EPHY MESS
Gesellschaft für Elektro-Physikalische Meßgeräte mbH

Manual

Temperature sensor PR-SPA-EX-NWT

1. Manufacturer and distributor

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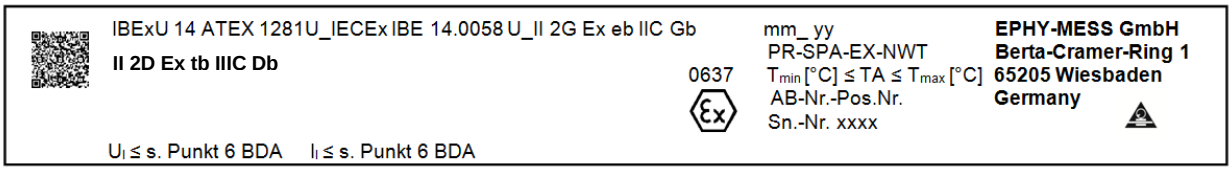
2. Applied standards

- DIN EN IEC 60079-0:2018 (IEC 60079-0:2017)
- DIN EN 60079-7:2015 (IEC 60079-7:2015)+A1:2018
- DIN EN 60079-11:2012 (IEC 60079-11:2011 + Cor.:2012)
- DIN EN 60079-31:2014 (IEC 60079-31:2013)

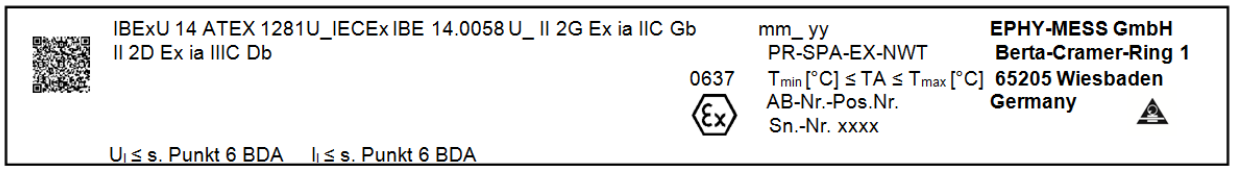
3. Labeling

3.1 Equipment protection by increased safety



Labeling according to manual

3.2 Equipment protection by intrinsic safety



Labeling according to manual

4. Assembly

4.1 Installation in the slot of an electrical machine

- When installing the temperature sensor in the slot of an electrical machine (e.g. motor, generator or transformer) no special conditions have to be observed.
- The dimensions allow the fixed assembly directly into the slots of the electrical machinery.
- The type of construction guarantees a good thermal contact between the monitored components and the temperature sensor.
- The sensors are mounted parallel to the windings directly into the corresponding slots.
- High bending loads (flexing) as well as mechanical point loads on the temperature sensor during installation and operation must be avoided.
- During installation one has to pay attention that no damage occurs to cable and insulation.
- The supply lines (connecting wires) have to be installed strain-relieved.

- The installation of the component is defined in the EC-Type Examination Certificate for the particular electrical device.
- Only mechanically protected sensors can be mounted.

4.2 Usage outside the slot of an electrical machine

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

$R (180°C) = 100\ \Omega \times (1 + 3.90802E^{-3} \times °C^{-1} \times 180°C + (-5.802E^{-7} \times °C^{-2} \times (180°C)^2) = 168.48\ \Omega$

$P (180°C) = 168.48\ \Omega \times (0.001\ A)^2$ ** = 0.00016848 W → 0.16848 mW

$\Delta T = 0.4\ K/mW \times 0.16848\ mW = 0.067392\ K$

$T = 180°C - 0.067392°C = 179.932608°C$

$P (180°C) = 168.48\ \Omega \times (0.002\ A)^2$ *** = 0.00067392 W → 0.67392 mW

$\Delta T = 0.4\ K/mW \times 0.67392\ mW = 0.269568\ K$

$T = 180°C - 0.269568°C = 179.730432°C$

* 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.
*** Recommended measuring current 2 mA for sensors with bifilar winding.

4.4 Self-heating coefficients

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

4.5 Electrical data

Characteristic values		Gas / Dust	
		Ex e	Ex i
Max. voltage U_I	*Class A*	DC 17 V	DC 17 V
	Class B	DC 25 V	DC 25 V
Max. current I_I	*Class A*	55 mA	55 mA
	Class B	80 mA	80 mA
Max. power P_I	*Class A*	1 W	1 W
	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. Connecting wires

- The supply lines of the sensors are color-coded according to the color code and type of circuit related to the used resistance sensor (see 9.1 circuit and labeling of 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 standards.
- The power supply must have a connection adequate to the thermometer's type of circuit (2-, 3- or 4-wire-circuit).
- The electrical performance 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-NWT sensor in another way than described under item 4 and 5.
- 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.

6. Technical data

Description	Temperature sensor PR-SPA-EX-NWT, acc. drawings: 999130613901001 (version 1) 999130613901002 (version 2) 999130613901003 (version 3) 999130613901004 (version 4)
Construction	Version PR-SPA-EX-NWT-ST (V1): insulated, bifilar coiled measuring wire mounted in multiple layers of mica laminate or incorporated into a backfilled with silicone recording HGW (hard glass fabric) body. Supply line through soft solder connection and strain relief securely connected. PR-SPA-EX-NWT-A = PR-SPA-EX-NWT-ST + shielding Version PR-SPA-EX-NWT-SH (V2): bifilar coiled measuring wire, mounted pressure-compensated in a flexible HGW (hard glass fabric) carrier body. Supply line through soft solder connection and strain relief securely connected. Version PR-SPA-EX-NWT-AK or PR-SPA-EX-NWT-KS (V3): resistance sensor inlaid in HGW (hard glass fabric) carrier body or plastic carrier body (KS), und permanently elastic filled with silicone or epoxy. Supply line with hard solder or crimp connection securely connected. Version PR-SPA-EX-NWT-ZS (V4): resistance sensor inlaid in HGW (hard glass fabric) inter-slide housing (ZS), und permanently elastic filled with silicone. Supply line with hard solder or crimp connection securely connected.
Approval	IBExU 14 ATEX 1281 U IECEx IBE 14.0058 U
Type of protection	II 2G Ex ia IIC Gb / II 2D Ex ia IIIC Db II 2G Ex eb IIC Gb / II 2D Ex tb IIIC Db

Sensor insulation	Version (V1): mica laminate or HGW-carrier body with silicone Version (V2): HGW-carrier body with insulation hose Version (V3): HGW-carrier body (AK) with cover or plastic body (KS) Version (V4): HGW-inter slide housing (ZS) with silicone		
Dimensions (TxWxL)	Version (V1-V4): T mm x W mm x L mm		
Ambient temperature	Resistance sensor (Pt):	-60°C … +180°C	
	Thermocouple (TE):	-60°C … +180°	
	Silicon-sensor (KTY83):	-55°C … +175°C	
	Silicon-sensor (KTY84):	-40°C … +180°C	
	Thermistor (PTC-NATxxx):	-45°C ... +180°C	
Resistance sensor (Pt/Ni/Cuxxxxx)	Material:	Platinum (Pt)	
	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:	0.2 ... 2 mA (bifilar coiled) 0.3 ... 1 mA (chip)	
	Self-heating:	0.4 K/mW at 0°C	
	Operating temperature:	-60°C … +180°C	
Thermocouples (TE)	Measuring circuits:	1 or 2	
	Max. voltage:	1.5 V	
	Max. current:	100 mA	
	Max. power:	25 mW	
	Self-heating:	-	
	Operating temperature:	-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:	-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:	-45°C … +NAT[1)] + 23 K	

Dielectric strength	Sensor:	0.5 kV / 50 Hz, 1min.
	Supply line:	0.5 kV / 50 Hz, 1min.
Supply line	Construction:	single litz, hose line flat hose line
	Insulation:	Teflon or silicone
	Color code:	acc. to DIN or resp. customer's request
	Cross section:	≥ AWG 30
	Cable capacitance (Ci):	negligible
	Cable inductance (Li):	negligible

[1] NAT= Nominal response temperature

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-NWT + variant identification (see 8. Variant identification)

PR	**SPA**	**EX**	**Design depending on the point of installation**	**Version**
				see 8. Variant identification
			NWT: Slot resistance sensor	
		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		
							t = thickness w= width l= length			
						2- ,3- or 4-wire circuit for RTD for TE, KTY, PTC (always 2-wire circuit)				
					Tolerance class according to DIN: 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]					
			Pt for RTD TE for thermocouple KTY for KTY-sensor EPTC,ZPTC,DPTC for thermistors (single, twin, triple) "Kombi" for combination of several sensor types							
		Number of measuring circuits / sensors								
	Titel of customer standards									

AK = carrier component
ST = rigid
ZS = intermediate slider case
SH = shrinking tube insulation
KS =plastic carrier

E. g.: SH,1Pt100B4,3.5x12x200,4000/500A1x20/19,24/7BU/BU/GY/GY,E1GN/YE,abg,2iso,UL
E. g.: ST,SN73264,1Pt100B2,3x10x500,1500/550-A-3.1,IECEx

SH		1	Pt	100	B	4	3,5x12x200	4000/500 A1x20/19,24/7 BU/BU/GY/GY	abg,2iso	UL
ST	SN 73264	1	Pt	100	B	2	3x10x500	1500/550	A	3.1,IECex

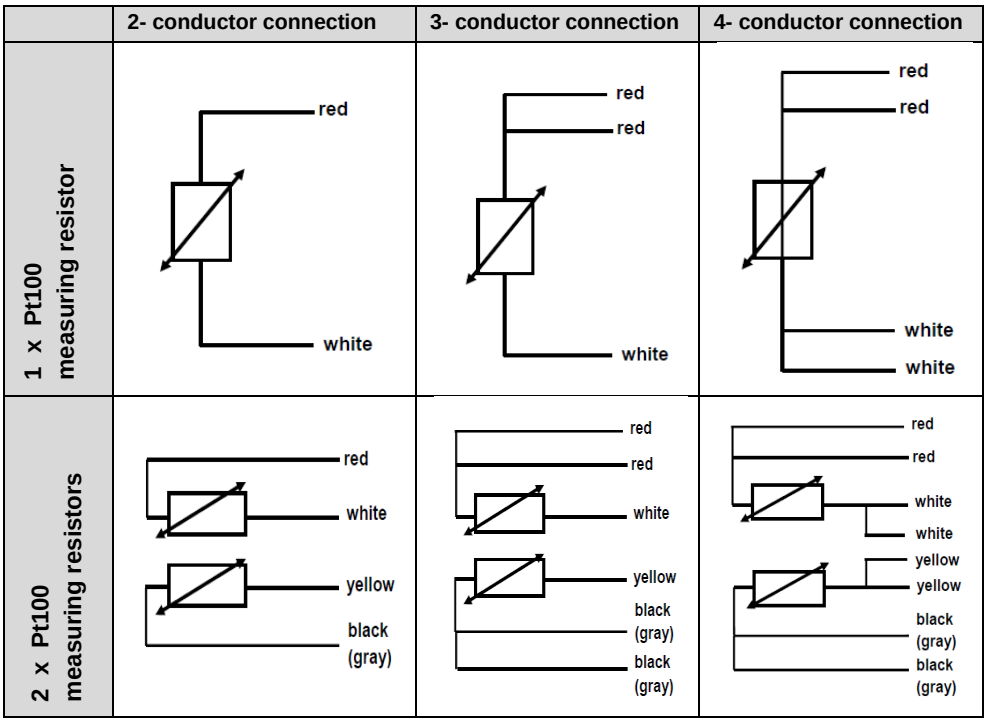
RTD = Resistance thermometer
NAT = Rated operation temperature
Pt = Platinum
1) Addition. E. g.: In KTY also be asked to specify color code and polarity of the line e. g.: YE (+) / GN (-)

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
- Thermocouples (TE) DIN EN 60584
- Thermistors (PTC) DIN 44081-82
- Silicon sensors (KTY) not standardized

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

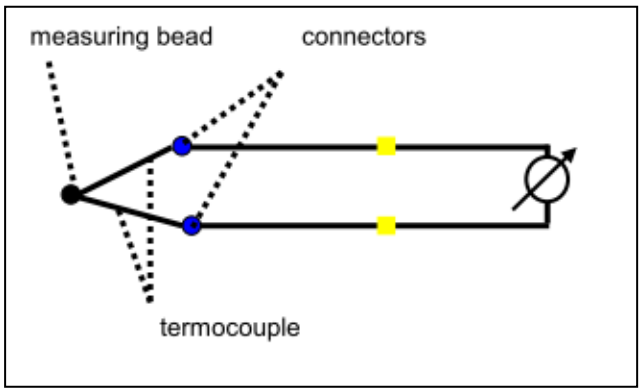


9.2 Circuit and labeling of connecting wires of thermocouples acc. standard (excerpt)

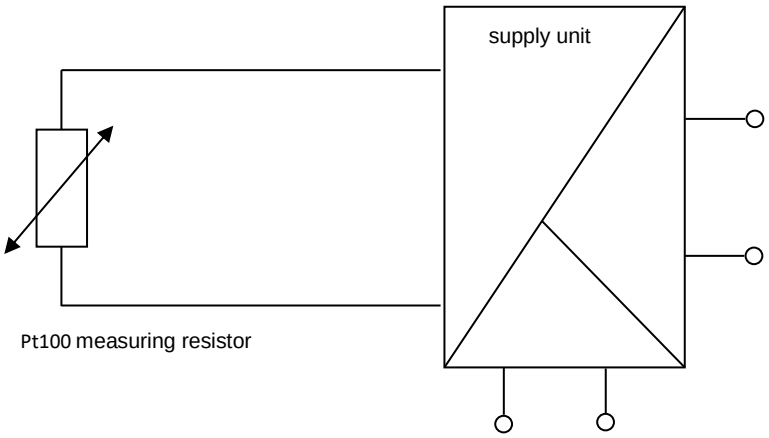
Type	Color	Standard
T	BN(BN$^{(+)}$ / WH$^{(-)}$)	EN 60584
J	BK(BK$^{(+)}$ / WH$^{(-)}$)	EN 60584
K	GN(GN$^{(+)}$ / WH$^{(-)}$)	EN 60584
S	OR(OR$^{(+)}$ / WH$^{(-)}$)	EN 60584

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 a suitable operating equipment)



Wiesbaden, 05th of January 2022