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JIS C 3801-1 : 1999

**Testing method for insulators—  
Part 1 : Insulators for overhead line**

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ICS 29.080.10

**Descriptors** : electric insulators, overhead line conductors, electrical porcelain, testing

**Reference number** : JIS C 3801-1 : 1999 (E)

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## Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS C 3801 : 1993** is replaced with **JIS C 3801-1 to -3 : 1999**.

In this revision, the contents of **JIS C 3801 : 1993** and **JIS C 3804 : 1982** are divided into three parts according to aimed products, and the International Standards corresponding to this part are stated as the Annexes (normative) for being in conformity with International Standards.

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.

**JIS C 3801** consists of the following parts with the general title *Testing method for insulators*.

Part 1 : *Insulators for overhead line*

Part 2 : *Post insulators for station*

Part 3 : *Hollow insulators*

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## Testing method for insulators— Part 1 : Insulators for overhead line

**Introduction** This Japanese Industrial Standard has been prepared based on IEC 60383-1 *Insulators for overhead lines with a nominal voltage above 1 000 V—Part 1 : Ceramic or glass insulator units for a.c. systems—Definitions, test methods and acceptance criteria* published in 1993 as the fourth edition and IEC 60383-2 *Insulators for overhead lines with a nominal voltage above 1 000 V—Part 2 : Insulator strings and insulator sets for a.c. systems—Definitions, test methods and acceptance criteria* published in 1993 as the first edition in such a manner that the testing method for insulators specified in the former JIS is adopted as the text and the International Standards corresponding to this JIS are stated in Annex 1 and Annex 2 without modifying the technical contents. However, the testing solution for porosity test is specified by modifying the contents of the International Standard to precede the safety.

The IEC Standard number is based on the new numbering system of IEC Standards put in force on January 1st 1997, and the Standard published before the said date is numbered by adding 60000 to the former number. This is only the change in the numbering system and the contents remain unchanged.

**1 Scope** This Standard specifies testing methods for porcelain suspension insulators, long rod insulators, line post insulators, pin insulators, etc. to be used for overhead lines (hereafter referred to as “insulators”).

Either of the specifications stated in this text or those stated in Annex (normative) shall be applied throughout to a product, and it is not allowed to apply the items or contents in the text and Annex confusedly.

**Remarks :** The International Standards corresponding to this Standard are given below.

IEC 60383-1 : 1993 *Insulators for overhead lines with a nominal voltage above 1 000 V—Part 1 : Ceramic or glass insulator units for a.c. systems—Definitions, test methods and acceptance criteria*

IEC 60383-2 : 1993 *Insulators for overhead lines with a nominal voltage above 1 000 V—Part 2 : Insulator strings and insulator sets for a.c. systems—Definitions, test methods and acceptance criteria*

**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 indicated below shall be applied.

JIS C 3802 *Permissible limits of visual defects for insulating porcelains*

JIS C 3803 *Glossary of terms for insulator and bushing*

JIS H 0401 *Methods of test for hot dip galvanized coatings*

JIS K 8891 *Methanol*

**3 Definitions** For the purposes of this Standard the principal definitions specified in **JIS C 3803** apply:

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

**Table 1 Classification of tests**

| Classification of tests                          | Applicable clause or subclause for test method | Classification of tests                   | Applicable clause or subclause for test method |
|--------------------------------------------------|------------------------------------------------|-------------------------------------------|------------------------------------------------|
| a) Construction test                             | <b>5</b>                                       | d) Mechanical tests                       | <b>8</b>                                       |
| b) Visual test                                   | <b>6</b>                                       | 1) Withstand load tests                   | <b>8.1</b>                                     |
| c) Electrical tests                              | <b>7</b>                                       | 1.1) Tensile withstand load test          | <b>8.1.1</b>                                   |
| 1) Dry power-frequency flashover voltage test    | <b>7.1</b>                                     | 1.2) Bending withstand load test          | <b>8.1.2</b>                                   |
| 2) Dry power-frequency withstand voltage test    | <b>7.2</b>                                     | 1.3) Impact withstand load test           | <b>8.1.3</b>                                   |
| 3) Wet power-frequency flashover voltage test    | <b>7.3</b>                                     | 2) Mechanical failing load tests          | <b>8.2</b>                                     |
| 4) Wet power-frequency withstand voltage test    | <b>7.4</b>                                     | 2.1) Tensile mechanical failing load test | <b>8.2.1</b>                                   |
| 5) Power-frequency puncture voltage test in oil  | <b>7.5</b>                                     | 2.2) Bending mechanical failing load test | <b>8.2.2</b>                                   |
| 6) Power-frequency voltage test                  | <b>7.6</b>                                     | 2.3) Impact mechanical failing load test  | <b>8.2.3</b>                                   |
| 7) High-frequency voltage test                   | <b>7.7</b>                                     | e) Electro-mechanical failing load test   | <b>9</b>                                       |
| 8) Lightning impulse flashover voltage test      | <b>7.8</b>                                     | f) Temperature cycle test                 | <b>10</b>                                      |
| 8.1) Determination of 50 % flashover voltage     | <b>7.8.3</b>                                   | g) Porosity test                          | <b>11</b>                                      |
| 8.2) Determination of voltage-time curve         | <b>7.8.4</b>                                   | h) Galvanizing test                       | <b>12</b>                                      |
| 9) Lightning impulse withstand voltage test      | <b>7.9</b>                                     |                                           |                                                |
| 10) Dry switching impulse flashover voltage test | <b>7.10</b>                                    |                                           |                                                |
| 11) Dry switching impulse withstand voltage test | <b>7.11</b>                                    |                                           |                                                |
| 12) Wet switching impulse flashover voltage test | <b>7.12</b>                                    |                                           |                                                |
| 13) Wet switching impulse withstand voltage test | <b>7.13</b>                                    |                                           |                                                |

**5 Construction test** The construction and dimensions of test specimens shall be checked.

**6 Visual test** The porcelain part of test specimens shall be visually checked in accordance with **JIS C 3802**. Parts other than porcelain shall be checked whether cracks, flaws and other detrimental defects to practical service exist or not.

**7 Electrical tests** Unless otherwise specified, the following electrical tests shall be made on clean test specimens under dry condition.

### **7.1 Dry power-frequency flashover voltage test**

**7.1.1 Mounting method of test specimens** The electrical tests of test specimens shall be made under the standard mounting conditions specified below. However, the test may be made under the condition that simulates the actual service condition subject to the agreement between the parties concerned.

#### **a) Suspension insulators and long rod insulators**

- 1) **Electrodes** The specimen shall be suspended vertically from a supporting structure by means of a grounded wire rope or suitable conductor. The distance between the metal fittings at the uppermost part of specimen and the supporting structure shall be not less than 1 m. A conductor having a diameter of about 1.5 % and a length 1.5 times or more the length of the specimen shall be fixed horizontally to the lowermost metal fitting by means of a suitable clamp, provided that the minimum diameter shall be 25 mm and the minimum length on one side shall be 1 m, and spherical or other suitable shaped shields shall be attached to the ends of the lower conductor when the test voltage is very high.

The distance from shed of the lowermost porcelain to the upper face of the lower conductor shall be as short as possible. However, the distance shall be not less than 0.5 times the diameter of the lowermost test specimen.

- 2) **Proximity to other objects** No grounded objects other than grounded parts of the testing apparatus shall be nearer to the lower electrode than 1.5 times the length of specimen. However, the distance shall be not less than 1 m.

#### **b) Line post insulators and pin insulators**

- 1) **Electrodes** The test specimen shall be mounted vertically on the centre of grounded horizontal channel bar. The width of the channel bar shall be nearly equal to the diameter of lower metal fittings of the specimen, and the length shall be twice or more the height of the specimen. The height of channel bar shall be 1 m or more from the ground. The conductor and the channel bar shall be set so as to cross each other at right angles. In the case of high voltage pin insulator, however, the pedestal shall be about 150 mm wide and 1.5 m long. The conductor shall be 5 mm or more in diameter, and shall be extended twice or more the height of the specimen both sides when fixed horizontally in the top wire groove (or side wire groove) by a wire of about 1 mm diameter.

When the insulator provides a clamp, the conductor shall be fixed to the clamp.

- 2) **Proximity to other objects** No grounded objects other than grounded parts of the testing apparatus shall be nearer to the upper electrode than 1.5 times the height of the test specimen. However, the distance shall be not less than 1 m with an exception of 0.3 m for high voltage insulator.

c) **High voltage strain insulators and similar insulators**

- 1) **Electrodes** The specimen shall be supported almost horizontally, the cap of the specimen shall be grounded, and the pin shall be used as the electrode.

The conductor shall have at least 5 mm diameter, 0.5 m length, and shall be supported almost horizontally and connected to the pin by a suitable way. The specimen shall be so mounted that the minimum distance between the specimen and the support becomes at least the height of the specimen.

- 2) **Proximity to other objects** The requirements are the same as specified in b) 2).

d) **Strain insulators**

- 1) **Electrodes** The specimen shall be assembled as in practical service, and be mounted almost horizontally to the support. A strap about 38 mm wide and about 3 mm thick shall be attached, grounded, and used as an electrode. The specimen shall be so mounted that the minimum distance between the specimen and the support becomes at least the height of the specimen. A conductor of about 4 mm diameter shall be wound around the wire groove by one turn, and one end of the conductor shall be extended parallel to and in the opposite direction to the strap, to serve as the other electrode.

- 2) **Proximity to other objects** The requirements are the same as specified in b) 2).

e) **Cube type guy insulators and ball type guy insulators**

- 1) **Electrodes** Stranded wires of about 10 mm diameter shall be fixed on the specimen as in practical service and suspended vertically without slack. Each of the stranded wires shall serve as an electrode while one of them being grounded.

- 2) **Proximity to other objects** The requirements are the same as specified in b) 2).

**7.1.2 Application of voltage** The test voltage shall be suitably increased up to about 75 % of the expected flashover voltage, and thereafter at an increment of about 2 % of this value per second until flashover takes place.

**7.1.3 Dry power-frequency flashover voltage** The average of flashover voltages measured consecutively 5 times or more shall be taken as the dry power-frequency flashover voltage of a specimen. The interval of voltage application shall be sufficiently long to avoid the effect of preceding applied voltage within a period during which the test specimen is not affected by the outer atmospheric condition.

**7.1.4 Correction of voltage**

- a) **Standard atmospheric condition** The standard atmospheric condition means an air pressure 1 013 hPa, temperature 20 °C and absolute humidity 11 g/m<sup>3</sup>.

- b) **Correction related to atmospheric condition** When the air pressure, temperature and absolute humidity at the time of test differ from those of the standard atmospheric condition, the flashover voltage and withstand voltage shall be corrected by the following formula:

$$V_S = V_{\delta h} \times \frac{K_h}{K_d}$$

where,  $V_S$ : flashover voltage at the standard atmospheric condition

$V_{\delta h}$ : flashover voltage at relative air density  $\delta$  and absolute humidity  $h$

$K_d$ : air density correction factor

$K_h$ : humidity correction factor

When the atmospheric condition is temperature  $t$  ( $^{\circ}\text{C}$ ), air pressure  $b$  (hPa) and absolute humidity  $h$  ( $\text{g}/\text{m}^3$ ),  $K_d$  and  $K_h$  are given by the following formulae:

$$K_d = \left( \frac{b}{1013} \right)^m \left( \frac{273+20}{273+t} \right)^n$$

$$K_h = (K)^w$$

$K$  shall be obtained from Fig. 2, and  $m$ ,  $n$  and  $w$  shall be obtained, correlating with the gap construction, polarity and waveform of the voltage, from Table 2 and Fig. 1. When carrying out the test under water spray, correction of humidity is not conducted.

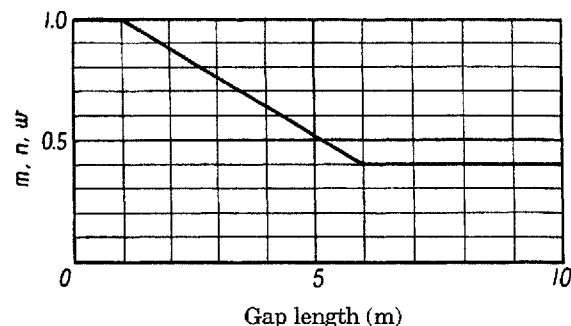


**Fig. 1 Relation between gap length and  $m$ ,  $n$ ,  $w$**

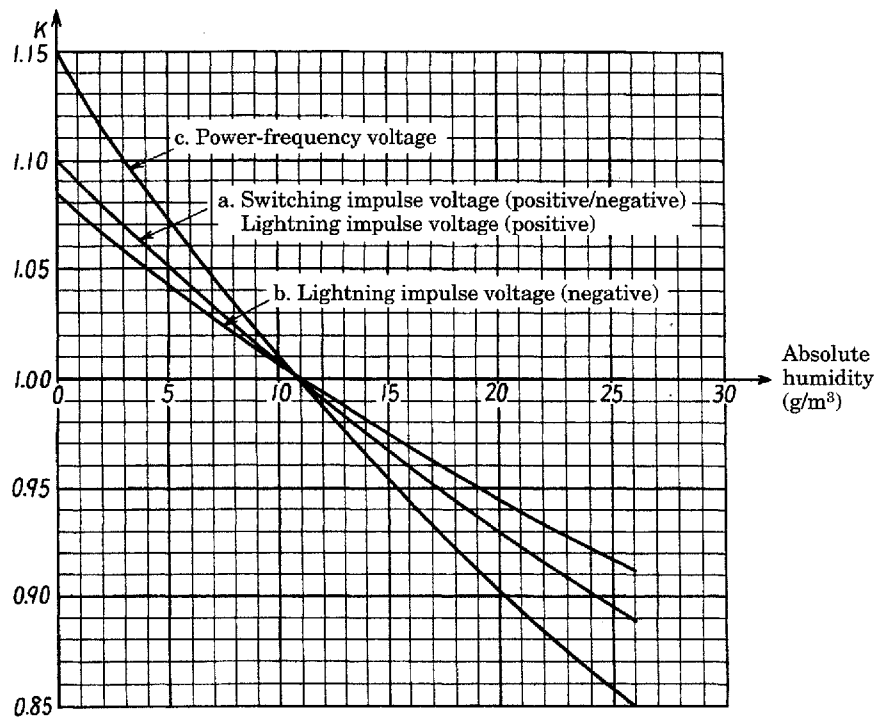


Fig. 2 Relation between  $K$  and humidity

Table 2 Correlation between gap construction, polarity and waveform of voltage,  $m$ ,  $n$  and  $w$

| Waveform of voltage | Lightning impulse voltage |     |             |     | Switching impulse voltage |        |             |   | Power-frequency voltage |        |
|---------------------|---------------------------|-----|-------------|-----|---------------------------|--------|-------------|---|-------------------------|--------|
| Polarity            | Positive                  |     | Negative    |     | Positive                  |        | Negative    |   | —                       |        |
| Gap construction    | A                         | B   | A           | B   | A                         | B      | A           | B | A                       | B      |
| Value of $m, n$     | 1.0                       | 1.0 | 1.0         | 1.0 | 1.0                       | Fig. 1 | 1.0         | 0 | 1.0                     | Fig. 1 |
| Curve of $K$        | a of Fig. 2               |     | b of Fig. 2 |     | a of Fig. 2               |        | a of Fig. 2 |   | c of Fig. 2             |        |
| Value of $w$        | 0                         | 1.0 | 0           | 1.0 | 0                         | Fig. 1 | 0           | 0 | 0                       | Fig. 1 |

Remarks : A is uniform gap or similar one.

B is rod-rod gap, symmetrical non-uniform gap such as suspension insulator.

## 7.2 Dry power-frequency withstand voltage test

**7.2.1 Mounting method of specimen** The mounting method shall follow 7.1.1.

**7.2.2 Application of voltage** The voltage shall be suitably increased up to about 75 % of the test voltage, and thereafter at an increment of about 2 % of the test voltage per second. The specified voltage shall be applied for 1 min, and whether the specimen causes flashover or insulation breakdown or not shall be examined.

**7.2.3 Correction of voltage** In the dry power-frequency withstand voltage test, the value of test voltage appropriate to the atmospheric condition at the time of test shall be obtained in accordance with 7.1.4. The test shall be made with the test voltage so obtained.

### 7.3 Wet power-frequency flashover voltage test

**7.3.1 Mounting method of specimen** The mounting method shall follow 7.1.1.

**7.3.2 Water spray** When carrying out the test under water spray, water shall be sprayed from spray nozzles under a constant pressure. The water drops shall be as small and uniform as possible and the spraying area shall be wide enough to cover the specimen sufficiently. The spraying quantity shall be not less than 3 mm/min in vertical component.

The spraying angle shall, as a rule, be 45° against vertical direction at the central part of the specimen.

The resistivity of spray water shall be  $100 \Omega \cdot m \pm 20 \%$ .

**7.3.3 Application of voltage** The voltage shall be applied in accordance with 7.1.2.

**7.3.4 Wet power-frequency flashover voltage** The average of flashover voltages measured consecutively 5 times or more shall be taken as the wet power-frequency flashover voltage of a specimen. The interval of voltage application shall be sufficiently long to avoid the effect of preceding applied voltage within a period during which the test specimen is not affected by the outer atmospheric conditions.

**7.3.5 Correction of voltage** The wet power-frequency flashover voltage shall be corrected to that under the standard atmospheric condition in accordance with the method specified in 7.1.4.

### 7.4 Wet power-frequency withstand voltage test

**7.4.1 Mounting method of specimen** The mounting method shall follow 7.1.1.

**7.4.2 Water spray** The water spray requirements are the same as that in 7.3.2.

**7.4.3 Application of voltage** The test voltage shall be applied in the same manner as that specified in 7.2.2.

**7.4.4 Correction of voltage** In the wet power-frequency withstand voltage test, the test voltage appropriate to the atmospheric condition at the time of test shall be obtained in accordance with 7.1.4. The test shall be made with the test voltage so obtained.

**7.5 Power-frequency puncture voltage test in oil** This test shall be made only on the specimen whose shortest puncture path through the solid insulating material is not more than 1/2 of its flashover distance.

- a) **Insulating oil** In this test, the insulating oil of volume resistivity  $10^6 \Omega \cdot m$  to  $10^9 \Omega \cdot m$  and almost room temperature shall be used.
- b) **Vessel** when a metal vessel is used, the minimum distance between the specimen and the vessel shall be not less than 1.5 times the maximum diameter of the specimen.

c) **Mounting method of specimen**

- 1) **Suspension insulators and high voltage strain insulators** The specimen shall be appropriately immersed upside down in the insulating oil. The cap and the pin shall be used as the electrodes while the cap is grounded.
- 2) **Pin insulators** The top of the specimen shall be covered with metallic foil to the side wire groove. The metallic foil and the pin shall serve as the lower and upper electrodes, respectively.
- 3) **Strain insulators** The specimen, the strap and the strap bolt shall be assembled as in practical service, and the wire groove shall be covered with metallic foil. The assembly so prepared shall be immersed in the insulating oil by suspending with the strap and the strap bolt. The strap and the metallic foil shall serve as the upper and lower electrodes respectively, while the lower electrode is grounded.
- 4) **Cube type guy insulators** Conductors (or chains) shall be fixed on the specimen as in practical service, and these shall serve as the electrodes.

d) **Application of voltage** The power-frequency voltage shall be applied and increased as rapidly as possible until it reaches the specified value, under the condition that the applied voltage can be confirmed with a measuring instrument. The voltage may, if necessary, be increased until the puncture of the specimen occurs.

**7.6 Power-frequency voltage test** This test shall be made only on the specimen whose shortest puncture path through the solid insulating material is not more than 1/2 of its flashover distance.

a) **Mounting method of specimen**

- 1) **Suspension insulators and high voltage strain insulators** The cap and pin shall serve as both electrodes.
- 2) **Pin insulators** The conductor attached to the top of the specimen and the pin shall serve as both electrodes.
- 3) **Strain insulators** The conductor fixed in the wire groove of the specimen and the conductive support of the specimen shall serve as both electrodes.
- 4) **Cube type guy insulators and ball type guy insulators** Two conductors fixed to individual wire groove of the specimen as in practical service shall serve as both electrodes.

b) **Application of voltage** The specified power-frequency voltage shall be applied to the specimen in the air, for 2 min, between both electrodes and whether any abnormality occurs at various parts of the specimen or not shall be examined. Momentary flashover during the power-frequency voltage test is permitted.

**7.7 High frequency voltage test** This test shall be made only on the specimen whose shortest puncture path through solid insulating material is not more than 1/2 of its flashover distance.

- a) **Mounting method of test specimens** The mounting method shall follow 7.6 a).
- b) **Application of voltage** A high-frequency voltage sufficient to cause flashover shall be applied for 3 s to 5 s across both electrodes of the specimen, and whether any abnormality occurs at various parts of the specimen or not shall be examined.

## 7.8 Lightning impulse flashover voltage test

**7.8.1 Voltage waveform** The standard lightning impulse voltage used for this test shall be a mono-polarity full-wave voltage having a time to peak of 1.2  $\mu$ s and a time of half-value of 50  $\mu$ s. This voltage waveform is expressed as 1.2/50 impulse. The tolerances on waveform shall be  $\pm 30$  % on the time to peak,  $\pm 20$  % on the time to half-value and  $\pm 3$  % on the crest value. The crest value of this impulse voltage shall be verified by either of a sphere gap or an oscilloscope.

**7.8.2 Mounting method of specimens** The mounting method shall follow 7.1.1.

**7.8.3 Determination of 50 % flashover voltage** The 50% impulse flashover voltage value shall be determined by either of the following methods:

- a) **Up and down method** Voltage  $U'_{50}$ , which is expected to be nearly equal to 50 % flashover voltage shall be applied, and if flashover occurs the voltage of  $U'_{50} - \Delta U$ , or if this voltage does not cause flashover, the voltage of  $U'_{50} + \Delta U$  shall be applied. As exemplified above the voltage level shall be adjusted by the results of previous test in such a manner that the voltage is lowered by  $\Delta U$  if flashover occurs or increased by  $\Delta U$  if flashover does not occur. The  $\Delta U$  shall be 0.5 to 2 times the standard deviation. The voltage shall be applied about 40 times. When the number of flashovers or non-flashovers in each voltage level is expressed  $n_0, n_1, \dots, n_k$ , starting from the level in which flashover or non-flashover was less, then the 50 % flashover voltage  $U_{50}$  can be obtained from the following formula:

$$U_{50} = U_0 + \Delta U \left( \frac{\sum_{i=0}^k i n_i}{\sum_{i=0}^k n_i} \pm \frac{1}{2} \right)$$

The double sign shall be read (+) when utilizing the number of non-flashovers, and (−) when utilizing the number of flashovers, and  $U_0$  corresponds to voltage for  $i = 0$ .

- b) **Interpolation method** The flashover factor shall be obtained by applying the same impulse voltage  $V_m$  on the specimen at least 10 times. The flashover factor so obtained shall be recorded as  $m$  %. Next, the flashover factor  $n$  % shall be obtained in the same way but by changing the voltage from  $V_m$  to  $V_n$ . It is necessary to adjust the applied voltage  $V_m$  and  $V_n$  so that  $80 > m > 50$  and  $50 > n > 20$  are established.

From these 2 measured values, the 50 % flashover voltage shall be obtained from the following formula:

$$V_{50} = \frac{V_m(50 - n) + V_n(m - 50)}{m - n}$$

**7.8.4 Voltage-time curve** The voltage-time curve shall be obtained by causing flashover on the specimen in such a manner that the lightning impulse voltage applied across both electrodes of the specimen is gradually increased, and that the crest value is changed at least 5 times, starting from a voltage close to the 50 % flashover voltage.

**7.8.5 Correction of voltage** The value of dry lightning impulse 50 % flashover voltage shall be corrected to that at the standard atmospheric condition in accordance with 7.1.4.

## **7.9 Lightning impulse withstand voltage test**

**7.9.1 Voltage waveform** The waveform shall be as specified in 7.8.1.

**7.9.2 Mounting method of specimen** The mounting method shall follow 7.1.1.

**7.9.3 Application of voltage** The lightning impulse withstand voltage test shall be made with both positive and negative polarities. But if it is clear that which polarity gives lower flashover voltage, then the test may be made with that polarity. The method to obtain lightning impulse withstand voltage shall comply with either of the following two methods.

- a) **Method by withstand voltage** The specified lightning impulse voltage shall be applied 15 times on the specimen. When the number of flashover is within 2, the product is accepted by this test.
- b) **Method by 50 % flashover voltage** The 50 % flashover voltage shall be obtained in accordance with the method specified in 7.8.3 a). If the value corrected by the method specified in 7.1.4 is  $\frac{1}{1-1.3\sigma} = 1.04$  times or more of the value of the specified withstand voltage, the product is accepted by this test. Where  $\sigma$  is the standard deviation assumed as 3 %. The number of voltage application shall be at least 30.

**7.9.4 Correction of voltage** In the dry lightning impulse withstand voltage test (withstand voltage method), the value of the test voltage appropriate to the atmospheric condition at the time of the test shall be obtained in accordance with 7.1.4. The test shall be made with this value.

## **7.10 Dry switching impulse flashover voltage test**

**7.10.1 Voltage waveform** The standard switching impulse voltage used for the switching impulse voltage test shall be a positive or negative full-wave voltage having a time to peak of 250  $\mu$ s and a time to half value of 2 500  $\mu$ s. This voltage waveform is expressed as a 250/2 500 impulse. The tolerances on waveform shall be  $\pm 20$  % on the time to peak,  $\pm 60$  % on the time of half-value, and  $\pm 3$  % on the crest value. The crest value of test voltage shall be verified by either of a sphere gap or an oscilloscope.

**7.10.2 Mounting method of specimen** The mounting of specimen shall be made in accordance with the following standard mounting method. However, the test may be made under the condition simulating the practical service, subject to the agreement between the parties concerned.

**For suspension insulator string and long rod insulator string** The specimen shall be suspended vertically from a structure simulating a transmission tower body and its arm. The tower body and the arm shall be simulated by a vertical member and a horizontal member respectively, and width of each member shall be 400 mm to 20 % of the specimen length. The distance between the tower body and the specimen shall be 1.2 to 1.5 times the specimen length. The distance between the uppermost part of the specimen and the lowermost part of the arm shall be about 300 mm. The height of the tower body shall be designed so that the height of the lowermost part of the arm becomes at least twice the specimen length.

Two conductors shall be fixed to the metal fittings at the lowermost part of the specimen perpendicular to the arm. The conductors shall be kept horizontally by means of spacers, with a space of about 1/10 the specimen length between them.

The length of the conductor shall be selected so that one side length is nearly equal to the specimen length. The diameter of the conductor shall be 0.75 % to 1.25 % of the specimen length. The height of conductors above the ground shall be 1.5 times or more of the specimen length. However, the height shall be 6 m minimum. For the purpose of preventing flashover from both ends, shields of suitable form shall be attached to both ends of the conductors. The proximity to other objects shall be as specified in 7.1.1 a) 2).

**7.10.3 Determination of 50 % flashover voltage** The voltage shall be determined in accordance with 7.8.3.

**7.10.4 Correction of voltage** The dry switching impulse 50 % flashover voltage shall be corrected to that at the standard atmospheric condition in accordance with the method specified in 7.1.4.

## **7.11 Dry switching impulse withstand voltage test**

**7.11.1 Voltage waveform** The waveform shall be as given in 7.10.1.

**7.11.2 Mounting method of specimen** The mounting method shall follow 7.10.2.

**7.11.3 Application of voltage** The switching impulse withstand voltage test shall be made with both positive and negative polarities. The method to obtain the switching impulse withstand voltage shall comply with either of the following two methods.

- a) **Method by withstand voltage** The specified switching impulse voltage shall be applied 15 times on the specimen. When the number of flashover is within 2, the product is accepted by this test.
- b) **Method by 50 % flashover voltage** The 50 % flashover voltage shall be obtained in accordance with the method specified in 7.8.3 a). If the value corrected by the method specified in 7.1.4 is  $\frac{1}{1-1.3\sigma} = 1.085$  times or more of the value of the specified withstand voltage, the product is accepted by this test. Where  $\sigma$  is the standard deviation assumed as 6 %. The number of voltage application shall be at least 30.

**7.11.4 Correction of voltage** In the dry switching impulse withstand voltage test (withstand voltage method), the value of test voltage appropriate to the atmospheric condition at the time of the test shall be obtained in accordance with 7.1.4. The test shall be made with this value.

## **7.12 Wet switching impulse flashover voltage test**

**7.12.1 Voltage waveform** The waveform shall be as given in 7.10.1.

**7.12.2 Mounting method of specimens** The mounting method shall follow 7.10.2.

**7.12.3 Water spray** The water spray requirements are the same as that given in 7.3.2.

**7.12.4 Determination of 50 % flashover voltage** The voltage shall be determined in accordance with 7.8.3.

**7.12.5 Correction of voltage** The wet switching impulse 50 % flashover voltage shall be corrected to that at the standard atmospheric condition in accordance with the method specified in 7.1.4.

## **7.13 Wet switching impulse withstand voltage test**

**7.13.1 Voltage waveform** The waveform shall be as given in 7.10.1.

**7.13.2 Mounting method of specimen** The mounting method shall follow 7.10.2.

**7.13.3 Water spray** The water spray requirements are the same as that given in 7.3.2.

**7.13.4 Application of voltage** The voltage shall be applied in accordance with 7.11.3.

**7.13.5 Correction of voltage** In the wet switching impulse withstand voltage test (withstand voltage method), the value of test voltage appropriate to the atmospheric condition at the time of the test shall be obtained in accordance with 7.1.4. The test shall be made with this value.

## **8 Mechanical tests**

### **8.1 Withstand load test**

#### **8.1.1 Tensile withstand load test**

##### **a) Mounting method of specimen**

- 1) **Suspension insulators, long rod insulators and high voltage strain insulators** The specimen shall be mounted in such a way that the load applied between both metal fittings of the specimen will act in line with the axis of the specimen.

- 2) **Strain insulators** The specimen shall be mounted as in practical service by means of the strap and the strap bolt, and stranded wire having a diameter of about 10 mm shall be fixed in the wire groove of the specimen so that mechanical load is applied in the direction perpendicular to the axis of the specimen. A strap bolt stronger than that in practical service may be used.
- 3) **Cube type guy insulators and ball type buy insulators** The specimen shall be mounted as in practical service by means of the specified stranded wires which serve to apply mechanical load. The distance between the clamp for fixing stranded wire and the specimen shall not exceed the specified length.

b) **Application of load**

- 1) The load shall be increased suitably up to about 75 % of the specified withstand load, and thereafter increased gradually to the specified load. The specified load shall be kept for 1 min, and the examination shall be made on various parts of the specimen for defects.
- 2) In the case of 100 % test, the specified load shall be applied for 10 s, and the examination shall be made on various parts of the specimen for defects.

**8.1.2 Bending withstand load test**

a) **Mounting method of specimen**

**For line post insulators and pin insulators** The specimen shall be mounted as in practical service on a fixed iron base by means of a regular clamping bolt. Stranded wire shall be placed in the side wire groove, and the load shall be applied to the wire in the direction perpendicular to the axis of the specimen. Application of load and measurement of deflection angle of pin insulator shall be as shown in Fig. 3.

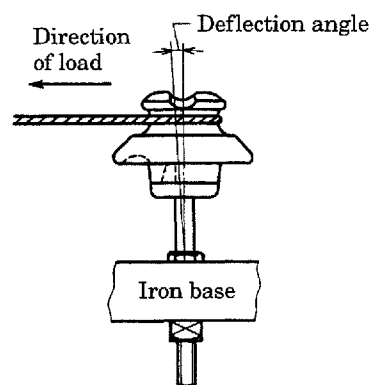


**Fig. 3 Application of load and deflection of pin insulator**

- b) **Application of load** The load shall be increased suitably up to about 75 % of the specified withstand load, and thereafter increased gradually to the specified load. The specified load shall be kept for 1 min, and the examination shall be made whether the deflection is the specified one or not, and on the other defects at various parts of the specimen.

### 8.1.3 Impact withstand load test

#### a) Mounting method of specimen

**Suspension insulators** The specimen shall be mounted on the tester by the method shown in Fig. 4, and a tensile load of 9.8 kN shall be applied. The supporting point of the impact pendulum shall be accurately adjusted so that, when released, the tip nose of the pendulum will strike the lowest point of the outer rim of the porcelain at its back, in the direction parallel to the axis of the specimen.

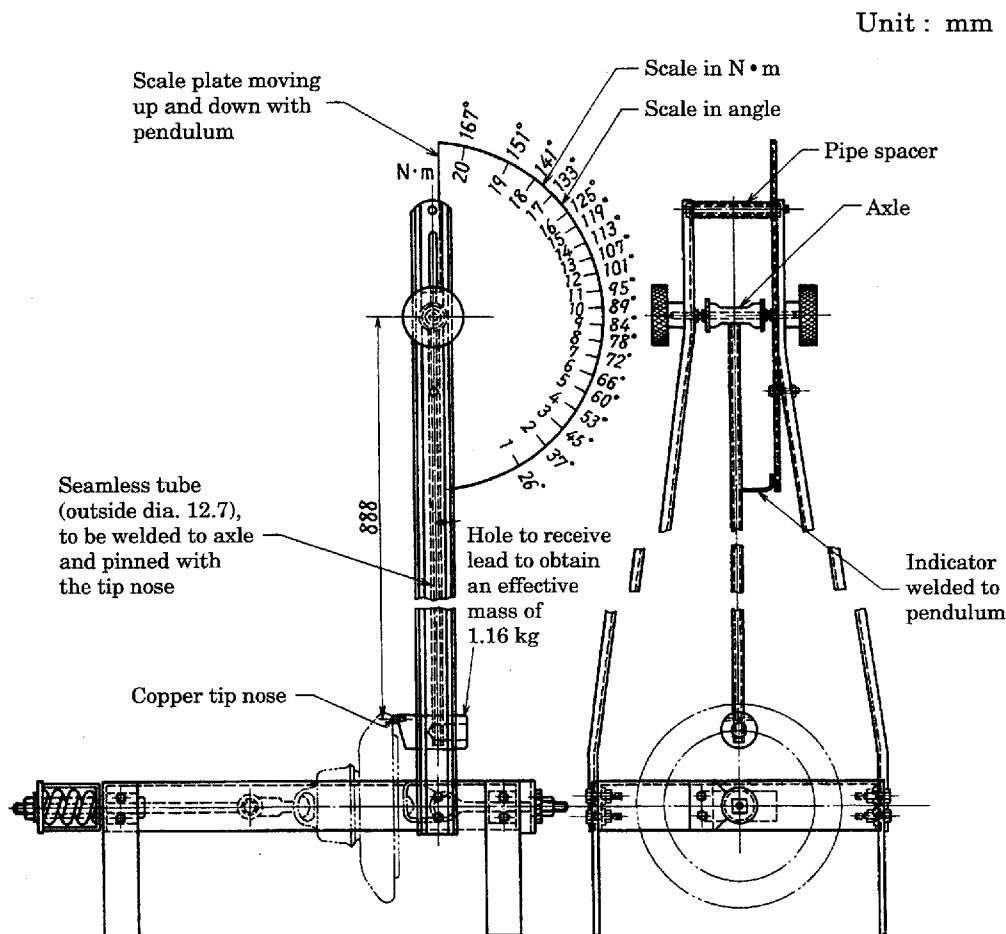


**Fig. 4 Impact tester**

- b) **Application of load** The pendulum shall be raised until its axis reaches an appropriate  $N \cdot m$  indication on the scale plate, then released, and examination shall be made on defects at various parts of the specimen. The pendulum shall be released without any initial speed.

### 8.2 Mechanical failing load tests

#### 8.2.1 Tensile mechanical failing load tests

- a) **Mounting method of specimen** The mounting method shall follow 8.1.1 a).
- b) **Application of load** The load shall be increased suitably up to about 75 % of the specified mechanical failing load, and thereafter increased gradually until mechanical failure occurs.

### 8.2.2 Bending mechanical failing load test

- a) **Mounting method of specimen** The mounting method shall follow 8.1.2 a).
- b) **Application of load** The load shall be applied as specified in 8.2.1 b).

### 8.2.3 Impact mechanical failing load test

- a) **Mounting method of specimen** The mounting method shall follow 8.1.3 a).
- b) **Application of load** The load shall be increased from 75 % of the specified mechanical failing load with an increment of about 1 N·m until actual mechanical failing load is observed.

**9 Electro-mechanical failing load test** In the electro-mechanical failing load test, a tensile load shall be applied to the specimen in the direction of its axis, while a voltage equal to wet power-frequency withstanding voltage of the specimen is being applied across both metal fittings of the specimen. The load shall be increased suitably up to about 75 % of the specified electro-mechanical failing load, and thereafter increased gradually at a uniform rate until mechanical failure occurs.

**10 Temperature cycle test** The temperature cycle test shall be made by immersing the specimen into hot water, cold water, hot water and cold water by turn. The specimen shall be completely immersed in the respective baths. The number of immersion in hot and cold water shall be 3 each, and the transfer time to another bath shall be as short as possible within 30 s. The duration of the immersion, the range of cold water temperature and the temperature difference between the cold water and the hot water shall be as specified.

The quantity of cold water and hot water in the baths shall be sufficient enough not to cause temperature variation of 5 °C or more due to immersion of the specimen.

Then, visual inspection shall be made on the porcelain part and the cementing of metal fittings. For the specimen whose shortest puncture path through the solid insulating material is not more than 1/2 of its flashover distance, existence or non-existence of abnormalities shall be examined by carrying out the power-frequency voltage test specified in 7.6.

## 11 Porosity test

**11.1 Sampling** The porcelain portion of the insulator under test shall be broken and the fragments having fresh clean broken surfaces shall be taken as the specimen.

**11.2 Testing solution** The testing solution used in this test shall be prepared by dissolving about 3 units (in mass) of Astrazon in 100 units (in mass) of the methanol specified in JIS K 8891.

**11.3 Test method** The specimen shall be completely immersed in the testing solution, and a pressure not less than 9.8 MPa shall be applied continuously at least for 4 h, at ordinary temperature. Then the specimen shall be taken out, dried and broken. Penetration of the dye shall be examined on the newly broken surface.

## 12 Galvanizing test

**12.1 Sampling** The test shall be made on zinc coating of the metal fittings forming a component of the insulator under test, and the sampling method shall comply with **JIS H 0401**.

**12.2 Test method** The test shall be carried out in accordance with informative reference (Method of testing film thickness) of **JIS H 0401**.

Information : For obtaining the mass of deposit per unit area from the measured film thickness, the following equation is used:

$$A = 7.2 \times t$$

where,     **A** : mass of zinc deposit per unit area (g/m<sup>2</sup>)  
              **7.2** : density of coated layer (g/cm<sup>3</sup>)  
              **t** : film thickness (μm)

Example : Film thickness corresponding to mass of deposit per unit area 500 g/m<sup>2</sup>: 69.4 μm

## Annex 1 (normative)

### Ceramic or glass insulator units for a.c. systems— Definition, test methods and acceptance criteria

**Introduction** This annex has been prepared based on **IEC 60383-1 : 1993** *Insulators for overhead lines with a nominal voltage above 1 000 V—Part 1 : Ceramic or glass insulator units for a.c. systems—Definitions, test methods and acceptance criteria* corresponding to the provisions stated in this text without modification in the technical contents.

In this annex, the portions underlined with dots mean the matter not stated in the original International Standard.

## Section 1: General

**1 Scope and object** This annex applies to insulators of ceramic material or glass for use on a.c. overhead power lines and overhead traction lines with a nominal voltage greater than 1 000 V and a frequency not greater than 100 Hz.

This annex also applies to insulators for use on d.c. overhead electric traction lines.

This annex applies to string insulator units, rigid overhead line insulators and to insulators of similar design when used in substations.

This annex does not apply to insulators forming parts of electrical apparatus or to parts used in their construction or to post insulators which are covered by **IEC 60168**.

This annex may be regarded as a provisional standard for insulators for use on d.c. overhead power lines. **IEC 60438** gives general guidance for those insulators.

**NOTE :** An international standard dealing with tests on insulators for d.c. overhead lines is in preparation and is intended to replace the relevant clauses of **IEC 60438**.

Tests on insulator strings and insulator sets (for example, wet switching impulse voltage) are dealt with in annex 2.

**NOTES 1** This annex does not include artificial pollution tests, radio-interference tests or residual strength tests. These subjects and relevant test methods are dealt with in the following **IEC** reports:

**IEC 60437** *Radio interference test on high-voltage insulators*

**IEC 60507** *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*

**IEC 60797** *Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric*

**2** The term “ceramic material” is used in this annex to refer to porcelain materials and, contrary to North American practice, does not include glasses.

The object of this annex is:

- to define the terms used;
- to define insulator characteristics and to prescribe the conditions under which the specified values of these characteristics shall be verified;
- to prescribe test methods;
- to prescribe acceptance criteria.

This annex does not include requirements dealing with the choice of insulators for specific operating conditions.

NOTE : A guide for the choice to insulators under polluted conditions has been published, see **IEC 60815**.

Numerical values for insulator characteristics are specified in **IEC 60305**, **IEC 60433** and **IEC 60720**.

**2 Normative references** The following normative documents contain provisions which, through reference in this annex, constitute provisions of this annex. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. Members of **IEC** and **ISO** maintain registers of currently valid International Standards.

IEC 60050(471) : 1984 *International Electrotechnical Vocabulary (IEV)—Chapter 471 : Insulators*

IEC 60060-1 : 1989 *High-voltage test techniques—Part 1 : General definitions and test requirements*

IEC 60120 : 1984 *Dimensions of ball and socket couplings of string insulator units*

IEC 60305 : 1978 *Characteristics of string insulator units of the cap and pin type*

IEC 60372 : 1984 *Locking devices for ball and socket couplings of string insulation units : Dimensions and tests*

IEC 60433 : 1980 *Characteristics of string insulator units of the long rod type*

IEC 60471 : 1977 *Dimensions of clevis and tongue couplings of string insulator units*

IEC 60720 : 1981 *Characteristics of line post insulators*

IEC XXX : 19XX *Puncture testing of insulators of glass or ceramic material for overhead lines with a nominal voltage greater than 1 000 V (under consideration)*

ISO 1459 : 1973 *Metallic coatings—Protection against corrosion by hot dip galvanizing—Guiding principles*

ISO 1460 : 1973 *Metallic coatings—Hot dip galvanized coatings on ferrous metals—Determination of the mass per unit area—Gravimetric method*

ISO 1461 : 1973 *Metallic coatings—Hot dip galvanized coatings on fabricated ferrous products—Requirements*

ISO 1463 : 1982 *Metallic and oxide coatings—Measurement of coating thickness—Microscopical method*