

Thermocouples and Resistance Thermometers

Operating Instructions

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1 Safety

Our information regarding our products, equipment, plants and processes is based on extensive research and experience in the field of applied engineering. We are making such information available, to the best of our knowledge and in written form, without assuming any liability over and above the terms of this contract but reserving the right to make technical changes of our products at any time without prior notification.

In addition, our applications engineers are available on request to provide further consultation and cooperation in solving production and application-related problems.

This however does not relieve the user from the obligation to verify the suitability of our information and recommendations before putting our products to use.

This applies particularly to deliveries destined for customers in foreign countries, especially in their obligation to ensure that no patent rights of third parties are infringed upon, including applications and processing methods which we have not expressly spelled out in writing.

In case of damage or quality deficiencies, our liabilities and indemnities are limited to the same volumes as stipulated in our General Terms of Supply and Delivery.

1.1 General Safety Information

The “Safety” chapter provides an overview of the safety aspects to be observed for the operation of the device.

The device is built based on state-of-the-art technology and is operationally safe. It was tested and left the factory in a proper state. The requirements in the manual as well as the documentation and certificates must be observed and followed in order to maintain this state for the period of operation.

The general safety requirements must be complied with completely during operation of the device. In addition to the general information, the individual chapters of the manual contain descriptions about processes or procedural instructions with specific safety information.

Only the observance of all safety information enables the optimal protection of personnel as well as the environment from hazards and the safe and trouble-free operation of the device.

1.2 Use in accordance with regulations

The temperature sensors are for temperature measurement in the most diverse process applications. The resistance thermometer or thermocouples can be used with and without thermowell.

1.3 Technical limits

The device is designed for use exclusively within the stated values on the name plate and in the technical specifications (see "Technical Specifications" chapter and/or data sheet). These must be complied with accordingly, e.g.:

- The maximum operating temperature may not be exceeded.
- The permitted operating temperature may not be exceeded.
- The housing protection system must be observed.

1.4 Warranty provision

A use contrary to the device's stipulated use, disregarding of this manual, the use of under-qualified personnel as well as unauthorized alterations excludes the manufacturer of liability from any resulting damages. The manufacturer's warranty expires.

1.5 Labels and symbols

1.5.1 Symbols and warnings



Danger – <Serious damage to health / risk to life>

One of these symbols in conjunction with the "Danger" warning indicates an imminent danger. If it is not avoided, death or serious injury will result.



Warning – <Bodily injury>

The symbol in conjunction with the "Warning" message indicates a possibly dangerous situation. If it is not avoided, death or serious injury could result.



Caution – <Slight injuries>

The symbol in conjunction with the "Caution" message indicates a possibly dangerous situation. If it is not avoided, slight or minor injury can result. May also be used for property damage warnings.



Attention – <Property damage>!

The symbol indicates a possibly damaging situation. If it is not avoided, the product or something in its area can be damaged.



Important!

The symbol indicates operator tips or especially useful information. This is not a message for a dangerous or damaging situation.

1.6 Operator liability

- Before the use of corrosive and abrasive materials to be measured, the operator must clarify the resistance of all parts that come into contact with the materials to be measured. ABB will gladly support you with the selection, however, cannot accept any liability.
- The operators must strictly observe the applicable national regulations in their countries with regards to installation, function tests, repairs, and maintenance of electrical devices.

1.7 Personnel qualification

The installation, commissioning and maintenance of the device may only be carried out through trained specialist personell authorized by the plant operator. The specialist personnel must have read and understood the manual and comply with its instructions.

1.8 Transport safety information

Observe the following information:

- Do not expose the device to moisture during transport. Pack the device accordingly.
- Pack the device so that it is protected from vibration during transport, e.g. through air-cushioned packaging.

Check the devices for possible damage that may have occurred from improper transport. Damages in transit must be recorded on the transport documents. All claims for damages must be claimed without delay against the shipper and before the installation.

1.9 Electrical installation safety information

The electrical connection may only be performed by authorized specialist personnel according to the electrical plans.

Observe the electrical connection information in the manual, otherwise the electrical protection can be affected.

The secure isolation of contact-dangerous electrical circuits is only guaranteed when the connected devices fulfil the requirements of the DIN VDE 0106 T.101 (basic requirements for secure isolation).

For secure isolation, run the supply lines separated from contact-dangerous electrical circuits or additionally isolate them.

2 Design and function

2.1 General

We are capable of supplying complete thermometer assemblies ready for immediate use.

These thermocouples or resistance thermometers are sensitive devices which contain either glass or ceramic parts. They must therefore be handled with due care.

On receiving the thermometer assembly, please make sure to unpack all supplied articles, including those that may be delivered in dismantled form.

Long thermometers must be supported at various points, and lifted up or transported in appropriate manner. The same care must be taken during the actual installation of the device. Prior to installation, please check the thermometers (see 5.1) to ensure that the device has suffered no transportation damages.

2.2 Thermocouples

Thermocouple assemblies are delivered with 1, 2, or sometimes 3 thermocouple elements. The measuring point is usually insulated but can still be connected to the protecting tube.

The connection of the thermocouple to the measuring instrument is established with a compensation lead (CL). Only the right type of compensation leads suiting the thermocouple and possessing the right polarity should be used for the connection. The leads should be at least 0.5 m away from the power cables, preferably laid in their own cable trays. Twisted and shielded cables suppress magnetic and electrical parasitical interferences.

2.3 Resistance Thermometers

Resistance thermometers are supplied with 1, 2, or sometimes with 3 measuring resistors.

The measuring point is isolated. The connection between resistance thermometer and measuring instrument is mostly of the 2-wire type (the sum and compensation of line resistance become part of the measurement). To obtain accurate measurements, the 3-wire technique is used. If highly accurate measurements are desired, the 4-wire technique with constant current and high resistance voltage pick-up are used.

Conventional copper cables usually found on the market, preferably with 1.5 mm² cross-section should be laid, possibly at about 0.5 m away from the power cables, at best on their own cable trays. Twisted and shielded cables suppress magnetic and electrical parasitical interferences.

Depending on the type, care must be taken not to exceed the measuring currents of 0.1 ... 10 mA, recommended by the manufacturer (errors may result from inherent heating).

2.4 Thermometer with head-mounted transmitter

The afore mentioned problems which could eventually be caused by transfer resistances in the cable and EMC can be prevented by installing a 2-wire transmitter (output signal 4 ... 20 mA) in the sensor head. Required is only a 2-core copper cable. Multiple wire circuits for resistance thermometers and compensation cables for thermocouples are not necessary.

When using the transmitter, please take notice of the following:

- the contents of these instructions or the operating manual provided with the transmitter
- the relevant rules involving the installation and operation of electrical systems, in some cases the regulations and directives for explosion protection.

3 Use in areas requiring ignition protection

1. In accordance with of ElexV, maintenance work (repairs) may be conducted only under the following conditions stated below:
 - 1.1 If a part of an electrical device which is important for explosion protection is repaired, this may be put into operation only after a technical expert has determined that the main explosion protection characteristics still correspond to the required standard and after issuing a certificate or awarding a test mark.
 - 1.2 Item 1.1 shall not be valid if the component has been individually tested by the manufacturer and it is confirmed that the main characteristics for application in hazardous areas comply with the stipulated technical requirements.
2. The ElexV is only valid within the Federal Republic of Germany. In foreign countries, the relevant binding regulation corresponding to ElexV must be adhered to.
3. Repair work may only be carried out using original components of the original manufacturer, otherwise the standards stipulated in the certificate of conformity shall not be fulfilled.
4. When ordering spare parts, exact information on previous delivery such as type of protection (Exd, Exi), No. of the certificate of conformity, serial and item No.s must be supplied.
5. Ex-protected thermometers only fulfil the required safety requirements as a unit component, as determined by the certificate of conformity. Measuring insets or connecting heads alone do not satisfy the explosion-protection requirements.
6. If ABB supplies thermometers destined for operation in hazardous areas without protecting tubes, it will be the responsibility of the owner to see to it that
 - these thermometers are deployed only in zones which are permissible in accordance with the certificate of conformity or with the manufacturer's declaration (e.g. zones 1or2),
 - a protecting tube is provided for an eventually necessary separation of a zone (e.g. zone 0 from zone 1). Such a tube must correspond fully to the "special conditions" spelled out in the respective certificate of conformity.
 - ABB shall inform the plant owner of the above subject matter in appropriate form, e.g. by drawing attention to this leaflet of instructions.

4 Installation

4.1 Installation

The thermometer (thermocouple, resistance thermometer) must be brought into contact with the medium to be measured in the best possible manner.

To avoid thermal conduction errors, the immersion depth should be:

- in fluids 6 ... 8 times greater than the protective tube diameter.
- in gases 10 ... 15 times greater than the protective tube diameter.

If only very short insertion lengths are possible, special designs should be applied. It is often helpful to install in a pipe bend, whereby the protective tube must be positioned against the flow of the medium.

4.2 Connecting wires

For all connecting wires it is important to ensure that proper contact has been established and that corrosion, humidity, pollution, electrical parasitic interferences of power cables etc. are avoided.

The cables should be insulated to counter the ambient influences (dry, humid, chemically aggressive, hot), whereby the ambient temperature of both the cable and the connection head may not exceed 100 °C.

Please pay attention to the valid standards and regulations when selecting the types of cables to be used.

If possible, all measuring systems should be operated in ungrounded condition, or only grounded at one point.

When using thermocouples connected to protective tubes, these should be the only ground/mass connection

4.3 Thermowells

Thermometers can be installed in any mounting position, preferably hanging vertically, up to temperatures reaching about 500 °C.

Ceramic thermowells must be protected from mechanical stress (bumps, bends), including temperature shocks e.g. through direct flame contact.

If they are applied to hot processes (e.g. when changing the thermocouple), they must be either prewarmed or inserted very slowly (1 ... 2 cm/min at 1600 °C, 10 ... 20 cm/min at 1200 °C). This also applies when removing the hot protecting tube.

Care must be taken to avoid suspending lengths > 500 mm for temperatures > 1200 °C.

5 Maintenance / Repair

The thermometer and the entire temperature measuring circuit must be checked at regular intervals for

- wear and tear of protecting tube or chemical activity,
- drifts of the measuring element caused by ageing,
- reduction of insulation resistance through humidity and pollution
- improper contact of the wire connections and
- mechanical and chemical damage of the thermometer and wires.

Resistance thermocouple circuits can be checked by replacing the measuring element with a known defined resistance, thereby simulating a specific temperature.

Thermoelement measuring circuits can be checked by connecting a mV voltage of a known variable to the measuring circuit, instead of the thermocouple.

In both cases, substantial deviations from the set point can be determined, also if the thermometer or the instrumentation is the cause of function errors.

The insulation resistance of the entire ungrounded measuring circuit (wires and thermometer) against ground should be $> 1 \text{ M}\Omega$ (measured with 100 V DC).

6 Error messages

6.1 Quick test

Perform quick tests of thermocouples and resistance thermometers as well as the associated measuring circuits in the uninstalled state.

Instruments required:

- Millivolt meter
- Resistance meter or resistance bridge
- Isolation meter with 60 ... 100 V voltage (all measurements at room temperature)

The following tests can be performed:

- Check opening and isolation at room temperature.
- Locate wire breaks by “knocking”.

A thermocouple is regarded as functioning correctly when $R < 20 \Omega$ (wire $> 0.5 \text{ mm } \varnothing$). The value depends on the wire cross section and the length. $R_{\text{isol}} = 100 \text{ M}\Omega$ (with isolated thermocouple).

A resistance thermometer is regarded as functioning correctly when $R \gg 110 \Omega$ (for Pt100), $R_{\text{isol}} > 100 \text{ M}\Omega$.

- The heating of the thermocouples or resistance thermometers to approx. 200 °C to 400 °C (without temperature controls) allows for further conclusions to be drawn about interruptions, reversed polarity (with thermocouples), too little isolation resistance, etc.



Note

The accuracy of temperature sensors according to the ISO 9000 requirements can only be checked by comparison with a reference element. In most cases, the deinstallation and test in a test oven are necessary.

6.2 Error table

The complete temperature measurement circuit should be routinely tested. The following tables contain the most important errors with the possible causes and suggestions for their remedy.

Error	Error cause	Error remedy
Measurement signal fault	<ul style="list-style-type: none"> Electrical/magnetic interspersion 	<ul style="list-style-type: none"> Keep at least 0.5 m distance between the measurement wires with parallel running. Electrostatic shielding via on a point grounded foil/netting. Twisting of the wires (pairs) against magnetic interspersion. Right angle intersecting of measurement wires with interfering leading wires. Use of transmitters.
	<ul style="list-style-type: none"> Ground loops 	<ul style="list-style-type: none"> Only one grounding point in measurement circuit or measurement system "floating" (not grounded).
	<ul style="list-style-type: none"> Removal of the isolation resistance 	<ul style="list-style-type: none"> Moisture has possibly penetrated into the thermometer or the measuring inset; dry if necessary and seal again. Replace measuring inset. Check whether the thermometer is thermally overloaded.

Error	Error cause	Error remedy
Response times too long, faulty signals	<ul style="list-style-type: none"> • Incorrect installation location: <ul style="list-style-type: none"> – In the flow shadow – In the influence of a heat source 	<ul style="list-style-type: none"> • Select installation location so that the medium can transfer its temperature undisturbed.
	<ul style="list-style-type: none"> • Incorrect installation-method: <ul style="list-style-type: none"> – Insufficient installation depth – Too much heat dissipation 	<ul style="list-style-type: none"> • Installation depth approx. temperature sensitive length + 6 x d (fluids) to 10 x (gases) d (d = outer thermowell diameter). • Ensure thermal contacts, above all with surface measurements, through appropriate contact surfaces and/or thermal conducting material.
	<ul style="list-style-type: none"> • Thermowell too thick • Thermowell hole too large 	<ul style="list-style-type: none"> • Select the smallest thermowell possible for the process. • Response time as a first approximation proportional to the cross section or volume of the thermometer, depending on the thermal transition values and air gaps in the installation. • The latter with contact agent.
	<ul style="list-style-type: none"> • Deposits on the thermowell 	<ul style="list-style-type: none"> • Remove during inspections. • If possible, select a different thermowell or another installation location.
Interruptions in the thermometer	<ul style="list-style-type: none"> • Vibration 	<ul style="list-style-type: none"> • Enforced springs on the measuring inset. • Shortening of the installation length. • Relocation of the measuring location (if possible). • Special construction of measuring inset and thermowell.
Heavily corroded thermowell	<ul style="list-style-type: none"> • Composition of the medium not as assumed or has changed • Improper thermowell material selected 	<ul style="list-style-type: none"> • Check medium • Possibly analyze the defective thermowell and then select a more suitable material. • Use an additional surface protectant. • Under certain circumstances, the thermowell may have to be replaced regularly as a wear part.

6.3 Specific errors with thermocouples:

Error description	Error cause	Error remedy
Fluctuating temperature indication with otherwise trouble-free measurement circuit assembly of the thermocouple	<ul style="list-style-type: none"> Reference junctions - temperature or voltage not constant 	<ul style="list-style-type: none"> Temperature or supply voltage must remain constant. <ul style="list-style-type: none"> < 0.1 % (check instruments). With non-stainless steel thermocouples, taken with the entire value into the measurement, with stainless steel thermocouples with only approx. half of the value.
Strong deviations of the temperature indicator from table values for thermocouples	<ul style="list-style-type: none"> Incorrect material combinations: Poor electrical contacts <ul style="list-style-type: none"> Parasitic voltages (thermovoltages, galvanic voltages) Incorrect compensating line 	<ul style="list-style-type: none"> Check thermocouples and lines for: <ul style="list-style-type: none"> Correct pairing. Correct compensating line. Correct polarity. Approved ambient temperature at connection head.

6.4 Specific errors with resistance thermometers:

Error description	Error cause	Error remedy
Too high or fluctuating temperature indicator despite known cross section and measurement resistance of the resistance thermometer	<ul style="list-style-type: none"> Line resistances too high, not compensated Temperature-related resistance change of the supply line 	<ul style="list-style-type: none"> If still possible: <ul style="list-style-type: none"> Running of 2 lines or larger cross section possibly only after a more accessible location. Shorten the supply line. Line compensation. Switching to 3- or 4-wire circuits. Use of head-mounted transmitters.
Fluctuating temperature indication with otherwise trouble-free measurement circuit assembly of the resistance thermometer	<ul style="list-style-type: none"> Voltage or power supply not constant 	<ul style="list-style-type: none"> Must be held constant to < 0.1 %. With out-of-tune bridges and power/voltage measurements (4-wire circuit), measured with the entire value.

7 Electrical connection

7.1 Resistance thermometers

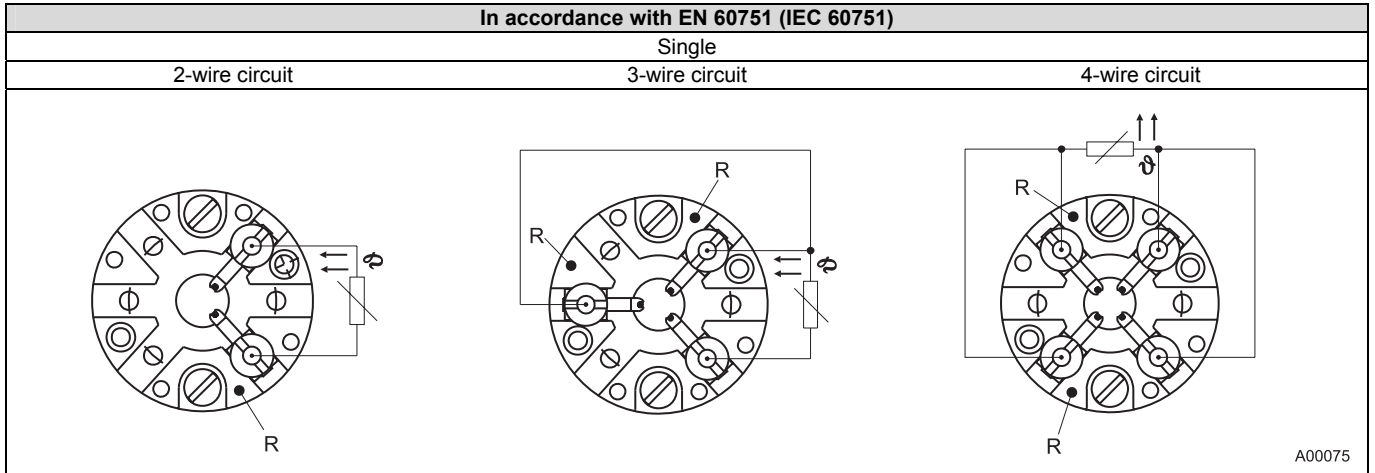


Fig. 1
R red

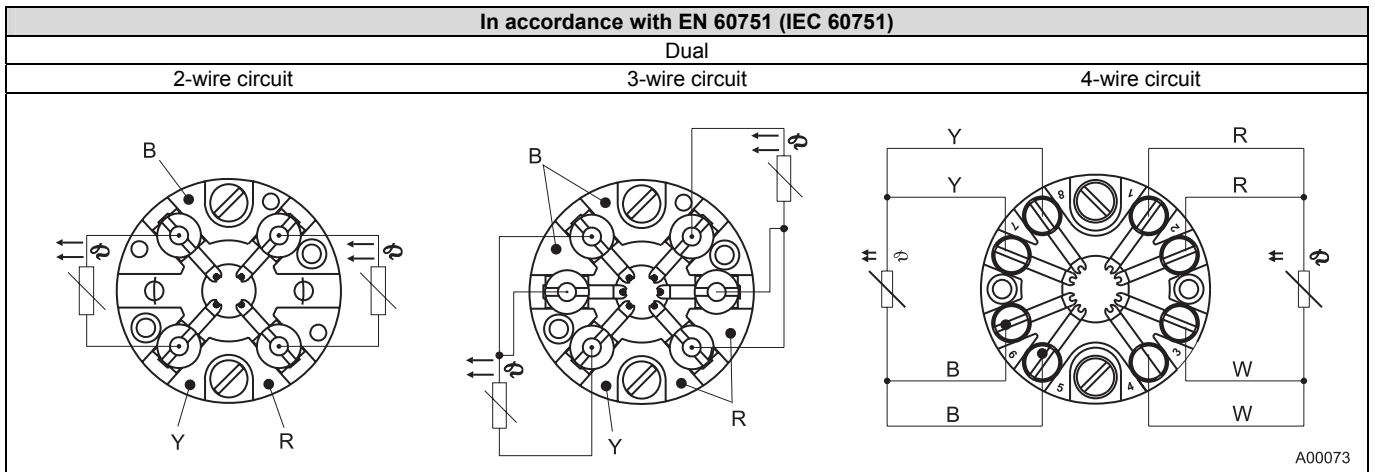


Fig. 2
Y yellow
B black
R red
W white

7.2 Thermoelements

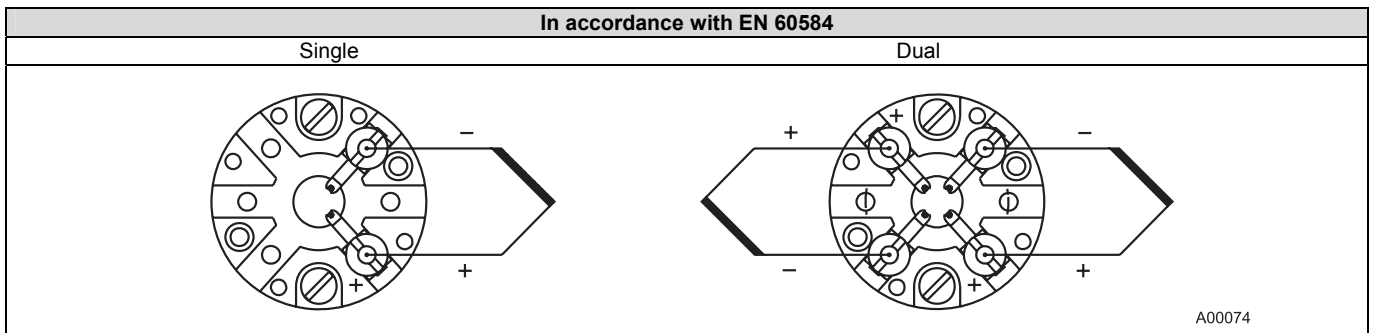


Fig. 3

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