ISTRUCTION MANUAL
Thermocouples & Thermoresistances

1. GENERAL INFORMATIONS

Temperatures probes described in this manual are made following the technical state of the art.
This instruction manual contains important information about the use of the instrument.
Follow this safety and operability instructions to operate in safe conditions.
Observe the local risk prevention regulations and general safety rules for the operating field of the instrument.
This manual must be accurately read by qualified personnel before any operation.

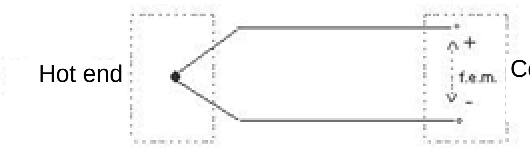
2. OPERATIONG AND FUNCTIONS

These thermocouples and thermoresistances are used for temperature measurement in industrial applications.
This manual describes standard version instruments. For dangerous areas applications special instruments are required.
This instrument has been designed and fabricated only for his intended use and it must be used only for this.

3. THERMOCOUPLES

3.1 DESCRIPTION

Thermocouples are made by two different homogeneous metal conductors isolated throughout their length.
The two elements are joined at one end (hot end) and connected to a measuring circuit at the other end (cold end).
The temperature difference between the hot and cold end creates a variable electromotive force in function of temperature and the conductors' type.



Between -200 and 1700 °C thermocouples allow obtaining precise and reliable measures depending on the type of thermocouple used.
The thermocouple type depends on the metals used as conductor, and they are resumed in the following table.

Symbol	Material	Operating temperatures (°C)	Description
K	Chromel / Alumel	0 - 1250	Thermocouple made of nickel alloy suitable for high temperature measurement in oxidizing environments. Not suitable for reducing environments.
J	Iron / Constantan	0 - 750	Suitable for medium temperatures in reducing environments in presence of hydrogen and coal. The iron presence makes it not suitable for oxidizing environments.
T	Copper / Constantan	-200 - 350	Thermocouple that allows accurate measures at low temperatures in oxidizing and reducing environments.
E	Chromel / Constantan	0 - 870	Thermocouple suitable for oxidizing environments.
S	Pt / Pt Rh 10%	0 - 1450	Thermocouple made of noble metals (platinum and rhodium) that allows very accurate measures. Especially resistant at high temperatures is usually used in oxidizing environments. Not suitable for reducing environments or containing metallic vapors.
R	Pt / Pt Rh 13%	0 - 1450	Like the S type thermocouple but with different percentage of the two metals.
B	Pt 30% Rh / Pt 6% Rh	0 - 1700	Thermocouple made of noble metals. The higher percentage of rhodium than the S and B types makes it more resistant at high temperatures and mechanical stresses.

N	Nicrosil / Nisil	0 - 1300	Alternative to the K type thermocouple in terms of accuracy and reproducibility.
W3	W3%Re / W25%Re	0 - 2310	Thermocouple for very high temperatures made of a positive pole in tungsten containing 3% rhenium and a negative pole in tungsten containing 25% rhenium. Especially resistant to reducing environments and with presence of hydrogen or other inert gases. Not suitable for use with air or other oxidizing environments.
W5	W5%Re / W26%Re	0 - 2310	Like thermocouple W3 but the different percentage of rhenium makes increase its mechanical resistance.

3.2 TOLERANCES AND APLICATION LIMITS

Officine Orobiche produce in conformity to:

- UNI 7938
- ANSI MC96
- IEC 584

Error limits according to IEC 584

Type of thermocouple	*Application field (°C)*	*Special Calibration Grade I*	*Standard Calibration Grade II*
K	0 - 1250	± 1,1 °C o ± 0,4% rdg	± 2,2 °C o ± 0,75% rdg
J	0 - 750	± 1,1 °C o ± 0,4% rdg	± 2,2 °C o ± 0,75% rdg
T	-200 - 350	± 0,5 °C o ± 0,4% rdg	± 1,0 °C o ± 0,75% rdg
E	0 - 900	± 1,0 °C o ± 0,4% rdg	± 1,7 °C o ± 0,50% rdg
S	0 - 1480	± 0,6 °C o ± 0,1% rdg	± 1,5 °C o ± 0,25% rdg
R	0 - 1760	± 0,6 °C o ± 0,1% rdg	± 1,5 °C o ± 0,25% rdg
B	760 - 1820		± 0,50% rdg
N	0 - 1300	± 1,1 °C o ± 0,4% rdg	± 2,2 °C o ± 0,75% rdg

For the calibration table of different thermocouples see the appendix.

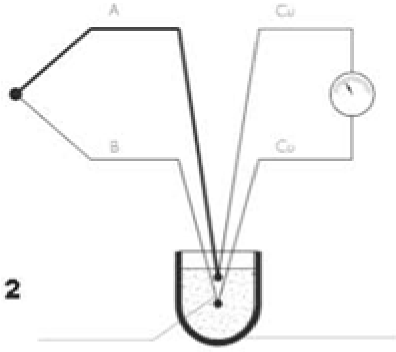
3.3 MEASUREMENT METHODS

The most used measurement method is the one shown in the picture below, it usually used in industrial fields where great accuracy is not needed.

1a **1b**

In this case the thermocouple is connected directly (1a) or by extension cables (1b) to the measuring instrument. In this case, the compensation of the measurement end is directly made by the measuring instrument that, detecting the temperature of the pole using other sensors electronically change the thermocouple signal so that the measure depends only by the temperature of the hot end.

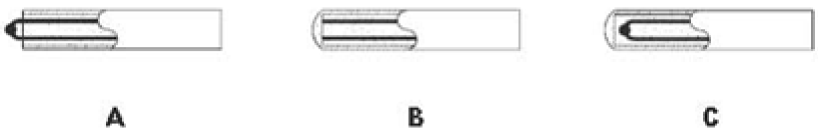
The system shown in Fig. 2 allows obtaining very accurate measures and for this reason, it is used exclusively in laboratory applications.



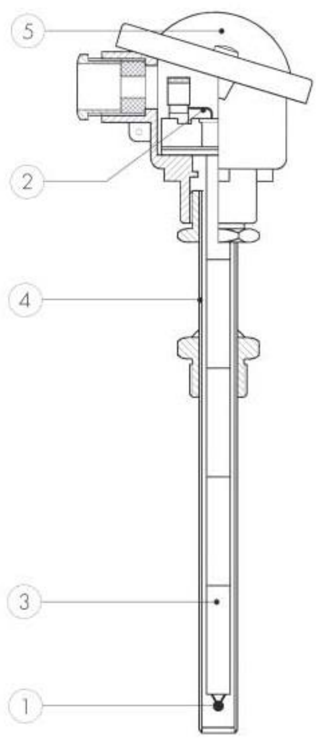
In this case, the temperature of the cold end is kept at a known and constant temperature (usually ice melting point 0°C) by manual or automatic methods in order to compensate the electromotive force detected by the measuring instrument with the one of the hot end.

3.4 TYPES OF JUNCTIONS

For this type of thermocouples are usually used these types of junctions:



A. **Hot junction exposed**
   It has a reduced time of response because the hot end is in contact with the environment to be measured. It is not suitable for the use because it lacks of protections by corrosive agents or mechanical damages.
B. **Hot junction grounded**
   The hot end is part of the protection jacket so the time of response is reduced. Suitable for high pressures.
C. **Hot junction isolated**
   The hot end is completely isolated by the protection jacket. It is suitable when electrical disturbs can alter the measure. The time of response is higher than the previous cases.



3.5 CONSTRUCTION TYPES

Thermocouples are usually divided in two categories

1. Thermocouple with thermoelement with traditional insulation.
2. Thermocouple with thermoelement with mineral insulation.

Traditional insulation thermocouples

Traditional insulation is made by ceramic insulators of various composition and percentage, with variable dimensions in function temperatures and applications.
It comprises:

1. Measuring junction
   The measuring junction or hot end is the zone where the two conductors of the thermocouple joint together. It can be considered point-like because of his small size. This junction must not present mechanical tensions on the conductors (especially for noble metals thermocouples) because it can compromise the thermocouple correct working at operating temperature.

2. Thermocouple wires
   Thermocouple wires have to be of proper size according to the operating conditions; it is possible to insert in the same probe two or more thermocouples.

3. Ceramic insulators
   Ceramic insulators are used to insulate the thermocouple wires, between them and the external jacket, along the entire probe length.

4. Protection jacket
   Protection jacket protects the thermocouple wires. It is important that it has the correct size and material because it is in contact with the process. It is usually metallic but with high temperatures, it can be ceramic. In particular applications thermowell is needed as an additional protection.

5. Connection head
   Connection head contains an additional terminal block in insulating material (usually ceramic) that allows the electrical connection of the thermocouple. For particular applications it is possible to use explosion-proof housing. Instead of the terminal block, it is possible to install a converter 4-20 mA output.

Mineral insulation MgO thermocouples
In mineral oxide insulation thermocouples conductors are isolated by a mineral dust (MgO), highly compressed and inserted in a metallic protection jacket (AISI 304, 316, 321, 347, 310, 446, Inconel 600, etc.). The high compression allows the exclusion of air from the jacket ensuring high thermic conductibility and dielectric strength.

The main characteristics of this type of thermocouples are:

- High mechanical resistance.
- Resistance to high temperatures.
- Protection against moisture and high pressures.
- Easy to install because the flexible cable can make short radius curves and adapt to any shape.
- High speed of response.

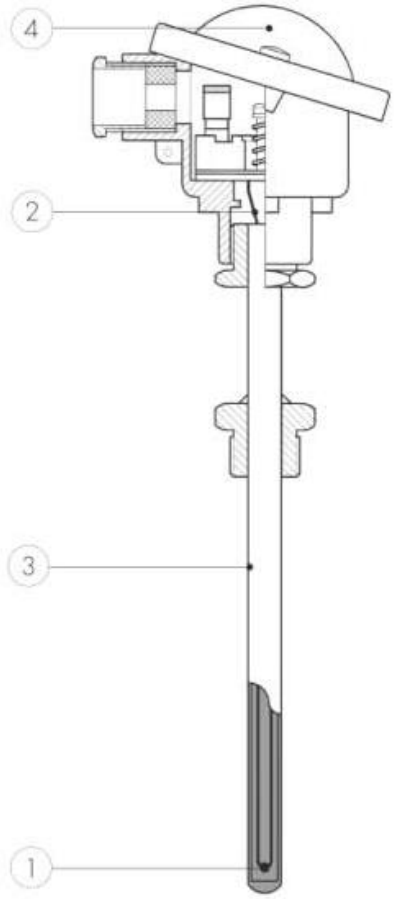
It comprises:

1. Measuring junction
   The two conductors are joint together inside the mineral oxide insulated cable using particular techniques before closing it. The measuring junction can be isolated, grounded or exposed (see table).

2. Thermocouple wires
   Inside the mineral oxide isolated cable there are two, four or six wires; so the thermocouple can be simple, double or triple.

3. Mineral insulating jacket
   It is made of a metallic jacket containing the conductors insulated between them and the jacket using highly compressed pure metallic oxides; standard insulator is magnesium oxide MgO.

4. Connection head
   Connection head contains a terminal block in insulating material (usually ceramic) that allows the electrical connection of the thermocouple, it is possible to use explosion-proof housing. Instead of the terminal block it is possible to install a converter 4-20 mA output.



3.6 MEASURE ERROR CAUSES

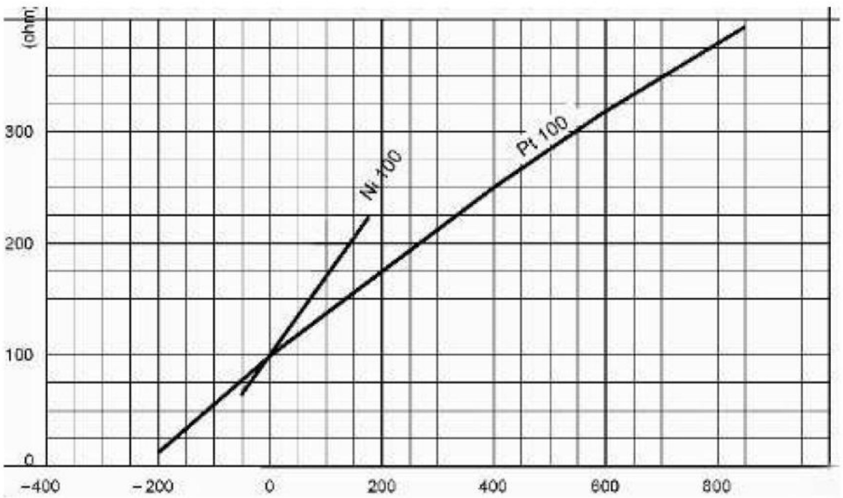
The principal error causes of the temperature measure with thermocouple are:

- The thermocouple is connected to the measuring instrument by a non suitable wire.
  All the connection between the thermocouple and the measuring instruments have to be made with fully compensated cables, the type and size of insulating depends by the operative conditions (see cables part).
- Reverse polarity in connections.
  All compensating or extension cables for thermocouples are colored so that it identify the type of thermocouple and his polarity. It's important pay attention to not reverse the polarity in the connections. It's a good practice, in connections between thermocouples and measuring instruments, making fewer connections as possible and using devices with compensated contacts that prevent reversing the polarity.
- Parasite electromotive forces.
  While using thermocouples with grounded measuring junction it's possible that some parasite electromotive forces are introduced between the thermocouple and the measuring instrument disturbing the thermocouple mV signal. In this case it's necessary using isolated junction thermocouples.
- Wrong compensation of the cold junction:
  Reference junction needs to be compensated; it's important that it's properly made by the measuring instrument.

4. THERMORESISTANCES

4.1 DESCRIPTION

The working principle of thermoresistances is the variation of electrical resistance of a metal in function of his temperature. In industrial field the most common metals are platinum and nickel that, with their high resistivity and stability, allows the creation of small size, reproducible thermoelements with great mechanical characteristics. Thermoresistance measures are more accurate and reliable than other probes as thermocouples and thermistors. Thermoresistances are usually identified by the symbol of the material used in the fabrication (Pt=platinum, Ni=nickel, etc.) followed by the nominal resistance at 0°C. The application field of industrial thermoresistances is between -200 and +850 °C as shown in table.



Platinum and nickel are used because they provide a linear function resistance / temperature.

The advantages of thermoresistances over thermocouples are:

- High value Resistance / °C of the output signal.
- Low sensibility to external noise signal.
- Better accuracy

Most of the thermoresistances have a resistance of 100 ohm at 0°C. Officine Orobiche can supply probes with different resistances for specific applications. Most commonly used values are 100, 500 and 1000 ohm.

Type of Thermoresistance	***Symbol***	***Application field (°C)***
Platinum	Pt 100 ohm	-200 - 850 °C
Nickel	Ni 100 ohm	-60 - 180 °C

4.2 STANDARD TOLERANCE

Officine Orobiche, produce in conformity to:

- UNI 7937
- DIN 43760
- IEC 751

There are 5 classes of accuracy:

Class B - Class A - Class 1/3B - Class 1/5B - Class 1/10B

Regulations require that for any temperature measured it's possible to calculate the maximum and minimum values that the instrument doesn't have to overcome to be considered in tolerance. With the following formulas it's possible to calculate the absolute error for every measured temperature.

B class error	±(0.30+0.005|T|)
A class error	±(0.15+0.002|T|)
1/3B class error	±(0.10+0.0016|T|)
1/5B class error	±(0.06+0.0010|T|)
1/10B class error	±(0.03+0.0005|T|)

|T| is the absolute value of the temperature in °C

Example: if we measure 125°C with a A class sensor, the maximum error is ± (0.15+0.002|125|) = ± 0.4 °C

The following table shows the error values in °C and ohm, for some temperature for the five classes of accuracy.

temp. [°C]	classe B		classe A		classe 1/3B		classe 1/5B		classe 1/10B	
	°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm
-200	1,3	0,56	0,55	0,24	0,42	0,16	0,26	0,10	0,13	0,05
-100	0,8	0,32	0,35	0,14	0,26	0,10	0,16	0,06	0,08	0,03
0	0,3	0,12	0,15	0,06	0,10	0,04	0,06	0,02	0,03	0,01
100	0,8	0,3	0,35	0,13	0,26	0,10	0,16	0,06	0,08	0,03
200	1,3	0,48	0,55	0,20	0,42	0,16	0,26	0,10	0,13	0,05
300	1,8	0,64	0,75	0,27	0,58	0,22	0,36	0,14	0,18	0,07
400	2,3	0,79	0,95	0,33	0,74	0,29	0,46	0,18	0,23	0,09
500	2,8	0,93	1,15	0,38	0,90	0,35	0,56	0,21	0,28	0,11
600	3,3	1,06	1,35	0,43	1,06	0,41	0,66	0,25	0,33	0,13
650	3,6	1,13	1,45	0,46	1,14	0,44	0,71	0,27	0,36	0,14

4.3 TYPE OF SENSORS

There are three types of platinum thermometers in relation to constructive technique adopted:

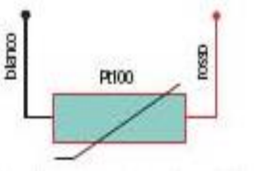
1. Ceramic (T max. 750 °C)
   A filament of platinum is coiled and encapsulated in a ceramic material shell. It is used in the fabrication of high accuracy thermometers or with high temperatures.

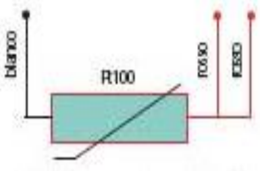
2. Glass (T max. 600 °C)
   A platinum filament is wrapped on a glass support, and then encapsulated in an external protective sleeve made of glass. It's used in fields where are necessary great accuracy and reproducibility (sample thermometers).

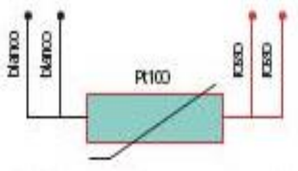
3. Thin film (T max. 450 °C)
   A platinum microfilm is deposited on a ceramic support, then a laser technology create an electrical circuit with the correct electrical resistance.

4.4 CONNECTIONS AND MESURING METHODS

There are different methods to connect the thermoresistances to the measuring units, the choice depends on the accuracy needed







Two wires connection | Three wires connection | Four wired connection

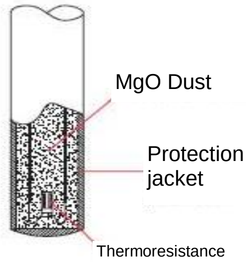
EFFECT OF THE CONDUCTORS ON THE THERMORESISTANCE ACCURACY

In the two-cable connection, the resistance in the extension cable between the thermoresistance and the controlling instrument is summed because the thermoresistance is a type of resistive sensor. This summed resistance isn't constant, because the conductor material change with the variation of the ambient temperature. This error can be fixed using a 3 wires or a 4 wires system. These solutions allows to quantify the resistance due to the single extension cables obtaining the correct measure of the value of the temperature.

- 2 WIRES TECHNIQUE
  It's the less accurate solution because the error introduced by the connecting cable length (line resistance) can't be compensated in any way by the measuring system. In industrial field, its use is limited to applications where the precision needed is very low. It's good practice don't use this solution even in generic applications.

- 3 WIRES TECHNIQUE
  Most of the industrial applications use this technique because it's the best compromise between cost and performance. The three wires connection allows to fix the error due to the line resistance because the measure of the voltage drop is performed independently.

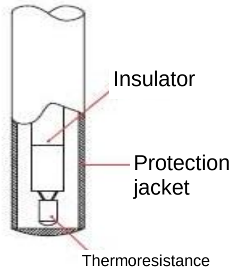
- 4 WIRES TECHNIQUE
  It allows the higher accuracy, it's used in laboratory measures or where is needed a great reliability (primary or secondary sample thermometers).



4.5 CONSTRUCTION TYPES

There are two categories like for the thermocouples.

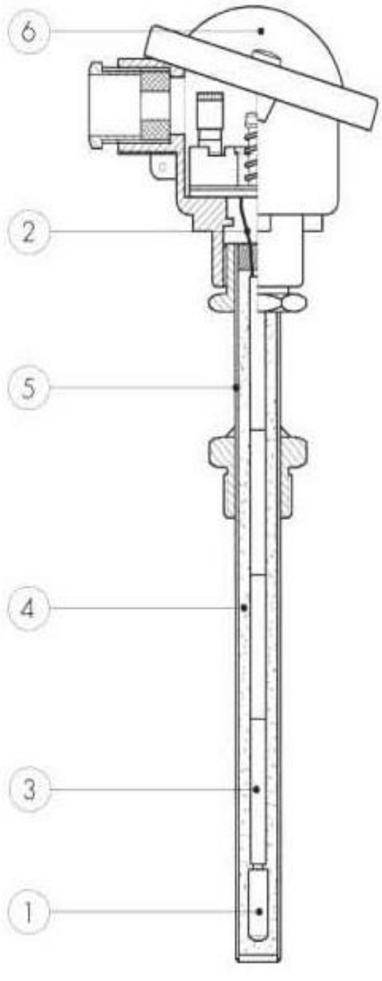
1. With mineral insulation
   Using insulated cables in magnesium oxide, made of an external metal jacket. Inside the jacket there are the conductors, isolated between them and the external jacket with compressed MgO dust. With this system is possible to obtain probes with higher resistance to impacts and vibrations more performing than the one build in the classic method. They can be bent to adapt to housing with tortuous paths. Response speed and durability are other typical characteristics of these probes.



2. With calibrated wires and insulators
   The wires are isolated by a rigid external jacket using ceramic insulators. The external jacket has to properly protect the conductors from gases or corrosive agents that can be present in the measuring environment. It's important to choose, in function of the application, conductors of proper type and diameter. It's possible to use insulator in ceramic or in fiberglass in function of the maximum operating temperature.

Traditionally insulated thermoresistances

Traditionally insulated thermoresistances are made of:



1. Sensitive element
   Sensitive element is the most important part of the instrument, a low quality sensitive element compromise the correct operating of the whole sensor. It is connected with connection wires and then put in the protection jacket. It's available with different accuracy or with double coil.

2. Connection wires
   The connection of the sensitive element can be made with 2, 3, or 4 wires. The wire material depends on the operating conditions of the probe.

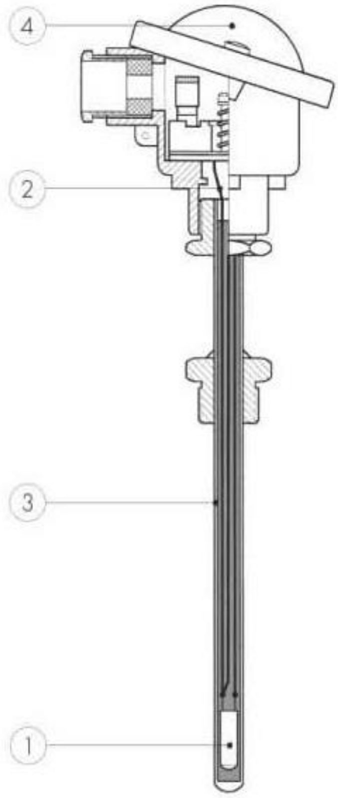
3. Ceramic insulators
   Ceramic insulators prevent short-circuits and thy insulate the connection wires from the protection jacket

4. Filler
   Filler is composed by alumina fine dust, dried and vibrated, that fills any gap protecting the sensor from vibrations

5. Protection jacket
   Protection jacket protects the sensitive element and the connection wires. It's important that it has the proper material and size because it's at direct contact with the process. In particular applications thermowell is needed as an additional protection.

6. Connection head
   Connection head contains a terminal block in insulating material (usually ceramic) that allows the electrical connection of the thermocouple, it's possible to use explosion-proof housing. Instead of the terminal block it is possible to install a converter 4-20 mA output.

Mineral insulation MgO thermoresistances
This technology allows to fabricate high performance thermoresistances with high mechanical characteristics. The main different properties compared to the original type are the ability to bend the jacket with small radius of curvature, the ability to weld the jacket during the installation and the ability to fabricate long probes.
Mineral insulation MgO thermoresistances are made of:



1. Sensitive element
   Using special techniques the sensitive element is connected to the insulated cable in mineral oxide. If needed it’s possible to use double sensitive elements and/or with different accuracy.

2. Connection wires
   The connection of the sensitive element can be made with 2, 3, or 4 wires.

3. Mineral insulation jacket
   It’s composed by an external metallic jacket and inside there are the conductors insulated between them and the jacket using highly compressed pure metallic oxides. Standard insulator is magnesium oxide MgO.

4. Connection head
   Connection head contains a terminal block in insulating material (usually ceramic) that allows the electrical connection of the thermocouple, it’s possible to use explosion-proof housing. Instead of the terminal block it is possible to install a converter 4-20 mA output.

4.6 MEASURE ERROR CAUSES
Thermoresistance measurement is simpler than other type of sensors. The main thermoresistance measure error causes are three:

1. SENSITIVE ELEMENT SELF-HEATING
   A high current value passing through the sensitive element can increase the temperature during the measuring by Joule effect. The increasing temperature depends by the type of sensitive element used and the measurement conditions. The same thermoresistance, at same temperature, will self-heat less in water than in air because the water dissipation factor is higher than the air one.
   Usually all measuring instruments using thermoresistances don’t have a high measuring current but it’s good practice don’t exceed 1 mA (IEC 751).

2. INSUFFICIENT ELECTRICAL INSULATION OF THE SENSITIVE ELEMENT
   To obtain a good measure it’s important to have a high electrical insulation between the conductors and the external jacket, especially at high temperatures. The insulation resistance can be seen as an electrical resistance in parallel with the sensitive element ones: at constant temperature, if the electrical insulation decrease, the tension at the end of the sensitive elements will decrease, introducing an error in the measure. The insulation resistance can decrease if used with too high temperatures, strong vibrations or under the influence of physical or chemical agents.

3. INSUFFICIENT IMMERSION DEPTH OF THE SENSITIVE ELEMENT
   It’s important to have a good immersion depth of the sensitive element because, in contrast to the point-like measure of the thermocouples, if not appropriate it can introduce several °C of error in the measure. That’s because of the jacket, usually metallic, that protects the sensitive element dissipates heat proportionally to the temperature difference between the hot and the cold zone, creating a temperature gradient over part of the length of the jacket. The immersion depth have to be suitable to avoid this thermal gradient. The minimal depth depends by the measuring physical conditions and the thermoresistance size (element length, etc.).

5. SAFETY

5.1 INTENDED USE

The probes described are suitable for the temperature measurement in industrial applications. Depending on the execution the temperature probes can be mounted directly on the process or on the thermowell. The thermowell execution have to consider the operative process data (temperature, pressure, density and flow).
Reparation and alterations are not allowed and they will nullify the validity of the guarantee and the respective certification. The manufacturer isn't responsible for constructive modifications after the supply of the instruments. The instrument was designed and made exclusively for his intended use and can be used only for this. The technical specification in this manual must be respected. Constructor isn't responsible for any complaint of any nature in case of using the instrument outside his intended use.

5.2 OPERATOR RESPONSIBILITY

The operator is responsible for the selection of the probe and his materials, to ensure this safe operation in the plant or in the machine. While preparing a quotation, Officine Orobiche can only give suggestions that are based on his experience in similar applications. Safety instructions inside this operation manual must be respected like safety, incidents prevention and the environmental protection rules. The operator must ensure that the nameplate is always visible.

5.3 PERSONELL QUALIFICATION

PERSONNEL QUALIFIED FOR ELECTRIC PART

The personnel qualified for electric part is the personnel that, based on his training technical courses, technical knowledge of instrumentation and control of national regulations and based on his experience can work on electric parts and recognize any possible danger. Electric part qualified personnel have to be specifically trained for the working environment and to know the relative regulations and national standards. Electric part qualified personnel have to comply to national regulations for prevention of accidents at work.

OPERATING PERSONNEL

The personnel trained by the operator is the personnel that, based on his training, knowledge and experience, is able to do the described work and independently recognize any possible danger. Any possible special operative condition require also specific knowledge, ex. Aggressive fluids.

6. TRANSPORT, PACKAGING AND STORAGE

6.1 TRANSPORT

Ensure that the instrument was not damaged during the transport. Evident damages must be immediately reported.

GAMAGE CAUSED BY INAPPRPRIATE TRANSPORT

The instrument can be seriously damaged by inappropriate transport. When packaged goods are unloaded during delivery, like during the whole transport, proceed with caution and respect the symbols on the packaging.
If the instrument is moved from a cold to an hot environment, condensate can be formed and cause an instrument malfunctioning. Before activating the instrument, wait for the instrument's temperature match the air temperature.

6.1 PACKING AND STORAGE

Remove the packing only right before the installation.

STORAGE CONDITIONS

Storage temperature:

- Probes without incorporated transmitter: -40 / +80 °C
- Probes without incorporated transmitter: see the relative transmitter instruction manual.

AVOID THE EXPOSURE TO THESE FACTORS

- Direct exposure to sunlight or proximity to hot objects.
- Vibrations and mechanical shocks (vigorously put down the instrument).

- Soot, vapors, dust and corrosive gases.
- Dangerous environments, flammable atmosphere

Keep the instrument in his original packaging in a place respecting the conditions above. If the original packaging is not available, pack and preserve the instrument following these indications:
- Place the instrument in a box with shock-absorbing material.
- If the instrument needs to be preserved for long times (more than 30 days), include a packet of moisture protection gel.

7. START-UP

7.1 MECHANICHAL MOUNTING

MULTIPOINT ASSEMBLIES
They are usually provided with a housing with mounted inside transmitters and terminal blocks. Digital displays/transmitters are mechanically fixed (ex. Guide system in the housing or support in the connection head).

CABLE PROBES
These are usually not provided with housing. However, they can be connected in an additional housing inside which transmitters and terminal blocks are mounted.

STRAIGHT THREADS
If connection head, extension tube, thermowell or process connection are connected with straight threads (ex. G ½, M20 x 1.5 etc.), they have to be fixed using gaskets that avoid liquids from leak into the probes.

TAPERED THREADS
With NPT or other tapered threads, it is necessary, if they need to settle them with PTFE or canvas tape. Threads have to be lubricate with a suitable lubricant before mounting.

ELECTRICAL MOUNTING
If using a digital transmitter/display (optional): follow the contents in the digital transmitter/display operative manual (see scope of supply).

CABLE GLANDS
Requirement to achieve the protection class:
- Only use cable glands inside the indicated tightening torque (cable diameter suitable for the cable gland).
- Do not use lower tightening area with soft cables.
- Only use circular section cables (if needed, slightly oval).
- Do not twist the cable.
- It is possible to open and close repeatedly the cable gland but only if needed because it would affect negatively on protection class.
- For cables with a strong “cold-flow” behavior, the screw connection have to be fully closed.

8. MANTEINANCE AND CLEANING

8.1 MANTEINANCE

The describe temperature probes are free form maintenance. Reparations have to be done only by the constructor.

8.2 CLEANING

PHYSICAL INJURIES AND DAMAGES TO PROPERTIES AND THE ENVIRONMENT
An improper cleaning can cause physical injuries and damages to properties and the environment. Process fluid residues in disassembled instruments can cause risks to people, environment and instrumentation.
Cleaning have to be done as follows:
1. Before cleaning, properly disconnect the instrument.
2. Use the protective equipment needed (depending on the application: the thermometer itself is not dangerous).

3. Clean the instrument with a moist clot. Especially the probes with a plastic housing and cable probes with plastic insulation cable, to avoid any risk of electrostatic charge. Electrical connection must not be in contact with the moisture!

DAMAGES TO THE INSTRUMENT
An improper cleaning can damage the instrument:
- Do not use harsh detergents.
- Do not use hard or sharp objects for cleaning.

To protect people and properties from the exposure with residual fluids, clean the instrument only if disassembled.

CALIBRATION AND RECALIBRATION
It is recommended to delay the measure insertion at regular intervals (thermoresistances: ca. 24 month, thermocouples: ca. 12 months). This period can be reduces based on the application. Calibration can be made by the constructor or on the spot by technical personnel equipped with calibration devices.

9. DISMOUNTING

9.1 PHYSICAL INJURIES AND DAMAGES TO PROPERTIES AND ENVIRONMENT CAUSED BY RESIDUAL FLUIDS
The contact with dangerous fluids (), hazardous fluids (), and refrigeration plants and compressors, can cause physical injuries and damages to properties and environment.
- Before storage, clean the disassembled instrument (after the use), to protect people and environment from the exposition to residual fluids.
- Use the protective equipment needed (depending on the application: the thermometer itself is not dangerous).
- Respect the information in the safety data sheet for the corresponding fluid.

Disconnect the probe only when the system is depressurized.

9.2 RISK OF BURNS
During the disassembling, there is the risk of leak of dangerously hot fluids. Let the instrument cool enough before the disassembling.