Mounting and
Installation Advice
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Resistance Thermometers and Thermocouple Assemblies

ROSEMOUNT® TEMPERATURE

FISHER-ROSEMOUNT

Mounting and Installation Advice for Resistance Thermometers and Thermocouple Assemblies

NOTICE

Read this manual before working with the product. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this product.

For further details please contact your local Rosemount representative.

⚠ CAUTION

The products described in this document are NOT designed for nuclear-qualified applications. Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause inaccurate readings.

For information on Rosemount nuclear-qualified products, contact your local Rosemount Sales Representative.

Cover Photo: Product Overview Temperature Sensors and Transmitters

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1

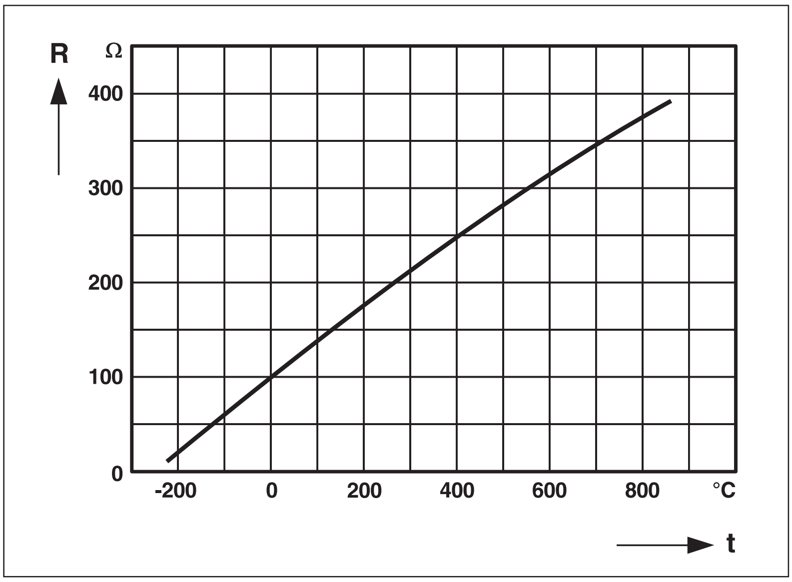
Temperature Measurement with Resistance Thermometers

DESCRIPTION AND MEASURING PRINCIPLE

Temperature measurement with resistance thermometers is based on the property possessed by all conductors and semiconductors, namely that their resistance varies as a function of temperature. This property is more or less pronounced, depending on the particular material. The relative change in the resistance as a function of temperature (dR/dt) is known as the temperature coefficient, the value of which is usually not constant over the range of temperature of interest, but is itself a function of temperature. The result is that the mathematical relationship between resistance and temperature takes the form of a high-order polynomial.

Figure 1 shows the change in resistance as a function of temperature for a Pt 100 resistance thermometer.

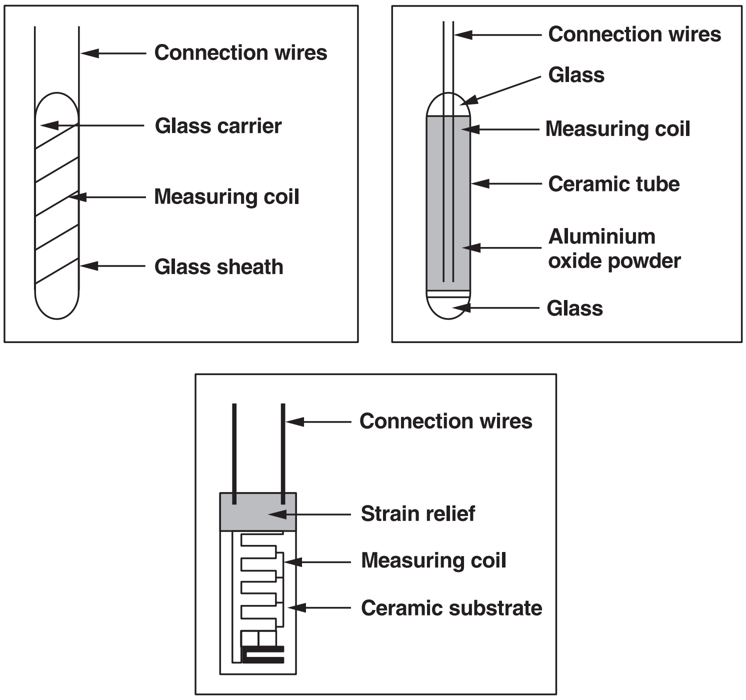
Figure 1:
Pt 100 characteristic curve



STRUCTURE

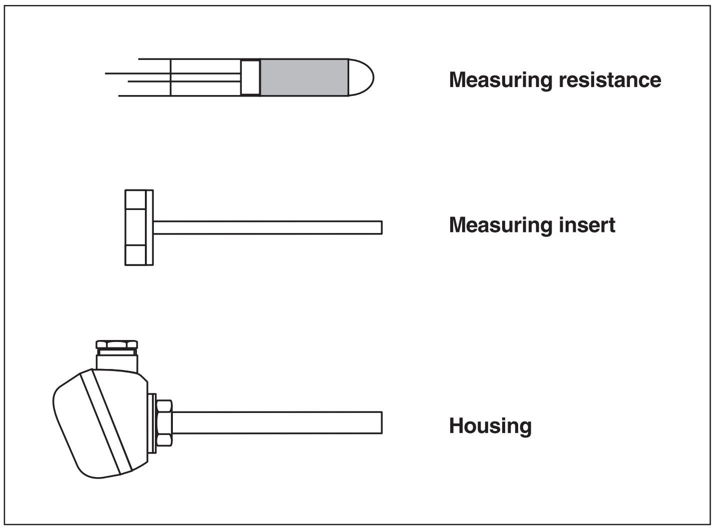
The resistance temperature detector is made up of a platinum coil wound on a suitable support. The wire coil is either fused into glass or embedded in ceramic. To meet today’s requirements for more compact dimensions and higher resistance values, extremely thin platinum layers are applied to a ceramic substrate instead of wires (see Fig. 2).

Figure 2:
Glass wire-wound, ceramic wire-wound and thin-film resistance thermometers



To protect them against mechanical damage (pressure or flowing liquid) these measuring elements are usually installed into suitable protective tubes (measuring inserts). This also ensures easy replacement without the need to replace the complete fitting. As resistance thermometers are contact-making temperature sensors (i.e. the sensor has to reach the temperature of the medium in which measurement is to be performed) the housing has to be adapted to the application (see Fig. 3).

Figure 3:
Resistance thermometer modules



METHODS OF CONNECTION

When using resistance thermometers for temperature measurement, the fact that the measurement result is influenced by the resistance of the selected lead wire must be taken into account.

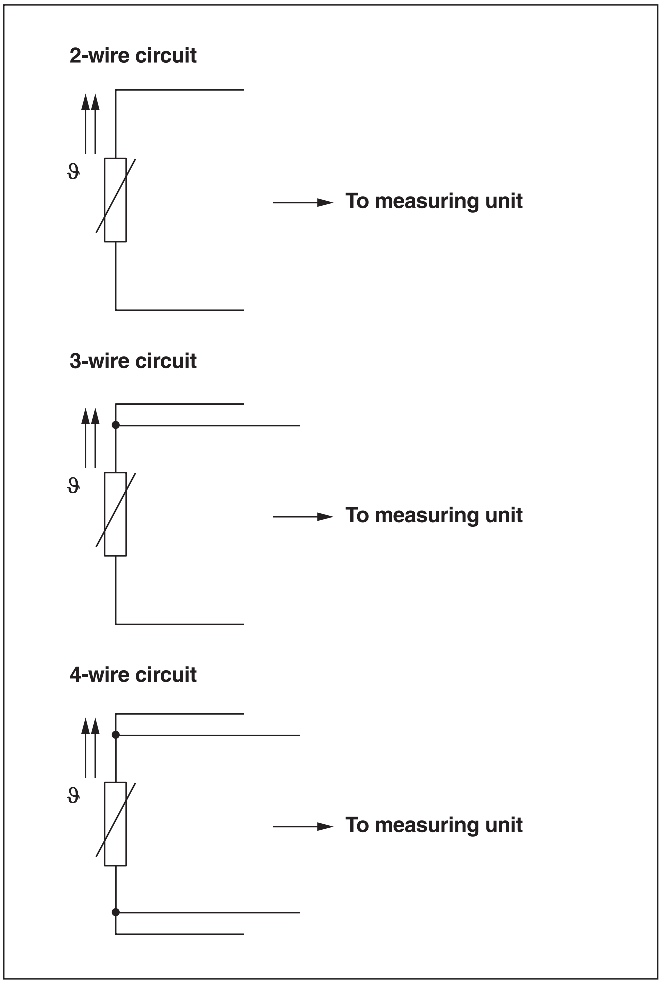
Three circuit types are commonly used: **2-wire, 3-wire and 4-wire circuits.**

The most accurate measurements are obtained with the **4-wire circuit**, as in this case the measurement is not affected by lead wire resistance or environment temperature of lead wires (see Fig. 4).

The **3-wire circuit** is normally used for eliminating the lead wire resistance (Wheatstone bridge).

In the case of the **2-wire circuit** the lead wire resistance is fully measured by the measuring bridge. By the use of modern control equipment the influence of the lead wire resistance at 2-wire circuit can be compensated by a line compensation resistor, which is independent of temperature.

Figure 4:
Methods of connection



AREAS OF APPLICATION

Resistance thermometers can be used over a temperature range of -220 °C to +600 °C.

Their **advantages** are:

- High temperature ranges
- Resistance to vibration
- High immunity to electrical interference
- Long-term stability
- Robust design
- High accuracy

Resistance thermometers are used in the following **industries**:

- Chemical industries
- Petrochemical industries
- Pharmaceutical industries
- Power generation
- Mechanical engineering
- Food & beverage
- Mining

Section

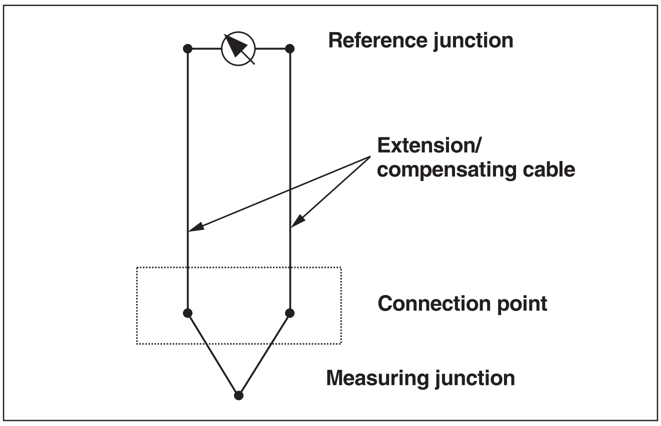
2

Temperature Measurement with Thermocouples

DESCRIPTION AND MEASUREMENT PRINCIPLE

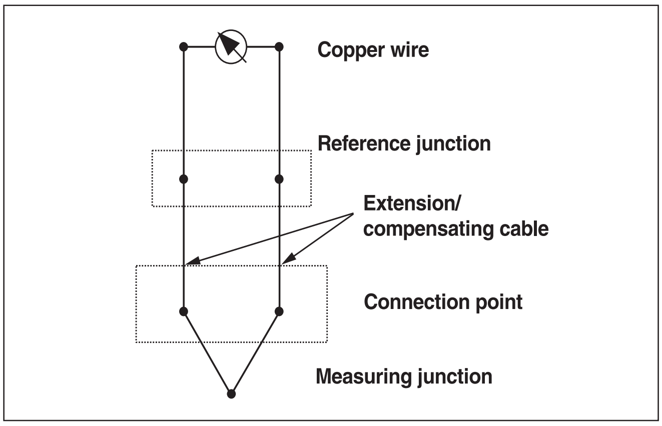
A thermocouple consists of two electrical conductors of different materials connected to one another at one end (measuring junction). The two free ends build a compensation point resp reference junction. The thermocouple can be extended by using an extension or a compensating cable. The extension or compensating cables are connected to a measuring instrument, e.g. a galvanometer or electronic measuring unit (see Fig. 5).

Figure 5



The thermoelectric voltage appearing at the reference junction depends on the thermocouple wire material and on the temperature difference between the measuring junction and the reference junction. For temperature measurement, the temperature of the reference junction must be kept constant (e.g. 0 °C) or must be well known, to make a appriopriate correction in mV (see Fig. 6).

Figure 6



Extension cables are manufactured of the same material as the corresponding thermocouple, e.g. Cu-CuNi, Fe-CuNi. Compensating cables are manufactured of special materials.

Up to 200 °C compensating cables supply the same thermoelectric voltage as the thermocouples to which they are connected. The thermoelectric voltages of the thermocouples are laid down in so-called basic value series.

e.g.	PtRh30%-PtRh6%	Type B
	Fe-CuNi	Type J
	NiCr-NiAl	Type K
	PtRh87/13%-Pt	Type R
	PtRh90/10%-Pt	Type S
	and others in DIN IEC 584-1	
and	Fe-CuNi	Type L
	Cu-CuNi	Type U

These thermocouples are not more available for use in new plants (thermoelectric voltage according to DIN 43710). Basic value tables are available on request only at manufacturer site.

The compensating cable for a thermocouple must be made of a material to suit the particular type of thermocouple, so compensating leads are colour-coded. For standardized compensating cable the regulations contained in DIN EN 60584 apply.
Maximum temperatures indicated by manufacturer have to be considered.

Most thermocouples are supplied ready for operation, that is in a protective mounting to prevent damage to the thermocouple by mechanical forces or chemical attack.

INSTALLATION OF PROTECTIVE TUBES

The protective tubes of thermocouples must be adapted to the particular operating conditions. Precious metal thermocouples are always protected with a ceramic tube, even if the unit has a metallic protective mounting.

At high temperatures the protective tubes should be installed vertically, where possible, i.e. suspended, to avoid damage deflection to the protective tube and thermocouple through bending. If specific conditions on site make a horizontal installation unavoidable, long protective tubes have to be suitably supported.

LEADS AND CONNECTIONS

When laying and connecting extension resp. compensating cables, care must be taken to connect the positive pole of the thermocouple to the positive terminal of the indicating instrument. If extension cables or compensating cable are used, care must be taken not to interchange positive and negative conductors. To prevent errors, the positive and negative leads bear a corresponding marking.

All connections must be absolutely clean and firmly tightened. The corresponding positive and negative terminals should have the same temperature potential.

The compensating cables between the thermocouple and the indicating instrument should comply with the requirements for insulated leads in power systems (VDE 0250) . In exceptional cases, the regulations for insulated leads in telecommunications systems (VDE 0810) may be applied.

AREAS OF APPLICATION

In the negative temperature range, thermocouples can be used down to -200 °C. For temperatures above 1000 °C thermocouples made of platinum and a platinum/rhodium alloy are used.

Advantages of thermocouples are:

- Very high temperature ranges
- Fast response
- Compact design
- Extremely high resistance to vibration
- Long term stability
- Robust design.

Thermocouples are used in the following and other **industries**:

- Chemical industries
- Pharmaceutical industries
- Power generation
- Mechanical engineering
- Food & beverage
- Mining
- Iron and steel
- Ceramics and glass

Assembly of Housing

RULES AND REGULATIONS

For assembly of housing following instructions are to be considered.

VDE/VDI 3511
Technical temperature measurement/instruction

VDE/VDI 3512
Set-up for temperature measurements

AD – instruction leaflets [1]
Working group pressure vessels

TRB – technical directions for tank construction [1]

Vd – TÜV regulations [1]

Operating stress

The stresses, indicated in the drawing, apply to the supplied housing. The load data, included in the standards for every type, are valid for housing according to DIN 43763 and DIN 43772.

Starting torques for screw-in type threads

Applicable to screw-in type threads of housing according to DIN 43763 and DIN 43772 as well as comparable housing according to customer's specification.

G ⅜, G ½	50 Nm
G ¾	100 Nm

Above starting torques are to be used as well for coupling rings with similar threads.

[1] To be considered in case of weld-in type protective tubes. Material, weld and pressure test according to operating conditions

Assembly of housing with flange mounting

The seal is to be selected according to the requirements. During insertion of the seal, a good support is necessary. Fastening screws are to be tightened evenly and crosswise.

Installation of ceramic housing in plants at operating temperature

Temperature of the plant:

- 1600 °C insertion speed: 1–2 cm/min
- 1200 °C insertion speed: 10–20 cm/min

Connection of transmitters

When connecting transmitter, the installation-, connection- and test instructions of the manufacturers are to be considered.

Appendix I and Appendix II

APPENDIX I

Limit tolerances of the basic values according to DIN IEC 751 and DIN 43760

	Basic values				Limit tolerances					
	according to DIN IEC 751 Platinum RTD-elements		according to DIN 43760 Nickel RTD-elements		according to DIN IEC 751 Platinum RTD-elements				according to DIN 43760 Nickel RTD-elements	
					Class A		Class B			
°C	Ohm	Ohm/K	Ohm	Ohm/K	Ohm	corresp. °C	Ohm	corresp. °C	Ohm	corresp. °C
-200	18.49	0.44	±0.24	±0.55	±0.56	±1.3				
-100	60.25	0.41	±0.14	±0.35	±0.32	±0.8				
-60			69.5	0.47	-				±1.0	±2.1
0	100.00	0.39	100.0	0.55	±0.06	±0.15	±0.12	±0.3	±0.2	±0.4
100	138.50	0.38	161.8	0.69	±0.13	±0.35	±0.30	±0.8	±0.8	±1.1
200	175.84	0.37	240.7	0.90	±0.20	±0.55	±0.48	±1.3	±1.6	±1.8
250			289.2	1.04					±2.3	±2.1
300	212.02	0.35			±0.27	±0.75	±0.64	±1.8		
400	247.04	0.34			±0.33	±0.95	±0.79	±2.3		
500	280.90	0.33			±0.38	±1.15	±0.93	±2.8		
600	313.59	0.33			±0.43	±1.35	±1.06	±3.3		
700	345.13	0.31					±1.17	±3.8		
800	375.71	0.30					±1.28	±4.3		
850	390.26	0.29					±1.34	±4.6		

APPENDIX II

Limit tolerances for thermocouples according DIN IEC 584-2

Class	1	2	3[(2)]
Limit tolerances [(1)]	0.5 °C or 0.004 x |t|	1 °C or 0.0075 x |t|	1°C or 0.015 x |t|
(±)	Limit tolerances apply to following temperature ranges		
Typ T	-40 °C up to 350 °C	-40 °C up to 350 °C	-200 °C up to 40 °C
Limit tolerances [(1)]	1.5 °C or 0.004 x |t|	2.5 °C or 0.0075 x |t|	2.5 °C or 0.015 x |t|
(±)	Limit tolerances apply to following temperature ranges		
Typ E	-40 °C up to 800 °C	-40 °C up to 900 °C	-200 °C up to 40 °C
Typ J	-40 °C up to 750 °C	-40 °C up to 750 °C	---
Typ K	-40 °C up to 1000 °C	-40 °C up to 1200 °C	-200 °C up to 40 °C
Limit tolerances [(1)]	1.0 °C or [1+(t-1100) x 003] °C	1.5 °C or 0.0025 x |t|	4 °C or 0.005 x |t|
(±)	Limit tolerances apply to following temperature ranges		
Type R and S	0 °C up to 1600 °C	0 °C up to 1600 °C	---
Type B	---	600 °C up to 1700 °C	600 °C up to 1700 °C

(1) Limit tolerances for thermocouples are indicated in degrees centigrade or as percentage of the measured temperature in degrees centigrade. Whichever value is greater applies.

(2) Thermocouples and thermocouple wires are usually supplied with limit tolerances according to the table above valid for temperature range above of -40 °C. The thermocouple limit tolerances of same material at temperatures below -40 °C may be exceeded as stated for tolerance class 3 according to DIN IEC 584-2. Thermocouples requested by purchaser with limit tolerances according to classes 1, 2 or 3 may be obtained by special material selection.

|t| = Temperature in degrees Centigrade

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