

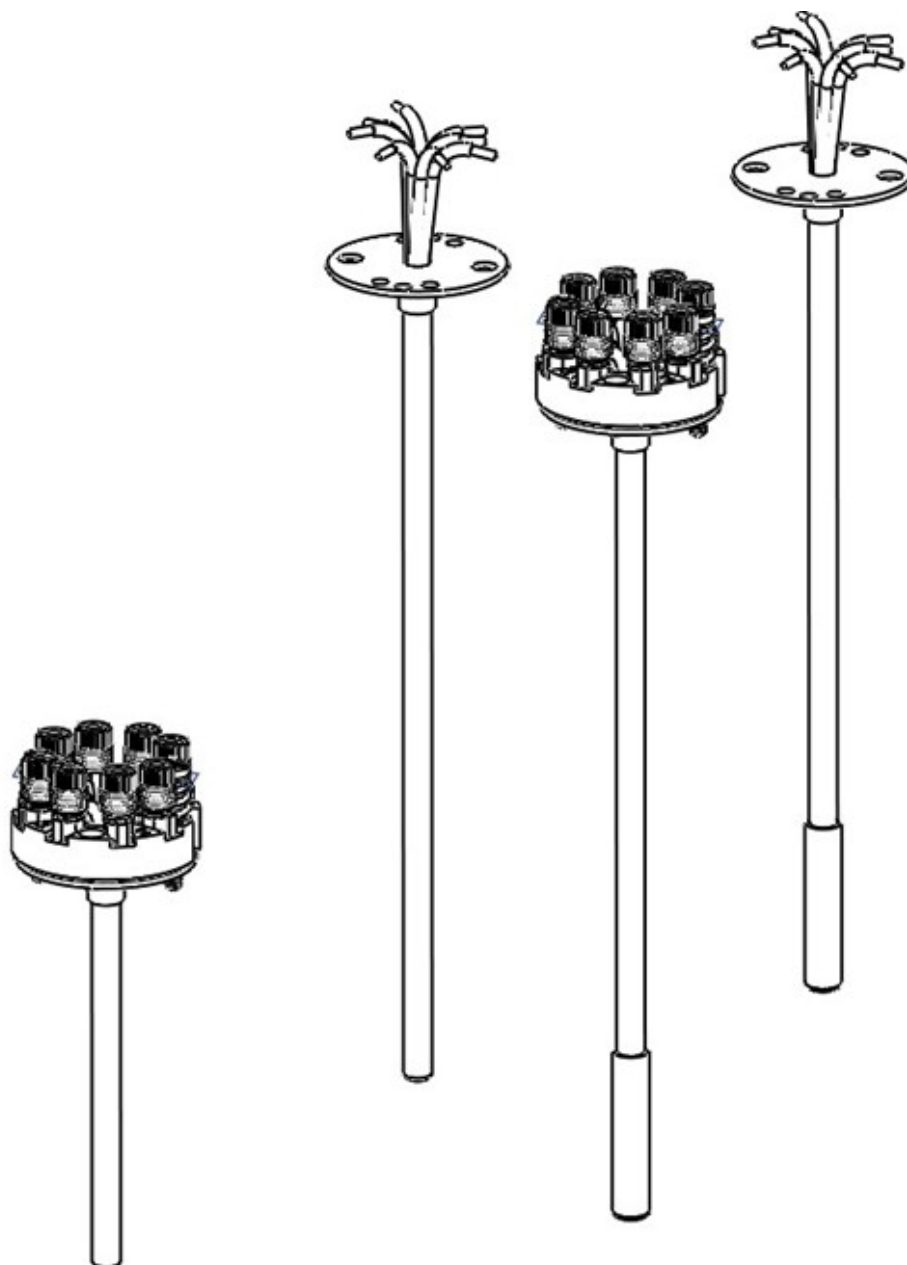
EPIC® SENSORS

Mineral insulated element

Type: T-M-Ø / W-M-Ø

EN, Installation Instructions and User Manual

Manual 7



Lapp Automation Ltd.
Äyritie 18
FI-01510 Vantaa, Finland
lapp.fi

Technical sales:
Tel: +358 (0)20 764 6410

Open orders:
Phone: +358 (0)20 764 6420

Domicile
Vantaa

Business ID: 1107293-1
VAT: FI11072931

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A Lapp Group Company

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General information

All components are carefully monitored for quality and compliance with standards. Our quality assurance is standardized according to ISO-9001, ISO-14001 and ISO-45001 certificates.

This manual contains important information for using the product. Particular attention should be paid to operating temperatures and environmental requirements.

Product description and intended use

Mineral insulated elements T-M-Ø (TC; thermocouple) and W-M-Ø (RTD; resistance temperature detector) are internal components used in temperature sensors. They are the components performing the actual temperature measurement in the temperature sensor and can be easily replaced if broken. Mineral insulated element typically contains 1 or 2 measurement points and the measurements can be done as 2-, 3- or as 4-wire measurement. Structure is according to DIN 43762.

Mineral insulated element is supplied with or without ceramic block. Ceramic block is used to continue the measuring loop with a cable, in other words, it is used to connect cable to the element. Alternatively temperature transmitter can be connected to the mineral insulated element as a replacement for the ceramic block. Temperature transmitter will convert voltage signal generated by the measurement point into more noise resistant mA-current signal. This is beneficial in electromagnetically noisy environments, where signal must be carried over by greater distances. Mineral insulated element is always supplied with ceramic block or without. Temperature transmitter is sold separately.

Wires of the mineral insulated element are color coded according to the standard in use. Also element with more than one measuring loop will have markings indicating the wires of different loops.

Most common measurement types are K-type thermocouple and 4-wire Pt100 resistance temperature measurement.

Jacket of the mineral insulated element is typically made of stainless steel AISI 316L or Inconel 600, which makes the elements bendable to desired shape. Bending the tip of the element is not possible, and should be avoided. Also continuous bending should be avoided, since it will eventually crack the jacket. Typical use of the element with temperature sensor does not require bending of the element. Various special versions of the mineral insulated element are available, i.e. tip reinforced element specially suited for applications with shaking and vibration, to prevent fault caused by mechanical stress.

The mineral insulated element is also available as ATEX and IECEx approved version, to be used as component in sensor for explosive atmospheres. Mineral insulated element does not meet ATEX requirements as alone, to be used in explosive atmosphere it will require sensor with suitable Ex protection class for housing.

EPIC® SENSORS temperature sensors are measuring devices for professional use. The user who performs the installation of the unit must be professionally qualified to perform installations in the environment of the installation site. The installer must have an understanding of the general and local requirements for mechanical and electrical installation, as well as the occupational safety instructions to be followed at the installation site. The work must be carried out using protective equipment appropriate to the task and the possession of a permit to work at the site must be ensured.

Temperatures, measuring point

The measuring temperature range of the sensor tip is typically:

- RTD; resistance temperature sensor -40...+450 °C (temporarily +550 °C)
- TC; thermocouple -40...+450 °C (temporarily +550 °C)

Note: This sensor type does not have a neck pipe for cooling. The process connection thread is close to the connection head. Make sure that the process temperature is not too high for the connection head and/or its contents.

Temperatures, connection head

The permissible ambient temperature range for the connection head and its internal components is:

- Without transmitter -40...+135 °C
- With transmitter according to the temperature tolerance of the transmitter, see the transmitter datasheet

Temperatures, Ex versions

For Ex versions only, special conditions are given in the ATEX and IECEx certificates. For more information, see the table of contents:

Ex d approved sensor, subtitle:

- *Special conditions for safe use of Ex d approved sensor*
(the sensor product name must contain the code -EXD-)

Ex i approved sensor, subtitle:

- *Special conditions for safe use of Ex i approved sensor*
(the sensor product name must contain the code -EXI)

Temperatures measuring element

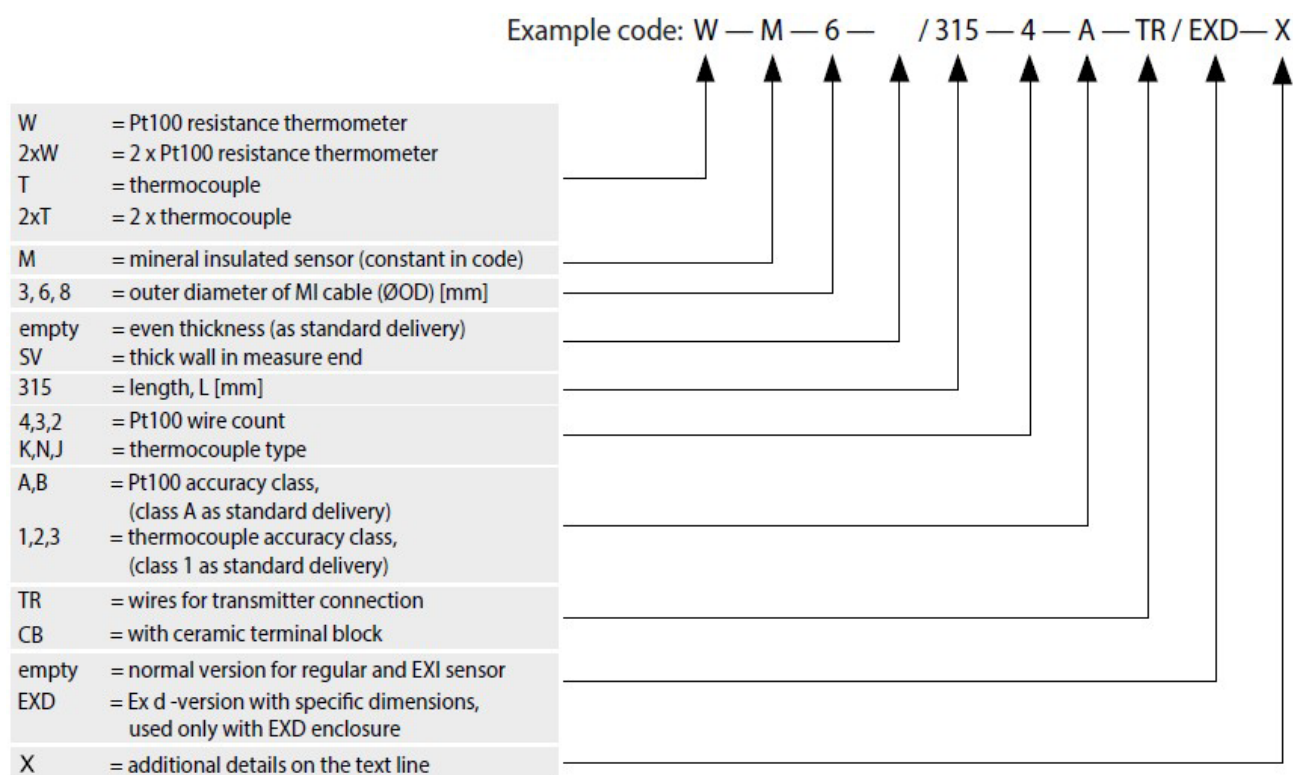
This section presents general temperature ranges for different measuring elements. The temperature ranges are indicative and only for the temperature measuring element itself. Temperature range presented does not take into account the other parts of the sensor structure around the measuring element, or their temperature tolerance, or their maximum limits:

- *Pt100* resistor -200...+850 °C, (depending on the resistor model)
- *Thermocouple type K* -200...+1260 °C
(commonly used element, accurate and reliable)
- *Thermocouple type L* -200...+600 °C
- *Thermocouple type J* +95...+760 °C
(note: oxidizes easily at high temperatures > +550 °C)
- *Thermocouple type S* +980...+1600°C, (temporarily +1700 °C)
- *Thermocouple type R* +870...+1480 °C
- *Thermocouple type B* +870...+1700 °C
(recommended range approx. +1370...+1700 °C)
- *Thermocouple type N* +650...+1260 °C
(better oxidation resistance than K-type, not a direct replacement)
- *Thermocouple type U* -200...+1260 °C
- *Thermocouple type T* -200...+370 °C
(stable at low temperatures, e. g. cryo applications)
- *Thermocouple type E* +95...+870 °C
(high response °C)

Note: Not all measuring elements listed here are economically or technically feasible to use with this sensor type, as the sensor design may not be able to withstand the temperatures suitable for the element. The recommended measuring elements for the sensor type in this manual are Pt100 and thermocouple type K.

Code key

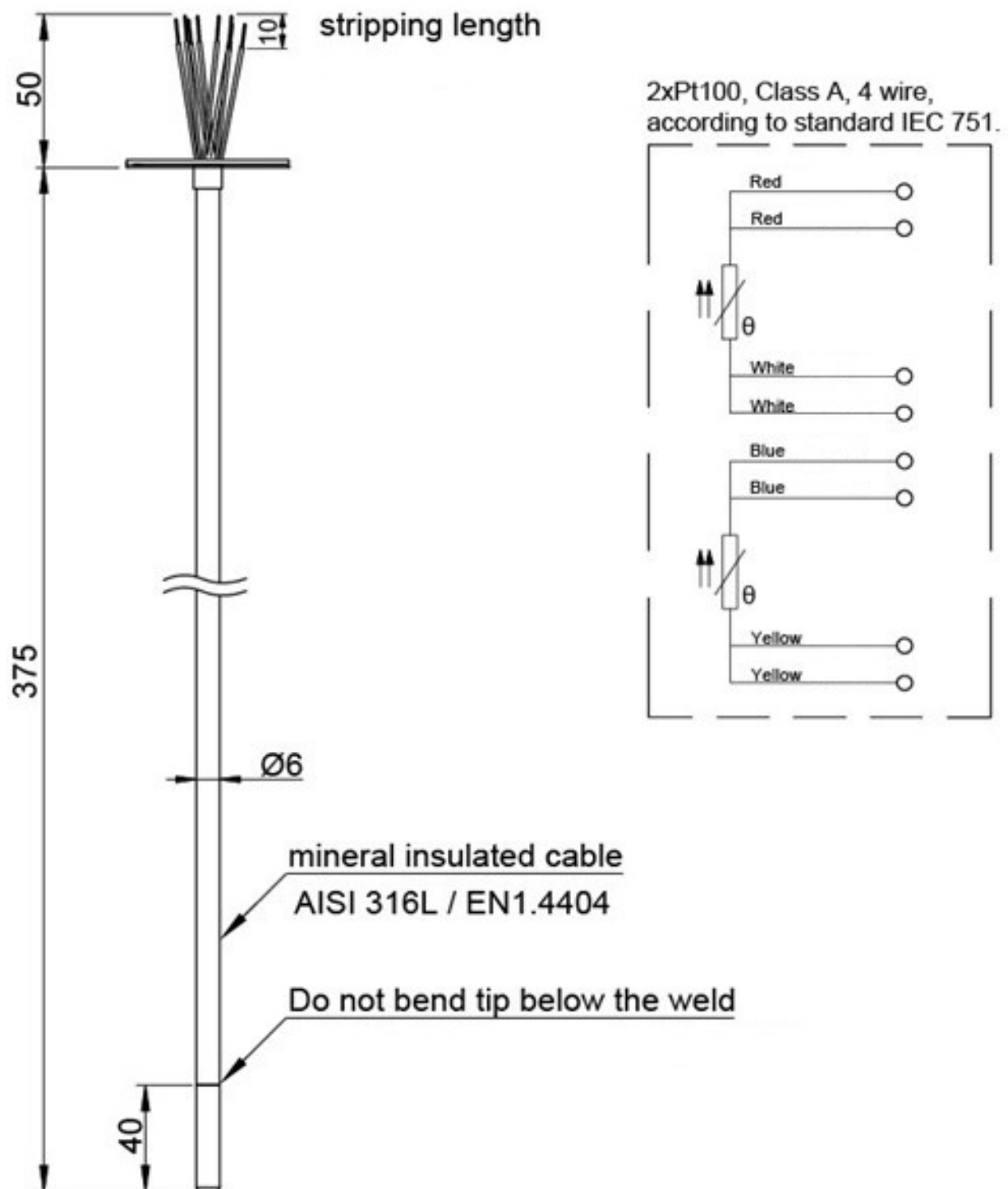
The code key can be used to read the product structure according to the product name. The image below shows the code key for the mineral insulated element:



Note. Ex d -approved element with double loop 2xPt100 4-wire measurement is not available. This is due to lack of 8 pin ceramic block. In practice this means that product 2xW-M-...-CB/EXD does not exist, since it has 8-wires and it would require 8 pin ceramic block. If double measurement for Ex sensor is required, it is recommended to use 2xPt100 with 3-wire measurement.

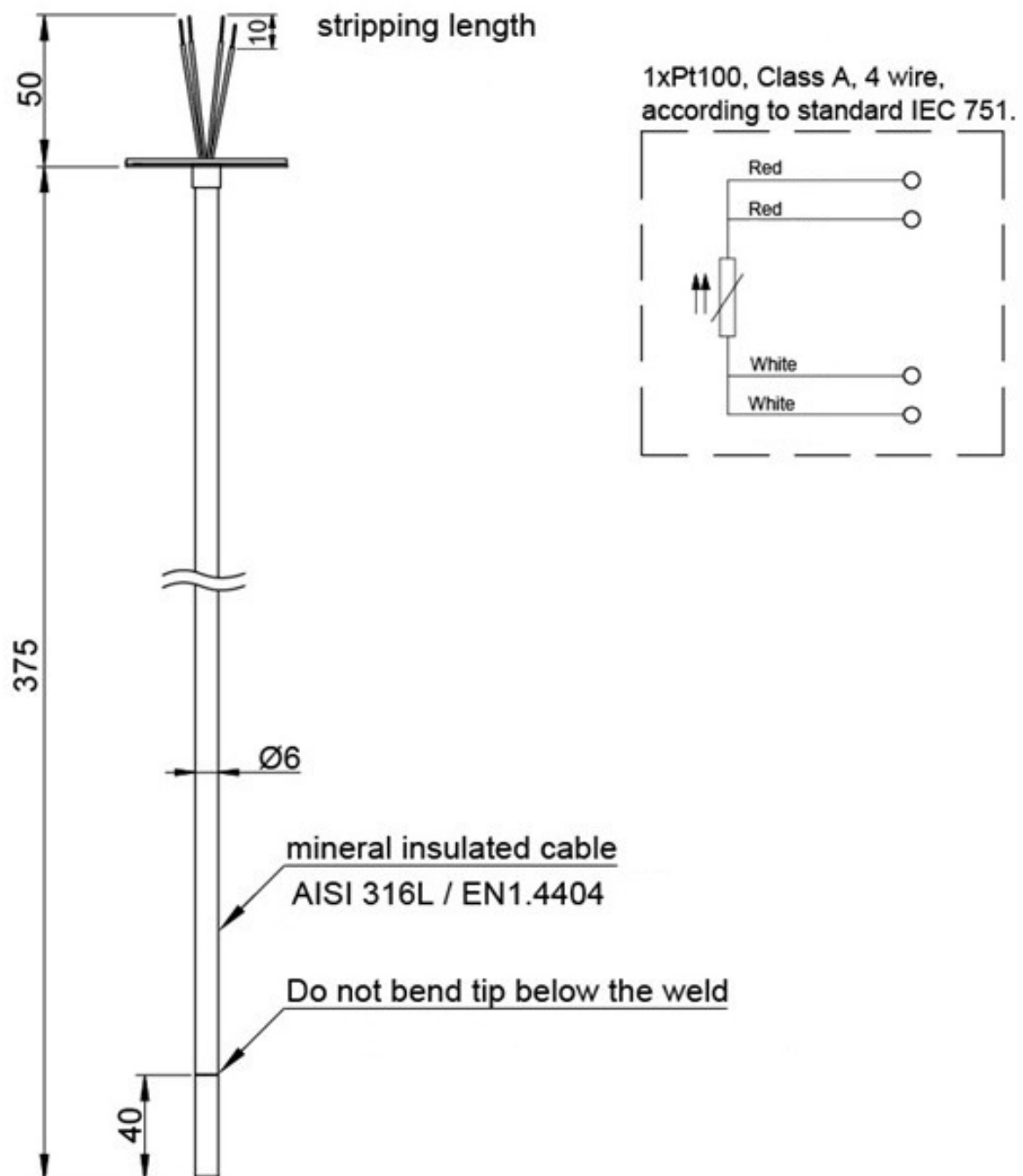
Example 1

Product name according to the codekey: 2xW-M-6/375-4-A-TR



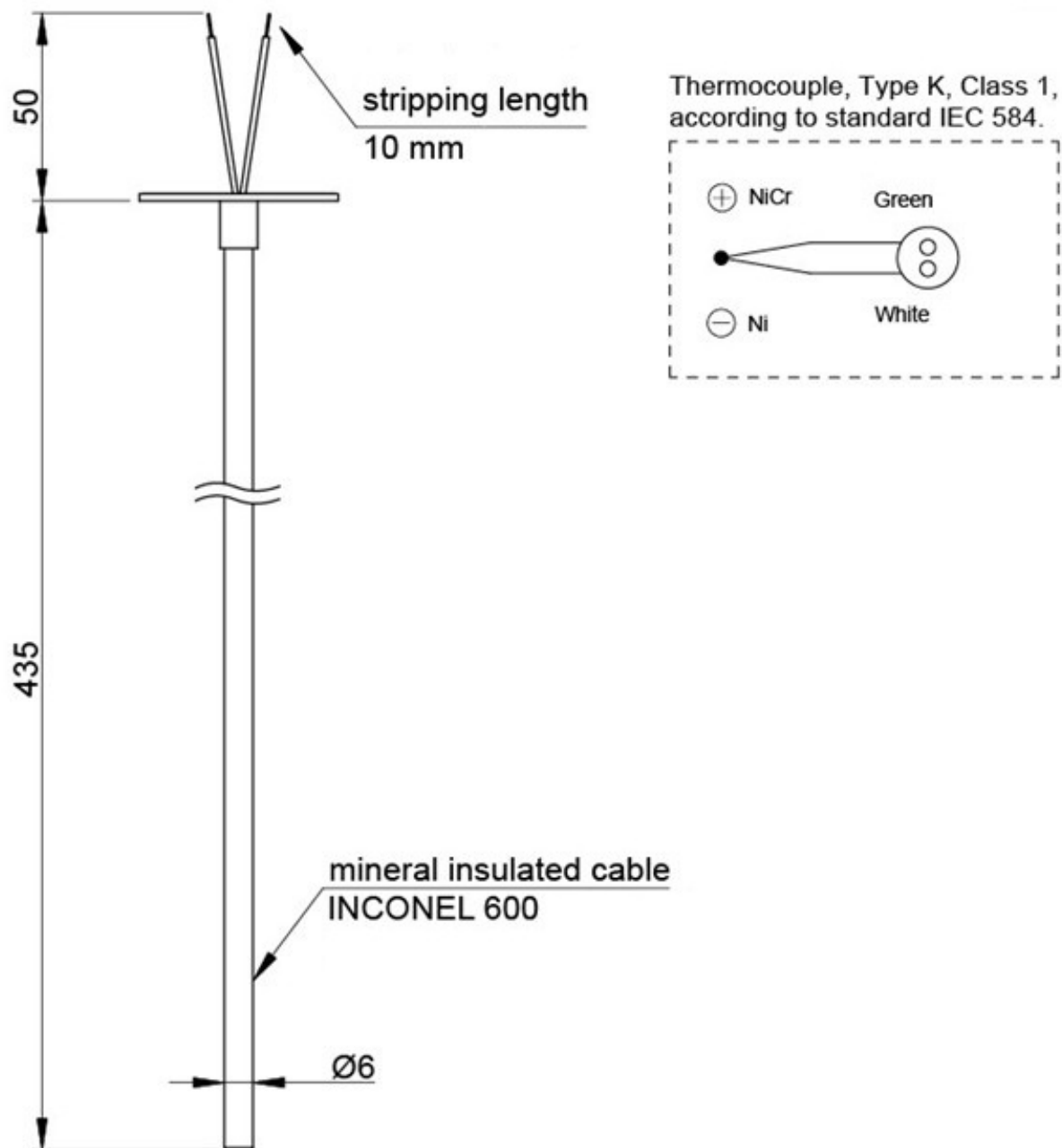
Example 2

Product name according to the codekey: W-M-6/375-4-A-TR



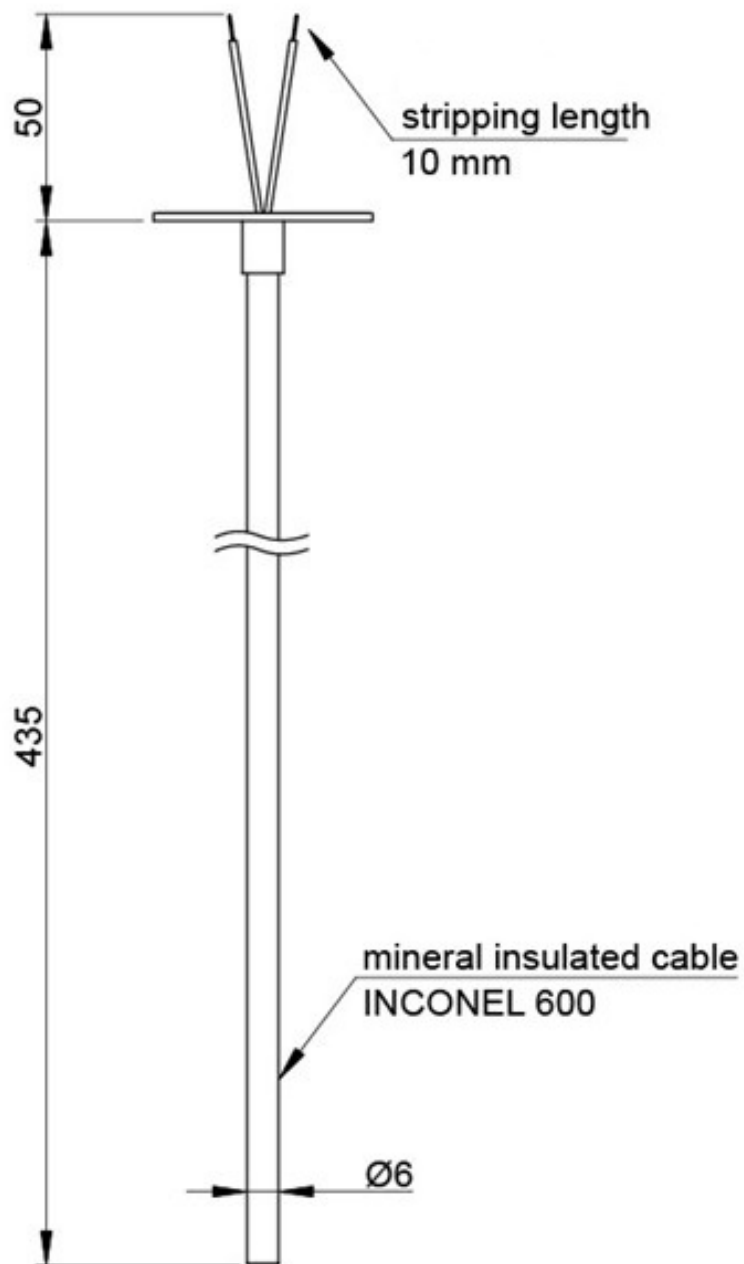
Example 3

Product name according to the codekey: T-M-6/435-K-1-TR

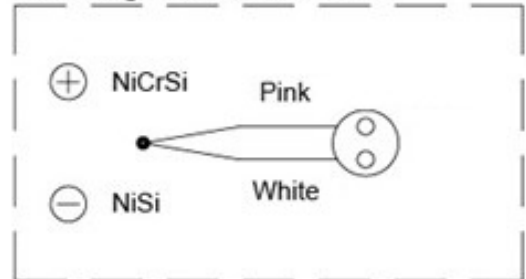


Example 4

Product name according to the codekey: T-M-6/435-N-1-TR

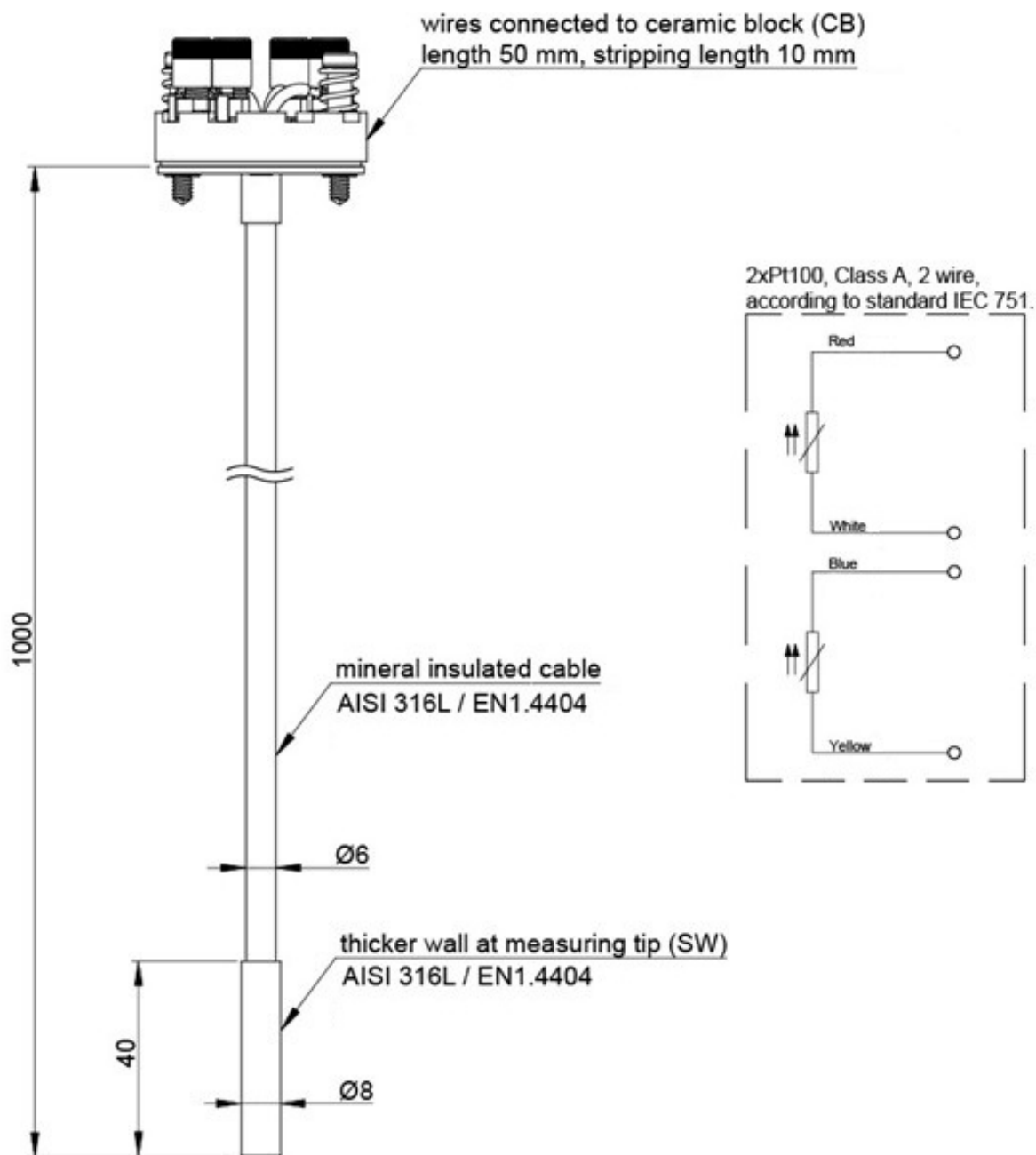


Thermocouple, Type N, Class 1,
according to standard IEC 584.



Example 5

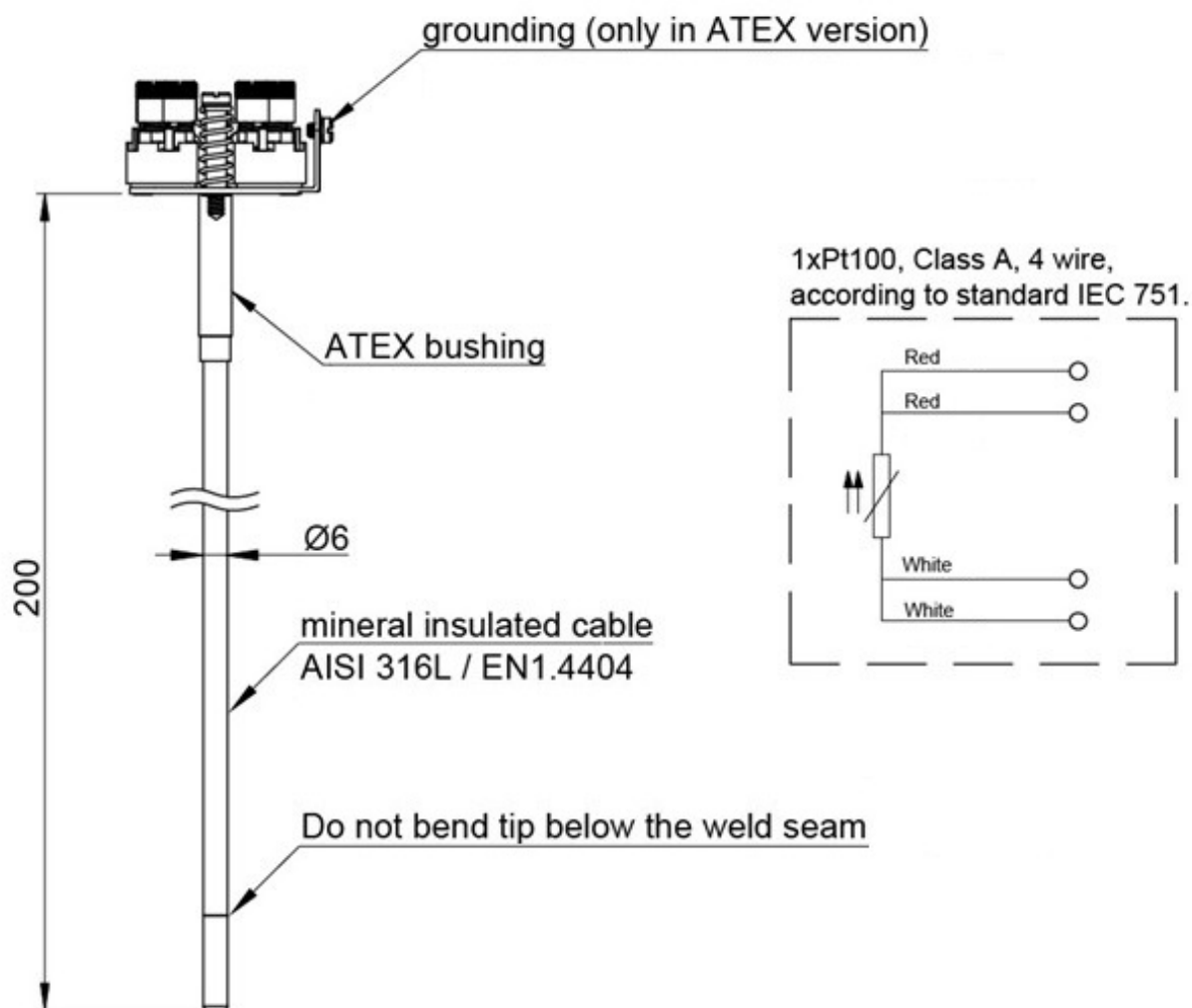
Product name according to the codekey: 2xW-M-8/SV/1000-2-A-CB



Note: Mineral insulated element with thicker wall at measuring tip, as in picture, is mainly used in temperature sensors where the internal diameter of the thermowell housing is much bigger than the external diameter of the element. Thicker wall at the measuring tip will prevent the element from moving within the sensor. This is mainly useful in applications where the vibration and motion can cause wear and tear.

Example 6

Product name according to the codekey: W-M-6/200-4-A-CB/EXD



Note: This version of the product is intended to be used in Ex d -approved sensors with the EXD connection head or enclosure. This version of the mineral insulated element is ATEX compatible and it has longer ATEX bushing which is able to withstand explosive pressures. This product version will always have /EXD text as a part of the product name.

Technical information

Materials	AISI 316L, max. temperature +550 °C, temporarily +600 °C INCONEL 600, max. temperature +1100 °C, temporarily +1200 °C Other materials on request
Tolerances Pt100 (IEC 60751)	AA tolerance $\pm 0.1 + 0.0017 \times t$, operating temperature -50...+250 °C A tolerance $\pm 0.15 + 0.002 \times t$, operating temperature -100...+450 °C B tolerance $\pm 0.3 + 0.005 \times t$, operating temperature -196...+600 °C B 1/3 DIN, 0.1 °C +0.5%, B1/ 10 DIN 0.03 °C +0.5%, operating temperature -196...+250 °C
Tolerances thermocouple (IEC 60584)	Type J tolerance class 1 = -40...375 °C ± 1.5 °C, 375...750 °C $\pm 0.004 \times t$ Type K and N tolerance class 1 = -40...375 °C ± 1.5 °C, 375...1000 °C $\pm 0.004 \times t$
*) Temperature range Pt100	-200...+550 °C, depending on sensor housing materials
*) Temperature range thermocouple	-200...+1200 °C, depending on thermocouple type and sensor housing materials
Approvals	ATEX, IECEx
Quality certificate	ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018 issued by DNV
IP rating	IP65, higher IP rating on request

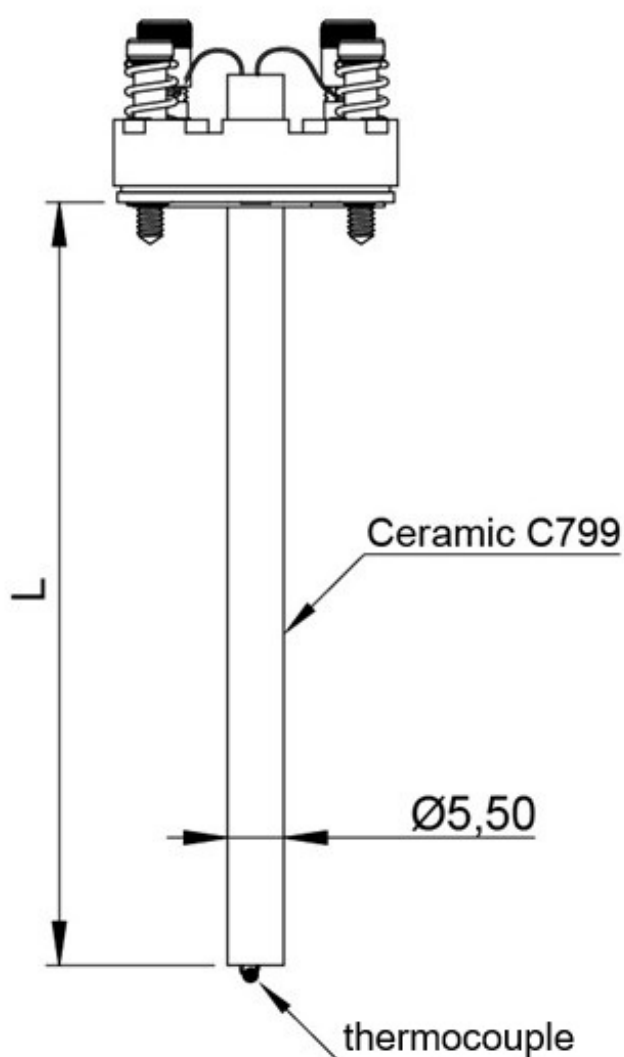
Materials

Component	Material
Mineral insulated element with Pt100	low carbon steel (EN1.4404 / AISI 316L)
Mineral insulated element with thermocouple	Inconel 600

Ceramic element

Ceramic element is a special version of the mineral insulated element and it is only used with the immersible thermocouple sensor, sensor product type: T-K / T-AK / T-AKK. Ceramic element is not recommended to be used with other sensor types. Ceramic element is always with thermocouple and it can withstand very high temperatures. Product name format of ceramic element is: "CER.INSULATOR 799 5,5X(4x1,2)XXXX", where value 5,5 is external diameter of the element as in metric [mm], XXXX = length of the element as in metric [mm] ja 799 is material: Alumina Ceramic C799. Part of the product name (4x1,2) is referring to the holes and their diameters of the ceramic tube.

Typical thermocouple material for ceramic element is Platinum-Rhodium -wire, which makes the ceramic element more expensive than normal mineral insulated element. Use and replacement of ceramic element is covered more closely in the manual of the immersible thermocouple sensor T-K / T-AK / T-AKK. Picture below will show the illustration of the ceramic element:



Length

Length of the measuring element is dimensioned according to the connection head in use, but also other aspects need to be considered; such as the length of the thread coupler under the connection head and the thickness of the thermowell. We do not currently provide inherent information on „how to select the length of the measuring element“ for the sensor. For selecting the length of the measuring element, please contact our sales team.

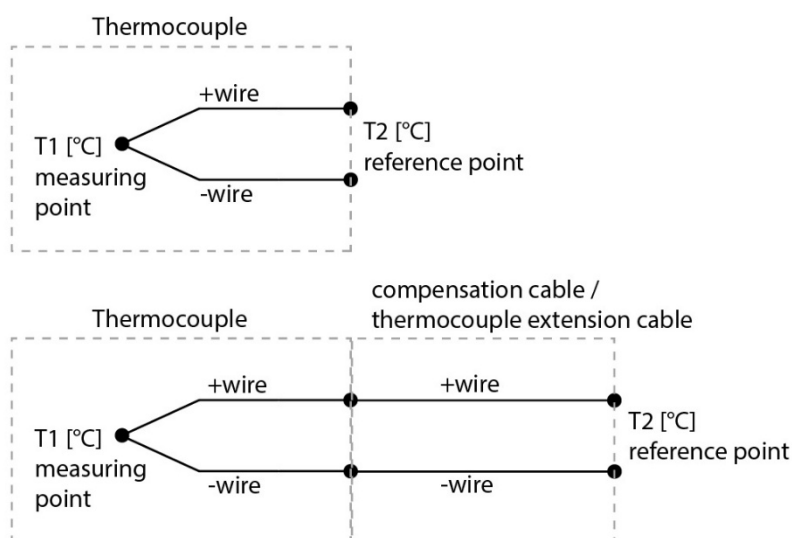
Inspection

Technical inspection of measuring element with Pt100 resistance temperature sensor can be done with a basic multimeter. Inspection is carried by measuring the resistance of the Pt100. Inspection must be done over the Pt100 and between all wires. This will eliminate the chance of broken wire or other abnormal behaviour. The value of the Pt100 resistance should be 100 Ω in temperature of 0 °C, and 110 Ω in temperature of +25 °C.

To inspect a thermocouple the measuring tip of the thermocouple must be heated. Heating must be accurately controlled while the response, millivolt [mV], value is measured. The measured response value must be then compensated with the reference point response value. The resulting millivolt [mV] value can then be compared with the values in standardized reference tables. If the values are matching, the thermocouple should be in working condition. This technique is called as cold junction compensation.

Most of the temperature measuring applications with thermocouples have an internal Pt100 sensing element to measure the reference point temperature. Temperature transmitters typically have their own reference point temperature measurement, that is used to compensate the measured temperature of the hot point. In thermocouple temperature measurement the reference temperature is always needed to accurately read the temperature of the hot point.

Picture below will show illustration of the hot measurement point and the location of the cold reference point:



To ease the inspection of thermocouple, it is recommended to keep T2 [°C] temperature as steady as possible. Reference point can be transferred to a location where the temperature is constant by using thermocouple extension cable. When using an extension cable, it is necessary to keep the material as unchanged between the hot point to the reference point. Never cross-connect the wires and always use suitable connectors: i.e. for K-type of thermocouple always use K-type of connectors. If positive wire is connected to the negative wire, the thermocouple will not work as intended, for more reference please see section "TC: Thermocouple cable color codes".

Reference table to inspect the thermocouple functionality can be found from standard IEC 60584. After the cold point compensation has been done, the response value of the thermocouple can be compared to the table values. T2 temperature of the reference point, for the table value comparison, should be at 0 [°C].

Calibration

Measuring element of the temperature sensor can be calibrated to customer specified temperature range. To specify the calibration area: two points on a temperature scale are needed. Calibration can also be done by a third party, typically accredited testing laboratory. Calibration should be done as liquid bath calibration, where the sensor tip is dipped to a constant temperature flowing liquid, typically silicone oil. Equipment to perform the calibration should be regularly calibrated for the best results.

Typical calibration intervals are:

- Pt100 resistance sensor: 12-24 months
- Thermocouple sensor: 12 months
- Re-calibration is recommended for sensors that has been stored for over than 3 years.

Calibration interval must be evaluated according to the process and possible risk involved. Always think what is the risk involved when the temperature sensor is going out of calibration. For example, in pharmaceutical industry where medicine is manufactured calibrations must be done on regular basis to minimize this risk. If process requires precision from the temperature, the calibration is then recommended to be done in short intervals.

Measuring element will age in use, and this ageing is not always linear with time. Ageing is faster in cyclic processes where the change in temperature is big in short duration of time. This ageing can be seen in the calibration, since it is possible to compare the calibration results to the initial calibration results of the sensor.

Measurement error and tolerance

Tolerance and measurement error of thermocouples, and any calculus related to them, is presented in standards: IEC 60584, DIN 43710 and ANSI MC96.1. Thermoelement accuracy class is typically 1.

Standard IEC 60751 has information about measurement error of Pt100 resistance sensor. In Pt100 resistance sensor some measurement error is often caused by the small resistance of the wires or cable in use. It is necessary to eliminate this small constant resistance if very accurate temperature reading is needed.

Insulation resistance

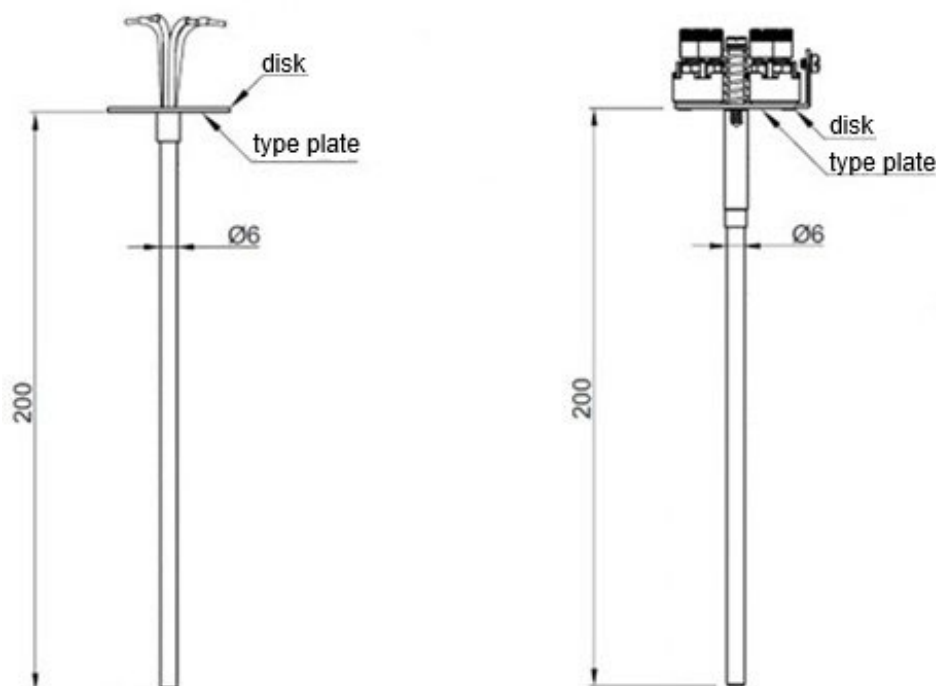
Insulation resistance of the measuring element is always inspected during the manufacturing. The insulation resistance is measured from the internal measuring loop to the external metal parts of the element. If multiple measuring loops are present, insulation resistance of each loop is measured and deemed to be sufficient. Insulation resistance should be $\geq 500 \text{ M}\Omega$ in room temperature in operational condition. Insulation resistance can be measured by using insulation resistance tester intended for this use. Always use tester that is calibrated.

Type plate

Each measuring element have their own individual type plate. In general there are two versions of the type plate; type plate for Ex d compatible measuring element and normal type plate. Pictures below will show the type plates:

 CE EPIC® SENSORS MADE IN FINLAND Tel: +358 (0) 20 764 6410 W-M-6/455-4-A-CB S/N: Prod. 1014978 260224-1414937-3	Type plate of normal and Ex i compatible element: CE-mark Product group Country of production Contact information Serial number as QR-code Product name, i.e. W-M-6/455-4-A-CB Product number, i.e. 1014978 Serial number, i.e. 260224-1414937-3
 W-M-6/455-4-A-CB/EXD Prod. 1014960 S/N: 260310-1408091-8 CE EPIC® SENSORS MADE IN FINLAND Tel: +358 (0) 20 764 6410	Type plate of Ex d compatible element: Product name, i.e. W-M-6/455-4-A-CB/EXD Product number, i.e. 1014960 Serial number, i.e. 260310-1408091-9 CE-mark Product group Country of production Contact information Serial number as QR-code

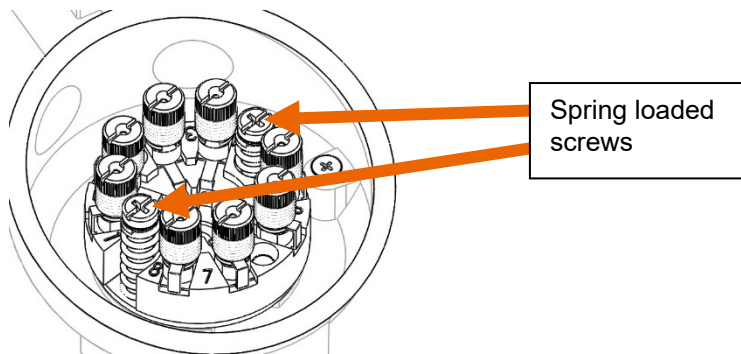
Type plate is located on the bottom side of the mineral insulated element. Mineral insulated element has to be removed from the sensor housing for the type plate to be read. Instructions to remove the element is in the next section of this manual. Following picture will show the location of the type plate under the disk:



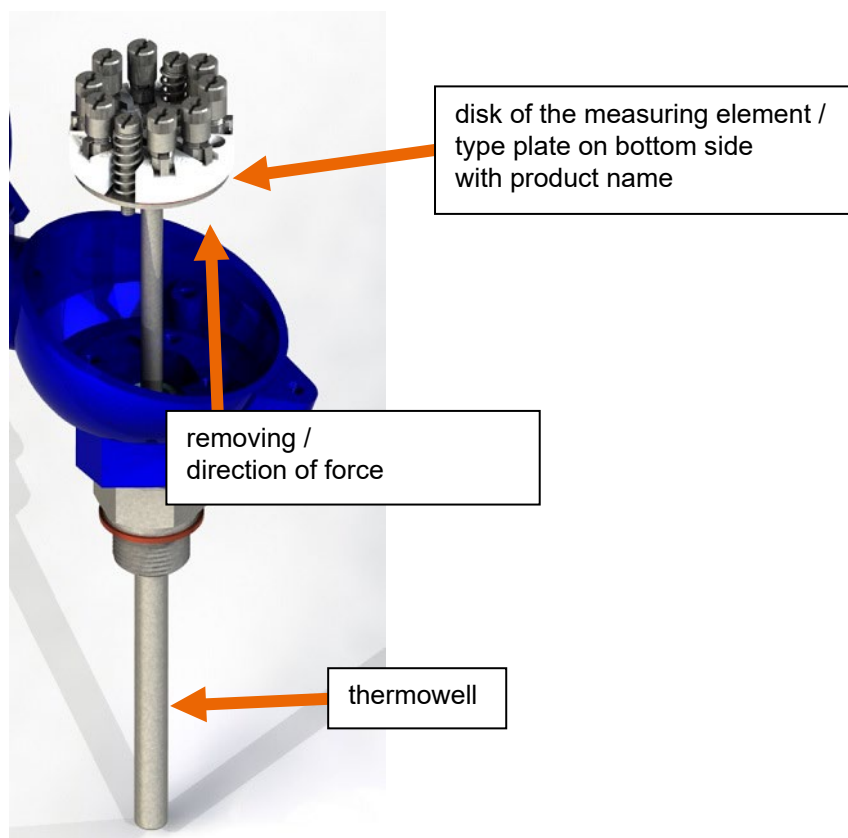
Replacing the measurement element

Note: The connection head contains live parts, make sure that it is possible to open the connection head.

- 1) Open the connection head. See section „Connection heads“ for information on how to open.
- 2) Remove any cable connection from the ceramic block or transmitter.
- 3) Measuring element is mechanically attached to the connection head with two spring loaded screws. Loosen these screws. Picture below will show the screws:



- 4) Remove the measuring element by pulling it straight upwards. See picture below:



- 5) See that the product name of the new measuring element is equal to the old removed measuring element. This can be read from type plate at bottom of the disk. If uncertainty exists, please contact our sales.
- 6) Fit the new measuring element to the thermowell, to the same place where the old removed measuring element was being housed.

Note: Disk of the measuring element does not need to be in direct contact with the connection head. Spring loaded screws will tolerate 8-10 millimeter gap to the surface of the connection head. In situation where the tip of the measuring element is pressed to the tip of the thermowell, the bottom surface of the disk is typically few millimeters above the internal surface of the connection head.

- 7) Connect cable back to the measuring element through the cable gland of the connection head.
- 8) Connect measuring element to the connection head by tightening the spring loaded screws.
- 9) Close the lid of the connection head.

Adding transmitter to the sensor

Note: The connection head contains live parts, make sure that it is possible to open the connection head.

Note: The measuring element must have -TR in product name, which enables that transmitter can be attached to it.

- 1) Open the connection head. See section „Connection heads“ for information on how to open.

- 2) Find the measuring element and bring it up. In new sensor it could be inside the connection head during the transportation.

- 3) Find the temperature transmitter and remove the two lock washers from the bottom side.

Note: Do not let screws or springs fall off during this step. Lock washers are needed later, store them in safe place.

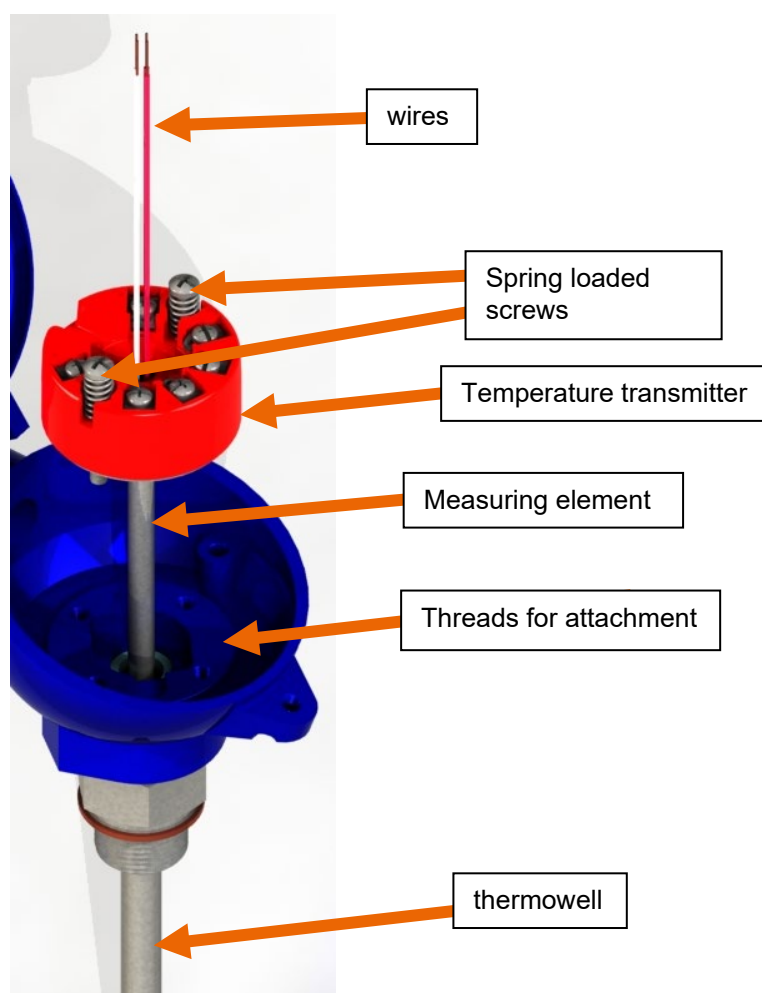
- 4) Connect the transmitter to the measuring element by bringing the wires of the measuring element through the hole in the center of the transmitter to the top side. Connect lock washers to the bottom side of the measuring element disk, to the same screws they were initially removed from.

Note: Transmitter should now be fixed to the measuring element disk.

- 5) Insert the measuring element with the transmitter to the thermowell of the sensor

Note: bottom of the measuring element disk does not need to meet with the connection head. There may be gap of few millimeters.

- 6) Connect the measuring element to the connection head with the spring loaded screws. See picture below:



- 7) Connect the wires of the measuring element to the transmitter in use. See correct connection and pin order from the datasheet of the transmitter in use. Most of the transmitter datasheets can be found online.

Connecting cable to the sensor

Note: The connection head contains live parts, make sure that it is possible to open the connection head.

Note: It is recommended to use SKINTOP® cable glands to achieve improved protection rating of the sensor unit.

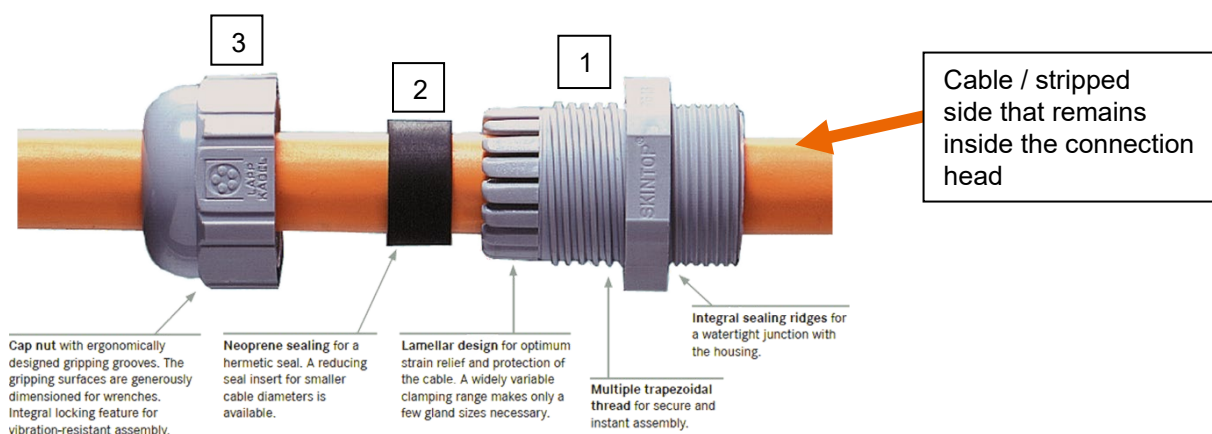
Note: When sensor is Pt100 resistor based, always use Copper (Cu) cable.

Note: When using thermoelement sensor without temperature transmitter, always use the same thermoelement material in the extension cable as in the measuring thermoelement.

Note: When using thermoelement sensor with temperature transmitter always use Copper (Cu) cable.

Steps to connect the cable to sensor unit:

- 1) Strip the cable to be connected. It is recommended to strip 50 – 70 millimeters of wires with insulation from the cable jacket. Similarly it is recommended to strip around 10 mm of each conductor to be visible for the connection. Simplified as 50 mm insulated wire with 10 mm of bare conductor at the end.
- 2) Depending on the cable and connection head in use, attach ground ring terminal to the ground of the cable. In case of EXD connection head, ground wire can be connected without the ground ring terminal.
- 3) Loosen the cable gland parts and bring them over the cable in the order of the picture below. During the transport the cable gland is typically attached to the sensor unit, where it can be detached from. If cable gland is delivered as separate part, there can be internal lock nut with it. Internal lock nut is not used with the connection head and can be discarded. All required parts are shown in the picture below:



- 4) Take the parts of the cable gland in the order of the picture into the cable entry thread of the connection head and tighten them in place. Part 2 should be positioned between cable jacket and the forks of the part 1 as a sealant. Tightening is performed by rotating part 3 to part 1. Tightening torques are mentioned in the cable gland datasheet if information is available.

Note: when taking the stripped cable end into the connection head, leave enough space for the transmitter. Transmitters are typically around Ø45 mm.

- 5) Test the cable gland functionality by pulling the cable. Cable should not slide off from the cable gland. If this happens, see that the cable gland parts are in correct order and add tension.

- 6) A) If Pt100 sensor is in use with ceramic block, then always use copper (Cu) cable. Ceramic block has terminals that can be rotated to open and close, for more information see section „RTD; resistance temperature sensor connections“. Connection is typically one cable conductor to one Pt100 wire terminal with Pt100 wire.

B) If Pt100 sensor is in use with temperature transmitter, see the temperature transmitter datasheet for correct connection. Most datasheets can be found online from the manufacturer. Use copper (Cu) cable with temperature transmitter.

C) If you are using ceramic terminal block and thermocouple; connection is done by connecting the positive wire of the extension cable under the positive wire of the thermocouple, and similarly negative wire is connected to the negative wire. Ceramic block has terminals that can be rotated to open and close, for more information see section „TC; thermocouple connection“.

Note: Use only same type of thermocouple and extension cable: i.e. K-type sensor will need K-type extension cable, where the conductor core material is the same. Try to set wires in the connection so that they are in direct contact with each other. Any other medium, in between the wires, can cause measurement error to occur.

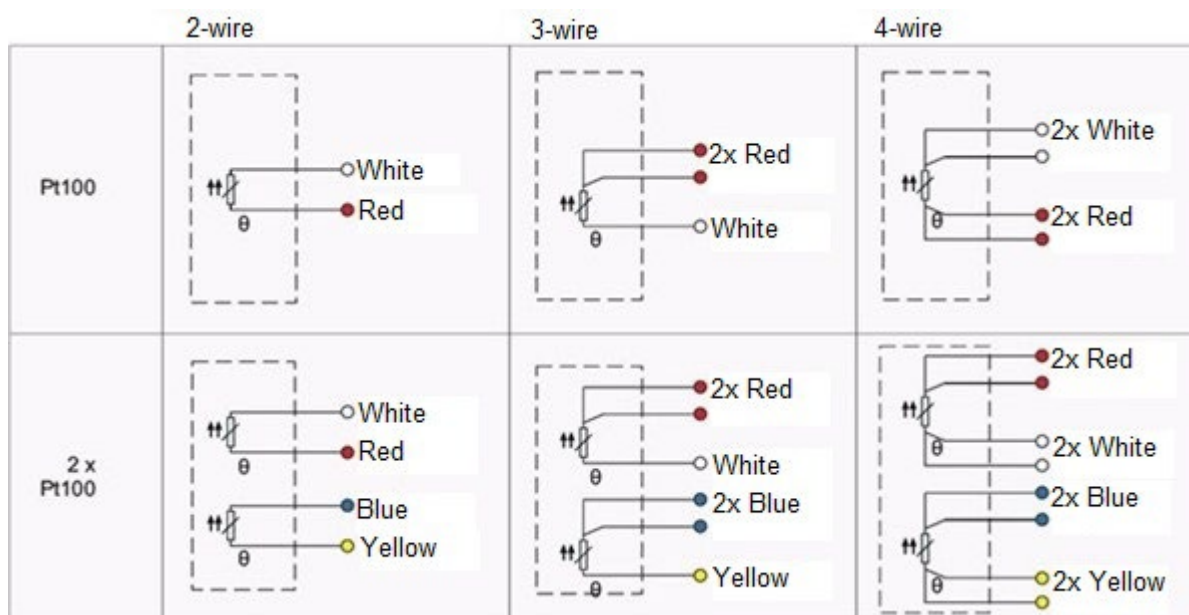
Note: Never use copper (Cu) cable as extension cable for thermocouple sensor with ceramic block.

D) If you are using thermocouple sensor with temperature transmitter, see the temperature transmitter datasheet for correct connection. Use copper (Cu) cable in the connection.

- 7) Insulate any cable conductors that will remain un-used within the connection head. This can be done with insulation sleeve or tape.
- 8) After cable has been connected: close the lid of the connection head.

RTD; resistance temperature sensor connections

Picture below will show IEC 751, international standard, Pt-100 connections and wire color codes:



Note: customer specific color codes and wiring is available on request.

RTD; measurement current

Maximum measurement current for Pt100 temperature sensor is depending on the manufacturer of the sensing element.

Generally allowable measurement currents are (Note: this is the maximum current by the manufacturer):

- Pt100 <1 mA
- Pt500 0,5 mA
- Pt1000 0,3 mA

Do not use measurement current above this limit, since it can destroy the sensing element.

Values presented above are normal values. Different values are used in Ex i certified sensor types for safety reasons. This is due to the fact that in Ex i sensor or sensing element the self heating is considered to be relevant. For more information of Ex i measurement current values, please see: Appendix A.

Response time

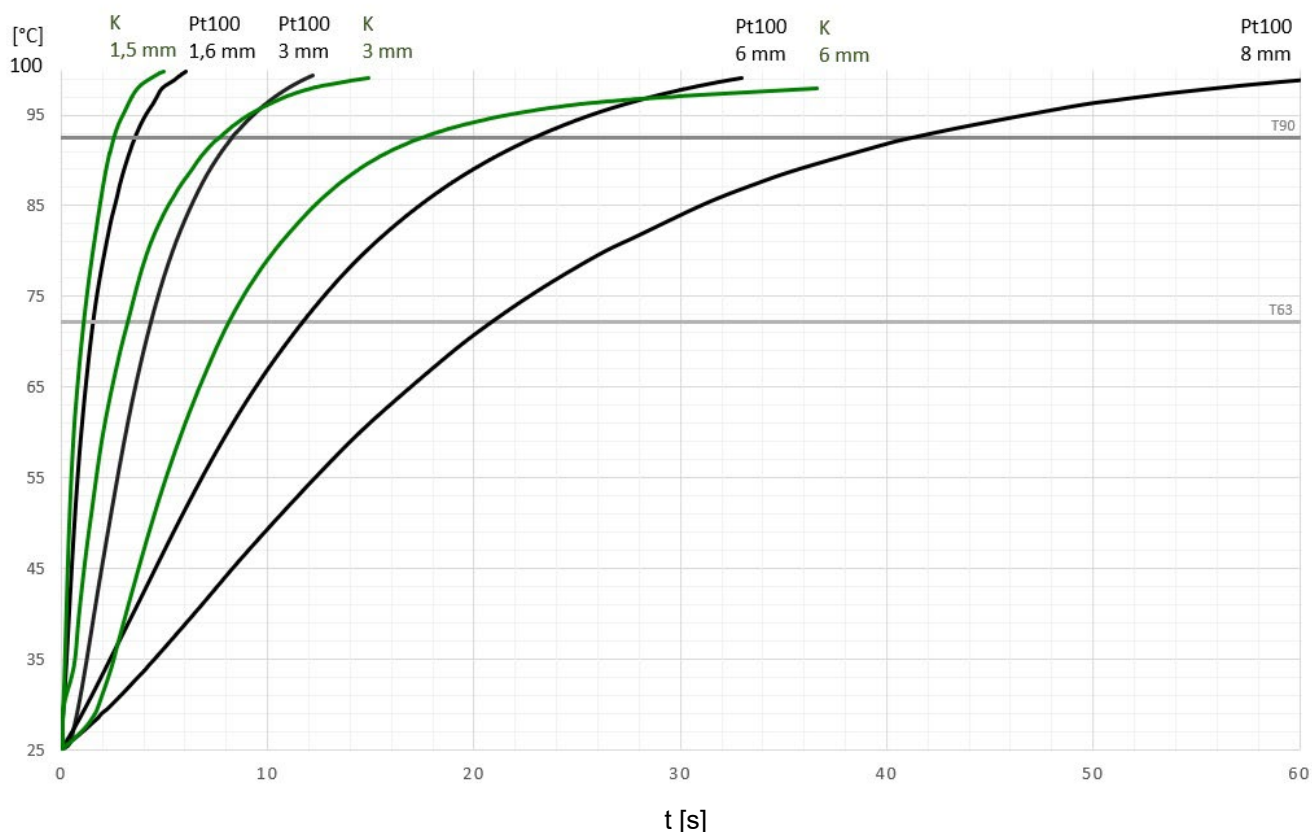
Response time of temperature sensor is highly depending on the structure around the sensing point and materials in use. Air around the measuring point will act as insulator and slow the response time. Ceramic thermowells, which contain lots of air, will typically slow the response time significantly. Any non-protected measuring element that is directly in contact with the medium to be measured, is fastest in response, but mechanical and chemical durability is lesser. Non-protected measuring elements can not be used in all cases for this reason.

Response time has two different values: T63 [s] and T90 [s]. The T63 time is the time it takes for the sensor to reach 63% of the final temperature and similarly the T90 time is the time it takes for the sensor to reach 90% of the final temperature. Response of temperature sensor is changing exponentially as function of time. This means that measuring the final temperature to a degree will take long time and is not practical in most of the cases. Knowing the T63 or T90 response time of the sensor is sometimes helpful, since this information with a few points of temperature measures, can be sufficient to calculate the current approximate temperature in the target under measurement.

Table below will show response times of different elements:

Sensor	Response time T63 [s]	Response time T90 [s]
Pt100, 1.6 mm element	1,7	3,6
Pt100, 3 mm element	4,2	8,2
Pt100, 6 mm element	13,7	24,7
Pt100, 8 mm element	27,6	47,5
Thermocouple, Type K, 1.5 mm element	1,1	2,4
Thermocouple, Type K, 3 mm element	3,1	7,5
Thermocouple, Type K, 6 mm element	8,2	17,2
Thermowell 6 mm, Pt100, 3 mm element	29,7	62,3
Thermowell 9 mm, Pt100, 6 mm element	39,9	75,3
Thermowell 11 mm, Pt100, 6 mm element	58,8	112,2
Thermowell D1, Pt100, 6 mm element	86,3	153,6
W-Cable sensor, Pt100, 6/60 mm tip	11,2	21,2
Margin of error: $\pm 0,2$ [s]		
These measurement are done by dipping the sensor element to a silicone oil bath, which is precisely temperature controlled. Flow of the silicone oil is constant during the measurements. Initial measurement temperature is $+25$ [°C] and temperature of silicone oil bath is $+100$ [°C].		

Chart below will show the response time for some Pt100 elements and K-type thermocouple elements:



TC; thermocouple structure

Thermocouple element can be exposed, grounded or isolated. Normally thermocouple elements are isolated, and element is also housed in thermowell. This way the measuring thermocouple has multiple layers of protection, and it can be used in various potentially corrosive processes.

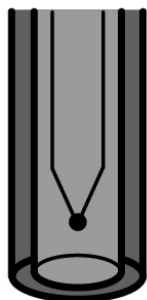
Exposed thermocouple means that the thermocouple metallic pair is directly in contact with the medium to be measured. There is no protective layer. In this case the response time is fastest possible, but the measurement is most likely very unstable and contains considerable amount of measuring errors. The electrical response generated by heat in the junction point of the two metals of the thermocouple will most likely leak out side the measuring loop.

Grounded thermocouple means that the metal pair of the thermocouple is connected to the metallic housing of the thermowell. There is no isolation between the measuring loop and the external part of the element. In this case the measurement loop can contain galvanically coupled measurement errors travelling from outside.

Isolated structure, also known as ungrounded structure, is most reliable and most shielded from any external interference. In isolated structure the thermocouple is shielded in closed metallic surface and the measuring loop is isolated from the external part of the element. This is the most common type of thermocouple element in temperature measurement.

Thermocouple shielding can be further increased with thermowell and other shielding parts around the measuring element. Thermowell material and thickness are the most significant factors when thinking of chemical and mechanical durability.

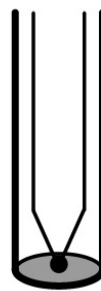
Picture below will show the different thermocouple structures:



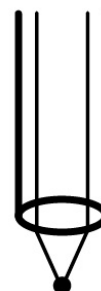
Isolated element
in thermowell



Isolated,
ungrounded structure,
thermopair is isolated
from the external metal
parts



Grounded structure,
thermopair is galvanically
connected to the external
metal parts



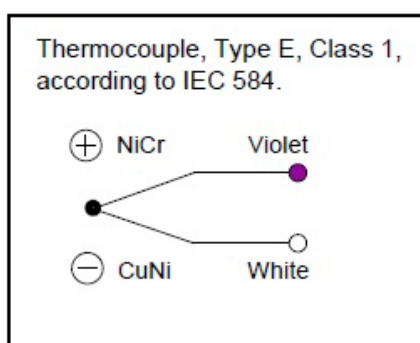
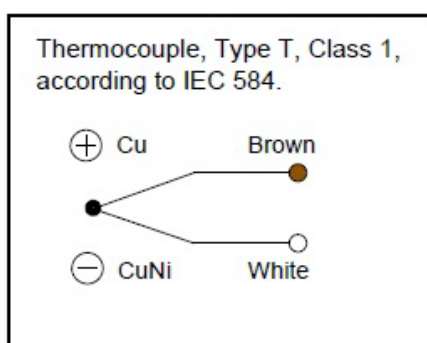
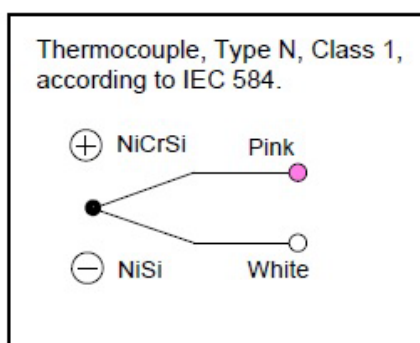
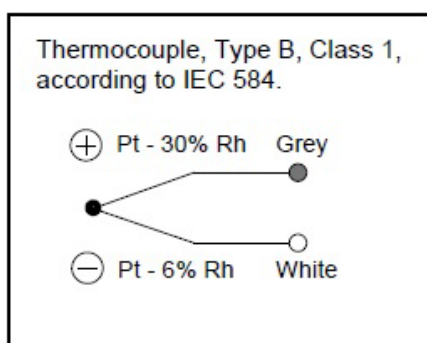
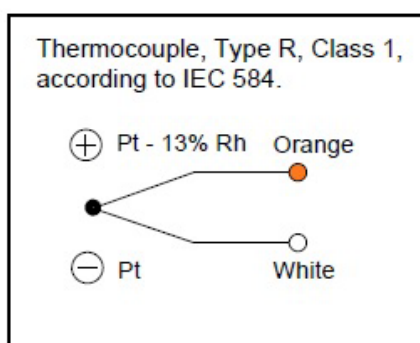
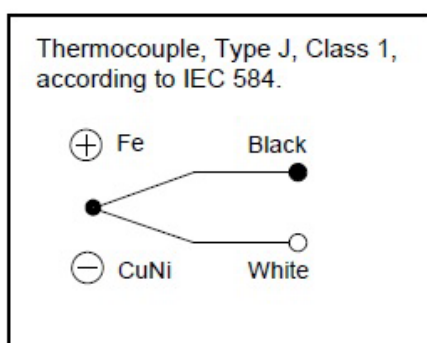
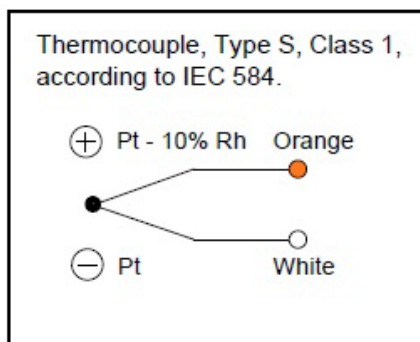
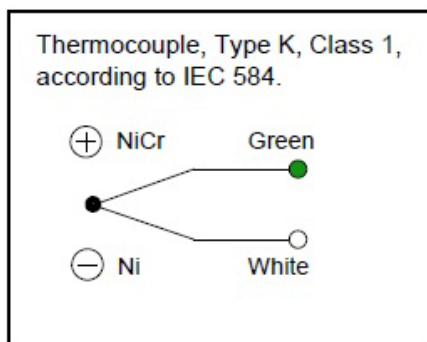
Exposed thermocouple,
thermopair is in direct
contact with the environment

Note: Grounded and ungrounded thermowells can not be used in same measuring loops, always use correct version.

Note: Grounded and exposed thermocouple structure is not allowed in zones with explosive hazards. They should not be used in Ex d or in Ex i certified sensors. For Ex sensor always use isolated, ungrounded, thermocouple element.

TC; thermocouple color codes (IEC 584)

Picture below will show thermocouple color codes according to international standard IEC 584:

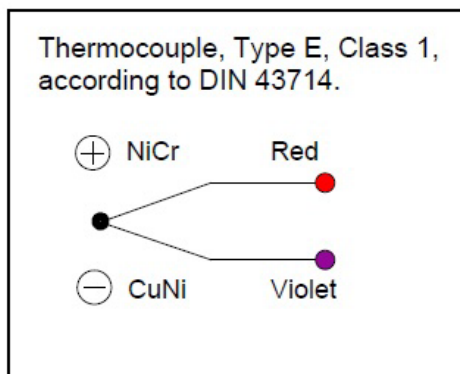
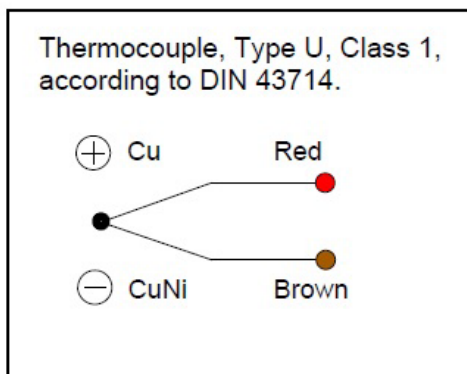
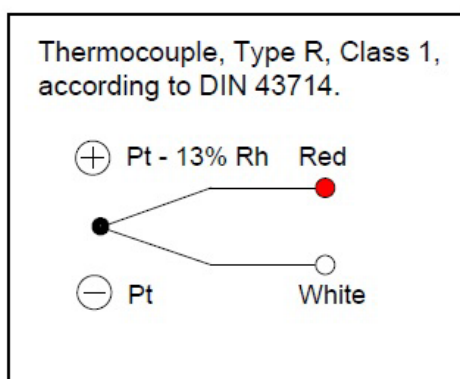
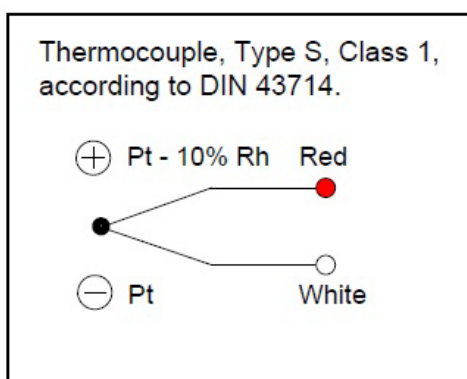
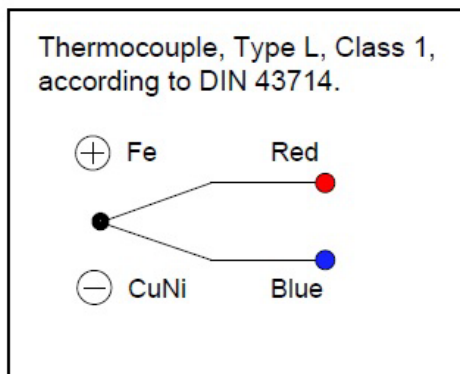
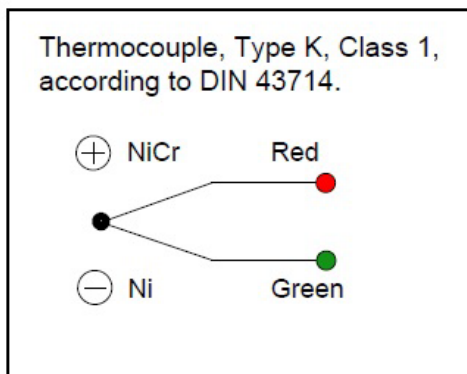


Note: If multiple thermocouples of same type exist on one sensor, thermocouple loops are numbered.

Note: customer specific color codes and wiring is available on request.

TC; thermocouple color codes (DIN 43714)

Picture below will show thermocouple color codes according to German standard DIN 43714:

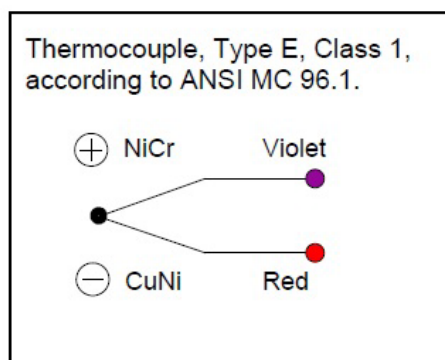
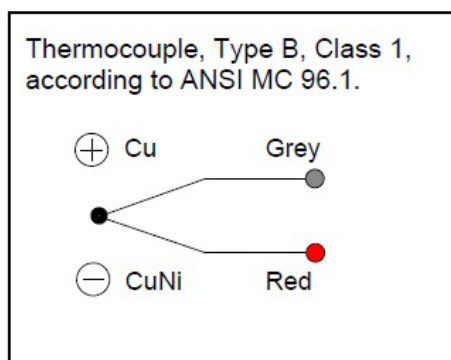
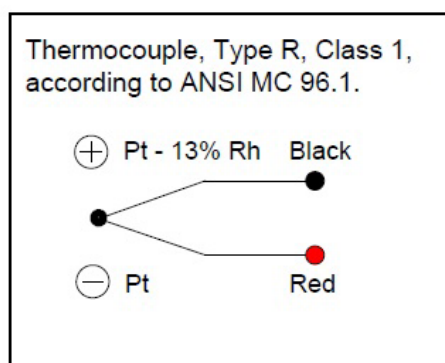
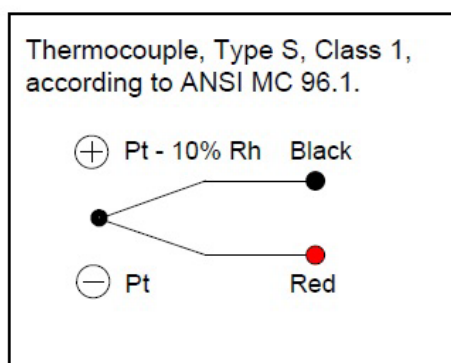
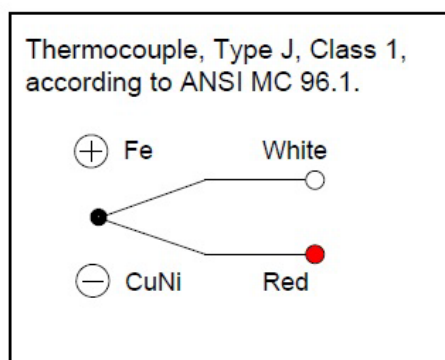
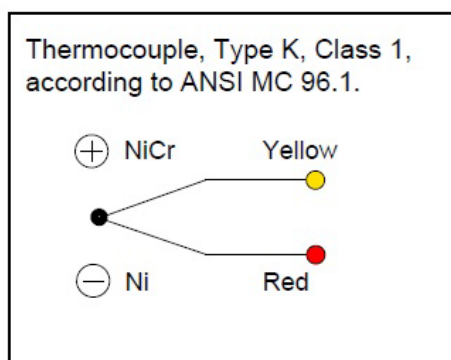


Note: If multiple thermocouples of same type exist on one sensor, thermocouple loops are numbered.

Note: customer specific color codes and wiring is available on request.

TC; thermocouple color codes (ANSI MC96.1)

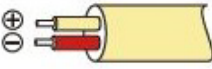
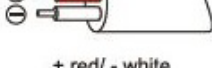
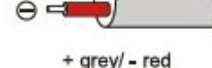
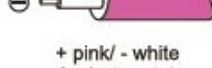
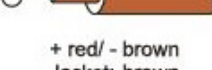
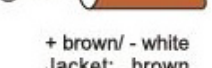
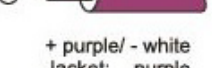
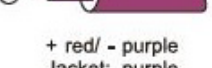
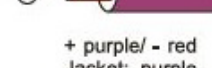
Picture below will show thermocouple color codes according to U.S. standard ANSI MC96.1:



Note: If multiple thermocouples of same type exist on one sensor, thermocouple loops are numbered.

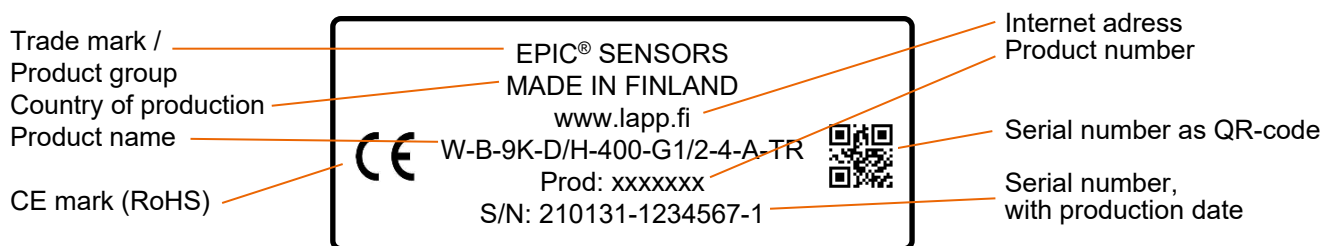
Note: customer specific color codes and wiring is available on request.

TC; Thermocouple cable color codes

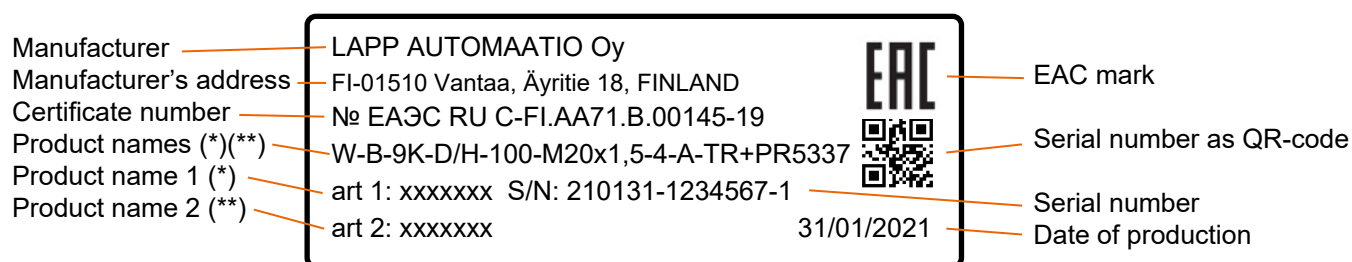
Thermo Type	IEC 584	DIN 43714	ANSI MC 96.1
NiCr-Ni / K KCA: Fe-CuNi	 + green/ - white Jacket: green	 + red/ - green Jacket: green	 + yellow/ - red Jacket: yellow
Fe-CuNi / L		 + red/ - blue Jacket: blue	
Fe-CuNi / J	 + black/ - white Jacket: black		 + white/ - red Jacket: black
Pt10Rh-Pt / S SCA: E-Cu/A-Cu	 + orange/ - white Jacket: orange	 + red/ - white Jacket: white	 + black/ - red Jacket: green
Pt13Rh-Pt / R RCA: E-Cu/A-Cu	 + orange/ - white Jacket: orange	 + red/ - white Jacket: white	 + black/ - red Jacket: green
Pt30Rh-Pt6Rh / B BC: S-Cu/E-Cu	 + grey/ - white Jacket: grey		 + grey/ - red Jacket: grey
NiCrosil-Nisil / N NC: Cu-CuNi	 + pink/ - white Jacket: pink		
Cu-CuNi / U		 + red/ - brown Jacket: brown	
Cu-CuNi / T	 + brown/ - white Jacket: brown		
NiCr-CuNi / E	 + purple/ - white Jacket: purple	 + red/ - purple Jacket: purple	 + purple/ - red Jacket: purple

Type plate

Each sensor has individual type plate attached. Picture below will show example of information found on sensor type plate:



Sensors with EAC EMC approval, that are transported to Eurasian Economic Union area, have their own type of type plate. Below picture will show type plate of EAC EMC approved product, with sensor (*) and transmitter (**).



Serial number

Serial number S/N is always printed to type plate in form of yymmdd-xxxxxx-x:

- | | |
|-----------|---|
| ▪ yymmdd | date of production, i.e. "210131" = 31.1.2021 |
| ▪ -xxxxxx | production order, i.e. "1234567" |
| ▪ -x | running number of production order, i.e. "1" |

Ex d approved sensor

Special conditions for safe use of Ex d approved sensor

Sensors with Ex d approval will meet ATEX and IECEx certificates, but their use should be under certain conditions. In general, sensor with Ex d approval can be recognized from the "EXD" text in product name. Below is text from certificate describing the special conditions of use:

For connection head without window:

-40 °C ... + 60 °C temperature class T6/T80 °C

-40 °C ... + 75 °C temperature class T5/T95 °C

For connection head with window:

-40 °C ... + 60 °C temperature class T6/T80 °C

Note: Drawing of Ex d approved sensor is supplied with the product. This drawing is declaration of compatibility of the product according to the current ATEX and IECEx certificates and it will show the sensor structure. Changes to the sensor structure is not allowed. In some cases the drawing can include instructions on „how to correctly use the sensor“ and these instructions should not be ignored.

Ex d approval ja Ex marking

Certificate	Issuer	Economic zone	Marking
ATEX EESF 18 ATEX 052X	Eurofins Expert Services Oy, EORI: FI2297513-2 Notified body (NANDO) Nr 0537	Europe	Ex II 2G Ex db IIC T6/T5 Gb Ex II 2D Ex tb IIIC T80°C/T95°C Db
IECEx IECEx EESF 20.0034X	Eurofins Expert Services Oy, EORI: FI2297513-2 Notified body (NANDO) Nr 0537	Global	Ex db IIC T6/T5 Gb Ex tb IIIC T80°C/T95 °C Db
EAC № EA3C RU C- FI.AA71.B.00130-19	Lenpromexpertiza OOO, Russia	Eurasian economic zone (Kazakhstan, Belarus, Russia)	1 Ex d IIC T6/T5 Gb X Ex tb IIIC T80°C/T95°C Db X

Type plate of Ex d approved sensor

ATEX and IECEx certified Ex d approved sensors have information on the type plate according to the complying classification. Picture below is an example of a type plate of Ex d approved sensor:

Lapp Automaatio Oy
Äyritie 18 FI-01510 Vantaa Finland
+358 (0) 20 764 6410
EPIC® SENSORS
MADE IN FINLAND
www.lapp.fi



EESF 18 ATEX 052X, IECEx EESF 20.0034X
W-B-9K-EXD-400-G1/2-4-A-CB
Prod: xxxxxxxx S/N: 210131-1234567-1
II 2G Ex db IIC T6/T5 Gb
II 2D Ex tb IIIC T80/T95°C Db
0537





Manufacturer



Certificates
Product name

Product number	Serial number, date of production
Ex mark	Ex classification
CE mark	Issuer Nr
	Serial number as QR code

EAC Ex d approved sensors used in Eurasian economic zone have their own type plate version. Picture below will show this type plate:



Manufacturer
 Manufacturer's address
 Certificate number
 Product name
 Product number
 Ex classification

Serial number

EAC and Ex marking
 Serial number as QR code
 Date of production

Ex i approved sensor

Special conditions for safe use of Ex i approved sensor

ATEX and IECEx certificates have technical information and special conditions of use for Ex i products. Part of this information is the allowable ambient temperatures. Any information related, special conditions of use and calculus of self heating is presented in appendix: **Appendix A – Technical information and special conditions of use - Ex i certified EPIC® SENSORS temperature sensors.**

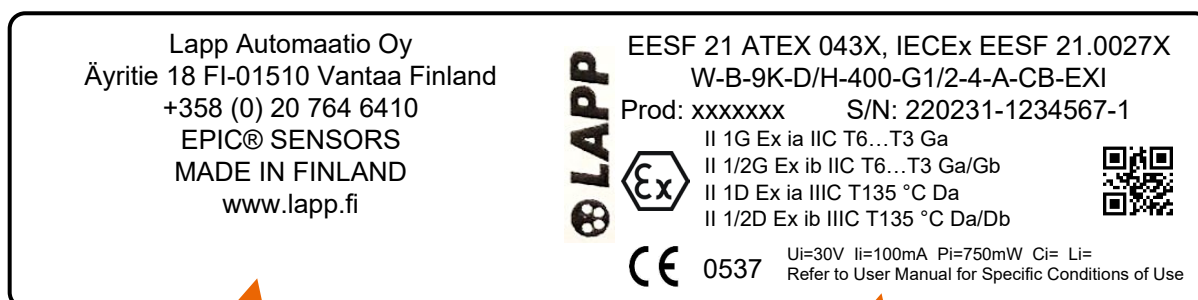
Note: Drawing of Ex i approved sensor is supplied with the product. This drawing is declaration of compatibility of the product according to the current ATEX and IECEx certificates and it will show the sensor structure. Changes to the sensor structure is not allowed. In some cases the drawing can include instructions on „how to correctly use the sensor“ and these instructions should not be ignored.

Ex i approval and Ex marking

Certificate	Issuer	Economic zone	Marking
ATEX EESF 21 ATEX 043X	Eurofins Electric & Electronics Finland Oy, Notified body (NANDO) Nr 0537	Europe	Ex II 1G Ex ia IIC T6...T3 Ga Ex II 1/2G Ex ib IIC T6...T3 Ga/Gb Ex II 1D Ex ia IIIC T135 °C Da Ex II 1/2D Ex ib IIIC T135 °C Da/Db
IECEx IECEx EESF 21.0027X	Eurofins Electric & Electronics Finland Oy, Notified body (NANDO) Nr 0537	Global	Ex ia IIC T6...T3 Ga Ex ib IIC T6...T3 Ga/Gb Ex ia IIIC T135 °C Da Ex ib IIIC T135 °C Da/Db

Type plate of Ex i approved sensor

ATEX and IECEx certified Ex i approved sensors have information on the type plate according to the complying classification. Picture below is an example of a type plate of Ex i approved sensor:



Manufacturer

Certificates
Product name

Product number

Serial number, date of production

Ex mark

Ex classification

CE mark

Issuer Nr

Serial number as QR code

Transportation, packaging and storage

Packaged goods can be transported in weatherproof closed containers on wheels, by rails, or by sea and air routes. Ambient temperature during the transportation should be between -20 ... +60 °C and relative air humidity in the package should be less than 80 %.

Package of goods must not be under pressure during the transportation and sudden stops or falls of movement during the loading and unloading must be avoided. Always attach the package during the transportation with suitable load bearing cargo straps.

Inspect the shipment of goods immediately upon receiving. Any breach and damage in the container and goods must be written to transporting courier's waybill. If seaworthy packaging is needed for transportation, please mention this to our sensor sales team. Products and packaging can be photographed and documented in prior sending the shipment.

Storage conditions: temperature between -20 ... +80 °C, relative humidity between 35 ... 85% (no condensing allowed).

Maintenance and cleaning

In general temperature sensors are maintenance free. In certain cases sensor can be transported to our premises for maintenance, repair or calibration. Note: Never use third party for repairs, only manufacturer has the „know how“ on how to repair. Unqualified repair work can lead to unit with safety issues.

Before sending the sensor, please remove any process residue. Use adequate safety gear during the cleaning. Fill maintenance letter found on our company webpage and put it into the same box of shipment as the sensor unit to be returned. Mention separately if the sensor unit has been in touch with dangerous or hazardous materials, like strong acidic or strong alkaline solutions. Use antistatic packing materials around the sensor unit. Sensors do need to be shipped to production and logistics address. Please find chapter „Manufacturer's addresses“.

Recycling and returns

Returns are accepted only if warranty conditions or other contract term allows.

Always consider the possible process residue in the sensor unit when recycling. Sensor units are processed as electronic and electrical equipment waste, but in case of hazardous process residue, please recycle the sensor unit as hazardous waste material. Use appropriate local waste disposal and recycling facility.

EU declaration of conformity

EU declaration of conformity can be submitted with the sensor unit. Sensor product specific certificates are available for download from company web page.

Manufacturer's addresses

Main office:

Lapp Automaatio Oy
 Street Äyritie 18
 Postal code, City 01510 Vantaa

Production and logistics: (address used for returns)

Lapp Automaatio Oy
 Street Varastokatu 10
 Postal code, City 05800 Hyvinkää

Tel. (sales) 020 764 6410

e-mail sales.fi.lav@lapp.com
 www <https://www.lapp.fi/>

Document version

Version / YYYYMMDD	Author(s)	Change description
20250801	TeMa	Update
20241007	VeTe	Specification of various technical information and updates of Ex product guides.
20230707	VeTe	Adding of Ex i and Ex d certified sensor unit grounding and other small changes.
20220822	JuPi	Phone number change
20220401	JuPi	Original

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We reserve the right to make changes to this document without further notice. © Lapp Automaatio Oy

Appendix A – Technical information and special conditions of use

- Ex i certified EPIC® SENSORS temperature sensors

Appendix A, page 1/4

Ex data for RTD (resistance) and TC (thermocouple) temperature sensors

Sensor Ex data, maximum permitted connection values, without transmitter and/or display.

Electrical values	for group IIC	for group IIIC
Voltage U_i	30 V	30 V
Current I_i	100 mA	100 mA
Power P_i	750 mW	550 mW @ $T_a +100\text{ °C}$
		650 mW @ $T_a +70\text{ °C}$
		750 mW @ $T_a +40\text{ °C}$
Capacitance C_i	Insignificant, *	Insignificant, *
Inductance L_i	Insignificant, *	Insignificant, *

Table 1. Sensor Ex data.

* For sensor with long cable, the parameters C_i and L_i must be included in the calculation.

Following values per meter can be used according to EN 60079-14:

$C_{\text{cable}} = 200\text{ pF/m}$ ja $L_{\text{cable}} = 1\text{ μH/m}$.

Allowed ambient temperatures - Ex i temperature class, without transmitter and/or display.

Marking, gas group IIC	Temperature class	Ambient temperature
II 1G Ex ia IIC T6 Ga II 1/2G Ex ib IIC T6-T3 Ga/Gb	T6	-40...+80 °C
II 1G Ex ia IIC T5 Ga II 1/2G Ex ib IIC T6-T3 Ga/Gb	T5	-40...+95 °C
II 1G Ex ia IIC T4-T3 Ga II 1/2G Ex ib IIC T6-T3 Ga/Gb	T4-T3	-40...+100 °C
Marking, dust group IIIC	Power P_i	Ambient temperature
II 1D Ex ia IIIC T135 °C Da II 1/2D Ex ib IIIC T135 °C Da/Db	750 mW	-40...+40 °C
II 1D Ex ia IIIC T135 °C Da II 1/2D Ex ib IIIC T135 °C Da/Db	650 mW	-40...+70 °C
II 1D Ex ia IIIC T135 °C Da II 1/2D Ex ib IIIC T135 °C Da/Db	550 mW	-40...+100 °C

Table 2. Ex i temperature classes and allowed ambient temperature ranges

Note!

The temperatures above are for sensors without cable glands.

The compatibility of cable glands must be according to the application specifications.

If the transmitter and/or display will be inside the transmitter housing, the specific Ex requirements of the transmitter and/or display installation must be noted.

The used materials must comply the needs of application, i. e. for the durability and the temperatures above.

For EPL Ga group IIC the aluminium parts in the connection heads are subjected to sparking by impacts or fiction.

For group IIIC the maximum input power P_i shall be observed.

When the sensor is mounted to boundary layer in between different zones, refer to IEC 60079-26 section 6 to ensure boundary layer is not compromised.

Appendix A – Technical information and special conditions of use

- Ex i certified EPIC® SENSORS temperature sensors

Appendix A, page 2/4

Considering sensor self-heating

Self-heating of the sensor tip shall be considered in respect with Temperature Classification and associated ambient temperature range, and manufacturer's instructions for calculating tip surface temperature according to thermal resistances stated in the instructions shall be observed.

Allowed ambient temperature range of sensor head or process connection for Groups IIC and IIIC with different temperature classes are listed in Table 2. For Group IIIC the maximum input power P_i shall be observed.

The process temperature shall not adversely affect ambient temperature range assigned for Temperature Classification.

Calculation of self-heating of the sensor tip or the thermowell tip

When the sensor tip is located in environment where the temperature is within T6...T3, it is needed to consider the self-heating of the sensor. Self-heating is of particularly significant when measuring low temperatures.

The self-heating at the sensor tip or thermowell tip depends on the sensor type (RTD/TC), the diameter of sensor and structure of sensor. It is also needed to consider the Ex i values for the transmitter. The table 3. shows the R_{th} values for different type of sensors structure.

	Thermal resistance R_{th} [°C / W]					
Sensor type	Resistance thermometer (RTD)			Thermocouple (TC)		
Measuring insert diameter	< 3 mm	3...<6 mm	6...8 mm	< 3 mm	3...<6 mm	6...8 mm
Without thermowell	350	250	100	100	25	10
With thermowell made from tube material (i.e. B-6K, B-9K, B-6, B-9, A-15, A-22, F-11, etc.)	185	140	55	50	13	5
With solid material thermowell (i.e. D-Dx, A-Ø-U)	65	50	20	20	5	1

Table 3. Thermal resistance based on Test report 211126

Note!

If the measuring device for RTD sensor is using measuring current > 1 mA, the maximum surface temperature of the sensor tip should be calculated and taken to account. Please see next page.

If sensor type has multiple sensing elements and those are used simultaneously, note that the maximum power for all sensing elements should not be more than the allowed total power P_i .

Maximum power must be limited to 750 mW. This must be guaranteed by process owner. (Not applicable for Multi-point temperature sensor types T-MP / W-MP or T-MPT / W-MPT with segregated Ex i circuits).

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Calculation of the maximum temperature:

The self-heating of the sensor tip can be calculated with the following formula:

$$T_{max} = P_o \times R_{th} + MT$$

- (T_{max}) = Maximum temperature = maximum temperature at the surface of the sensor tip
- (P_o) = Maximum operating power of the sensor (see the transmitter certificate)
- (R_{th}) = Thermal resistance (K/W, Taulukko 3.)
- (MT) = Temperature of the medium under measurement.

Calculation of the maximum permissible temperature at the tip of the sensor:

Example 1 – Calculation for RTD sensor tip with thermowell

Sensor is used in Zone 0

RTD sensor type: W-M-9K ... (RTD sensor with transmitter mounted).

Sensor with thermowell, thermowell diameter Ø 9 mm.

Temperature of medium under measurement (MT) is 120 °C

Components are PR electronics head mounted transmitter 5437D and isolated barrier PR 9106 B.

Maximum temperature (T_{max}) can be calculated by adding the temperature of the medium that you are measuring and the self-heating. The self-heating of the sensor tip can be calculated from the Maximum power (P_o) which is feeding the sensor and R_{th}-value of used sensor type. (See the Table 3.)

Supplied power by PR 5437 D is (P_o) = 23,3 mW (from the transmitter Ex-certificate)

Temperature class T4 (135 °C) must not be exceeded.

Thermal resistance (R_{th}) for the sensor is = 55 K/W (from Table 3).

Self-heating is 0.0233 W * 55 K/W = 1,28 K

Maximum temperature (T_{max}) is MT + self-heating: 120 °C + 1,28 °C = 121,28 °C

The result in this example shows that, the self-heating at the sensor tip is insignificant.

The safety margin for (T₆ to T₃) is 5 °C and that must be subtracted from 135 °C; this means that temperature of sensor tip up to 130 °C, with self-heating included, would be acceptable. In this example the temperature of class T4 is not exceeded.

Example 2 – Calculation for RTD sensor tip without the thermowell

Sensor is used in Zone 1

RTD sensor type: W-M-6/303 ... (RTD sensor with cable, no transmitter mounted)

Sensor without thermowell, diameter of measuring tip/element Ø 6 mm.

Temperature of medium under measurement (MT) is 40 °C

Components are PR electronics isolated barrier/transmitter PR 9113 D.

Maximum temperature (T_{max}) can be calculated by adding the temperature of the medium that you are measuring and the self-heating. The self-heating of the sensor tip can be calculated from the Maximum power (P_o) which is feeding the sensor and R_{th}-value of used sensor type. (See the Table 3.)

Supplied power by PR 9113D is (P_o) = 40,0 mW (from the transmitter Ex-certificate)

Temperature class T3 (200 °C) must not be exceeded.

Thermal resistance (R_{th}) for the sensor is = 100 K/W (from Table 3).

Self-heating is 0.040 W * 100 K/W = 4,00 K

Maximum temperature (T_{max}) is MT + self-heating: 40 °C + 4,00 °C = 44,00 °C

The result in this example shows that, the self-heating at the sensor tip is insignificant.

The safety margin for (T₆ to T₃) is 5 °C and that must be subtracted from 200 °C; this means that temperature of sensor tip up to 195 °C, with self-heating included, would be acceptable. In this example the temperature of class T3 is not exceeded.

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Additional information for Group II devices: (according to EN IEC 60079-0: 2019 section: 5.3.2.2 and 26.5.1)

Temperature class for T3 = 200 °C

Temperature class for T4 = 135 °C

Safety margin for T3 to T6 = 5 K

Safety margin for T1 to T2 = 10 K.

Note!

This Appendix A is an instructional document on specifications.

For original regulatory data on specific conditions, always refer to ATEX and IECEx certificates:

EESF 21 ATEX 043X
IECEx EESF 21.0027X