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JAPANESE INDUSTRIAL STANDARD

Testing methods of varnishes for electrical insulation

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Testing methods of varnishes for
electrical insulation

C 2103-1991

1. Scope

This Japanese Industrial Standard specifies the testing methods of varnishes and enamels for electrical insulation (hereafter referred to as the "varnishes").

Remarks 1. The applicable standards to this Standard are shown in Attached Table 1.

2. The International Standard corresponding to this Standard is shown below:

IEC 464-2 (1974) Specification for insulating varnishes
containing solvent.
Part 2 : Test methods

3. The units and numerical values given in { } in this Standard are based on the traditional units and are appended for informative reference.

2. Classification of test

This Standard covers the tests enumerated in Table 1.

Table 1. Classification of test

Test item	Applicable clause	Test item	Applicable clause
Appearance	6.	Thermosoftening	17.
Specific gravity	7.	Volume resistivity	18.
Viscosity	8.	Electric loss tangent and specific inductive capacity	19.
Non-volatile content	9.	Dielectric breakdown strength	20.
Acid value	10.	Arc resistance	21.
Stability	11.	Flexibility	22.
Thinning easiness	12.	Low temperature flexibility	23.
Film adhesion	13.	Heating loss	24.
Drying time	14.	Oil resistance	25.
Bubbling	15.	Change due to heating	26.
Internal hardening	16.	Film bonding	27.

3. Conditions for Testing

3.1 Atmospheric conditions The test shall be carried out at ordinary temperature and ordinary humidity specified in JIS Z 8703, i.e. at $20 \pm 15^{\circ}\text{C}$ in temperature and $65 \pm 20\%$ in humidity, unless otherwise specified.

3.2 Sampling method The test specimen shall be taken as follows: Designate the product of every manufacture number as one lot, and, at the time of sampling, stir the varnish of every lot thoroughly as needed, then take approximately 0.5 kg of test specimen in a clean container with care not to allow any impurity to enter the test specimen, and then store it as plugged hermetically in order to prevent the volatile matter from transpiration.

3.3 Treatment of test specimens Keep the test specimens in a dark, cool place, as far as possible, until the commencement of tests. The tests of and the preparation of test specimen of liquid state shall be commenced within 72 h after it is sampled.

4. Rounding-off of numerical values

The observed values and the averages thereof obtained by the tests shall be rounded off to the digits given in Table 2 by the rules provided in JIS Z 8401.

Table 2. Rounding-off of numerical values

Test item	To be rounded off to:
Specific gravity	2 places of decimals
Viscosity	2 significant figures
Non-volatile content	
Acid value	
Film adhesion	
Volume resistivity	
Electric loss tangent and specific inductive capacity	
Dielectric breakdown strength	
Arc resistance	3 significant figures
Heating loss	2 significant figures
Film bonding	

5. Test pieces

5.1 Base materials for test pieces The base materials for test pieces shall be as specified below.

- (1) Metal sheets The metal sheets shall be flat sheets specified in JIS G 3141, JIS G 3303 or JIS G 4305. They shall be free from visual fault and shall measure the dimensions specified in Table 3.

Table 3. Size of metal sheets

Unit: mm

Test item	Size of metal sheet		
	Width	Length	Thickness
Drying time Heating loss Oil resistance Change due to heating	Approx. 50	Approx. 90	0.2 to 0.3 (¹)
Appearance of dry film Film adhesion Flexibility	Approx. 50	Approx. 180	
Volume resistivity Electric loss tangent and specific inductive capacity Dielectric breakdown strength	Approx. 130	Approx. 180	

Note (¹) The metallic sheet for flexibility test shall have 0.23 to 0.26 mm in thickness.

- (2) Piano wires Piano wire shall be the tin coated piano wire for armature binding which is straight and free from any visual fault, and shall measure approximately 1.2 mm in diameter, and 50 ± 1 mm and approximately 100 mm in length.
- (3) Pressboards Class 2 pressboards specified in JIS C 2305. They shall measure approximately 0.5 mm in thickness, 15 mm in width and approximately 150 mm in length.
- (4) Annealed copper wires As specified in JIS C 3102. They shall be straight and free from any visual fault, and shall measure approximately 0.2 mm in diameter and approximately 200 mm in length.
- (5) Glass sheets As specified in JIS R 3201. They shall measure approximately 3 mm in thickness, approximately 130 mm in width and approximately 180 mm in length.
- (6) Glass fabrics Alkali-free fabrics EP 10 A or EP 10 B specified in JIS R 3414. They shall have been subjected to heat cleaning treatment.

5.2 Treatment of metallic base materials The metal sheets and piano wires specified in 5.1 shall be polished well with abrasives finer than $44\text{ }\mu\text{m}$ wetted with water so as not to have any adhering substance such as rust, etc., then washed well in running water and wiped with a clean cloth, dried in a thermostatic oven kept at approximately 100°C , and then stored in a desiccator containing solid desiccant. As the abrasives, red iron oxide for paint, clay, diatom earth or precipitated magnesium oxide, which do not contain any coarse grain, are recommendable.

The metal sheets which have been coated with test specimen can be reused, and, in this case, it is recommended to remove the coated film after being immersed in xylene, etc. for a short time.

5.3 Preparation of test pieces

5.3.1 Test pieces of metal sheet After measuring the thickness of metal sheets which have been treated in accordance with 5.2, wipe them with a clean cloth wetted with ethylalcohol, acetone or xylene and dry, and then apply the test specimen onto them. Suspend them in the lengthwise direction ⁽²⁾, and, after leaving them uninterrupted at room temperature for 30 min, dry under the specified conditions ⁽³⁾.

Measure the thickness of varnish film thus coated, and adjust the concentration of the specimen so that the observed thickness lies within the specified value. No adjustment, however, is required for the test of film adhesion.

Application of the test specimen shall be made as specified below and the number of times of application shall be as given in Table 4.

- (1) Application of varnish onto one side Allow the specimen to flow on the one side of metal sheet which is kept in oblique posture.
- (2) Application of varnish on both sides Immerse the metal sheet in the test specimen, and then draw out the sheet at a rate of approximately 0.02 m/s . In any case of (1) and (2) above, the suspension of the metal sheet shall be inverse in the flow direction of test specimen at the first and second time to make the thickness of coated film as even as possible.

Notes (2) To hang the metal sheet, it is convenient to make a hole at a distance of approximately 3 to 4 mm from both ends in the longitudinal direction in the middle of width and then to attach a hook of twisted S form to the hole, as shown in Fig. 1, or to clip this portion with a paper clip of a suitable size.

- (3) In case that the specified heat-drying time exceeds 6 h and the continuous heating is not possible, the heating may be continued for 4 h or longer at the beginning, followed by intermittent heating for the remaining hour. The number of times of heating, however, shall not exceed 4.

Fig. 1. Suspending method for hook and metal sheet

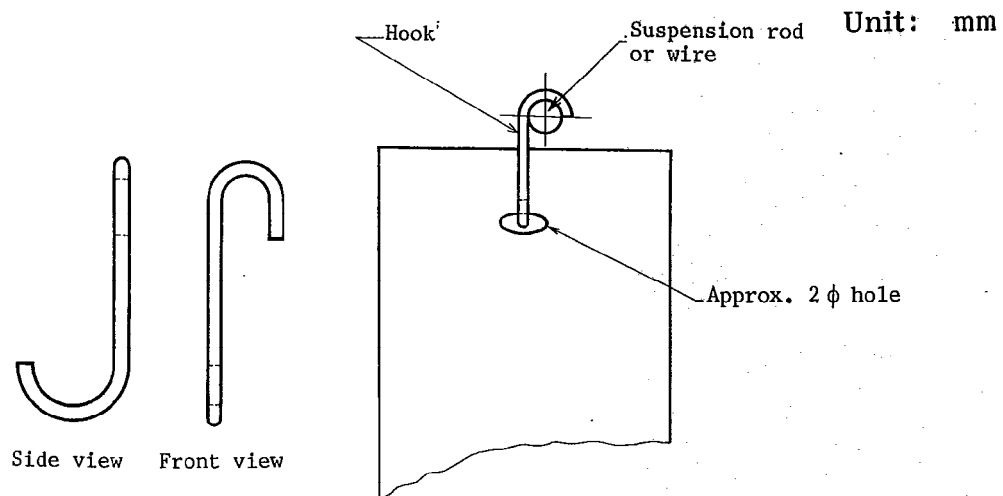


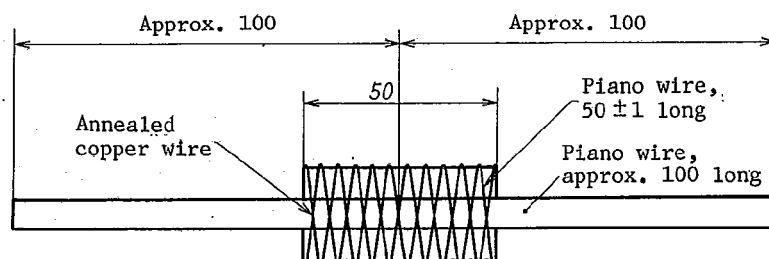
Table 4. Number of times of application

Test item	Number of times of application
Appearance of coated film	1 time on one side
Film adhesion	
Volume resistivity	2 times on one side
Electric loss tangent and specific inductive capacity	
Dielectric breakdown strength	
Flexibility	
Drying time	1 time on one side
Oil resistance	
Change due to heating	
Heating loss	2 times on both sides

5.3.2 Test pieces of piano wires Take 2 pieces each of piano wires having been treated in accordance with 5.2, make one end of long wire to butt against one end of the other long wire, as shown in Fig. 2, bring 2 short wires along with the both sides of long wire with their middles positioned at the butted point of long wires, wind lightly one annealed copper wire of approximately 0.2 mm in diameter around them so that it turns 10 times in one way and thereby 20 times in both ways. Apply the varnish as it is of original concentration thoroughly onto the joint wound part with a brush, leave them uninterrupted horizontally at a room temperature for approximately 30 min, and then dry them under the specified conditions.

Fig. 2. Test piece of piano wire

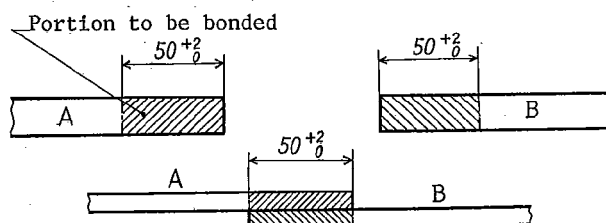
Unit: mm



5.3.3 Test pieces of pressboard Apply the test specimen as it is of original concentration by dipcoating one time onto each end, 50^{+2}_0 mm distant, of 2 sheets of pressboards specified in 5.1 (3), leave them still at normal temperature for approximately 10 min, and bond them as shown in Fig. 3. Applying the load 4.9 N {0.5 kgf} evenly onto them, dry them under the specified conditions.

Fig. 3. Test piece of pressboard

Unit: mm

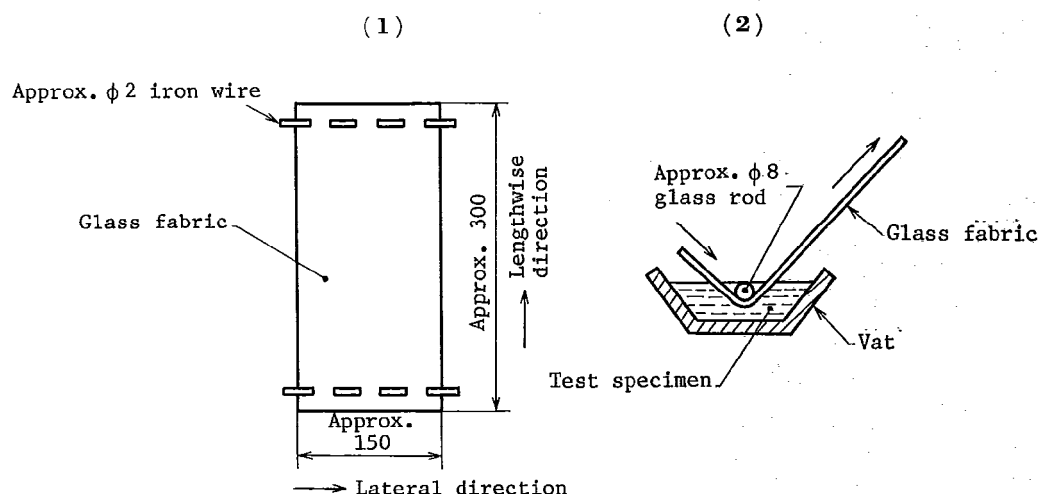


5.3.4 Test pieces of glass sheet Cleanse thoroughly the surface of glass sheet with a clean cloth wetted with ethylalcohol, acetone or xylene, dry it, and measure the thickness of glass sheet. Thereafter apply the test specimen 6 to 8 times in accordance with the method specified in 5.3.1 (1) and dry under the specified conditions. At this time, the concentration of test specimen shall be adjusted so that the thickness of coated film obtained by 6 to 8 times application reaches 0.3 to 0.4 mm.

5.3.5 Test pieces of glass fabric Cut the glass fabric specified in 5.1 (6) along the both directions, lengthwise and lateral, to a size of approximately 150 mm × approximately 300 mm, sew it with an iron wire as shown in Fig. 4 (1), dry it at a temperature of $105 \pm 3^\circ\text{C}$ for 30 min or longer, let it cool down in a desiccator, immerse it in the test specimen as shown in Fig. 4 (2), draw it up gently in the direction of arrow, hang it with its lengthwise direction being vertical at room temperature for approximately 30 min, and then dry it under the specified conditions. When the application of the test specimen is to be made twice or more, the bottom end of the glass fabric which has been hung before shall be positioned upward in order that the thickness of coated film gets as even as possible, and the thickness thus obtained shall prove itself to be in the range of $0.18^{+0.02}_{-0.01}$ mm when the thickness is measured. For this purpose, the concentration of test specimen shall be adjusted. Attention shall be paid to no entrance of bubbles in the coated film.

Fig. 4. Test piece of glass fabric

Unit: mm

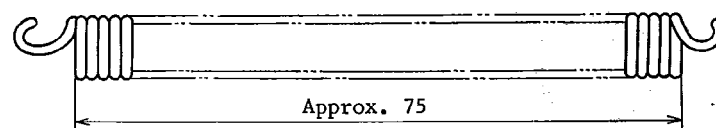


5.3.6 Test pieces of helical coil In order to make a helical coil of approximately 75 mm length wind an enamelled copper wire, 1.0 mm in conductor diameter and 0.025 mm in minimum film thickness, around a round mandrel of 5.0 mm in outside diameter, having the smooth surface so that the copper wires contact tightly with each other shown in Fig. 5, and then draw off the round mandrel. Immerse the helical coil thus obtained in the test specimen for 5 min, take it out of the specimen, hang it lengthwise at room temperature for approximately 30 min, and then dry it under the specified conditions. Next, in order to obtain the thickness as even as possible of the coated film, repeat the procedure same as that for the beginning to make the test piece. At this time, the hanging of test piece shall be made so that the flow direction of test specimen is inverse.

In making this test piece, adjustment shall be made so that the adhesion of test specimen to the helical coil weighs 0.35 to 0.40 g per one piece of helical coil.

Fig. 5. Test piece of helical coil

Unit: mm



5.4 Measurement method for thickness of test pieces For measurement of the thickness of base materials and test pieces, employ an external micrometer (0.01 mm graduated) of approximately 6.5 mm in spindle diameter and not exceeding 25 mm in measuring length specified in JIS B 7502. Pressure for measurement shall be 4.9 ± 0.49 N {500 ± 50 gf}.

When measuring the thickness of the test pieces which have been coated with the test specimen, care shall be taken so as not to injure the coated film.

6. Appearance test

6.1 Implements As specified below.

- (1) Test tube As specified in JIS R 3503, measuring 12 mm in outside diameter of cylinder.
- (2) Metal sheet As specified in 5.1 (1).

6.2 Test method The test shall be made by the method specified below.

- (1) For liquid test specimen Put the test specimen in the test tube specified in 6.1 (1) to the depth not less than 30 mm, and look through it from the side under diffused daylight, to examine for the existence of turbidity and impurity.
- (2) For dry coated film Apply the test specimen onto the metal sheet specified in 5.1 (1), suspend it in lengthwise direction, leave it undisturbed in a room for approximately 30 min, dry it at the specified temperature for the specified time, and thereafter examine its smoothness and gloss and for the existence of bubbles and holes.

6.3 Test report The test report shall include the following particulars:

- (1) Appearance of liquid test specimen (Existence or non-existence of turbidity and impurity)
- (2) Appearance of dried coated film of test specimen (Conditions of coated film)

7. Test for specific gravity

7.1 Implements The implements used shall be as specified below.

- (1) Hydrometer As specified in JIS B 7525.
- (2) Glass container Transparent and having suitable size.

7.2 Test method Measure the specific gravity of test specimen with the hydrometer specified in 7.1 (1) at a temperature of $25 \pm 0.5^\circ\text{C}$.

7.3 Test report The test report shall include the following particulars:

- (1) Temperature ($^\circ\text{C}$) at the time of measurement
- (2) Specific gravity

8. Viscosity test

8.1 Test method Measure the viscosity of test specimen with a viscometer as appropriate at a temperature of $25 \pm 0.5^\circ\text{C}$.

8.2 Test report The test report shall include the following particulars:

- (1) Temperature ($^\circ\text{C}$) at the time of measurement