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Foreword

This Japanese Industrial Standard has been 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 a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied *mutatis mutandis* pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS C 1605** : 1995), which has been technically revised.

However, **JIS C 1605** : 1995 may be applied in the **JIS** mark certification based on the relevant provisions of Article 30, paragraph (1), etc. of the Industrial Standardization Act until 19 June 2023.

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Mineral insulated thermocouples

Introduction

This Japanese Industrial Standard has been prepared based on **IEC 61515** : 2016, Edition 2, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JD.

1 Scope

This Standard specifies requirements for mineral insulated metal-sheathed thermocouples at the time of delivery used for the temperature measurement and mineral insulated metal-sheathed thermocouple cables used for mineral insulated metal-sheathed thermocouples.

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

IEC 61515 : 2016 *Mineral insulated metal-sheathed thermocouple cables and thermocouples* (MOD)

In addition, 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

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. For standards indicated below, only the editions of the indicated year shall be applied and any revisions (including amendments) made thereafter shall not be applied.

JIS B 0659-1 : 2002	<i>Geometrical Product Specifications (GPS) — Surface texture : Profile method; Measurement standards — Part 1 : Material measures</i>
JIS B 7502 : 2016	<i>Micrometers</i>
JIS C 1302 : 2018	<i>Insulation resistance testers</i>
JIS C 1602 : 2015	<i>Thermocouples</i>
JIS C 1610 : 2012	<i>Extension and compensating cables for thermocouples</i>
JIS Z 8103 : 2019	<i>Glossary of terms used in measurement</i>
JIS Z 8703 : 1983	<i>Standard atmospheric conditions for testing</i>

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions, and those given in **JIS C 1602 : 2015** and **JIS Z 8103 : 2019** apply.

3.1

mineral insulated metal-sheathed thermocouple

thermocouple processed into integrated construction using mineral insulated metal-sheathed thermocouple cable

3.2

mineral insulated metal-sheathed thermocouple cable

bendable thermocouple cable insulated and processed into integrated construction, in which powdery inorganic insulation is filled up between the sheath and one, two or three pairs of thermocouple element wires and sealed

3.3

inorganic insulation

powdery substance of superior quality to insulate electrically sheath and thermocouple element wires

Note 1 to entry An example is magnesium oxide of purification 96 % or more.

3.4

sheath

metallic tube to prevent the thermocouple element wires from directly contacting with the article under thermometry or atmosphere by enclosing the thermocouple element wires together with inorganic insulation

3.5

grounded junction, bonded junction, earthed junction

measuring junction electrically connected to the sheath

3.6

insulated junction, ungrounded junction

measuring junction electrically insulated from the sheath

3.7

thermal response time

time for the indicated value to reach a specified percentage to a step change in temperature

3.8

conductor

conductive object which is electrically connected including an integrated thermocouple element wire, compensating cable, connector, connecting terminal, etc.

4 Classification**4.1 Classification of mineral insulated metal-sheathed thermocouple cable****4.1.1 Classification of mineral insulated metal-sheathed thermocouple element wire**

Mineral insulated metal-sheathed thermocouple element wires are classified according to the composing materials as given in Table 1.

Table 1 Classification of mineral insulated metal-sheathed thermocouple element wire

Symbol of type	Composing material of mineral insulated metal-sheathed thermocouple element wire	
	Positive side element wire	Negative side element wire
SN	Alloy mainly consisting of nickel, chromium and silicon	Alloy mainly consisting of nickel and silicon
SK	Alloy mainly consisting of nickel and chromium	Alloy mainly consisting of nickel or alloy mainly consisting of nickel and aluminium
SE	Alloy mainly consisting of nickel and chromium	Alloy mainly consisting of copper and nickel
SJ	Iron	Alloy mainly consisting of copper and nickel
ST	Copper	Alloy mainly consisting of copper and nickel

4.1.2 Classification of sheath

Sheaths are classified according to the quality of materials as given in Table 2.

Table 2 Classification of sheath

Symbol	Quality of material
A	Austenitic stainless steel
B	Corrosion resistant and heat resistant superalloy ^{a)}
Note ^{a)} In accordance with Table 3 of JIS Z 8704 : 1993 .	

4.2 Classification of mineral insulated metal-sheathed thermocouple

Mineral insulated metal-sheathed thermocouples are classified as given in Table 1 and Table 2.

4.3 Classification of measuring junction

Measuring junctions are classified as given in Table 3. The shapes are shown in Figure 1.

Table 3 Classification of measuring junction

Symbol	Shape
G	Grounded
U	Insulated

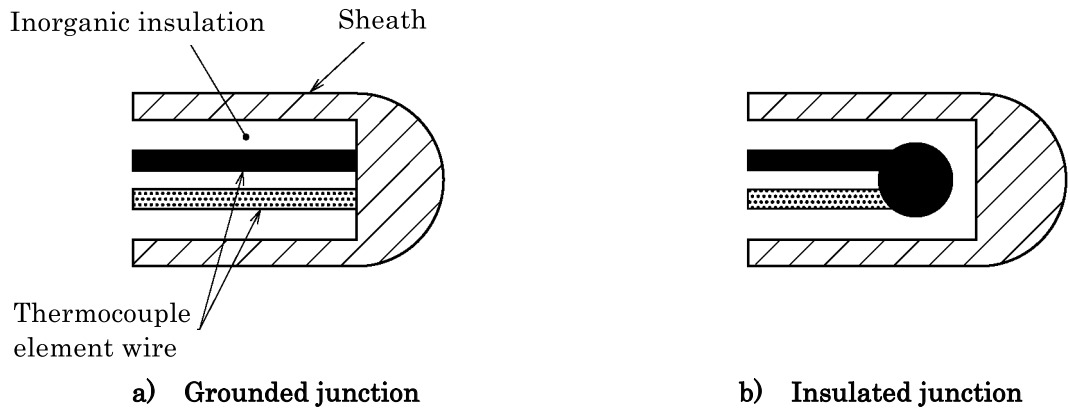


Figure 1 Shape of measuring junction

5 Reference electromotive force

The reference electromotive force is defined by the reference function. The reference function is represented by Polynomial (1). However, Polynomial (2) is used for Type K thermocouples at temperatures in the range of 0 °C to 1 372 °C. The coefficients of the polynomial for each type of mineral insulated metal-sheathed thermocouple element wire and the temperature range are as given in Annex JA.

$$E = a_0 + \sum_{i=1}^n a_i t^i \dots\dots\dots(1)$$

$$E = b_0 + \sum_{i=1}^n b_i t^i + c_0 \exp \left[c_1 (t - 126.968 \text{ } ^\circ\text{C})^2 \right] \dots\dots\dots(2)$$

where, E : reference electromotive force (unit : μV)
 t : arbitrary temperature (unit : $^\circ\text{C}$)
 a_0, b_0, a_i, b_i, c_0 and c_1 : coefficients of polynomial
 n : order of polynomial

The tables of the reference electromotive force obtained by using the reference function are given in Annex JB.

6 Tolerances

The tolerances are classified according to each type of mineral insulated metal-sheathed thermocouple cable and mineral insulated metal-sheathed thermocouple as given in Table 4.

Table 4 Tolerances

Sym- bol of type		Classification by tolerance		
		Class 1	Class 2	Class 3 ^{a)}
<u>SN</u>	Temperature range	–40 °C or over to and excl. 375 °C	–40 °C or over to and excl. 333 °C	–167 °C or over to and excl. 40 °C
	Tolerance	±1.5 °C	±2.5 °C	±2.5 °C
	Temperature range	375 °C or over to and excl. 1 000 °C	333 °C or over to and excl. 1 200 °C	–200 °C or over to and excl. –167 °C
	Tolerance	±0.004 • <i>t</i>	±0.007 5 • <i>t</i>	±0.015 • <i>t</i>
<u>SK</u>	Temperature range	–40 °C or over to and excl. 375 °C	–40 °C or over to and excl. 333 °C	–167 °C or over to and excl. 40 °C
	Tolerance	±1.5 °C	±2.5 °C	±2.5 °C
	Temperature range	375 °C or over to and excl. 1 000 °C	333 °C or over to and excl. 1 200 °C	–200 °C or over to and excl. –167 °C
	Tolerance	±0.004 • <i>t</i>	±0.007 5 • <i>t</i>	±0.015 • <i>t</i>
<u>SE</u>	Temperature range	–40 °C or over to and excl. 375 °C	–40 °C or over to and excl. 333 °C	–167 °C or over to and excl. 40 °C
	Tolerance	±1.5 °C	±2.5 °C	±2.5 °C
	Temperature range	375 °C or over to and excl. 800 °C	333 °C or over to and excl. 900 °C	–200 °C or over to and excl. –167 °C
	Tolerance	±0.004 • <i>t</i>	±0.007 5 • <i>t</i>	±0.015 • <i>t</i>
<u>SJ</u>	Temperature range	–40 °C or over to and excl. 375 °C	–40 °C or over to and excl. 333 °C	—
	Tolerance	±1.5 °C	±2.5 °C	—
	Temperature range	375 °C or over to and excl. 750 °C	333 °C or over to and excl. 750 °C	—
	Tolerance	±0.004 • <i>t</i>	±0.007 5 • <i>t</i>	—
<u>ST</u>	Temperature range	–40 °C or over to and excl. 125 °C	–40 °C or over to and excl. 133 °C	–67 °C or over to and excl. 40 °C
	Tolerance	±0.5 °C	±1 °C	±1 °C
	Temperature range	125 °C or over to and excl. 350 °C	133 °C or over to and excl. 350 °C	–200 °C or over to and excl. –67 °C
	Tolerance	±0.004 • <i>t</i>	±0.007 5 • <i>t</i>	±0.015 • <i>t</i>
NOTE 1 <i>t</i> means the value of measured temperature (°C) regardless of the sign of + or –.				
NOTE 2 The tolerances apply to only mineral insulated metal-sheathed thermocouple cables and mineral insulated metal-sheathed thermocouples at the time of the acceptance inspection.				
Note ^{a)} Pay attention to Type N, K, E and T thermocouples which satisfy the tolerance Class 1 and Class 2 in the temperature range of –40 °C and above, but do not satisfy the tolerance in the temperature ranges given to Class 3 except special cases.				

7 Limit of normal service

The limit of normal service shall be as given in Table 5.

Table 5 Limit of normal service

Symbol of type	Outside diameter of sheath mm	Limit of normal service °C	
		A	B
SN	0.5	600	
	1.0, 1.5, 1.6, 2.0	650	
	3.0, 3.2	750	
	4.5, 4.8	800	900
	6.0, 6.4	800	1 000
	8.0	900	1 050
SK	0.5	600	
	1.0, 1.5, 1.6, 2.0	650	
	3.0, 3.2	750	
	4.5, 4.8	800	900
	6.0, 6.4	800	1 000
	8.0	900	1 050
SE	0.5	600	
	1.0, 1.5, 1.6, 2.0	650	
	3.0, 3.2	750	
	4.5, 4.8	800	900
	6.0, 6.4	800	900
	8.0	800	900
SJ	0.5	400	
	1.0, 1.5, 1.6, 2.0	450	
	3.0, 3.2	650	
	4.5, 4.8	750	
	6.0, 6.4	750	
	8.0	750	
ST	0.5	300	
	1.0, 1.5, 1.6, 2.0	300	
	3.0, 3.2	350	
	4.5, 4.8	350	
	6.0, 6.4	350	
	8.0	350	
NOTE A and B indicate symbols in Table 2.			

8 Characteristics

8.1 Characteristics of mineral insulated metal-sheathed thermocouple cable

8.1.1 Temperature characteristics

The temperature characteristics shall satisfy requirements in Table 6.

Table 6 Temperature characteristics

Item	Characteristics	Applicable subclause for test method
Electromotive force characteristics	Conform to value in Table 4	11.2.1.3
Stability of electromotive force	Not more than 1/5 of value in Table 4	11.2.1.4

8.1.2 Electrical characteristics

8.1.2.1 Electrical continuity

When tested in accordance with **11.2.1.11**, each thermocouple element wire shall be electrically continuous.

8.1.2.2 Electrical resistance of thermocouple element wire

When tested in accordance with **11.2.1.12**, the electrical resistance of each thermocouple element wire shall be not more than the maximum value specified by the manufacturer.

8.1.2.3 Dielectric withstand voltage

When tested in accordance with **11.2.1.6**, no breakdown shall occur.

8.1.2.4 Insulation resistance at ambient temperature

When tested in accordance with **11.2.1.5.2**, the minimum insulation resistance values specified in Table 7 shall be attained within 1 min.

Table 7 Insulation resistance at ambient temperature

Outside diameter of mineral insulated metal-sheathed thermocouple cable mm	Test voltage VDC	Insulation resistance MΩ·m
0.5, 1.0	50 to 100	1 000
1.5, 1.6	50 to 100	5 000
2.0, 3.0, 3.2, 4.5, 4.8, 6.0, 6.4, 8.0	450 to 550	10 000

8.1.2.5 Insulation resistance at elevated temperature

When tested in accordance with **11.2.1.5.3**, the minimum insulation resistance values specified in Table 8 shall be attained within 1 min.

Application of values other than those in Table 8 shall be as agreed between the interested parties.

Table 8 Insulation resistance at elevated temperature

Applicable symbol of type	Test temperature °C	Insulation resistance		
		Outside diameter of mineral insulated metal-sheathed thermocouple cable mm 0.5, 1.0, 1.5, 1.6	Outside diameter of mineral insulated metal-sheathed thermocouple cable mm 2.0, 3.0, 3.2	Outside diameter of mineral insulated metal-sheathed thermocouple cable mm 4.5, 4.8, 6.0, 6.4, 8.0
		Test voltage 50 VDC	Test voltage 100 VDC	Test voltage 100 VDC
ST, SJ, SE, SK, SN	300 ± 15	150 MΩ	300 MΩ	1 000 MΩ
SJ, SE, SK, SN	500 ± 15	7.5 MΩ	15 MΩ	30 MΩ
SE, SK, SN	800 ± 15	0.075 MΩ	0.15 MΩ	0.3 MΩ
SK, SN	1 000 ± 15	—	0.003 MΩ	0.006 MΩ

8.1.3 Mechanical properties

8.1.3.1 Sheath integrity

To ensure that the sheath is free from penetration of gases and liquids, when tested in accordance with 11.2.1.7, the sheath shall satisfy requirements in 8.1.2.4.

8.1.3.2 Sheath ductility

When tested in accordance with 11.2.1.8, sheath ductility shall satisfy requirements in 8.1.2.4.

8.1.3.3 Ductility of thermocouple element wire

When tested in accordance with 11.2.1.9, thermocouple element wire shall be free from cracks and other defects.

8.2 Characteristics of mineral insulated metal-sheathed thermocouple

8.2.1 Temperature characteristics

The temperature characteristics shall satisfy values in Table 6.

8.2.2 Electrical characteristics

8.2.2.1 Electrical continuity

When tested in accordance with 11.3.1.8, mineral insulated metal-sheathed thermocouple shall be electrically continuous.

8.2.2.2 Electrical resistance of a conductor

When tested in accordance with 11.3.1.12, the reciprocating electrical resistance of a conductor shall be not more than the maximum value specified by the manufacturer.

8.2.2.3 Polarity

When tested in accordance with 11.3.1.9, the polarity shall be connected correctly.

8.2.2.4 Dielectric withstand voltage

When tested in accordance with 11.3.1.10, no breakdown shall occur except for grounded junction.

8.2.2.5 Insulation resistance at ambient temperature

When tested in accordance with 11.3.1.11.2 and 11.3.1.4.2, the minimum insulation resistance values specified in Table 9 shall be attained within 1 min except for grounded junction. For thermocouples of over 10 m in length, the insulation resistance shall be as agreed between the interested parties.

Table 9 Insulation resistance at ambient temperature

Outside diameter of mineral insulated metal-sheathed thermocouple mm	Test voltage VDC	Insulation resistance MΩ
0.5, 1.0, 1.5, 1.6	100	20
2.0, 3.0, 3.2, 4.5, 4.8, 6.0, 6.4, 8.0	500	1 000

8.2.2.6 Insulation resistance at elevated temperature

When tested in accordance with 11.3.1.11.3, the minimum insulation resistance values specified in Table 10 shall be attained within 1 min except for grounded junction.

Adoption of specified values other than those in Table 10 shall be as agreed between the interested parties.

Table 10 Insulation resistance at elevated temperature

Applicable symbol of type	Test temperature °C	Insulation resistance value		
		Outside diameter of mineral insulated metal-sheathed thermocouple mm 0.5, 1.0, 1.5, 1.6	Outside diameter of mineral insulated metal-sheathed thermocouple mm 2.0, 3.0, 3.2	Outside diameter of mineral insulated metal-sheathed thermocouple mm 4.5, 4.8, 6.0, 6.4, 8.0
		Test voltage 50 VDC	Test voltage 100 VDC	Test voltage 100 VDC
ST, SJ, SE, SK, SN	300 ± 15	250 MΩ	500 MΩ	1 000 MΩ
SJ, SE, SK, SN	500 ± 15	25 MΩ	50 MΩ	100 MΩ
SE, SK, SN	800 ± 15	0.25 MΩ	0.5 MΩ	1 MΩ
SK, SN	1 000 ± 15	—	0.01 MΩ	0.02 MΩ
The length of the sample immersed in the elevated temperature is 0.1 m.				

8.2.3 Mechanical properties

8.2.3.1 Weld closure integrity

When tested in accordance with 11.3.1.4, weld closure integrity shall be verified.

8.2.3.2 Moisture resistance at the end portion

When tested in accordance with 11.3.1.5, the moisture resistance at the sealed end portion shall satisfy requirements in 8.2.2.5.

8.2.3.3 Vibration resistance

When tested in accordance with 11.3.1.6, the vibration resistance shall satisfy requirements in 10.2 and acceptance criteria specified by agreement between the interested parties.

8.2.3.4 Impact resistance

When tested in accordance with 11.3.1.7, the impact resistance shall satisfy requirements in 10.2 and requirements in 8.2.2.1 and 8.2.2.5.

9 Construction and dimensions

9.1 Construction and dimensions of mineral insulated metal-sheathed thermocouple cable

9.1.1 Construction of mineral insulated metal-sheathed thermocouple cable

9.1.1.1 General construction

The general construction of mineral insulated metal-sheathed thermocouple cable shall be as follows.

- a) Mineral insulated metal-sheathed thermocouple cables shall be elastic, mechanically robust and durable in characteristics.
- b) The minimum bending radius of mineral insulated metal-sheathed thermocouple cable shall be 5 times the outside diameter of sheath.

9.1.1.2 Inorganic insulation

The inorganic insulation shall have enough stability at the working temperature and shall not give influence upon the electrical characteristics.

9.1.1.3 Sheath

The sheath shall have sufficient heat resistance and durability under the service conditions so that the measuring junction and thermocouple element wires will not be affected by the article under thermometry or atmosphere.

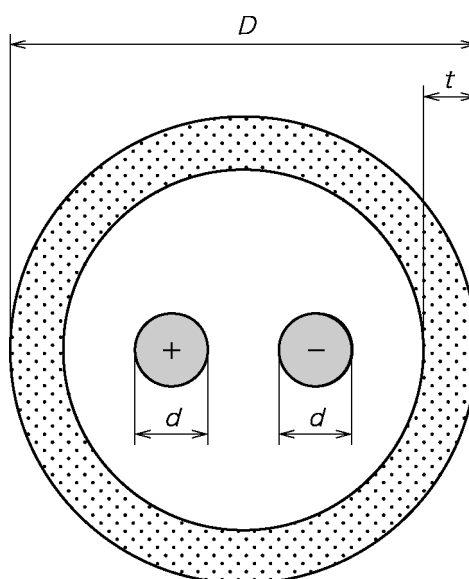
9.1.2 Dimensions of mineral insulated metal-sheathed thermocouple cable

9.1.2.1 Dimensions of simplex mineral insulated metal-sheathed thermocouple cable

The dimensions of simplex mineral insulated metal-sheathed thermocouple cable shall be as given in Table 11. An example of transverse section is shown in Figure 2.

Table 11 Dimensions of simplex mineral insulated metal-sheathed thermocouple cable

Unit: mm		
Outside diameter D	0.5, 1.0, 1.5, 1.6, 2.0, 3.0, 3.2, 4.5, 4.8, 6.0, 6.4, 8.0	
Tolerance on outside diameter D	Outside diameter under 2.5 mm : ± 0.025 mm	Outside diameter 2.5 mm or over : $\pm 0.01 D$
Wall thickness t	0.10 D min.	
Outside diameter of element wire d	0.15 D min.	

**Figure 2 Example of transverse section of simplex mineral insulated metal-sheathed thermocouple cable****9.1.2.2 Dimensions of duplex mineral insulated metal-sheathed thermocouple cable**

The dimensions of duplex mineral insulated metal-sheathed thermocouple cable shall be as given in Table 12. An example of transverse section is shown in Figure 3.

Table 12 Dimensions of duplex mineral insulated metal-sheathed thermocouple cable

Unit: mm		
Outside diameter D	1.5, 1.6, 2.0, 3.0, 3.2, 4.5, 4.8, 6.0, 6.4, 8.0	
Tolerance on outside diameter D	Outside diameter under 2.5 mm : ± 0.025 mm	Outside diameter 2.5 mm or over : $\pm 0.01 D$
Wall thickness t	0.09 D min.	
Outside diameter of element wire d	0.11 D min.	

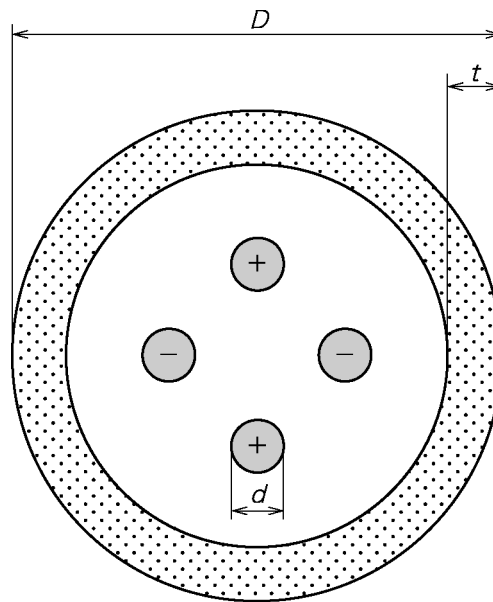


Figure 3 Example of transverse section of duplex mineral insulated metal-sheathed thermocouple cable

9.1.2.3 Dimensions of triplex mineral insulated metal-sheathed thermocouple cable

The dimensions of triplex mineral insulated metal-sheathed thermocouple cable shall be as given in Table 13. An example of transverse section is shown in Figure 4.

Table 13 Dimensions of triplex mineral insulated metal-sheathed thermocouple cable

Unit: mm	
Outside diameter D	3.0, 3.2, 4.5, 4.8, 6.0, 6.4, 8.0
Tolerance on outside diameter D	$\pm 0.01 D$
Wall thickness t	$0.08 D$ min.
Outside diameter of element wire d	$0.09 D$ min.