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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial platinum resistance thermometers and platinum temperature sensors

Thermomètres à résistance de platine et capteurs hermométriques de platine industriels

IEC 60751:2022-01(en-fr)

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INTERNATIONAL
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INDUSTRIAL PLATINUM RESISTANCE THERMOMETERS AND PLATINUM TEMPERATURE SENSORS

FOREWORD

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IEC 60751 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) formula of resistance versus temperature relationship become the standard specification and the numerical table ceases to be the standard,
b) new clause "Compliance and requirement" is introduced,
c) tolerance acceptance test is modified,
d) an expanded marking system is introduced to accommodate special valid temperature range,
e) vibration test method is revised,
f) cold seal is introduced as an additional type test,

g) numerical table of resistance versus temperature is included in Annex A as information.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65B/1210/FDIS	65B/1214/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INDUSTRIAL PLATINUM RESISTANCE THERMOMETERS AND PLATINUM TEMPERATURE SENSORS

1 Scope

This International Standard specifies the requirements, in addition to the resistance versus temperature relationship, for both industrial platinum resistance thermometers (later referred to as "thermometers") and industrial platinum resistance temperature sensors (later referred to as "platinum resistors") whose electrical resistance is derived from defined functions of temperature.

Values of temperature in this document are in terms of the International Temperature Scale of 1990, ITS-90. A temperature in the unit °C of this scale is denoted by the symbol t, except in Table A.1 where the full nomenclature t_{90} /°C is used.

This document applies to platinum resistors whose temperature coefficient α, defined as

$$\alpha = \frac{R_{100} - R_0}{R_0 \cdot 100\,°\mathrm{C}},$$

is conventionally written as $\alpha = 3{,}851 \cdot 10^{-3}$ °C^{-1}, where R_{100} is the resistance at t = 100 °C and R_0 is the resistance at t = 0 °C.

This document covers platinum resistors and thermometers for the temperature range −200 °C to +850 °C with different tolerance classes. It can also cover particular platinum resistors or thermometers for a part of this temperature range.

For resistance versus temperature relationships with uncertainties less than 0,1 °C, which are possible only for platinum resistors or thermometers with exceptionally high stability and individual calibration, a more complex interpolation equation than is presented in this document can be necessary. The specification of such equations is outside the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 61152, *Dimensions of metal-sheathed thermometer elements*

IEC 61515:2016, *Mineral insulated metal-sheathed thermocouple cables and thermocouples*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
platinum resistor
resistor made from a platinum wire or film with defined electrical characteristics, embedded in an insulator (in most cases glass or ceramic), designed to be assembled into a platinum resistance thermometer or into an integrated circuit

3.2
platinum resistance thermometer
thermometer
PRT
temperature-responsive device consisting of one or more sensing platinum resistors within a protective sheath, internal connecting wires, and external terminals to permit connection of electrical measurement instruments

Note 1 to entry: Mounting means and connection heads can be included. Not included is any separable protection tube or thermowell.

3.3
nominal resistance
expected resistance R_0 of a platinum resistor or thermometer at 0 °C, declared by the supplier and shown in the thermometer marking, usually rounded to the nearest ohm

Note 1 to entry: Platinum resistors are often characterized by their nominal resistance. For example, a platinum resistor with R_0 = 100 Ω is often referred to as a Pt100

3.4
terminals
termination of the connections supplied with the platinum resistance thermometer

Note 1 to entry: Typical types of terminals are:

- screws or clamps on the terminal socket,
- pins of fixed connectors,
- open ends of fixed cables or equivalents.

3.5
temperature-sensitive length
length of the thermometer whose temperature directly influences the resistance measured

Note 1 to entry: Usually, the temperature-sensitive length is related to the length of the platinum resistor.

3.6
minimum immersion depth
immersion depth at which the change from the calibration at full immersion does not exceed 0,1 °C

3.7
tolerance
maximum allowable deviation of $R(t)$ measured at temperature t from the nominal resistance versus temperature relationship expressed as $\Delta t(t)$ in °C

3.8
dielectric strength
maximum voltage between all parts of the electric circuit and the sheath of the thermometer or, in the case of a thermometer with two or more sensing circuits, between two individual circuits that the thermometer can withstand without damage

3.9
insulation resistance
electrical resistance measured between any part of the electric circuit and the sheath at ambient or elevated temperatures and with a specified measuring voltage (AC or DC)

3.10
self-heating
increase of the temperature of the platinum resistor or of the platinum resistor in a thermometer caused by the dissipated energy of the measuring current

3.11
self-heating coefficient
temperature rise due to dissipated energy by measuring current in a resistor expressed with the unit °C/mW

3.12
thermal response time
time a thermometer takes to reach a specified percentage of a step change in temperature

3.13
thermoelectric effect
effect of inducing electro-motive force (abbreviated by e.m.f hereafter) caused by different metals used in the electric circuit of the thermometer and by thermoelectric inhomogeneity of the internal leads at the conditions of temperature gradients along the leads

3.14
hysteresis
resistance difference at the middle of the temperature range between before and after exposing the thermometer to the lower and upper limit of the temperature range

3.15
expanded uncertainty
quantity defining an interval about the result of a measurement that can be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

Note 1 to entry: For reference, see 3.16.

3.16
coverage factor
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

Note 1 to entry: Coverage factor, k, is typically in the range 2 to 3. In this document, $k = 2$ is chosen, the confidence level of which is 95 %. Refer to Bibliography [1].

4 Characteristics

4.1 General

The nominal resistance versus temperature relationship for platinum resistors and thermometers and their tolerance class are standardized. This specification is applied to a sensing platinum resistor at its connecting points and to a complete thermometer at its terminals.

In the case of two-wire connections (see 5.5), the resistance values of the leads between the connecting point of the platinum resistor and the terminals shall be considered. They shall be subtracted from measured resistances. In some cases, it is also advisable to consider the temperature coefficient of the lead wires, the geometrical characteristics of the wires, and the temperature distribution along their length. This information may be supplied to users as additional information (refer to Clause 7).

4.2 Nominal resistance versus temperature relationship

The resistance versus temperature relationships used in this document are as follows:

For the range −200 °C to 0 °C:

$$R_t = R_0\ [1 + \mathrm{A}t + \mathrm{B}t^2 + \mathrm{C}(t - 100\ °\mathrm{C})\ t^3]$$

For the range of 0 °C to 850 °C:

$$R_t = R_0\ (1 + \mathrm{A}t + \mathrm{B}t^2)$$

where

R_t is the resistance at the temperature t,

R_0 is the resistance at t = 0 °C.

The constants in these equations are,

A = 3,908 3 × 10^{-3} °C^{-1}

B = −5,775 × 10^{-7} °C^{-2}

C = −4,183 × 10^{-12} °C^{-4}.

4.3 Numerical table of resistance values

Table A.1 and Table A.2 are derived from the equations and coefficients specified in 4.2 for a thermometer or platinum resistor of nominal resistance R_0 of 100 Ω.

Table A.1 and Table A.2 are applicable to any thermometer and platinum resistor having any value of R_0.

In this case, the resistance values in Table A.1 and Table A.2 shall be multiplied by the factor R_0 / 100 Ω.

NOTE 1 In this edition, the numerical tables given in Annex A cease to be normative; they are now informative. The specification of this document is the formula described in 4.2 with which user can calculate numerical value of R_t.

NOTE 2 The most frequently used device has R_0 of 100 Ω. Devices with R_0 of 10 Ω, 500 Ω or 1000 Ω are used frequently as well.

5 Compliance and requirements

5.1 Compliance

In order for a thermometer to be compliant with this document, it shall be made from a platinum resistor which is compliant with this document.

Platinum resistors and thermometers shall be tested to prove that the device meets all the applicable requirements specified in this document. Suppliers shall be responsible for conducting the tests and for proving that the device conforms to this document before transferring the device to the user. The test method and evaluation are specified in this document.

5.2 Tolerance classes

5.2.1 Tolerance class and its temperature range of validity

Tolerance classes are given in Table 1 for a platinum resistor and in Table 2 for a thermometer for any value of R_0.

These tolerance classes are closely related to the operable temperature range. Therefore, the temperature ranges of validity of a tolerance class are shown in the adjacent column in the table. Temperature ranges of validity are based on the working experience with film and wire platinum resistors.

A thermometer that has a modified tolerance or temperature range of validity can still be compliant with this document provided it satisfies all the applicable requirements, other than the tolerance or the temperature range of validity, and the modification is notified to the user. Details on this are described in 5.2.3.2.

Thermometers or platinum resistors without the specified temperature range of validity for the tolerance are not permitted in this document.

5.2.2 Tolerance class of platinum resistors

Table 1 specifies the tolerance class for platinum resistors. Tolerances and ranges of validity that differ from values given in Table 1 shall be agreed between the supplier and the user.

Table 1 – Tolerance class of platinum resistors

Wire wound platinum resistors		Film platinum resistors		Tolerance (°C)
Tolerance class	**Temperature range of validity** (°C)	**Tolerance class**	**Temperature range of validity** (°C)	
W 0,1	−100 to +350	F 0,1	0 to +150	±(0,1 + 0,001 7 ∣ t ∣)
W 0,15	−100 to +450	F 0,15	−30 to +300	±(0,15 + 0,002 ∣ t ∣)
W 0,3	−196 to +660	F 0,3	−50 to +500	±(0,3 + 0,005 ∣ t ∣)
W 0,6	−196 to +660	F 0,6	−50 to +600	±(0,6 + 0,01 ∣ t ∣)
NOTE The symbol ∣ t ∣ denotes modulus of temperature in °C without regard to the sign.				

5.2.3 Tolerance classes and marking of thermometers

5.2.3.1 Tolerance classes of thermometers

Table 2 specifies the tolerance class for thermometers.

Table 2 – Tolerance class of thermometers

Tolerance class	Temperature range of validity (°C) for thermometers made using		Tolerance (°C)
	Wire wound platinum resistors	Film platinum resistors	
AA	−50 to +250	0 to +150	±(0,1 + 0,0017 | t |)
A	−100 to +450	−30 to +300	±(0,15 + 0,002 | t |)
B	−196 to +600	−50 to +500	±(0,3 + 0,005 | t |)
C	−196 to +600	−50 to +600	±(0,6 + 0,01 | t |)
NOTE The symbol | t | denotes modulus of temperature in °C without regard to the sign.			

5.2.3.2 Special tolerance classes of thermometers

Tolerances and ranges of validity that differ from the values given in Table 2 shall be agreed between the supplier and the user. These special thermometers shall be clearly distinguished from a standard device by the "-sp" marking as is specified in 5.2.3.3. Recommended special tolerance classes may be constructed as multiples or fractions of class B tolerance. Example 1 in 5.2.3.3 demonstrates this case.

It is also left to the suppliers and the users to establish a special class for their thermometers with a temperature range different from the ranges in Table 2. Special temperature ranges of validity may be defined for restricted or extended temperature ranges. Example 2 in 5.2.3.3 demonstrates this case.

5.2.3.3 Marking of thermometers

Each thermometer shall be marked or labelled accordingly so that the user can confirm, either directly or indirectly, the number of platinum resistors, connecting wire configuration, tolerance class, and its temperature range of validity.

Marking Example1: 2 × Pt100 / (2/3B) –F-sp / 3 / −50 / +250

This means:

- Two platinum resistor construction,
- Nominal resistance: R_0 = 100 Ω,
- Tolerance class: 2/3B [Tolerance value ±(0,2 + 0,0033 | t |)],
- Platinum resistor type: F (film),
- Special tolerance class [(2/3)B]: suffix –sp of F is the notification. It means that the tolerance class is different from Table 2 and range of validity differs also,
- Wire configuration: 3 wire configuration (see Figure 1),
- Range of validity: −50 °C to +250 °C,
- Lower temperature limit of the thermometer: −50 °C,
- Upper temperature limit of the thermometer: +250 °C.

Marking Example 2: 1 × Pt100 / AA-W-sp / 4 / −50 / +300

This means:

- One platinum resistor construction,
- Nominal resistance: R_0 = 100 Ω,

- Tolerance class: AA,
- Platinum resistor type: W (wire wound),
- Special range of validity; suffix -sp of W means that range of validity is different from Table 2,
- Wire configuration: 4 wire configuration (see Figure 1),
- Range of validity: −50 °C to +300 °C,
- Lower temperature limit of the thermometer: −50 °C,
- Upper temperature limit of the thermometer: +300 °C.

5.3 Measuring current

The measuring current of a platinum resistor or thermometer shall be limited to a value at which the self-heating of the thermometer under conditions specified in 6.4.3 does not exceed 25 % of the tolerance value of the declared tolerance class. The measuring current is usually not more than 1 mA for a 100 Ω wire wound platinum resistor.

5.4 Electrical supply

Platinum resistors and thermometers shall be constructed so that they are suitable for use in measuring systems using direct current or alternating current at frequencies up to 100 Hz. Some measuring systems may require operation at higher frequencies.

5.5 Connecting wire configuration

Thermometers of tolerance class better than class B shall have 3-wire or 4-wire configuration with 4-wire configuration being recommended.

Thermometers may be constructed with one or more platinum resistors and a variety of internal connecting wire configurations. A typical example of identification and designation of the terminals is shown in Figure 1.

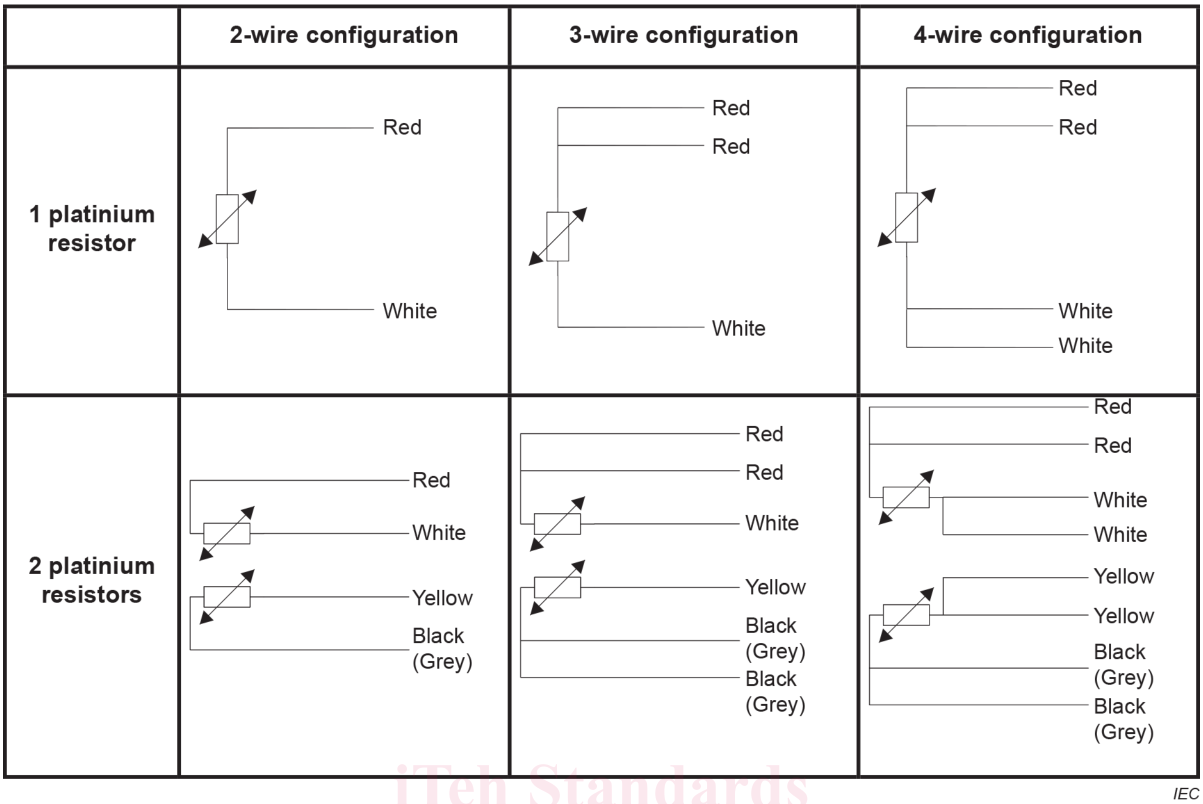

Figure 1 – Example of connecting configurations

6 Tests

6.1 General

6.1.1 Test categories

Tests shall be performed to prove that platinum resistors or thermometers conform to the requirements of this document. The tests are categorised as routine production test, type test, and additional type test. It is not intended or recommended that all tests be performed on every platinum resistor or thermometer supplied. Different kinds of tests are therefore described from 6.1.2 to 6.1.5.

6.1.2 Routine production tests

The routine production test shall be performed on every platinum resistor or thermometer manufactured in accordance with this document. This routine production test can be replaced by a sampling test provided that technically established control procedures are in place to demonstrate that the statistical sampling test is sufficient. If the routine production test is replaced by a sampling test, the user shall be informed.

6.1.3 Type tests

Type tests shall be carried out on a platinum resistor or a thermometer of each particular design and temperature range of operation. The routine production test items shall also be performed on the type tests. These tests are subdivided into tests for all forms of platinum resistors or thermometers.