5. Connection

Constructions with plugs are generally available with Ex i ignition protection. The operating temperatures and the electrical values of the each plug must be considered.

5.1 Connecting wires (V1/V2)

- The supply lines of the sensors are color-coded according to the color code and type of circuit related to the used resistance sensor / thermocouple (see 9.1 and 9.2 Circuit and labeling of the connecting wires).
- The connector ends have to be attached to suitable clamps only.
- The sensor supply lines (connecting wires) may only be connected to power supply units suitable and approved for passive resistance sensors / thermocouples according to the corresponding resistance thermometers / thermocouples standards.

- The power supply must have a connection adequate to the thermometer's type of circuit (2- 3- or 4-wire circuit).
- The electrical operation data have to be observed (see 6. Technical data).
- The sensor signal for the resistance sensor version and the thermistor version has no polarity. The color code of the supply line is used only for the identification of sensor and circuit!
- The sensor signal for the thermocouple version and KTY-sensor version has polarity. For the thermocouples the plus- and minus pole are color coded according the valid standard. The KTY is color coded.
- The connecting cables must be laid straight and without loops.
- It is not allowed to connect, install or apply the PR-SPA-EX-LTH sensor in another way than described under item 4 and 5.
- Only mechanically protected sensors can be mounted.
- The cable of a sensor with a bimetallic switch as a measuring element must not be laid overlapping and touchingly.

5.2 Connecting wires (V3)

- The distances of the clearance and creepage distances between the housing and the measuring circuits of the plug-in socket in the connection head have to be at least 3 mm.
- The connecting wires of the PR-SPA-EX-LTH-sensors are color coded according color code and mode of circuit of the used resistance sensors / thermocouples (see 9.1 and 9.2 circuit and labeling of connecting wires).
- The connector ends have to be attached to suitable clamps only. When using clamp socket and free connected supply line, the customer has to follow the requirements of EN 60079-7 point 4.2.1.
  - Point 4.2.1 a-f) to make sure these points bolting torques and prestressing forces should be in accordance to the DIN standards - DIN 912, 931, 933, 934, ISO 4762, 4014, 4017, 4032.
  - Point 4.2.1 g-j): only clamp connectors have to be used, which are provided for the intended use.
  - The torque for EM 24 clamp socket are defined with 0.35 Nm and clamp socket type: SB-B10S-G4Lr (or similar) with 2 Nm.
- The recommended hose line should be according to VDE 0250 and following, but it is replaceable by equivalent if it is in accordance to the purpose and conditions of this manual instructions.
- The sensor supply lines (connecting wires) may only be connected to power supply units suitable and approved for passive resistance sensors / thermocouples according to the corresponding resistance thermometers / thermocouples standards.
- The power supply must have a connection adequate to the thermometer's type of circuit (2-, 3- or 4-wire-circuit).
- The electrical operation data have to be observed (see 6. Technical data).
- The sensor signal for the resistance sensor version and the thermistor version has no polarity. The color code of the supply line is used only for the identification of sensor and circuit!
- The sensor signal for the thermocouple version and KTY-sensor version has polarity. For the thermocouples the plus- and minus pole are color coded according the valid standard. The KTY is color coded.
- The connecting cables must be laid straight and without loops.
- It is not allowed to connect, install or apply the sensor in another way than described under item 4 and 5. Only mechanically protected sensors can be mounted.
- The cable of a sensor with a bimetallic switch as a measuring element must not be laid overlapping and touchingly.

6. Technical data

Description

Temperature sensor PR-SPA-EX-LTH, acc. to drawings:
999130613986001 (version 1), 999130613986002 (version 2),
999130613986003 (version 3)

Construction

Version (V1): insulated temperature sensor, shockproof mounted in metallic protection pipe with encapsulated cable exit and fix connected supply line. Supply line through soft solder connection and strain relief securely connected in an encapsulated connection head LTH. Optionally available with or without cover.

Version (V2): insulated temperature sensor, shockproof mounted in metallic protection pipe with encapsulated cable exit and fix connected supply line. Supply line through hard solder or crimp connection with insulation hose in an encapsulated connection head LTH. Optionally available with or without cover.

Version (V3): insulated temperature sensor, shockproof mounted in metallic protection pipe with fix connected supply line. Connection with clamp socket in a connection head LTH and cover.

Approval

IBExU 14 ATEX 1291 X
IECEx IBE 14.0048 X

Type of protection

II 2G Ex ia IIC T6-T3 Gb / II 2D Ex ia IIIC T80°C T95°C T130°C T180°C Db
II 2G Ex eb IIC T6-T3 Gb* / II 2D Ex tb IIIC T80°C T95°C T130°C T180°C Db*
**Not for bimetallic switches*

Sensor insulation

Version (V1): insulation hose and silicone
Version (V2): insulation hose and silicone
Version (V3): insulation hose

Ambient temperature
(Area of connection head)

Resistance sensor (Pt/Ni/Cuxxxxx):	-60°C … 100°C
Thermocouples (TE):	-60°C … 100°C
Silicon-sensor (KTY83):	-55°C … +100°C
Silicon-sensor (KTY84):	-40°C … +100°C
Thermistor (PTC-NATxxx):	-45°C ... +NAT1) + 23 K
Bimetallic switch (BIS):	-25°C ... +100°C

Resistance sensor (Pt/Ni/Cuxxxxx)

Material:	Platinum (Pt) / Nickel (Ni) / Copper (Cu)
Nominal value:	5 … 2000 Ω at [0°C]
Tolerance class:	according to respective standard
Measuring circuits:	1 or 2
Mode of connection:	2-, 3- or 4-wire circuit
Measuring current:	0.3 ... 1 mA (chip)
Self-heating:	0.4 K/mW at 0°C
Operating temperature[2)]:	-60°C … +180°C

Thermocouple (TE)

Measuring circuits:	1 or 2
Max. voltage:	1.5 V
Max. current:	100 mA

	Max. power:	25 mW	
	Self-heating:	-	
	Operating temperature[2)]:	-60°C … 180°C	
Silicon-sensor (KTY)	Model series:	KTY83	KTY84
	Measuring circuits:	1 or 2	1 or 2
	Nominal value:	1000 Ω at 25°C	1000 Ω at 100°C
	Measuring current:	1 mA	2 mA
	Max. voltage:	5 V	5 V
	Max. power:	6.3 mW	6.3 mW
	Self-heating:	0.4 K/mW at 0°C	0.4 K/mW at 0°C
	Operating temperature[2)]:	-55°C … +175°C	-40°C … +180°C
Thermistor (PTC)	Measuring circuits:	1 or 2	
	NAT[1)]:	60°C … 180°C	
	Max. current:	2 mA	
	Max. voltage:	2.5 V	
	Power:	4.7 mW	
	Self-heating:	not relevant because of characteristic curve	
	Operating temperature[2)]:	-45°C … +180°C	

Bimetallic switches (BIS)	Type series:		
	Opener	S.01 / C.01 / L.01	S.06 / C.06 / L.06
	Closer	S.02 / C.02 / L.02	S.08 / C.08 / L.08
	Nominal switching temperature:	60°C ... 200°C	70°C ... 200°C
	Operational voltage range AC/DC up until:	500 V AC / 14 V DC*	500 V AC / 28 DC*
	Rated voltage AC:	250 V	250 V
	Rated voltage DC:	12 V*	24 V*
	Max. switching current AC:		
	cos φ = 1,0 / cycles	6.3 A / 3000	25.0 A / 2000
	cos φ = 0,4 / cycles	7.2 A / 1000	
	Max. switching current DC:	40.0 A / 5000*	40.0 A / 8000*
	Rated current AC:		
	cos φ = 1,0 / cycles	2.5 A / 10000	10.0 A / 10000
	cos φ = 0,6 / cycles	1.6 A / 10000	6.3 A / 10000
	cos φ = 0,4 / cycles	1.8 A / 10000	
	High voltage resistance:	2.0 kV	2.0 kV

*just Opener

Dimensions (TxWxL)	Protection pipe:	øD mm x L mm
	Cable exit:	ø24±0.2 x 29±0.2 mm
		ø38±0.2 x 33±0.2 mm
	Installation fitting:	M16x1.5, M20x1.5, M24x1.5
		alternative PG9/PG16 or others

Protection pipe stainless steel, bare or with shrinking hose insulation

Dielectric strength	Sensor:	0.5kV / 50Hz, 1min.
	Supply line:	0.5kV / 50Hz, 1min.
Supply line	Construction:	hose line (Si/Si alternative PTFE), fix connected
	Color code:	acc. to DIN or resp. customer's request
	Cross section:	≥ AWG 30
	Cable capacitance (Ci):	negligible
	Cable inductance (Li):	negligible
Installation fitting	moveable:	stainless steel with thread M10x1, G1/4", 1/2", G3/8" or others
	accessories:	conical PTFE-, brass or stainless steel clamp ring
	fixed:	G3/8" or others

[1] NAT= Nominal response temperature
[2] Operating temperature using elastomer (depend on used elastomer material) for insulation only ... + 150°C

General hints:

When mounting one has to pay attention that no damage will occur to the supply line and the insulation of the sensor. The supply line must be installed strain-relieved. Extreme bending load as well as punctual, mechanical stress to the sensor should be avoided.

The special security hints for the mounting regarding the ATEX approval are fixed in the above-named ATEX-approval which is available at EPHY-MESS or at www.ephy-mess.de.

7. Type identification

PR-SPA-EX-LTH + variant identification (see point 8)

PR	SPA	EX	Design depending on the installation location	Version
				see point 8
			LTH: bearing thermometer	
		EX-certification		
	Sensor, passive			
Product				

8. Variant identification

Version	Customer standards (optional)	Measu-ring circuits	Sensor	Nominal value	Tolerance	Wire circuit	Dimensions in mm	Supply line	Sensor version (optional)	Addition[1)]
									Screened =abg Number of isolations	
								Information about cable		
							ø= diameter l= length			
						2- ,3- or 4-wire circuit for RTD for TE, KTY, PTC (always 2-wire circuit)				
					Tolerance class according to DIN - for example: Class A; B for RTD Class 1; 2; 3 for TE In % for KTY, PTC-sensors					
				100, 500 or 1000 for RTD-Nominal value in [Ω] J, K … etc. for thermocouple type 83 or 84 for KTY-sensor type 60, 70, 80 … etc. for NAT in [°C] 60, 70, 80 … etc. for NST in [°C]						
			Pt, Cu or Ni for RTD TE for thermocouple KTY for silicon-sensor EPTC,ZPTC,DPTC for thermistors (single, twin, triple) BIS for bimetallic switch "Kombi" for combination of several sensor types							
		Number of measuring circuits / sensors								
	Title of customer standards									

EM = EPHY-MESS Head
DN = DIN Head
AN = others

E. g.: EM,1Pt100B2,ø6x70x100,M10x1,S4x0,5,4000RDBN/2xRD/2xWH,180°C2.5kV,LTH24

E. g.: DN,1Pt100B2,ø6x60x90M8x1,S2x0.25,2000RDBN/RD/WH,B

E. g.: DN,1Pt100B2,ø5x60x90,M8x1,S2x0.25,2000RDBN/RD/WH,B-Head

E. g.: AN,1Pt100B4,ø6x200x270S,G1/2,G4x24/7,7000BK/2xRD/2xWH180°C,1kV,LTH-Steck

EM	1	Pt	100	B	2	ø6x70x100 M10x1	S4x0,5, 4000RDBN/ 2xRD/2xWH	180°C, 2.5kV, LTH24
DN	1	Pt	100	B	2	ø6x60x90, M8x1	S2x0.25, 2000RDBN/ RD/WH	B
DN	1	Pt	100	B	2	ø5x60x90, M8x1	S2x0.25, 2000RDBN/ RD/WH	B-Head
AN	1	Pt	100	B	4	ø6x200x270S,G1/2	G4x24/7, 7000BK/ 2xRD/2xWH	180°C,1kV, LTH-Steck

RTD = Resistance thermometer
NAT = Rated operation temperature
NST = Nominal switching temperature
Pt = Platinum
Cu = Copper
Ni = Nickel

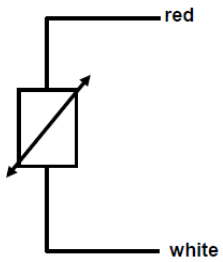
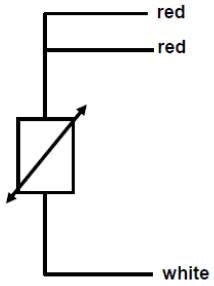
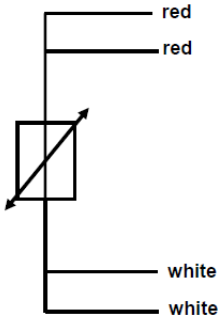
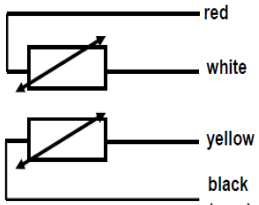
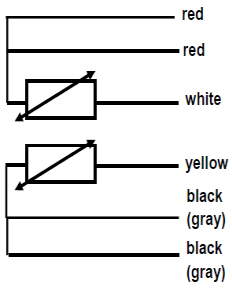
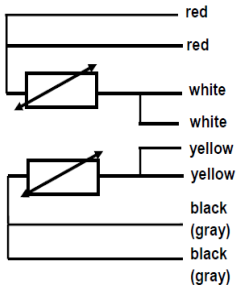
1) Addition. E. g.: In KTY also be asked to specify color code and polarity of the line e. g.: YE (+) / GN (-)

9. Nominal values / characteristics

Nominal values and characteristics for the individual measuring resistors are specified in the following standards:

Platinum resistance thermometer	DIN EN 60751
Nickel resistance thermometer	not standardized
Copper resistance thermometer	not standardized
Thermocouples (TE)	DIN EN 60584
Thermistors (PTC)	DIN 44081-82
Silicon sensors (KTY)	not standardized
Bimetallic switches (BIS)	not standardized

9.1 Circuit and labeling of connecting wires of Pt100 sensors acc. to EN 60751

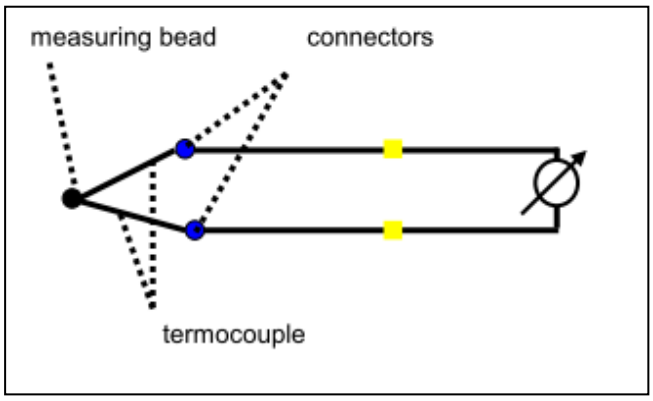
	2- wire circuit	3- wire circuit	4- wire circuit
1 x Pt100 measuring resistor			
2 x Pt100 measuring resistors			

9.2 Circuit and labeling of connecting wires of thermocouples acc. standard (excerpt)

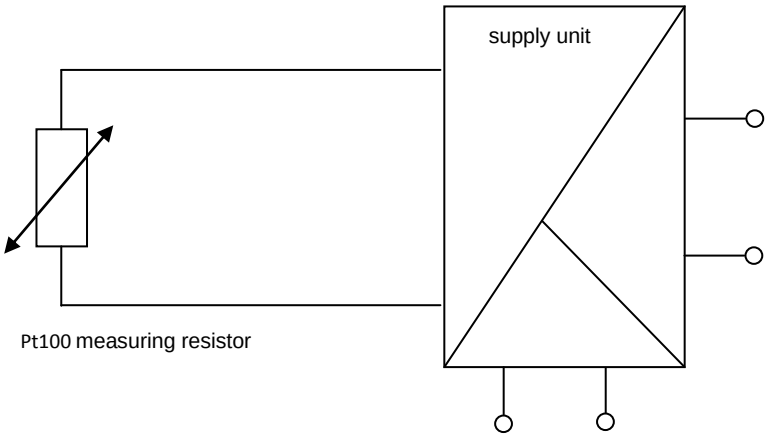
Type	Color	Standard
T	BN(BN$^{(+)}$ / WH$^{(-)}$)	EN 60584
J	BK(BK$^{(+)}$ / WH$^{(-)}$)	EN 60584
K	GN(GN$^{(+)}$ / WH$^{(-)}$)	EN 60584
S	OR(OR$^{(+)}$ / WH$^{(-)}$)	EN 60584

9.3 Connection diagram

9.3.1 Connection diagram equipment protection by increased safety (Principle sketch of thermocouples)



9.3.2 Connection diagram equipment protection by intrinsic safety (Use of suitable operating equipment)



10. Cable assembly

For versions of srew-in thermometers where a cable could be assembled you have to ensure that the cable complies with all operating conditions specified under point 6.

The protection class IP6x must be guaranteed after the cable installation.

It is only allowed to install the cable outside hazardous areas.

When using a cable screw connection the above-mentioned facts must be ensured. A possible variation for the cable screw connection could be the type 65052 m 17 or TPE 6.21651d1509 07ex or equivalent products of other manufacturers.

Wiesbaden, 23rd of June 2017