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**Test methods for rubber or plastic
insulated wires and cables**

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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 The Japanese Electric Wire & Cable Makers' Association (JCMA)/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 3005:2000** is replaced with this Standard.

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Test methods for rubber or plastic insulated wires and cables

Introduction

This Japanese Industrial Standard was established in 1960 and has gone through nine revisions up to the present. The last revision was made in 2000, and the revision at this time is to respond to the diversification of materials, easiness of selecting testing devices, availability of reagents and so on.

No corresponding International Standard has been established at this point, but this Standard refers to IEC 60227-2, IEC 60245-2, IEC 60332-1-1, IEC 60332-1-2, IEC 60332-1-3, IEC 60502-2 and IEC 60811 series.

1 Scope

This Standard specifies general test methods for wires, cables and cords insulated or sheathed by various rubber materials or plastic materials (hereafter referred to as “wires”).

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 7184 *Profile projectors*

JIS B 7502 *Micrometer callipers*

JIS B 7503 *Mechanical dial gauges*

JIS B 7507 *Vernier, dial and digital callipers*

JIS B 7512 *Steel tape measures*

JIS B 7516 *Metal rules*

JIS B 7522 *Textile tape measures*

JIS B 7721 *Tension/compression testing machines—Verification and calibration of the force-measuring system*

JIS C 3002 *Testing methods of electrical copper and aluminium wires*

JIS K 6249 *Testing methods for uncured and cured silicone rubber*

JIS K 6251 *Rubber, vulcanized or thermoplastics—Determination of tensile stress-strain properties*

JIS K 6258 *Rubber, vulcanized or thermoplastic—Determination of the effect of liquids*

JIS K 7112 *Plastics—Methods of determining the density and relative density of non-cellular plastics*

JIS K 7212 *Plastics—Determination of thermal stability of thermoplastics—Oven method*

JIS K 7216 *Testing method for brittleness temperature of plastics*

JIS K 8271 *Xylene (Reagent)*

JIS R 6001 *Bonded abrasive grain sizes*

3 Classification of tests

The classification of tests shall be as given in table 1.

Table 1 Classification of tests

Classification	Applicable subclause for test method	Classification	Applicable subclause for test method
Appearance	4.1	Tensile properties of insulation and sheath	4.16
Wire length	4.2	Thermal aging	4.17
Construction	4.3	Oil resistance	4.18
Conductor resistance	4.4	Heat shock	4.19
Continuity	4.5	Cold bend	4.20
Dielectric withstand voltage	4.6	Heat shrinkage	4.21
Insulation resistance	4.7	Low-temperature impact	4.22
Capacitance	4.8	Heat deformation	4.23
Dielectric loss tangent	4.9	Ozone resistance	4.24
Long-duration power frequency withstand voltage (AC long-duration withstand voltage)	4.10	Degree of cross-linking	4.25
		Flame retardance	4.26
Lightning impulse withstand voltage (impulse withstand voltage)	4.11	Bending	4.27
Creepage withstand voltage	4.12	Impact	4.28
Tracking resistance	4.13	Abrasion	4.29
Resistance to surface leakage	4.14	Twisting	4.30
Thermal discolouration of conductor	4.15		

4 Test method

4.1 Appearance

Examine visually or manually the appearance for flaws, surface smoothness, braiding conditions, colour, marking and the like.

4.2 Wire length

Measure the wire length with an apparatus like rotary measure, and tape measure specified in **JIS B 7512** or **JIS B 7522**.

4.3 Construction

4.3.1 Measuring apparatus

Measure the diameter, thickness and pitch with a micrometer calliper for external measurement specified in **JIS B 7502**, a mechanical dial gauge specified in **JIS B 7503**, a vernier calliper (graduated in 0.05 mm) specified in **JIS B 7507** or measuring apparatus of accuracy at least equivalent thereto with care being taken to limit the pressure, or measure them with a profile projector specified in **JIS B 7184**. A circumferential measuring tape may be used to measure the diameter, and a metal rule specified in **JIS B 7516** may be used to measure the pitch.

4.3.2 Measuring procedure

Take suitable length of samples to measure as follows.

- a) **Diameter** Measure the diameter directly at two or more positions at nearly equal angles on the same plane perpendicular to the wire axis as shown in figure 1 (at two or more positions along the wire length when using a circumferential measuring tape), and express in the mean value. A circumferential measuring tape shall be used only when the outside diameter exceeds 25 mm. In the case of flat wires, measure the diameter directly on the same plane perpendicular to the wire axis as shown in figure 2.

When direct measurement is inapplicable, calculate the diameter from the mean value of two or more diameters measured on the component wires. In the case of three-core wires, measure directly the diameter d of the component wires as shown in figure 3, obtain the mean value d_m , then obtain the outside diameter D by the following formula. The same procedure applies to calculating the diameters of four-core wires and five-core wires. When the external layer consists of an odd number of at least seven cores, measure the diameter directly with a circumferential measuring tape.

Calculating formulae	three-core wires	$D = 2.155 d_m$
	four-core wires	$D = 2.414 d_m$
	five-core wires	$D = 2.700 d_m$

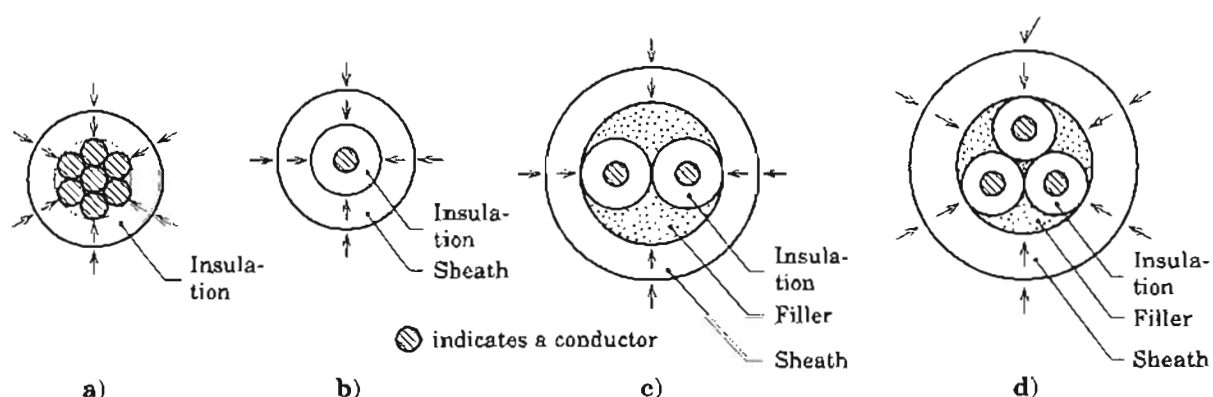


Figure 1 Measured points for round wires

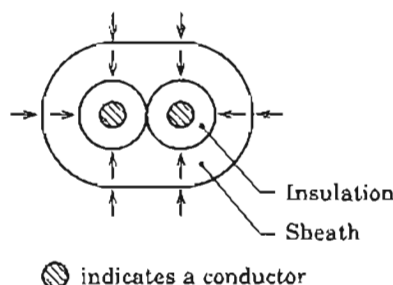


Figure 2 Measured points for flat wires

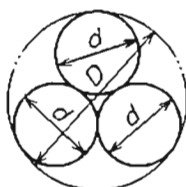


Figure 3 Measured points and outside diameter D for three-core wires

- b) **Insulation thickness** Measure the insulation thickness directly, or measure the inside and outside diameters of the insulation to two decimal places by the method of a) and take one half of the difference between them. In direct measurement, measure three or more points at nearly equal angles in the same cross-section perpendicular to the wire axis to obtain the mean value. If the insulation thickness is 0.5 mm or less, obtain the value to three decimal places. Obtain the minimum thickness by identifying the thinnest point (including the part of the covering with the indented marking) visually or by other means, and by measuring the thickness directly with magnifying lens with graduated scale, etc.
- c) **Sheath thickness** Measure the sheath thickness directly, or measure the inside and outside diameters of the sheath to two decimal places by the method of a) and take one half of the difference between them. In direct measurement, measure two or more points at nearly equal angles in the same cross-section perpendicular to the wire axis to obtain the mean value. Obtain the minimum thickness by identifying the thinnest point (including the part of the covering with the indented marking) visually or by other means, and by measuring the thickness directly to two decimal places with a vernier calliper, etc.
- d) **Thickness of tapes, padding and covering** Measure the thickness of tapes, padding and covering directly, or measure the inside and outside diameters of tapes, padding and covering and take one half of the difference between them.
- e) **Pitch** The thickness of tapes, padding and covering shall be as follows.
 - 1) **Concentric lay conductor** Measure the concentric lay conductor according to (3) (c) in clause 4 of JIS C 3002.
 - 2) **Core stranding** For the core stranding, count the number of cores n of that layer, apply a metal rule in the axial direction, measure the distance from the reference core to the $(n + 1)$ th core (obtain the value in integer) to take as the pitch. Lay ratio, when expressed by a multiple of pitch circle diameter ¹⁾, shall be obtained by the following formula.

$$P_n = \frac{P}{D_1}$$

where, P_n : lay ratio
 P : pitch (mm)
 D_1 : pitch circle diameter (mm)

Note ¹⁾ Pitch circle diameter D_1 refers to the diameter of a circle connecting centres of all cores contained in that layer as shown in figure 4, to be obtained by the following formula.

$$D_1 = D - d$$

where, D : outside diameter over laid-up cores (mm)
 d : outside diameter of core in this layer (mm)

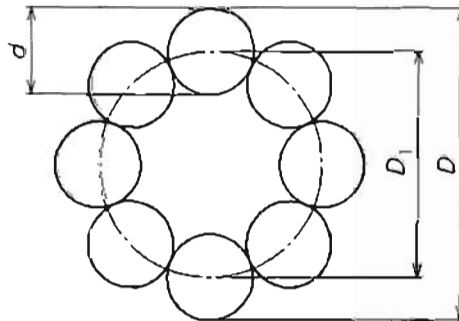


Figure 4 Pitch circle diameter

- f) **Outside diameter over laid-up cores** Outside diameter over laid-up cores shall be measured by the method of a).

4.4 Conductor resistance

Measure the conductor resistance on overall length of product or a wire of length at least 1 m, by the Wheatstone bridge method given in figure 5 or other appropriate methods, and convert by the following formula to the value per kilometre in wire length at 20 °C.

$$R_{20} = R_t \times K_t \times \frac{1000}{l}$$

where, R_{20} : conductor resistance (Ω/km) converted to the value per kilometre at 20 °C
 R_t : measured value (Ω) at t °C, excluding the resistance of lead wire, if any.
 K_t : temperature conversion coefficient given in table 2 to convert the measured value t °C to 20 °C
 l : wire length (m)

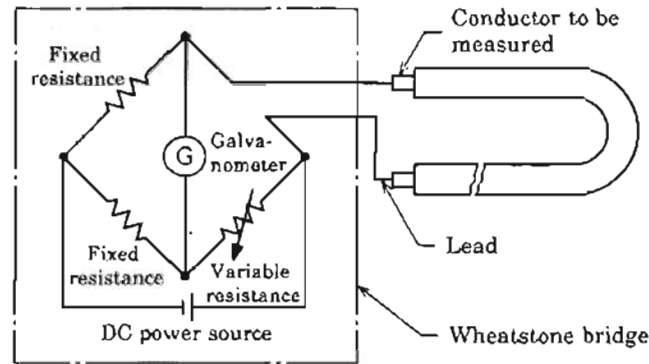


Figure 5 Wheatstone bridge method

**Table 2 Temperature conversion coefficient for conductor resistance
(reference temperature 20 °C)**

Temperature (<i>t</i>) °C	Copper (<i>K_t</i>)	Aluminium (<i>K_t</i>)	Temperature (<i>t</i>) °C	Copper (<i>K_t</i>)	Aluminium (<i>K_t</i>)	Temperature (<i>t</i>) °C	Copper (<i>K_t</i>)	Aluminium (<i>K_t</i>)
0	1.085	1.087	14	1.024	1.025	28	0.970	0.969
1	1.081	1.082	15	1.020	1.020	29	0.966	0.965
2	1.076	1.078	16	1.016	1.016	30	0.962	0.962
3	1.072	1.073	17	1.012	1.012	31	0.959	0.958
4	1.067	1.068	18	1.008	1.008	32	0.955	0.954
5	1.063	1.064	19	1.004	1.004	33	0.951	0.951
6	1.058	1.059	20	1.000	1.000	34	0.948	0.947
7	1.054	1.055	21	0.996	0.996	35	0.944	0.943
8	1.050	1.050	22	0.992	0.992	36	0.941	0.939
9	1.045	1.046	23	0.988	0.988	37	0.937	0.936
10	1.041	1.042	24	0.985	0.984	38	0.934	0.932
11	1.037	1.037	25	0.981	0.980	39	0.931	0.929
12	1.033	1.033	26	0.977	0.977	40	0.927	0.925
13	1.028	1.029	27	0.973	0.973			

4.5 Continuity

For the continuity, examine for breaks by passing a current from a power supply not exceeding 50 V through the wire to activate a bell or a buzzer.

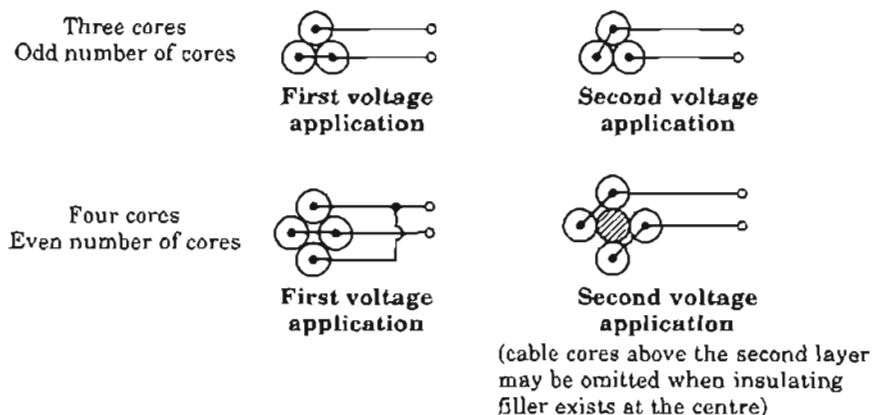
4.6 Dielectric withstand voltage

Examine dielectric withstand voltage by one of the following methods.

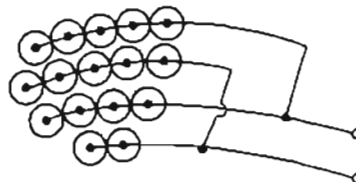
Examples of wiring methods are shown in figure 6.

Use overall length of product or a wire of length at least 1 m to take as the sample for dielectric withstand voltage test.

- a) **In water** Immerse the wire in clear water grounded previously for 1 h or longer, and test the wire as it is immersed. Apply AC voltage of nearly sinusoidal waveform at a frequency of 50 Hz or 60 Hz specified in individual standard, between the conductor and the clear water for single core wires, and between the conductors and between the conductors and the clear water for multi-core wires. Examine whether the test piece withstands for the period specified in individual standard. The disconnected conductors shall be grounded.
- b) **In air** Apply in air AC voltage of nearly sinusoidal waveform at a frequency of 50 Hz or 60 Hz specified in individual standard between the conductors, and examine whether the test piece withstands for the period specified in individual standard. For wires with metallic covering, carry out the test between the conductors and between the conductors and the grounded metallic covering. The disconnected conductors shall be grounded.



a) Voltage application across cores



b) Voltage application across layers

Figure 6 Wiring method

- c) **Spark** Use the spark tester in air as shown in figure 7, apply AC voltage of nearly sinusoidal waveform at a frequency of 50 Hz or 60 Hz specified in individual standard between the conductor grounded previously and the electrode for 0.15 s or more, or at least nine cycles in the case of high frequency, and examine whether the test piece withstands this voltage.

In the spark tester of figure 7, the components ① are metal chain or bead electrodes, each suspended 12 mm or less apart in the axial direction and 9 mm or less in the lateral direction. The length of chains shall be slightly longer than the depth of the electrode box so that chains may sufficiently make contact with the wire surface irrespective of the diameters of the wires.

The component ② is an U-shaped or V-shaped electrode box, and the width of the attachment part of upper chain shall be larger than the maximum wire diameter by 33 mm or longer.

In the case of frequency other than 50 Hz or 60 Hz, obtain the minimum length of electrode by the following formula. Metal chain or bead electrode may be replaced by water electrode.

$$L_{\min} = \frac{v_{\max}}{f} \times 150$$

where, $L_{\min}$: minimum length of electrode (mm)

$v_{\max}$: maximum allowable speed of wire (maximum winding speed) (m/min)

f : frequency (Hz)

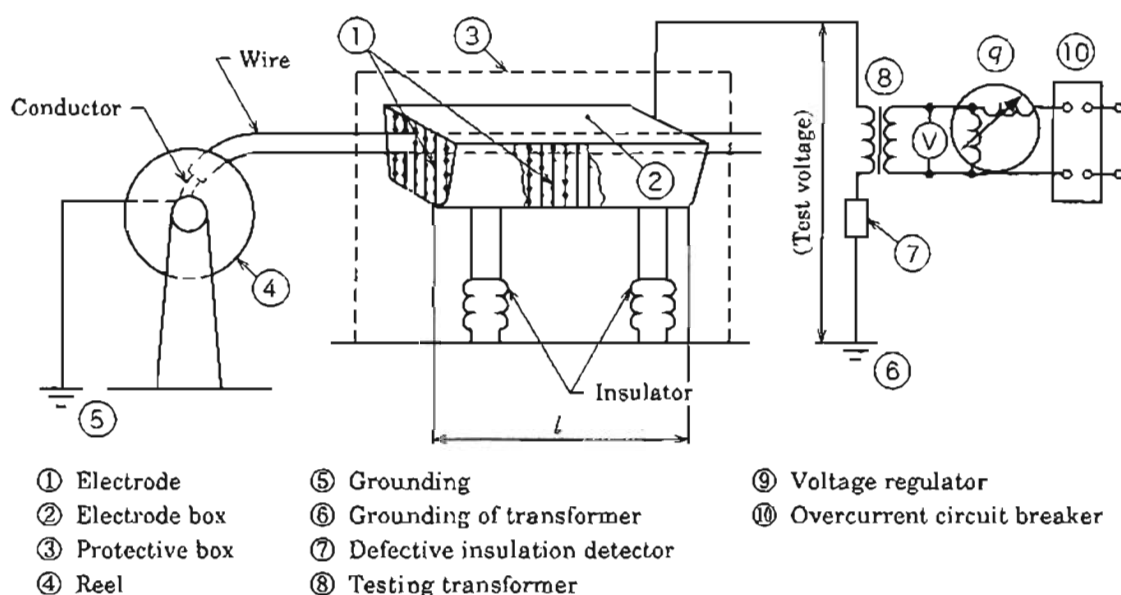


Figure 7 Outline and circuit diagram of spark tester

4.7 Insulation resistance

4.7.1 Insulation resistance at ordinary temperature

Use overall length of product or a wire of length at least 1 m to take as the sample for insulation resistance test at ordinary temperature.

Measure the insulation resistance by the method in **a)** or **b)**, and convert to the value per kilometre in wire length at 20 °C by the following formula.

Materials of high insulation resistance, like polyethylene, shall be in accordance with individual standard. When no specifications are given in individual standard, $K_1 = 1$ shall be used. An example of measuring circuit diagram is shown in figure 8.

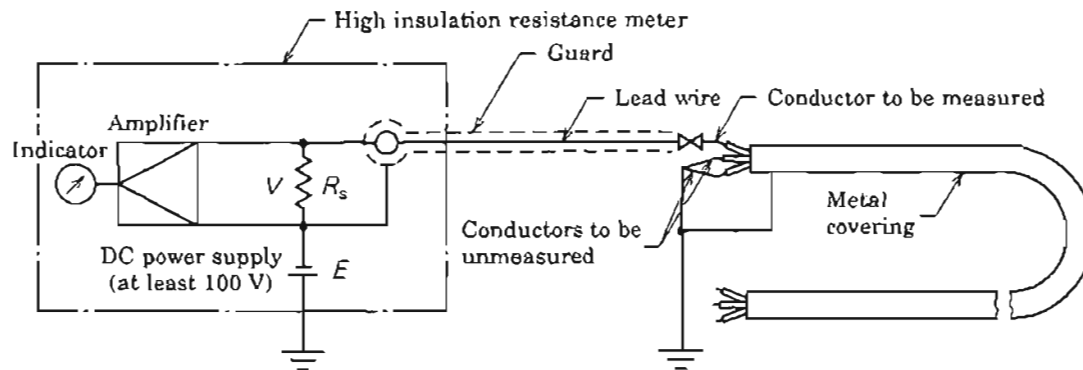
$$R_{20} = R_1 \times K_1 \times \frac{l}{1000}$$

where, R_{20} : insulation resistance converted to the value per kilometre at 20 °C (MΩ · km)

R_t : measured value at t °C, excluding the resistance of lead wire, if any (MΩ)

K_t : temperature conversion coefficient given in table 3 to convert the measured value at t °C into the value at 20 °C

l : wire length (m)



DC power supply E shall be a battery or a stabilized DC power supply.

The standard resistance R_s shall be sufficiently smaller than the insulation resistance of the conductor to be measured.

As for the indicated value R_i on the high insulation resistance tester, $R_t = R_i \times \frac{E}{V}$ holds, where V is the voltage which appears across R_s at the time of measurement and where E is the voltage of DC power supply used for this measurement.

Figure 8 Test circuits for insulation resistance measurements by means of high insulation resistance meter

- a) **In water** Immerse the wire in clear water grounded previously for 1 h or longer, and test the wire while it is immersed. Apply DC voltage of 100 V or more between the conductor and the clear water for single core wires, and between the conductors and between the conductors and the clear water for multi-core wires. Measure the insulation resistance after 1 min or longer but no later than 5 min from the voltage application, by means of devices like high insulation resistance meter given in figure 8.

For wires with metallic covering, the covering shall be grounded.

- b) **In air** Apply DC voltage of 100 V or more between the conductors in air, and measure the insulation resistance after 1 min or longer but no later than 5 min from the voltage application by means of devices like high insulation resistance meter given in figure 8. For wires with metallic covering, carry out the test between the conductors and between the conductors and the grounded metallic covering.