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Technical Information
iTHERM ProfileSens TS901

Patented multipoint temperature cable probe for oil & gas and petrochemical applications. To be used as measurement insert in multipoint assemblies such as MultiSens Flex TMS0x.

Application

- Cable probe with multiple measurement points for temperature profiling in reactors and vessels
- Specifically designed for heavy duty applications in oil & gas and petrochemical industries
- Measuring range: −40 to 920 °C (−40 to 1 688 °F), depending on thermocouple type and conditions
- Static pressure range: Up to 400 bar (5 800 psi)
- Minimum degree of protection: IP65

Your benefits

- Fewer process connections required (nozzles)
- Up to 4 individual thermocouples, single or duplex, in one single probe
- Long operative life time guaranteed also in aggressive media
- Time and thus cost saving during installation and maintenance operations (simpler and faster installation)

Unique on the market:

- Extremely high reliability due to complete independency of the different measuring points
- High robustness thanks to double metal sheathing technology

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Function and system design

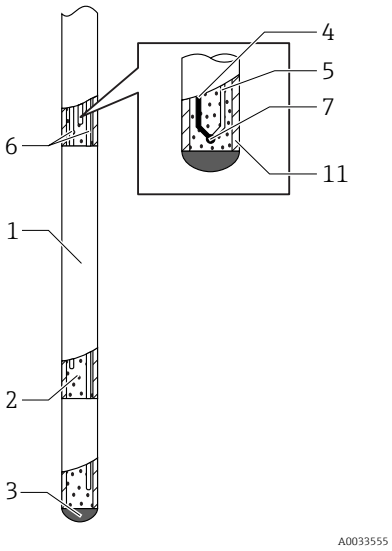
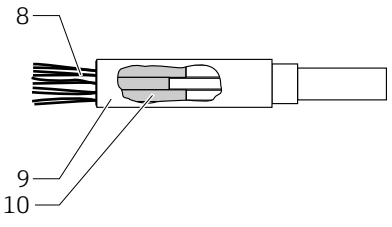
Measuring principle

Thermocouples (TC)

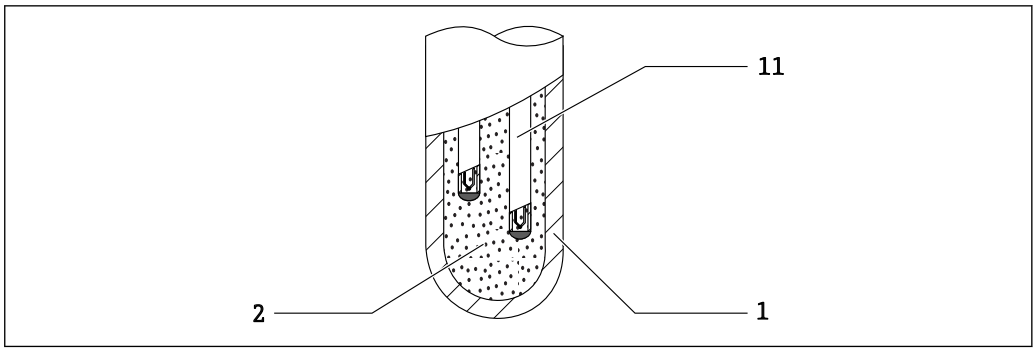
Thermocouples are comparatively simple, robust temperature sensors which use the Seebeck effect for temperature measurement: if two electrical conductors made of different materials are connected at a point, a weak electrical voltage can be measured between the two open conductor ends if the conductors are subjected to a thermal gradient. This voltage is called thermoelectric voltage or electromotive force (emf). Its magnitude depends on the type of conducting materials and the temperature difference between the "measuring point" (the junction of the two conductors) and the "cold junction" (the open conductor ends). Accordingly, thermocouples primarily only measure differences in temperature. The absolute temperature at the measuring point can be determined from these if the associated temperature at the cold junction is known or is measured separately and compensated for. The material combinations and associated thermoelectric voltage/temperature characteristics of the most common types of thermocouple are standardized in the IEC 60584 and ASTM E230/ANSI MC96.1 standard.

Equipment architecture

The TS901 is a double metal-sheathed mineral insulated cable (MI cable) with multiple independent MI insulated thermocouples (TC) already provided with extension cables as electrical terminals.

Design		Available options
	(1) Outer sheath (2) MgO powder (3) Tip closure	External sheath material: ▪ AISI 316L ▪ AISI 321 ▪ Inconel 600 Outer probe diameter OD: ▪ 8 mm (0.31 in) ▪ 9.5 mm (0.37 in) External sheath thickness T: ▪ Standard wall (SW) ▪ Heavy wall (HW) Note: SW=min 10% of OD (single wall) Note: HW=min 15% of OD (single wall)
	(4-5) TC legs (6) Sheathed TC cable (7) Hot junction (11) TC metal sheath	**Number of sensors:** From 2 to 4 independent thermocouples. **Selectable TC type (single or duplex):** ▪ K ▪ N ▪ Others on request According to IEC or ANSI/ASTM standards. Insulation with Magnesium Oxide (high purity).
	(8) Extension cables (9) Main sleeve (10) Inserts' cold junctions	Main sleeve containing individual seal pots, all filled with epoxy resin (max T=150°C) for insulating and protecting cold junctions. Extension cables according to IEC or ANSI/ASTM standard color codes.

Detail of the last two measuring points:



1 1st metal sheath barrier (probe outer sheath)
2 MgO high purity compacted powder (~80%)
11 2nd metal sheath barrier (sheath of individual TC cable)

The probe is composed of the following parts:
- Individual TC cables (6): composed of metal-sheathed TC cables, already provided with seal pot and extension cables
- Main sleeve (9): sealing pot containing all the single TC sleeves and insulating resin
- MgO Powder filling (2): each insert is kept in position by means of high purity MgO powder with a proper compaction density (>80%)
- Outer sheath (1): additional mechanical external protection made of Stainless steel or Nickel alloys.

Allowing the following features:
- Many measuring points are embedded in a sheath
- Two independent barriers (1+11) to protect the TC legs (4+5)
- High overall mechanical robustness and flexibility
- Complete independency of each measuring point in case of external-sheath failure

The space between each TC insert is filled with compacted Magnesium Oxide powder, offering the following advantages:
- Increase of the probe bendability
- Increase of vibration resistance
- Increase of overall mechanical robustness
- Increase of overall electrical insulation
- Prevention of any fluid flow inside the probe in case of external-sheath failure

Input

Measured variable

Millivolt (linearization to °C/°F)

Measuring range

Lower and upper temperature limits

The table below gives recommendations for the minimum and maximum temperatures at which mineral insulated metal-sheathed thermocouple (TC) should be used, continuously in non-circulating air.

Input	Designation	Recommended measuring range limits
Mineral insulated metal-sheathed (Inconel600) TC – flying leads – as per IEC60584 and ASTM E230	Type K (NiCr–Ni)	–210 to 920 °C (–346 to 1 688 °F)
	Type N (NiCrSI-NiSi)	–210 to 920 °C (–346 to 1 688 °F)

Output

Output signal

The measured value can be transmitted in one of the following ways:
- Directly-wired sensors: measured values forwarded without a transmitter.
- Via all common protocols by selecting an appropriate Endress+Hauser iTEMP temperature transmitter, e.g. in the junction box of the multipoint assembly (see below).

Swift and easy operation, visualization and maintenance using a PC directly from the control panel, e. g. using operating software, Endress+Hauser FieldCare, Simatic PDM or AMS. For more information, see the relative Technical Information.

Family of temperature transmitters

Thermometers fitted with iTEMP transmitters are an installation-ready complete solution to improve temperature measurement by significantly increasing accuracy and reliability, when compared to direct wired sensors, as well as reducing both wiring and maintenance costs.

Advantages of the iTEMP transmitters:
- Dual or single sensor input
- Unsurpassed reliability, accuracy and long-term stability in critical processes
- Mathematical functions

Advanced diagnostic functionality:
- Monitoring of the thermometer drift, sensor backup functionality
- Sensor-transmitter matching for dual sensor input transmitter, based on Callendar/Van Dusen coefficients

PC programmable transmitters

They offer a high degree of flexibility, thereby supporting universal application with low inventory storage. The iTEMP transmitters can be configured quickly and easily at a PC. Endress+Hauser offers free configuration software which can be downloaded from the Endress+Hauser Website. More information can be found in the Technical Information.

HART® programmable transmitters

The transmitter is a 2-wire device with one or two measuring inputs and one analog output. The device not only transfers converted signals from resistance thermometers (RTD) and thermocouples (TC), it also transfers resistance and voltage signals using HART® communication. It can be installed as an intrinsically safe apparatus in Zone 1 hazardous areas and is used for instrumentation in the terminal head (flat face) as per DIN EN 50446. Swift and easy operation, visualization and maintenance by PC using operating software, Simatic PDM or AMS. For more information, see the Technical Information.

PROFIBUS® PA transmitters

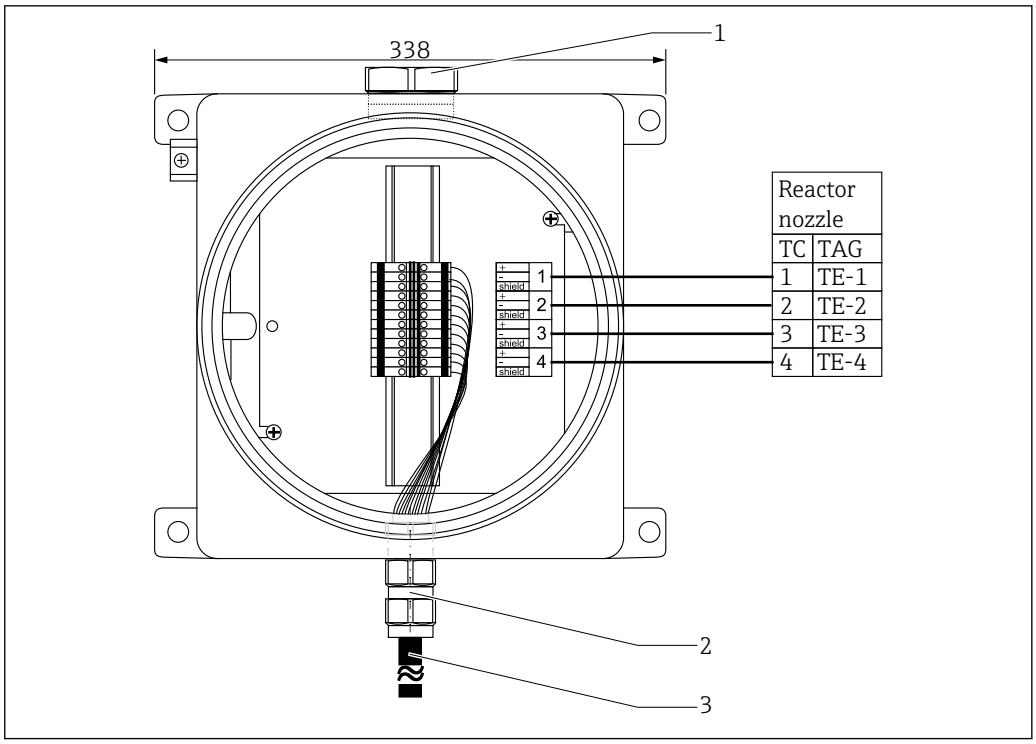
Universally programmable head transmitter with PROFIBUS® PA communication. Conversion of various input signals into digital output signals. High accuracy over the complete ambient temperature range. Swift and easy operation, visualization and maintenance using a PC directly from the control panel, e. g. using operating software, Simatic PDM or AMS. For more information, see the Technical Information.

FOUNDATION Fieldbus™ transmitters

Universally programmable head transmitter with FOUNDATION Fieldbus™ communication. Conversion of various input signals into digital output signals. High accuracy over the complete ambient temperature range. Swift and easy operation, visualization and maintenance using a PC directly from the control panel, e.g. using operating software such as ControlCare from Endress +Hauser or NI Configurator from National Instruments. For more information, see the Technical Information.

Power supply

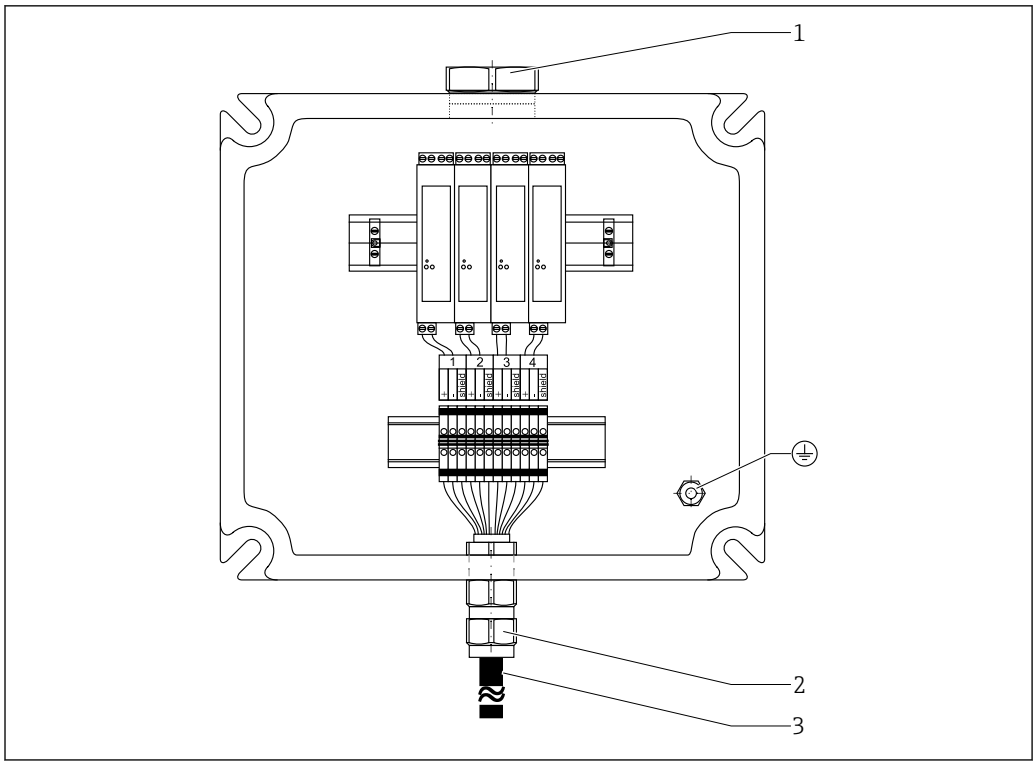
The cable sensor is, by default, provided with flying leads, in order to connect it to a separate temperature transmitter or to electrical terminals, for example inside a junction box.



1 Possible connection of a TS901 with 4 inserts TC 1xK IEC 60584 with shielded extension cable inside a junction box.

1 Output
2 Cable gland
3 Flexible hose

It is also possible to have both electrical terminals and temperature transmitters inside the same junction box.



1 Output
2 Cable gland
3 Flexible hose

Color codes:

As per IEC 60584	As per ASTM E230/ANSI MC96.1
Type K: green (+), white (-) Type N: pink (+), white (-)	Type K: yellow (+), red (-) Type N: orange (+), red(-)

Other types of thermocouples are available on request, based on international standard.

Performance characteristics

Response time

Tests in water at 0.4 m/s (1.3 ft/s), according to IEC 60584; 10 K (18 °F) temperature step change:

Cable probe diameter	Response time (without transmitter)	
8 mm (0.31 in)	T50 T90	2.4 s 6.2 s
9.5 mm (0.37 in)	T50 T90	2.8 s 7.5 s

Response time for the cable probe without transmitter.

Maximum measured error

Standard	Type	Standard tolerance	Special tolerance (on request)
ASTM E230/ MC. 96.1		Deviation, the larger respective value applies	
	K (NiCr-Ni)	±2.2 K (±3.96 °F) or ±0.02·|t| (−200 to 0 °C (−328 to 32 °F) ±2.2 K (±3.96 °F) or ±0.0075·|t| (0 to 1 260 °C (32 to 2 300 °F)	±1.1 K (±1.98 °F) or ±0.004·|t| (0 to 1 260 °C (32 to 2 300 °F)
	N (NiCrSI-NiSi)	±2.2 K (±3.96 °F) or ±0.02·|t| (−200 to 0 °C (−328 to 32 °F) ±2.2 K (±3.96 °F) or ±0.0075·|t| (0 to 1 260 °C (32 to 2 300 °F)	±1.1 K (±1.98 °F) or ±0.004·|t| (0 to 1 260 °C (32 to 2 300 °F)

Standard	Type	Standard tolerance		Special tolerance (on request)	
IEC60584		Class	Deviation	Class	Deviation
	K (NiCr-Ni)	2	±2.5 °C (±4.5 °F) (−40 to 333 °C (−40 to 631.4 °F) ±0.0075·|t| (333 to 1 200 °C (631.4 to 2 192 °F)	1	±1.5 °C (±2.7 °F) (−40 to 375 °C (−40 to 707 °F) ±0.004·|t| (375 to 1 000 °C (707 to 1 832 °F)
	N (NiCrSI-NiSi)	2	±2.5 °C (±4.5 °F) (−40 to 333 °C (−40 to 631.4 °F) ±0.0075·|t| (333 to 1 200 °C (631.4 to 2 192 °F)	1	±1.5 °C (±2.7 °F) (−40 to 375 °C (−40 to 707 °F) ±0.004·|t| (375 to 1 000 °C (707 to 1 832 °F)

Additional tests

Final assembly functional test, temperature profile test report:

Functional test measurement with a given thermal gradient distributed over the entire probe length: this test allows to validate the location of the measuring points and the relative correct wiring. This test is run at atmospheric pressure and has not to be seen as a calibration test.

Calibration

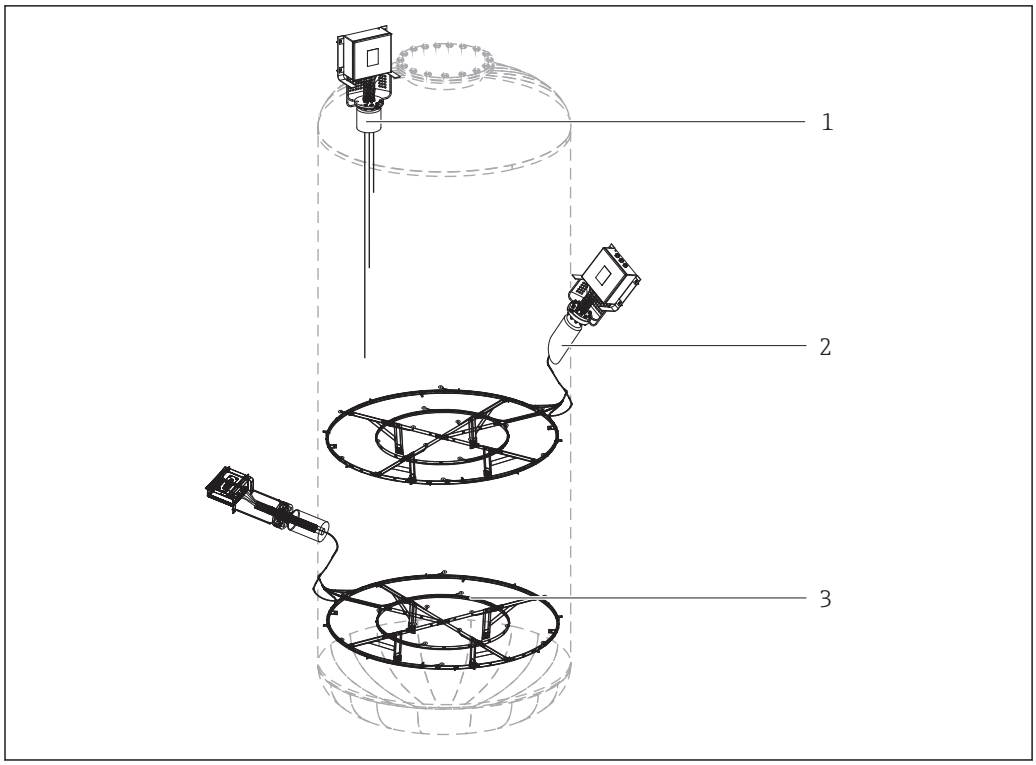
Calibration involves comparing the measured values of a device under test (DUT) with those of a more precise calibration standard using a defined and reproducible measurement method. The aim is to determine the deviation of the DUT's measured values from the true value of the measured variable.

Used method: Comparison calibration against a precise reference thermometer. The thermometer to be calibrated must display the temperature of the reference thermometer as accurately as possible.

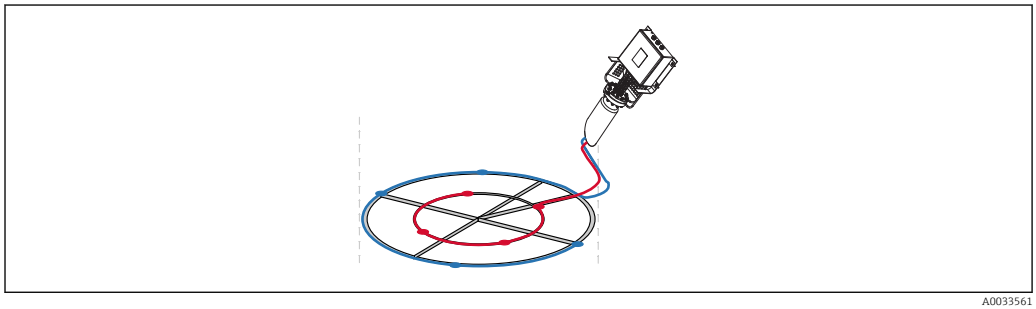
Temperature-controlled calibration baths between −80 to 550 °C (−112 to 1 022 °F) can be used only for the last measuring point (when (NL-LMPn)<100 mm) for either factory calibration or accredited calibration. Special bore through calibration furnaces with homogeneous distribution of temperature are used for thermometer factory calibration along the length, between 200 to 550 °C (392 to 1 022 °F).

The DUT and the reference thermometer are placed closely together into the bath or furnace at a sufficient depth. The measurement uncertainty can increase due to heat conduction errors and short immersion lengths. The existing measurement uncertainty is listed on the individual calibration certificate.

Installation



1 Vertical installation with linear configuration
2 Oblique installation with 3D distribution configuration
3 Horizontal installation with 3D distribution configuration



2 Example of 8 measuring points on two different circles, reached by two Multipoint Cable Sensors TS901.

Mounting location

The installation location must meet the requirements listed in this documentation, such as ambient temperature, protection classification, climate class.

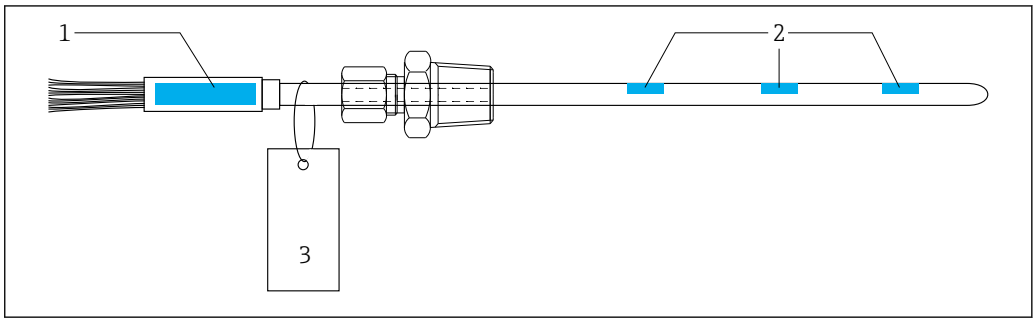
Care should be taken on checking the sizes of possible existing support beams welded on the reactor's wall or of any other existing frame in the installation area.

iTHERM ProfileSens has been designed to be easily installed into reactors/vessels, either individually or together with Endress+Hauser iTHERM MultiSens products. iTHERM ProfileSens can be bent within the specified limits (min bending radius r=5*OD) in order to reach the desired measuring points locations into the inner space of the reactor/vessel, in tube reactors or any other heavy duty application which requires temperature profiling.

Orientation

No restrictions. The TS901 can be installed either in horizontal, oblique or in vertical way.

Marking



1 Tagging (TAG), on device
2 Tagging (TAG), Measuring point (MP) location
3 Tagging (TAG), metal

Environment

Ambient temperature

The permitted ambient temperature is dependent on the material used for the electrical connecting cable and the cable sheath insulation:

Material Connection cable / sheath insulation	Maximum temperature in °C (°F)
FEP/FEP (fluorinated ethylene propylene)	200 °C (392 °F)
PFA/PFA (Perfluoroalkoxy alkane)	260 °C (500 °F)

Degree of protection

minimum IP65

Shock and vibration resistance

4g / 2 to 150 Hz as per IEC 60068-2-6

Insulation resistance

Insulation resistance (measured with a voltage of 100 V_{DC}) ≥ 100 MΩ at ambient temperature.

Process

The process temperature and process pressure are the minimum input parameters for the selection of the right product configuration. In case of special product requirements, additional data such as process fluid type, phases, concentration, viscosity, stream turbulences and corrosion rate have to be considered for the whole product definition.

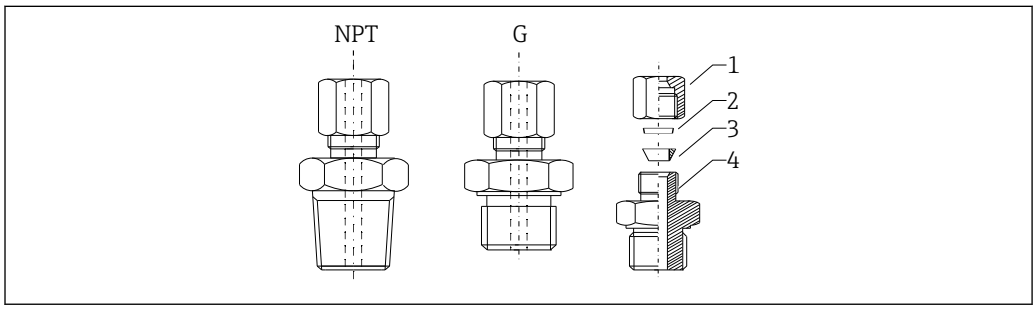
Process pressure range

iTHERM ProfileSens is able to withstand up to 400 bar (5 800 psi), and it has been designed for the most demanding and critical applications, such us (but not limited to):
- Olefins production
- Ethylene production
- Propylene production
- Aromatics production
- Benzene production
- N-based inorganics
- Urea production
- NGTL production
- Distillation units and hydrogenation
- Vacuum distillation
- Atmospheric distillation
- Hydrocracking
- Hydrotreating
- Hydrodesulfurization

Process connection

iTHERM ProfileSens can be installed to the process connection (such as a flange) of a complete Multipoint thermometer by means of compression fittings (welded or threaded) or directly welded to it.

In case of a compression fitting, the iTHERM ProfileSens is pushed through the fitting and fixed using a compression ferrule (detail 1 in figure → 🖼 3, 🖹 10).



🖼 3 *Compression fitting*

1 Nut
2 Back ferrule
3 Front ferrule
4 Body

Please be aware that SS316 compression ferrule can only be used once. Fully adjustable insertion length on initial installation is possible along the probe.

Maximum allowable working pressures at ambient temperature for fittings are shown below; to determine the maximum allowable working pressure at elevated temperatures, multiply the values by the factor in the table below.

Temperature	Factor
93 °C (200 °F)	1.00
204 °C (400 °F)	0.96
315 °C (600 °F)	0.85
426 °C (800 °F)	0.79
537 °C (1000 °F)	0.76

Type	Dimension	Maximum allowable working pressure at ambient temperature
Threaded	1/2" NPTM	530 bar (7687 psi)
	3/4" NPTM	500 bar (7252 psi)
	1" NPTM	370 bar (5366 psi)
	1/2" G	530 bar (7687 psi)
Welded [1)]	Pipe 3/8"	515 (7469)
	Pipe 1/2"	460 (6672)
	Pipe 3/4"	400 (5802)
	Pipe 1"	320 (4641)

1) Allowable working pressures are calculated from an S value of 137.8 MPa (20000 psi) for ASTM A269 tubing at −28 to 37 °C (−20 to 100 °F), as listed in ASME B31.3 and ASTM A213 tubing at −28 to 37 °C (−20 to 100 °F), as listed in ASME B31.1.

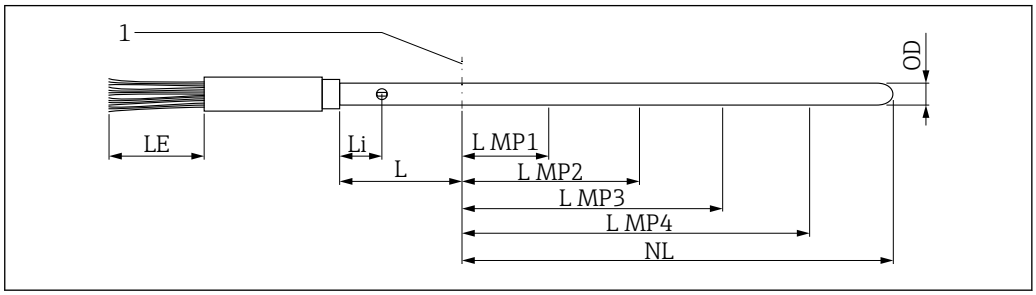
Mechanical construction

Design, dimensions

iTHERM ProfileSens is composed of different parts available in various materials and dimensions, based upon customer requirements.

In order to have the best process compatibility, several insert types and configurations are available. The extension cables may be provided with high resistance sheath materials (shielded) to withstand different environmental conditions and to ensure a steady and noiseless signal.

The transition between the single TC cables and the extension cables is obtained by the usage of special sealing pots, positioned inside the main sleeve that is itself sealed with epoxy resin. In addition, each inner insert is provided of a dedicated small transition sleeve to guarantee full isolation and independence between the different measuring points in any failure condition.



1	*Process connection location*	*LE*	*Extension cable length 500 to 15 000 mm (19.7 to 590.6 in)*
L	*External MI cable length*	*Li*	*Location of bleeding hole*
NL	*Insertion length*	*OD*	*Probe outside diameter*
L MPi	*Length of the i measuring point (i=2, 3, 4) – based upon customer requirements*		

Outer sheath probe

L+NL [mm (in)]	OD [mm (in)]	Thickness	Material
200 to 9 000 (7.87 to 354.3)	8 (0.31) 9.5 (0.37)	Standard wall (single wall, min 10% of OD) Heavy wall (single wall, min 15% of OD)	AISI 316L AISI 347 AISI 321 Inconel 600

Individual TC cables

Diameter [mm (in)]	Wires AWG	Type	Standard	Hot junction type	Sheath material
1 (0.04) 1.5 (0.06)	15 19	1 x K 2 x K 1 x J 2 x J 1 X N 2 x N	ASTM E230 IEC 60584	Ungrounded	Inconel 600

Extension cables

Cable isolation/External coating	Standard
FEP/FEP (fluorinated ethylene propylene)	IEC 60584 ASTM E230
PFA/PFA (Perfluoroalkoxy alkane)	

Extension cables can be either not protected or protected by external flexible conduit (material Polyamide) for increased mechanical protection.

Main Sleeve

Length [mm (in)] [1]	Diameter [mm (in)]	Material
110 to 200 (4.3 to 7.9) [1]	25 (0.98) with flexible conduit	AISI 316L
110 to 200 (4.3 to 7.9) [1]	32 (1.25) with flexible conduit	AISI 316L

1) Depending on the number of sensors

Outer sheath interruption

On request, a bleeding hole on the outer cable sheath is performed. In case of probes damages, it allows a safe fluids and pressure release into the diagnostic chamber, instead of in the environment. In particular, the interruption is suggested to be used only if the TS901 is installed on an iTHERM MultiSens TMS02 thermometer.

Weight

Weights depends on the overall probe length and diameter. (e.g. 4 measuring points ; 8 m (26.25 ft) length ~ 3 kg (6.6 lb))

Materials

Material name	Short form	Recommended maximum temperature for continuous use in air	Properties
AISI 316/1.4401	X5CrNiMo 17-12-2	650 °C (1 202 °F)	▪ Austenitic, stainless steel ▪ High corrosion resistance in general ▪ Particularly high corrosion resistance in chlorine based and acidic, non-oxidizing atmospheres through the addition of molybdenum (e.g. phosphoric and sulfuric acids, acetic and tartaric acids with a low concentration)
AISI 316L/ 1.4404	X2CrNiMo17-12-2	650 °C (1 202 °F)	▪ Austenitic, stainless steel ▪ High corrosion resistance in general ▪ Particularly high corrosion resistance in chlorine based and acidic, non-oxidizing atmospheres through the addition of molybdenum (e.g. phosphoric and sulfuric acids, acetic and tartaric acids with a low concentration) ▪ Good weldability
Alloy600/ 2.4816	NiCr15Fe	1 100 °C (2 012 °F)	▪ A nickel/chromium alloy with very good resistance to aggressive, oxidizing and reducing atmospheres, even at high temperatures ▪ Resistance to corrosion caused by chlorine gases and chlorinated media as well as many oxidizing mineral and organic acids, sea water etc. ▪ Corrosion from ultrapure water ▪ Not to be used in sulfur-containing atmospheres
AISI 321/1.4541	X6CrNiTi18-10	815 °C (1 499 °F)	▪ Austenitic stainless steel ▪ High resistance to intergranular corrosion even after welding ▪ Good welding characteristics, suitable to all standard welding methods ▪ It is used in many sectors of the chemical industry, petrochemical, and pressurized vessels
AISI 347/1.4550	X6CrNiNb10-10	815 °C (1 499 °F)	▪ Austenitic stainless steel ▪ Good resistance to a wide variety of environments in the chemical, textile, oil refining, dairy and food industries ▪ Added niobium makes this steel impervious to intergranular corrosion ▪ Good weldability ▪ Main applications are furnace fire walls, pressure vessels, welded structures, turbine blades

Certificates and approvals

- Factory calibration on final assembly
- EN 10204 3.1 Material Certificates for wetted parts
- Check on surface hardness and surface finish on probe sheath
- Helium Leakage test
- Hydrostatic Pressure test

Other quality tests:
- Insulation and electrical continuity test
- Radiographic inspections on hot junctions
- Bending test
- Dye penetrant test on welds

Ordering information

Detailed ordering information is available from the following sources:
- In the Product Configurator on the Endress+Hauser website: www.endress.com → Select country → Instruments → Select device → Product page function: Configure this product
- From your Endress+Hauser Sales Center: www.endress.com/worldwide

Product Configurator - the tool for individual product configuration
- Up-to-the-minute configuration data
- Depending on the device: Direct input of measuring point-specific information such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

Overview of the scope of delivery see the configuration table below.

Outer sheath		
Material	316/316L, 321, 347 [1], Alloy 600	_____
External cable length (L)	… mm	_____
Insertion length (NL)	… mm NL= max. 8.9 m (29.2 ft)	_____
Outside diameter (OD)	▪ 8 mm (0.31 in) ▪ 9.5 mm (0.37 in)	_____
Thickness (T)	▪ Standard wall ▪ Heavy wall	_____

1) On request

Insert, thermocouple		
Type	▪ K ▪ J [1] ▪ N ▪ Special on request	_____
Design	▪ TC single ▪ TC double	_____

1) On request

Measuring point distribution		
	▪ Equispaced ▪ Customized	_____
Number of measuring points	▪ 2 ▪ 3 ▪ 4	_____

Insertion length	TAG (description)	L MPx in mm
MP1 (min. 100 mm (3.94 in))	_____	_____
MP2	_____	_____
MP3	_____	_____
MP4	_____	_____

Additional request		
Extension cables length (max. 15 000 mm (590.6 in))	Specification in mm	_____
Extension cables material (Isolation/External coating)	▪ FEP/FEP ▪ PFA/PFA	❑ ❑
Extension cables design	Single pairs or cable conduit	_____
Interruption on external sheath (bleeding hole)	▪ Not needed ▪ Needed	❑ ❑

Documentation

Operating manuals iTEMP temperature transmitters:
- TMT180, PC-programmable, single-channel, Pt100 (KA00118R)
- TMT181, PC programmable, single-channel, RTD, TC, Ω, mV (KA00141R)
- HART® TMT182, single-channel, RTD, TC, Ω, mV (KA00142R)
- HART® TMT82, two-channel, RTD, TC, Ω, mV (BA01028T)
- PROFIBUS® PA TMT84, two-channel, RTD, TC, Ω, mV (BA00257R)
- FOUNDATION Fieldbus™ TMT85, two-channel, RTD, TC, Ω, mV (BA00251R)
- FOUNDATION Fieldbus™ TMT125, 8 channel, RTD, TC, Ω, mV (BA00240R)

Technical Information of Multipoints assemblies:
- iTHERM TMS01 MultiSens Flex, Modular Multipoint thermometer (TI01256T)
- iTHERM TMS02 MultiSens Flex, Modular Multipoint thermometer with diagnostic chamber (TI01361T)

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