

ABB MEASUREMENT & ANALYTICS | TECHNICAL DESCRIPTION

TSP341-N Remote Sensor Apparatus

Non-invasive temperature measurement using TTF300



Measurement made easy

TSP341-N Remote Sensor
Apparatus

Introduction

Non-invasive temperature measurement

A simpler and safer way of measuring your process temperature without the need to shutdown, engineer and install a thermowell.

Further Information

The described documents are available in their newest revision in the ABB download area at www.abb.com/temperature. Alternatively simply scan this code:



1 Scope

ABB offers two successful devices for temperature measurement:

- TSP341-N, a specially designed 2x3-wire RTD sensor for non-invasive temperature measurement. The TSP341-N includes a uniquely programmed transmitter with capability for high accuracy measurement in non-invasive applications.
- TTF300, a field-mount temperature transmitter with defined classified hazardous area approvals.

This Technical Description describes adapted variants of TSP341-N and TTF300 to be combined to support non-invasive temperature measurements.

The document focuses on differences and additions to the standard devices and the description in their data sheets and operating manuals. It is not possible to fully give all information for the devices in this document. It is necessary to refer to the data sheet or operating instructions of the individual devices.

The described documents are available in their newest revision in the ABB download area at www.abb.com/temperature.

If you have further questions, please contact ABB Automation Products GmbH.

2 Introduction

Classic temperature measurement in process technology is made by directly introducing the temperature sensor into the measuring medium.

The measuring medium (gaseous, liquid or paste-like) is usually in a vessel or piping.

The measuring medium can stand idle or flow at high speed.

Depending on the material properties, the temperature sensor needs special protection to protect it from chemical and mechanical loads. For example, abrasive dust or sands, which move through the piping at high speeds, present a special challenge.

To protect the temperature sensor, the thermowells used must be inspected regularly and replaced as needed.

Chemically aggressive or abrasive media can lead to the erosion of thermowell material.

A thermowell placed in flowing media can also begin to vibrate due to vortex formation and in extreme cases it can break.

Therefore, guidelines and standards for the stability of thermowells have become more restrictive over time, and so the costs of maintenance and exchange have increased as well.

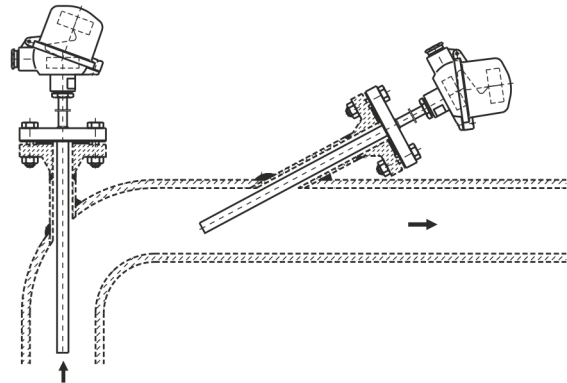


Figure 1: Installation of classic, invasive temperature sensors in piping

In addition to the running costs, other costs are already incurred during planning and design of an installation for openings in vessels and piping, through which the temperature sensor is introduced into the measuring medium. Here, for example, flanges or structural reinforcements are required.

The costs mentioned above can be eliminated if the process temperature could be measured indirectly and outside of the process. Using non-invasive temperature measurement, it is often possible to record process temperatures with an accuracy which is sufficient for the application.

The TSP341-N remote sensor apparatus when connected to a TTF300 (with non-invasive model) now combines non-invasive temperature measurement with the established HART® communications protocol in two-wire technology.

The 'N' in TSP341-N stands for non-invasive temperature measurement here. The calculation algorithms developed by ABB for non-invasive temperature measurement take ambient conditions, among other factors, into account during the measurement and therefore increase the accuracy of the surface measurement significantly.

Surface temperature measurement is especially suited in low-viscosity measuring media, in measuring media with high thermal conductivity and in processes with high medium velocity or turbulent flow. Examples: water, watery solutions and water-based liquids as well as fast flowing oil or saturated steam.

3 System structure

For non-invasive temperature measurement, the temperature sensor is fastened to a piping or vessel surface. Installation is made using two clamp collars, which fix the retaining plate to the foot of the sensor.

Clips with different expansion coefficients are available to adapt to the piping or vessel material. Metallic materials are required for surface measurement. The surface under the measurement sensor must be straight, without foreign matter and without any coating.

To shorten the response time of the sensor, there is a hole in the retaining plate, through which the sensor element is guided directly to the surface of the measuring point.

See OI/TSP341-N or CI/TSP341-N and TSP341-N product videos for detailed mounting instructions.

Pure surface measurement is often less accurate than temperature measurement directly in the process. However, thanks to the ambient temperature effect taken into consideration by the TSP341-N, the accuracy has been improved to the point that along with the obtainable response time, it is comparable to the values of classic measurement using a thermowell.

Accuracy and response time can be increased even more with suited insulation at the measuring point.

By using the algorithms for accurate non-invasive temperature calculation, a process temperature range of -40 to 400 °C (-40 to 752 °F) with an ambient temperature of -40 to 85 °C (-40 to 185 °F) is covered.

The remote transmitter TTF300 with non-invasive model can be configured using the software provided by ABB with TSP341-N-support (DTM and EDD) and tools such as Field Information Manager (FIM) in accordance with the current conditions of use.

Through the device configuration option (DTM, EDD, FIM) provided for the TSP341-N and also for the TTF300 with non-invasive model, the insulation of the measuring point is taken into consideration during temperature calculation (preset upon delivery of the device).

4 TSP341-N remote sensor for split installation

The temperature sensor TSP341-N allows for reliable temperature measurement without intervention in the process. Plant safety is clearly increased as a result. Thanks to the quick and easy surface mounting and by eliminating the thermowell and the need to open the process, substantial cost reductions are achieved.



Figure 2: TSP341-N Remote Sensor Apparatus. Cable glands may differ from those shown in the image

The non-invasive remote sensor measurement presented here consists of two components:

- A passive measuring component consisting of temperature measurement insets (2×3-wire Pt100 sensors) as used in the non-invasive temperature sensor TSP341-N but without a temperature transmitter and display.
- A processing and displaying component in a field housing. For this, a field-mount temperature transmitter TTF300 is used with non-invasive functionality and a display type BS without keys.

This document here focuses on describing the TSP341-N non-invasive remote sensor, its mechanical, electrical and thermal characteristics when connecting this sensor with a temperature transmitter.

Aside from the material connected in this document, the related operating and commissioning instructions of the TSP341-N sensor for non-invasive temperature measurement and the TTF300 Field-mount transmitter must be carefully studied for information and secure operation.

Required additional documentation

- DS/TSP341-N and OI/TSP341-N or CI/TSP341-N
- DS/TTF300 and OI/TTF300 or CI/TTF300

The described documents are available in their newest revision in the ABB download area at www.abb.com/temperature

5 Overview of temperature sensors

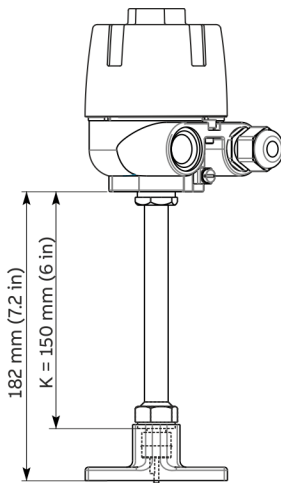


Figure 3: Overview

Design

Remote Temperature Sensor for surface mounting

Components

Retaining plate, measuring inset with measuring tip, extension tube, connection head

Materials

- Retaining plate: stainless steel 1.4408 (J92900)
- Measuring inset: stainless steel 1.4571 (ASTM 316Ti)
- Measuring tip: pure nickel 2.4068 (LC-Ni99)
- Extension tube: stainless steel 1.4571 (ASTM 316Ti)
- Gasket for connection head: EPDM (ethylene propylene diene-monomer rubber)

Process connection

Surface mounting to vessels and piping

Transport temperature / Storage temperature

-20 to 70 °C (-4 to 158 °F)

Measuring range (Surface temperature)

-40 to 400 °C (-40 to 752 °F)

Sensors

Thin film resistor Pt100 in three-wire circuit, accuracy class A in accordance with IEC 60751, measuring range -40 to 400 °C (-40 to 752 °F)

Extension tube

Extension tube diameter: 15 mm (0.59 in)

Extension tube length: K = 150 mm (6 in)

Note

For the distance from connection head to vessel or piping include additional ≈ 32 mm (≈ 1.3 in) for the retaining plate.

Clamp collars

Clamp collars for a variety of thermal expansion coefficients are available.

Clamp collars are available for pipe diameters of 40 to 2500 mm (1.5 to 98 in).

Recommendation for pipes and vessels made of chrome steel or carbon steel

Clamp collar material: chrome steel 1.4016 (ASTM 430),
 $\alpha = 10$ to $10.5 \cdot 10^{-6}/K$

Recommendation for pipes and vessels made of chrome-nickel steel

Clamp collar material: stainless steel 1.4301 (ASTM 304),
 $\alpha = 16$ to $17.5 \cdot 10^{-6}/K$

According to the measuring principle, the outside of the pipeline takes on the temperature of the measuring medium. It can therefore vary considerably. If the thermal expansion coefficient α of the piping significantly differs from the corresponding value α of the clamp bands used, a secure hold of the sensor on the piping can no longer be guaranteed at larger temperature changes of the measuring medium. In such a case, use clamp bands which feature a thermal expansion coefficient corresponding to that of the piping material.

NOTICE

Inappropriate thermal expansion coefficients α of clamp bands and raw materials can lead to a loss of secure hold of the sensor with larger or regular temperature changes of the measuring medium, with the effect that the sensor will start to move due to vibration, for example.

This can cause damage to the sensor and in its vicinity. Precise temperature measurement can no longer be guaranteed.

6 Relevant specifications

Mechanical and thermal specifications

Measuring accuracy

The temperature sensors used correspond to accuracy class A in accordance with the IEC 60751 standard, measuring range -40 to 400 °C (-40 to 752 °F).

Both temperature sensors of the TSP341-N remote temperature sensor are connected in a three-wire circuit.

This increases measuring accuracy when compared to the less accurate two-wire circuit, in which line and contact resistances flow into the measurement.

Vibration resistance

Temperature sensor with AGL connection head in accordance with IEC 60068-2-6:

- 10 to 58 Hz: 0.075 mm (0.003 in)
- > 58 to 2000 Hz: 10 m/s² (1 g)

Insulation resistance of measuring inset

The insulation resistance is measured between the outer sheath and both measuring loops. In addition, the insulation resistance between both measuring loops is also measured.

Thanks to a special process used during manufacturing, ABB measuring insets can boast outstanding insulation values even at high temperatures.

Insulation resistance R_{iso}

≥ 500 M Ω with a ambient temperature range from 15 to 35 °C (59 to 95 °F)

Air humidity

< 80 %

Extension tube

The extension tube as a module between the retaining plate and connection head allows for the use of insulation material at the measuring point.

Extension tube length TSP341-N Remote Sensor

$K = 150$ mm (6 in), plus the height of the retaining plate of approximately 32 mm (approximately 1.3 in)

Extension tube outer diameter

15 mm (0.59 in)

Extension tube material

Stainless steel 1.4571 (ASTM 316Ti)

Ambient temperature at connection head

The permissible ambient temperature range T_{amb} on the connection head must be in the range of -40 to 85 °C (-40 to 185 °F). See operating instruction OI/TSP341-N, chapter 'Temperature data', 'Ambient temperature at connection head'.

Note

The operator must make sure, with the help of measurements if needed, that the maximum permissible temperature in the connection head is not up-scaled.

Electrical and thermal specifications

Electrical Data

The TSP341-N remote sensor apparatus does not store or generate more than 1.2 V, 100 mA or 25 mW of power.

When connecting the TSP341-N Remote Sensor to a temperature transmitter, the following maximum input values must be observed regardless of the combination of voltage and current:

Max. Voltage	$U_i \leq 6.5$ V
Max. Current	$I_i \leq 25$ mA
Max. Power	$P_i \leq 38$ mW
Inductance	$L_i \approx 0$ mH (negligible, passive sensor)
Capacitance	$C_i \leq 1.65$ μ F

Thermal resistance

In addition to measurement of the surface temperature, a temperature measurement at a reference test point at small physical distance is made to improve measuring accuracy. For this, the measuring inset has two temperature sensors in two separate mineral insulated cables.

Temperature rise in the event of a fault

In the event of a fault, the temperature sensors will exhibit a temperature rise Δt as appropriate for the applied power. This temperature rise Δt must be considered when determining permissible temperature classes.

A dynamic short-circuit current that occurs in the measurement circuit for a matter of milli-seconds in the event of a fault is irrelevant with regard to heating.

The temperature rise Δt can be calculated using the following formula:

$$\Delta t = R_{th} \times P_o \quad [K/W \times W]$$

Δt Temperature rise

R_{th} Thermal resistance

P_o Output power of the connected transmitter

Example in case of a connection to TTF300 transmitter: please refer to OI/TTF300

Resistance thermometer diameter approximately 3 mm (0.12 in) without thermowell:

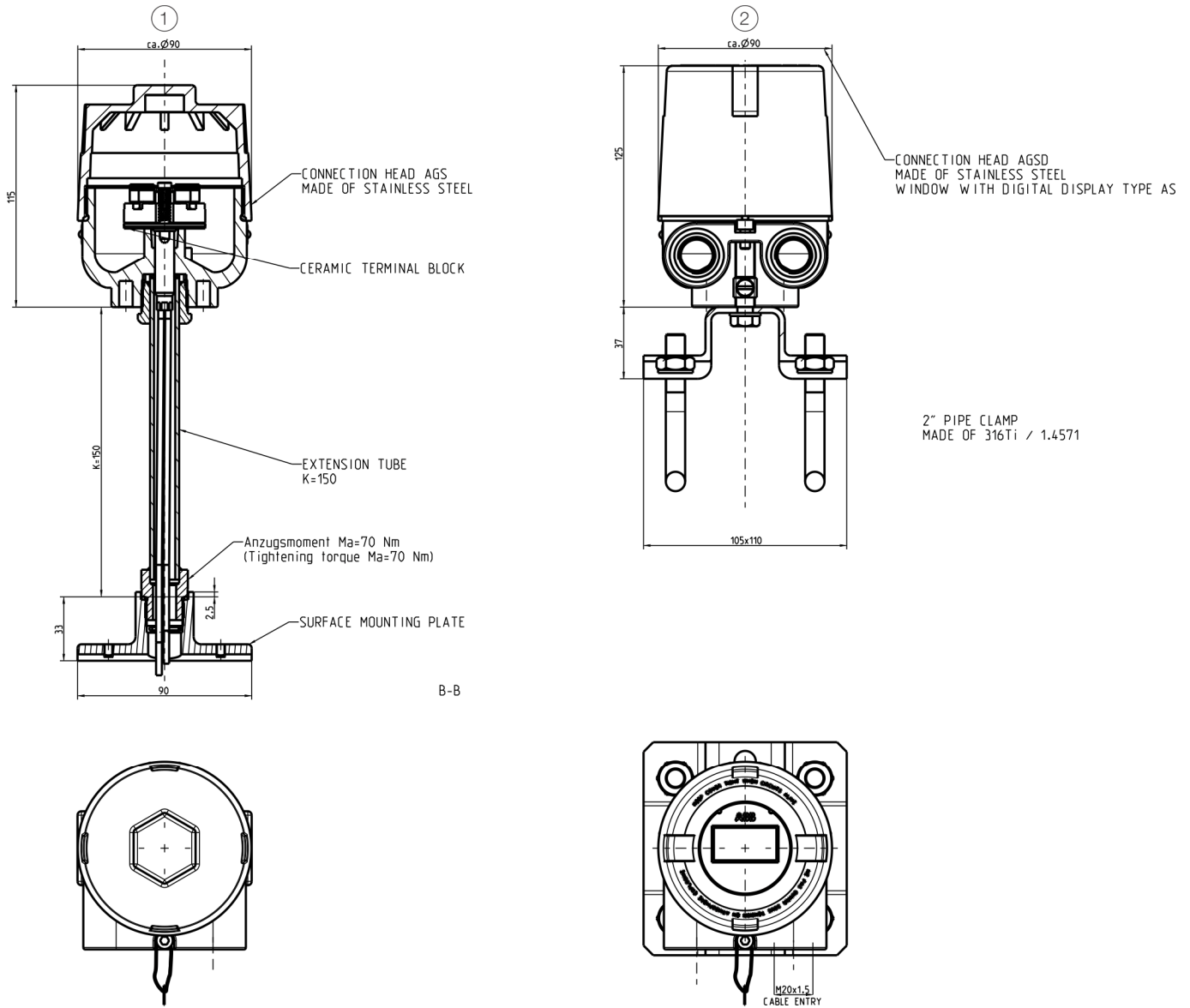
$$R_{th} = 200 \text{ K/W,}$$

$$P_o = 38 \text{ mW}$$

$$\Delta t = 200 \text{ K/W} \times 0.038 \text{ W} = 7.6 \text{ K}$$

For a transmitter output power $P_o = 38 \text{ mW}$, a temperature rise of approx. 8 K results in the event of a fault.

7 Mounting and connecting to a transmitter (specifically TTF300 with noninvasive model)



① TSP341-N Remote sensor 2× Pt100 3-Wire, Ø 3 mm

② TTF300 Transmitter with non-invasive software model

Figure 4: Example of paired TTF300 with non-invasive model and TSP341-N Remote sensor apparatus. See OI/TTF300, CI/TTF300 for more information.

Mounting the TSP341-N Remote sensor apparatus on a pipe

Follow the mounting instructions outlined in section 6 in the operating instructions OI/TSP341-N. A detailed step by step guide to preparing the device, straps and precautions is also available in the detailed installation instructions document (IN/TSP341-N/INSTALLATION_INSTRUCTION-XA).

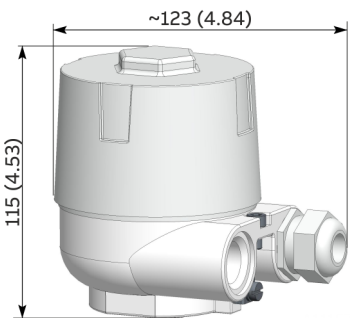
The sensor can be connected to the TTF300 with non-invasive model either prior to or after mounting in location.

Connections TSP341-N Remote sensor apparatus

When the connection cable is fed into the connection head, a special cable guide cable automatically positions it inside the connection area. The flat base of the housing ensures optimum access to the connection area.

The non-invasive device has two resistance sensors, each in three-wire circuit internally. Sensor 1 (surface sensor) is assigned to colors RED and WHITE, sensor 2 (reference sensor) to colors BLACK and YELLOW.

Dimensions in mm (in)

Head form	AGL / AGS
	
Material	AGL: Aluminum, epoxy-coated AGS: Stainless steel
Cover locking system	Screw-on cap
Cable gland	M20 × 1.5, optional cable entry ½ in NPT, without screwed connection
IP rating	IP 66 / IP 67
Transmitter mounting	No integral transmitter

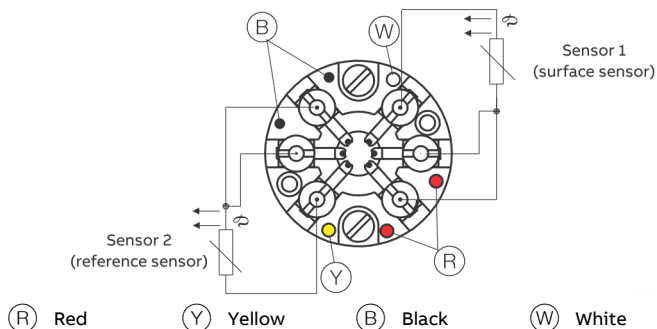


Figure 5: Pin assignment for ceramic terminal block of measuring component (view from above)

Note

For the correct connection to the ceramic terminal block, the color markings described are decisive, rather than any numbers that may be on the base.

... 7 Mounting and connecting to a transmitter (specifically TTF300 with noninvasive model)

Connecting to a TTF300 with non-invasive model

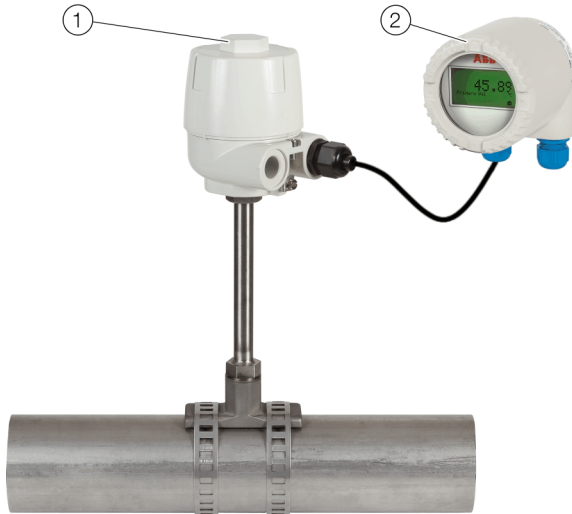


Figure 6: Example of installing TTF300 (2) with non-invasive model with TSP341-N remote sensor apparatus (1)

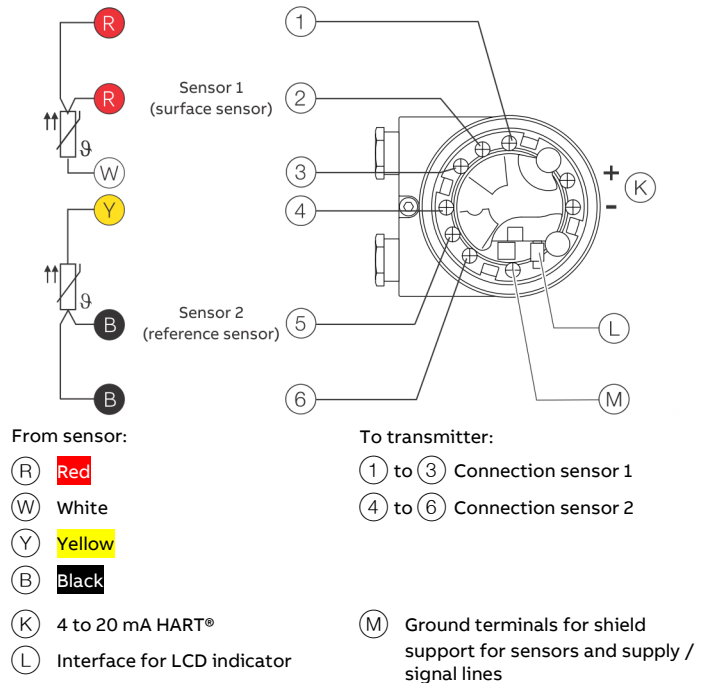
For use with the TSP341-N remote sensor apparatus, the TTF300 with non-invasive model differs from the standard transmitter in the following manner:

1. The display of TTF300, type B with keys, is replaced by a display of type BS without keys, since non-invasive technology currently does not support operation via keys.
2. The TTF300 firmware is upgraded to support ABB's calculation algorithms for non-invasive temperature measurement.
3. This TTF300 with non-invasive model does not support the following functionality.
 - a. Drift monitoring is disabled as both sensor inputs are utilized.
 - b. Sensor adjustment capabilities are disabled.
 - c. The transmitter is solely available with a 4 to 20 mA signal and HART functionality.
 - d. The transmitter only functions with 2 × 3 wire RTD; potentiometer, two wire, four wire, thermocouple and voltage measurement circuits are disabled.



Figure 7: Adapted design of TTF300 with non-invasive model (Display type BS, no keys) for use with TSP341-N Remote sensor apparatus.
Note: Cable glands may differ from those shown in the image

For connecting the transmitter to the measuring component, see the pin assignment description in the operating / commissioning instruction of TTF300 (OI/TTF300 or CI/TTF300). An extract from the operating instruction is shown in the figure below:



When connected to the TSP341-N Remote sensor apparatus, sensor 1 is the surface sensor and sensor 2 is the reference sensor.

Figure 8: Pin assignment for processing and displaying component.

NOTICE

If the sensor is connected to any 2-channel temperature transmitter other than the TTF300 with non-invasive model, the temperature measurements from the sensors will still function as two independent, 3-wire, Pt100s. However, the design of the TSP341-N Remote sensor apparatus is not suitable for any other measurement application other than to measure the surface temperature of piping and vessels. In such a case, the red and white contacts would provide the surface sensor temperature and the yellow and black would provide reference sensor (ambient) temperature in the vicinity of the surface sensor. No relation to the process temperature can be provided

Commissioning the TTF300 with non-invasive model

Refer to operating instructions OI/TSP341-N, section 7 'operation', and control for details on the process display, parametrization capabilities and error codes. Section 8 in the same document provides an outline of error messages and malfunctions.

Additional Information

Tests and certificates

In order to increase the safety and accuracy of the process, ABB offers various mechanical and electrical tests. The results are confirmed with certificates in accordance with EN 10204.

The following certificates are issued:

- Declaration of compliance according EN 10204-2.1, with the order
- Inspection certificate according EN 10204-3.1, visual, dimensional and functional test of the temperature sensor

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