

JIS

JAPANESE INDUSTRIAL STANDARD

**Test methods of directly
heated negative temperature
coefficient thermistors**

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Test methods of directly heated negative
temperature coefficient thermistors

C 2571-1995

1. **Scope** This Japanese Industrial Standard specifies test methods of directly heated negative temperature coefficient thermistors which are mainly used in electronic equipment as heat sensitive elements or circuit components. (hereafter referred to as "thermistors").

If there is any discrepancy between the provisions of this Standard and the relevant detail specification, the provision of the detail specification shall be followed.

Remarks 1. For application of this Standard, necessary test items shall be chosen according to the kind and use of the thermistor.

2. The standards cited in this Standard and the International Standard corresponding to this Standard are shown in Attached Table 1.

2. **Definitions** For the purpose of this Standard, in addition to the definitions in JIS C 2570, the following principal definitions apply:

(1) **test (wide sense)** This means a series of procedures for investigation of performances of the thermistor to be tested (specimen) and consists of the items prescribed below. However, the items (a) to (e) and intermediate measurement are applicable when specified.

(a) preconditioning

(b) initial measurement

(c) test (narrow sense) or measurement (including intermediate measurement)

(d) recovery

(e) final measurement

(2) **preconditioning** Such treatments as given below to be done on the specimen for increasing stabilization of characteristic and reproducibility of test results, to avoid dispute on the test results.

(a) To remove the effect due to the history.

(b) To stabilize the characteristics under the test conditions.

- (3) test (narrow sense) or measurement (including intermediate measurement) This means to place the specimen under particular test conditions and (or) to examine the appearance, electrical and mechanical performances under the said test conditions, for the purpose of investigating the influence of the said test conditions on the specimen.

In some cases intermediate measurements are included.

- (4) recovery To carry out such treatments as leaving alone and drying before the final measurement to stabilize the characteristics of the specimen.
- (5) ambient temperature The temperature of the medium surrounding the specimen. If the specimen generates heat itself, this means the temperature of the medium at a position where the effect of the self heating is negligible.
- (6) thermal equilibrium (temperature stabilization) Such a state that the resistance of the specimen does not change almost, when the measurement is repeated on the specimen maintained in the medium at a specified temperature.

3. Test conditions

3.1 Standard conditions Unless otherwise prescribed in the detail specification, the tests shall be carried out under the standard conditions given in Table 1. If there is any dispute on the measured values under this standard conditions, or if especially required the conditions of 3.3 shall be employed.

If the detail specification calls for conversion of measured values the reference temperature shall be as given in 3.2.

If it is difficult to carry out the measurement under the standard conditions, the test and measurement may be carried out under the conditions other than the standard conditions unless doubt arises on the decision.

Table 1. Standard conditions

Temperature	15°C to 35°C
Relative humidity	25% to 85%
Air pressure	86 kPa to 106 kPa

Remarks: In some cases, the temperature in this standard conditions is called ordinary temperature in this Standard.

3.2 Reference conditions The reference conditions shall be as given in Table 2. However, only the temperature may be employed as the reference condition.

Table 2. Reference conditions

Temperature	25°C
Relative humidity	50%
Air pressure	101.3 kPa

3.3 Referee conditions The referee conditions shall be one of the combinations given in Table 3. If there is no provision in the detail specification the condition C grade 2 given in Table 3 shall be employed.

Table 3. Referee conditions

Condition	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	48 to 52	25±2	45 to 55
D	27±1	63 to 67	27±2	60 to 70

Remarks: The air pressure shall be 86 kPa to 106 kPa.

3.4 Precaution

- (1) Such factors which influence on the test results as direct sunshine, direct radiation from heat or cooling source and forced ventilation shall be avoided for the specimen through the period before and after the test.
- (2) The resistance of lead wires for connecting the specimen with the measuring device shall be small enough so that it will not give influence on the measurement results.

4. Appearance and dimension tests

4.1 Purpose The purpose of these tests is to examine the appearance, marking and dimensions of a thermistor.

4.2 Equipment The equipment shall be as given below. If there is no dispute on the decision, other appropriate equipment may be used.

- (1) The vernier calliper with the minimum reading value of not more than 0.05 mm specified in JIS B 7507.
- (2) The micrometer for external measurement specified in JIS B 7502.

- (3) Projector or magnifying lens with an appropriate magnification (used when prescribed in the detail specification).

4.3 Tests

4.3.1 Appearance Carry out the appearance test by visual check.

4.3.2 Marking Carry out the marking test by visual check.

4.3.3 Dimension Carry out the dimensional test using the equipment of 4.2 on the dimensions prescribed in the detail specification.

4.4 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Test equipment (if test equipment other than that of 4.2 is used)
- (2) Application of projector or magnifying lens and its magnification (if use of such apparatus is specified) [see 4.2 (3)]
- (3) Positions of dimension measurement

5. Electrical performance tests

5.1 Zero-power resistance test

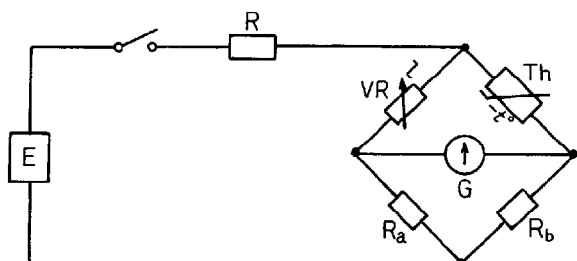
5.1.1 Purpose The purpose of this test is to obtain the zero-power resistance of a thermistor at an optional temperature.

5.1.2 Equipment

5.1.2.1 Resistance measuring device The resistance measuring device shall be as follows:

- (1) The resistance measuring device shall be a zero method resistance bridge of the circuit system shown in Fig. 1, or a device at least equivalent in accuracy.

Fig. 1. Zero method resistance bridge



- E : variable d.c. power supply
 R : protective resistor
 R_a , R_b : proportional arm resistors
 G : galvanometer
 VR : stepwise variable resistor
 Th : specimen

- (2) The accuracy of the resistance measuring device shall be within $\frac{5}{100}$ of the tolerances on resistance of the specimen ($\pm\%$).

Example 1: The accuracy shall be $\pm 0.25\%$ if the tolerances on resistance are $\pm 5\%$.

Example 2: The accuracy shall be $\pm 0.05\%$ if the tolerances on resistance are $\pm 1\%$.

5.1.2.2 Measurement chamber The measurement chamber shall have the following accuracies in temperature:

- (1) The accuracy of temperature control shall be $\pm 0.3^\circ\text{C}$, when the temperature setting is exceeding -55°C up to and including -25°C .
- (2) The accuracy of temperature control shall be $\pm 0.1^\circ\text{C}$, when the temperature setting is exceeding -25°C up to and including 100°C .
- (3) The accuracy of temperature control shall be $\pm[(\text{set temperature})^2 \times 10^{-5}]^\circ\text{C}$, when the temperature setting is exceeding 100°C up to and including 1100°C .

Example 1. The accuracy in temperature control shall be $\pm 0.4^\circ\text{C}$ when the set temperature is 200°C .

Example 2. The accuracy in temperature control shall be $\pm 10^\circ\text{C}$ when the set temperature is 1000°C .

- (4) The accuracy of temperature control shall be as specified in the detail specification when the temperature setting is not exceeding -55°C or is exceeding 1100°C .

5.1.2.3 Thermometer The thermometer shall be the one graduated in accordance with the calibration method specified in 7. of JIS Z 8710, having at least an appropriate accuracy given below.

- (1) The resistance bulb of grade A specified in JIS C 1604 shall be used for the temperature range of -55°C to $+650^\circ\text{C}$.
- (2) The enclosed-scale mercury-in-glass thermometer with graduation of 0.1°C specified in JIS B 7412 shall be used for the temperature range of -30°C to $+360^\circ\text{C}$.
- (3) The thermocouple specified in JIS C 1602 shall be used for the temperature range of 630°C to 1100°C .

5.1.3 Preparation

- (1) Previously maintain the measurement chamber at the temperature for test before placing the specimen in the chamber.
- (2) Previously switch on the power supply to the resistance measuring device, and allow the device to stand until the operation stabilizes sufficiently.

- (3) Maintain enough electrical insulation between the specimen and the thermal medium in the measurement chamber.

5.1.4 Test

- (1) Insert the specimen and the thermometer into the medium in the measurement chamber with their heat sensitive parts adjacent each other, and allow them to stand for the period necessary for thermal equilibrium at the specified temperature. In this procedure, insert the specimen into the medium to enough depth to avoid the dispute on the measurement results.
- (2) Adjust the measuring current for the specimen so that the temperature rise due to self heating becomes 0.1°C or less when calculated from the dissipation factor.
- (3) Connect the specimen with the measuring device and read the indicated value after the value stabilized.

5.1.5 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Accuracy of resistance measuring device (if necessary) [see 5.1.2.1 (2)]
- (2) Accuracy of temperature control in measurement chamber (if necessary) (see 5.1.2.2)
- (3) Measuring current (if necessary) [see 5.1.4 (2)]

5.2 B-value test

5.2.1 Purpose The purpose of this test is to obtain B-value of a thermistor.

5.2.2 Equipment The equipment shall be as specified in 5.1.2.

5.2.3 Preparation The preparation shall be as specified in 5.1.3.

5.2.4 Test

- (1) Obtain the resistance value (R_1) at temperature (T_1) [$T_1(\text{K}) = t_1 (\text{°C}) + 273.15$ (K)] in accordance with 5.1.4.
- (2) Obtain the resistance value (R_2) at temperature (T_2) [$T_2(\text{K}) = t_2 (\text{°C}) + 273.15$ (K)] different from temperature (T_1) in accordance with 5.1.4.

5.2.5 Calculation Calculate the B-value (K) from the following formula:

$$B(\text{K}) = \frac{\log_e R_1 - \log_e R_2}{\frac{1}{T_1} - \frac{1}{T_2}}$$

where, R_1 : zero-power resistance value at $T_1(\text{K})$ (Ω)

R_2 : zero-power resistance value at $T_2(\text{K})$ (Ω)

T_1 : an optional temperature (K)

T_2 : an optional temperature different from $T_1(\text{K})$

5.2.6 Item to be prescribed in detail specification The following item shall be prescribed in detail specifications:

- (1) Two temperatures $T_1(K)$ and $T_2(K)$ (see 5.2.4)

5.3 Dissipation factor test

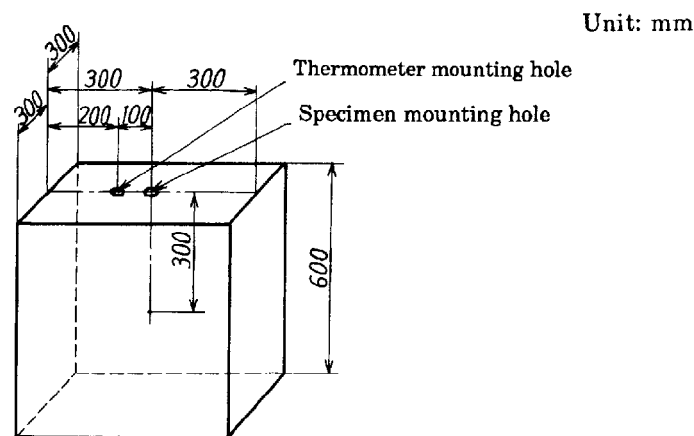
5.3.1 Purpose The purpose of this test is to obtain the dissipation factor of a thermistor in still air.

5.3.2 Equipment

5.3.2.1 Measuring container The measuring container shall be capable of supporting the specimen in still air and shall have enough volume to avoid the influence on the measurement results.

An example of measuring container is shown in Fig. 2.

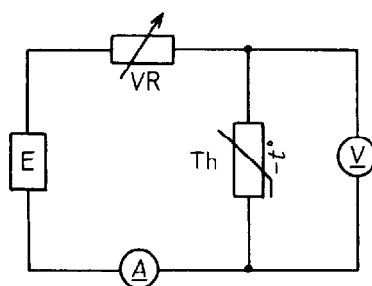
Fig. 2. An example of measuring container



5.3.2.2 Measuring circuit and apparatus

- (1) In general, the measuring circuit shall be as given in Fig. 3.

Fig. 3. Measuring circuit



E : variable d.c. power supply
VR : variable resistor
V : d.c. voltmeter
A : d.c. ammeter
Th : specimen

- (2) The voltmeter shall have sufficiently high impedance compared with the resistance of the thermistor.

5.3.3 Preparation

- (1) Measure the zero-power resistance value of the specimen at a temperature (t_1), in accordance with the zero-power resistance test method of 5.1. Unless otherwise specified the temperature (t_1) shall be 85°C.
- (2) Insert the specimen through the specimen mounting hole shown in Fig. 2 and mount it so that its heat sensitive part positions at equal distance from any plane of the container.

5.3.4 Test Connect the specimen with the measuring circuit, and adjust the current by means of the measuring power supply voltage or the variable resistor so that the resistance value at thermal equilibrium obtained from the terminal voltage and the current falls within a range of $\pm 2\%$ from the zero-power resistance value at temperature (t_1).

In the above state, obtain the power consumption (W) and read the ambient temperature (t_2) by means of the thermometer inserted into the measuring container.

5.3.5 Calculation Calculate the dissipation factor (δ) of the specimen by means of the following formula:

$$\delta (\text{mW}/^\circ\text{C}) = \frac{W}{t_1 - t_2}$$

where, W : power consumption of specimen (mW)

t_1 : temperature of specimen at thermal equilibrium due to self heating ($^\circ\text{C}$)

t_2 : ambient temperature of specimen ($^\circ\text{C}$)

5.3.6 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Heating temperature t_1 (if different from 85°C) [see 5.3.3 (1)]
- (2) Ambient temperature t_2 (if necessary) (see 5.3.4)

5.4 Thermal time constant test

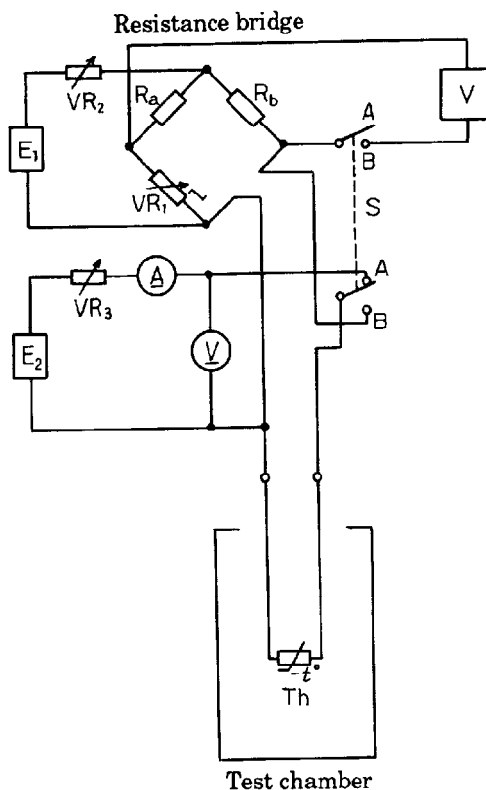
5.4.1 Purpose The purpose of this test is to obtain the thermal time constant which is a measure of thermal responsibility of a thermistor.

5.4.2 Method I (by self heating)

5.4.2.1 Equipment The equipment by which the change of zero-power resistance value with time can be obtained shall be prepared.

The measuring circuit and the test chamber are shown in Fig. 4 as an example of the equipment.

Fig. 4. An example of measuring equipment



- E_1 : variable d.c. power supply
 VR_1 : stepwise variable resistor
 VR_2 : variable resistor
 R_a, R_b : proportional arm resistors
 S : linked switch
 V : recording voltmeter
 E_2 : variable d.c. power supply (for self heating)
 VR_3 : variable resistor
 $\underline{V}$: d.c. voltmeter
 $\underline{A}$: d.c. ammeter
 Th : specimen

- (1) Resistance measuring device The resistance measuring device shall be as specified in 5.1.2.1.
- (2) Thermometer The thermometer shall be as specified in 5.1.2.3.
- (3) Test chamber
 - (a) The test chamber shall be capable of maintaining the preset temperature stably.
 - (b) The test chamber shall have enough volume so that the set temperature does not affected by the specimen.

- (c) The thermal medium in the test chamber shall be as given in the detail specification.

(4) Recording voltmeter

- (a) The recording voltmeter shall have sufficient sensitivity for the output of the resistance bridge.
- (b) The feeding speed of recording paper shall be such that change of the resistance bridge output with time can be sufficiently read.

5.4.2.2 Preparation

- (1) Consider the initial temperature of the thermistor as t_1 , and the finally reached temperature as t_2 . Obtain temperature (t_r) from the formula below.

Here, $t_1 > t_2$ holds.

$$t_r (^{\circ}\text{C}) = t_1 - (t_1 - t_2) \times 0.632$$

- (2) Obtain zero-power resistance values R_1 , R_2 and R_r of the specimen at temperatures t_1 , t_2 and t_r , respectively, in accordance with 5.1.
- (3) Set the temperature of test chamber to t_2 .
- (4) The temperature setting of test chamber, switching on of power supply to measuring device, and electrical insulation of the specimen shall be as specified in 5.1.3.
- (5) Adjust the zero indication of recording voltmeter to the middle of the full scale of recording paper.

5.4.2.3 Test Carry out the measurements as prescribed below, by using the measuring device as shown in Fig. 4.

- (1) Confirm that the temperature of test chamber is at t_2 .
- (2) Place the specimen in the test chamber, throw linked switch (S) to side A, and adjust the load current by means of variable d.c. power supply (E_2) and variable resistor (VR_3) so that the resistance value at thermal equilibrium of the specimen obtained from the voltage across terminations of thermistor and the load current becomes equal to R_1 .
- (3) Set stepwise variable resistor (VR_1) of the bridge to R_r . Next cut the load current and connect the specimen to the bridge by changing over linked switch (S) to side B. At the same time, record the change of bridge output with time, on the recording voltmeter.
- (4) Read the period of time from the instant when the load current is cut off to the instant when the bridge output passes the zero point, on the recording paper of recording voltmeter. The time so read is the thermal time constant.

5.4.2.4 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

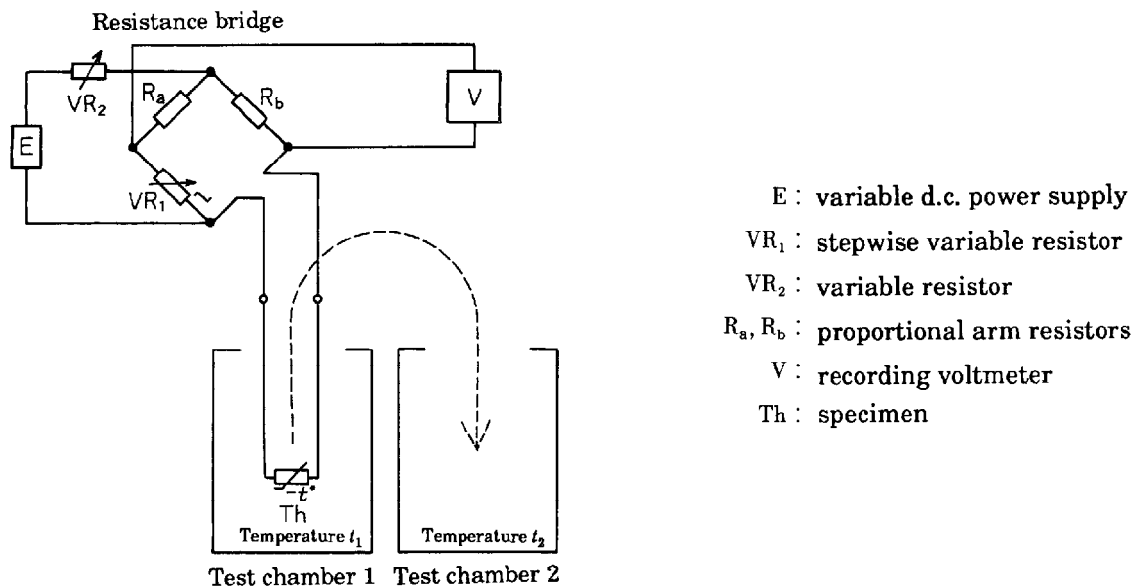
- (1) Thermal medium [see 5.4.2.1. (3) (c)]
- (2) Initial temperature (t_1) and finally reached temperature (t_2) in the test [see 5.4.2.2 (1)]

5.4.3 Method II (by ambient temperature change)

5.4.3.1 Equipment The equipment by which the change of zero-power resistance value with time can be obtained shall be prepared.

The measuring circuit and the test chamber are shown in Fig. 5, as an example of the equipment.

Fig. 5. An example of measuring equipment



- (1) Resistance measuring device The resistance measuring device shall be as specified in 5.1.2.1.
- (2) Thermometer The thermometer shall be as specified in 5.1.2.3.
- (3) Test chamber
 - (a) Each of test chambers 1 and 2 shall be capable of maintaining the relevant preset temperature stably.
 - (b) Each of test chambers 1 and 2 shall have enough volume so that the set temperature does not affected by the specimen.
 - (c) Thermal media for test chambers 1 and 2 shall be as prescribed in the detail specification.

- (4) Recording voltmeter The recording voltmeter shall be as specified in 5.4.2.1 (4).

5.4.3.2 Preparation

- (1) Consider the initial temperature of the thermistor as t_1 and the finally reached temperature as t_2 . Obtain temperature (t_r) from the formula below.

$$t_r(^{\circ}\text{C}) = t_1 - (t_1 - t_2) \times 0.632$$

- (2) Obtain zero-power resistance values R_1 , R_2 and R_r of the specimen at temperatures t_1 , t_2 and t_r , respectively, in accordance with 5.1.
- (3) Set the test chamber 1 to temperature t_1 and test chamber 2 to temperature t_2 .
- (4) The temperature setting of test chambers, switching on of power supply to measuring device, and electrical insulation of the specimen shall be as specified in 5.1.3.
- (5) Adjust the zero indication of recording voltmeter to the middle of the full scale of recording paper.

5.4.3.3 Test Carry out the measurements as prescribed below, by using the measuring device as shown in Fig. 5.

- (1) Confirm that test chambers 1 and 2 are at temperatures t_1 and t_2 , respectively.
- (2) Set stepwise variable resistor (VR_1) in the bridge to the value corresponding to R_r , place the specimen in the test chamber 1 and allow it to stand until the indication of recording voltmeter stabilizes.
- (3) Quickly transfer the specimen into the test chamber 2, and record the change of bridge output with time.
- (4) Read the period of time from the instant when the specimen is transferred to the test chamber 2 to the instant when the bridge output passes the zero point, on the recording paper of recording voltmeter. The time so read is the thermal time constant.

5.4.3.4 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Thermal medium [see 5.4.3.1 (3) (c)]
- (2) Initial temperature (t_1) and finally reached temperature (t_2) in the test [see 5.4.3.2 (1)]

5.5 Maximum permissible power test

5.5.1 Purpose The purpose of this test is to investigate the endurance of the thermistor in which the resistance change caused mainly by electrical loading is utilized, when the maximum permissible power is applied.

5.5.2 Equipment

- (1) The test chamber shall have enough volume so that the set temperature will not be affected by the specimen.
- (2) In general, the testing circuit shall be as given in Fig. 3 (Measuring circuit) of 5.3.2.2.
- (3) The power supply shall have appropriate output voltage, output current and internal impedance so that it can apply the electrical load to the specimen without any trouble.

5.5.3 Test

5.5.3.1 Initial measurement Measure the zero-power resistance value and the B-value at a specified temperature, and examine the appearance.

Measure the insulation resistance, in addition, for insulated thermistors.

5.5.3.2 Test method

- (1) Arrange the specimens in still air at a specified temperature so that they will not thermally affect each other.
- (2) Apply the maximum permissible power prescribed in the detail specification to the specimens for one of the durations given in Table 4 continuously.

Table 4. Duration of maximum permissible power test

Duration of test	Unit: h			
	96 (4 days)	240 (10 days)	500 (about 21 days)	1000 (about 42 days)
Tolerance on duration	± 4	± 8	+24 0	+48 0

5.5.3.3 Recovery After completion of the test, allow the specimen to stand under the standard conditions for at least 1 h.

5.5.3.4 Final measurement Carry out the measurements on the same measurement items under the same conditions as those in the initial measurement, and then examine the appearance.

5.5.4 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Test temperature [see 5.5.3.2 (1)]
- (2) Maximum permissible value of power [see 5.5.3.2 (2)]
- (3) Duration of voltage application [see 5.5.3.2 (2)]

5.6 Insulation resistance test

5.6.1 Purpose The purpose of this test is to investigate the insulation resistance of insulated portions of a thermistor.

5.6.2 Equipment An insulation resistance tester shall be used as the equipment. A high resistance bridge or other instrument may be used, if necessary.

5.6.3 Preparation Connect the terminations of the specimen together to form one electrode in this test. Employ one of the electrodes given in Table 5 as the other electrode.

Take enough spacing between the conductor connecting one electrode with the insulation resistance tester and the opposite electrode, to avoid dispute on the measurement results.

5.6.4 Test Apply the d.c. voltage prescribed in the detail specification across the both electrodes, maintain the voltage for about 1 min and then measure the insulation resistance.

If the reading of insulation resistance tester stabilizes or further increases exceeding the specified insulation resistance value, the decision may be made within 1 min.

Table 5. Electrode and mounting method

Condition	Electrode	Mounting method
A	Metallic V-block	Place the thermistor on the through of V-block.
B	Metal plates	Clamp the thermistor with metal plates.
C	Metal fittings of thermistor	—
D	Small metal balls	Embed the thermistor in small metal balls contained in a vessel.
E	Metal foil	Wrap a metal foil around the thermistor with a space of about 2 mm or more left from each termination.
F	Clean water	Immerse the thermistor into clean water contained in a vessel.

5.6.5 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Mounting method of electrode (see 5.6.3)
- (2) D.C. voltage (see 5.6.4)

5.7 Dielectric withstand voltage

5.7.1 Purpose The purpose of this test is to investigate the dielectric withstand voltage of the insulated portions of a thermistor.

5.7.2 Equipment The equipment for this test shall be that satisfying the following requirements:

- (1) The test power supply shall be a commercial a.c. power supply at a frequency of 50 Hz or 60 Hz with a small waveform distortion, and without remarkable voltage fluctuation due to the load.
- (2) The accuracy of test voltage shall be within $\pm 5\%$.
- (3) An alarm which operates when the current exceeds 1 mA shall be provided.
- (4) The test voltage shall be capable of being raised and lowered gradually.

5.7.3 Preparation Connect the terminations of the specimen together to form one electrode in this test. Employ one of the electrodes given in Table 5 as the other electrode.

5.7.4 Test Allow the specimen to stand under the standard conditions for at least 30 min, apply the test voltage prescribed in the detail specification across both electrodes specified in 5.7.3, and examine whether there are such abnormalities as flashover, burning and dielectric breakdown or not.

Unless otherwise specified, raise the voltage gradually from almost 0 V at a rate of 100 V per second up to the specified voltage, maintain the voltage as it is for $1 \text{ min} \pm 10 \text{ s}$, and then lower the voltage gradually to almost 0 V.

If there is no dispute on the decision, the test may be made by applying a voltage equal to 120% of the specified voltage from the beginning for 1 s.

5.7.5 Item to be prescribed in detail specification The following items shall be prescribed in detail specifications:

- (1) Mounting conditions (see 5.7.3)
- (2) Test voltage (see 5.7.4)
- (3) Duration of voltage application (if other than one minute) (see 5.7.4)

6. Mechanical performance tests

6.1 Test for robustness of termination

6.1.1 Purpose The purpose of this test is to investigate whether or not the strength of termination or external conductor is enough to resist the external force applied thereto during the mounting, wiring or use.

6.1.2 Equipment The equipment for this test shall not cause flaw or strain, which will affect the test result, on the specimen.

6.1.3 Test

6.1.3.1 Initial measurement Measure the zero-power resistance value and the B-value at a specified temperature and examine the appearance.

Measure the insulation resistance, in addition, for insulated thermistors.