ALF SENSOR SPÓŁKA JAWNA

INSTRUCTION MANUAL

version 2.8

THERMOCOUPLES WITH CONNECTION HEAD

TER-PD-07-.../Exi
TER-PKG-08-.../Exi
TER-PF-09-.../Exi
TER-P-10-.../Exi
TER-W-11-.../Exi
TER-P-44-.../Exi
TER-PD-54-.../Exi
TER-PF-60-.../Exi
TER-PKG-64-.../Exi
TER-PKG-78-.../Exi
TER-PKG-79-.../Exi
TER-PF-97-.../Exi
TER-PKG-99-.../Exi
TER-Pdm-142-.../Exi
TER-PKG-143-.../Exi
TER-PKG-157-.../Exi

TER-PF/PKG-nxJ/K-189.../Exi

31-342 Kraków, ul. Narcyzowa 3 * tel.(012) 258 08 40, 285 43 46 * fax (012) 285 43 18
http://www.alf-sensor.com.pl * e-mail: biuro@alf-sensor.com.pl

1. CATALOGUE CARD

1.1 Technical parameters
1.2. Ordering information

(Space for thermocouple catalogue card)

2. APPLICATION

Thermocouples act for transformation of measuring environment in the range of -200 to +1600°C into a thermoelectric force, in the way defined by the thermometer characteristics of thermoelements installed in sensors. Together with particular instruments, they allow a far distance measurement, record or temperature control of industry processes. Due to special construction (significant thermal inertia) sensors are designed for static temperature measurements i.e. in environments where slow temperature changes are noticed. Thermocouples with a sheathed element are resistant to any vibrations and can be bended without any thermoelectrodes line to line fault. That is why they can be installed in places, difficult to reach, where is a need of introducing flexible sensors with small thermal inertia. Thermocouples type TER.../Exi - intrinsic safe version have the designation ⟨Ex⟩ II 1/2 G Exia IIC T6 and ⟨Ex⟩ II 1 D Ex iaD 20 T85°C– certification KDB 04 ATEX 037X. In zone 0 can be placed protection tube only. Connection head can be in zones 1 or 2 only. The limit between zones is, mounted in thermowell, a connection fitting (threaded or flanged)

3. PRINCIPLE OF OPERATION

Thermocouple measuring thermoelement, consists of two electric heterogeneous thermoelectrodes, connected together. Spot of the connection acts as a hot measuring junction. If measuring junction is situated in environment of different temperature than a cold junction, thermoelectric power appears between junctions. This power is proportional to difference between temperatures, as function of both temperatures according to thermoelectric characteristic specified in the norm PN-EN 60584. If we put the thermocouple cold junction in stable (fixed) temperature, thermoelectric power, which appears between junctions, is only a function of the hot junction temperature. Particular environment temperature measurements, where thermocouple is installed, can be done by thermoelectric power measurement using a suitable instrument, mostly adjusted in temperature units. Independence from cold junction temperature changes can be achieved using a special thermostat or connecting a special instrument (compensative can),

which compensate electrically influence of these changes. A measuring transmitter can also be introduced. It transforms a signal from thermocouple to current, proportional to temperature. The transmitter has also compensation of the cold junction.

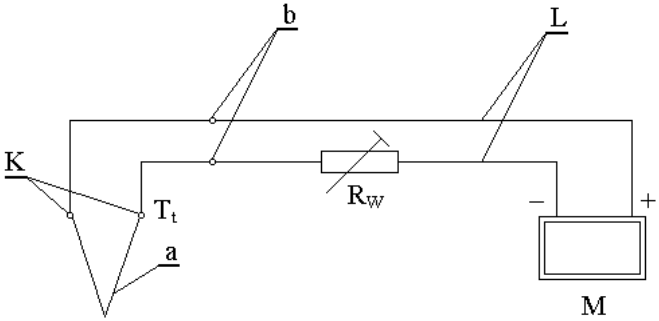


Fig. 1. Schematic diagram of electrical thermometer with thermocouple

T_t - thermocouple, M – cooperative indicative instrument,
R_w – line resistor compensation,
K – compensation cables, L – connecting cables,
a – hot junction, b – cold junction.

4. DESIGN

Thermocouple consists of (fig. 2) outer stainless steel or ceramic protection tube 3, connection head 4 and measuring insert 5 type WP-TE-02 or WP-TE-02ds1.

Protection tubes are designed as straight pipes (fig. 2) or welded pipes with angle 90°. Depending on upper operating temperature value and type of thermoelement, protection tubes are made uniform or composed metal (welded of stainless steel heat-resisting pipes) or from ceramic material. Ceramic protection tube of sensor are strengthened by metal protection tube, on which mounting elements for sensor are fixed. In sheathed version, the thermoelement is made of a thin pipe called sheath, filled with insulating material (aluminium oxide), in which electrodes are placed.

A dust and splash-proof connection head is made of an Al Alloy < 6% Mg, and is covered by a chalky lacquer. A terminal block or a measuring transmitter U/I (4 - 20 mA) can be put in the head. Cables are lead through cable inlet in the head, connecting thermocouple with a derivative instrument. Single or double measuring insert, fixed in outer protection tube, is the thermocouple replaceable part. In case of damage, it can be replaced to new one.

In intrinsic safe version, thermocouple has Certification KDB 04 ATEX 037X, as a independent instrument.

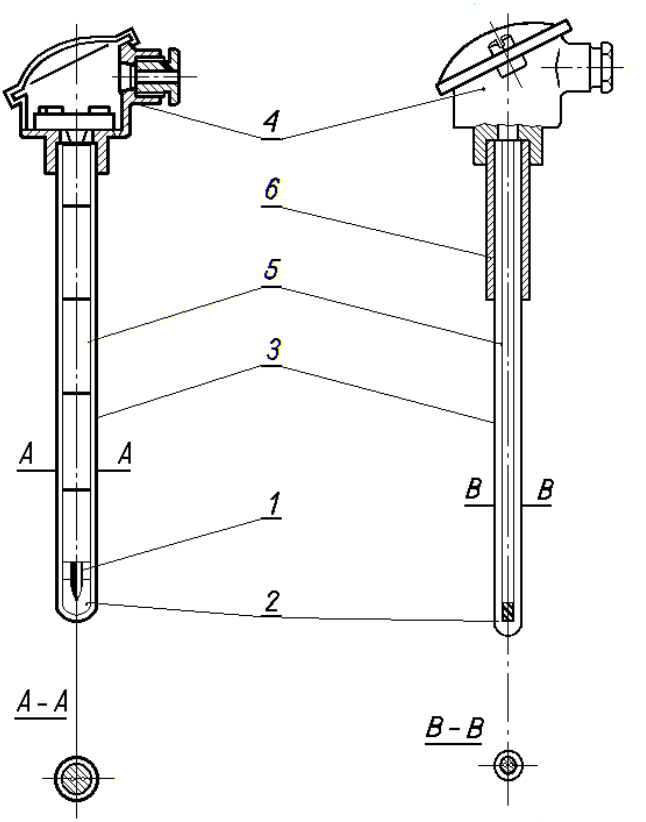


Figure 2. Construction of thermo-electrical sensor

1 - thermoelectrode, 2 - hot junction of thermoelement, 3 - metal or ceramic outer protection tube, 4 - connection head with clips, 5 - inner insulating protection tube, 6 - protection tube

Table 1

Types and executions of manufactured thermocouples

Sensor type	Thermo-element type	Wire diameter (mm)	Protection tube outer inner	Tube dia-meter(mm)	Temperature range	
					permanent	momentary
TER-P-J-10	Fe-CuNi	3	Steel 15HM Steel H23N18 Steel 1.4841 Steel 1.4762	21,3 20,0 22,0 22,0	550 650 650 650	700 900 900 900
TER-PD-J-07 TER-PKG-J-08 TER-PF-J-09	Fe-CuNi	0,35 - 0,8	Steel 15HM Steel 1.4541 Steel 1.4571 Steel 1H18N9T Steel 1.4841	15,0 9-10 9-10 10-12 10,0	550 600 600 600 600	700 600 600 600 600
TER-P-K-10	NiCr-Ni	3	Steel 15HM Steel H23N18 Steel 1.4841 Steel 1.4762	21,3 20,0 22,0 22,0	600 900 900 900	700 1050 1150 1200
TER-PD-K-07 TER-PKG-K-08 TER-PF-K-09	NiCr-Ni	0,35 - 0,8	Steel 15HM Steel 1.4541 Steel 1.4571 Steel 1H18N9T Steel 1.4841	15,0 9-10 9-10 10-12 10,0	600 800 800 800 800	700 800 800 800 1000
TER-W-K/J-11	Fe-CuNi NiCr-Ni	Sheath 3, 6	Steel 15HM18 Steel 10H2M	18, 24	600	600
TER-P-S-44 TER-P-S-45 TER-P-S-60 TER-PKG-S-64	PtRh10-Pt	0,5	Outer Steel 1.4841 Inner Ker 610	22 15	1100	1150
			Outer Steel 1.4762 Inner Ker 610	22-32	1100	1150
			Outer Ker 610 Inner Ker 610	15 8,5	1300	1400
			Outer Ker 710 Inner Ker 610	15 8,5	1300	1400
			Outer Ker 710 Inner Ker 710	15 8,5	1300	1600
			Outer Ker 530 Outer Ker 710 Inner Ker 710	26 15 8,5	1300	1600
TER-P-B-44 TER-P-B-45 TER-P-B-60 TER-PKG-B-64	PtRh30- -PtRh6	0,5	Outer Steel 1.4841 Inner Ker 610	22 15	1150	1150
			Outer Steel 1.4762 Inner Ker 610	22-32	1100	1150
			Outer Ker 710 Inner Ker 710	15 8,5	1600	1800
			Outer Ker 530 Middle Ker 710 Inner Ker 710	26 15 8,5	1600	1600
TER-P-S-61 TER-P-S-63	PtRh10-Pt	0,5	Outer Kanthal Inner Ker 610	15 5,8	1350	1350
TER-P-B-61 TER-P-B-63	PtRh30- -PtRh6	0,5	Outer Kanthal Inner Ker 610	15 5,8	1350	1350

Table 2

Protection tube thermal resistance for common used environments.

Protection tube material	Environment
15HM 1.7335	zinc - up to 480°C; air, steam, salt and nitrogen baths - up to 550°C; lead, tin, H_2S - up to 600°C
1H18N9T 1.4571	nitric acid - up to 100°C; hydrogen sulfide, fatty acid - up to 200°C; tin - up to 300°C, phenol, vinegar aldehyde, tri, latex - up to 500°C, potassium nitrate - up to 550°C, steam, ammonia vapour - up to 600°C; air, dry chlorine - up to 800°C
10H2M 1.7380	
1.4841	
1.4762	
Ceramic material 530	vapours of hydrochloric acid - 1000°C; combustion gases up to - 1600°C (air 1600°C)
Ceramic material 610	bases and gases without fluid gases up to - 1400°C (air 1400°C)
Ceramic material 710	inside sulfur burners - up to 1000°C; inside coke ovens - up to 1200°C; acetylene, industrial gases, hydrogen, glass - 1300°C, air - 1800°C

Table 3

Characteristic of heat-resisting steels (acc. PN-71/H-860022)

Steel number	German equivalent acc. STAHLSCHLUSSEL	type RFN acc. STAHLSCHLUSSEL	heat resistant in air up to temp. (in °C)
H23N18	1.4843	CrNi2520	1050
H23N20S2	-		1200 creep limit
H24JS	1.4762	X10CrAl 24	1150
H25T	-		1100
H25N20S2	1.4841	X15CrNiSi2520	1150
	1.4765	kanthal	1350
15HM	1.7335	13CrMo44	500-700
1H18N9T	1.4541	XCrNiTi18 10	500-800
	1.4571		

Attention: Manufacturer reserves the right of making protection tubes of equivalent materials with similar characteristic.

Measuring insert type WP-TE-02 or WP-TE-02ds1 is a thermocouple subassembly, and has to be placed in outer protection tube with a connection head.

5. COOPERATIVE INSTRUMENTS

Sensors can cooperate with any instruments adjusted to work with thermocouple. For intrinsic safe versions thermocouples have to cooperate with intrinsic safe circuits. A receiver adjusted to current signal 4-20 mA have to be used for thermocouple with installed transmitter.

6. EQUIPMENT

Basic equipment of thermometer consists of:

- Instruction manual
- Guarantee card
- Certification ATEX (for intrinsic safe version)
- Declaration of conformity (for intrinsic safe version)

Additional equipment attached to sensors for special request only are grips, used to fix sensors in tag points.

7. TECHNICAL ACCEPTANCE

Approval and authorization for operation by Quality Control Department of manufacturer is done basing on control sensor conformity with standards EN 60079-0, EN 60079-11, EN 61241-11.

8. GUARANTEE

Manufacturer guarantees proper operation of instruments under condition of operating instrument according to requirements issued in this instruction manual.

9. STORAGE AND TRANSPORTATION

Temperature sensors should be stored in closed rooms at temperature from +5°C to +50°C and humidity maximum 80%. Surrounding air should not include elements causing corrosion and destroying protection coatings. Transport of goods should be done by canvas cover means of transport.

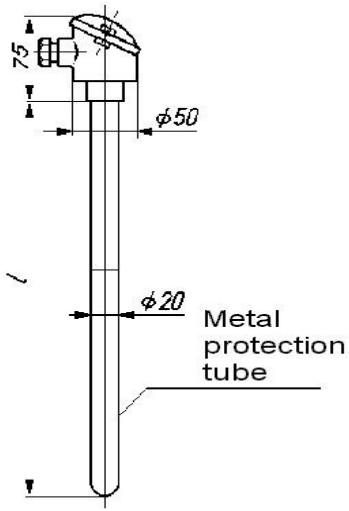


Figure 3. Sensor TER-P-J/K-10

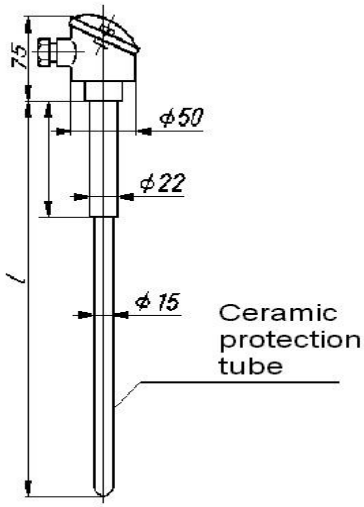


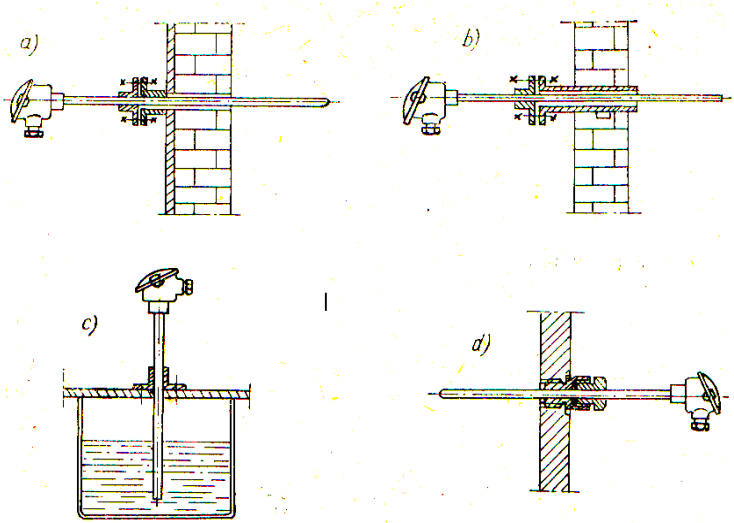
Figure 4. Sensor TER-P-S-44

10. MOUNTING

10.1. Sensor mounting in a tag point

Depending on the sensor type, the places where measurement is to be performed as well as type of medium, the following guidelines should be consider:

a) Sensors should be mounted in easy to access places, where the maintenance, as well as changing of measurement insert is facilitated and unrestricted.
b) sensors in basic execution should not be installed in places under permanent vibrations eg. in vibrating pipelines. Such vibrations shorten lifetime of the instrument.
c) if sensor jutting out part is exposed to a thermal radiation, one should use a protection shields. If the protection shield is exposed to the thermal radiation which can raise the temperature over measuring tag point, one should use protective screens against radiation (heating insulation of jutting out metal parts)
d) before connecting sensors to welded protection tubes type W (fig. 7a), one should protect tubes against any contaminations during welding.



e) One should apply sensors of shorter length in case of a small immersion length. When there is possibility to let sensor into object and to reach beneficial ratio between sensor length in ambient temperature and overall length - one should apply longer sensors.
f) Sensors of a bigger length should be mounted in a vertical position, to avoid bending them under their own weight.
g) When mounting explosion-proof sensor, the thermal conduction of the thermowell and ambient temperature „Ta" should be taken into consideration, to make provision for a suitable temperature class of the temperature sensor.

Temperature clas	Max. surface temperature	Combustion temperature
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

Table 4 Sensors temperature class

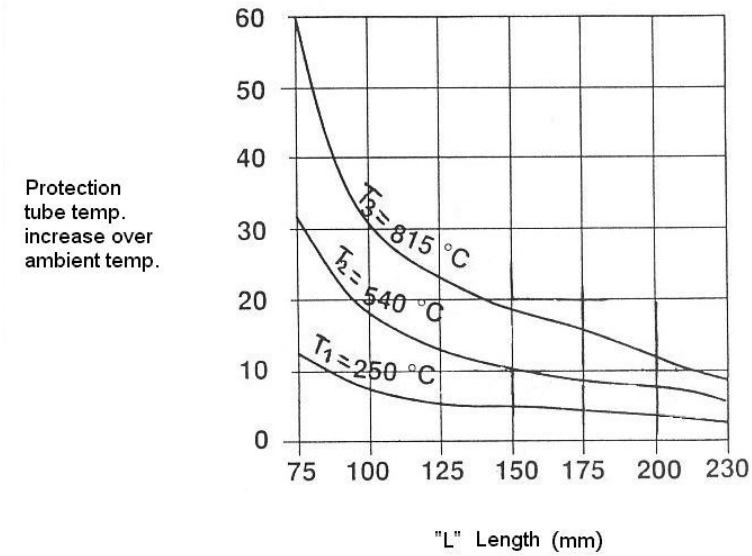


Figure No 5 Protection tube temp. increase on its length „L" for a test installation

For the test installation Fig. 5 represents build up of the sensor thermowell temperature above the ambient temperature "Ta" depending on its length "L" in the compartment 75 mm < "L" < 230 mm for different temperatures "T" of the measured medium . In the test installation measurements for T1 = 250°C; T2 = 540°C; T3 = 815°C were performed. It has been assumed that for "L"= 0, the thermowell has got the measured medium temperature "T".

From the Fig. No 5 for "L"=90 mm: temperature of the thermowell will grow 22 ° C above the ambient temperature. We assume, that "L"=100mm, what will assure a safe increase of the thermowell temperature. Therefore, when we measure e.g. temperature of medium in the pipeline, this should have thermal insulation of minimum thickness 100 mm. If we measure the temperature sensor with head mounted transmitter, the range should be matched to the ambient temperature Ta for a given temperature class, which is specified in the attached ATEX certificate of the transmitter.

E.g. IPAQ – HX Type transmitter, has the following temperature classes:

T4 -40°C<Ta<85°C
T5 -40°C<Ta<65°C
T6 -40°C<Ta<50°C

Mounting of the sensors in explosion risk area should be done in compliance with the operation rules for the explosion-proof devices to EN 60079-14. Electrical devices in explosion risk areas. Selection, installing, maintenance and repair of electrical devices intended to use in explosion risk areas.

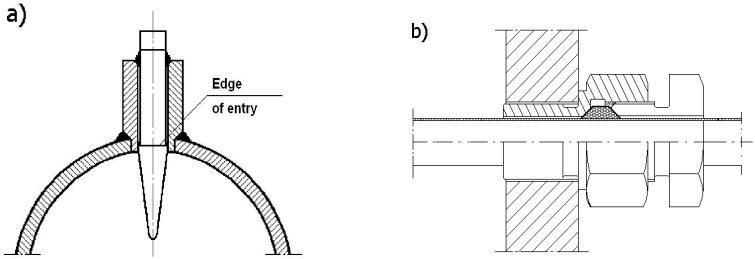


Figure 7. Sensors mounting (examples)
a) for high temperature applications TER-P-K/J-10 with protection tube type W
b) straight TER-P-K-J/K-07 with assembly jig UZG-47

The accuracy of temperature measurement using thermoelectric thermometer depends meaningfully on the way of the sensor installation. Big thermal capacity of sensor protection tube and small thermal conduction ratio make bigger thermal inertia of sensor and lower its speed of response on temperature changes. Part of sensor metal protection tube, which stays in ambient temperature, carries away heat to the atmosphere changing the temperature of thermoelement hot junction. The bigger hot junction temperature is, the bigger ratio of sensor length in ambient temperature to sensor whole length makes. Measuring accuracy depends on heat trasfer intensity by sensor protection tube from the medium (ratio of heat transfer, depends on type of medium and its flow velocity).

h) **Temperature limitations in the presence of flammable dusts.**

The maximum temperature of a temperature sensor surface should not cross two thirds of the ignition temperature of dust mixture with air given in °C.

The maximum temperature of the temperature sensor surface, should not cross the value lower by 75 K from the minimum temperature of ignition of layer of a given dust having the thickness from 5 mm to 50 mm. If the layer of dust can built-up on the sensor, having the thickness from 5 mm to 50 mm, then the maximum admissible temperature of the surface should be lowered adequately according to EN 61241-0.

10.2. Cold junctions (compensation wires).

The principles of thermoelectric sensor operation say that accurate temperature measurement is possible only if a cold junction is kept in constant temperature. However, in real, connection head temperature varies, so cold junction should be lengthen using compensating wires and lead to the place of constant temperature. Practically elimination of temperature fluctuation is achieved by connecting compensating wires to the special thermostat or compensating can, electrically correcting influence of temperature fluctuation. If we do not need such accuracy, we can only apply leading cold junction using compensating wire to the place of relative stable temperature. The compensating wires are made of the same materials as thermoelement or substitute materials, which have the same thermoelectric characteristic as thermoelement wires, in the range from 0°C to +200°C.

Connecting them to the sensor one should take under consideration the rule of joining „plus" to „plus" and „minus" to "minus". One can apply a measuring transmitter as well (fig. 8), which has the cold junction compensation set.

10.3.Driving connection line

A cold junction connection lines (compensating can, thermostats, transmitters) with measuring instruments (meters, recorders) should be executed using Cu wires with at least 0,5 mm^2 cross-section. The compensating and Cu wires should be driven according to the low voltage installation regulations. Moreover, one should select the type of wire insulations taking under consideration protection against: temperature, mechanical damage etc. The wires can be also driven in protective tubes. Connecting the wires during line installation is not recommended. If it is necessary, one should use solder connections only.

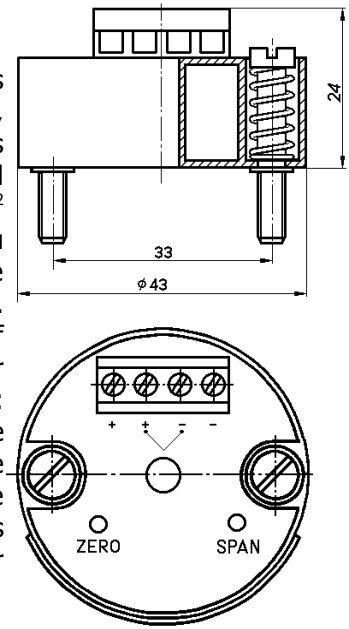


Figure 8. Transmitter U/I TU-51

10.4. Compensating resistor.

Measuring elements of thermometers or elements of automatic control systems, connected with thermoelectric sensors, are calibrated under particular outer circuit resistance i.e. of sensor and connecting line. To make measurement or the line length regulation independent one should adjust its resistance to the nominal value, specified on collaborating instrument (eg. on a meter), using compensation resistor R_W, included in line in series.

Outer circuit resistance consists of compensating can or thermostat and sensor resistance. Accurate line resistance adjustment is particularly important when internal resistance of collaborating instrument is small (comparing with standard line resistance).

The sensor resistance depends on the temperature, where it is placed, that is why one should measure outer circuit resistance after placing sensor in a tag point, in the normal operating temperature.

The effecting thermoelectric power makes additional measuring error and the measurement should be done twice, changing every time the polarity of wires, connected to the resistance meter. One should assume the average resistance value from these two measurements.

The compensating resistor can be build in a meter or in a controller. However, after it is supplied as a separate part, which should be installed in a cupboard or on a regulating board, near the meter or other connecting instrument.

10.5. Measuring transmitters installed in sensor connection head.

Instead of terminal block one can install a transmitter, which converts thermocouple voltage into normalized current signal 4-20 mA proportional to the temperature. The transmitter has a system of cold junctions compensation. The signal 4-20 mA can be led on long distances up to appropriate collaborating instrument.

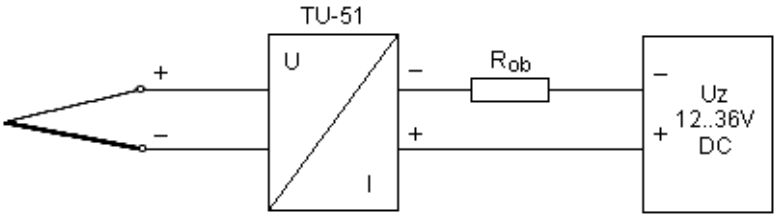


Figure 9. A transmitter connecting diagram

10.6. Typical sensors applications.

Thermoelectric thermometer sensors can be used in various measuring systems or in automatic, industrial temperature control systems. The most typical applications are:

a) direct temperature measurement using single point indicating thermometer,
b) indirect temperature measurement using thermometer and multi-point indicating instrument,
c) direct temperature measurement and record using thermometer and single or multi-point indicating recording instrument,

Configuration of sensors connections with mentioned instruments are specified in instruction manuals of particular instruments.

10.7. Electrical parameters for intrinsically safe thermometers.

U_0= 50mV; I_0= 100mA; Ci= 80nF; Li=400µH

Electrical parameters for thermometers with temperature transmitter are shown in table below.

Lp.	Transmitter type	Ci (nF)	Li (uH)	Ui (V)	Ii (mA)	Pi (W)
3	APAQ-HRFX	30	10	30	100	0,7
4	IPAQ-HX	0	0	30	100	0,9
5	MESO-HX	1	1000	30	100	0,9
6	FLEX Top 2201	10	10	28	100	0,7
7	FLEX Top 2211 ; FLEX Top 2221	5	15	30	100	0,75
8	PR 5333B ; PR 5335B	1	10	30	120	0,84
9	PR 5334B	1	10	28	120	0,84
10	Model 144H	1	10	28	120	0,84
11	Model 244 ; Model 644	10	0	30	200	0,67
12	Model 248	3,6	0	30	130	1
13	TMT – 187 ; TMT – 188	0	0	30	100	0,75
14	SEM 210X	10	0	30	100	0,75
15	Model 644H	10	0	30	200	0,67

11. USE AND MAINTENANCE

During sensors operation, included in measuring or control system, one should temporarily:

a) every half year check resistance of line insulation (compensating and connecting wires); resistance between wires, every wire and ground should be at least 3 MΩ.
b) every half year, if sensors most often operate in hard conditions, check resistance of sensors insulation in ambient temperature (after two hours of conditioning). Resistance should be measured between shorted terminals and sensor housing, measured by a coil 100 V should not be lower than 10 MΩ.
c) every half year check wire connection in the head and eventually tighten screws;
d) every half year or more frequent (if sensor operates near the upper temperature limit) check conformity with sensor characteristics specified in PN-EN 60584.

12. OPERATING INSTRUCTIONS

12.1. Thermometers type TOP-.../Exi retain „ia" intrinsic safe category only by cooperation with approved intrinsic safe circuits of „ia" category acc. EN 60079.

12.2. In case of cooperation with „ib" category circuits acc. EN 60079, the intrinsic safe category must be lowered to „ib".

12.3. Maximum thermocouple temperature depends on the way and place of its installation.

User, after over-building a place of work, should check if maximum outer temperature of thermometer, by maximum temperature measurement, do not exceed approved temperature values for steam and gases, specified in table 1 of standards EN 60079-0.

FINAL REMARK

In case of any troubles in starting or operation of thermometers, our company will provide you technical information or advices related to the encountered problems.