

JAPANESE INDUSTRIAL STANDARD
JIS C 5102-1994
Test methods of fixed capacitors for
use in electronic equipment

September, 1996

ERRATA

Page 72

Subclause 8.11.1

First paragraph, the heading and line 2, replace "Resistance of board to bending" with "Resistance to board bending" .

Remarks: This errata is for correcting the first edition of this Standard.
Japanese Standards Association

JIS

JAPANESE INDUSTRIAL STANDARD

Test methods of fixed capacitors for use in electronic equipment

JIS C 5102—1994

Translated and Published

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Printed in Japan

In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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Test methods of fixed capacitors for
use in electronic equipment

C 5102-1994

1. Scope This Japanese Industrial Standard specifies the test methods of fixed capacitors (hereafter referred to as "capacitors") used mainly for electronic equipment. If any difference in the specifications between this Standard and the detail specification arises, the detail specification applies.

Remarks: The cited standards and the corresponding International standards are listed in Attached Table 1.

2. Definitions For the purpose of this Standard, in addition to the definitions given in JIS C 0010, JIS C 5101 and JIS C 5602, the following principal definitions apply:

- (1) test (wide sense) This is a series of procedures to examine the performance of specimens, and consists of the following items. Each item is applied in the case of being specified.
 - (a) preconditioning
 - (b) initial measurement
 - (c) test (narrow sense) or measurement (including intermediate measurement)
 - (d) recovery
 - (e) final measurement
- (2) preconditioning This is the treatment applied to specimens for increasing accuracy of tests, to avoid questions in the test results, as shown in the following:
 - (a) To eliminate the influence of past history.
 - (b) To stabilize the characteristics under test conditions.
 - (c) To eliminate partially the past history.
- (3) test (narrow sense) or measurement This means to locate specimens under the specified conditions and/or to examine the appearance, electrical and mechanical performances, for the purpose of examining the influence of test conditions to the specimens.

There is a case of including intermediate measurements.

- (4) recovery This means to carry out such treatment that is to allow the specimen to stand as it is or to dry the specimen before the final measurement, for the purpose of stabilizing the characteristics of specimens. The standing time in this recovery is sometimes called the recovery time.
- (5) temperature stability (thermal equilibrium) The conditions that the capacitances of specimen measured twice consecutively at intervals of 5 min on the specimen kept at a specified temperature, become nearly equal.

- (6) insulated type capacitor A capacitor in which the specified voltage can be applied between all the terminations and the enclosure.

Remarks: The enclosure dealt with here includes a metal case on which insulation treatment is applied such as covering of insulation sleeve.

- (7) non-insulated type capacitor A capacitor in which the specified voltage can not be applied between all the terminations and the enclosure.

- (8) ambient temperature The temperature of air in the free space at the position which is far enough from the specimen and where the effect of heat radiation is negligible.

- (9) rated temperature (upper category temperature at rated voltage) The maximum ambient temperature at which the rated voltage can be applied continuously to the capacitor.

Remarks: In capacitors for which temperature derated voltage is not applicable, the rated temperature is equal to the upper category temperature.

- (10) rated voltage (symbol: U_R) The maximum value of peak voltage (the sum of d.c. voltage and permissible a.c. peak voltage) which can be applied continuously to a capacitor at the rated temperature.

Remarks 1. In capacitors for a.c., the rated voltage is the r.m.s. value of continuously applicable a.c. voltage of a specified frequency.

2. In capacitors for pulse, the rated voltage is the maximum value of continuously applicable a.c. voltage of a specified frequency and waveform.

- (11) temperature derated voltage The maximum voltage which can be applied continuously to a capacitor at a temperature exceeding its rated temperature (within its upper category temperature).

- (12) category voltage (symbol: U_C) The maximum voltage which can be applied continuously to a capacitor at its upper category temperature.

- (13) variation of capacitance due to temperature This is expressed by any of the following:

- (a) Temperature characteristic of capacitance
- (b) Temperature coefficient of capacitance and temperature cycle drift of capacitance

- (14) temperature characteristic of capacitance The relative variation of capacitance at a temperature in category temperature range from that at reference temperature (20°C). It is expressed in percent (%).

Remarks: The above is applicable to a capacitor the capacitance of which changes nonlinearly to the temperature.

- (15) temperature coefficient of capacitance The relative capacitance change per 1°C between the reference temperature (20°C) and a specified temperature within the category temperature range of a capacitor.

Remarks 1. The above is applied to a capacitor in which the capacitance change due to temperature is linear or almost linear.

2. The temperature coefficient of capacitance is expressed in the unit of ppm/°C ($10^{-6}/^{\circ}\text{C}$).

- (16) temperature cyclic drift of capacitance The difference between the capacitances at 20°C in the steps 1, 3 and 5 each other, when a capacitor is subjected once to the temperature cycle specified in the following table.

- Remarks 1. The difference in capacitance is expressed as a rate (%) of drift or an amount of drift.
2. When it is expressed as an amount of drift, the amount is the difference between the maximum and minimum values of capacitances in the steps 1, 3 and 5.
3. When it is expressed as a rate of drift (%), unless otherwise specified, the rate is the value of the drift specified in the above 2 divided by the capacitance in the step 3.

Step	Temperature °C
1	20
2	Lower category temperature
3	20
4	Upper category temperature
5	20

- (17) test reverse voltage The value of reverse voltage used for reverse voltage test. This is applied to an electrolytic capacitor.
- (18) rated reverse voltage The maximum value of reverse voltage which a capacitor can withstand in a specified temperature range. This is applied to an electrolytic capacitor.
- (19) climatic category This definition indicates the conditions of climatic tests of capacitors in common terms throughout relevant standards. It means a combination of test temperature for cold-proof, test temperature for heat-proof and test days for damp-proof (steady state) which the capacitor can withstand.

Remarks: The category is expressed as follows:

XX/YYY/ZZ

where,

XX : test temperature for cold-proof, normally the lower category temperature (example: -40°C)

YYY : test temperature for heat-proof, normally the upper category temperature (example: 85°C)

ZZ : test days for damp-proof (steady state 40°C) (example: 10 days)

Example: 40/085/10

- (20) chip capacitors Small capacitors of square or cylindrical shape which are suitable for surface mounting by providing capacitor elements with electrodes or terminals.

In this Standard, this may be sometimes called SMD (surface mounting devices).

- (21) polarizing voltage D.C. voltage applied across a capacitor with its terminal as a positive pole and with its mounting fixture as a negative pole. The purpose is to examine whether electrolysis accelerates deterioration of insulation of insulators of capacitors.

Informative reference: The above words are the same as those in IEC.

3. Test conditions

3.1 Standard conditions The test shall, unless otherwise specified, be carried out under the standard conditions as shown in Table 1. If any doubt arises on the judgement based on the measured values under this standard conditions, or when especially required, the condition of 3.3 shall be applied.

If the specimens are large, or if the maintenance of temperature in the testing place is difficult, the test may be carried out under conditions other than the standard conditions in accordance with relevant detail specifications. In such case, the temperature shall be in the range of 5°C to 40°C.

Table 1. Standard conditions

Temperature	15 °C to 35°C
Relative humidity	45 % to 75 %
Air pressure	86 kPa to 106 kPa

- Remarks 1. The relative humidity may be neglected if it does not affect the tests and measurement results.
2. The temperature in the standard conditions is occasionally called ordinary temperature.

3.2 Reference conditions The reference conditions shall be based on 5.1 of JIS C 0010 and given in Table 2. However, the reference conditions may be specified by temperature only.

Table 2. Reference conditions

Temperature	20°C
Air pressure	101.3 kPa

Remarks: It is generally impossible to correct the performance values against the relative humidity by means of calculation. Therefore, the relative humidity is not specified.

3.3 Referee conditions The referee conditions shall be based on 5.2 of JIS C 0010 and selected among Table 3 as specified by the relevant detail specification.

Unless otherwise specified, the grade 2 of symbol A in Table 3 shall apply.

Table 3. Referee conditions

Symbol	Grade 1		Grade 2	
	Temperature °C	Relative humidity %	Temperature °C	Relative humidity %
A	20 ± 1	63 to 67	20 ± 2	60 to 70
B	23 ± 1	48 to 52	23 ± 2	45 to 55
C	25 ± 1		25 ± 2	
D	27 ± 1	63 to 67	27 ± 2	60 to 70

Remarks: Air pressure is 86 kPa to 106 kPa.

3.4 Matters to be cared Sun light, heat radiation from other heat sources, and other factors which may affect the results of measurement on the specimens, shall be avoided throughout the test.

4. Treatment before and after test

4.1 Preconditioning At the test or measurement, the specimens shall be allowed to stand at the testing or measuring temperature for 30 min or more, and discharged completely.

4.2 Recovery Before the final measurement, the specimens shall be allowed to stand under the standard conditions for 1 h to 2 h.

4.3 Forced drying Before the initial or final measurement, the specimens shall be dried under the conditions specified in the detail specification.

The conditions specified in the detail specification shall be selected from Table 4.

After drying, the specimens shall be cooled in a desiccator with the activated alumina, silica-gel or other desiccants, or in the atmosphere of relative humidity 20 % or less.

Table 4. Conditions for forced drying

Condition	Condition 1	Condition 2
Temperature	55 ± 2°C	
Relative humidity	20 % max.	
Air pressure	86 kPa to 106 kPa	
Duration of standing	6 ± 0.5 h	96 ± 4 h

Informative reference: Condition 2 corresponds to the condition specified by IEC 384-1.

4.4 Voltage treatment Before the initial or final measurement, the protective resistor of about 1 kΩ shall be connected in series to the specimen. A d.c. voltage which is equal to the rated voltage is applied for 1 h. Next, the specimens shall be discharged through the resistor of about 1 Ω/V. Then, it shall be allowed to stand under the standard conditions for 12 h to 48 h.

4.5 Heat treatment Before the initial or final measurement, the specimen shall be allowed to stand for about 1 h at the upper category temperature. Then, it shall be allowed to stand for 24 ± 1 h in the normal condition.

5. Test apparatus and equipment

5.1 Direct current power supply The d.c. power supply shall, unless otherwise specified, be of the two kinds shown in Table 5.

Table 5. D. C. power supply

Kind of d.c.	Ripple content ⁽¹⁾ %		Stability of d.c. voltage ⁽²⁾ %
	50, 60 Hz	100, 120 Hz	
A	2 or less	1 or less	± 3
B	0.1 or less	0.1 or less	± 0.1

Notes ⁽¹⁾ Ripple content is the ratio of peak a.c. voltage superposed on d.c. voltage to the d.c. voltage.

⁽²⁾ Stability of d.c. voltage is the relative variation of d.c. output voltage in use to the initial set value of d.c. output voltage.

5.2 Alternating current power supply The a.c. power supply shall have substantially sinusoidal waveform at a frequency of 50 Hz or 60 Hz. The power capacity shall be 500 VA or more which can withstand the test current.

5.3 Test chamber The test chamber shall be capable of maintaining the specified testing temperature and relative humidity. It shall be so constructed that the specimens will not receive heat radiation directly from the heat sources wherever the specimens are placed.

Damp-proof test chamber shall be so constructed that the condensed water does not drip on to the specimens from the ceiling or wall of chamber.

Test chamber other than damp-proof testing shall be so designed that the damp does not condense during the test on the specimens or their measurement terminations.

5.4 Other test apparatus and equipment Other test apparatus and equipment shall be adequate and have sufficient accuracy for respective tests.

6. Appearance and dimension test

6.1 Equipment The equipment shall be those prescribed below, unless particularly specified. If no doubt arises on the judgement, other appropriate equipment may also be used.

- (1) The vernier callipers specified in JIS B 7507
- (2) The micrometer callipers for external measurement specified in JIS B 7502
- (3) The limit gauges for metric coarse screw threads specified in JIS B 0251
- (4) The limit gauges for metric fine screw threads specified in JIS B 0252
- (5) The gauges specified in Fig. 1 (applied to capacitors with unidirectional terminations)

- (6) The gauges specified in Fig. 4 or Fig. 5 (applied to cylindrical capacitors with two axial terminations)
- (7) Projectors or magnifiers of suitable magnification (applied when specified in the relevant detail specification. If not specified, the magnification shall be 10.)

6.2 Test

6.2.1 Appearance The appearance shall be tested by visual check.

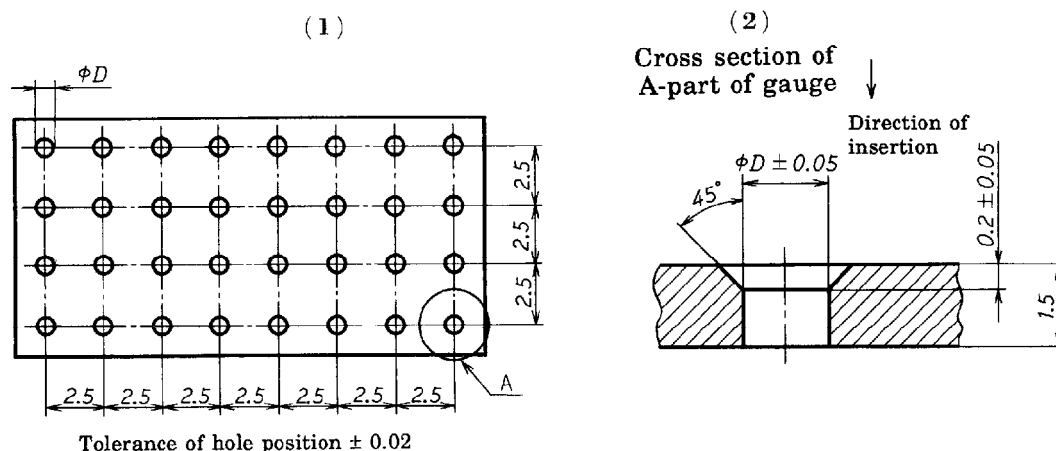
6.2.2 Marking The marking shall be tested by visual check, and if specified in the detail specification, examine the solvent resistance in accordance with the specification of 8.7.

6.2.3 Dimensions The dimensions specified in the detail specification shall be tested using the equipments specified in 6.1. If specified in the detail specification, the tests for capacitors with unidirectional terminations and cylindrical capacitors with two axial terminations shall be made as given in 6.2.4 and 6.2.5, respectively.

6.2.4 Dimensions of capacitors with unidirectional terminations (informative reference: This corresponds to IEC 717) The terminations of specimen shall be inserted into the gauge shown in Fig. 1, and the dimensions of specimen shall be measured.

Fig. 1. Dimension gauge for unidirectional terminations

Unit: mm



Tolerance of hole position ± 0.02

Hole diameter of gauge (D) as a function of nominal diameter of wire termination

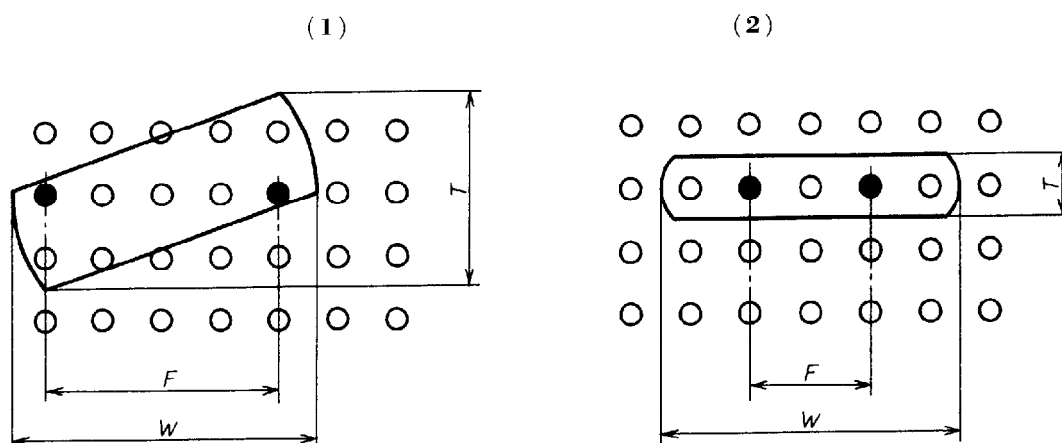
Diameter of wire termination	0.5 max.	0.6	0.7, 0.8	1.0	1.2
Hole diameter of gauge	0.8	1.0	1.3	1.6	1.8

Remarks: Rectangular terminations shall, unless otherwise specified in the detail specification, be taken as cylindrical terminations, the nearest nominal diameter of which is equal to or greater than the diagonal of the cross-section.

- (1) Insertion of specimen into gauge Excess force shall not be applied to insert the specimen into the gauge.
- (2) Width and thickness of capacitor body and spacing of wire terminations As shown in Fig. 2, the distances shall be measured between two planes which are parallel to the center lines in two directions (X and Y) of grid holes of the gauge and tangential to the corresponding pair of sides of the specimen. These are width (W) and thickness (T).

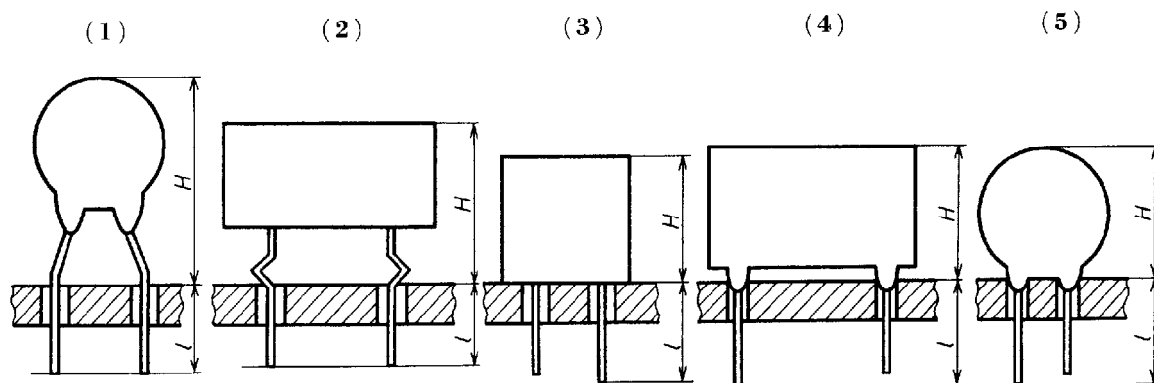
The distance shall be measured between holes of gauge into which lead wires are inserted. This is spacing (F) of wire terminations.

Fig. 2. Width and thickness of capacitor body and spacing of wire terminations



- (3) Height of capacitor body As shown in Fig. 3, the distance and height (H) from the face of gauge to the top of specimen shall be measured.

Fig. 3. Height of capacitor body and length of wire termination



- (4) Length of wire termination The length (l) of wire termination shall be measured as shown in Fig. 3.
- (5) Sagging of coating The sagging of coating shall be examined in accordance with the relevant detail specification.

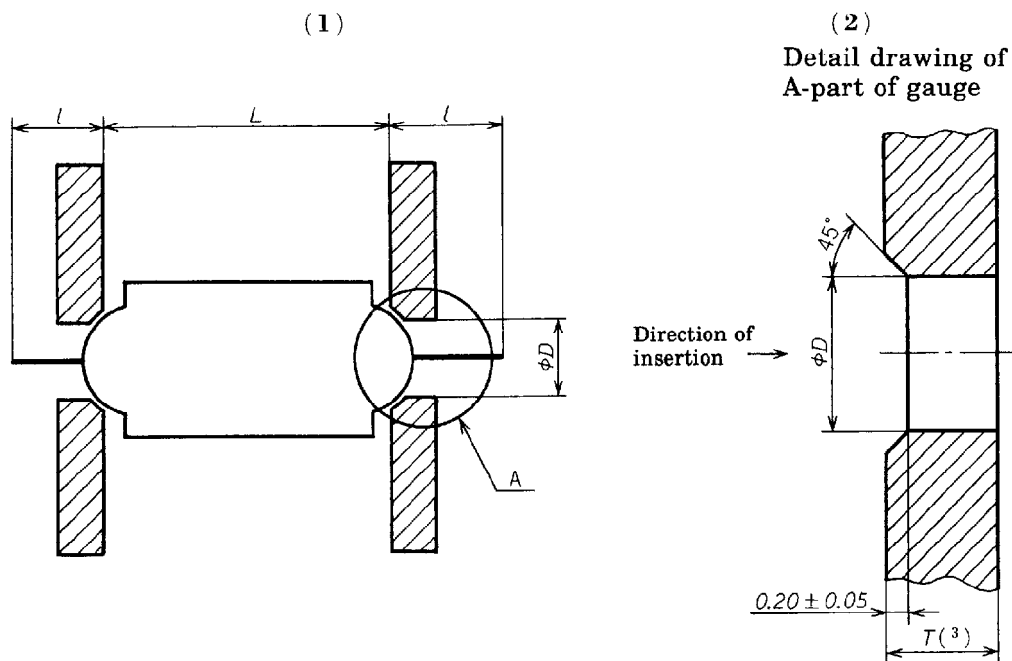
6.2.5 Dimensions of cylindrical capacitors with two axial terminations (informative reference: This corresponds to IEC 294.)

6.2.5.1 Method 1 The method 1 is as follows:

- (1) Insertion of specimen into gauge The specimen shall be inserted into two gauge plates as shown in Fig. 4, and these two gauge plates shall be brought close in parallel to each other without deforming the body or terminations.
- (2) Length of body and length of wire termination The length (L) of body and the length (l) of wire termination shall be measured as shown in Fig. 4.
- (3) Sagging of coating The sagging of coating shall be examined in accordance with the detail specification.
- (4) Diameter of body Hold a cylindrical gauge vertically whose internal diameter is 0.1 mm (tolerance ± 0.05 mm) larger than the maximum diameter of the body specified in the detail specification and which is as long as the maximum length of the body specified in the detail specification. Then, examine whether the specimen can pass through the cylindrical gauge by its own weight.

Fig. 4. Dimension gauge for cylindrical capacitors with two axial wire terminations (Method 1)

Unit: mm



Note ⁽³⁾ This dimension is 1.50 ± 0.05 mm for capacitors used in printed wiring board and 4.00 ± 0.05 mm for others.

Diameter of gauge hole (D) as a function of diameter of wire termination

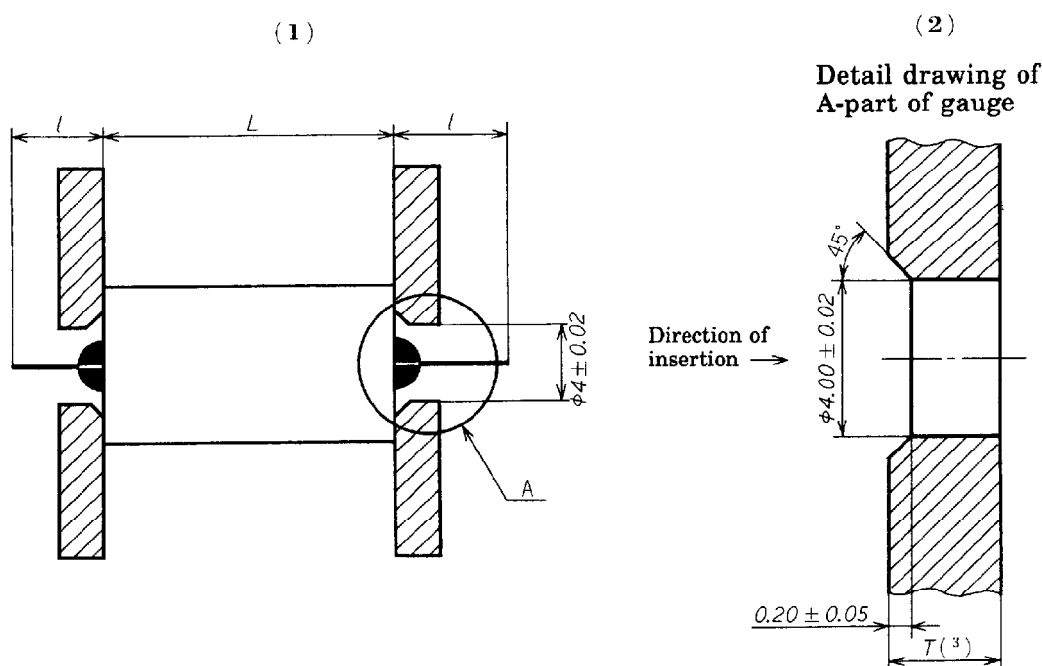
Nominal diameter of wire	Diameter of gauge hole (D)	Nominal diameter of wire	Diameter of gauge hole (D)
0.45 max.	0.80 ± 0.02	Over 0.9 up to and incl. 1.15	1.50 ± 0.02
Over 0.45 up to and incl. 0.7	1.00 ± 0.02	Over 1.15 up to and incl. 1.32	1.80 ± 0.02
Over 0.7 up to and incl. 0.9	1.20 ± 0.02	Over 1.32 up to and incl. 2.0	3.00 ± 0.02

6.2.5.2 Method 2 This test method shall be applied to the following capacitors with a body diameter not less than 5 mm.

- (a) Capacitors with glass-sealed wire terminations
 - (b) Capacitors with wire terminations having welded points
 - (c) Others which are not suitable to apply the gauge given in Fig. 4
- (1) Insertion of specimen into gauge The specimen shall be inserted into two gauge plates as shown in Fig. 5, and these two gauge plates shall be brought close in parallel each other without deforming the body.
 - (2) Length of body and length of wire termination The length (L) of body and the length (l) of wire termination shall be measured as shown in Fig. 5.
 - (3) Sagging of coating The sagging of coating shall be examined in accordance with the detail specification.
 - (4) Diameter of body The diameter of body shall be measured in accordance with 6.2.5.1 (4).

Fig. 5. Dimension gauge for cylindrical capacitors with two axial wire terminations (Method 2)

Unit: mm



Note (3) This dimension is 1.50 ± 0.05 mm for capacitors used in printed wiring board and 4.00 ± 0.05 mm for others.

6.3 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Test equipment (when other equipment than 6.1 is specified)
- (2) Application of projectors or magnifiers and their magnification (when use of a projector or magnifier is specified, or when magnification is other than 10)

- (3) Method of dimension test (when 6.2.4 or 6.2.5 is employed)
- (4) Sagging of coating [when specified, refer to 6.2.4 (5), 6.2.5.1 (3) and 6.2.5.2 (3)]

7. Electrical performance test

7.1 Voltage proof (d.c. voltage)

7.1.1 Equipment The equipment shall be as follows:

- (1) Power supply The power supply shall be the type A of d.c. power supply specified in 5.1. If no doubt arises on the judgement, other power supplies may be used.
- (2) Test circuit and apparatus
 - (a) Test circuit As a rule, the test circuit shall be as given in Fig. 6 (1) or (2). However, Fig. 6 (1) is recommended.
 - (b) Voltmeter Internal resistance of the voltmeter shall be 10 kΩ or more per 1 V.
 - (c) Protective resistor The protective resistor shall have resistance which satisfies the time constant or the charging currents specified in the detail specification.
 - (d) Capacitance of C_o in Fig. 6 (1) The capacitance of C_o shall be 10 times or more larger than that of C_x , and shall satisfy the following equation, unless particularly specified in the detail specification.

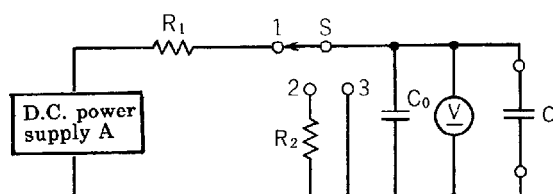
$$R_1 (C_o + C_x) \leq 1s$$

$$R_2 (C_o + C_x) \leq 1s$$

where, R_1 : protective resistor (including internal resistance of power supply) (Ω)
 R_2 : protective resistor (Ω)
 C_o : capacitance of C_o (F)
 C_x : nominal capacitance of specimen (F)

Fig. 6. Voltage-proof test circuit

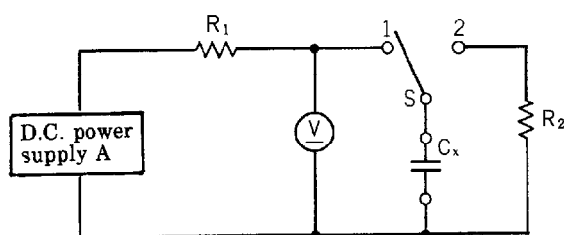
(1) (Informative reference: circuit specified in IEC 384-1)



R_1, R_2 : protective resistors
 C_o : capacitor
 ⓧV : d.c. voltmeter
 S : switch
 C_x : specimen capacitor

Fig. 6. (continued)

(2)



Switch position

- 1 : test voltage application
- 2 : discharge
- 3 : short circuit
[only for Fig. 6 (1)]

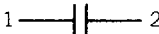
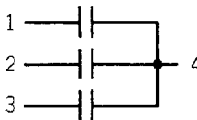
7.1.2 Preconditioning Before the test, the preconditioning of 4.1 shall be carried out.

7.1.3 Test The test voltage specified in the relevant detail specification shall be applied, using the equipment of 7.1.1, in accordance with the method of (1) to (3) unless particularly specified in the detail specification, to the portions of capacitor shown in Table 6. The voltage of d.c. power supply shall be previously set to the test voltage at the switch position 2 or 3 in Fig. 6. Then, the switch shall be turned to position 1 in Fig. 6, and after the reading of voltmeter has reached the specified test voltage, this condition shall be kept as it is for the specified time. During the test, check for flashover or dielectric breakdown. Then, the specimen shall be completely discharged by turning the switch to position 2 [in the case of Fig. 6 (1), until the reading of voltmeter drops to zero, and then by turning the switch to position 3], and removed from the circuit. Its appearance shall be examined.

Table 6. Points of voltage application

Classification by voltage applying portion	Applicable capacitor	Points of voltage application		
		Single section capacitor	Multiple section capacitor with common terminations	Multiple section capacitor without common terminations
Between terminations (A)	All capacitors	(1a) Between terminations Example: Between 1-2	(2a) Between each of terminations and common termination Example: Between 1-4, 2-4, 3-4	(3a) Between terminations of each section Example: Between 1-2, 3-4, 5-6
Internal insulation (B)	Insulated type capacitor with metal case	(1b) Between all terminations connected together and case Example: Between terminations 1, 2 connected together and metal case	(2b) Between all terminations connected together and case Example: Between terminations 1, 2, 3, 4 connected together and metal case	(3b) Between all terminations connected together and case Example: Between terminations 1, 2, 3, 4, 5, 6 connected together and metal case

Table 6. (continued)

Classification by voltage applying portion	Applicable capacitor	Points of voltage application		
		Single section capacitor	Multiple section capacitor with common terminations	Multiple section capacitor without common terminations
				
Internal insulation (B) (continued)	Multiple section insulated and non-insulated type capacitor	—	(2c) Between non-common terminations of each section, and terminations of other section and common terminations connected together Example: In the case of section 2-4, between termination 2 and terminations 1, 3, 4 connected together	(3c) Between two terminations of each section connected together and all the other terminations connected together Example: In the case of section 1-2, between terminations 1, 2 connected together and terminations 3, 4, 5, 6 connected together
External insulation (C)	Insulated type capacitors with non-metallic case, non-metal enclosure, or insulated metal case	(1c) Between all terminations connected together and metal foil, metal plate, metal V block, metal small ball or metal block	(2d)	(3d)
	Capacitors with metal case having insulation sleeve	(1d) Between case and metal foil, metal plate or metal V block	(2e)	(3e)
		(1e) Between bare wires wound on insulation sleeve	(2f)	(3f)

Informative reference: This table is based on Table 1 of IEC 384-1. However, the following methods are added: insulation sleeve test methods, (1d), (1e), (2e), (3e), (2f) and (3f) for capacitors with metal case having insulation sleeve of external insulation (C).

- (1) **Between terminations (Type A in classification by voltage applying portion)**
 The test voltage shall be applied between the terminations of the specimen [(1a), (2a) or (3a) in Table 6].

In the case of multiple section capacitor in (2a) or (3a) in Table 6, if no doubt arises on the judgement, capacitors may be tested with each termination connected together.

Example: In the case of (3a) in Table 6, the test voltage shall be applied between terminations 1, 3, 5 connected together and terminations 2, 4, 6 connected together.

(2) Internal insulation (Type B in classification by voltage applying portion)

- (a) Insulated type capacitors with metal case The test voltage shall be applied between the metal case and the terminations connected together of the specimen [(1b), (2b) or (3b) in Table 6].
- (b) Multiple section capacitor The test voltage shall be applied between terminations each other of the specimen (or the sections each other) [(2c) or (3c) in Table 6].

(3) External insulation (Type C in classification by voltage applying portion) (applied to insulated type capacitor) The test voltage shall be applied to the specimens, in accordance with any method prescribed in the following (3.1) to (3.6), at the portion specified in (1c), (1d), (1e), (2d), (2e), (2f), (3d), (3e), or (3f) in Table 6.

(3.1) V block method Each termination of the specimen is connected together. The body of specimen is placed in the bottom of V block. The test voltage is applied between the terminations and V block.

The capacitor is kept in moderate contact with the face of V block and arranged as specified in the following (a) or (b). However, the capacitor with two axial terminations shall be arranged with the out-of-center positioning of emergence of the terminations ignored, i.e. the terminations are considered being located at the center of the body.

The V block shall be longer than the body of capacitor, and made of metal. The angle of V is 90 degrees.

- (a) Cylindrical capacitor The most distant termination from the center axis of capacitor shall be arranged nearest to the face of V block.
- (b) Rectangular capacitor The nearest termination to the edge of capacitor shall be arranged nearest to the face of V block.

(3.2) Metal foil method As shown in Fig. 7 (1), metal foil shall be wound firmly on the body of capacitor with at least 5 mm in width, apart from the terminations by about at least 1 mm per 1 kV of test voltage (however, at least 1 mm). The test voltage shall be applied between the foil and all the terminations connected together. If the metal foil cannot be far from the termination by 1 mm or longer per 1 kV, the width of foil may be narrowed.

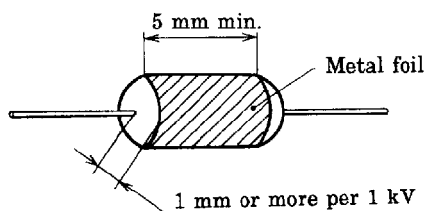
(3.3) Metal small ball method The specimen with its all terminations connected together, shall be put into a container filled with metal small balls of about 1 mm in diameter, 2 mm apart from the surface of balls as shown in Fig. 7 (2). The test voltage shall be applied between all the terminations of capacitor connected together and the metallic small balls.

(3.4) Metal plate method (applied to capacitors with metal fittings) The capacitor shall be mounted in its normal manner on a metal plate which is at least 12.7 mm wide from the mounting face of the capacitor. The test voltage shall be applied between all the terminations of capacitor connected together and the metal plate.

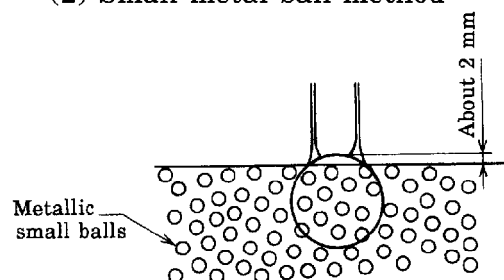
- (3.5) **Bare wire method** (applied to capacitor with insulation sleeve) Bare copper wire of about 1 mm diameter shall be tightly wound around the insulation sleeve by 3 turns in each of the 2 parts approximately 13 mm apart. The test voltage (d.c. 4 kV) shall be applied between them for about 1 s.
- (3.6) **Metal block method** (applied to chip capacitor)
- Square chip capacitor** Using method 1 of Fig. 7 (3), apply the test voltage between the metal V block and the metal plate.
 - Cylindrical chip capacitor** Using method 2 of Fig. 7 (4), apply the test voltage between the metal V block and the metal plate.

Fig. 7. Method of voltage application for external insulation

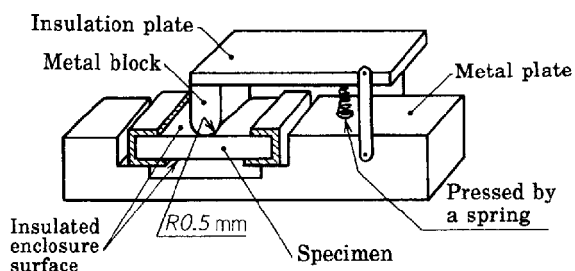
(1) Metal foil method



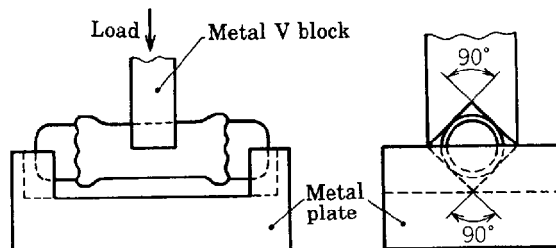
(2) Small metal ball method



(3) Metal block Method 1



(4) Metal block Method 2



7.1.4 Final measurement The electrical performances shall be measured according to the relevant detail specification, and the appearance shall be also inspected.

7.1.5 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- The test circuit (if different from 7.1.1)
- The positions of voltage application (refer to Table 6)
- The test voltage and the duration of application (refer to 7.1.3)
- The limits of charging and discharging current, the time constant or the protective resistance (refer to 7.1.1)
- The method of test voltage application for external insulation [refer to (3.1) to (3.6) of 7.1.3 (3)]

7.2 Voltage proof (1) (mainly applied to capacitors conforming to JIS C 5150)**7.2.1 Equipment** The equipment is as follows:

- (1) **Power supply** The power supply shall be the a.c. power supply as specified in 5.2.
- (2) **Test circuit** The test circuit shall be as shown in Fig. 6 (2). However, an a.c. voltmeter shall be used for the voltmeter and the protection resistor R_1 , shall be omitted. The value of protection resistor R_2 is not particularly specified.

7.2.2 Preconditioning The preconditioning of 4.1 shall be performed before the test.**7.2.3 Test** The test is as follows:

- (1) **Application method of test voltage** At first, approximately $\frac{1}{2}$ of the specified test voltage shall be applied and then the voltage shall be gradually increased to reach the test voltage within 10 s. After maintaining this condition for the specified duration, the voltage shall be decreased quickly, and the specimen shall be taken out.
- (2) **Test between terminations** The test voltage specified in Table 7 shall be applied for 1 min across the terminations of specimen to check if any abnormality exists.
- (3) **Between terminations connected together and case or enclosure** The test voltage specified in Table 7 shall be applied for 1 min between the terminations connected together and the case or enclosure of specimen to check if any abnormality exists.

If the case of specimen is made of insulating materials, comply with 7.1.3 (3), (3.2) or (3.3).

Table 7. Test voltage and position of application for voltage-proof (1)

Test voltage		Remarks (4)	
Between terminations	Between terminations connected together and case or enclosure (5)	Type	Safety performance
Voltage equal to 2.3 times rated voltage (5)	For rated voltage 150 Vrms or less: 1 kVrms For rated voltage over 150 Vrms: 1.5 kVrms (5)	CQS, CFS, CCS, CKS, CMS	A1, A2
For rated voltage 150 Vrms or less: 1 kVrms (5) For rated voltage over 150 Vrms: 1.5 kVrms (5)			B1, B2
Voltage equal to 2.3 times rated voltage		CQS	C1, C2
Voltage equal to 1.75 times rated voltage		CFS	

Notes (4) Type and safety performance are expressed with symbols specified in JIS C 5150.

(5) When the test voltage is 1.2 times the specified value, duration of application may be 1 s.

7.2.4 Final measurement The electrical performances shall be measured in accordance with the detail specification, and the appearance shall be inspected.

7.2.5 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

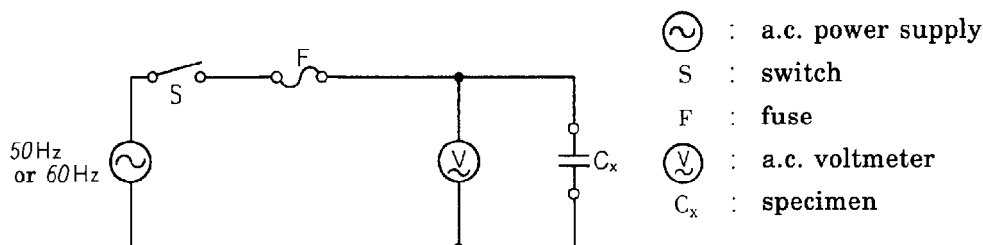
- (1) **Test voltage and duration of application** (refer to 7.2.3)
- (2) **Applying method of test voltage** (in the case of specimen is made of insulating materials) (refer to 7.2.3)

7.3 Voltage proof (2) (applied mainly to capacitors of safety performance C2 in JIS C 5150)

7.3.1 Equipment The equipment is as follows:

- (1) **D.C. power supply for preconditioning** It shall be the type A of d.c. power supply specified in 5.1. If no doubt arises on the judgement, other power supplies may be used.
- (2) **Test chamber** The test chamber shall be as specified in 5.3.
- (3) **Test circuit** The test circuit shall be as given in Fig. 8.
 - (a) **A.C. power supply** The capacity of a.c. power supply shall be such that the short circuit current is 300 A or over.
 - (b) **Rated current of fuse** The rated current of fuse shall be 20 A or 10 times the rated current of specimen, whichever is larger.

Fig. 8. Test circuit of voltage proof (2)



7.3.2 Preconditioning, preparation and test

7.3.2.1 For plastic film capacitors They shall be specified as follows:

- (1) **Preconditioning and preparation** A d.c. voltage of 2.5 kV shall be applied between the terminations of specimen for 1 min. Then, the d.c. voltage is removed, and the specimen is discharged. The specimen shall be wound with gauze (the Japanese Pharmacopoeia) by one turn and put into the test chamber at a temperature of $85 \pm 3^\circ\text{C}$.
- (2) **Test** After the specimen has reached the temperature of test chamber, apply an a.c. voltage equal to 1.3 times the rated voltage across the terminations for 5 h continuously. Check for any abnormality.

7.3.2.2 For metallized plastic film capacitors They shall be specified as follows:

- (1) Preconditioning and preparation A d.c. voltage equal to 2 times the rated voltage shall be applied between the terminations of specimen for 10 min. In this period, the capacitor is discharged 5 times by instantaneously short circuiting the terminations at an interval of about 2 min. The specimen finally discharged shall be wound with gauze (the Japanese Pharmacopoeia) by one turn and put into the test chamber at a temperature of $85 \pm 3^\circ\text{C}$.
- (2) Test After the specimen has reached the temperature of test chamber, apply an a.c. voltage equal to 1.6 times the rated voltage for 8 h continuously across the terminations. If there is no abnormality, apply an a.c. voltage equal to twice the rated voltage further for 8 h. If the fuse breaks during the application of voltages equal to 1.6 and 2 times the rated voltage, the fuse may be replaced up to 3 times. But when the breaking exceeds 3 times, the voltage application shall be stopped.

During and after the test, check for any abnormality of the specimen.

7.3.3 Final measurement The electrical performances shall be measured in accordance with the relevant detail specification, and the appearance shall be inspected.

7.3.4 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

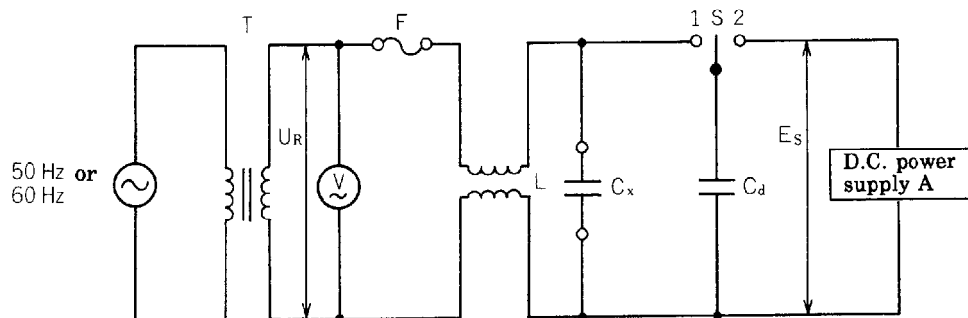
Test method (if different from those specified in 7.3.2.1 or 7.3.2.2)

7.4 Voltage proof (3) (applied mainly to capacitors of safety performance A2 in JIS C 5150)

7.4.1 Equipment The equipment shall be the following test circuit.

Test circuit The test circuit shall be as shown in Fig. 9.

Fig. 9. Test circuit for voltage-proof (3)



- (Symbol: circle with a tilde) : a.c. power supply
 (Symbol: circle with a V) : a.c. voltmeter
 U_R : rated voltage
 T : insulating transformer of 3 kVA or more for blocking pulse
 E_s : voltage of d.c. power supply A
 L : 3 mH, 0.03 Ω
 C_d : capacitor for accumulating shock energy (refer to Table 8)
 F : fuse, rated current 30 A
 S : high voltage switch
 C_x : specimen

7.4.2 Preparation The preparation is as follows:

- (1) Gauze (the Japanese Pharmacopoeia) shall be wound around the specimen by one turn.
- (2) The specimen shall be fixed in a regular way. If the capacitor can be fixed by its wire, the length of wire termination shall be as long as possible.
- (3) D.C. voltage to be applied to the capacitor for accumulating shock energy shall be calculated from the following formula:

The relation between specimen and capacitor for accumulating shock energy shall be as shown in Table 8.

$$E_s = \frac{5000 (C_d + C_x)}{C_d}$$

where, E_s : applied d.c. voltage (V)
 C_d : capacitance of capacitor for accumulating shock energy (F)
 C_x : capacitance of specimen (F)

Table 8. Relation between specimen and capacitor for accumulating shock energy

Measured capacitance of specimen C_x μF	Capacitance of capacitor C_d for accumulating shock energy μF	Dielectric loss tangent of capacitor C_d for accumulating shock energy
0.0047 and under	0.005 to 0.0055	0.005 and under
Over 0.0047 to 0.047	0.05 to 0.055	
Over 0.047 to 0.47	0.5 to 0.55	

7.4.3 Preconditioning Before the test, the preconditioning specified in 4.1 shall be carried out.**7.4.4 Test** The test is as follows:

- (1) The capacitor for accumulating shock energy shall be charged by applying the voltage specified in (3) of 7.4.2 by turning the high voltage switch to side 2.
- (2) The charged voltage of the capacitor for accumulating shock energy shall then be discharged for 1 s to the specimen on which the rated voltage being applied by means of the high voltage switch. This operation shall be continuously carried out 4 times at intervals of 5 s.
- (3) If the specimen does not cause dielectric breakdown during this test, the rated voltage shall be continuously applied for 30 s after the fourth discharge.

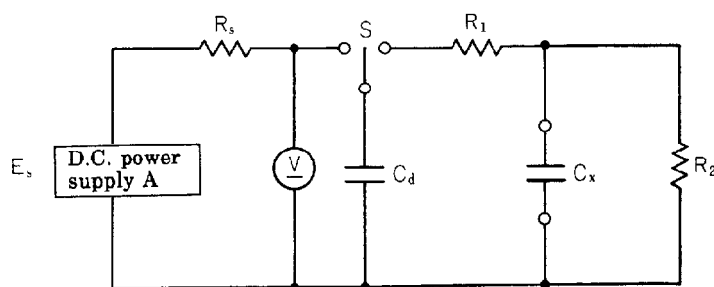
During and after the test, check for any abnormality of the specimen.

7.4.5 Final measurement The electrical performances shall be measured in accordance with the relevant detail specification, and the appearance shall be inspected.

7.5 Voltage proof (4) (applied mainly to safety performance B2 in JIS C 5150)**7.5.1 Equipment** The equipment is as follows:

- (1) **Power supply** The power supply shall be the type A specified in 5.1. If no doubt arises on the judgement, other power supplies may be used.
- (2) **Test circuit** The test circuit shall be as shown in Fig. 10.

Fig. 10. Test circuit for voltage-proof (4)

 C_d : capacitor for accumulating energy $1000 \text{ pF} \pm 10 \%$ R_s : protective resistor R_1 : current-limiting resistor $1 \text{ k}\Omega \pm 10 \%$ R_2 : discharge resistor $4 \text{ M}\Omega \pm 10 \%$ E_3 : d.c. power supply 10 kV S : high voltage switch $\textcircled{V}$: d.c. voltmeter C_x : specimen**7.5.2 Preparation** The preparation is as follows:

- (1) Gauze (the Japanese Pharmacopoeia) shall be wound around specimen by one turn.
- (2) The specimen shall be fixed in the regular method. If the specimen can be fixed by its wire terminations, the length of wire termination should be as long as possible.

7.5.3 Preconditioning Before the test, the preconditioning specified in 4.1 shall be carried out.

7.5.4 Test A d.c. voltage of 10 kV shall be applied to charge the capacitor for accumulating energy. Then, the voltage of the capacitor for accumulating energy shall be discharged to the specimen for about 1 s by means of the high voltage switch. This operation is continuously carried out 50 times at intervals of 5 s .

During and after the test, check for any abnormality.

7.5.5 Final measurement The electrical performances shall be measured in accordance with the detail specification, and the appearance shall be inspected.**7.6 Insulation resistance****7.6.1 Equipment** The high insulation resistance meter specified in JIS C 1303 or at least equivalent shall be used.

7.6.2 Preconditioning Before the test, the preconditioning specified in 4.1 shall be carried out.

7.6.3 Measurement Apply the measuring voltage specified in Table 9, using the equipment of 7.6.1, in accordance with the methods of (1) to (3) unless particularly specified, to the portion of specimen shown in Table 6. The indicated value after 60 ± 5 s shall be read. However, when the reading of instrument stabilizes or tends to increase exceeding the specified insulation resistance within the specified time, the decision may be made by such behavior.

When the measurement is carried out at a temperature other than the temperature specified as the reference conditions (hereafter called "reference temperature"), if any doubt arises on the judgement, the measured value shall be multiplied by the temperature compensation factor specified in the relevant detail specification. They shall be converted to those at the reference temperature.

Table 9. Measuring voltage of insulation resistance

Unit: V

Condition	Measuring voltage	Rated voltage of specimen
1	Rated voltage ± 10 %	Under 10
2	$10 \pm 1^{(6)}$	10 and over to and excl. 100
3	100 ± 15	100 and over to and excl. 500
4	500 ± 50	500 and over

Note ⁽⁶⁾ If no doubt arises on the measurement results, the rated voltage may be used as the measuring voltage.

Remarks: For measurement at the upper category temperature, the rated voltage in Table 9 shall be replaced by the category voltage.

- (1) **Between terminations** (voltage applying portion A) The measuring voltage shall be applied between the terminations of specimen [Table 6 (1a), (2a) or (3a)].
- (2) **Internal insulation** (voltage applying portion B)
 - (a) **Insulated type capacitor with metal case** The measuring voltage shall be applied between metal case and terminations connected together of the specimen [Table 6 (1b), (2b) or (3b)].
 When the measurement is made between the terminations connected together and the case, the insulation resistance is obtained by multiplying the measured value by the number of terminations.
 - (b) **Multiple-section capacitor** The measuring voltage shall be applied between the terminations of the specimen each other (between sections each other) [Table 6 (2c) or (3c)].
- (3) **External insulation** (voltage applying portion C) (applied to insulated type capacitor) The measuring voltage shall be applied, in accordance with one of the following methods (3.1) to (3.6), to the part of specimen specified as (1c), (1d), (1e), (2d), (2e), (2f), (3d), (3e) or (3f) in Table 6.

- (3.1) V block method The body of specimen is placed in the bottom of V block with all the sections connected together. The measuring voltage is applied between the terminations and V block.

The capacitor shall be kept in moderate contact with the face of V block and arranged as specified in the following (a) or (b). However, the capacitor with two axial terminations shall be arranged with the out-of-center positioning of emergence of the terminations ignored, i.e. the terminations are considered being located at the center of the body.

The V block shall be longer than the body of capacitor. The angle of V shall be 90 degrees. It shall be made of metal.

- (a) Cylindrical capacitor The most distant termination from the center axis of capacitor shall be arranged nearest to the face of V block.
- (b) Rectangular capacitor The nearest termination to the edge of capacitor shall be arranged nearest to the face of V block.

- (3.2) Metal foil method Metal foil shall be wound tightly on the body of capacitor apart from the terminations by 1 mm or more, and 5 mm or more in width as shown in Fig. 7 (1). The measuring voltage shall be applied between the foil and all the terminations connected together. If the metal foil cannot be far from the termination by 1 mm or more, the width of foil may be narrowed and intervals between the metal foil and termination shall be 1 mm or more.

Likewise, intervals between metal foils and terminations shall be apart 1 mm or more for unidirectional capacitors.

- (3.3) Metal small ball method The specimen with its terminations connected together, shall be put into a container filled with metal pellets of about 1 mm in diameter, about 2 mm apart as shown in Fig. 7 (2) unless particularly specified. Then, the measuring voltage shall be applied between all the terminations of capacitor connected together and the small metal balls.
- (3.4) Metal plate method (applied to capacitors with metal fittings) The specimen shall be mounted in its normal manner on a metal plate which is at least 12.7 mm wider than the mounting face of the capacitor. The measuring voltage shall be applied between all the terminations of capacitor connected together and the metal plate.
- (3.5) Bare wire method (applied to capacitor with insulation sleeve) Bare copper wire of 1 mm diameter shall be tightly wound around the insulation sleeve by 3 turns in each of the 2 parts about 13 mm apart. The measuring voltage shall be applied between the two parts.
- (3.6) Metal block method (applied to chip capacitor)
- (a) Square chip capacitor Using Fig. 7 (3) method 1, apply the measuring voltage between the metal block and the metal plate.
- (b) Cylindrical chip capacitor Using Fig. 7 (4) method 2, apply the measuring voltage between the metal V block and the metal plate.

7.6.4 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Preconditioning (if different from 7.6.2)
- (2) Measuring voltage (if different from Table 9)
- (3) The positions of voltage application (if different from 7.6.3)
- (4) Duration of measuring voltage application (if different from 7.6.3)

(5) Temperature compensating factor (if applied) (refer to 7.6.3)

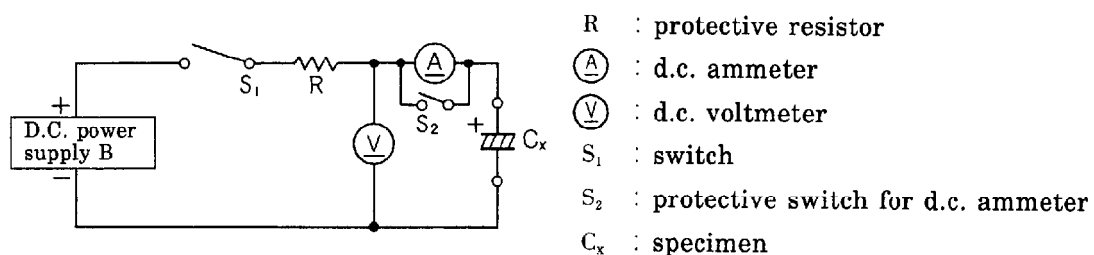
7.7 Leakage current (applied to electrolytic capacitor)

7.7.1 Equipment The equipment is as follows:

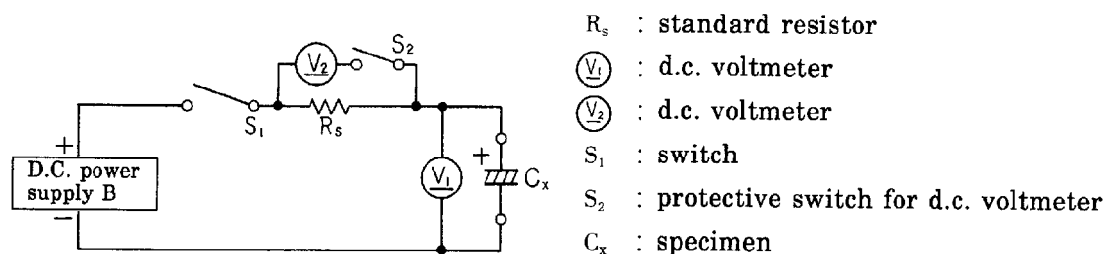
- (1) Power supply The power supply shall be the type B of d.c. power supply specified in 5.1. If no doubt arises on the judgement, other power supplies may be used.
- (2) Measuring circuit and apparatus
 - (a) Measuring circuit The measuring circuit shall be as shown in Fig. 11 (1) or Fig. 11 (2). If no doubt arises on the judgement, other circuits may be used.
 - (b) D.C. ammeter The impedance of ammeters shall be sufficiently low as compared with that of the specimen.
 - (c) D.C. voltmeter The impedance of d.c. voltmeter (V) in Fig. 11 (1) and (V₁) in Fig. 11 (2) shall be sufficiently high as compared with that of the specimen. The impedance of d.c. voltmeter (V₂) in Fig. 11 (2) shall be sufficiently high as compared with the standard resistor.
 - (d) Series protective resistor The resistance of this resistor shall be about 1 kΩ unless specified.
 - (e) Standard resistor The resistance of this resistor shall be as specified in the relevant detail specification.
 - (f) Accuracy of measuring equipment The accuracy shall be within 5 % of the specified value or 0.1 μA, whichever is larger.

Fig. 11. Measuring circuit of leakage current

(1) Current method circuit



(2) Voltage drop method circuit



7.7.2 Preconditioning Before the test, the voltage treatment of 4.4 and the preconditioning of 4.1 shall be carried out. If no doubt arises on the judgement, the voltage treatment may be omitted.

7.7.3 Measurement The voltage shall be applied between the terminations of specimen, using the equipment shown in 7.7.1 at such rate that the voltage across terminations reaches the rated voltage within 1 min. Make measurement 5 min after the voltage has reached the rated voltage.

When the current method circuit in Fig. 11 (1) is employed, measure the current of d.c. ammeter (A).

When the voltage drop method circuit in Fig. 11 (2) is employed, measure the voltage of d.c. voltmeter (V₂). However, when the current falls below the specified leakage current within the specified time, and the reading of instrument stabilizes or tends to fall down, the judgement may be made by such behavior.

The protective switch S₂ for d.c. ammeter in Fig. 11 (1) and the protective switch S₂ for d.c. voltmeter in Fig. 11 (2) protect the instruments from damage due to the initial charging current at the voltage application. Short circuit the instrument (d.c. ammeter), or open-circuited the instrument (d.c. voltmeter) at the initial stage of voltage application.

When the measurement is carried out at a temperature other than the reference temperature and if any doubt arises on the judgement, the measured value shall be multiplied by the temperature compensation factor specified in the detail specification. It shall be converted to that at the reference temperature.

7.7.4 Calculation In the case of Fig. 11 (2), the leakage current shall be calculated from the following equation, based on the measured values obtained in 7.7.3.

$$I = \frac{E}{R_s}$$

where,

I : leakage current value (A)

E : voltage value (V) of d.c. voltmeter (V₂)

R_s : resistance value (Ω) of standard resistor

7.7.5 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Resistance of protective resistor (if different from about 1 kΩ, refer to 7.7.1)
- (2) Resistance of standard resistor (refer to 7.7.1)
- (3) Preconditioning (if different from 7.7.2)
- (4) Applied voltage (if different from 7.7.3)
- (5) Duration of voltage application (if different from 7.7.3)
- (6) Measuring temperature other than standard condition (if applied) (refer to 7.7.3)
- (7) Temperature compensation factor (if applied) (refer to 7.7.3)

7.8 Capacitance

7.8.1 Equipment The equipment shall be the one which allows the measurement under the conditions shown in Table 10.

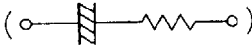
At the measurement, attention shall be paid to minimize the measurement error due to stray capacitance or the like.

7.8.2 Preconditioning The preconditioning of 4.1 shall be carried out before the test.

7.8.3 Measurement The measurements shall be carried out under the conditions shown in Table 10. The measuring voltage shall, unless any doubt arises on the judgement, be as low as possible.

When a d.c. voltage is superposed, this voltage shall be larger than the peak a.c. voltage. The sum of the peak a.c. voltage and the d.c. voltage shall not exceed the rated voltage or the category voltage of the specimen.

Table 10. Measuring condition of capacitance

Measuring condition	Measuring frequency (tolerance $\pm 20\%$)	Nominal capacitance range	Measuring voltage	Accuracy of instrument	Remarks
1	50 Hz or 60 Hz, 100 Hz ⁽⁷⁾ or 120 Hz or 1 kHz ⁽⁷⁾	Over 10 μF	20 % of rated voltage or 70 Vrms, whichever is smaller	In the case of measuring absolute value, 10 % of tolerance or 2 % of measured value of the capacitance, whichever is smaller In the case of measuring variable, 10 % or less of the specified maximum variable	Capacitors other than electrolytic capacitor
2	1 kHz or 10 kHz ⁽⁷⁾ (recommended 1 kHz)	Over 1000 pF up to and incl. 10 μF	3 % of rated voltage or 5 Vrms, whichever is smaller		
3	1 kHz ⁽⁷⁾ , 100 kHz ⁽⁷⁾ , 1 MHz or 10 MHz ⁽⁷⁾ (recommended 1 MHz)	1000 pF or less			
4	100 Hz ⁽⁷⁾ or 120 Hz (recommended 120 Hz)	—	0.5 Vrms or less + 2.1 V to 2.5 Vdc ⁽⁸⁾		Electrolytic capacitor For measuring circuit, use the series equivalent circuit. 

Notes ⁽⁷⁾ This is applied when specified in detail specification.

⁽⁸⁾ If there is no doubt on judgement, the d.c. voltage may be 1.5 V to 2.0 V, or superposition may be omitted.

7.8.4 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Preconditioning (if different from 7.8.2)
- (2) Measuring conditions (refer to 7.8.3)
- (3) Measuring temperature other than that in the standard conditions (if applied) (refer to 3.1 and 7.8.3)

- (4) Measuring frequency [if different from Table 10 and if the frequency of Note (7) is applied]
- (5) Measuring voltage (if different from Table 10)
- (6) Superimposed d.c. voltage (if applied) (refer to 7.8.3)

7.9 Tangent of loss angle

7.9.1 Equipment The equipment shall be the one which allows the measurement under the conditions shown in Table 10.

Accuracy of the instrument shall be 10 % of the specified value or 1×10^{-4} , whichever is larger.

At the measurement, attention shall be paid to minimize the measurement error due to stray capacitance or the like.

7.9.2 Preconditioning Before the test, the preconditioning of 4.1 shall be carried out.

7.9.3 Measurement The measurement shall be carried out under the condition shown in Table 10. The measuring voltage shall, unless any doubt arises on the judgement, be as low as possible.

When a d.c. voltage is superimposed, this voltage shall be larger than the peak a.c. voltage. The sum of the peak a.c. voltage and the d.c. voltage shall not exceed the rated voltage of the specimen.

Remarks: When it is expressed in Q, inverse dielectric tangent is used.

7.9.4 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

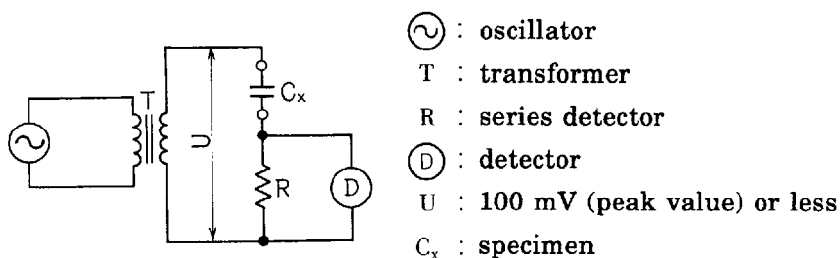
- (1) Preconditioning (if different from 7.9.2)
- (2) Measuring condition (refer to 7.9.3)
- (3) Measuring temperature other than that in the standard conditions (if applied) (refer to 3.1 and 7.9.3)
- (4) Measuring frequency [if different from Table 10 and if the frequency of Note (7) is applied]
- (5) Measuring voltage (if different from Table 10)
- (6) Superimposed d.c. voltage (if applied) (refer to 7.9.3)

7.10 Connection between sections

7.10.1 Equipment The equipment is as follows:

- (1) **Test circuit** The test circuit shall be as shown in Fig. 12.

Fig. 12. Test circuit for connection between sections



- (2) Series detector The resistance of the series detector shall be as follows:

$$R = \frac{150}{C}$$

Where, R : resistance of series detector (Ω)
 C : nominal capacitance of specimen C_x (μF)

- (3) Detector Impedance of the detector shall be sufficiently large as compared with that of the specimen.
 (4) Output voltage of the transformer It shall be 100 mV (peak value) or less in any condition of the test.

7.10.2 Preconditioning Before the test, the preconditioning of 4.1 shall be carried out.

7.10.3 Test Using the equipment of 7.10.1, an a.c. voltage of 100 mV (peak value) or less shall be applied to the specimen through the series resistor. A light shock shall be applied to the specimen, and defective connection or disconnection between the sections shall be examined from the change in the condition of indication of detector.

7.10.4 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Test voltage [if different from 7.10.1 (4)]
 (2) Measuring frequency

7.11 Impedance

7.11.1 Equipment The equipment is as follows:

- (1) Measuring circuit and apparatus
 (a) Measuring circuit The measuring circuit shall be as shown in Fig. 13 (1) or Fig. 13 (2).

At the measurement, attention shall be paid to minimize the measurement error due to stray capacitance or the like.

Fig. 13. Measuring circuit of impedance

(1)

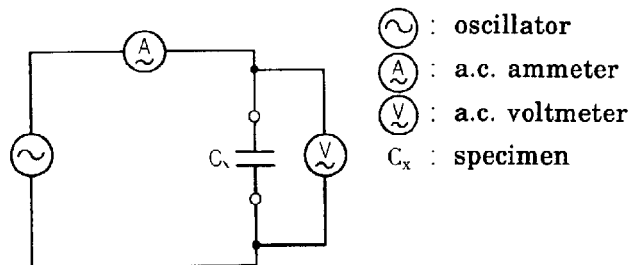
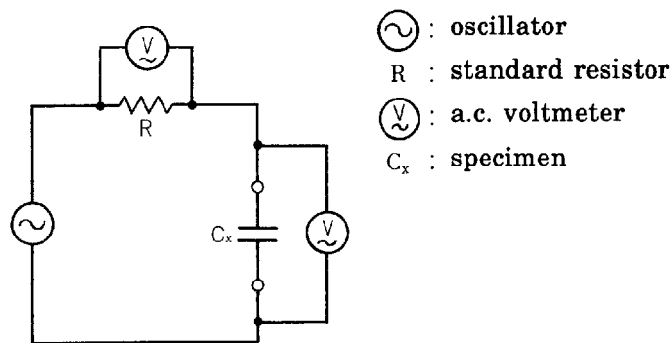


Fig. 13. (continued)

(2)



- (b) A.C. voltmeter The impedances of the a.c. voltmeter shall be sufficiently large as compared with that of the specimen.
- (c) Standard resistor Standard resistor of Fig. 13 (2) shall be non-inductive type. Unless otherwise specified, the resistance shall be 10 Ω.
- (d) A.C. ammeter The impedance of a.c. ammeter shall be sufficiently small as compared with that of the specimen.
- (2) Accuracy of measuring apparatus The accuracy shall be within 10 % the specified value.
- 7.11.2 Preconditioning Before the measurement, the preconditioning of 4.1 shall be carried out.
- 7.11.3 Measurement The measurement is as follows:
- (1) Measuring frequency The measuring frequency shall be the value specified in the detail specification selected from among the frequencies in Table 11.

Table 11. Measuring frequency of impedance

Measuring frequency	Tolerance
50 Hz, 60 Hz, 100 Hz, 120 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 10 MHz	± 10 %

- (2) Measuring voltage or current The measuring voltage or the current flowing through the specimen shall be such that the measured value does not change during the continuous application for 1 min.
- However, for the case of a polarized capacitor, the measuring voltage shall not exceed 0.5 V_{rms}.
- (3) Measuring method After the specimen has reached the temperature stability (thermal balance) at the specified temperature, a voltage shall be applied. When the reading of the a.c. voltmeter and/or a.c. ammeter becomes stable, they shall be read.

7.11.4 Calculation Calculate the impedance as follows:

- (1) In the case of Fig. 13 (1)

$$Z = \frac{U}{I}$$

where, Z : impedance of specimen (Ω)
 U : voltage of a.c. voltmeter (Vrms)
 I : current of a.c. ammeter (Arms)

(2) In the case of Fig. 13 (2)

$$Z = \frac{U_1 \cdot R}{U_2}$$

where, Z : impedance of specimen (Ω)
 U_1 : voltage of a.c. voltmeter connected across terminations of specimen (Vrms)
 U_2 : voltage of a.c. voltmeter connected across the terminations of standard resistor (Vrms)
 R : measured resistance of standard resistor (Ω)

7.11.5 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Measuring circuit [if different from 7.11.1 (1) (a)]
- (2) Accuracy of measuring apparatus [if different from 7.11.1 (2)]
- (3) Preconditioning (if different from 7.11.2)
- (4) Measuring frequency [refer to 7.11.3 (1)]
- (5) Measuring temperature [refer to 7.11.3 (3)]

7.12 Variation of characteristics by temperature

7.12.1 Equipment The equipment is as follows:

- (1) Test chamber The test chamber shall be that specified in 5.3.

When dynamic method is employed, the intermediate temperatures between each step of Table 12 can also change continuously.

- (2) Measuring circuit and apparatus

- (a) Measuring circuit For measurement of capacitance, comply with the conditions shown in 7.8.1 and 7.8.3. For other cases, comply with the detail specification.

Attention shall be paid to minimize the measurement error in whole equipment due to stray capacitance or the like.

- (b) Fixture The fixtures shall be specified in the relevant detail specification.

If it is not specified in the detail specification, an appropriate fixture may be used.

- (3) Equipment for dynamic method The equipment shall be such that the same result as that from the static method can be obtained.

The test results may be displayed in a graph.

- (4) Accuracy of measuring equipment The accuracy shall be sufficient for the specified values.

7.12.2 Preconditioning The preconditioning of 4.1 shall be carried out before the test.

7.12.3 Measurement The measurement is as follows:

- (1) **Application of measuring method** There are two kinds of measuring methods as follows. Apply, in principle, the static method. Apply the dynamic method only when it is so specified by the relevant detail specification and when the same test result as the static method is expected.
- (2) **Static method** The specimen shall be kept at the temperatures and in the sequence specified in Table 12. After the specimen has reached thermal equilibrium at each specified temperature, the electrical performances specified in the relevant detail specification shall be measured in each step.

Table 12. Condition of temperature change

Steps	Temperature °C
1	20 ± 2
2	Lower category temperature ± 3
3	20 ± 2
4	Upper category temperature ± 2
5	20 ± 2

- (3) **Dynamic method** The temperature of the specimen shall be changed slowly and continuously in the order from steps 1 to 5 specified in Table 12. Such operation shall be repeated 2 cycles. During these cycles, the electrical performances specified in the detail specification shall be continuously measured.

When the capacitance or the relative capacitance change is measured and displayed in a graph as a function of temperature, the output of the bridge or comparison unit shall be connected to Y axis, and the output of the temperature sensor, to X axis.

Measure the temperatures by placing the sensing part of temperature sensor into a container having the same heat capacity as the specimen. This is to keep the temperature sensor and the specimen at the same temperature.

7.12.4 Calculation When capacitance change due to temperature was measured, use the capacitance at each temperature obtained in 7.12.3 (2) or (3), and calculate the relative capacitance change (temperature characteristic of capacitance), the temperature coefficient of capacitance and the drift of capacitance.

- (1) **Relative capacitance change (temperature characteristic of capacitance)**

$$\frac{\Delta C}{C} = \frac{C_2 - C_1}{C_1} \times 100$$

where, $\frac{\Delta C}{C}$: temperature characteristic of capacitance (%)
 C_1 : capacitance at step 3 (F)
 C_2 : capacitance at step 2 or step 4 (F)

(2) Temperature coefficient of capacitance

$$\alpha_i = \frac{C_2 - C_1}{C_1 (T_2 - T_1)} \times 10^6$$

where, α_i : temperature coefficient of capacitance (ppm/°C)
 C_1 : capacitance at step 3 (F)
 C_2 : capacitance at step 2 or step 4 (F)
 T_1 : temperature at measurement of step 3 (°C)
 T_2 : temperature at measurement of step 2 or step 4 (°C)

(3) Drift of capacitance

$$\delta_{ij} (\%) = \frac{C_{\max} - C_{\min}}{C_1} \times 100$$

or

$$\delta_{ij} (\text{F}) = C_{\max} - C_{\min}$$

where, δ_{ij} : drift of capacitance (% or F)
 $C_{\max}$: maximum value of 3 measured values at steps 1, 3 and 5 (F)
 $C_{\min}$: minimum value of 3 measured values at steps 1, 3 and 5 (F)
 C_1 : capacitance at step 3 (F)

7.12.5 Items to be specified in detail specification The relevant detail specification shall prescribe the following:

- (1) Fixture (if specified) [refer to 7.12.1 (2) (b)]
- (2) Preconditioning (if different from 7.12.2)
- (3) Measuring method (if dynamic method is applied) (refer to 7.12.3)
- (4) The reference temperature, if a temperature other than the temperature $20 \pm 2^\circ\text{C}$ of step 3 is specified (refer to 7.12.3 and Table 12)
- (5) Lower category temperature and upper category temperature (refer to Table 12)
- (6) Measuring temperature other than that specified in this Standard (if specified) (refer to Table 12)
- (7) Rising rate and falling rate of temperature (if specified) [refer to Table 12 and 7.12.3 (3)]
- (8) Holding time at measuring temperature (if different from 7.12.3)
- (9) Electrical measuring items [refer to 7.12.3 (2) and (3)]

7.13 Dielectric absorption

7.13.1 Equipment The equipment is as follows: