



JAPANESE  
INDUSTRIAL  
STANDARD

Translated and Published by  
Japanese Standards Association

---

---

JIS C 1731-2 : 1998

**Instrument transformers  
for testing purpose and  
used with general instrument  
Part 2 : Voltage transformers**

---

ICS 17.220.20

**Descriptors** : instrument transformers, potential transformers, transformers

**Reference number** : JIS C 1731-2 : 1998 (E)

C 1731-2 : 1998

**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. By this establishment JIS C 1731 : 1988 is withdrawn and replaced by this Standard.

**Constitution of Standard**

JIS C 1731-1 *Instrument transformers for testing purpose and used with general instrument Part 1 : Current transformers*

JIS C 1731-2 *Instrument transformers for testing purpose and used with general instrument Part 2 : Voltage transformers*

Date of Establishment: 1998-03-20

Date of Public Notice in Official Gazette: 1998-03-20

Investigated by: Japanese Industrial Standards Committee  
Divisional Council on Electricity

---

JIS C 1731-2:1998, First English edition published in 2000-09

Translated and published by: Japanese Standards Association  
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

---

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

© JSA 2000

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

**Contents**

|                                                          | Page |
|----------------------------------------------------------|------|
| Introduction .....                                       | 1    |
| 1 Scope .....                                            | 1    |
| 2 Definitions .....                                      | 1    |
| 3 Service conditions .....                               | 3    |
| 3.1 Standard service conditions .....                    | 3    |
| 3.2 Special service conditions .....                     | 3    |
| 4 Construction .....                                     | 3    |
| 4.1 Construction in general .....                        | 3    |
| 4.2 Mechanical strength .....                            | 4    |
| 4.3 Porcelain tubes .....                                | 4    |
| 4.4 Internal construction .....                          | 4    |
| 4.5 Sealing .....                                        | 4    |
| 4.6 Polarity .....                                       | 4    |
| 5 Classification and ratings .....                       | 4    |
| 5.1 Highest voltage for equipment .....                  | 4    |
| 5.2 Rated voltages .....                                 | 5    |
| 5.3 Accuracy classes .....                               | 6    |
| 5.4 Rated burdens .....                                  | 7    |
| 5.5 Rated frequencies .....                              | 7    |
| 6 Performances .....                                     | 7    |
| 6.1 Secondary short-circuit (withstand capability) ..... | 7    |
| 6.2 Temperature rise .....                               | 7    |
| 6.3 Dielectric withstanding voltage .....                | 8    |
| 6.3.1 Lightning impulse withstand voltage .....          | 8    |
| 6.3.2 Power frequency withstand voltage .....            | 8    |
| 6.3.3 Induced withstand voltage .....                    | 8    |

## C 1731-2: 1998

|                     |                                                                                         |    |
|---------------------|-----------------------------------------------------------------------------------------|----|
| 6.3.4               | Partial discharge .....                                                                 | 8  |
| 6.3.5               | Long-time power frequency withstand voltage .....                                       | 9  |
| 6.4                 | Abnormal phenomenon .....                                                               | 9  |
| 6.5                 | Limits of ratio error and phase displacement .....                                      | 13 |
| 6.6                 | Frequency characteristic .....                                                          | 14 |
| 7                   | Tests .....                                                                             | 14 |
| 7.1                 | Classification of tests .....                                                           | 14 |
| 7.2                 | Items and sequence of tests .....                                                       | 14 |
| 7.3                 | Test methods .....                                                                      | 15 |
| 7.3.1               | Secondary short-circuit .....                                                           | 15 |
| 7.3.2               | Temperature rise .....                                                                  | 16 |
| 7.3.3               | Dielectric withstand voltage tests .....                                                | 16 |
| 7.3.4               | Abnormal phenomenon .....                                                               | 21 |
| 7.3.5               | Ratio error and phase displacement .....                                                | 22 |
| 7.3.6               | Frequency characteristic .....                                                          | 22 |
| 8                   | Terminals .....                                                                         | 22 |
| 8.1                 | Location of terminals .....                                                             | 22 |
| 8.2                 | Terminal marks .....                                                                    | 22 |
| 9                   | Markings .....                                                                          | 24 |
| Annex 1 (normative) | Inductive voltage transformers .....                                                    | 27 |
| Introduction        | .....                                                                                   | 27 |
| 1                   | General .....                                                                           | 27 |
| 1.1                 | Scope .....                                                                             | 27 |
| 1.2                 | Normative references .....                                                              | 27 |
| 2                   | Definitions .....                                                                       | 28 |
| 2.1                 | General definitions .....                                                               | 28 |
| 2.2                 | Additional definitions for single-phase inductive protective voltage transformers ..... | 31 |

|     |                                                                                                |    |
|-----|------------------------------------------------------------------------------------------------|----|
| 3   | General requirements .....                                                                     | 31 |
| 4   | Normal and special service conditions .....                                                    | 31 |
| 4.1 | Normal service conditions .....                                                                | 31 |
| 4.2 | Special service conditions .....                                                               | 33 |
| 4.3 | System earthing .....                                                                          | 33 |
| 5   | Ratings .....                                                                                  | 34 |
| 5.1 | Standard values of rated voltages .....                                                        | 34 |
| 5.2 | Standard values of rated output .....                                                          | 34 |
| 5.3 | Standard values of rated voltage factor .....                                                  | 35 |
| 5.4 | Limits of temperature rise .....                                                               | 35 |
| 6   | Design requirements .....                                                                      | 37 |
| 6.1 | Insulation requirements .....                                                                  | 37 |
| 6.2 | Short-circuit withstand capability .....                                                       | 42 |
| 6.3 | Mechanical requirements .....                                                                  | 42 |
| 7   | Classification of tests .....                                                                  | 43 |
| 7.1 | Type tests .....                                                                               | 43 |
| 7.2 | Routine tests .....                                                                            | 44 |
| 7.3 | Special tests .....                                                                            | 44 |
| 8   | Type tests .....                                                                               | 44 |
| 8.1 | Temperature-rise test .....                                                                    | 44 |
| 8.2 | Short-circuit withstand capability test .....                                                  | 45 |
| 8.3 | Impulse test on primary winding .....                                                          | 45 |
| 8.4 | Wet test for outdoor type transformers .....                                                   | 47 |
| 9   | Routine tests .....                                                                            | 47 |
| 9.1 | Verification of terminal markings .....                                                        | 47 |
| 9.2 | Power-frequency withstand tests on primary windings and partial<br>discharge measurement ..... | 47 |
| 9.3 | Power-frequency withstand tests between sections and on secondary<br>windings .....            | 49 |

## C 1731-2: 1998

|      |                                                                                          |    |
|------|------------------------------------------------------------------------------------------|----|
| 10   | Special tests .....                                                                      | 50 |
| 10.1 | Chopped impulse test on primary winding .....                                            | 50 |
| 10.2 | Measurement of capacitance and dielectric dissipation factor .....                       | 50 |
| 10.3 | Mechanical tests .....                                                                   | 50 |
| 11   | Markings .....                                                                           | 51 |
| 11.1 | Rating plate markings .....                                                              | 51 |
| 11.2 | Terminal markings .....                                                                  | 52 |
| 12   | Accuracy requirements for single-phase inductive measuring voltage transformers .....    | 53 |
| 12.1 | Accuracy class designation for measuring voltage transformers .....                      | 53 |
| 12.2 | Limits of voltage error and phase displacement for measuring voltage transformers .....  | 53 |
| 12.3 | Type tests for accuracy of measuring voltage transformers .....                          | 54 |
| 12.4 | Routine tests for accuracy of measuring voltage transformers .....                       | 54 |
| 12.5 | Marking of the rating plate of a measuring voltage transformer .....                     | 54 |
| 13   | Additional requirements for single-phase inductive protective voltage transformers ..... | 54 |
| 13.1 | Accuracy class designation for protective voltage transformers .....                     | 54 |
| 13.2 | Limits of voltage error and phase displacement for protective voltage transformers ..... | 54 |
| 13.3 | Rated voltages for secondary windings intended to produce a residual voltage .....       | 55 |
| 13.4 | Output for secondary windings intended to produce a residual voltage .....               | 55 |
| 13.5 | Accuracy class for secondary windings intended to produce a residual voltage .....       | 56 |
| 13.6 | Type tests for protective voltage transformers .....                                     | 56 |
| 13.7 | Routine tests for protective voltage transformers .....                                  | 56 |
| 13.8 | Marking of the rating plate of a protective voltage transformer .....                    | 57 |

# Instrument transformers for testing purpose and used with general instrument

## Part 2 : Voltage transformers

**Introduction** This Japanese Industrial Standard specifies voltage transformers, of the instrument transformers formerly specified in JIS, in its text, while the items stated in the corresponding International Standard IEC 60044-2, *Instrument transformers—Part 2 : Inductive voltage transformers* published in 1997 as the first edition are adopted in Annex 1 (normative) without any modification in the technical contents.

For capacitor voltage transformers not specified in IEC 60044-2, IEC 60186 applies.

**1 Scope** This Standard specifies newly manufactured voltage transformers for testing purpose and used with general instrument which serve within power frequency range.

**2 Definitions** For the purpose of this Standard, the following principal definitions apply:

- a) **instrument transformer** This is an equipment for transformation of current or voltage used with electric instrument(s) or measuring device(s). This is the generic name of current transformer and voltage transformer.
- b) **voltage transformer** An instrument transformer in which the primary voltage is transformed to the secondary voltage which is proportional to the former.
- c) **unearthed voltage transformer** A voltage transformer in which the both primary terminals are connected across the lines during its service.
- d) **earthed voltage transformer** A voltage transformer in which one primary terminal is connected to the line and the other terminal is earthed during its service.
- e) **capacitor voltage transformer** A voltage transformer which utilizes the divided voltages by the capacitors.
- f) **voltage transformer for protected region** A voltage transformer to be used in a region always protected by lightning arrester(s).
- g) **voltage transformer for non-protected region** A voltage transformer to be used in a region not always protected by lightning arrester(s).
- h) **high-voltage capacitor of capacitor voltage transformer** A capacitor connected between primary line side terminal and voltage dividing point of a capacitor voltage transformer.
- i) **intermediate-voltage capacitor of capacitor transformer** A capacitor connected between the voltage dividing point and earth terminal of a capacitor voltage transformer.

- j) **electromagnetic unit of capacitor voltage transformer** A transformer connected to the intermediate-voltage capacitor in parallel, directly or through a resonance reactor.
- k) **intermediate voltage of capacitor transformer** The voltage which appears across terminals of intermediate-voltage capacitor when a primary voltage is applied to a capacitor transformer.
- l) **thermal limiting output of voltage transformer** The limit of load within which a voltage transformer can be used continuously at the rated primary voltage of the rated frequency without exceeding the prescribed temperature rise. It is expressed by the apparent power (VA) at the rated secondary voltage.
- m) **primary winding** The winding to which the voltage to be transformed is applied.
- n) **secondary winding** The winding which supplies the voltage to electrical instrument(s) or measuring apparatus(es).
- o) **secondary circuit** The external circuit which receives the voltage supplied by the secondary winding of a voltage transformer.
- p) **highest voltage for equipment** The highest circuit voltage which will occur normally and at which the performances specified in this Standard are ensured under the specified conditions.
- q) **rated voltage** This means the primary voltage and secondary voltage based on which the performances specified in this Standard are ensured under the specified conditions. The value is marked on the rating plate.
- r) **actual transformation ratio** The ratio of the voltage actually applied to the primary winding to the voltage supplied from the secondary winding. It is the value obtained from the measurement.
- s) **rated transformation ratio** The ratio of the rated primary voltage to the rated secondary voltage.
- t) **voltage error (ratio error)** The error which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio and the value is expressed by the following equation:

$$\varepsilon_v = \frac{K_n - K}{K} \times 100$$

where,  $\varepsilon_v$  : voltage error (%)

$K_n$  : rated transformation ratio

$K$  : actual transformation ratio

- u) **phase displacement** The difference in phase between the primary and secondary voltage vectors, the direction of the vector being so chosen that the angle is zero for a perfect voltage transformer. The phase displacement is said to be positive when the secondary voltage vector leads, and expressed in minutes.
- v) **burden** The load connected across the secondary terminals of a voltage transformer. The burden is expressed as the apparent power (VA) consumed in the load under the rated secondary voltage at the rated frequency and the power factor of the load.

- w) **rated burden** The burden per winding at which the performances specified in this Standard are ensured under the specified conditions. This value is marked on the rating plate.
- x) **rated frequency** The frequency at which the performances specified in this Standard are ensured under the specified conditions. The value is marked on the rating plate.
- y) **accuracy class** The class assigned to a voltage transformer to indicate its accuracy, and the value is marked on the rating plate. It is expressed in the limit of ratio error when the rated voltage at the rated frequency is applied under the rated burden.

### 3 Service conditions

**3.1 Standard service conditions** This Standard is applicable to voltage transformers used under conditions stated below.

The standard service conditions are the conditions meeting all of the following requirements:

- a) The ambient temperature is within the range from 40 °C to -20 °C and the average ambient temperature over 24 h does not exceed 35 °C.
- b) The altitude of installation site does not exceed 1 000 m.
- c) None of the items in 3.2 is applicable.

**3.2 Special service conditions** This Standard is also applicable to voltage transformers used under the conditions stated below.

The service conditions which include any one of the conditions stated below are regarded as special service conditions. These service conditions shall be specified especially. Transformers are used in a place:

- a) where the altitude or ambient temperature is outside the range specified in 3.1,
- b) where atmosphere is remarkably affected by salty air;
- c) where air is humid,
- d) where excessive water or oil vapour exists;
- e) where explosive, inflammable or other harmful gas exists or may attack;
- f) where excessive dust exists;
- g) where abnormal vibration or shock is anticipated;
- h) where much ice and snow exist; or
- i) where special conditions other than stated above exist.

### 4 Construction

**4.1 Construction in general** Voltage transformers shall be so constructed that they have enough endurance electrically and mechanically, the tightened part will not work loose, and the maintenance and inspection can be made safely and easily.

**4.2 Mechanical strength** Each part of a voltage transformer shall have enough strength to withstand the following loads:

- a) Static constant horizontal acceleration of  $4.9 \text{ m/s}^2$ .
- b) Wind pressure load at maximum wind velocity of  $40 \text{ m/s}$  (indoor transformers are excluded).

**4.3 Porcelain tubes** The porcelain tubes shall have prescribed good electrical and mechanical characteristics and shall be capable of serving for a long period of time.

**4.4 Internal construction** Material of good quality shall be used for iron cores, windings, etc., and the assembly of transformers shall be robust so that no loosening of tighten parts nor change in relative positions of components shall occur during transportation and service of a long period.

**4.5 Sealing** Sealing of voltage transformers shall be as follows:

- a) Inside of oil immersed voltage transformer shall be hermetically structured so that nitrogen gas is filled on the oil surface or the oil is filled entirely.
- b) Inside of gas insulated voltage transformer shall be filled with such insulating gas as  $\text{SF}_6$ , and so structured that sealing of transformer itself is possible.

**4.6 Polarity** The polarity shall be subtractive. Primary and secondary terminals of a voltage transformer shall be marked clearly and indelibly with the terminal marks which indicate subtractive polarity, and the arrangement of terminals shall also indicate subtractive polarity, as a rule.

Note : As for the positions and marks of terminals, see 8.1 and 8.2.

## 5 Classification and ratings

**5.1 Highest voltage for equipment** The highest voltages for equipment (denoted by  $U_m$ ) of voltage transformers shall be as stated in Table 1.

**Table 1 Highest voltages for equipment of voltage transformers**

Unit : kV

| Nominal voltage | Highest voltage for equipment | Nominal voltage | Highest voltage for equipment |
|-----------------|-------------------------------|-----------------|-------------------------------|
| 0.22            | 0.23                          | 66              | 69                            |
| 0.44            | 0.46                          | 77              | 80.5                          |
| 1.1             | 1.15                          | 110             | 115                           |
| 3.3             | 3.45                          | 132             | 138 <sup>(2)</sup>            |
| 6.6             | 6.9                           | 154             | 161                           |
| 11              | 11.5                          | 187             | 195.5 <sup>(3)</sup>          |
| 13.2            | 13.8 <sup>(1)</sup>           | 220             | 230 <sup>(3)</sup>            |
| 16.5            | 17.25 <sup>(1)</sup>          | 275             | 287.5 <sup>(3)</sup>          |
| 22              | 23                            | 500             | 550 <sup>(3)</sup>            |
| 33              | 34.5                          |                 |                               |

Notes (1) Voltage transformers with  $U_m = 13.8$  kV and  $U_m = 17.25$  kV are ones used in generator circuit only.

(2) Voltage transformers with  $U_m = 138$  kV are special ones.

(3) Voltage transformers with  $U_m \geq 195.5$  kV are applicable for lines of effectively earthed system.

**5.2 Rated voltages** Rated voltages of voltage transformers shall be as stated in Tables 2, 3 and 4.

**Table 2 Rated voltages of voltage transformers for testing purpose**

| Rated primary voltage kV |     |                |                 | Rated secondary voltage V |
|--------------------------|-----|----------------|-----------------|---------------------------|
| 0.11                     | 1.1 | 11             | 110             | 110                       |
| —                        | —   | —              | 154             |                           |
| 0.22                     | 2.2 | 22             | —               |                           |
| —                        | 3.3 | 33             | —               |                           |
| 0.44                     | —   | —              | —               |                           |
| —                        | 6.6 | 66             | —               |                           |
| —                        | —   | 77             | —               | 110/ $\sqrt{3}$           |
| —                        | —   | —              | 110/ $\sqrt{3}$ |                           |
| —                        | —   | —              | 154/ $\sqrt{3}$ |                           |
| —                        | —   | —              | 220/ $\sqrt{3}$ |                           |
| —                        | —   | —              | 275/ $\sqrt{3}$ |                           |
| —                        | —   | 66/ $\sqrt{3}$ | 500/ $\sqrt{3}$ |                           |
| —                        | —   | 77/ $\sqrt{3}$ | 550/ $\sqrt{3}$ |                           |

**Table 3 Rated voltages of unearthed voltage transformers  
and of earthed three-phase voltage transformers**

| Rated primary voltage kV |     |                     |                    | Rated secondary voltage V |
|--------------------------|-----|---------------------|--------------------|---------------------------|
| —                        | 1.1 | 11                  | 110                | 110                       |
| —                        | —   | 13.2 <sup>(4)</sup> | 132 <sup>(5)</sup> |                           |
| —                        | —   | 16.5 <sup>(4)</sup> | 154                |                           |
| 0.22                     | —   | 22                  | —                  |                           |
| —                        | 3.3 | 33                  | —                  |                           |
| 0.44                     | —   | —                   | —                  |                           |
| —                        | 6.6 | 66                  | —                  |                           |
| —                        | —   | 77                  | —                  |                           |

Notes (4) Voltage transformers with rated primary voltage of 13.2 kV and of 16.5 kV are ones used in generator circuit only.

(5) Voltage transformers with rated primary voltage 132 kV are special ones.

**Table 4 Rated voltages of earthed single-phase  
voltage transformer**

| Rated primary voltage kV       |                               | Rated secondary voltage V |
|--------------------------------|-------------------------------|---------------------------|
| $11/\sqrt{3}$                  | $110/\sqrt{3}$                | $110/\sqrt{3}$            |
| $13.2/\sqrt{3}$ <sup>(6)</sup> | $132/\sqrt{3}$ <sup>(7)</sup> |                           |
| $16.5/\sqrt{3}$ <sup>(6)</sup> | $154/\sqrt{3}$                |                           |
| —                              | $187/\sqrt{3}$                |                           |
| $22/\sqrt{3}$                  | $220/\sqrt{3}$                |                           |
| —                              | $275/\sqrt{3}$                |                           |
| $33/\sqrt{3}$                  | —                             |                           |
| $66/\sqrt{3}$                  | $550/\sqrt{3}$                |                           |
| $77/\sqrt{3}$                  | —                             |                           |

Notes (6) Voltage transformers with rated primary voltage of  $13.2/\sqrt{3}$  kV and of  $16.5/\sqrt{3}$  kV are ones used in generator circuit only.

(7) Voltage transformers with rated primary voltage  $132/\sqrt{3}$  kV are special ones.

**5.3 Accuracy classes** The accuracy classes of voltage transformers shall be five classes as shown in Table 5.

**Table 5 Accuracy classes of voltage transformers**

| Accuracy class | Designation         | Principally used for —                                                            |
|----------------|---------------------|-----------------------------------------------------------------------------------|
| Class 0.1      | Testing purpose     | Standard apparatus for testing voltage transformer or special precise measurement |
| Class 0.2      |                     |                                                                                   |
| Class 0.5      | General measurement | Precise measurement                                                               |
| Class 1.0      |                     | General measurement, switchboard                                                  |
| Class 3.0      |                     |                                                                                   |

**5.4 Rated burdens** Rated burdens of voltage transformers shall have appropriate value given in Table 6.

**Table 6 Rated burdens of voltage transformers**

Unit : VA

| Accuracy class | Rated burden |    |    |    |     |     |
|----------------|--------------|----|----|----|-----|-----|
| Class 0.1      | 10           | 15 | 25 | —  | —   | —   |
| Class 0.2      | 10           | 15 | 25 | —  | —   | —   |
| Class 0.5      | —            | 15 | —  | 50 | 100 | 200 |
| Class 1.0      | —            | 15 | —  | 50 | 100 | 200 |
| Class 3.0      | —            | 15 | —  | 50 | 100 | 200 |

**5.5 Rated frequencies** Rated frequencies of voltage transformers shall be 50 Hz, 60 Hz or 50 Hz/60 Hz.

## 6 Performances

**6.1 Secondary short-circuit (withstand capability)** Voltage transformers shall be subjected to the test for secondary short-circuit in accordance with 7.3.1 and shall not be damaged electrically nor mechanically.

**6.2 Temperature rise** Voltage transformers shall be subjected to the test for temperature rise in accordance with 7.3.2 and shall not exceed the appropriate limit value given in Table 7.

**Table 7 Limits of temperature rise of current transformer**

Unit : K

| Measuring point                                                           |                                                                           | Limits of temperature rise                            |                    |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------|--------------------|
|                                                                           |                                                                           | Class A insulation                                    | Class B insulation |
| Winding                                                                   | for dry self cooled type                                                  | 55                                                    | 75                 |
|                                                                           | for oil immersed self cooled type                                         |                                                       | —                  |
| Oil                                                                       | when oil in main tank comes in contact with external air directly         | 50                                                    | —                  |
|                                                                           | when oil in main tank does not come in contact with external air directly | 55                                                    |                    |
| The surface of terminal or other metallic part in contact with insulation |                                                                           | Temperature which will not damage adjacent insulation |                    |

**6.3 Dielectric withstanding voltage** The performance on dielectric withstanding voltage of voltage transformers shall be as stated below.

**6.3.1 Lightning impulse withstand voltage** The lightning impulse test of a voltage transformer with  $U_m \geq 3.45$  kV shall be carried out in accordance with 7.3.3 b) and the transformer shall withstand the appropriate test voltage given in Table 8. However, voltage transformers for testing purpose are excluded.

**6.3.2 Power frequency withstand voltage** The power frequency voltage test of a voltage transformer with  $U_m \leq 161$  kV used in non-effectively earthed system shall be carried out in accordance with 7.3.3 c) and the primary winding shall withstand the appropriate test voltage given in Table 9 and the secondary winding shall withstand the test voltage stated below.

Test voltage of 2 kV: applied between secondary windings and enclosure, and between sections of secondary winding if it is consisting of two or more secondary winding insulated each other.

Note : Such transformers as those for testing purpose for which the dielectric withstand voltage of main circuit side is not specified shall be tested at the highest voltage for equipment, and the transformer shall withstand the voltage.

**6.3.3 Induced withstand voltage** Voltage transformers with  $U_m \leq 161$  kV used in non-effectively earthed system shall be subjected to induced voltage withstand test in accordance with 7.3.3 d) and the transformer shall withstand the test voltage appropriate to the classification of transformer given in Table 10.

**6.3.4 Partial discharge** Voltage transformers of moulded type with  $U_m \geq 6.9$  kV and oil immersed or gas insulated type with  $6.9 \text{ kV} \leq U_m \leq 161$  kV used in a non effectively earthed system shall be tested for their partial discharge in accordance with 7.3.3 e) and the discharged electric charge, including effects of external noise or the like shall not exceed 50 pC. However, voltage transformers for testing purpose are excluded.

**6.3.5 Long-time power frequency withstand voltage** The test for long-time power frequency withstand voltage of a voltage transformer with  $U_m \geq 195.5$  kV used in effectively earthed system shall be made in accordance with 7.3.3 f), and no internal partial discharge shall be detected throughout the period from end of application of the appropriate test voltage given in Table 9 to completion of the test. However, voltage transformers for testing purpose<sup>(8)</sup> are excluded.

Note <sup>(8)</sup> For a voltage transformer for testing purpose, the withstand voltage test shall be carried out at the highest voltage for equipment in accordance with 6.3.2 and the transformer shall withstand the test voltage.

**6.4 Abnormal phenomenon** The test for abnormal phenomenon of capacitor voltage transformers shall be carried out in accordance with 7.3.4 and no abnormal voltage shall be generated across the secondary terminals.

**Table 8 Test voltages for voltage transformers  
(lightning impulse withstand voltage)**

Unit : kV

| Nominal voltage | Highest voltage for equipment | Test voltage                                                     |                                                                                       |                                                                                         |
|-----------------|-------------------------------|------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
|                 |                               | Full-wave                                                        | Chopped-wave                                                                          | Full-wave                                                                               |
|                 |                               | Unearthed and earthed voltage transformers                       | Unearthed and earthed voltage transformers (excluding capacitor voltage transformers) | Voltage transformer used out of the area covered by arrester (for non protected region) |
| 3.3             | 3.45                          | 30 <sup>(11)</sup><br>45                                         | —<br>50                                                                               | —                                                                                       |
| 6.6             | 6.9                           | 45 <sup>(11)</sup><br>60                                         | —<br>65                                                                               | —                                                                                       |
| 11              | 11.5                          | 75 <sup>(11)</sup><br>90                                         | —<br>100                                                                              | —                                                                                       |
| 13.2            | 13.8 <sup>(9)</sup>           | 100 <sup>(11)</sup><br>115                                       | —<br>125                                                                              | —                                                                                       |
| 16.5            | 17.25 <sup>(9)</sup>          | 100<br>115                                                       | —<br>125                                                                              | —                                                                                       |
| 22              | 23                            | 100 <sup>(12)</sup><br>125 <sup>(11)</sup><br>150                | —<br>—<br>165                                                                         | 180                                                                                     |
| 33              | 34.5                          | 150 <sup>(12)</sup><br>170 <sup>(11)</sup><br>200                | —<br>—<br>220                                                                         | 240                                                                                     |
| 66              | 69                            | 350                                                              | 385                                                                                   | 420                                                                                     |
| 77              | 80.5                          | 400                                                              | 440                                                                                   | 480                                                                                     |
| 110             | 115                           | 550                                                              | 605                                                                                   | 660                                                                                     |
| 132             | 138 <sup>(10)</sup>           | 650                                                              | 715                                                                                   | 780                                                                                     |
| 154             | 161                           | 750                                                              | 825                                                                                   | 900                                                                                     |
| 187             | 195.5                         | 650 <sup>(12)</sup><br>750                                       | 715<br>825                                                                            | 900                                                                                     |
| 220             | 230                           | 750 <sup>(12)</sup><br>900                                       | 825<br>990                                                                            | 1 080                                                                                   |
| 275             | 287.5                         | 950 <sup>(12)</sup><br>1 050                                     | 1 045<br>1 155                                                                        | 1 260                                                                                   |
| 500             | 550                           | 1 300 <sup>(12)</sup><br>1 425 <sup>(12)</sup><br>1 550<br>1 800 | 1 430<br>1 568<br>1 705<br>1 980                                                      | 1 800                                                                                   |

Notes (9) Voltage transformers with  $U_m = 13.8$  kV and  $U_m = 17.25$  kV are ones used in generator circuit only.

(10) Voltage transformers with  $U_m = 138$  kV are special ones.

- (11) This is applicable for such a case that the overvoltage is suppressed to a low level by means of such protective device as arrester or that the frequency of ingress of lightning overvoltage and/or the overvoltage level are low.
- (12) Applicable in such a case that arrester with improved performance is installed.

**Table 9 Test voltages for voltage transformers (power frequency withstand voltage, long-time power frequency withstand voltage)**

Unit: kV

| Nominal voltage | Highest voltage for equipment | Test voltage                                                                                        |                                                                                  |                                                                                                                                   |                                                                                                                                     |
|-----------------|-------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
|                 |                               | Power frequency withstand voltage                                                                   |                                                                                  |                                                                                                                                   | Long-time power frequency withstand voltage <sup>(16)</sup>                                                                         |
|                 |                               | Between primary windings connected together and secondary windings and enclosure connected together | Between primary earth side terminal and enclosure of earthed voltage transformer | Between terminals of intermediate capacitor of capacitor voltage transformer                                                      | Between primary line side terminal and primary earth side terminal of earthed voltage transformer and capacitor voltage transformer |
|                 |                               | Between primary line side terminal and primary earth side terminal of capacitor voltage transformer |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 0.22            | 0.23                          | 2                                                                                                   | 2 <sup>(15)</sup>                                                                | —                                                                                                                                 | —                                                                                                                                   |
| 0.44            | 0.46                          | 3                                                                                                   |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 1.1             | 1.15                          | 4                                                                                                   |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 3.3             | 3.45                          | 10<br>16                                                                                            |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 6.6             | 6.9                           | 16<br>22                                                                                            |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 11              | 11.5                          | 28                                                                                                  |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 13.2            | 13.8 <sup>(13)</sup>          | 39                                                                                                  |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 16.5            | 17.25 <sup>(13)</sup>         | 39                                                                                                  |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 22              | 23                            | 50                                                                                                  |                                                                                  | Partial voltage of power frequency withstand voltage between primary line side terminal and primary earth side terminal           |                                                                                                                                     |
| 33              | 34.5                          | 70                                                                                                  |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 66              | 69                            | 140                                                                                                 |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 77              | 80.5                          | 160                                                                                                 |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 110             | 115                           | 230                                                                                                 |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 132             | 138 <sup>(14)</sup>           | 275                                                                                                 |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 154             | 161                           | 325                                                                                                 |                                                                                  |                                                                                                                                   |                                                                                                                                     |
| 187             | 195.5                         | —                                                                                                   |                                                                                  | Partial voltage of long-time power frequency withstand voltage between primary line side terminal and primary earth side terminal | 170-225-170                                                                                                                         |
| 220             | 230                           |                                                                                                     |                                                                                  |                                                                                                                                   | 200-265-200                                                                                                                         |
| 275             | 287.5                         |                                                                                                     |                                                                                  |                                                                                                                                   | 250-330-250                                                                                                                         |
| 500             | 550                           |                                                                                                     |                                                                                  |                                                                                                                                   | 475-635-475                                                                                                                         |

Notes <sup>(13)</sup> Voltage transformers with  $U_m = 13.8$  kV are  $U_m = 17.25$  kV are ones used in generator circuit only.

<sup>(14)</sup> Voltage transformers with  $U_m = 138$  kV are special ones.

- (15) When increase of insulation performance of primary earth side terminal is specified, the product is deemed as a special product, and the withstand voltage shall be 4 kV for transformers with  $U_m = 11.5$  kV, 13.8 kV or 17.25 kV, and 10 kV for transformers with  $U_m \geq 23$  kV.
- (16) For application pattern of long-time power frequency withstand voltage, see 7.3.3 f).

**Table 10 Test voltages for voltage transformers  
(induced withstand voltage)**

| Classification                                          | Test voltage                                                                                                                |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| Unearthed voltage transformer                           | Rated voltage $\times 2$                                                                                                    |
| Earthed single-phase voltage transformer                | Rated voltage $\times 3.46$                                                                                                 |
| Earthed three-phase voltage transformer <sup>(17)</sup> | Rated voltage $\times 2$                                                                                                    |
| Electromagnetic unit of capacitor voltage transformer   | Partial voltage of the test voltage between primary line side terminal and primary earth side terminal specified in Table 9 |

Note (17) The test voltage for earthed three-phase voltage transformer shall be induced across the primary line side terminal and primary earth side terminal.

**6.5 Limits of ratio error and phase displacement** The ratio error and phase displacement of a voltage transformer shall be examined in accordance with 7.3.5 and shall not exceed the appropriate values stated in Table 11 or Table 12.

The limits of ratio error and phase displacement at an intermediate voltage shall those obtained by interpolation method.

**Table 11 Limits of ratio error and phase displacement  
of voltage transformers for testing purpose**

| Accuracy class | Ratio error % |            |                  | Phase displacement min |            |                  |
|----------------|---------------|------------|------------------|------------------------|------------|------------------|
|                | 0.02 $V_n$    | 0.25 $V_n$ | 0.7 to 1.1 $V_n$ | 0.02 $V_n$             | 0.25 $V_n$ | 0.7 to 1.1 $V_n$ |
| Class 0.1      | $\pm 0.3$     | $\pm 0.15$ | $\pm 0.1$        | $\pm 15$               | $\pm 7.5$  | $\pm 5$          |
| Class 0.2      | $\pm 0.6$     | $\pm 0.3$  | $\pm 0.2$        | $\pm 30$               | $\pm 15$   | $\pm 10$         |

Note :  $V_n$  denotes the rated primary voltage at the rated frequency.

**Table 12 Limits of ratio error and phase displacement of voltage  
transformers used with general instrument**

| Accuracy class | Ratio error %    | Phase displacement min |
|----------------|------------------|------------------------|
|                | 0.7 to 1.1 $V_n$ | 0.7 to 1.1 $V_n$       |
| Class 0.5      | $\pm 0.5$        | $\pm 20$               |
| Class 1.0      | $\pm 1.0$        | $\pm 40$               |
| Class 3.0      | $\pm 3.0$        | $\pm 120$              |

Note :  $V_n$  denotes the rated primary voltage at the rated frequency.

**6.6 Frequency characteristic** Capacitor voltage transformers shall be subjected to the frequency characteristic test as stated in 7.3.6, and the changes in the ratio error and phase displacement due to the frequency change shall not exceed the respective values given in Table 13.

**Table 13 Frequency characteristic of capacitor transformers**

| Accuracy class | Frequency range   | Limit of change |                        |
|----------------|-------------------|-----------------|------------------------|
|                |                   | Ratio error %   | Phase displacement min |
| Class 0.1      | 0.95 to 1.0 $f_n$ | 0.2             | 10                     |
|                | 1.0 to 1.05 $f_n$ |                 |                        |
| Class 0.2      | 0.95 to 1.0 $f_n$ | 0.4             | 20                     |
|                | 1.0 to 1.05 $f_n$ |                 |                        |
| Class 0.5      | 0.95 to 1.0 $f_n$ | 1.0             | 40                     |
|                | 1.0 to 1.05 $f_n$ |                 |                        |
| Class 1.0      | 0.95 to 1.0 $f_n$ | 2.0             | 80                     |
|                | 1.0 to 1.05 $f_n$ |                 |                        |
| Class 3.0      | 0.95 to 1.0 $f_n$ | 6.0             | 240                    |
|                | 1.0 to 1.05 $f_n$ |                 |                        |

Note : The  $f_n$  denotes the rated frequency.

## 7 Tests

**7.1 Classification of tests** The tests are classified into the two classes stated below.

- Type test** Type test means the test carried out on each type to demonstrate all transformers of this type satisfies the construction, performances, etc. required by this Standard.
- Routine test** Routine test means the test to demonstrate that the delivered products have equivalent construction and performances to those of product which passed the type test.

**7.2 Items and sequence of tests** The tests shall be carried out by covering all the matters related with the construction and performances determined by this Standard. The items and sequence of tests shall be as stated in Table 14.

**Table 14 Items and sequence of tests of voltage transformers**

| Test item                                   | Type test                 |                             | Routine test              |                             | Description                                                                                            |
|---------------------------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|--------------------------------------------------------------------------------------------------------|
|                                             | $U_m \leq 161 \text{ kV}$ | $U_m \geq 195.5 \text{ kV}$ | $U_m \leq 161 \text{ kV}$ | $U_m \geq 195.5 \text{ kV}$ |                                                                                                        |
| Construction                                | ①                         | ①                           | ①                         | ①                           |                                                                                                        |
| Polarity                                    | ②                         | ②                           | ②                         | ②                           | May be carried out before ratio error and phase displacement tests.                                    |
| Secondary short circuit                     | ③                         | ③                           | —                         | —                           |                                                                                                        |
| Temperature rise                            | ④                         | ④                           | —                         | —                           |                                                                                                        |
| Lightning impulse withstand voltage         | ⑤                         | ⑤                           | —                         | —                           | The test under wet condition is for outdoor transformers only and may be omitted subject to agreement. |
| Power frequency withstand voltage           | ⑥                         | —                           | ③                         | —                           | The test under wet condition is for outdoor transformers only and may be omitted subject to agreement. |
| Induced withstand voltage                   | ⑦                         | —                           | ④                         | —                           |                                                                                                        |
| Partial discharge <sup>(18)</sup>           | ⑧                         | —                           | ⑤                         | —                           |                                                                                                        |
| Long-time power frequency withstand voltage | —                         | ⑥                           | —                         | ③                           |                                                                                                        |
| Abnormal phenomenon                         | ⑨                         | ⑦                           | —                         | —                           | For capacitor voltage transformers only.                                                               |
| Ratio error and phase displacement          | ⑩                         | ⑧                           | ⑥                         | ④                           |                                                                                                        |
| Frequency characteristic                    | ⑪                         | ⑨                           | ⑦                         | ⑤                           | For capacitor voltage transformers only. May be omitted subject to agreement.                          |

Note (18) The partial discharge test is applicable to voltage transformers of moulded type with  $U_m \geq 6.9 \text{ kV}$ , and of oil immersed type and gas insulated type with  $6.9 \text{ kV} \leq U_m \leq 161 \text{ kV}$  only.

Note: The numeral in ○ shows the sequence of test.

### 7.3 Test methods

**7.3.1 Secondary short-circuit** In the secondary short-circuit test of voltage transformers, the secondary terminals of specimen shall be short circuited with the rated primary voltage applied.