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Platinum resistance thermometers

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Electric Measuring Instruments Manufacturers' Association (JEMIMA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS C 1604:1997** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

Platinum resistance thermometers

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **IEC 60751** published in 2008 with some modifications of the technical contents adding some specifications that are not given in the corresponding International Standard.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies the platinum resistance thermometer used for temperature measurement (hereafter referred to as “platinum resistance thermometer”) and the platinum resistor integrated into a platinum resistance thermometer to measure temperature (hereafter referred to as “platinum resistor”).

NOTE 1 Values of temperature in this Standard are in terms of the International Temperature Scale of 1990, **ITS-90**.

NOTE 2 Temperatures in degrees Celsius are denoted by the symbol t .

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

IEC 60751 : 2008 *Industrial platinum resistance thermometers and platinum temperature sensors* (MOD)

The symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7502 *Micrometer callipers*

JIS B 7507 *Vernier, dial and digital callipers*

JIS B 7516 *Metal rules*

JIS Z 8103 *Glossary of terms used in measurement*

JIS Z 8703 *Standard atmospheric conditions for testing*

JIS Z 8704 *Temperature measurement—Electrical methods*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS Z 8103** and the following apply.

3.1 platinum resistance thermometer

platinum thermometer consisting of platinum resistor, internal connecting wire, insulation material, protection tube and terminal, except any separable protection tube or thermowell

3.2 metal sheathed resistance thermometer

platinum resistance thermometer which is so manufactured that it has flexibility and integrated structure by embedding the protection tube, the internal connecting wires and platinum resistor in insulating materials

3.3 platinum resistor

resistor made from a platinum wire or film with defined electrical characteristics, embedded in an insulator (in most cases glass or ceramic)

3.4 internal connecting wire

connecting wires which connect terminals of the platinum resistor and platinum resistance thermometer

3.5 insulating material

insulation for preventing short circuit of internal connecting wires to each other and protection tube

3.6 protection tube

tube to be attached for protecting the platinum resistor and the internal connecting wires from directly affected by an article under temperature measurement or atmosphere

3.7 temperature sensitive length

part of a platinum resistance thermometer which is to have the same temperature as that of measurement object

The platinum resistor and a part of protection tube in the vicinity thereof are included.

3.8 terminals

termination of metal fittings or of internal connecting wires which have been fitted to the platinum resistance thermometer for the purpose of leading out the resistance variation of the platinum resistor due to temperature

3.9 reference resistance

resistance value which the platinum resistance thermometer or platinum resistor should have at the determined temperature

NOTE : The resistance value is obtained by formula (2) or (3).

3.10 measuring current

current to be passed through the platinum resistor for measuring the resistance value

3.11 dielectric strength

maximum voltage (d.c. or a.c.) between all parts of the electric circuit and the sheath of the platinum resistance thermometer or, in the case of a thermometer with two or more sensing circuits, between two individual circuits which the thermometer can withstand without damage

3.12 insulation resistance

electrical resistance measured between any part of the electric circuit and the protection tube at ambient or elevated temperature and with a specified measuring voltage (a.c. or d.c.)

3.13 nominal resistance

expected resistance of the platinum resistor or the platinum resistance thermometer at 0 °C

3.14 self-heating

increase of the temperature of the platinum resistor or the platinum resistor in a platinum resistance thermometer caused by the dissipated energy of the measuring current

3.15 self-heating coefficient

coefficient which describes the temperature increase of the platinum resistor per unit power dissipated

NOTE : The coefficient is expressed in °C/mW.

3.16 thermal response time

time a platinum resistance thermometer takes to respond at a specified percentage to a step change in temperature

3.17 thermoelectric effect

effect of inducing the electro-motive force (EMF) caused by different metals used in the electric circuit of the platinum resistance thermometer and by thermoelectric inhomogeneity of the internal leads at the conditions of temperature gradients along the leads

3.18 tolerance

range in which this Standard requires the value obtained by subtracting the reference resistance from the resistance value of a platinum resistor or a platinum resistance thermometer to be as a value of which the temperature conversion is performed

3.19 hysteresis

property of a platinum resistor or platinum resistance thermometer whereby it gives different output values in relation to its input values depending on the directional sequence in which the input values have been applied

3.20 uncertainty

non-negative parameter characterizing the variation of the quantity values, being attributed to a measurand based on the information used

NOTE : The parameter may be, for example, a standard deviation called standard measurement uncertainty (or a given multiple of it), or the half-width of an interval having a stated coverage probability.

3.21 expanded uncertainty

quantity defining an interval that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

3.22 standard uncertainty

measurement uncertainty expressed as a standard deviation

3.23 combined standard uncertainty

standard measurement uncertainty obtained using the individual standard measurement uncertainty accompanying the input quantities in a measurement model

3.24 coverage factor

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

3.25 control band

range which is set up and controlled by a user in order to maintain the soundness of a system

3.26 rectangular distribution

probability distribution assuming that observed values are uniformly distributed in a certain interval

3.27 pool values

standard deviation calculated from the accumulated data obtained from the long-term continuous measurement under the same measurement condition, the existing information, the technical information supplied by the manufacturer, etc.

3.28 uncertainty budget table

table in which measurement uncertainty, components of the measurement uncertainty, and their calculations and combined results are listed

NOTE : The uncertainty budget should include the measurement model, measurement uncertainty accompanying estimates and quantities of measurement model, covariance, type of the probability density function applied, degree of freedom, type of evaluation of measurement uncertainty and coverage factor.

3.29 traceability

property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of comparison, each contributing to the measurement uncertainty

The reference is normally a national standard or an international standard.

4 Classification

4.1 Classification of platinum resistors

The platinum resistors shall be generally classified as given in table 1.

In addition, the platinum resistor may have other nominal resistance than those in table 1.

Table 1 Classification

Symbol	Nominal resistance Ω	R_{100}/R_0
Pt100	100	1.385 1
Pt500	500	1.385 1
Pt1000	1 000	1.385 1
NOTE 1 R_{100} is the resistance value of the platinum resistor at 100 °C.		
NOTE 2 R_0 is the resistance value of the platinum resistor at 0 °C.		

The temperature coefficient α of the platinum resistor is calculated by formula (1).

where, when R_{100} is the resistance value at $t = 100$ °C and R_0 is the resistance value at $t = 0$ °C, $\alpha = 3.851 \times 10^{-3}$ °C⁻¹.

$$\alpha = \frac{R_{100} - R_0}{100 \text{ °C} \times R_0} \dots\dots\dots (1)$$

4.2 Classification of platinum resistance thermometers

The classification of the platinum resistance thermometer shall be the same as that the platinum resistor used.

5 Tolerances

5.1 Tolerances of platinum resistors

The tolerances of platinum resistors shall be as given in table 2. When the temperature range of validity is different from that in table 2, this Standard may be applied by always stating the temperature range clearly.

Table 2 Tolerances of platinum resistors

Wire wound platinum resistors		Film platinum resistors		Tolerance ^{a)}
Tolerance class	Temperature range of validity °C	Tolerance class	Temperature range of validity °C	
W0.1	– 100 to 350	F0.1	0 to 150	$\pm (0.1\text{ °C} + 0.001\,7 t)$
W0.15	– 100 to 450	F0.15	– 30 to 300	$\pm (0.15\text{ °C} + 0.002 t)$
W0.3	– 196 ^{b)} to 660	F0.3	– 50 to 500	$\pm (0.3\text{ °C} + 0.005 t)$
W0.6	– 196 ^{b)} to 660	F0.6	– 50 to 600	$\pm (0.6\text{ °C} + 0.01 t)$
Notes ^{a)} $ t $ is an absolute value of temperature (unit: °C).				
^{b)} A temperature of – 196 °C is selected as a temperature near the boiling point of liquid nitrogen.				

5.2 Tolerances of platinum resistance thermometers

The classification of tolerances of platinum resistance thermometers shall be as given in table 3. When the temperature range of validity is different from that in table 3, this Standard may be applied by always stating the temperature range clearly. Furthermore, the concrete tolerances and the temperature range of validity of platinum resistance thermometers shall be as given in table 4 and table 5. However, the tolerance classes AA and A shall not be applied to the platinum resistance thermometers of 2-wire-configuration.

Table 3 Tolerances of platinum resistance thermometers

Tolerance class	Temperature range of validity °C		Tolerance ^{a)}
	Wire wound platinum resistors	Film platinum resistors	
AA	– 50 to 250	0 to 150	$\pm (0.1\text{ °C} + 0.001\,7 t)$
A	– 100 to 450	– 30 to 300	$\pm (0.15\text{ °C} + 0.002 t)$
B	– 196 ^{b)} to 600	– 50 to 500	$\pm (0.3\text{ °C} + 0.005 t)$
C	– 196 ^{b)} to 600	– 50 to 600	$\pm (0.6\text{ °C} + 0.01 t)$
Notes ^{a)} $ t $ is an absolute value of temperature (unit: °C).			
^{b)} A temperature of – 196 °C is selected as a temperature near the boiling point of liquid nitrogen.			

Table 4 Tolerances of platinum resistance thermometers using wire wound platinum resistors

Measurement temperature	Tolerance class							
	Platinum resistance thermometer AA		Platinum resistance thermometer A		Platinum resistance thermometer B		Platinum resistance thermometer C	
	Platinum resistor to be used							
	Platinum resistor W0.1		Platinum resistor W0.15		Platinum resistor W0.3		Platinum resistor W0.6	
− 196 °C	—	—	—	—	± 1.28 °C	± 0.55 Ω	± 2.56 °C	± 1.10 Ω
− 150 °C	—	—	—	—	± 1.05 °C	± 0.44 Ω	± 2.10 °C	± 0.87 Ω
− 100 °C	—	—	± 0.35 °C	± 0.14 Ω	± 0.80 °C	± 0.32 Ω	± 1.60 °C	± 0.65 Ω
− 50 °C	± 0.19 °C	± 0.07 Ω	± 0.25 °C	± 0.10 Ω	± 0.55 °C	± 0.22 Ω	± 1.10 °C	± 0.44 Ω
− 30 °C	± 0.15 °C	± 0.06 Ω	± 0.21 °C	± 0.08 Ω	± 0.45 °C	± 0.18 Ω	± 0.90 °C	± 0.35 Ω
0 °C	± 0.10 °C	± 0.04 Ω	± 0.15 °C	± 0.06 Ω	± 0.30 °C	± 0.12 Ω	± 0.60 °C	± 0.23 Ω
50 °C	± 0.19 °C	± 0.07 Ω	± 0.25 °C	± 0.10 Ω	± 0.55 °C	± 0.21 Ω	± 1.10 °C	± 0.42 Ω
100 °C	± 0.27 °C	± 0.10 Ω	± 0.35 °C	± 0.13 Ω	± 0.80 °C	± 0.30 Ω	± 1.60 °C	± 0.61 Ω
150 °C	± 0.36 °C	± 0.13 Ω	± 0.45 °C	± 0.17 Ω	± 1.05 °C	± 0.39 Ω	± 2.10 °C	± 0.78 Ω
200 °C	± 0.44 °C	± 0.16 Ω	± 0.55 °C	± 0.20 Ω	± 1.30 °C	± 0.48 Ω	± 2.60 °C	± 0.96 Ω
250 °C	± 0.53 °C	± 0.19 Ω	± 0.65 °C	± 0.24 Ω	± 1.55 °C	± 0.56 Ω	± 3.10 °C	± 1.12 Ω
300 °C	—	—	± 0.75 °C	± 0.27 Ω	± 1.80 °C	± 0.64 Ω	± 3.60 °C	± 1.28 Ω
350 °C	—	—	± 0.85 °C	± 0.30 Ω	± 2.05 °C	± 0.72 Ω	± 4.10 °C	± 1.44 Ω
400 °C	—	—	± 0.95 °C	± 0.33 Ω	± 2.30 °C	± 0.79 Ω	± 4.60 °C	± 1.58 Ω
450 °C	—	—	± 1.05 °C	± 0.36 Ω	± 2.55° C	± 0.86 Ω	± 5.10 °C	± 1.73 Ω
500 °C	—	—	—	—	± 2.80 °C	± 0.93 Ω	± 5.60° C	± 1.86 Ω
550 °C	—	—	—	—	± 3.05 °C	± 1.00 Ω	± 6.10 °C	± 1.99 Ω
600 °C	—	—	—	—	± 3.30 °C	± 1.06 Ω	± 6.60 °C	± 2.12 Ω
NOTE : The resistance values in the table show the example of calculation of Pt100.								

Table 5 Tolerances of platinum resistance thermometer using film platinum resistors

Measurement temperature	Tolerance class							
	Platinum resistance thermometer AA		Platinum resistance thermometer A		Platinum resistance thermometer B		Platinum resistance thermometer C	
	Platinum resistor to be used							
	Platinum resistor F0.1		Platinum resistor F0.15		Platinum resistor F0.3		Platinum resistor F0.6	
− 50 °C	—	—	—	—	± 0.55 °C	± 0.22 Ω	± 1.10 °C	± 0.44 Ω
− 30 °C	—	—	± 0.21 °C	± 0.08 Ω	± 0.45 °C	± 0.18 Ω	± 0.90 °C	± 0.35 Ω
0 °C	± 0.10 °C	± 0.04 Ω	± 0.15 °C	± 0.06 Ω	± 0.30 °C	± 0.12 Ω	± 0.60 °C	± 0.23 Ω
50 °C	± 0.19 °C	± 0.07 Ω	± 0.25 °C	± 0.10 Ω	± 0.55 °C	± 0.21 Ω	± 1.10 °C	± 0.42 Ω
100 °C	± 0.27 °C	± 0.10 Ω	± 0.35 °C	± 0.13 Ω	± 0.80 °C	± 0.30 Ω	± 1.60 °C	± 0.61 Ω
150 °C	± 0.36 °C	± 0.13 Ω	± 0.45 °C	± 0.17 Ω	± 1.05 °C	± 0.39 Ω	± 2.10 °C	± 0.78 Ω
200 °C	—	—	± 0.55 °C	± 0.20 Ω	± 1.30 °C	± 0.48 Ω	± 2.60 °C	± 0.96 Ω
250 °C	—	—	± 0.65 °C	± 0.24 Ω	± 1.55 °C	± 0.56 Ω	± 3.10 °C	± 1.12 Ω
300 °C	—	—	± 0.75 °C	± 0.27 Ω	± 1.80 °C	± 0.64 Ω	± 3.60 °C	± 1.28 Ω
350 °C	—	—	—	—	± 2.05 °C	± 0.72 Ω	± 4.10 °C	± 1.44 Ω
400 °C	—	—	—	—	± 2.30 °C	± 0.79 Ω	± 4.60 °C	± 1.58 Ω
450 °C	—	—	—	—	± 2.55 °C	± 0.86 Ω	± 5.10 °C	± 1.73 Ω
500 °C	—	—	—	—	± 2.80 °C	± 0.93 Ω	± 5.60 °C	± 1.86 Ω
550 °C	—	—	—	—	—	—	± 6.10 °C	± 1.99 Ω
600 °C	—	—	—	—	—	—	± 6.60 °C	± 2.12 Ω
NOTE : The resistance values in the table show the example of calculation of Pt100.								

5.3 Special tolerance classes and special temperature ranges of validity

The tolerances that are not specified in table 2 and table 3 shall be as follows.

- The tolerance classes and temperature ranges of validity that are not specified in table 2 and table 3 shall be agreed and decided between the parties concerned with delivery.
- When the tolerance classes that are not specified in table 2 and table 3 are set, they should be a numerical value comprised of the multiple or fraction of the tolerance value of the tolerance class B.
- When the temperature ranges that are not specified in table 2 and table 3 are set, they shall be agreed and decided between the parties concerned with delivery.
- The tolerance class in which the temperature range is not specified shall not be valid.

5.4 Tolerance judgement

When the manufacturer judges whether or not to accept tolerances, they are accepted only if the whole temperature difference is inside the tolerance width with the result obtained by measuring the deviation from the reference resistance attached with the temperature difference with expanded uncertainty. Also when the purchaser judges whether or not to accept tolerances, they are rejected only if the whole temperature difference is outside the tolerance width with the result obtained by measuring the deviation from the reference resistance attached with the temperature difference with expanded uncertainty. If necessary, the composition of a measurement system and the evaluation of uncertainty shall be agreed and decided between the parties concerned with delivery.

In addition, on the occasion of the tolerance judgement, the following matters shall be taken into consideration.

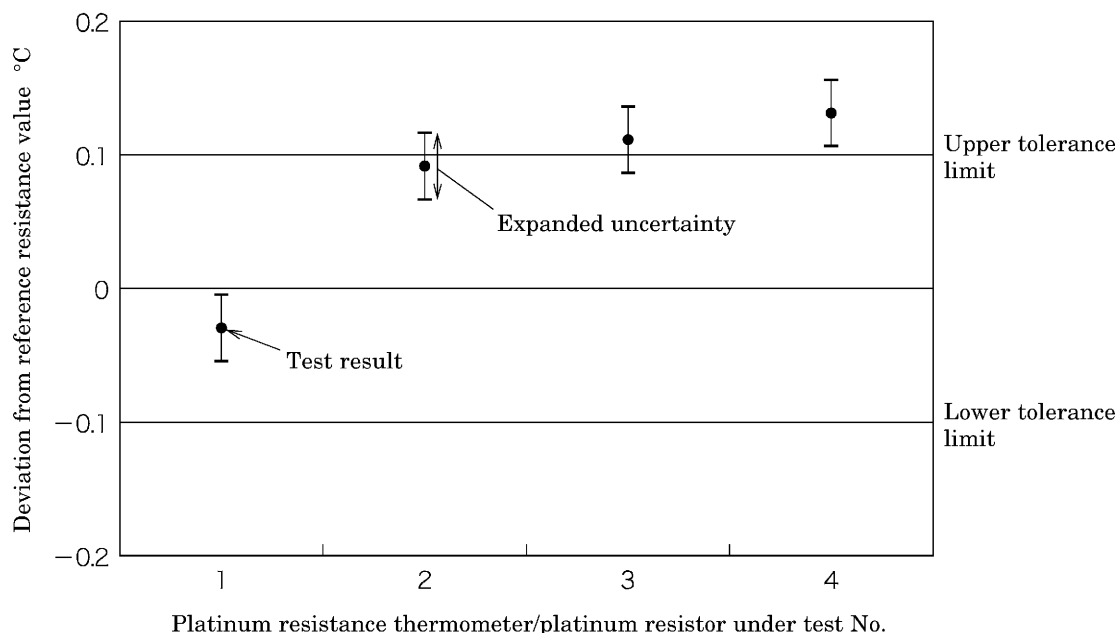
- a) When tolerances are judged, uncertainty in a measurement shall be evaluated.

The uncertainty of each test result shall be given by expanded uncertainty (coverage factor $k = 2$).

- b) When tolerances are judged, difference in measurement results may occur in the case where measurements are performed under the conditions that are different between the parties concerned with delivery.

Especially, when the medium in which the temperature sensitive length of a platinum resistor and a platinum resistance thermometer is immersed and the current values are different, tolerances are affected by self-heating. Furthermore, when the ambient environment and the immersion depth are different, care shall be taken to the occurrence of difference in results due to inflow of heat. When the judgement results are compared between the parties concerned with delivery, the measures such as the unification of both measurement conditions shall be taken or the difference due to self-heating quantity shall be corrected. If necessary, agreement and decision shall be made.

Example: An example is given in table 1 indicating the test results of the platinum resistance thermometer under test and platinum resistor under test, expressed by expanded uncertainty. In this case, if measured by the manufacturer, only platinum resistance thermometer/platinum resistor No. 1 is accepted. If measured by the purchaser, No. 1 to No. 3 are accepted, but only No. 4 is rejected. The measurement uncertainty of the purchaser and the manufacturer are assumed to be the same.



NOTE : The guideline concerning uncertainty factors required to be considered in the test performed for the purpose of judging whether or not to accept tolerances is given in Annex JA.

Figure 1 Example of test results for platinum resistance thermometer/platinum resistor under test

6 Reference resistance

The reference resistance shall be calculated by the following formula (2) or (3).

$$\text{Range of } -200\text{ }^{\circ}\text{C to } 0\text{ }^{\circ}\text{C: } R_t = R_0[1 + At + Bt^2 + C(t - 100\text{ }^{\circ}\text{C})t^3] \dots (2)$$

$$\text{Range of } 0\text{ }^{\circ}\text{C to } 850\text{ }^{\circ}\text{C: } R_t = R_0(1 + At + Bt^2) \dots (3)$$

$$\text{where, } A = 3.908\ 3 \times 10^{-3}\text{ }^{\circ}\text{C}^{-1}$$

$$B = -5.775 \times 10^{-7}\text{ }^{\circ}\text{C}^{-2}$$

$$C = -4.183 \times 10^{-12}\text{ }^{\circ}\text{C}^{-4}$$

R_0 means the resistance value at $0\text{ }^{\circ}\text{C}$ and R_t means that at $t\text{ }^{\circ}\text{C}$

NOTE : These relational expressions are to calculate the reference resistances of this Standard, but not to calculate the coefficient of an individual platinum resistance thermometer to use it.

The reference resistance of the platinum resistor with nominal resistance of $100\ \Omega$ is given in table JB.1 for information. For other nominal resistances R_0 , such as; $500\ \Omega$ or $1\ 000\ \Omega$, the table can be used by multiplying the values in table JB.1 with the factor $R_0/100\ \Omega$.

7 Measuring current

When the resistance value is measured, the measuring current passed through a platinum resistor or a platinum resistance thermometer shall be d.c. or a.c. of 100 Hz or less. Under the measurement condition specified by the manufacturer, higher frequencies may be used. However, the measuring current used for the test and