

JIS

JAPANESE INDUSTRIAL STANDARD

**Test methods of
potentiometers for use
in electronic equipment**

JIS C 5261—1993

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

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JAPANESE INDUSTRIAL STANDARD

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Test methods of potentiometers
for use in electronic equipment

C 5261-1993

1. **Scope** This Japanese Industrial Standard specifies test methods of potentiometers mainly used for electronic equipment (hereafter referred to as "resistors") If there is any discrepancy in provisions between this Standard and detail specification, the provisions in detail specification shall be complied with.

- Remarks**
1. In this Standard, expression is mainly made to conform with rotary potentiometers. For slide type and linear travelling shaft type, the following interpretation apply:
 - (1) Actuator means shaft or lever.
 - (2) Angle of rotation means distance of actuation or distance of movement.
 - (3) Angle means distance.
 - (4) Rotation means actuation or movement.
 - (5) Torque means actuating force.
 2. The standards cited in this Standard are given in Attached Table 1.
 3. The International standard corresponding to this Standard is given below:
IEC 393-1 (1989) Potentiometers for use in electronic equipment. Part 1: Generic specification

2. **Definitions** For the purpose of this Standard, in addition to the definitions specified in JIS C 0010, JIS C 5260 and JIS C 5602, the following definitions apply:

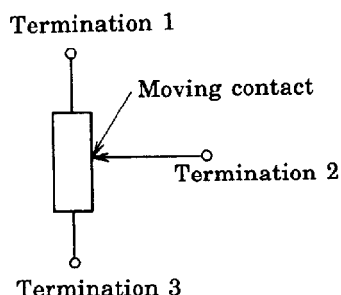
- (1) **actuator** A part of resistor to which an external force is applied directly so that the moving contact in contact with the resistance element moves to a desired position.

If there is an attached switch, the contact of switch is also included.

- Remarks**
1. This is also called a driving mechanism.
 2. The actuator of rotary resistor is called rotary spindle, and it is abbreviated as spindle if there is no doubt.
 3. The actuator of slide (not rotate) type resistor is sometimes called a lever.
 4. The actuator which moves linearly by push and pull is called linear travelling shaft and sometimes abbreviated as shaft.

- (2) (designation of) terminations 1, 2 and 3 The terminations connected with both ends of a resistance element are called termination 1 and termination 3.

The termination connected with a moving contact is called termination 2.



- (3) minimum resistance value The minimum value of resistance between terminations 1 and 2 or terminations 2 and 3, when the moving contact comes close to the relevant end of resistance element.
- (4) mutual deviation The deviation in resistance change characteristic (actual resistance law) between plural unit resistors comprising a tandem resistor.
- (5) total mechanical (actuating) range The mechanical angle of rotation or distance of travel of an actuator between the ends of termination-1 side and termination-3 side.

It is also called total angle of rotation.

- (6) total electrical (actuating) range Such actuating range in total mechanical range that no discontinuity exists between the moving contact and resistance element. That is the sum of effective electrical (actuating) range and non-effective electrical (actuating) range.

Remarks 1. In a resistor in which both ends of this range coincide with the positions of both end stops or the positions where the clutch release mechanism operates, the total electrical range is equal to the total mechanical range.

2. When the range is expressed in angle, it is called total electrical angle of rotation.

- (7) effective electrical range The angle of rotation of actuator necessary to slide the moving contact in such a manner that the resistance value or relative output voltage changes as prescribed by the specified resistance law (characteristic of resistance change relative to moving contact position).

It is also called angle of effective rotation.

- (8) travelling force A force necessary to move the actuator of slide type ones.
- (9) precision potentiometer A rotary resistor mainly used for measurements of high accuracy, servo controls, etc. in which the relation between the spindle rotation angle and the relative output voltage, the shape and dimensions of mounting part, and other necessary performances are strictly specified.

- (10) linearly travelling precision potentiometer A linearly travelling resistor used mainly for measurements of high accuracy or the like, in which the relation between the actuator operation range and the relative output voltage, shape and dimensions of mounting part, and other necessary performances are strictly specified.

- (11) spindle run-out The eccentricity of the spindle diameter with respect to the rotational axis of the spindle at the specified distance from the end of the spindle.

Remarks: Mainly applicable to precision potentiometers.

- (12) lateral run-out The perpendicularity of the mounting surface with respect to the rotational axis of the spindle.

Remarks: Mainly applicable to precision potentiometers.

- (13) spigot diameter run-out The eccentricity of the spigot diameter with respect to the rotational axis of the spindle.

Remarks: Mainly applicable to precision potentiometers.

- (14) dither The repeated rotation of the rotary spindle within a narrow range to simulate the conditions produced in a servo system.

Remarks: Mainly applicable to precision potentiometers.

- (15) concentration and contact resistance The sum of the surface contact resistances and the concentration resistances due to concentration of current in some contacts existing between terminations of a resistor. It is obtained from the following formula:

$$CR = \frac{1}{2} \times [(R_{12} + R_{23}) - R_{13}]$$

where, CR : concentration and contact resistance (Ω)

R_{12} : resistance between terminations 1 and 2 (Ω)

R_{23} : resistance between terminations 2 and 3 (Ω)

R_{13} : resistance between terminations 1 and 3 (Ω)

Remarks: The value of concentration and contact resistance which depends upon the characteristics (especially specific resistivity) and shape (width, thickness of film, etc.) of the material of resistance element, and the material, shape, contact area, etc. of the moving contact, is large. Especially in the case of resistors of coated film system, it shows several percent of the value of total resistance.

- (16) SMD A potentiometer which is in the category of surface mounting device (SMD) soldered to the surface of a printed wiring board.

Remarks: This is also called chip type potentiometer.

- (17) isolation voltage The maximum peak voltage capable of being applied continuously between the terminations together and the spindle and mounting surface together in a potentiometer.

3. Test conditions

3.1 Standard conditions Unless otherwise specified, the test and measurements shall be carried out under the conditions of Table 1. If doubt arises on the decision based on the measured values under the standard conditions, the referee conditions of 3.3 shall be employed.

Table 1. Standard conditions

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

When conversion is necessary, the conditions of 3.2 shall be employed.

When it is difficult to carry out the tests and measurements under the standard conditions, the tests and measurements may be carried out under the conditions other than the standard conditions, if no doubt arises on the decision (see 5.3 of JIS C 0010).

3.2 Reference conditions The reference conditions shall be as specified in Table 2. However, only the temperature may be employed as the reference conditions (see 5.1 of JIS C 0010).

Table 2. Reference conditions

Temperature °C	Relative humidity %	Air pressure kPa
20	—	101.3

Remarks: The requirement for correction to relative humidity is not specified, because the correction by calculation is generally impossible.

3.3 Referee conditions The referee conditions shall be selected from Table 3. Unless otherwise specified, the conditions of symbol A Grade 2 specified in Table 3 shall be employed (see 5.2 of JIS C 0010).

Table 3. Referee conditions

Symbol	Temperature °C			Relative humidity %		Air pressure kPa
	Nominal value	Grade 1	Grade 2	Grade 1	Grade 2	
A	20	± 1	± 2	63 to 67	60 to 70	86 to 106
B	23			48 to 52	45 to 55	
C	25					
D	27			63 to 67	60 to 70	

Informative reference: The relative humidity may be neglected, if it does not influence on the results of tests and measurements.

3.4 Drying

3.4.1 Drying conditions If it is specified in the detail specification to dry resistors to be tested (specimens) before the tests or measurements, the drying shall be carried out under either of the following conditions:

- (1) **Condition A** At a temperature $55 \pm 2^\circ\text{C}$ and relative humidity 20 % or less, for 24 ± 4 h
- (2) **Condition B** At a temperature $100 \pm 5^\circ\text{C}$, for 96 ± 4 h

3.4.2 Dry storage Only when specified in this Standard or detail specifications, the dried specimens shall be stored as stated below.

The dried specimens shall be placed in a desiccator employing such appropriate desiccant as activated alumina or silica gel, stored in cool state, and then taken out of the desiccator before commencement of the specified test or measurement.

3.4.3 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Drying condition (see 3.4.1)
- (2) Application of dry storage (if necessary) (see 3.4.2)

4. Tests for appearance, construction and dimensions

4.1 Appearance and construction The tests for appearance and construction shall be carried out visually. If there is special provision, the construction shall be tested by disassembling the specimen.

4.2 Marking The test for marking shall be carried out visually. If it is necessary, the resistance to solvent shall be examined as specified in 6.17.

4.3 Dimensions The dimension test shall be carried out by means of the vernier calliper specified in JIS B 7507, or the micrometer callipers for external measurement specified in JIS B 7502.

The screw threads shall be tested with the limit gauge for metric coarse screw thread specified in JIS B 0251 or that for metric fine screw thread specified in JIS B 0252.

If there is no dispute, other measuring apparatus may be used.

4.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Internal construction (if necessary) (see 4.1)
- (2) Marking (if necessary) (see 4.2)
- (3) Resistance to solvent (if necessary) (see 4.2)
- (4) Measuring apparatus (if necessary) (see 4.3)

5. Electrical performance test

5.1 Resistance

5.1.1 Equipment The equipment for this test shall be a measuring apparatus which is reliable enough to check whether the error in resistance is within the specified tolerance for the specimen, and the change of resistance is within the change permitted for this test.

The accuracy of measuring apparatus shall, unless otherwise specified, not exceed 10 % of the said tolerance or permitted change.

In the measurement of resistance law by voltage method or of attenuation, the input impedance of measuring system shall be not less than 1 M Ω or 10 times the nominal total resistance of the specimen.

5.1.2 Preconditioning Before the measurement, the specimens shall be allowed to stand at the temperature at which measurements are to be carried out (measurement temperature), long enough to preclude dispute on the measurement results (at least 30 min unless otherwise specified).

Adequate means shall be provided to eliminate such factors which will influence the measurement of specimens as excessive draft and direct heat radiation from the sun or other heat sources, before, during and after the measurements.

5.1.3 Test

- (1) Total resistance Place the actuator at its end of termination 1 or 3, and measure the resistance between terminations 1 and 3, unless otherwise specified.
- (2) Resistance law
 - (a) Resistance method Place the actuator at specified positions and measure the resistance between terminations 1 and 2 or between terminations 2 and 3, and then calculate the percentage of the resistance so measured to the resistance between terminations 1 and 3.

- (b) Voltage method Apply a specified voltage across terminations 1 and 3, place the actuator at specified positions, measure the voltage across terminations 1 and 2 or across terminations 2 and 3, and then calculate the percentage of the voltage so measured to the voltage across terminations 1 and 3.
- (3) Residual resistance Place the actuator at the end of total electrical range on termination-1 side, and measure the resistance between terminations 1 and 2.
- Next, place the actuator at the end of total electrical range on termination-3 side, and measure the resistance between terminations 2 and 3.
- As for the residual resistance at a tap, place the actuator to a specified position, and measure the resistance between the tap termination and termination 2.
- (4) Minimum resistance (termination resistance) Operate the actuator to minimize the resistance between terminations 1 and 2 in the vicinity of the end of total electrical range on termination-1 side, and measure the value.
- Next, operate the actuator to minimize the resistance between terminations 2 and 3 in the vicinity of termination-3 side end of total electrical range, and measure the value.
- As for the minimum resistance at a tap, operate the actuator to minimize the resistance between the tap termination and termination 2, and measure the value.
- (5) Attenuation For resistors the resistance law of which is specified based on termination 1, apply a specified voltage at 1.0 ± 0.2 kHz across terminations 1 and 3, place the actuator at the end of total electrical range on termination-1 side, measure the voltage across terminations 1 and 2, and then calculate the attenuation relative to the voltage across terminations 1 and 3 (maximum attenuation).
- Next, place the actuator at the end of total electrical range on termination-3 side, measure the voltage across terminations 1 and 2, and then calculate the attenuation relative to the voltage across terminations 1 and 3 (insertion loss).
- For resistors the resistance law of which is specified based on termination 3, place the actuator at the end of total electrical range on termination-3 side, measure the voltage across terminations 2 and 3, and then calculate the attenuation relative to the voltage across terminations 1 and 3 (maximum attenuation).
- Next, place the actuator at the end of total electrical range on termination-1 side, measure the voltage across terminations 2 and 3, and then calculate the attenuation relative to the voltage across terminations 1 and 3 (insertion loss).

5.1.4 Measurement The measurements shall be carried out as prescribed in (1) to (3) below:

- (1) The duration of voltage application to the specimen shall not exceed 5 s.

- (2) The applied voltage shall be as specified in Table 4.

If there is no dispute on the decision, other voltages are allowed.

- (3) At the time of the test for the same item on the same specimen, the measurements shall be carried out by means of the same measuring apparatus at the same applied voltage. If there is no dispute on the decision, the above requirements are not necessarily fulfilled.

Table 4. Classification of applied voltage

Unit: V

Nominal total resistance or specified resistance r	Applied voltage	
	Voltage value	Tolerances %
$r < 10 \Omega$	0.1	0 – 10
$10 \Omega \leq r < 100 \Omega$	0.3	
$100 \Omega \leq r < 1 \text{ k}\Omega$	1	
$1 \text{ k}\Omega \leq r < 10 \text{ k}\Omega$	3	
$10 \text{ k}\Omega \leq r < 100 \text{ k}\Omega$	10	
$100 \text{ k}\Omega \leq r < 1 \text{ M}\Omega$	25	
$1 \text{ M}\Omega \leq r$	50	

5.1.5 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Accuracy of measuring apparatus (if necessary) (see 5.1.1)
- (2) Identification of resistance method or voltage method [see 5.1.3 (2)]
- (3) Position of actuator [see 5.1.3 (2) and (3)]

5.2 Matching of resistance law (applicable for ganged potentiometers other than precision potentiometer)

5.2.1 Equipment The equipment shall, unless otherwise specified, be the voltmeter of Grade 1.0 specified in JIS C 1102, or voltmeters at least equivalent thereto in accuracy.

The input impedance of voltage measuring system shall be not less than 1 M Ω or 10 times the nominal total resistance.

5.2.2 Preconditioning At the measurement, the specimens shall be allowed to stand at the measurement temperature long enough to preclude dispute on the measurement results (at least 30 min, unless otherwise specified).

Adequate means shall be provided to eliminate such factors which will influence the measurement of specimens as excessive draft and direct heat radiation from the sun or other heat sources before, during and after the measurements.

5.2.3 Test Place the actuator at a specified position, unless otherwise specified, apply a voltage of 2 V to 15 V (r.m.s. value of sine wave) at 1.0 ± 0.2 kHz across terminations 1 and 3 of respective resistor units, measure the voltage across terminations 1 and 2 (or terminations 2 and 3) of each resistor unit, and then calculate the matching of resistance law (G_e) from the formula given below.

A test voltage of d.c. may be used if there is no dispute on the decision.

$$G_e \text{ (dB)} = 20 \log_{10} \frac{U_2}{U_1}$$

where, G_e : matching of resistance law (dB)
 U_1 : voltage across terminations 1 and 2 (or terminations 2 and 3) of reference resistor unit (V)
 U_2 : voltage across terminations 1 and 2 (or terminations 2 and 3) of other resistor unit than reference one (V)

5.2.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Accuracy of measuring apparatus (if necessary) (see 5.2.1)
- (2) Test voltage (if necessary) (see 5.2.2)
- (3) Position of actuator (see 5.2.2)
- (4) Reference resistor unit (see 5.2.3)

5.3 Temperature characteristic of resistance and deviation of total resistance

5.3.1 Equipment Caution should be exerted to prevent condensation of moisture on the specimen in the thermostatic chamber for this test.

All the measuring equipment including the test chamber shall be provided with adequate means to minimize the errors in the measurements due to influence of resistance of connecting wires, contact resistance of points, thermoelectromotive force, etc.

5.3.2 Test Carry out the test as follows:

- (1) **Measurement** According to either of the conditions A or B of Table 5, maintain the specimen at each specified temperature in the order given in the said table, measure the total resistance in accordance with 5.1 when the specimen stabilizes each specified temperature, and record the measured value together with the temperatures.

Carry out the test at each step consecutively.

Unless otherwise specified, employ the temperature in step 4 as the reference temperature. However, only when the temperature in step 1 is employed as the reference temperature, the test may be interrupted if the interval between step 3 and step 4 is within 24 h.

Table 5. Conditions of ambient temperature

Unit: °C

Step	Condition		Remarks
	A	B	
1	$20 \begin{smallmatrix} +5 \\ -1 \end{smallmatrix}$	$20 \begin{smallmatrix} +5 \\ -1 \end{smallmatrix}$ (may be room temperature)	Applicable as the reference for lower temperature region only, if specified.
2	—	-15 ± 2	Applicable only when the characteristic is obviously nonlinear.
3	Lower category temperature ± 3	Lower category temperature ± 3	—
4	$20 \begin{smallmatrix} +5 \\ -1 \end{smallmatrix}$	$20 \begin{smallmatrix} +5 \\ -1 \end{smallmatrix}$ (may be room temperature)	The reference temperature for temperature characteristic of resistance. However, only applicable as the reference for higher temperature region, if specified.
5	—	60 ± 2	Applicable only when the characteristic is obviously nonlinear.
6	70 ± 2	100 ± 2	Applicable only for resistors having an upper category temperature of 125°C or higher.
7	Upper category temperature ± 3	Upper category temperature ± 3	—
8	70 ± 2	—	Applicable only for resistors having an upper category temperature of 125°C or higher.
9	$20 \begin{smallmatrix} +5 \\ -1 \end{smallmatrix}$	$20 \begin{smallmatrix} +5 \\ -1 \end{smallmatrix}$ (may be room temperature)	Applicable only for deviation of total resistance.

Remarks 1. Temperature stabilization means such a state that the total resistance values measured at intervals of 5 min or more show changes of equal to or smaller than the accuracy of the measuring apparatus.

2. The error in the temperature measurements shall not exceed 1°C.

(2) Calculation Calculate the temperature coefficient of resistance, resistance change rate or deviation of total resistance in accordance with either of Method 1 or Method 2 based on each resistance and temperature obtained in (1).

(2.1) Method 1

$$(a) \quad TCR = \frac{R - R_0}{R_0} \times \frac{1}{t - t_0} \times 10^6$$

$$(b) \quad RC = \frac{R - R_0}{R_0} \times 100$$

where, TCR : temperature coefficient of resistance (ppm/°C)

RC : resistance change rate (%)

R : actually measured total resistance at t °C (Ω)

R_0 : actually measured total resistance at t_0 °C (Ω)

t : actually measured test temperature (°C)

t_0 : actually measured reference temperature (°C)

.....Unless otherwise specified, the reference temperature mentioned here means that in step 4. When the temperature in step 1 is employed in addition to that in step 4, this is used as the reference temperature for steps following to step 1 in lower temperature region, and the temperature in step 4 is used as the reference temperature for steps following to step 4 in higher temperature region.

$$(c) \quad RD = \frac{R - R_0}{R_0} \times 100$$

where, RD : deviation of total resistance (%)

R : actually measured total resistance in step 9 (Ω)

R_0 : actually measured total resistance in step 1 (Ω)

(2.2) Method 2 (based on IEC 393-1)

$$(a) \quad TCR = \frac{\Delta R}{R \times \Delta t} \times 10^6$$

where, TCR : temperature coefficients of resistance (ppm/°C)

R : actually measured total resistance at reference temperature (Ω)

When actually measured total resistances in steps 1, 4 and 9 of Table 5 are denoted as R_1 , R_4 , and R_9 respectively, then —

In the case of test on low-temperature side,

$$R = \frac{1}{2}(R_1 + R_4)$$

In the case of test on high-temperature side,

$$R = \frac{1}{2}(R_4 + R_9)$$

ΔR : difference between total resistance actually measured at test temperature and that at reference temperature (Ω)

When actually measured total resistances in steps 3, 6, 7 and 8 of Table 5 are denoted as R_3 , R_6 , R_7 and R_8 respectively, then —

In the case of lower category temperature,

$$\Delta R = R_3 - R$$

In the case of upper category temperature,

$$\Delta R = R_7 - R$$

In the case of 70°C under condition A,

$$\Delta R = \frac{R_6 + R_8}{2} - R$$

Δt : difference between test temperature and reference temperature (°C)

When actually measured temperatures in steps 1 to 9 of Table 5 are denoted as t_1 to t_9 respectively, then —

In the case of lower category temperature,

$$\Delta t = t_3 - \frac{t_1 + t_4}{2}$$

In the case of upper category temperature,

$$\Delta t = t_7 - \frac{t_4 + t_9}{2}$$

In the case of 70°C under condition A,

$$\Delta t = \frac{t_6 + t_8}{2} - \frac{t_4 + t_9}{2}$$

$$(b) \quad RC = \frac{\Delta R}{R} \times 100 \quad \text{where, } RC : \text{change rate of resistance (\%)}$$

$$(c) \quad RD = \frac{R_7 - R_1}{2} \times 100 \quad \text{where, } RD : \text{deviation of total resistance (\%)}$$

5.3.3 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Reference temperature (if necessary) (see 5.3.2)
- (2) Conditions (see Table 5)
- (3) Steps to be applied or excluded according to the conditions (see Table 5)
- (4) Application of step 1 as the reference temperature for temperature characteristic of resistance (if necessary) [see 5.3.2 (2)]
- (5) Expression of temperature characteristic of resistance [see 5.3.2 (2)]
- (6) Calculation [see 5.3.2 (2)]
- (7) Position of actuator and measurement termination (if necessary) [see 5.3.2 (1)]

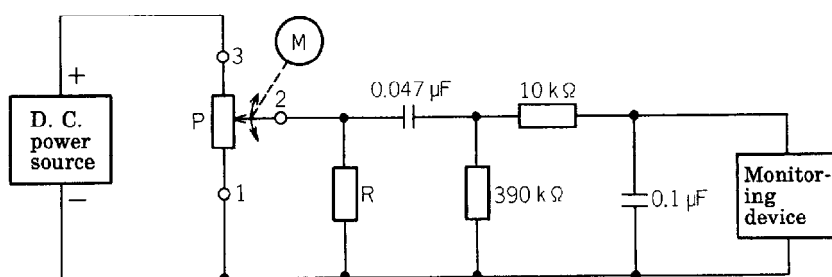
5.4 Output smoothness (applicable to non-wirewound precision potentiometer)

5.4.1 Equipment Unless otherwise specified, the equipment shall be as required below:

- (1) **Power source** A d.c. power source of 10 V or rated voltage specified in the detail specification, whichever is the lower.
- (2) **Monitoring device** The device shall be an oscilloscope or an instrument of at least equivalent in performance. The input impedance shall be not less than 1 M Ω .
- (3) **Constant speed driving device** A driving device which can rotate the actuating mechanism of specimen clockwise and counterclockwise alternately at least through the effective electrical range repeatedly and which can maintain a constant rotational speed at least through 70 % of the testing range.

5.4.2 Preparation Unless otherwise specified, the specimen shall be mounted to the constant speed driving device in normal way and wired as illustrated in the measuring circuit of Fig. 1. The load resistor for the moving contact circuit shall be a fixed resistor having a resistance equal to 100 times the nominal total resistance of the specimen, unless otherwise specified.

Fig. 1. Measuring circuit of output smoothness



Ⓜ : constant speed driving device

P : specimen

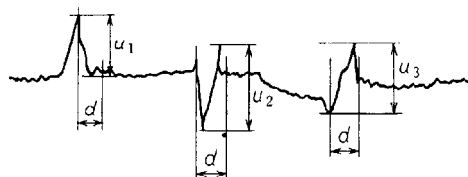
R : fixed load resistor

5.4.3 Test Rotate the actuator of specimen at a rate of 3 to 5 revolutions per minute by means of the constant speed driving device and record the change in output voltage over 70 % or more of the effective electrical range by using the monitoring device. Unless otherwise specified, the rate of sweep of the monitoring device shall be such that the rate allows the measurement of small increment equal to 1 % of the effective electrical range.

Fig. 2 shows an example of the recorded data of output smoothness.

For the correct evaluation of the test data, set the rotational speed of constant speed driving device and the rate of sweep of monitoring device adequately in advance.

Fig. 2. Example of recorded data for output smoothness



d : small increment equal to 1 % of effective electrical range

u_1, u_2, u_3 : peak values in small increment d . u_2 is the maximum voltage change when $u_1 < u_3 < u_2$.

5.4.4 Calculation Unless otherwise specified, obtain the maximum voltage change in a small increment equal to 1 % of effective electrical range from the recorded data (see Fig. 2), divide it by the total applied voltage, and express the quotient in percentage.

At the calculation, exclude the data recorded at the end, vicinity thereof and transposition point where steep change in output voltage appears.

- (1) Calculation of output smoothness Calculate the output smoothness from the following formula:

$$OS = \frac{u}{U} \times 100$$

where, OS : output smoothness (%)

u : maximum voltage change in a small increment equal to 1 % of effective electrical range (V)

U : total applied voltage (V)

- (2) Calculation formula of small increment Calculate the small increment equal to 1 % of the effective electrical range from the following formula:

$$d = \frac{\Theta_E}{100} \times \frac{1}{n \times \Theta_M} \times V_T$$

where, d : small increment on recorded data (mm)

Θ_E : effective electrical range (°)

n : number of revolutions of driving part of constant speed driving device per unit time (s⁻¹)

Θ_M : total mechanical range (°)

V_T : rate of sweep of monitoring device (mm/s)

Example of calculation

When $\Theta_E = 300^\circ$, $n = 4 \text{ rpm} = \frac{4}{60} \text{ s}^{-1}$, $\Theta_M = 360^\circ$, $V_T = 20 \text{ mm/s}$, then the small increment d is

$$d = \frac{300}{100} \times \frac{1}{\frac{4}{60} \times 360} \times 20 = 2.5$$

It shows that the small increment is 2.5 mm.

5.4.5 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Equipment (if necessary) (see 5.4.1)
- (2) Speed of rotation (if necessary) (see 5.4.1)
- (3) Mounting method (if necessary) (see 5.4.2)
- (4) Resistance of fixed load resistor (if necessary) (see 5.4.2)
- (5) Measurement range (if necessary) (see 5.4.3)
- (6) Small increment (if necessary) (see 5.4.3)

5.5 Rated load

5.5.1 Equipment For temperature measurements, the thermocouple thermometers of grade 1.0 specified in JIS C 1601 or measuring instruments at least equivalent in performance shall be used.

5.5.2 Preparation The specimen shall be mounted in still air so that it will not be influenced by heat from other sources. The mounting method, arrangement, existence or non-existence of heat sinks and dimensions of the heat sinks, if exist, shall be as specified in the detail specification.

5.5.3 Test Unless otherwise specified, apply the rated voltage across terminations 1 and 3 of the specimen, and measure the surface temperature successively until it saturates (consider as saturated when the difference in successive readings of thermometer observed at intervals of 5 min becomes within 0.5°C). If the loading duration is specified in the detail specification, carry out the loading for the specified duration and measure the temperature within 10 min with the specimen loaded.

Finally examine the specimen visually whether there is remarkable abnormality on its appearance, and whether its marking is readable or not.

Measure the total resistance in accordance with 5.1 before and after the test and calculate the variation (amount) of the total resistance, if specified in the detail specification.

Unless otherwise specified, the test voltage, measurement of ambient temperature and the measurement point on specimen shall be as follows:

- (1) Test voltage When the ambient temperature is higher than the rated ambient temperature, reduce the test voltage according to the reducing curve specified in the detail specification. However, the above reduction may be omitted if there is no dispute on the decision.
- (2) Measurement of ambient temperature Measure the ambient temperature at a point approx. 300 mm apart from the nearest part of the specimen in the same height as the specimen.
- (3) Measurement point Select a point on the surface of specimen where the temperature is the highest as the measurement point.

5.5.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Detail of mounting (see 5.5.2)
- (2) Loading duration (if necessary) (see 5.5.3)
- (3) Measurement point of ambient temperature (if necessary) [see 5.5.3 (2)]
- (4) Measurement of total resistance (if necessary) (see 5.5.3)

5.6 Insulation resistance

5.6.1 Equipment The insulation resistance tester specified in JIS C 1302 or JIS C 1303, or a high resistance bridge at least equivalent in accuracy shall be used as the equipment in this test.

5.6.2 Preparation The connection between the positions for measurement of insulation resistance and the equipment shall be made surely by means of adequate connectors to eliminate errors due to connection.

If special preparation or mounting is necessary before the test, such work shall be carried out as specified in the detail specification.

5.6.3 Test Unless otherwise specified, apply the test voltage specified in the detail specification from among those given in Table 6 to the positions prescribed in (1) to (4) given below, maintain the voltage for $1 \text{ min} \pm 5 \text{ s}$, and measure the insulation resistances with the voltage applied. If the reading of measuring apparatus stabilizes or rises further exceeding the specified insulation resistance, the decision may be made by such behavior even within the specified duration.

- (1) Between the metal parts exposed outside and the resistor terminations/switch terminations (if provided) connected together. If the actuator consists of insulating materials, wind metal foil around the part operated by a man, and carry out the test by considering this foil as the exposed metal.
- (2) Between terminations of one resistor unit and terminations of another resistor unit in a ganged resistor.
- (3) Between terminations of different polarity in a switch
- (4) Between terminations of the same pole in a switch under open state (OFF)

Table 6. Voltage for testing insulation resistance

Unit: V

Condition	Test voltage (d.c.)
A	100 ± 10
B	250 ± 25
C	500 ± 50
D	1000 ± 100
E	10 ± 1
F	50 ± 5

5.6.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Accuracy of measuring apparatus (if necessary) (see 5.6.1)
- (2) Special preparation, mounting, etc. (if necessary) (see 5.6.2)
- (3) Position of measurement (if necessary) (see 5.6.3)
- (4) Test voltage (see 5.6.3 and Table 6)
- (5) Duration of voltage application (if necessary) (see 5.6.3)

5.7 Dielectric withstand voltage (voltage proof)

5.7.1 Equipment The a.c. power source of this test equipment shall be capable of gradually raising and lowering the output voltage covering the extent from the specified test voltage (r.m.s. value at power frequency) to 0 V, and shall not cause remarkable waveform distortion or remarkable voltage fluctuation under the loading conditions of this test.

When the test voltage is 1000 V or over, the capacity of power source shall be not less than 500 VA. The voltmeter of Grade 1.5 or better specified in JIS C 1102 shall be used.

When it is necessary to check the dielectric breakdown which may occur in the specimen and when the observation of the breakdown by human eye is difficult, an adequate indicating device which can indicate generation of the dielectric breakdown discharge and the leakage current shall be provided.

5.7.2 Preparation The connection between the positions to be tested and the equipment shall be made surely by using adequate connectors. Special preparation and mounting before the test shall be as specified in the detail specification.

5.7.3 Test Unless otherwise specified, apply the test voltage specified in the detail specification from among those given in Tables 7 and 8 to the positions prescribed in (1) to (4) given below while the actuator is rotated unless otherwise specified, and examine whether such abnormalities as flashover and dielectric breakdown occur on the specimen or not.

The test voltage of Table 8 is applicable only to resistors with switch in such a case that the conditions according to rated voltage of switch is specified, where the rated voltage of switch is specified in the detail specification.

- (1) Between the metal parts exposed outside, and the resistor terminations and switch terminations (if any) connected together. If the actuator consists of insulating materials, wind metal foil around the part operated by a man, and carry out the test by considering this foil as the exposed metal.
- (2) Between terminations of one resistor unit and terminations of another resistor unit in a ganged resistor
- (3) Between terminations of different polarity in a switch
- (4) Between terminations of the same pole in a switch under open state (OFF)

Unless otherwise specified, apply the voltage starting from about 0 V, raise the voltage gradually up to the specified test voltage (in column X of Table 7 or Table 8) at a rate of about 100 V per second, maintain the voltage for $1 \text{ min} + {}^{10}_0 \text{ s}$ as it is, and then lower the voltage rapidly to about 0 V.

If there is no dispute on the decision, the test may be made by applying the appropriate voltage in column Y of Table 7 for 1 s from the beginning.

Table 7. Voltage for testing dielectric withstand voltage
(for resistors without switch and with switch)

Unit: V

Condition	Test voltage (a.c.)		Condition	Test voltage (a.c.)	
	X	Y		X	Y
A	$100 + {}^5_0$	$120 + {}^6_0$	F	$1500 + {}^{75}_0$	$1800 + {}^{90}_0$
B	$150 + {}^{7.5}_0$	$180 + {}^9_0$	G	$2000 + {}^{100}_0$	$2400 + {}^{120}_0$
C	$250 + {}^{12.5}_0$	$300 + {}^{15}_0$	H	$3000 + {}^{150}_0$	—
D	$500 + {}^{25}_0$	$600 + {}^{30}_0$	I	$4000 + {}^{200}_0$	—
E	$1000 + {}^{50}_0$	$1200 + {}^{60}_0$	J	$50 + {}^{2.5}_0$	$60 + {}^3_0$

Table 8. Voltage for testing dielectric withstand voltage
(for resistors with switch)

Unit: V

Condition	Test voltage (a.c.)	Rated voltage of switch
1	$900 + {}^{45}_0$	$UR \leq 120$
2	$(2UR + 1 \text{ kV}) + {}^{50}_0$	$120 < UR$

Remarks: Symbol UR in this Table is the rated voltage of switch.

5.7.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Tolerance of voltmeter (if necessary) (see 5.7.1)
- (2) Special preparation, mounting, etc. (if necessary) (see 5.7.2)
- (3) Position to be tested (if necessary) (see 5.7.3)
- (4) Rotation of actuator during test (if necessary) (see 5.7.3)
- (5) Test voltage (see 5.7.3 and Table 7 or Table 8)

5.8 Rotational noise

5.8.1 Equipment

- (1) **Measuring equipment** The equipment for this test shall consist of one of the measuring circuits illustrated in Fig. 3 and Figs. 5 to 7, and shall have an accuracy of 10 % or better, or the ones at least equivalent in performances.
- (2) **Constant speed driving device** The device shall be such that it is capable of rotating the actuator of specimen alternately and repeatedly through at least 80 % of the effective electrical range, the rotational speed is 4 ± 1 r.p.m. unless otherwise specified, and it can maintain a constant speed in 70 % or more of the testing range.

Fig. 3. Constant voltage method (Method A)

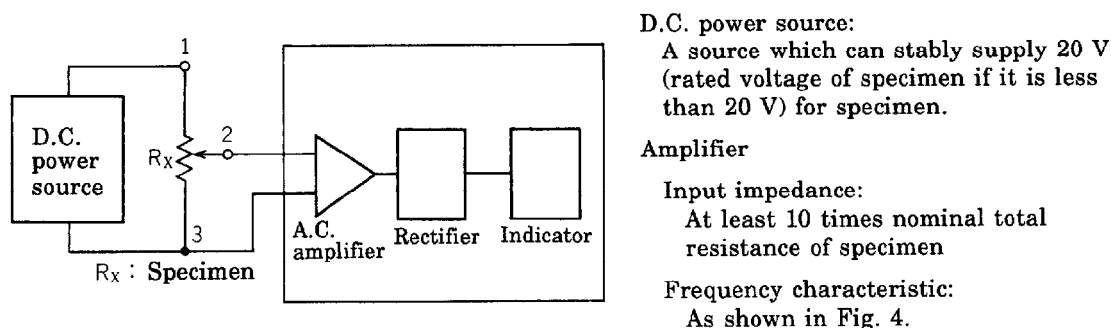


Fig. 4. Frequency characteristic of amplifier for rotational noise measuring apparatus

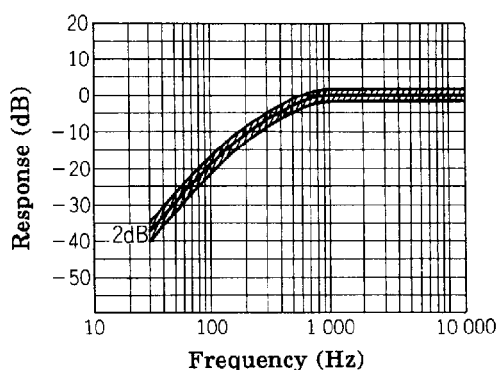
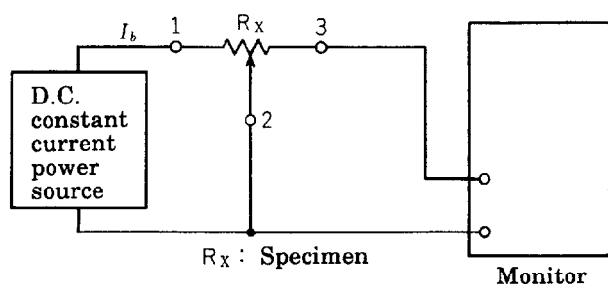


Fig. 5. Constant current method (Method B)



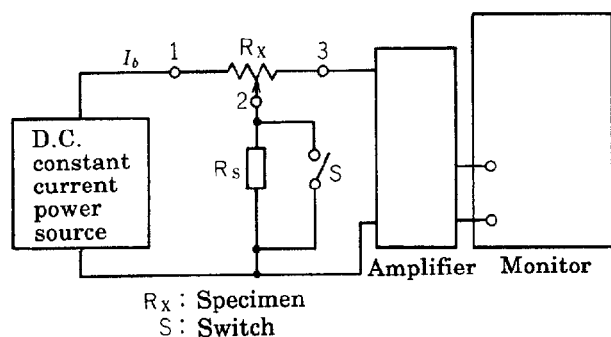
D.C. constant current power source:
a source which can stably supply test current I_b specified in detail specification.

Monitor: oscilloscope

Input impedance:
1.0 M Ω or more at 400 Hz

Frequency characteristic:
d.c. to 50 kHz

Fig. 6. Constant current method (Method C)



D.C. constant current power source:
a source which can stably supply test current I_b of Table 9, unless otherwise specified in detail specification.

Amplifier

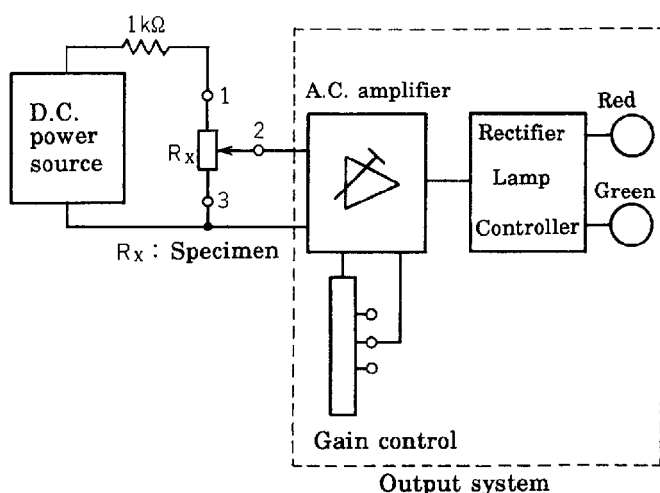
Frequency characteristic:
100 Hz to 50 kHz

Input impedance:
at least 10 times nominal total resistance of specimen

Monitor: oscilloscope

R_s : a calibration resistor equal to equivalent noise resistance specified in detail specification. The calibration is carried out by opening and closing switch S, with termination 2 of R_s positioned at termination 1 side.

Fig. 7. Constant voltage method (Method D)



D.C. power source:

a source which can stably supply voltage to specimen

Output system:
a system with input impedance not less than 10 times nominal total resistance of specimen

Frequency characteristic:
(assuming 0 dB at 1 kHz)
- 6 dB at 60 Hz and 20 kHz
- 20 dB at 20 Hz and 45 kHz
- 30 dB or less at 80 Hz or over

Gain control:

a control which can be so adjusted that red lamp operates when measured noise exceeds the criterion value specified in detail specification

5.8.2 Test Rotate the actuator over the specified operating range at the specified speed, and measure the noise voltage produced in the above operation in accordance with either of a Method A, B, C or D specified in the detail specification. In Methods B and C, however, express the noise in the resistance value (called equivalent noise resistance) obtained by dividing the noise voltage by test current (I_b).

In Method C, the resistance value is sometimes expressed in percentage of total resistance value.

- (1) **Method A** Connect the specimen to the measuring circuit illustrated in Fig. 3, apply a d.c. voltage of 20 V (rated voltage of the resistor if it is less than 20 V) across terminations 1 and 3, and then carry out the test.
- (2) **Method B** Connect the specimen to the measuring circuit illustrated in Fig. 5, pass the constant d.c. current specified in detail specification through terminations 1 and 2, and then carry out the test.
- (3) **Method C** Connect the specimen to the measuring circuit illustrated in Fig. 6, pass the constant d.c. current specified in Table 9 through terminations 1 and 2 unless otherwise specified in the detail specification, and then carry out the test. When calibration is made, carry it out with the moving contact of specimen positioned at the end of termination-1 side.

Table 9. Test current

Unit: mA	
Nominal total resistance (r)	Test current I_b
$r < 100 \Omega$	50
$100 \Omega \leq r < 1 \text{ k}\Omega$	10
$1 \text{ k}\Omega \leq r < 10 \text{ k}\Omega$	1
$10 \text{ k}\Omega \leq r < 100 \text{ k}\Omega$	0.1
$100 \text{ k}\Omega \leq r < 2 \text{ M}\Omega$	0.05
$2 \text{ M}\Omega \leq r$	0.01

- (4) **Method D** Connect the specimen to the measuring circuit illustrated in Fig. 7, apply a d.c. voltage of 20 V across terminations 1 and 3, and then rotate the actuator over the total mechanical range excluding the switch, at a rate of 10 cycles to 17 cycles per min, for testing.

5.8.3 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Test method (see 5.8.2)
- (2) Rotating rate of actuator at measurement (if necessary) (see 5.8.2)
- (3) Operating range of actuator at noise measurement (see 5.8.2)
- (4) Test current (see 5.8.2 methods B and C)

5.9 Concentration and contact resistance

5.9.1 Equipment In addition to the appropriate test chamber, the device for measuring resistance shall be the measuring apparatus specified in 5.1.1 or that at least equivalent in performances.

5.9.2 Test Carry out the test by either of the Method A or B stated below as specified in the detail specification.

Fix the actuator so that the moving contact will not move during the test.

- (1) **Method A (resistance method)** Place the moving contact at a point so that the resistance between terminations 1 and 2 is almost $\frac{1}{2}$ of the resistance between terminations 1 and 3, measure the resistances between terminations 1 and 2, between terminations 2 and 3, and between terminations 1 and 3, and then calculate the concentration and contact resistance [CR (%)] from the following formula:

$$CR = \frac{(R_{12} + R_{23}) - R_{13}}{2R_{13}} \times 100$$

where, R_{12} : resistance between terminations 1 and 2 (Ω)
 R_{23} : resistance between terminations 2 and 3 (Ω)
 R_{13} : resistance between terminations 1 and 3 (Ω)

Next, maintain the specimen at the temperature specified in the detail specification for 350 ± 12 h, take it out in air at room temperature, measure the resistance again after about 1 h, and calculate the concentration and contact resistance by means of the above formula.

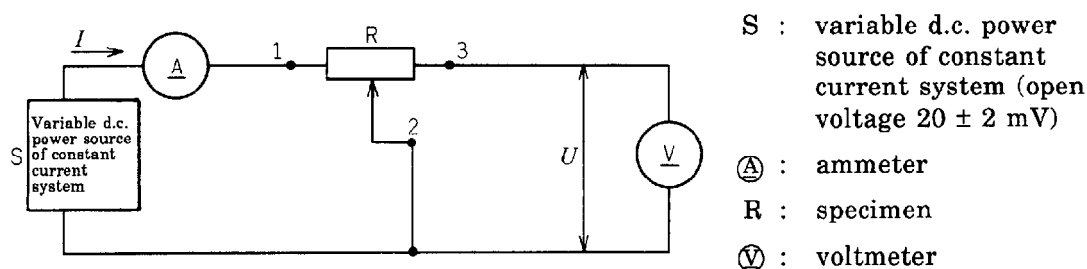
- (2) **Method B (low voltage method)** Place the moving contact at a position within 40 % to 60 % of the effective electrical range, measure the voltage (U) and current (I) in the measuring circuit illustrated in Fig. 8, and calculate the resistance by dividing the voltage (U) by the current (I).

When current result is not available in the measurement at very low voltage ($U < 3$ mV) due to thermoelectromotive force of the specimen, reverse the polarity of the power supply, adjust the current to the same value and repeat the measurement.

In this procedure, calculate the contact resistance by dividing the arithmetical average of the absolute values of measured voltages by the absolute value of the current.

If there is no influence on the test results (example: excluding such a case that a wirewound resistor has autotransformer action), a.c. voltage of 20 mV peak value may be used instead of the a.c. power source. Use the d.c. voltage method, if any doubt arises.

Fig. 8. Measuring circuit for method B



5.9.3 Items to be specified in detail specification

The following items shall be specified in detail specifications:

- (1) Test method (see 5.9.2)
- (2) Applicable range of total resistance (if necessary)
- (3) Applicable resistance variation characteristic (if necessary)
- (4) Test temperature (if necessary) (see 5.9.2)

5.10 Contact resistance of switch (see JIS C 5441)

5.10.1 Equipment The equipment for this test shall consist of the measuring circuit illustrated in Fig. 9 or Fig. 10, and shall have an accuracy of 10 % or better. The measuring device of resistance shall have at least equivalent performances to the device specified in 5.1.1.

Fig. 9. Measuring circuit for contact resistance of switch (by d.c.)

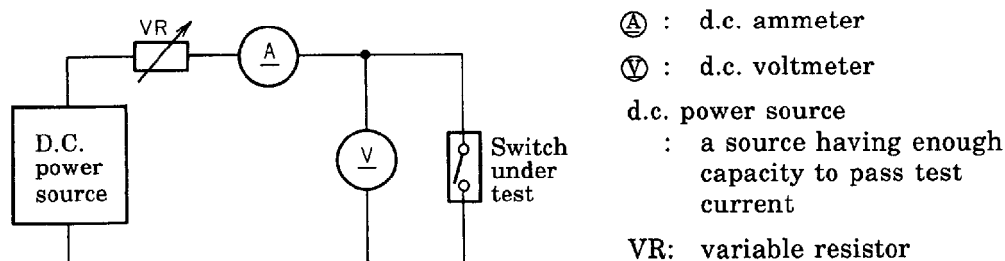
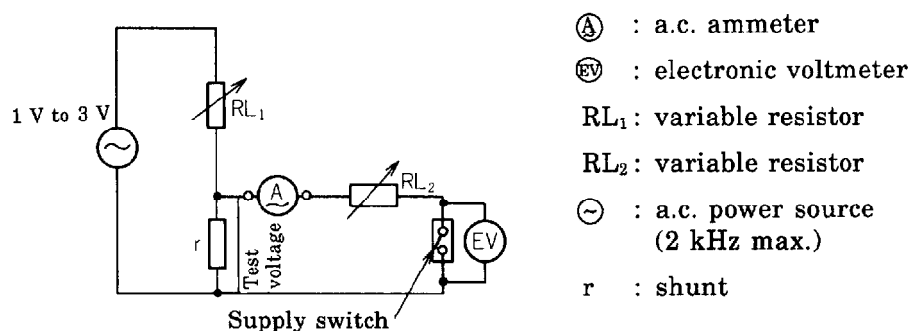
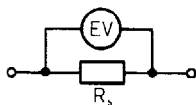


Fig. 10. Low-voltage and low-current method (by a.c.)



Remarks: When there is some trouble in the measurement due to high internal resistance of a.c. ammeter, replace the ammeter with the circuit shown below:



EV : electronic voltmeter

R_s : standard resistor (non-inductive)

5.10.2 Preparation The connection between the switch under test and the equipment shall be made surely by means of adequate connectors to eliminate errors in the measurements.

If cleaning of contacts, other special preparation or mounting before the test is necessary, such work shall be carried out as specified in the detail specification.

5.10.3 Test Employ the portion of the switch under test to which external wiring is connected at the point of measurement, and carry out the test in accordance with either of Method A or Method B stated below as specified in the detail specification.

If several measurements are necessary on one point, carry out the test as specified in the detail specification.

- (1) **Method A (by d.c.)** The test voltage shall be 1 V to 6 V and the test current shall have the value specified in the detail specification. Carry out the test in the sequence of (a) to (c). If specified in the detail specification, carry out the measurement with the direction of test current reversed. The measuring circuit shall be as shown in Fig. 9.
 - (a) Close the contacts under test (ON).
 - (b) Pass the test current through the contacts under test and measure the voltage drop across the contacts under test.
 - (c) Calculate the contact resistance from the measured voltage drop.
- (2) **Method B (by a.c.)** The test voltage shall be 20 mV (a.c. peak value) in open circuit at the maximum, the test frequency shall be 1.0 ± 0.2 kHz and the test current shall be not more than 1 A or be as specified in the detail specification. Carry out the test in the sequence of (a) to (c). The measuring circuit shall be as shown in Fig. 10.
 - (a) Close the contacts under test (ON).
 - (b) Pass the test current through the contacts under test and measure the voltage drop across the contacts under test.
 - (c) Calculate the contact resistance from the measured voltage drop.

5.10.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Measuring device (including measuring circuit) and accuracy (if necessary) (see 5.10.1)
- (2) Special preparation or mounting (see 5.10.2)
- (3) Test method (see 5.10.3)

- (4) Test current (see 5.10.3)
- (5) Test voltage (see 5.10.3)
- (6) Point of measurement (if necessary) (see 5.10.3)
- (7) Number of measurements (if necessary) (see 5.10.3)
- (8) Power source voltage for test (if necessary) [see 5.10.3 (1) and (2)]
- (9) Test frequency [see 5.10.3 (2)]
- (10) Change-over of direction of test current (if necessary) (see 5.10.3)
- (11) Maximum test voltage at open circuit (if necessary) [see 5.10.3 (2)]

5.11 Temperature rise of contact (see JIS C 5441)

5.11.1 Equipment The thermocouple of material composition T, grade 0.75 and element wire diameter 0.32 mm specified in JIS C 1602 shall be used. The reference junction shall be ice point type reference junction, thermostat type reference junction or compensation type reference junction. In addition to the above the moving coil voltmeter of Grade 0.5 specified in JIS C 1102 or a voltmeter at least equivalent thereto shall be used.

5.11.2 Preparation The switch under test shall be mounted in still air so as to prevent influence of heat from others, and unless otherwise specified, the thermocouple shall be fixed to the part of termination of contact of the switch under test that is outside and nearest to the enclosure by soldering or other methods.

The wire used for connection of the switch under test shall be as specified in 4. (4) of JIS C 8306, unless otherwise specified. If there is no dispute, the length of wire shall be 500 mm or more. The diameter of conductor may follow the detail specification.

5.11.3 Test Unless otherwise specified, pass the rated current through the switch under test, measure the values of temperature rise (difference between temperature of measurement point and ambient temperature) until there is no difference of 5°C or higher in the temperature successively measured three times at intervals of about 10 min. Measure the ambient temperature at a point about 300 mm apart from the nearest part of the switch under test.

5.11.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Kind and thickness of thermocouple (if necessary) (see 5.11.1)
- (2) Contact point and contact method with thermocouple (if necessary) (see 5.11.2)
- (3) Conductor diameter of wire (if necessary) (see 5.11.2)
- (4) Test current (if necessary) (see 5.11.3)

5.12 Microlinearity (applicable to precision potentiometer)

5.12.1 Equipment Unless otherwise specified, the equipment to be used in this test shall comply with the following requirements:

- (1) Master unit A precision potentiometer of analog output or the digital master unit shown in Annex 1 Fig. 1 shall be used as the master unit. Unless otherwise specified, the accuracy shall not exceed 10 % of the allowable error for the measuring system.
- (2) Amplifier The amplifier shall be a differential one.
- (3) Filter The filter shall be a band-pass filter which passes all frequencies from the lower cut-off frequency to 100 times thereof.

The lower cut-off frequency shall be calculated from the following formula:

$$f_c = \frac{m}{i \times t_R}$$

where, f_c : lower cut-off frequency (Hz)
 i : small increment (mm)
 m : effective electrical range (mm)
 t_R : time for traverse of effective electrical range (s)

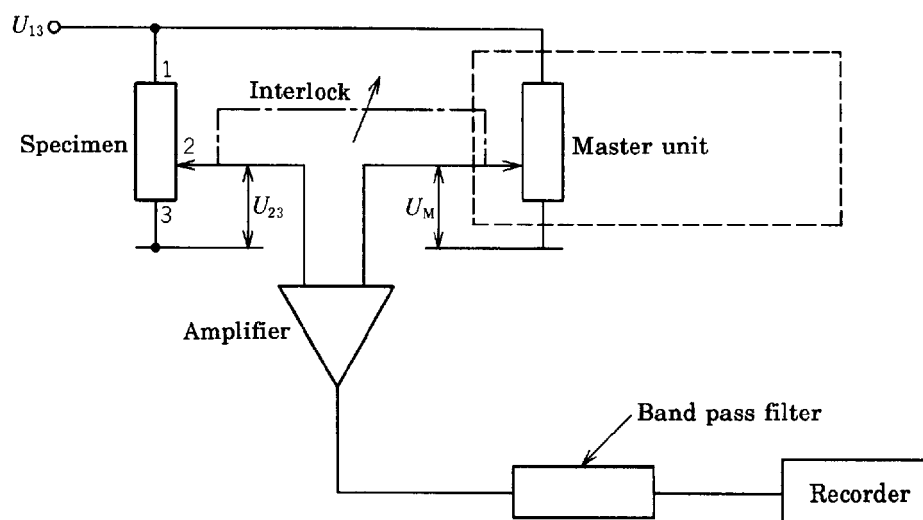
- (4) Recorder The recorder shall provide the following conditions:
 - (a) The frequency characteristic shall be flat so that it shows not more than 3 dB in difference from d.c. to at least 100 Hz.
 - (b) The drift of recorder shall not exceed 1 %/h.
 - (c) The stability of zero reference line of amplifier shall not exceed 1 %/h.

The input impedance of voltage measuring system shall be not less than 10 times the nominal total resistance.
- (5) Constant speed driving device [see 5.4.1 (3)]

5.12.2 Preparation The specimen shall be mounted to the constant speed driving device and connected to the circuit of Fig. 11.

The maximum loading current of moving contact shall be 1 μ A.

Fig. 11. Measuring circuit of microlinearity

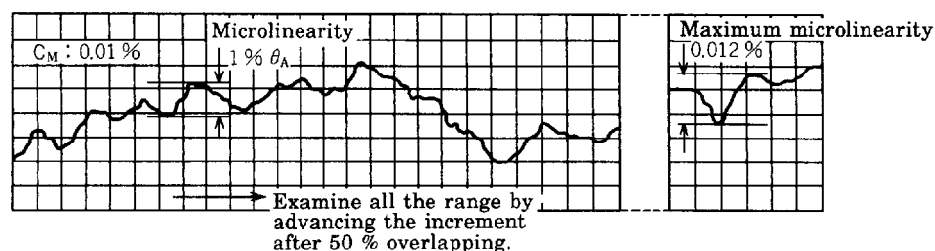


U_{13} : total applied voltage (V)

U_{23} : output voltage of specimen (V)

U_M : output voltage of master unit (V)

Fig. 12. Example of recorded data of microlinearity



$1 \% \theta_A$: 1 % of effective electrical range

5.12.3 Test Unless otherwise specified, rotate the actuator of specimen at a rate of 3 to 5 revolutions per minute by the constant speed driving device. Unless otherwise specified, record the change in linearity by using a recorder covering all the effective electrical range of specimen.

Calculate the microlinearity in such a manner that the recorded data are examined, unless otherwise specified, on a small increment equal to 1 % of the effective electrical range, with an overlap of at least 50 %, covering all the actuating range to find out the part where the maximum change occurs and then the maximum voltage change is divided by the total applied voltage.

An example of recorded data for microlinearity is shown in Fig. 12.

The calculation method of small increment shall be as specified in the test method of output smoothness stated in 5.4.

5.12.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Accuracy of master unit (if necessary) [see 5.12.1 (1)]

- (2) Rotational speed of constant speed driving device (if necessary) (see 5.12.3)
- (3) Measurement range (if necessary) (see 5.12.3)
- (4) Size of small increment (if necessary) (see 5.12.3)

5.13 Linearity (applicable to precision potentiometer)

5.13.1 Independent linearity (applicable to wire-wound type)

5.13.1.1 Equipment The equipment for this test shall be as follows:

- (1) Functional accuracy testing device The functional accuracy testing device shall consist of movable range measuring device and precision master potentiometer as shown in Fig. 13 and shall comply with the following requirements:
 - (a) Unless otherwise specified, the master potentiometer shall have at least such a performance that the accuracy of the total device can be maintained at a value not exceeding 10 % of the accuracy of the function under test, or at least equivalent in performance.
 - (b) The movable range measuring device shall be capable of rotating the actuator of master potentiometer and the actuator of specimen at constant speed simultaneously and shall not cause error due to misalignment of both actuators.
 - (c) Unless otherwise specified, the speed and direction of driving during the measurement shall be such that the device is capable of rotating the actuator clockwise at a rate of 1 ± 0.1 revolution per minute in the case of rotary type.

In the case of sliding type and linear travelling shaft type, the device shall be capable of moving the actuator in the direction of increasing output at a rate of 2.5 ± 0.25 mm/min.

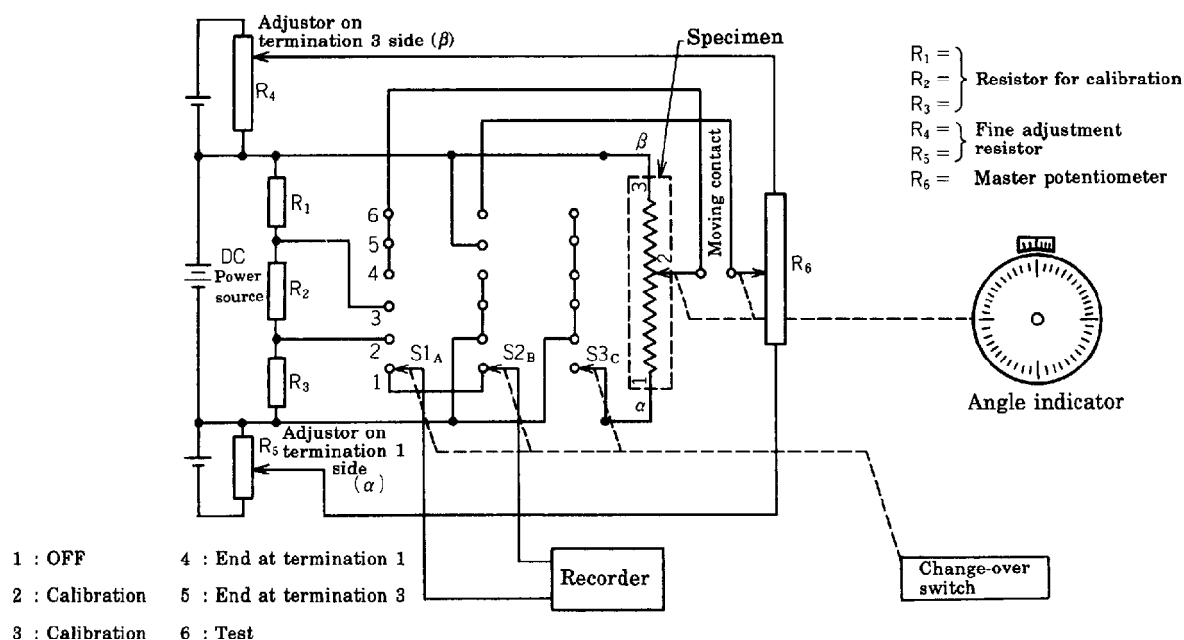
- (2) Power source As specified in 5.4.1 (1).
- (3) Recorder As specified in 5.12.1 (4).

5.13.1.2 Preparation The preparation shall be carried out in the following procedures:

- (1) Connect the specimen electrically with the functioned accuracy testing device of Fig. 13.
- (2) Set the change-over switch to position 1 and adjust the indication of recorder so that zero is indicated at the center of recorder chart.
- (3) Set the change-over switch to either of position 2 or 3, and adjust the amplification of recorder so that desired sensitivity can be obtained.
- (4) Set the change-over switch to position 4, and find out almost end of termination 1 by rotating the actuator of specimen (when moving contact comes to the end of termination 1, the recorder shows zero).
- (5) Set the angle indicator of function accuracy testing device to almost zero and mount the specimen to the device (also fix the actuator of specimen).

- (6) Find out the correct position of termination 1 of specimen by means of the angle indicator of function accuracy testing device, read the scale of indicator at that time and record it.
- (7) Set the change-over switch to position 6, and adjust the adjustor (α) on termination-1 side so that the indication of recorder becomes zero.
- (8) Set the change-over switch to position 5, find out correct position of termination 3 by rotating the angle indicator, read the scale of angle indicator at that time and record it (when the moving contact comes to the end of termination 3, the recorder shows zero).
- (9) Set the change-over switch to position 6, and adjust the adjustor (β) on termination 3 side so that the indication of recorder becomes zero.
- (10) The adjustment of balance at the ends of terminations 1 and 3 has mutual action, therefore repeat the procedures of (7) to (9) several times so that the indication of recorder becomes zero at both ends.

Fig. 13. Functional accuracy testing device

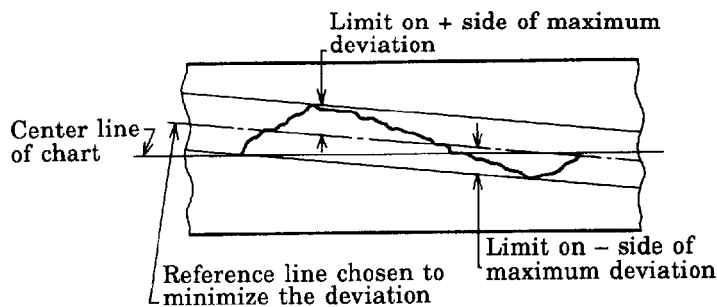


5.13.1.3 Test

Carry out the test by the following procedures:

- (1) Set the change-over switch to position 6, and rotate the angle indicator to end of α .
- (2) Operate the recorder, rotate the device along the specified direction at uniform speed over the total area of effective electrical range, and let the recorder record the deviation from linearity.
- (3) Draw a straight line on the chart so that the maximum positive and negative deviations from the straight line are minimized regardless to the position or the slope, as shown by the allowable limits in Fig. 14, and then determine the independent linearity.

Fig. 14. Allowable limits



5.13.1.4 Items to be specified in detail specification The following items shall be specified in detail specifications:

- (1) Test method for independent linearity (if necessary) (see 5.13.1)
- (2) Accuracy of testing device (if necessary) (see 5.13.1.1)
- (3) Speed during measurement (if necessary) [see 5.13.1.1 (c)]
- (4) Test method (if necessary) (see 5.13.1.3)

5.13.2 Independent linearity (applicable to non-wirewound type)

5.13.2.1 Equipment The equipment for this test shall be as follows:

- (1) Power source As specified in 5.4.1 (2).
- (2) Functional accuracy testing device As specified in 5.13.1.1 (1).
- (3) Recorder As specified in 5.12.1 (4).
- (4) Output voltage ratio measuring device Unless otherwise specified, either of the following devices shall be used.
 - (a) Decayed voltage divider
 - (b) Digital ratio meter

5.13.2.2 Preparation Preparation shall be made in the following procedures.

- (1) Rotate the angle indicator of functional accuracy testing device, so as the indicator shows the angle of index point.
- (2) Rotate the actuator of specimen so that the output voltage ratio measuring device shows the prescribed output voltage ratio at index point.
- (3) Mount the specimen to the functional accuracy testing device (also fix the actuator of specimen).
- (4) Confirm that the output of specimen shows the output voltage ratio of index point, and then connect the above assembly electrically with the functional accuracy testing device of Fig. 13.
- (5) Set the change-over switch to position 1, and carry out the adjustment so that the recorder indicates zero at the center of its chart.