EPHY MESS
Gesellschaft für Elektro-Physikalische Meßgeräte mbH

Manual

Temperature sensor PR-SPA-EX-WKF

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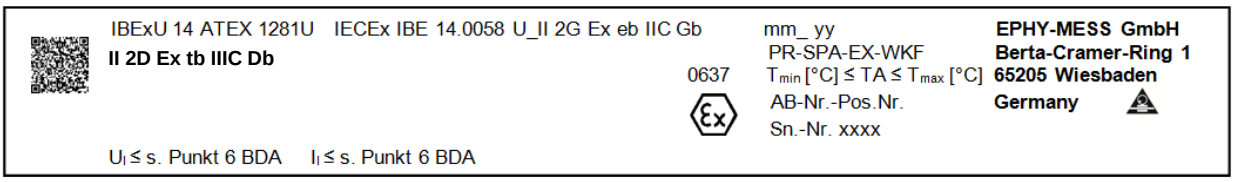
2. Applied standards

- EN IEC 60079-0:2018
- EN IEC 60079-7:2015/A1:2018
- EN 60079-11:2012
- EN 60079-31:2014

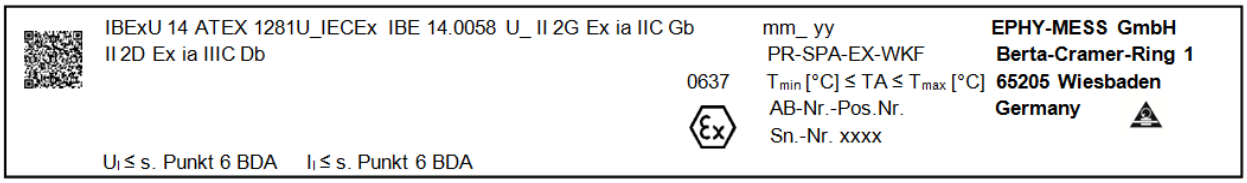
3. Labeling

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

4.1 Installation in the winding of an electrical machine (V1/V2)

- There are any special conditions, which must be observed during installation of temperature sensors PR-SPA-EX-WKF in the winding of electrical machines (for example: motor, generator or transformer).
- The dimensions allow the fixed assembly directly between the coil wires of the electrical machinery.
- The type of construction guarantees a good thermal contact between the monitored components and the temperature sensor.
- 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 sensor user must specify the used protection type and document it carefully.

4.2 Installation in the slot of an electrical machine (V3 + V4)

- Temperature sensors of type PR-SPA-EX-WKF are specially designed for the assembly into blind hole drillings in electric motors (generators) or other electrical machinery.
- The assembly / the installation can be done with a specific moveable fitting with plastic, Teflon, brass or steel clamp ring, aligned to the protection pipe diameter, or with a bayonet cap system.
- If moveable fittings are used the nominal length can be matched to the requirements on-site.
- The protection pipe of the thermometer must be mounted protected along its full length (e.g. in a blind hole- or through bore-hole).
- Bending loads (flexing) as well as mechanical loads on the temperature sensor (protection pipe and cable exit) 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 sensor may be operated only in according to regulations and in undamaged, clean state.
- The temperature sensors must be connected to the local potential equalization.
- The thermometers don't need to be grounded in the case of a completely insulated protection pipe. If a clamp fitting is used the clamp ring must be made of Teflon.
- During mounting and installations at and with the sensor, as well as during the on-site installation, the national and international safety- and accident prevention regulation must be observed.
- For long supply lines the specific length dependent capacities and inductances have to be observed.
- The special conditions of the type examination certificate have to be observed.
- The sensor user must specify the used protection type and document it carefully.

4.3 Usage outside the winding 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

4.4 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, KmW^{-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

* 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.

4.5 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
BIS	Not applicable*

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

4.6 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. 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 (see 9.1 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 according to the standards belonging to the resistance thermometer.
- The power supply must have a connection adequate to the thermometer's type of circuit (2- 3- or 4-wire circuit).

- The electrical operation values have to be observed (see Technical data, p.6).
- 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 in another way than described under the points 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 + V4)

- The connecting wires 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.
- 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.
- If the sensor is intended to be used in an explosive-area, the connection may be performed only in a connection area, which is approved according the valid standards or outside the explosive-area.
- The power supply must have a connection adequate to the thermometer's type of circuit (2-, 3- or 4-wire-circuit).
- The electrical operation values have to be observed (see Technical data, p.6).
- 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 potential equalization occurs via assembly fitting.
- The thermometers don't need to be grounded in the case of a completely insulated protection pipe and an installation with a clamp fitting with Teflon clamp ring.
- The connecting cables must be laid straight and without loops.
- It is not allowed to connect, install or apply the PR-SPA-EX-WKF 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-WKF, acc. to drawings: 999130613906001 (version 1- version 3), 666100522906001 (version 4)
Construction	Version (V1): measuring resistance with fix connected supply lines, insulated with single shrinking tube. Solder joints insulated with shrinking tube. Version (V2): measuring resistance with fix connected supply lines and encapsulated with silicone in ceramic sleeve. Solder joints insulated with shrinking tube. Version (V3): measuring resistance with fix connected supply lines, shockproof mounted in metallic protection pipe (casted, corrugated or closed by rolling bead). Version (V4): measuring resistance with fix connected supply lines, shockproof mounted in plastic protection pipe (casted)
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* **Not for bimetallic switches*
Sensor insulation	Version (V1): insulation hose (shrinking tube) Version (V2): ceramic sleeve and silicone Version (V3): insulation hose and metallic protection pipe (casted, corrugated or closed by rolling bead) Version (V4): insulation hose and plastic protection pipe (casted)
Dimensions (TxWxL)	Version (V1-V4): T mm x W mm x L mm

Ambient temperature

Resistance sensor (Pt):	-55°C*/-60°C … +180°C
Thermocouple (TE):	-55°C*/-60°C … +180°
Silicon-sensor (KTY83):	-55°C … +175°C
Silicon-sensor (KTY84):	-40°C … +180°C
Thermistor (PTC-NATxxx):	-45°C ... +180°C
Bimetallic switch (BIS):	-25°C ... +180°C

**Ambient temperature -55°C just for PR-SPA-EX-WKF version MH, corrugated or closed by rolling bead and version KG.*

Resistance sensor (Pt)

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:	0.3 ... 1 mA (chip)
Self-heating:	0.4 K/mW at 0°C
Operating temperature[2)3)]:	-55°C/-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)3)]:	-55°C/-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 … + NAT[1)] + 23 K	
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		
Dielectric strength	Sensor:	0.5 kV / 50Hz, 1min.	
	Supply line:	0.5 kV / 50Hz, 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
[2] Operating temperature using elastomer (depend on used elastomer material) for insulation only ... + 150°C
[3] Operating temperature -55°C just by PR-SPA-EX-WKF version corrugated or closed by rolling bead

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-WKF + variant identification (see point 8)

PR	**SPA**	**EX**	**Design depending on the point of installation**	**Version**
				see 8. Variant identification
			WKF: sensor for winding head	
		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 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								
	Titel of customer standards									

SH = Isolated with shrinkable tube
KH = Ceramic sleeve
MH = Metall sleeve
KG = Plastic housing

E.g.: SH,1Pt100A3,ø3x20,E1x24/7,1200RD/WH

E.g.: KH,1Pt100A3,ø3x20,E1x24/7,1200RD/WH

E.g.: MH,1Pt100A3,ø3x20,E1x24/7,1200RD/WH

E.g.: KG, 1Pt100A3,ø3x20,E1x24/7,1200RD/WH

SH	1	Pt	100	A	3	ø3x20	E1x24/7RD/WH
KH	1	Pt	100	A	3	ø3x20	E1x24/7RD/WH
MH	1	Pt	100	A	3	ø3x20	E1x24/7RD/WH
KG	1	Pt	100	A	3	ø3x20	E1x24/7RD/WH

RTD = Resistance thermometer
NAT = Nominal response temperature
NST = Nominal switching temperature
Pt = Platinum

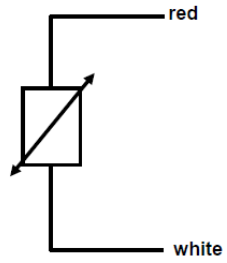
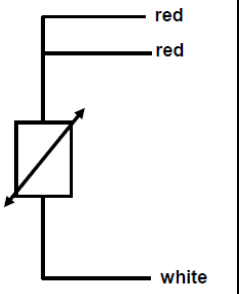
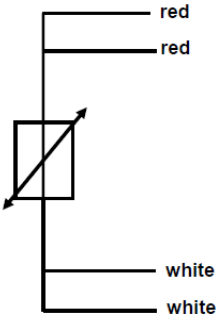
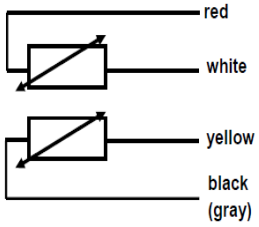
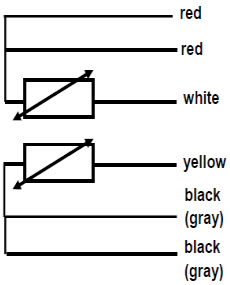
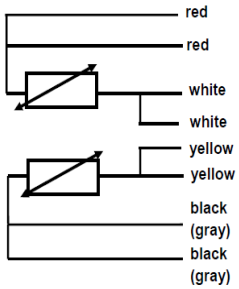
1) Addition. E. g.: In KTY also be asked to specify color code and polarity of the line e. g.: YE (+) / GN (-)

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
Nickel resistance thermometer	not standardized
Copper resistance thermometer	not standardized
Thermocouples (TE)	DIN EN 60584
Thermistors (PTC)	DIN VDE V 0898-1-401
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

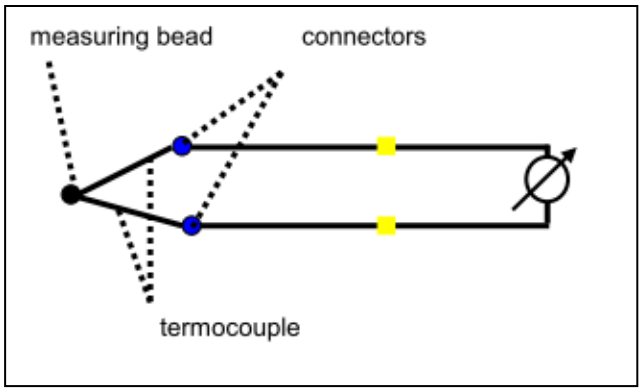
	2- conductor connection	3- conductor connection	4- conductor connection
1 x Pt100 measuring resistor			
2 x Pt100 measuring resistors			

9.2 Circuit and labeling of connecting wires of thermocouples acc. to DIN EN 60584-3 (excerpt)

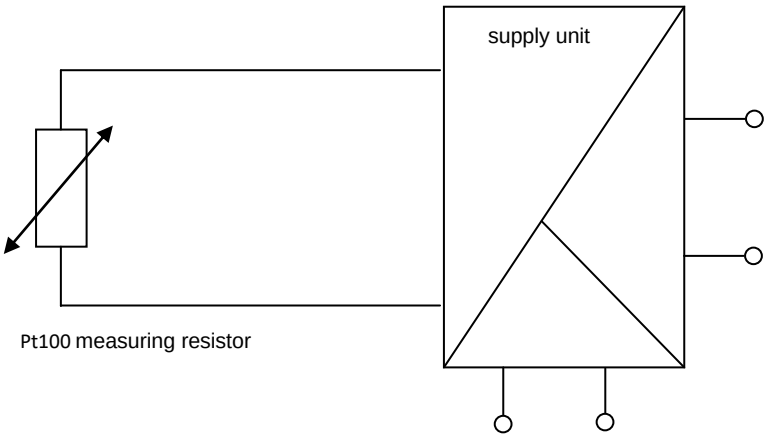
Type	Color	Standard
T	BN(BN$^{(+)}$ / WH$^{(-)}$)	EN 60584
J	BK(BK$^{(+)}$ / WH$^{(-)}$)	EN 60584
K	GN(GN$^{(+)}$ / WH$^{(-)}$)	EN 60584
S	OR(OR$^{(+)}$ / WH$^{(-)}$)	EN 60584

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, 29th of April 2022