JAPANESE INDUSTRIAL STANDARD
JIS C 3005 : 2000
Test methods for rubber or plastic insulated wires and cables

November 4, 2003

ERRATA

Page 20
Subclause 4.22.2
second line in the third paragraph

Error: 2.0 mm ± 0.2 mm

Correct: 2.0 m ± 0.2 m

Remarks: This erratum is for correcting the first edition of this Standard.

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JIS C 3005 : 2000

(JCMA)

Test methods for rubber or plastic insulated wires and cables

ICS 19.080; 29.060.20

Descriptors : sheathed conductors, sheathed cables, plastics, synthetic rubber

Reference number : **JIS C 3005 : 2000 (E)**

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International 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 and Cable Maker's Association (JCMA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law. Consequently **JIS C 3005** : 1993 is replaced with this Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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In the event of any doubts arising as to the contents, the original JIS is to be the final authority.

Contents

Test methods for rubber or plastic insulated wires and cables

Introduction This Standard is a Japanese Industrial Standard corresponding to the International Standards shown in Attached Table 1, but has been prepared by modifying the technical contents according to the circumstances of this country.

Japanese Industrial Standards prepared based on the said International Standards without modification in technical contents have been separately established (see Attached Table 1).

1 Scope This Japanese Industrial Standard specifies general testing methods for wires, cables and cords insulated or sheathed by various rubber materials or plastic materials (hereafter referred to as "wires").

Remarks 1 The International Standards corresponding to this Standard are shown in Attached Table 1.

The symbols which express the degree of correspondence are IDT (identical), MOD (modified) and NEQ (not equivalent), based on **ISO/IEC Guide 21**.

2 Normative references The following standards contain provisions which, through reference in this Standard, 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 7503 *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 *Verification of the force measuring system of the tensile testing machine*

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

JIS K 6251 *Tensile testing methods for vulcanized rubber*

JIS K 6258 *Testing methods of the effect of liquids for vulcanized rubber*

JIS K 6259 *Testing methods of resistance to ozone cracking for vulcanized rubber*

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 8001 *General rule for test methods of reagents*

JIS K 8271 *Xylene*

JIS R 6001 *Bonded abrasive grain sizes*

3 Classification of tests The tests are classified as shown in Table 1.

Table 1 Classification of tests

Item	Applicable sub-clause for test method	Item	Applicable sub-clause for test method
Appearance	**4.1**	Thermal discoloration of conductor	**4.15**
Wire length	**4.2**	Tensile properties of insulation and sheath	**4.16**
Construction	**4.3**	Thermal aging	**4.17**
Conductor resistance	**4.4**	Oil resistance	**4.18**
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Dielectric withstand voltage	**4.6**	Cold bend	**4.20**
Insulation resistance	**4.7**	Heat shrinkage	**4.21**
Capacitance	**4.8**	Low-temperature impact	**4.22**
Dielectric loss tangent	**4.9**	Heat deformation	**4.23**
Power frequency long term withstand voltage (a.c. long term withstand voltage)	**4.10**	Ozone resistance	**4.24**
Lightning impulse withstand voltage (impulse withstand voltage)	**4.11**	Degree of cross-linking	**4.25**
Creepage withstand voltage	**4.12**	Flame retardance	**4.26**
Tracking resistance	**4.13**	Bending	**4.27**
Surface leakage resistance	**4.14**	Impact	**4.28**
		Abrasion	**4.29**
		Twisting	**4.30**

4 Test methods

4.1 Appearance Examine the appearance visually and by touch for flaws, surface smoothness, condition of braiding, color, marking, etc.

4.2 Wire length Measure the wire length with a rotary measure, a measuring tape specified in **JIS B 7512** or in **JIS B 7522**, or the like.

4.3 Construction

4.3.1 Measuring instruments Measure the diameter, thickness, and pitch with the external micrometer specified in **JIS B 7502**, the dial gauge specified in **JIS B 7503**, the vernier calliper (graduated in 0.05 mm) specified in **JIS B 7507**, or measuring instruments equivalent or superior in accuracy, paying attention to the pressure, or using a graduated magnifying glass. A circumferential measuring tape may be used for the diameter, and the metal rule specified in **JIS B 7516** may be used for the pitch.

4.3.2 Measuring methods Sample suitable lengths of products and carry out tests on each of the items prescribed below.

a) **Diameter** Measure the diameter directly at 2 or more positions at approximately the same angle on the same plane perpendicular to the axis of the wire, as shown in Fig. 1 (if using a circumferential measuring tape, at 2 or more positions along the wire length) and express the mean value. If using a circumferential measuring tape, the outer diameter shall be 25 mm or more. For flat wire, measure the diameter directly on the same plane perpendicular to the axis of the wire, as shown in Fig. 2.

When direct measurement is impossible, calculate the diameter from the average value of two or more diameters measured on the component wires. For a 3-core wire, measure directly the diameter d of the component wires as shown in Fig. 3, obtain the mean value d m, and then calculate the outer diameter D. For a 4-core wire and a 5-core wire, calculate by similar method. When the outer layer consists of cores of a odd number of 7 or more, measure the diameter directly using a circumferential measuring tape.

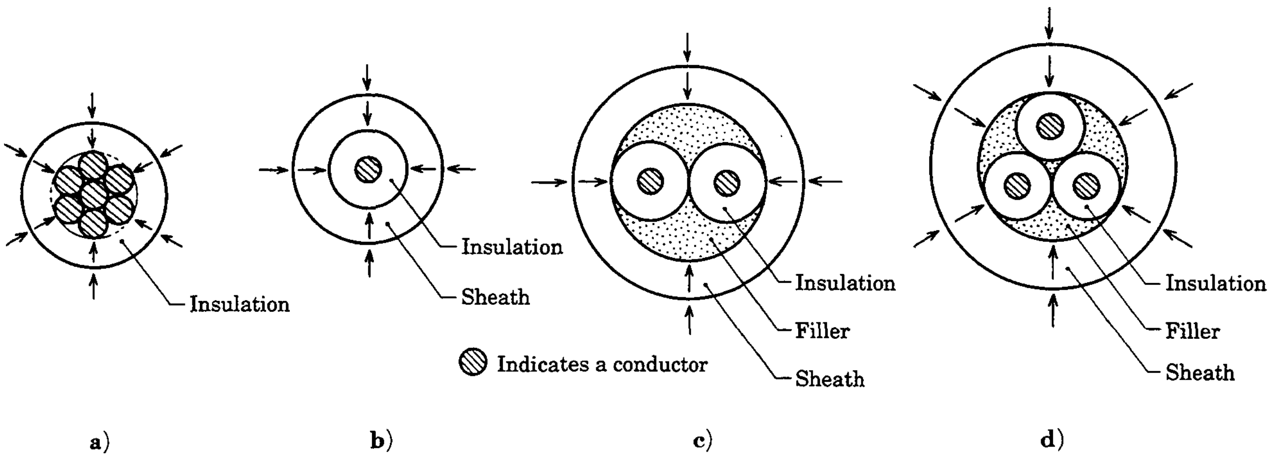


Fig. 1 Measuring positions for round wires

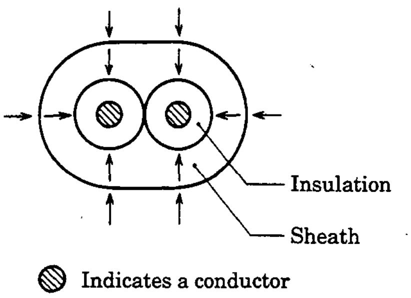


Fig. 2 Measuring positions for flat wires

Calculating formulae $D = 2.155d$ m for 3-core wires

$D = 2.414d$ m for 4-core wires

$D = 2.700d$ m for 5-core wires

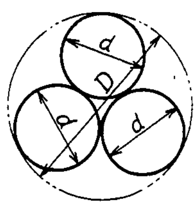


Fig. 3 Measuring positions and outer diameter D for 3-core wires

b) **Thickness of insulation** For the thickness of the insulation, measure the inner and outer diameters of the insulation by the method of **a**) to 2 decimal places, and take one half of the difference between them or measure the thickness directly. For direct measurement, measure 3 or more portions at nearly equal angles in the same section perpendicular to the wire axis and obtain the mean value. If the thickness of insulation is not more than 0.5 mm, obtain to 3 decimal places. For the minimum thickness, select the thinnest portion (including the portion of covering where the indentation of surface marking exists) visually or by other means, and then directly measure the thickness at that position with a graduated magnifying glass, etc.

c) **Thickness of sheath** For the thickness of the sheath, measure the inner and outer diameters of the sheath by the method of **a**), to 2 decimal places, and take one half of the difference between them or measure the thickness directly. For direct measurement, measure 2 or more portions at nearly equal angles in the same section perpendicular to the wire axis and take the mean value. For the minimum thickness, select the thinnest portion (including the portion of covering where the indentation of surface marking exists) visually or by other means, and then directly measure the thickness at that portion with the vernier calliper to 2 decimal places.

d) **Thickness of tapes, padding and covering** For the thickness of the tapes, padding and covering, measure the inner and outer diameters and take one half of the difference between them, or measure the thickness directly.

e) **Pitch**

1) **Concentric-lay conductor** Measure the pitch of the concentric-lay conductor according to **4** (**3**) (**c**) of **JIS C 3002**.

2) **Core stranding** For the core stranding, count the number of the cores n of that layer, apply a metal rule in the axial direction, measure the distance from the core as the reference to the $(n+1)$th core (obtain the value in integer), and then take it as the pitch. If expressing the pitch by the multiple of pitch circle diameter(1) (lay ratio), calculate it from 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) The pitch circle diameter D_1 is the diameter of a circle, as shown in Fig. 4, connecting centers of all cores contained in that layer, and is calculated from the following formula:

$$D_1 = D - d$$

where, D : outside diameter of stranded cores (mm)

d : outside diameter of core in this layer (mm)

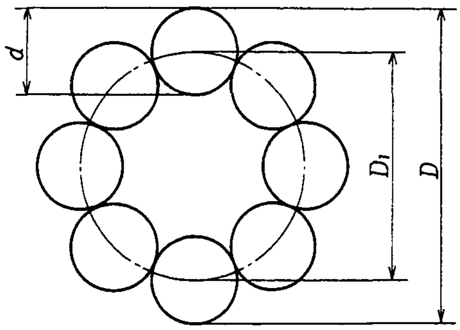


Fig. 4 Pitch circle diameter

f) **Outer diameter of stranded conductor** Measure the outer diameter of stranded conductor by the method of **a**).

4.4 Conductor resistance Measure the conductor resistance on overall length of completed product or a wire of at least 1 m in length by the Wheatstone bridge method given in Fig. 5 or other appropriate methods, convert it to that at 20 °C per 1 km wire length from the following formula:

$$R_{20} = R_t \times K_t \times \frac{1\,000}{l}$$

where, R_{20} : conductor resistance (Ω/km) converted to that per 1 km at 20 °C

R_t : measured value (Ω) at t °C. The resistance of lead wire, if included, shall be excluded.

K_t : temperature conversion factors given in Table 2 for converting the measured value at t °C into that at 20 °C

l : wire length (m)

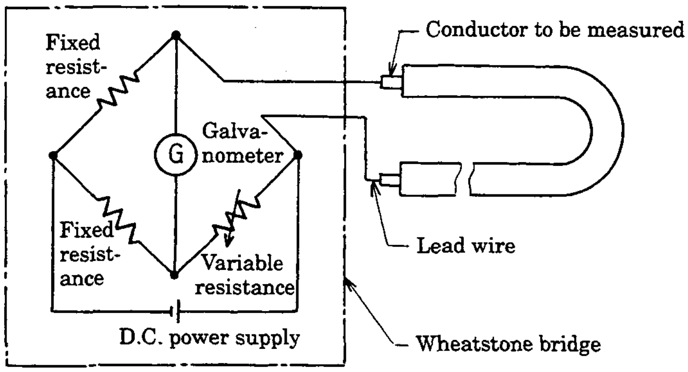


Fig. 5 Wheatstone bridge method

Table 2 Temperature conversion factor for conductor resistance (Reference temperature 20 °C)

Temperature (t) ℃	Copper (K_t)	Aluminium (K_t)	Temperature (t) ℃	Copper (K_t)	Aluminium (K_t)	Temperature (t) ℃	Copper (K_t)	Aluminium (K_t)
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 test, pass a current from a power supply not exceeding 50 V through the wire to activate a bell or a buzzer and examine for disconnection.

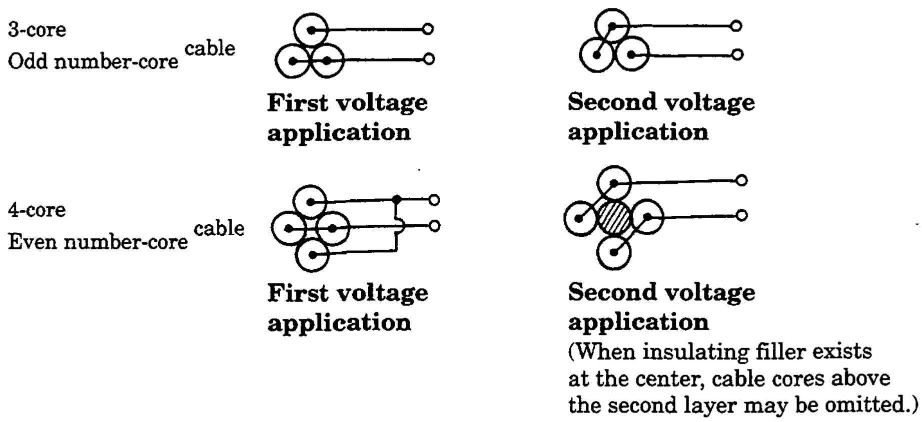
4.6 Dielectric withstand voltage Examine the dielectric withstand voltage by one of the methods stated below.

Examples of wiring methods are given in Fig. 6.

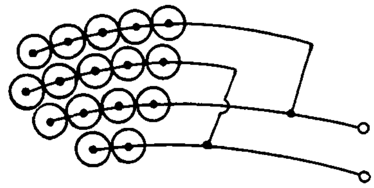
Use overall length of completed product or a core sample of at least 1 m in length as the specimen for dielectric withstand voltage test.

a) **In water** Immerse the wire in clear water grounded previously for at least 1 h, and test the wire while still immersed. Apply a specified a.c. voltage of nearly sinusoidal waveform at 50 Hz or 60 Hz between the conductor and the clear water for single core wire, and between the conductors, and between the conductors and the clear water for multi-core wire. Then examine whether the specimen withstands for a specified period or not. Provided that the conductors which are not connected are grounded.

b) **In air** Apply a specified a.c. voltage of nearly sinusoidal waveform at 50 Hz or 60 Hz between the conductors in air, and then examine whether the specimen withstands for a specified period or not. For wire with a metallic covering, carry out the test between the conductors and between the conductors and the grounded metallic covering. Provided that the conductors which are not connected are grounded.



a) **Voltage application across cores**



b) **Voltage application across layers**

Fig. 6 Wiring method

c) **Spark** Use the spark tester in air as shown in Fig. 7, apply the specified a.c. voltage of nearly sinusoidal waveform at frequency 50 Hz or 60 Hz between the conductor grounded previously and the electrode for 0.15 s or more, or for 9 cycles or more if it is high frequency and examine whether the specimen withstands this voltage or not.

In the spark tester of Fig. 7, the components ① are electrodes of metal chain or beads, suspended 12 mm or less apart in the direction of wire axis and 9 mm or less in the lateral direction. The length of chains shall be somewhat longer than the depth of the electrode box, so that they may sufficiently contact with the wire surface regardless of the diameters of the wires.

The part ② is a U-shape or V-shape electrode box, the width of the upper chain fitting part is larger than the maximum wire diameter by 33 mm or more.

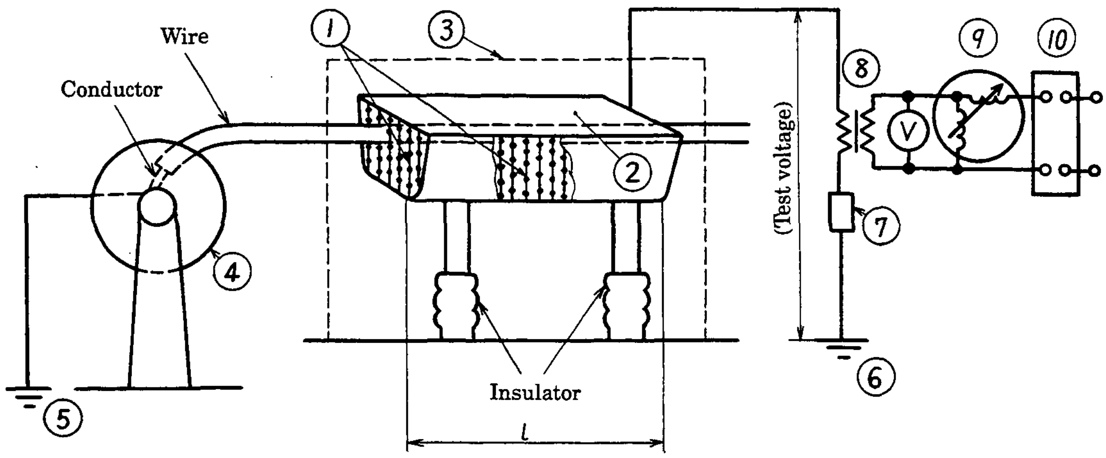
In the case of high frequency, calculate the length from the formula given below. Instead of the above-mentioned metal chain or bead-like electrode, a water electrode may be used.

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

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

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

f : frequency (Hz)



① Electrode
② Electrode box
③ Protective box
④ Reel
⑤ Grounding
⑥ Grounding for transformer
⑦ Device for detecting defective insulation
⑧ Testing transformer
⑨ Voltage regulator
⑩ Overcurrent circuit-breaker

Fig. 7 Outline of spark tester and circuit diagram

4.7 Insulation resistance Use overall length of completed product or a wire of at least 1 m in length as the specimen for insulation resistance test.

4.7.1 Insulation resistance at normal temperature Measure the insulation resistance by one of the methods given below, and convert it to the value per 1 km wire length at 20 °C by means of the following formula:

For such material with high insulation resistance as polyethylene, conversion shall be as specified in the detail specification. If not specified, $K_t = 1$. An example of measuring circuit diagram is shown in Fig. 8.

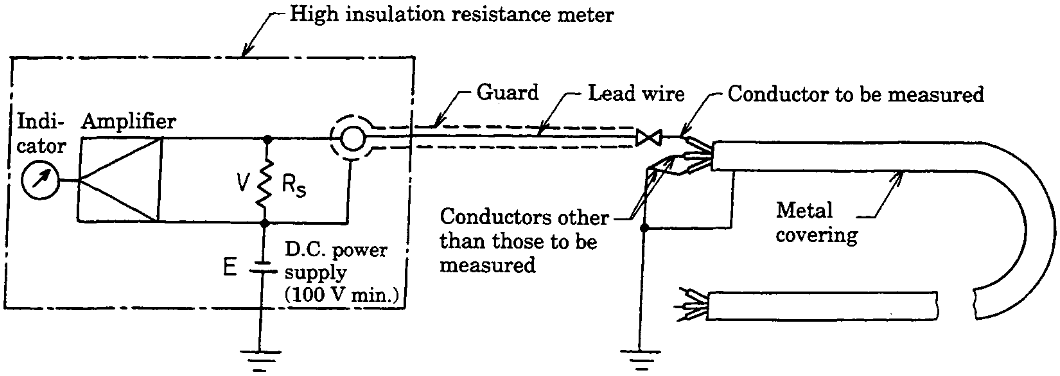
$$R_{20} = R_t \times K_t \times \frac{l}{1\,000}$$

where, R_{20} : insulation resistance converted to that per 1 km at 20 °C (MΩkm)

R_t : measured value at t °C (MΩ). The resistance of lead wire, if included, is eliminated.

K_t : temperature conversion factor of Table 3 for conversion of the value at measuring temperature t °C to that at 20 °C.

l : wire length (m)



where, 1 The d.c. power supply E shall be a battery or a stabilized d.c. power supply.

2 The standard resistance R_s shall be sufficiently smaller as compared with the insulation resistance of the conductor to be measured.

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

Fig. 8 Insulation resistance measurement circuit by means of high insulation resistance meter

a) **In water** Immerse the wire in clear water grounded previously for at least 1 h, and test the wire while still immersed. Apply a d.c. voltage of 100 V or more between the conductor and the clear water for single-core wire, and between the conductors and between the conductors and the clear water for multi-core wire. Measure the insulation resistance after 1 min or more but within 5 min from the voltage application, by means of high insulation resistance meter given in Fig. 8 or the like.

For wire with a metallic covering, the covering shall be grounded.

b) **In air** Apply a d.c. voltage of 100 V or more between the conductors in air and measure the insulation resistance after 1 min or more but within 5 min from the voltage application, by means of high insulation resistance meter given in Fig. 8 or the like. For metal covered wire, measure the resistance between conductors and between conductors and grounded metallic covering.

Table 3 Temperature conversion factor for insulation resistance (Reference temperature 20 °C)

Temperature (t) °C	Natural rubber (K_t)	Isobutylene-isoprene rubber (K_t)	Styrene-butadiene rubber (K_t)	Silicone rubber (K_t)	Chloroprene rubber (K_t)	Ethylene propylene rubber (K_t)	Chlorosulfonated polyethylene rubber (K_t)	Vinyl (K_t)	Temperature (t) °C	Natural rubber (K_t)	Isobutylene-isoprene rubber (K_t)	Styrene-butadiene rubber (K_t)	Silicone rubber (K_t)	Chloroprene rubber (K_t)	Ethylene propylene rubber (K_t)	Chlorosulfonated polyethylene rubber (K_t)	Vinyl (K_t)
0	0.37	0.34	0.34	0.26	0.14	0.42	0.05	0.42	21	1.05	1.07	1.09	1.07	1.10	1.05	1.14	1.11
1	0.39	0.35	0.36	0.28	0.15	0.43	0.06	0.43	22	1.10	1.14	1.18	1.14	1.20	1.10	1.30	1.24
2	0.41	0.38	0.38	0.30	0.17	0.45	0.07	0.44	23	1.16	1.22	1.27	1.23	1.30	1.15	1.50	1.39
3	0.43	0.40	0.40	0.32	0.19	0.48	0.08	0.45	24	1.22	1.30	1.36	1.31	1.45	1.20	1.70	1.55
4	0.45	0.42	0.42	0.34	0.21	0.50	0.09	0.46	25	1.28	1.38	1.45	1.40	1.60	1.25	1.93	1.74
5	0.48	0.44	0.44	0.37	0.23	0.52	0.10	0.48	26	1.35	1.45	1.55	1.50	1.75	1.30	2.20	1.96
6	0.50	0.46	0.47	0.40	0.25	0.54	0.12	0.49	27	1.42	1.55	1.70	1.61	1.95	1.35	2.50	2.22
7	0.53	0.49	0.50	0.43	0.28	0.56	0.14	0.50	28	1.49	1.65	1.85	1.73	2.15	1.42	2.85	2.52
8	0.55	0.52	0.53	0.46	0.31	0.59	0.16	0.52	29	1.56	1.77	2.00	1.87	2.35	1.48	3.25	2.87
9	0.58	0.54	0.56	0.49	0.34	0.62	0.19	0.53	30	1.64	1.89	2.15	2.01	2.60	1.55	3.70	3.25
10	0.61	0.58	0.59	0.52	0.37	0.65	0.22	0.55	31	1.72	2.00	2.30	2.16	2.90	1.62	4.20	3.75
11	0.64	0.61	0.62	0.56	0.41	0.68	0.25	0.57	32	1.81	2.15	2.50	2.32	3.20	1.70	4.75	4.25
12	0.67	0.64	0.65	0.60	0.45	0.70	0.30	0.60	33	1.90	2.32	2.70	2.49	3.50	1.78	5.40	4.90
13	0.71	0.68	0.69	0.64	0.49	0.74	0.35	0.63	34	2.00	2.50	2.90	2.68	3.80	1.84	6.15	5.60
14	0.74	0.72	0.73	0.69	0.54	0.77	0.40	0.66	35	2.10	2.69	3.20	2.88	4.20	1.90	7.05	6.45
15	0.78	0.76	0.77	0.72	0.60	0.80	0.47	0.70	36	2.21	2.91	3.45	3.09	4.58	1.98	—	7.40
16	0.82	0.81	0.81	0.78	0.66	0.84	0.54	0.74	37	2.33	3.17	3.75	3.30	4.99	2.06	—	8.50
17	0.86	0.85	0.85	0.83	0.73	0.86	0.64	0.79	38	2.50	3.46	4.10	3.54	5.41	2.13	—	9.80
18	0.91	0.90	0.90	0.87	0.81	0.91	0.74	0.85	39	2.58	3.78	4.48	3.78	5.85	2.21	—	11.2
19	0.95	0.96	0.95	0.93	0.90	0.95	0.86	0.92	40	2.72	4.15	4.90	4.03	6.30	2.28	—	12.9
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00									

4.7.2 Insulation resistance at high temperature Immerse the specimen in water at the specified temperature ± 1 °C, until the temperature of the insulation is stabilized, and then measure the insulation resistance by the method of **4.7.1**. Do not carry out temperature conversion.

4.8 Capacitance Measure the capacitance on overall length of completed product or a wire of at least 1 m in length. For single-core wire, immerse the wire in grounded clear water and measure the capacitance between the conductor and the grounded clear water, and for multi-core wire, measure the capacitance between the conductors in air (all conductors are grounded except the one to be measured) at a frequency of 1 000 Hz using an a.c. bridge method or employing a portable direct reading capacitance measuring apparatus or by other suitable methods. In either case, convert the values into the equivalent per km of wire length. For metal covered wire, measure the capacitance in air with the metallic covering grounded.

4.9 Dielectric loss tangent Sample a suitable length of core specimen from the product, apply the specified nearly sinusoidal a.c. voltage at 50 Hz or 60 Hz between the conductor and the shield, and measure the capacitance by Schering bridge given in Fig. 9 or by other suitable methods.

The dielectric loss tangent is expressed in the unit of % but it may be expressed by the absolute value.

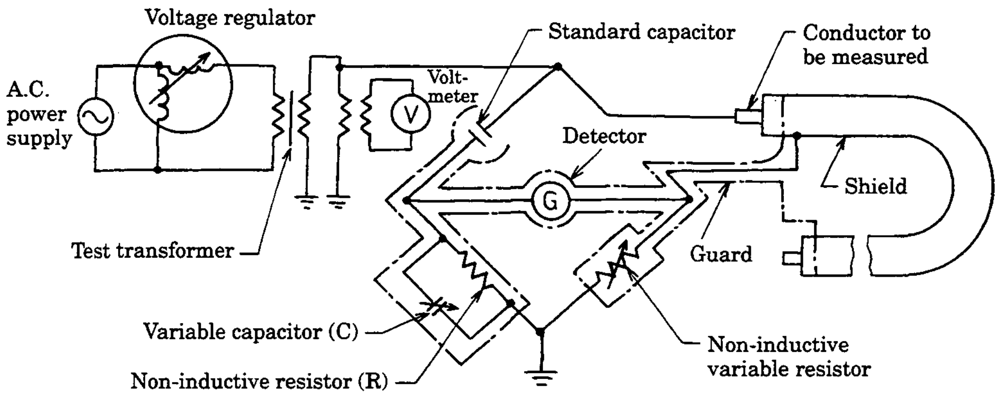


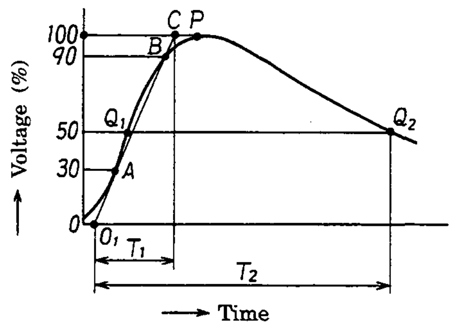
Fig. 9 Schering bridge

4.10 Power frequency long term withstand voltage (a.c. long term withstand voltage) Sample a suitable length of core specimen from the product. Remove the metallic shield from both ends, leaving at least 600 mm on the middle part if the sample has a metallic shield, or apply a metal shield of 600 mm or more on the middle part if the sample has no metallic shield. Bend this core specimen approximately 180° around a circumference of approximately 10 times the outer diameter of the core at room temperature. Apply a specified a.c. voltage of nearly sinusoidal waveform at a frequency 50 Hz or 60 Hz continuously for the specified duration across the conductor and the shield. Examine whether the core specimen withstands this test voltage or not.

Instead of a metallic shield, a water electrode may be used.

4.11 Lightning impulse withstand voltage (impulse withstand voltage) Sample a suitable length of core specimen from the product. Remove the metallic shield from both ends, leaving at least 600 mm on the middle part, if the sample has a metallic shield, or apply a metallic shield of 600 mm or more on the middle part if the sample has no metallic shield. Bend this core specimen approximately 180° around a circumference of approximately 10 times the outer diameter of the core at room temperature. Apply a lightning impulse voltage with a standard waveform as shown in Fig. 10 across the conductor and the shield, and examine whether the core specimen withstands this test voltage or not. The tolerance on the waveform is within the range of 0.5 μs to 5 μs for wave front and 40 μs to 60 μs for wave tail.

Instead of a metal shield, a water electrode may be used. Unless otherwise specified, make the conductor side the negative polarity, and apply the test voltage three times.



T_1 : virtual front time (1.2 μs)
T_2 : virtual time to half value (50 μs)
P : peak value
O_1 : virtual origin
Q_1, Q_2 : half-wave crest

Fig. 10 Standard waveform of lightning impulse voltage

4.12 Creepage withstand voltage Take a sample of approximately 300 mm long from the product, and immerse it in water at normal temperature for 30 min. Wipe the water off the surface, wind copper wire of approximately 1 mm in diameter around the sample at 2 places at a specified distance in the middle part of the sample. Employ them as electrodes, and apply the specified a.c. voltage of nearly sinusoidal waveform at a frequency 50 Hz or 60 Hz across both electrodes for 1 min. Examine whether the sample emits smoke, burns, or produces flashover or not.

4.13 Tracking resistance Take a sample of 150 mm or more from the product, as shown in Fig. 11, remove the insulation of approximately 20 mm from one end at right angles to the lengthwise direction so as to expose the conductor, wind a bare copper wire of 1 mm in diameter around the insulation at a distance of 100 mm from the cut end, and employ this wire and conductor as the electrodes. Hold the sample vertically, and apply a nearly sinusoidal a.c. voltage of 4 kV at a frequency 50 Hz or 60 Hz across the electrodes.

Spray a test solution [1 *l* of water containing 2 g of sodium chloride and 1 ml (7.5 mol) nylphenyl polyoxyethylene glycolether with conductivity of approximately 3 000 μS/cm] on the test sample for the specified number of cycles at a spray speed of approximately 3 m/s (at the position of the test sample), at a spray rate of 0.5 mm/min ± 0.1 mm/min (rate of mist fall), keeping a distance of approximately 500 mm across the test sample and the nozzle. Examine the surface to see whether there is leakage current and whether it burns.

Count a spray of 10 s and a rest of 20 s as one cycle of spraying.

Unit : mm

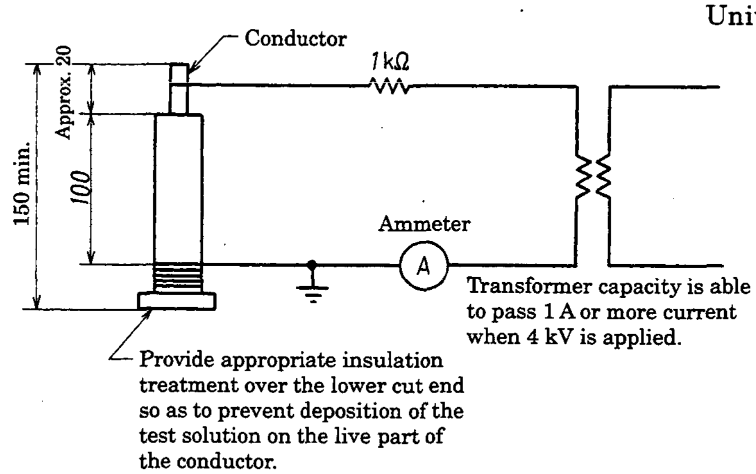


Fig. 11 Circuit diagram

4.14 Surface leakage resistance Take a sample of 100 mm from the product, wind copper wire of approximately 1 mm in diameter around the middle part of sample at 2 places at a distance of 50 mm, place it in a thermostatic chamber at a temperature 18 °C to 28 °C and relative humidity 90 % ± 5 %, allow it to stand for 6 h, and take it out of the chamber. Apply a d.c. voltage of 100 V or more across the copper wires wound on the sample for 1 min, and read the measured value of insulation resistance.

4.15 Thermal discoloration of conductor Take a suitable length of core specimen from the product, keep it in a thermostatic chamber at 130 °C ± 3 °C for 6 h, take it out of the chamber and examine the extent of discoloration on the outside of the conductor.

4.16 Tensile properties of insulation and sheath

4.16.1 Preparation of test pieces

4.16.1.1 Sampling Sample at least three test pieces from the product. If taking the test pieces from the product is impossible or inappropriate, prepare a sheet 1 mm to 2 mm thick rolled from a compound of identical quality to the insulation, leave it exposed at normal temperature for 5 h (24 h after cross linking, if the compound has cross linking), and then take the test pieces from the sheet.

4.16.1.2 Shape and preparation of test pieces The test pieces shall be of tubular shape for insulation with an inner diameter less than 5 mm, while for others they shall be normally dumbbell shaped. For insulation of 2 mm or more in thickness, the test pieces can be dumbbell shaped even if the inner diameter is less than 5 mm.

Normally, test pieces of the sheath shall be of dumbbell shaped, while ones with an inner diameter less than 6 mm can be of tubular.

Tubular test pieces shall be approximately 150 mm long and provided with gauge marks 50 mm apart in the middle part.

Treat the dumbbell shaped test pieces so that they have a smooth surface by eliminating irregularities by suitable means. Make their thickness as near to the original as possible, or adjust to approximately 2 mm if the original thickness exceeds 2 mm.

Punch out the dumbbell shaped test pieces using the punching die for dumbbell No. 3 or No. 4 specified in **4.1** of **JIS K 6251**, and graduate gauge marks at a spacing of 20 mm in the middle of the piece. The width of the grip shown in Fig. 12 may be made as narrow as 7 mm.

Unit : mm

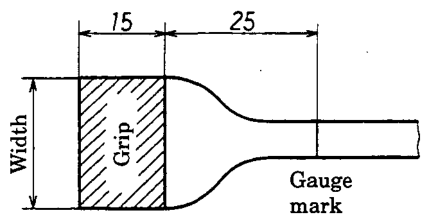


Fig. 12 Grip of dumbbell shaped test pieces

4.16.1.3 Calculation of cross-sectional area The method of calculation of the cross-sectional area is as follows:

a) **Tubular test pieces** Calculate tubular test pieces by one of the following methods:

   1) **Method by dimensions** Measure the outer diameter of the insulation at 3 or more points, and calculate the cross-sectional area from the following formula using the minimum measured value and the outer diameter of the conductor:

$$A = \frac{\pi}{4}(D^2 - d^2)$$

where, A : cross-sectional area (mm^2)

D : outer diameter of insulation (mm)

d : outer diameter of conductor (mm)

2) **Method by density, mass and length** Prepare a suitable length of sample from insulation or sheath, and calculate the cross-sectional area from the following formula:

$$A = \frac{1\,000m}{\rho \times l}$$

where, A : cross-sectional area (mm^2)

m : mass of test piece (g)

l : length (mm)

ρ : density (g/cm^3) Measure down to 3 decimal places in accordance with **JIS K 7112**.

b) **Dumbbell shaped test pieces** For dumbbell shaped test pieces, measure the thickness at least at 5 points with a micrometer or dial gauge, and calculate the cross-sectional area by multiplying the measured minimum value by the width of the parallel portion (for width, the width of the punching die is used).

4.16.2 Testing conditions

4.16.2.1 Temperature The temperature shall be room temperature of 18 °C to 28 °C, and the room temperature at the time of test shall be recorded.

4.16.2.2 Conditions of test pieces Keep the test piece at the room temperature of **4.16.2.1** for at least 1 h before the test.

4.16.2.3 Testing machine The testing machine is specified in **JIS B 7721**, and its capacity shall be such that the maximum tensile load of the test pieces falls within the range of 15 % or over up to and including 85 % of its capacity. Calibrate the testing machine so that the error in its indicated value is always within 2 %.

4.16.3 Testing method Chuck the test piece properly and surely so that it will not be distorted or show other trouble during the test, draw it at one of the rates of pulling A, B, C or D in Table 4, and measure the maximum tensile load and gauge length at rupture of the test piece.

Table 4 Rate of pulling

Class	Rate of pulling mm/min	Applicable material
A	Approx. 500	Soft vinyl Natural rubber, synthetic rubber
B	Approx. 200	Polyethylene (including cross-linked polyethylene) Semi-hard vinyl
C	Approx. 50	High-density polyethylene
D	Approx. 25	

4.16.4 Method of calculating tensile strength and elongation

4.16.4.1 Tensile strength Convert the tensile strength to a value per unit area using the following formula:

$$\delta = \frac{F}{A}$$

where, δ : tensile strength (MPa)

F : maximum tensile load (N)

A : cross-sectional area of test piece (mm^2)

4.16.4.2 Elongation Measure the reference length at the time of rupture, and calculate the elongation from the following formula:

$$\varepsilon = \frac{l_1 - l_0}{l_0} \times 100$$

where, ε : elongation (%)

l_1 : reference length at rupture (mm)

l_0 : reference length (mm)

4.16.4.3 Determination of values Obtain the average of the values from three test pieces.

4.16.4.4 Breaking outside gauge marks If any of the test pieces breaks outside the gauge marks and fails to conform to the specification, remove that test piece and carry out a test on an additional test piece.

4.17 Thermal aging

4.17.1 Heating tester Unless otherwise specified, use a tester similar to the type B tester specified in **JIS K 7212**. The air inside the tester shall be replaced by 1 to 20 times the volume per hour.

4.17.2 Testing method Put the test pieces prepared by **4.16.1** into the tester. The volume of the test pieces shall not exceed 2 % of the inner volume of the tester. Hang the test pieces on the sample holder so that the test pieces will not contact each other or the wall of the tester, and place the assembly into the tester (no agents interacting with test pieces shall be placed in the tester). Heat the test pieces at one of the temperatures and the durations specified as A, B, C, D, E, F, G, H or I in Table 5, take them out of the tester and allow them to stand in ordinary temperature for not less than 4 h, measure the tensile strength and elongation within 96 h after that, in accordance with **4.16.2** to **4.16.4** and calculate the unaged percentage from the formula given below. The cross-sectional area is the calculated value by **4.16.1.3** before heating and the gauge marks are to be marked after heating.

$$X \times \frac{C_1}{C_0} \times 100$$

where, X : unaged percentage (%)

C_0 : mean value before heating

C_1 : mean value after heating

Table 5 Heating temperature and duration of heating

Class	Heating temperature °C	Duration of heating h
A	90 ± 2	96
B	100 ± 2	48
C		96
D	120 ± 3	48
E		96
F		120
G	200 ± 3	96
H	220 ± 3	
I	250 ± 3	

4.18 Oil resistance Immerse the test pieces prepared by **4.16.1** in the test oil under one of the conditions A, B and C of Table 6, take them out of the oil and lightly wipe off the excessive oil adhering to the surface. Allow them to stand at ordinary temperature for 4 h or more, measure the tensile strength and the elongation within 96 h in accordance with **4.16.2** to **4.16.4** and calculate the unaged percentage from the formula given below. The cross-sectional area is the value calculated by **4.16.1.3** before oil immersion, and the gauge marks are to be marked after oil immersion.

$$X \times \frac{C_1}{C_0} \times 100$$

where, X : unaged percentage (%)

C_0 : mean value before oil immersion

C_1 : mean value after oil immersion

Table 6 Temperature and duration of oil immersion

Class	Temperature of oil immersion °C	Duration of oil immersion h
A	70 ± 2	4
B	85 ± 2	
C	120 ± 2	18

Unless otherwise specified, use No. 2 oil of **JIS K 6258** or equivalent oil.

Informative reference : IRM 902 specified in **ASTM D-471** (see related standard in the last page) is an equivalent oil to No. 2 test lubricant oil specified in **JIS K 6258**.

4.19 Heat shock

4.19.1 Method A Remove from the product all outer coverings on sheath, if any, take a sample of suitable length of wire or core, and carry out a heat shock test by either of the following methods:

a) For solid wire or wire of nominal conductor cross-sectional area not exceeding 100 mm², wrap the sample closely around a mandrel of a specified diameter by a specified number of turns or simply bend the sample. Heat it for 1 h in a thermostatic chamber at a specified temperature, remove it from the chamber, and examine the surface visually for formation of flaws or cracks.

b) For wire of nominal conductor cross-sectional area exceeding 100 mm², take a slender test piece which has a width 1.5 or more times (minimum 4 mm) the thickness of the insulation or sheath of sample and as uniform in width as possible, by cutting along the axis of wire or core. Wrap the test piece by 3 or more turns closely around a mandrel with a diameter of 1.5 to 2.0 times the thickness of the test piece. Heat it for 1 h in a thermostatic chamber at a specified temperature, remove it from the chamber, and examine the surface visually for formation of flaws or cracks.

   Select a mandrel of thinner diameter, in mm unit, diameters equal to 1.5 to 2.0 times the thickness of the test piece.

4.19.2 Method B Remove all outer coverings on sheath from the product, if any, take a sample of suitable length of wire or core, and carry out a heat shock test by either of the following methods:

a) If the outer diameter of the sample is 12.5 mm or smaller (exclusive of wire using non-cross-linked polyethylene insulated core and sector core), wrap the test piece closely around a mandrel with the appropriate diameter of Table 7, for the number of turns specified in Table 7. Heat it for 1 h in a thermostatic chamber at a specified temperature, remove it from the chamber and examine visually the surface for formation of flaws or cracks.

   For flat wire, select the diameter of the mandrel based on its minor axis, and wrap the wire with its major axis side in contact with the mandrel.

   The method for testing wires employing non-cross-linked polyethylene insulated core and sector cores shall be as described in **b**) below.

Table 7 Diameter of mandrel and number of turns

Outer diameter of sample mm	Diameter of mandrel mm	Number of turns
Up to and incl. 2.5	5	6
Over 2.5 up to and incl. 4.5	9	
Over 4.5 up to and incl. 6.5	13	
Over 6.5 up to and incl. 9.5	19	4
Over 9.5 up to and incl. 12.5	40	2

b) If the outer diameter of sample exceeds 12.5 mm, take a slender test piece which has a width 1.5 or more times (minimum 4 mm) the thickness of insulation or sheath of sample and is as uniform in width as possible, by cutting along the axis of wire or core. For sector core, take a sample by cutting along the axis of core from the circumscribed circle side of core.

If the thickness of test piece exceeds 5 mm, reduce the thickness to 4 mm to 5 mm by polishing taking care not to overheat the outside. Adjust the width of test piece to 1.5 times or more the thickness of the thinner part of the test piece.

Wrap the test piece closely around a mandrel with the appropriate diameter shown in Table 8 for the number of turns specified in Table 8 so as to make the inner side of test piece in contact with the mandrel. Heat the assembly in a thermostatic chamber at a specified temperature for 1 h, remove it from the chamber, and examine the surface visually for formation of flaws or cracks.

Table 8 Diameter of mandrel and number of turns

Outer diameter of sample mm	Diameter of mandrel mm	Number of turns
Up to and incl. 1	2	6
Over 1 up to and incl. 2	4	
Over 2 up to and incl. 3	6	
Over 3 up to and incl. 4	8	4
Over 4 up to and incl. 5	10	2

4.20 Cold bend

4.20.1 Method A Remove all outer coverings on sheath, if any, from the product, take a sample of suitable length of wire or core, and carry out the test by either of the following methods:

a) For solid wire or wire of nominal conductor cross-sectional area not exceeding 100 mm^2, cool the sample in a cooling chamber at specified temperature for 1 h, and remove it from the chamber. Immediately wrap the sample closely or simply bend around the mandrel of a specified diameter at a uniform speed. Examine visually the surface for formation of flaws or cracks.

b) For wire of nominal conductor cross-sectional area exceeding 100 mm^2, take a slender test piece which has a width 1.5 or more times (minimum 4 mm) the thickness of the insulation of sample and is as uniform in width as possible, by cutting along the axis of wire or core.

Wrap the test piece closely around a mandrel with a diameter 1.5 times to 2.0 times the thickness of the test piece by 3 or more turns. Cool the assembly in a cooling chamber at specified temperature for 1 h, and remove it from the chamber. Immediately rewind the test piece closely on another mandrel with the same diameter at a uniform speed. Examine the surface visually for formation of flaws or cracks.

Select a mandrel of thinner diameter, in mm unit, from diameters 1.5 times to 2.0 times the thickness of the test piece.

4.20.2 Method B Remove all outer coverings on sheath, if any, from the product, take a sample of suitable length of wire or core, and carry out the test by either of the following methods:

a) If the outer diameter of the sample is 12.5 mm or less or the sample is a sector core, cool the sample in a cooling chamber at specified temperature for 1 h, and remove it from the chamber. Immediately wrap the sample closely around a mandrel with a diameter of 4 times to 5 times the outer diameter of sample at a constant rate for the number of turns specified in Table 9. Examine the surface visually for formation of flaws or cracks.

For flat wire, select the diameter of the mandrel based on its minor axis, and wrap the wire with its major axis side in contact with the mandrel.

For sector core, select the diameter of the mandrel based on the outer diameter of radius direction, and wrap the core with its circumscribed circle side in contact with the mandrel.

If the diameter of mandrel equal to 4 times to 5 times the outer diameter of the sample is 20 mm or smaller, take a thinner diameter of the even number in mm unit, and if the calculated diameter exceeds 20 mm take a diameter of a multiple of 5 mm thinner than the calculated one.

Table 9 Number of turns

Outer diameter of sample mm	Number of turns
Up to and incl. 2.5	10
Over 2.5 up to and incl. 4.5	6
Over 4.5 up to and incl. 6.5	4
Over 6.5 up to and incl. 8.5	3
Over 8.5 up to and incl. 12.5	2

b) If the outer diameter of the sample exceeds 12.5 mm, take a slender test piece which has a width 1.5 or more times (minimum 4 mm) the thickness of insulation or sheath of sample and is as uniform in width as possible, by cutting along the axis of wire or core.

Wrap the test piece by 3 turns or more closely around a mandrel with a diameter of 1.5 to 2.0 times its thickness. Cool the assembly in a cooling chamber at specified temperature for 1 h, and remove it from the chamber. Immediately rewind the test piece closely on another mandrel with the same diameter at a uniform speed. Examine the surface visually for the formation of flaws or cracks.

Select a mandrel of thinner diameter, in mm unit, from diameters 1.5 times to 2.0 times the thickness of test piece.

4.21 Heat shrinkage Take a sample of core approximately 150 mm in length from the product, remove the insulation from both ends by approximately 5 mm each, and mark gauge marks 100 mm apart in its middle as shown in Fig. 13. Keep it in a thermostatic chamber at 100 °C ± 2 °C for 1 h, and remove it from the chamber. Allow it to stand in normal temperature for 1 h, then measure the gauge length and calculate the relative shrinkage from the following formula.

$$X = \frac{100 - l}{100} \times 100$$

where, X : relative shrinkage (%)

l : length after heating (mm)

Unit : mm

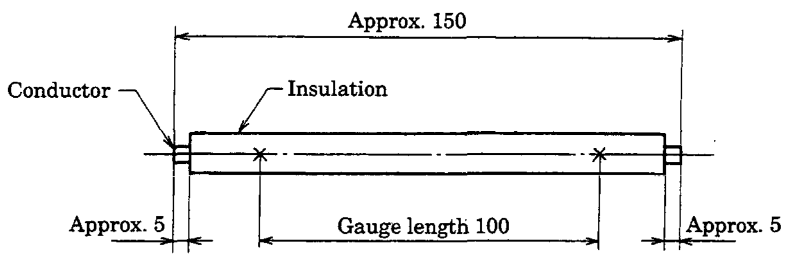


Fig. 13 Sample for heat shrinkage

4.22 Low-temperature impact

4.22.1 Preparation of test pieces Take 3 test pieces 38.0 mm ± 2.0 mm in length, 6.0 mm ± 0.4 mm in width, and 2.0 mm ± 0.2 mm in thickness, from the product. If it is impracticable or inappropriate to make test pieces from the product, make them from a compound of the same quality.

4.22.2 Testing apparatus The testing apparatus consists of a test piece clamp, a striker, and a thermostatic chamber.

The test piece clamp shall be capable of holding firmly the test piece, by clamping as shown in Fig. 14.

The striker has a tip 1.6 mm ± 0.1 mm in radius and shall operate at a uniform linear speed of 2.0 mm ± 0.2 mm per second when striking the test piece and during the travel of at least approximately 5 mm after striking. For the relative position between the striker and the clamp, the distance between the center line of striker and the clamp end at the time of striking is 8.0 mm ± 0.2 mm, as shown in Fig. 14. The distance between the striker and the clamp end at the time of striking and immediately thereafter shall always be 6.4 mm ± 0.2 mm.

The thermostatic chamber shall be capable of maintaining the liquid cooling medium (hereafter referred to as "medium") uniformly at a specified temperature.

Unit : mm

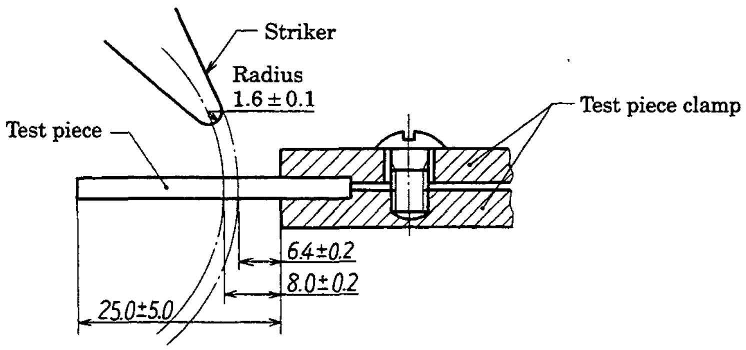


Fig. 14 Striking method

4.22.3 Testing method Pour a medium which will not affect the test piece at the specified test temperature into the testing apparatus, and regulate the apparatus to the specified testing temperature. Fix the test piece to the test piece clamp. Immerse the assembly in the medium for 2.5 min ± 0.5 min, record the temperature, drive the striker, and examine whether the test piece breaks.

The breaking implies splitting of the test piece into two or more pieces, and not the formation of cleavages or cracks.

4.23 Heat deformation

4.23.1 Preparation of test pieces

4.23.1.1 Insulation Prepare the insulation test pieces by one of the following methods:

a) If the conductor is a solid wire, a concentric-lay-stranded conductor, or a bunch-stranded conductor of 5.5 mm^2 or less, sample a core of approximately 30 mm long from the product and use it as the test piece. The length of conductor may exceed 30 mm.

   For bunch-stranded conductors, it is permissible to draw out conductors of core and insert a metallic or wooden rod with the same diameter as the conductor.

b) If the conductor is a bunch-stranded conductor of over 5.5 mm^2 or a rope-lay stranded conductor, cut out a circular arc strip approximately 30 mm long from the product in parallel to the core axis. Finish the inside surface smooth, and use it as the test piece.

c) If **a**) and **b**) are impracticable or inappropriate, take the sample from a compound of the same quality as the insulation, kneed it appropriately, form it into a sheet of approximately 2 mm in thickness, approximately 15 mm in width and approximately 30 mm in length by pressing, and use the sheet as the test piece.

4.23.1.2 Sheath Prepare the sheath test piece by one of the following methods:

a) If the sheath is tubular, take sample of approximately 30 mm in length from the product, draw out of it all the core to make it into a tubular test piece, or else cut the sheath in parallel to the wire axis to obtain a test piece of a circular arc shape.

b) For solid multi-core wire, take a sample of approximately 30 mm in length from the product, cut it in parallel to the wire axis into a circular arc shape and finish its inside surface smooth to obtain a test piece.

c) If **a**) and **b**) are impracticable or inappropriate, take a sample from a compound of the same quality as the sheath, knead it appropriately, form it into a sheet of approximately 2 mm in thickness, approximately 15 mm in width and approximately 30 mm in length by pressing, and use the sheet as the test piece.

4.23.2 Preparation of test pieces Carry out preparation of test pieces by one of the following methods:

a) For core test pieces, the preparation is as described in **4.23.1.1 a**).

b) For circular arc test pieces, place the test pieces of **4.23.1.1 b**) as well as **4.23.1.2 a**) and **b**) on a semicircular rod approximately 35 mm in length, with a diameter not more than the diameter of the conductor or the core before it is cut.

c) For tubular test pieces, insert a rod approximately 35 mm in length with the same diameter as the inner diameter of the test piece of **4.23.1.2 a**) into the tube.

d) For sheet test pieces, place the test pieces of **4.23.1.1 c**) and **4.23.1.2 c**) on a semicircular rod approximately 35 mm in length, with a radius of 5 mm.

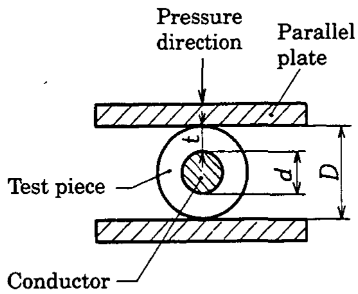
4.23.3 Testing method Measure the thickness (t), before heating, of the test piece prepared by **4.23.2** at ordinary temperature as shown in Fig. 15, with the dial gauge specified in **JIS B 7503**, the vernier calliper specified in **JIS B 7507**, or other measuring instruments equivalent or superior in accuracy. Put the test piece into the testing apparatus heated to the specified temperature in advance, heat it for 30 min, place the test piece between the parallel plates of the measuring apparatus, apply the specified weight, maintain such loading state for 30 min at the same temperature, and measure the thickness of test piece. Calculate the reduction factor from the thickness before heating and that after heating, by means of the following formula:

$$X = \frac{t_0 - t_1}{t_0} \times 100$$

where, X : reduction factor (%)

t_0 : thickness before heating (mm)

t_1 : thickness after heating (mm)

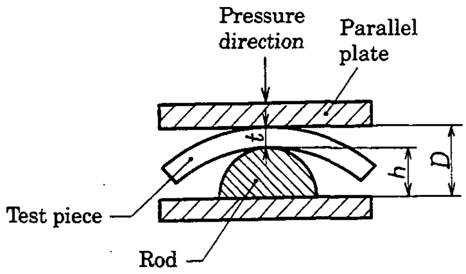


t : thickness of insulation or sheath

d : diameter of conductor or circular rod

D : outer diameter of insulation or sheath

$$t = \frac{D-d}{2}$$

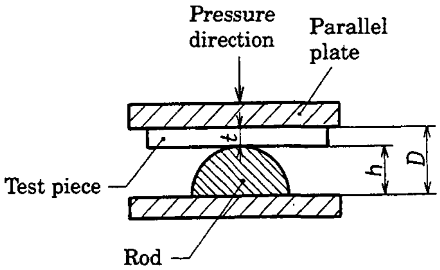


t : thickness of insulation or sheath

h : height of semicircular rod

$D = h + t$

$t = D - h$



t : thickness of test piece

h : height of semicircular rod

$D = h + t$

$t = D - h$

Fig. 15 Measuring method of thickness in heat deformation test

4.24 Ozone resistance

4.24.1 Preparation of test pieces Prepare No. 1 dumbbell shaped test pieces specified in Table 1 and Fig. 1 in **4.1** of **JIS K 6251** and, polish as smooth as possible by a suitable method, if necessary. If it is impossible to punch a dumbbell shape, prepare tubular test pieces.

In advance, confirm that there is no mechanical flaw on the test piece.

4.24.2 Testing device As a rule, the testing device shall comply with **1** in the Annex.

4.24.3 Testing method Before putting the test piece into the testing chamber, operate the device for 15 min or more. When the conditions such as temperature, flow rate, ozone concentration and internal pressure have reached the stationary state, carry out the test.

The measurement of ozone concentration shall comply with **2** in the Annex.

Unless otherwise specified, put the test piece, with an elongation of 25 % applied by appropriate grips, into the testing chamber, where ozone concentration is 0.010 % to 0.015 % (volume), air flow rate is 5 l/min to 10 l/min and room temperature is 18 °C to 28 °C, and examine the surface visually whether the cracks appear within 3 h or not.

Place the test piece in the center of the chamber so as to protect it from contact with other things.

4.25 Degree of cross-linking

4.25.1 Test piece and solvent

4.25.1.1 Test piece Sample a test piece from the core sample taken from the product, so as to make its mass approximately 0.5 g by the method shown in Fig. 16. If the mass exceeds 0.5 g per test piece, adjust it as shown in Fig. 17. If the mass is under 0.5 g per test piece, adjust the mass by the number of test pieces, and adjust one of the test pieces as shown in Fig. 17.

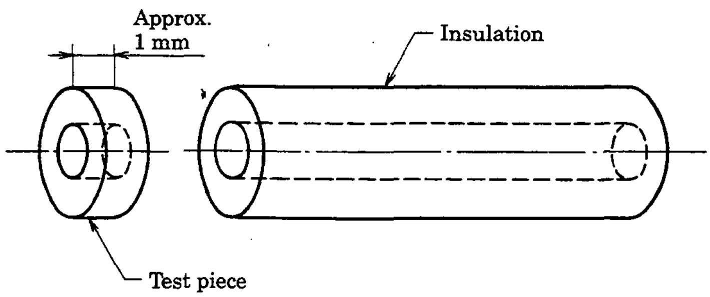
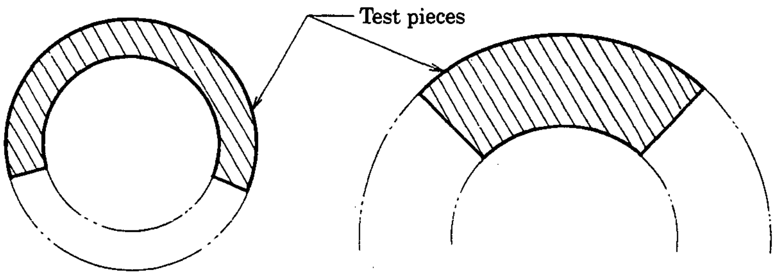


Fig. 16 Sampling of test piece



a) b)

Fig. 17 Adjustment of test piece

4.25.1.2 Solvent The solvent is class 1 xylene specified in **JIS K 8271**, and application is only once.

4.25.2 Testing method Carry out the test by the following method:

a) Measure the mass (m_1) of the test piece to the nearest mg.

b) Pour the solvent stated in **4.25.1** of approximately 50 g (approximately 58 ml) into a test tube, and put the test piece into it.

c) Keep the test tube containing the test piece at 110 °C ± 2 °C for 24 h.

d) After **c**), remove the test piece from the test tube and put into a vacuum desiccator and dry at a temperature 100 °C ± 2 °C and a vacuum of 1.3 kPa or less for 24 h or more.

e) After the drying, measure the mass (m_2) of the test piece to the nearest mg.

Be careful so that xylene vapor will not ignite or explode (attach a reflux condenser, for instance).

4.25.3 Degree of cross-linking Calculate the degree of cross-linking from the following formula:

$$X = \frac{m_2}{m_1} \times 100$$

where, X: degree of cross-linking (%)

m_1: mass before test (mg)

m_2: mass after test (mg)

4.26 Flame retardance

4.26.1 Test apparatus

a) **Test chamber** The test chamber shall be made from metallic sheet to a size of approximately 610 mm in height, approximately 310 mm in width, and approximately 360 mm in depth, covering both sides and the rear.

b) **Sample support** The sample support shall be made of metal, and capable of holding the sample horizontally or in an inclined position.

c) **Heating source** The heating source is a Bunsen burner with a bore of approximately 10 mm and regulated to give an oxidizing flame of approximately 130 mm with a reducing flame of approximately 35 mm.

For the fuel, use industrial methane gas of approximately 37 MJ/m^3 or a fuel equivalent or superior in calorific value.

4.26.2 Testing method

a) **Horizontal test** In the horizontal test, as shown in Fig. 18 **a**), support horizontally a sample of approximately 300 mm in length taken from the product, apply the tip of the reducing flame to the underside of the middle portion of the sample until the sample burns but for 30 s at the maximum, then remove the flame gently and examine the sample for the degree of burning.

b) **Inclined test** In the inclined test, as shown in Fig. 18 **b**), support a sample of approximately 300 mm in length taken from the product inclined at an angle of approximately 60° to the horizontal, apply the tip of the reducing flame to the part of approximately 20 mm from the bottom end of the sample until the sample burns but for 30 s at the maximum, remove the flame gently, and examine the sample for the degree of burning.

Unit : mm

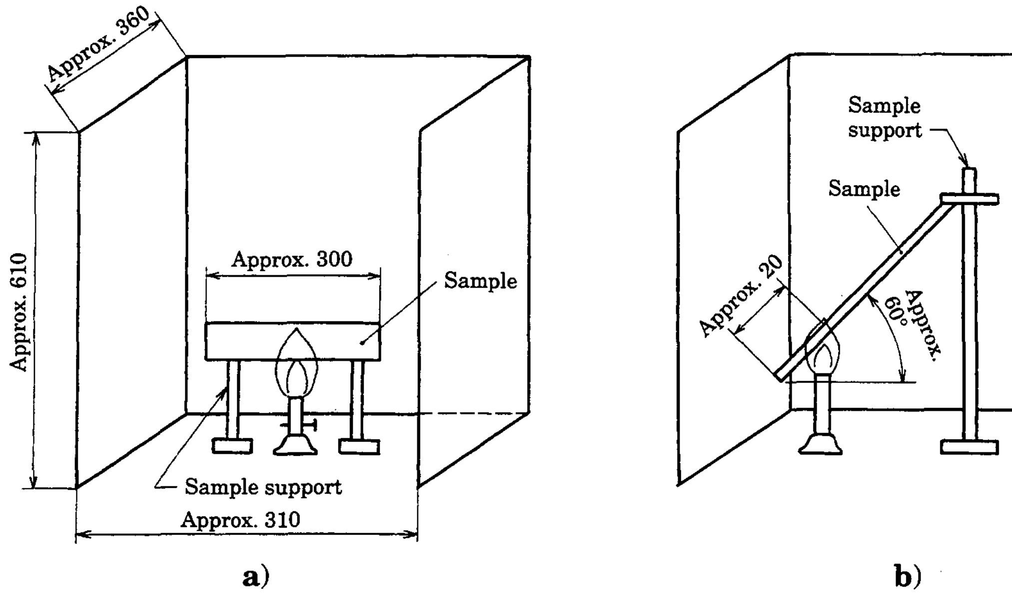


Fig. 18 Testing set for combustion

4.27 Bending Carry out the bending by one of the following methods according to the construction:

4.27.1 Cabtire construction

a) **Round type** Take a sample of suitable length from the product, fix both ends, through the sample passage hole on the rotor of the bending tester, appropriate to the thickness of sample, as shown in Fig. 19. Mount the sample so that it will have *r* and *l* given A or B of Table 10, according to the class of wire. Rotate the rotor 200 revolutions continuously at a rate of approximately 20 revolutions per minute. Examine the sample for the extent of breakage or flaws and cracking generated, and for the number of broken component wires of each core, at the fixed points and the passage hole.

Keep away the part of sample in the passage from being twisted by suitable means.

Unit : mm

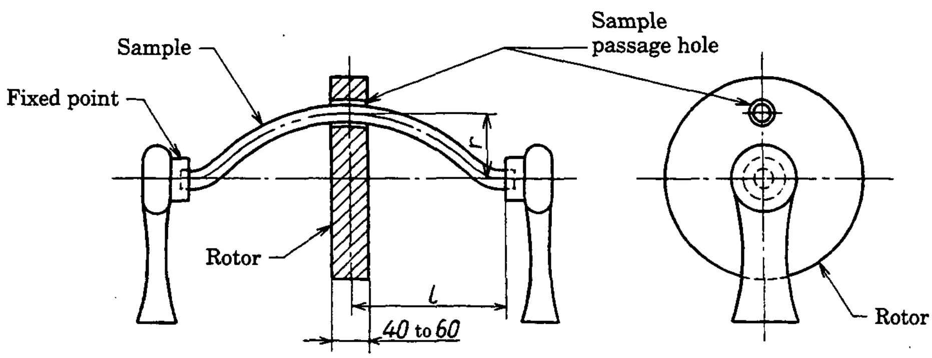


Fig. 19 Bending tester

Table 10 Fixing distance and bending radius

Classification	*r* mm	*l* mm
A	100	300
B	150	200

b) **Flat type** Take a sample of suitable length from the product, bend it through 90° along the circular arc of a mandrel with a diameter of 5 times the minor axis of cable, return it to the straight position, bend it through 90° in the opposite direction, and return it to the straight position. When this series of operations is carried out at a rate of 10 cycles per minute (6 cycles for the conductor nominal cross-sectional area over 38 mm²) continuously for 200 cycles, examine the sample for the extent of breakage or flaws and crackings generated and for the number of broken component wires of each core.

4.27.2 Lead sheath construction Take a sample of suitable length from the product, bend it gradually through approximately 180° along a circular arc with a diameter of approximately 20 times the outside diameter of the lead sheath (use the minor axis for flat type), return it to the straight position, and bend it in the opposite direction and back again. Repeat this series of operations 3 times (6 bends), and examine the lead sheath for the generation of cleavage.

4.27.3 Braiding construction Take a sample of suitable length from the product, keep it at a temperature of 200 °C ± 3 °C for 6 h, and then allow it to stand in the ordinary temperature for 24 h or more. Bend it through approximately 90° along the specified circular arc, return it to the original position, further bend it through approximately 90° in the opposite direction, and then return to the original position.

Repeat this series of operations twice (4 bends), and examine the braiding for the generation of cleavage or peeling off of the coating.

4.27.4 Flat-type construction (cord) Carry out the test on flat-type construction by the following method:

a) Take a sample of suitable length from the product, fix one end to the fixing gadget of the tester shown in Fig. 20 through the space between two metal cylinders whose surfaces are smooth of 5 mm in diameter, and hang a weight of 150 g per 1 mm² of cross-sectional area of conductor (500 g, if less than 500 g) to the other end. Bend the sample by rotating right and left alternately, through approximately 180° each while a current equal to the allowable current of sample is passed (take this operation as one cycle). Carry out this operation continuously for 100 cycles at a rate of approximately 10 cycles per minute. Examine the number of broken component wires of each core. The 2 cylinders and the fixing gadget of the bending tester are to be rotated as one body.

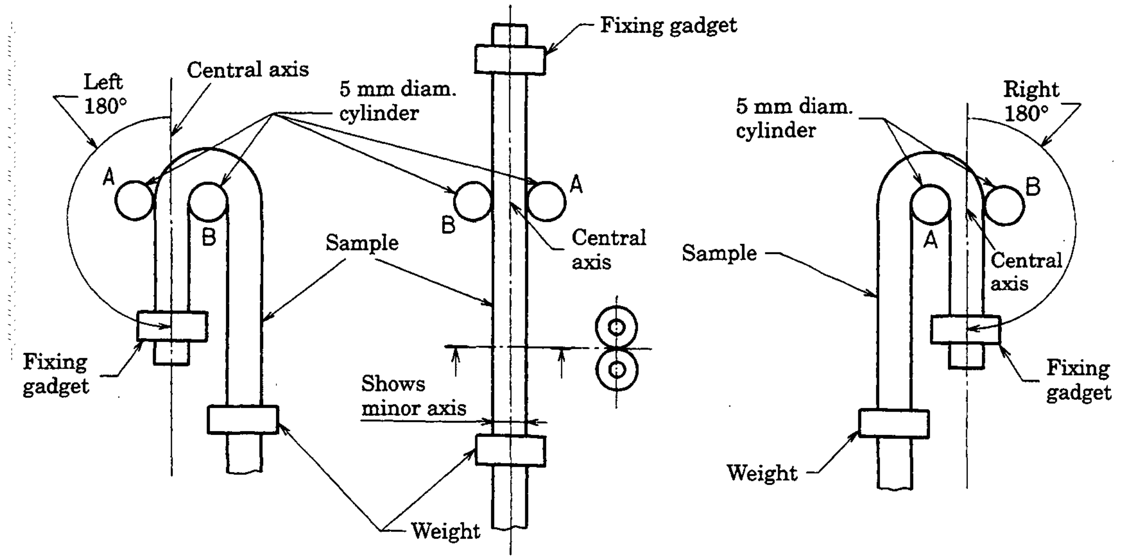


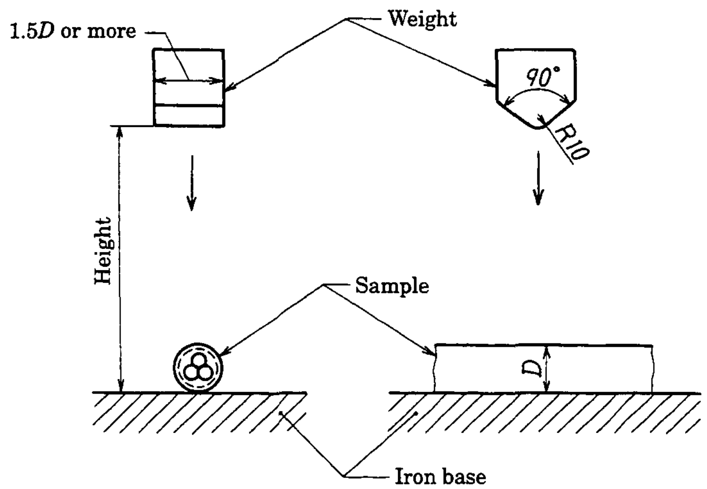
Fig. 20 Bending tester

b) Take a sample of suitable length from the product, keep it at a temperature of 100 °C for 48 h, test it by the method specified in **a)** until one core is broken down, and then examine the sample for generation of short circuits between lines and existence of flaws, cracks or other abnormalities on the insulation.

4.28 Impact Take a sample of suitable length from the product, and place it on the iron base of the impact tester shown in Fig. 21. Drop a specified weight (made of iron) on it from a specified height and examine the damage, flaws, cracks of insulation and sheath, and the number of broken component wires of each core.

The iron base shall not deform due to the impact.

Unit : mm



D is the outside diameter of the sample.

Fig. 21 Impact tester

4.29 Abrasion Take a sample of suitable length from the product, fix one end to the support located approximately 300 mm above the center of the abrasion disc of the abrasion tester shown in Fig. 22, and hang a specified weight on the other end. Let the surface of sample in contact with the circumference of this abrasion disc, rotate the disc in the direction as the gravity acting to the weight at a rate of approximately 60 revolutions per minute. When the specified number of revolutions is attained, examine whether the covering is worn and the insulation inside is exposed or not.

The abrasion disc of the tester shall consist of a material employing silicon carbide with grain size 36 specified in **JIS R 6001** as the principal constituent.

Unit : mm

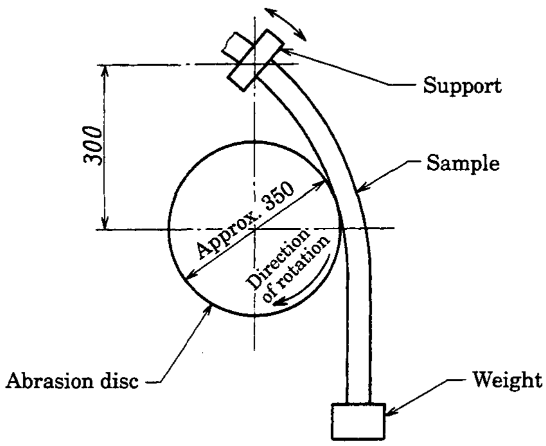


Fig. 22 Abrasion tester

4.30 Twisting Take a sample of approximately 1.5 m in length from the product, hang the weight specified in Table 11 on its center, fold the sample double at that point, hold both ends of the sample and twist them in the direction of the lay of core 10 turns initially, return the twist by applying tension on both ends of the sample, and then loosen the tension. Repeat this series of operations continuously 30 times, and then examine the sample for the number of broken component wires of each core.

Table 11 Mass of weight

Nominal cross-sectional area mm^2	Mass of weight kg
Under 1	0.3
1 and over	0.5

Attached Table 1 International Standards corresponding to this Standard

IEC 60502-2 : 1994 *Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV (NEQ)*

IEC 60811-1-1 : 1993 *Common test methods for insulating and sheathing materials of electric cables—Part 1 : Methods for general application—Section 1 : Measurement of thickness and overall dimensions—Tests for determining the mechanical properties (NEQ)*

Informative reference : There is **JIS C 3660-1-1** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

IEC 60811-1-2 : 1985 *Common test methods for insulating and sheathing materials of electric cables—Part 1 : Methods for general application—Section 2 : Thermal ageing methods (NEQ)*

Informative reference : There is **JIS C 3660-1-2** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

IEC 60811-1-3 : 1993 *Common test methods for insulating and sheathing materials of electric cables—Part 1 : Methods for general application—Section 3 : Methods for determining the density—Water absorption tests—Shrinkage test (NEQ)*

Informative reference : There is **JIS C 3660-1-3** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

IEC 60811-1-4 : 1993 *Common test methods for insulating and sheathing materials of electric cables—Part 1 : Methods for general application—Section 4 : Test at low temperature (NEQ)*

Informative reference : There is **JIS C 3660-1-4** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

IEC 60811-2-1 : 1986 *Common test methods for insulating and sheathing materials of electric cables—Part 2-1 : Methods specific to elastomeric compounds—Ozone resistance, hot set and mineral oil immersion tests (NEQ)*

Informative reference : There is **JIS C 3660-2-1** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

IEC 60811-3-1 : 1985 *Common test methods for insulating and sheathing materials of electric cables—Part 3 : Methods specific to PVC compounds—Section 1 : Pressure test at high temperature—Tests for resistance to cracking (NEQ)*

Informative reference : There is **JIS C 3660-3-1** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

IEC 60811-3-2 : 1985 *Common test methods for insulating and sheathing materials of electric cables—Part 3 : Methods specific to PVC compounds—Section 2 : Loss of mass test—Thermal stability test (NEQ)*

Informative reference : There is **JIS C 3660-3-2** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

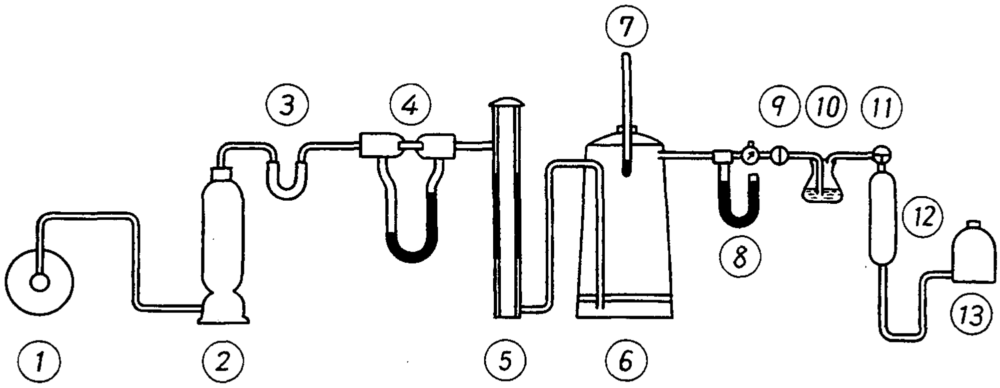
IEC 60885-1 : 1987 *Electrical test methods for electric cables—Part 1 : Electrical tests for cables, cords and wires for voltages up to and including 450/750 V (NEQ)*

Informative reference : There is **JIS C 3661-1** : 1998 as the Japanese Industrial Standard prepared based on the above Standard without modification in the technical contents.

Annex (normative)

Ozone testing device and measurement of concentration

1 Ozone testing device The ozone testing device is shown in Annex Fig. 1. Under certain circumstances, however, some parts of the device may be increased or omitted.



① Air supplying apparatus
② Drier
③ Moisture detector
④ Flowmeter
⑤ Ozonizer
⑥ Testing chamber
⑦ Thermometer
⑧ Manometer
⑨ Cock A
⑩ Ozone collecting bottle
⑪ Cock of gas burret
⑫ Gas burret
⑬ Aspirator

Annex Fig. 1 Ozone testing device

a) **Air supplying apparatus** The air supplying apparatus shall be capable of sending air into the testing chamber and controlling the air flow rate at 5 *l*/min to 10 *l*/min during test.

b) **Drier** The drier shall contain a desiccating agent, such as anhydrous calcium chloride or calcium sulfate, which will not discolor the moisture detecting agent in the moisture detector during the test.

c) **Moisture detector** The moisture detector shall be a glass tube containing a moisture detecting agent, such as anhydrous copper sulfate or cobalt chloride.

d) **Flowmeter** The capacity of the flowmeter shall be at least 10 *l*/min.

e) **Ozonizer** The ozonizer shall be an apparatus to ozonize air, for example, by such means that air is passed through the space of a double-glass tube, an a.c. voltage of nearly sinusoidal wave at 50 Hz or 60 Hz is applied between the inside and the outside of the glass tubes, and the quantity of generated ozone is regulated by a voltage regulator.

f) **Testing chamber** A container of 10 *l* or more in capacity made of materials unaffected by ozone, such as glass, shall be used as the testing chamber. A perforated disc is placed in the bottom of the chamber, and the bottom space is filled with glass wool or the like so that the ozonized air passes through the chamber uniformly from the bottom.

g) **Thermometer** The thermometer shall be inserted as closely as possible to the test piece.

h) **Manometer** The manometer shall be capable of measuring the internal pressure 150 Pa of the testing chamber.

i) **Ozone collecting bottle** An ozone collecting bottle with a capacity of approximately 250 ml to 500 ml shall be used.

j) **Gas burret** A gas burret with a capacity of 500 ml shall be used.

k) **Aspirator** A bottom mouthed bottle having a capacity of 1 *l* shall be used.

2 Measurement of ozone concentration

2.1 Reagents

a) **Preparation of starch solution** This shall comply with the preparation method of an indicator solution for titration specified in **4.4** of **JIS K 8001**.

b) For the preparation and standardization of 0.02 mol/*l* sodium thiosulfate solution, dilute 0.1 mol/*l* sodium thiosulfate solution specified in **4.5 (21.2)** of **JIS K 8001** exactly 50 times. For the factor (titer), use the value of 0.1 mol/*l* sodium thiosulfate solution.

c) **Potassium iodide solution** Dissolve 10 g of potassium iodide in approximately 1 *l* of water.

d) **Acetic acid solution** Dilute 10 g of acetic acid with water to make 100 ml.

2.2 Measuring method Pour 100 ml of potassium iodide solution into the ozone collecting bottle and, acidify it by adding a few drops of acetic acid solution. As shown in Annex Fig. 1, connect it with cock A and the cock of the gas burret.

Open the cock of the gas burret into the air, and by raising the aspirator, fill water in the gas burret up to the marked line. Close the cock of gas burret to the air, and open it to the ozone collecting bottle side. Introduce the ozonized air into the potassium iodide solution of the ozone collecting bottle, by opening cock A of the test chamber. Lower the aspirator until the gas burret becomes empty. Through this series of operations, 500 ml ozonized air will react with potassium iodide, forming iodine.

When the gas burret has become empty, close cock A and take out the collecting bottle.

Titrate it with 0.002 mol/*l* sodium thiosulfate solution and, when the solution becomes light yellow, add a few drops of starch solution, and make the instant when the solution turns from yellow to colorless as the end point.

In this test, carry out the blank test.

3 Calculating method Calculate the concentration from the following formula:

$$O = \frac{2.24(n - n_0)f}{S}\left(1 + \frac{t}{273}\right)$$

where, O : ozone concentration (volume %)

n : volume in ml of 0.002 mol/l sodium thiosulfate solution required to titrate the sample

n_0 : volume in ml of 0.002 mol/l sodium thiosulfate solution required for titration in the blank test

t : test temperature (°C)

S : volume in ml of air sampled

f : factor (titer) in 0.1 mol/l sodium thiosulfate solution standardization method specified in **4.5** (**21.2**) of **JIS K 8001**. Calculate f from the following formula:

$$f = 28.04 \times \frac{A}{n' - n_0'}$$

where, A : sampled quantity (g) of potassium iodate

n' : volume in ml of 0.1 mol/l sodium thiosulfate solution required to titrate potassium iodate

n_0' : volume in ml of 0.1 mol/l sodium thiosulfate solution required for titration in the blank test

Related standards :

IEC 60227-2 : 1997 *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V—Part 2 : Test methods*

IEC 60245-2 : 1997 *Rubber insulated cables of rated voltages up to and including 450/750 V—Part 2 : Test methods*

ASTM D-471 : 1979 *Standard test method for rubber property-effect of liquids*

Errata for JIS (English edition) are printed in *Standardization Journal*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

Errata will be provided upon request, please contact:
Standardization Promotion Department, Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN
TEL. 03-3583-8002 FAX. 03-3583-0462