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## Plasticized polyvinyl chloride compounds

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ICS 83.08.20

**Descriptors** : plasticized polyvinyl chloride, electric cables, plastics, insulating  
coatings, electrical insulating materials

**Reference number** : JIS K 6723 : 1995 (E)

K 6723 : 1995

## 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 Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

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## Plasticized polyvinyl chloride compounds

**1 Scope** This Standard specifies the plasticized polyvinyl chloride compounds, (hereinafter referred to as the "compounds"), used for the polyvinyl chloride insulated wire, polyvinyl chloride cord and cable sheath for 600 V.

Remarks 1 The standards cited in this Standard are as follows:

|            |                                                                                                                       |
|------------|-----------------------------------------------------------------------------------------------------------------------|
| JIS B 7503 | <i>Dial gauges</i>                                                                                                    |
| JIS C 2320 | <i>Electrical insulating oils</i>                                                                                     |
| JIS K 6258 | <i>Testing methods of the effect of liquids for vulcanized rubber</i>                                                 |
| JIS K 7113 | <i>Testing method for tensile properties of plastics</i>                                                              |
| JIS K 7212 | <i>General rules for tests for thermal ageing properties of thermoplastics in the form of sheet by means of ovens</i> |
| JIS K 7216 | <i>Testing method for brittleness temperature of plastics</i>                                                         |
| JIS K 8295 | <i>Glycerol</i>                                                                                                       |
| JIS R 3503 | <i>Glass apparatus for chemical analysis</i>                                                                          |

2 The international standards corresponding to this Standard are as follows:

|                  |                                                                                                                                                                                                                                             |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ISO 182-1 : 1990 | <i>Plastics — Determination of the tendency of compounds and products based on vinyl chloride homopolymers and copolymers to evolve hydrogen chloride and any other acidic products at elevated temperatures — Part 1: Congo red method</i> |
| ISO 291 : 1977   | <i>Plastics — Standard atmospheres for conditioning and testing</i>                                                                                                                                                                         |
| ISO R 527 : 1966 | <i>Plastics — Determination of tensile properties</i>                                                                                                                                                                                       |
| ISO 974 : 1980   | <i>Plastics — Determination of the brittleness temperature by impact</i>                                                                                                                                                                    |
| ISO 2898 : 1986  | <i>Plastics — Plasticized compounds of homopolymers and copolymers of vinyl chloride (PVC-P) — Part 1: Designation, Part 2: Preparation of test specimens and determination of properties</i>                                               |

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

**2 Classification** The classification of compounds shall be as shown in Table 1.

**Table 1 Classification**

| Class   |       | Remark                    |
|---------|-------|---------------------------|
| Class 1 | No. 1 | For general insulation    |
|         | No. 2 | For general cord          |
|         | No. 3 | For general sheath        |
| Class 2 | No. 1 | For heat-proof insulation |
|         | No. 2 | For heat-proof cord       |
|         | No. 3 | For heat-proof sheath     |

**3 Quality** The compounds shall be tested in accordance with **6** and shall conform to the requirements specified in Table 2.

**Table 2 Quality**

| Test Item                  |                                 |                                                | Class 1                                 |                                    |                             | Class 2                            |                                    |                             | Applicable sub-clauses |
|----------------------------|---------------------------------|------------------------------------------------|-----------------------------------------|------------------------------------|-----------------------------|------------------------------------|------------------------------------|-----------------------------|------------------------|
|                            |                                 |                                                | No. 1                                   | No. 2                              | No. 3                       | No. 1                              | No. 2                              | No. 3                       |                        |
| Tensile test               |                                 | Tensile strength<br>MPa {kgf/mm <sup>2</sup> } | Not less than<br>14.7 {1.5}             | Not less than<br>12.7 {1.3}        | Not less than<br>11.8 {1.2} | Not less than<br>14.7 {1.5}        | Not less than<br>12.7 {1.3}        | Not less than<br>11.8 {1.2} | 6.3                    |
|                            |                                 | Elongation %                                   | Not less than 180                       | Not less than 180                  | Not less than 200           | Not less than 180                  | Not less than 180                  | Not less than 200           |                        |
| Tensile test after heating | 100 °C ± 2 °C                   | Retention of tensile strength %                | Not less than 90                        | Not less than 90                   | Not less than 90            | —                                  | —                                  | —                           | 6.4                    |
|                            |                                 | Retention of elongation %                      | Not less than 70                        | Not less than 70                   | Not less than 70            | —                                  | —                                  | —                           |                        |
|                            | 120 °C ± 3 °C                   | Retention of tensile strength %                | —                                       | —                                  | —                           | Not less than 90                   | Not less than 90                   | Not less than 90            |                        |
|                            |                                 | Retention of elongation %                      | —                                       | —                                  | —                           | Not less than 80                   | Not less than 75                   | Not less than 80            |                        |
| Heat deformation rate %    |                                 |                                                | Not more than 40                        | Not more than 40                   | Not more than 40            | Not more than 25                   | Not more than 25                   | Not more than 25            | 6.5                    |
| Low temperature resistance |                                 |                                                | No breakage at a temperature in Table 4 |                                    |                             |                                    |                                    |                             | 6.6                    |
| Heat stability h           |                                 |                                                | Not less than 2                         | Not less than 2                    | Not less than 2             | Not less than 2                    | Not less than 2                    | Not less than 2             | 6.7                    |
| Volume resistivity         | 30 °C ± 0.5 °C Ω cm             |                                                | Not less than 5 × 10 <sup>13</sup>      | Not less than 1 × 10 <sup>12</sup> | —                           | Not less than 5 × 10 <sup>13</sup> | Not less than 1 × 10 <sup>12</sup> | —                           | 6.8                    |
|                            | 60 °C ± 0.5 °C Ω cm             |                                                | Not less than 5 × 10 <sup>11</sup>      | Not less than 1 × 10 <sup>10</sup> | —                           | —                                  | —                                  | —                           |                        |
|                            | 75 °C ± 0.5 °C Ω cm             |                                                | —                                       | —                                  | —                           | Not less than 2 × 10 <sup>11</sup> | Not less than 5 × 10 <sup>9</sup>  | —                           |                        |
| Oil resistance             | Retention of tensile strength % |                                                | Not less than 85                        | —                                  | Not less than 85            | Not less than 85                   | —                                  | Not less than 85            | 6.9                    |
|                            | Retention of elongation %       |                                                | Not less than 80                        | —                                  | Not less than 75            | Not less than 85                   | —                                  | Not less than 75            |                        |

**4 Colour** The colour of compounds shall be as agreed between the parties concerned.

**5 Material and process method** The compounds shall be the material of granular form or powder form processed by mixing necessary plasticizer, stabilizer, lubricant, filler, coloring agent, etc., with polyvinyl chloride as main material.

## **6 Test methods**

**6.1 Method for sampling** At random take one sample for each lot of compounds of the quality considerable same and take it as test sample. In this case, take the quantity required for carrying out each test in 6.3 to 6.9 as one sample.

**6.2 Preparation, annealing and conditioning of test piece** The preparation, annealing and conditioning of test piece shall be in accordance with the methods specified as follows. However, when the test is carried out under conditions other than the following methods according to special agreements between the parties concerned, clearly record the conditions on the test results.

- (1) **Preparation of test piece** Mix the sample taken according to 6.1 by roll milling under the optimum condition, and form the sheets of specified thickness by compression. Cut or punch out the test piece of specified shape from the formed sheets by the specified method.
- (2) **Annealing** Unless specially specified, do not carry out annealing.
- (3) **Conditioning** Unless specially specified, condition the test piece at a temperature of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  for not less than 1 h before test.

**6.3 Tensile test** The tensile test shall be carried out in accordance with **JIS K 7113**. In this case, for the test machine, the tensile test machine of pendulum type may be used. For the test piece, that of No. 2 shall be used. After leaving the sheets of  $1.00\text{ mm} \pm 0.15\text{ mm}$  in thickness formed according to 6.2 (1) at room temperature for not less than 12 h, they shall be punched out. The test shall be carried out in the room at a temperature of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  and the test speed shall be  $200\text{ mm/min} \pm 10\%$ . The test shall be carried out concerning 5 test pieces, and the mean value of them shall be obtained.

## **6.4 Tensile test after heating**

**6.4.1 Apparatus** For the apparatus for tensile test after heating, that of type B specified in **JIS K 7212** shall be used. The test piece shall be heated with vertically attaching to the frame for attaching test piece. The test pieces shall not touch each other or the wall of oven. Anything action on each other shall not be put in the apparatus at the same time.

Furthermore, the inner volume of oven shall be not less than 100 ml per 1 g of test piece.

**6.4.2 Operation** Make the test piece of No. 2 specified in 6.3 and scribe the marked line on it. Measure its thickness with the dial gauge of scale interval 0.01 mm specified in **JIS B 7503**. Then, after heating it in the oven conditioned by heating at a temperature given in Table 3 for 120 h, take it out and leave it in an atmosphere at a temperature of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  for not less than 12 h. Carry out the tensile test specified in 6.3 within 48 h.

**Table 3 Temperature of oven**

| Classification             | Temperature of oven °C |
|----------------------------|------------------------|
| Nos. 1, 2 and 3 of Class 1 | 100 ± 2                |
| Nos. 1, 2 and 3 of Class 2 | 120 ± 3                |

Calculate the retention of tensile strength and the retention of elongation after heating from the following formulae:

$$\gamma_T = \frac{T_2}{T_1} \times 100$$

$$\gamma_L = \frac{L_2}{L_1} \times 100$$

where,  $\gamma_T$ : retention of tensile strength (%)

$\gamma_L$ : retention of elongation (%)

$T_1$ : tensile strength before heating (MPa) {kgf/mm<sup>2</sup>}

$T_2$ : tensile strength after heating (MPa) {kgf/mm<sup>2</sup>}

$L_1$ : elongation before heating (%)

$L_2$ : elongation after heating (%)

Carry out each test concerning 5 test pieces, and obtain the mean value of them.

## 6.5 Test for heat deformation

**6.5.1 Test machine** For the test machine for heat deformation, that equipped with the following conditions shall be used.

- (1) The test machine shall be equivalent to the plastometer of parallel plate form, and shall be able to add accurately the load of 9.806 7 N {1 000 gf} on the test piece.
- (2) The parallel plate shall be equipped with the dial gauge of scale interval 0.01 mm specified in **JIS B 7503**, or with other measuring device with the accuracy equal or superior thereto, and shall be able to accurately measure the relative travelling between the upper plate and the lower one of test piece to 0.01 mm.

**6.5.2 Operation** Take out the test piece of about 35 mm × 35 mm from the sample of 2.0 mm ± 0.2 mm in thickness manufactured according to **6.2 (1)**, and measure its thickness before heating at ordinary temperature with the dial gauge of scale interval 0.01 mm specified in **JIS B 7503** or with other measuring device having the accuracy equal or superior thereto. Heat this test piece and the inner part of test machine for heat deformation at a temperature of 120 °C ± 3 °C. Put the metal rod of the dimension given in Fig. 1 between the parallel plates of test machine for heat deformation as shown in Fig. 2 (a), and read the graduation of dial gauge at that time. Thereafter, put the preheated test piece on the metal rod as shown in Fig. 2 (b), and put it between the parallel plates. Add the load of 9.806 7 N {1 000 gf} through the upper parallel plate. After heating it as it is at a test temperature of 120 °C ± 3 °C for 1 h, read the graduation of dial gauge. Take the difference between the readings of dial gauge as the thickness after heating. Calculate the heat deformation rate from the following formula:

$$d_T = \frac{t_1 - t_2}{t_1} \times 100$$

where,  $d_T$ : heat deformation rate (%)

$t_1$ : thickness before heating (mm)

$t_2$ : thickness after heating (mm)

Carry out the test concerning 3 test pieces and obtain the mean value of them.

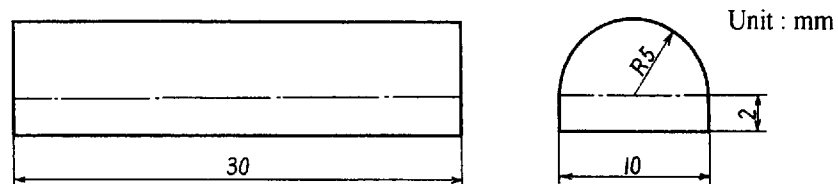


Fig. 1 Metal rod

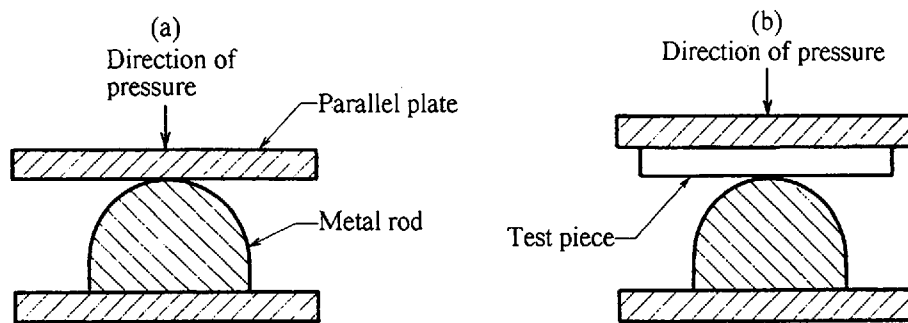


Fig. 2 Method for measuring thickness of test piece after heating

## 6.6 Test for low temperature resistance

**6.6.1 Apparatus** The apparatus for low temperature resistance test shall be in accordance with JIS K 7216. In this case, the gripping device and the impact hammer shall be as shown in Fig. 3.

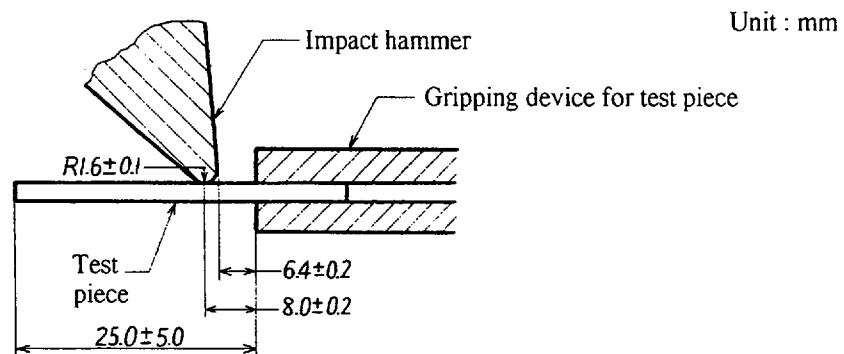


Fig. 3 Gripping device for test piece and impact hammer

**6.6.2 Operation** Prepare the test piece of  $38.0 \text{ mm} \pm 2.0 \text{ mm}$  in length,  $6.0 \text{ mm} \pm 0.4 \text{ mm}$  in width and  $2.0 \text{ mm} \pm 0.2 \text{ mm}$  in thickness from the sample manufactured in accordance with 6.2 (1). Take the liquid giving no effect on the test piece at a temperature given in Table 4 as the heat transfer medium <sup>(1)</sup>, (hereinafter referred to as the “medium”), and preliminarily put the medium into the test vessel. Condition it at a temperature given in Table 4. Attach the test piece to the gripping device, and record the temperature after dipping it into the medium for  $3.0 \text{ min} \pm 0.1 \text{ min}$ . Add an impact once to it with the impact hammer. Take the number of test pieces as 3 pieces, and confirm that all 3 test pieces do not rupture at a temperature given in Table 4. Take the rupture specified herein as the fact that test piece separates into not less than 2 pieces, and do not take the generation of fissure or crazing as the rupture.

Note <sup>(1)</sup> For the medium, monomer of methanol or ethanol, or each mixture with water, etc., are used.

Remarks: The test piece should preferably be attached to the gripping device in the normal state, with a torque of about  $0.19 \text{ J}$   $\{2 \text{ kgf}\cdot\text{cm}\}$  by use of torque driver, torque wrench, etc., for each test piece, if possible.

**Table 4 Temperature of test vessel**

| Classification                           | Temperature of test vessel °C |
|------------------------------------------|-------------------------------|
| No. 1 of Class 1 and<br>No. 1 of Class 2 | − 15                          |
| No. 2 of Class 1 and<br>No. 2 of Class 2 | − 10                          |
| No. 3 of Class 1 and<br>No. 3 of Class 2 | − 15                          |

## 6.7 Test for heat stability

**6.7.1 Reagent and apparatus** The reagent and apparatus shall be as follows:

- (1) **Glycerol** For the glycerol, guaranteed grade specified in **JIS K 8295** shall be used.
- (2) **Test tube** For the test tube, the hard glass test tube of 15 mm in outer diameter and 150 mm in length specified in **JIS R 3503** shall be used.

**6.7.2 Operation** Cut the sample prepared in accordance with 6.2 so that each side of it becomes not more than 1 mm, and take 2 g of it into the test tube. Wet the Congo red test paper of 7 mm in width and 40 mm in length with the specified glycerol. After wiping off the excessive portion of it by putting it between the filter papers, hold the upper end of not more than 10 mm with refined cotton as shown in Fig. 4. Insert it vertically into the center of tube as possible so that the lower end of test paper becomes at the position of 100 mm from the bottom of test tube, and fix it. Vertically dip the prepared test tube as above-mentioned into the oil vessel kept at a temperature of  $180 \text{ }^{\circ}\text{C} \pm 3 \text{ }^{\circ}\text{C}$  so that the bottom of test tube becomes at 70 mm under the surface of liquid, and keep it with an appropriate method. Measure the time between the instance when the test tube is inserted into the oil vessel and the instance when the colour of the upper end of test paper changes to distinct blue colour. However, it may be

terminated with a certain moderate time according to the agreement between the parties concerned.

Remarks: It sometimes happens that the colour of test paper changes not to distinct blue colour but to purple colour or other colour according to an effect of stabilizer, or the like. In this case, new test paper may be changed thereto. Furthermore, the report shall be appended with the time to the initial coloration.

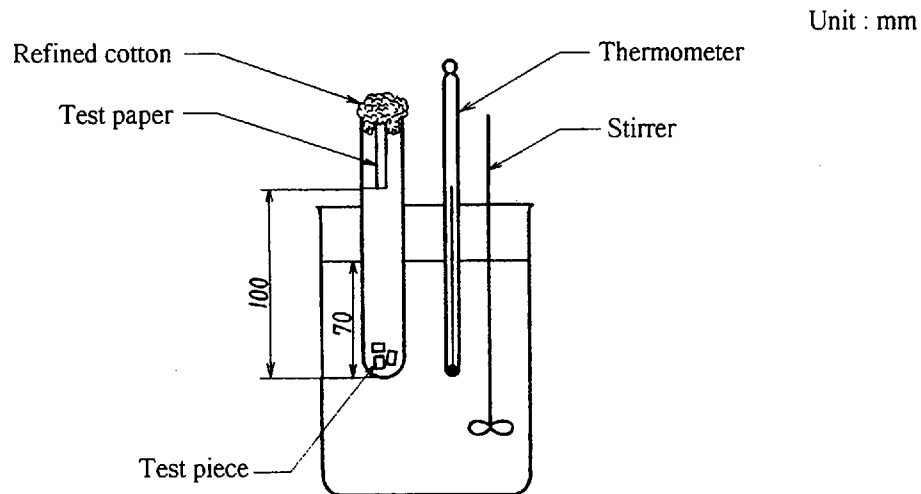


Fig. 4 Test apparatus for heat stability

## 6.8 Test for volume resistivity

### 6.8.1 Device for measurement and electrodes

- (1) **Device for measurement** For the device for measurement, the combination of galvanometer and universal shunt, or the super insulation tester shall be used.
- (2) **Electrodes** The construction and the connection method of electrodes shall be as shown in Fig. 5, and the main electrode and the guard electrode shall be concentric. The dimensions of electrodes shall be as shown in Fig. 6 and any one of the following shall be used for the electrode.
  - (a) The electrode stuck together with such metal foil as aluminum or tin of 0.005 mm to 0.01 mm in thickness by a small amount of vaseline or silicone grease.
  - (b) The electrode coated with the conductive coating using silver powder, graphite powder, etc., and dried.
  - (c) The electrode stuck together with test piece by other appropriate method.

Remarks: Because the electrode stuck together with metal foil is apt to generate bubbles between the test piece and the metal foil during high temperature test, special caution should be taken about it.

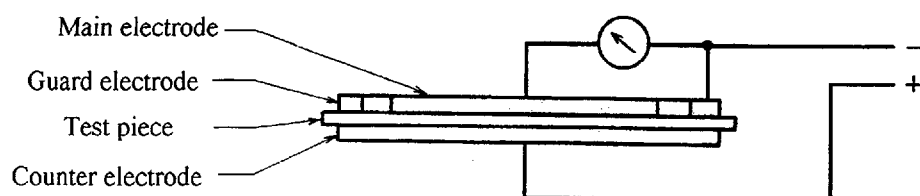


Fig. 5 Construction and connection method of electrodes

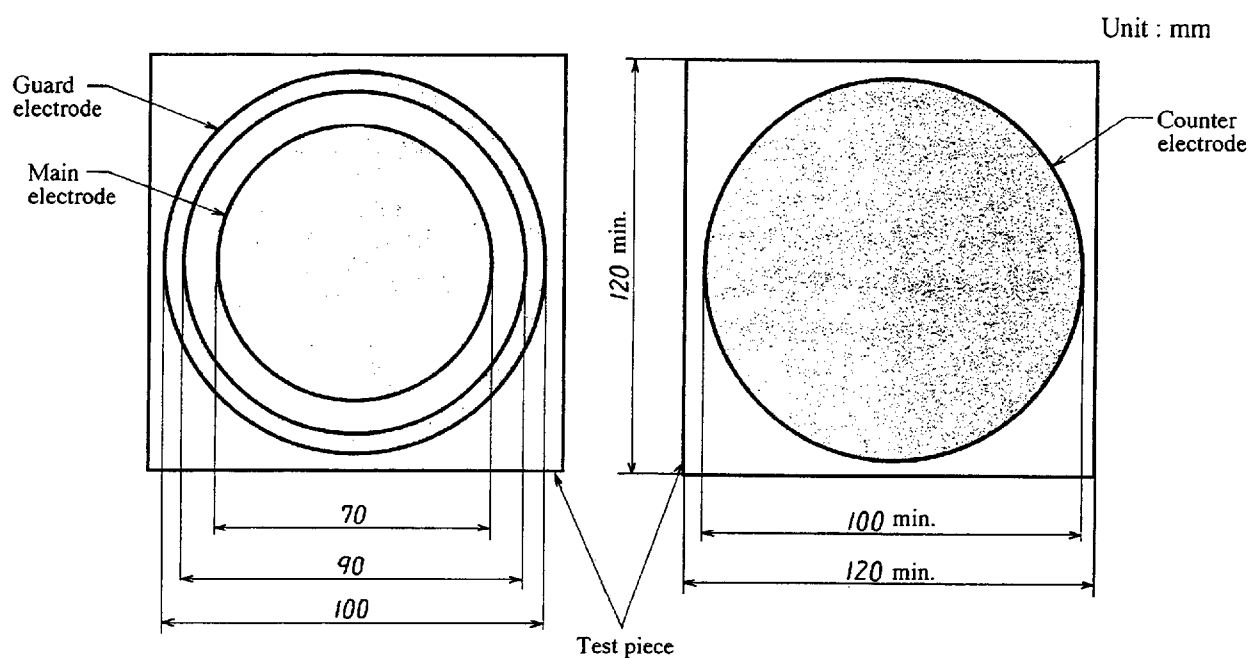


Fig. 6 Dimensions of electrodes

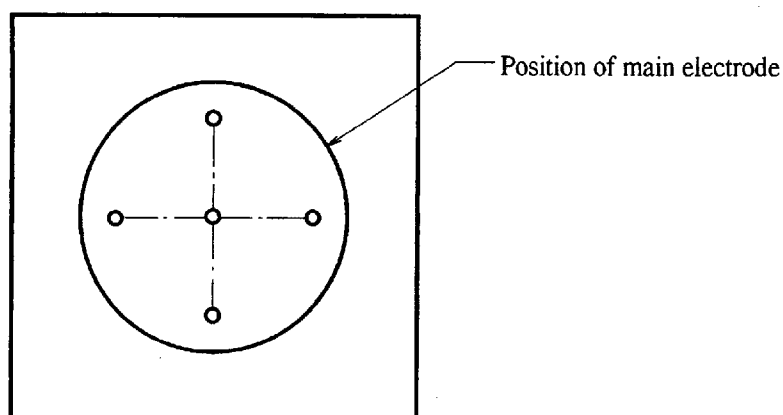


Fig. 7 Position of measuring thickness

**6.8.2 Test piece and measurement of thickness of test piece** Punch out the test piece of not less than 120 mm in both width and length from the sheet of  $1.00 \text{ mm} \pm 0.15 \text{ mm}$  in thickness made in accordance with 6.2 (1). For the thickness of test piece, measure the 5 positions shown in Fig. 7 at the ordinary temperature, and calculate the mean value of them. Make the thickness of it as uniform as possible and let the difference between the maximum and the minimum thicknesses at the 5 positions be not more than 0.1 mm. Further, let the test piece be not warped and its surface be as smooth as possible.

**6.8.3 Operation** Attach the electrodes to the test piece of which thickness is measured in accordance with 6.8.2. After keeping it in the thermostatical vessel at a temperature given in Table 5 for not less than 30 min, connect it to the circuit as shown in Fig. 5 and apply to it the voltage of 500 V in direct current or the voltage of not less than 500 V near this in direct current. Measure the volume resistivity after charging for 1 min. Calculate the volume resistivity from the following formula:

$$\rho = \frac{\pi d^2}{4t} R_v$$

where,  $\rho$ : volume resistivity ( $\Omega \text{ cm}$ )

$d$ : diameter of main electrode (cm)

$t$ : thickness of test piece (cm)

$R_v$ : volume resistance ( $\Omega$ )

**Table 5 Temperature of thermostatical vessel**

| Classification                        | Temperature of thermostatical vessel °C |
|---------------------------------------|-----------------------------------------|
| No. 1 of Class 1 and No. 2 of Class 1 | $30 \pm 0.5$ and $60 \pm 0.5$           |
| No. 1 of Class 2 and No. 2 of Class 2 | $30 \pm 0.5$ and $75 \pm 0.5$           |

## 6.9 Test for oil resistance

**6.9.1 Oil for test** For the oil for test, the electrical insulating oil of No. 2 of Class 1 specified in JIS C 2320. However, the lubricant for test of No. 2 specified in JIS K 6258 may be used in accordance with the agreement between the parties concerned. In this case, that purport shall be recorded on the test results.

**6.9.2 Operation** Prepare the test piece of No. 2 specified in 6.3, and measure its thickness. After dipping it in the oil for test at a temperature of  $70^\circ\text{C} \pm 2^\circ\text{C}$  for 4 h, take it out. Thereafter, lightly wipe off the excessive oil adhering to its surface. After leaving it at a temperature of  $23^\circ\text{C} \pm 2^\circ\text{C}$  for not less than 12 h, mark bench marks, and carry out the tensile test within 48 h in accordance with 6.3. Calculate the retention of tensile strength and the retention of elongation after dipping in oil from the following formulae:

$$\gamma_T = \frac{T_2}{T_1} \times 100$$

$$\gamma_L = \frac{L_2}{L_1} \times 100$$

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where,  $\gamma_T$ : retention of tensile strength (%)

$\gamma_L$ : retention of elongation (%)

$T_1$ : tensile strength before dipping in oil (MPa) {kgf/mm<sup>2</sup>}

$T_2$ : tensile strength after dipping in oil (MPa) {kgf/mm<sup>2</sup>}

$L_1$ : elongation before dipping in oil (%)

$L_2$ : elongation after dipping in oil (%)

Carry out the test concerning 5 test pieces and obtain the mean value of them.

**7 Report** Obtain the test results to one place under the specified numerical value and round off it in accordance with JIS Z 8401.

**8 Packaging and marking** The packaging shall protect the quality of compounds and sufficiently endure the general handling during transportation. It shall be marked with the following information:

- (1) Name and classification
- (2) Net mass
- (3) Colour
- (4) Year and month of manufacture or mark
- (5) Manufacturer's name or mark

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**Standardization Promotion Department, Japanese Standards Association**  
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN  
TEL. 03-3583-8002 FAX. 03-3583-0462