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**Direct acting indicating analogue
electrical measuring instruments
and their accessories
Part 9 : Recommended test
methods**

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This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. By this establishment **JIS C 1102 : 1981** is withdrawn and replaced by this Standard.

Constitution of Standard

JIS C 1102 consists of the following nine parts under the common title *Direct acting indicating analogue electrical measuring instruments and their accessories*.

- Part 1 : *Definitions and general requirements common to all parts*
- Part 2 : *Special requirements for ammeters and voltmeters*
- Part 3 : *Special requirements for wattmeters and varmeters*
- Part 4 : *Special requirements for frequency meters*
- Part 5 : *Special requirements for phase meters, power factor meters and synchrosopes*
- Part 6 : *Special requirements for ohmmeters (impedance meters) and conductance meters*
- Part 7 : *Special requirements for multi-function instruments*
- Part 8 : *Special requirements for accessories*
- Part 9 : *Recommended test methods*

The requirements are not included in **JIS C 1102-9**. The requirements are specified in **JIS C 1102-1** to **C 1102-8** and the reference to each test item of **JIS C 1102-9** is also shown in the said Standard.

For the test items stated below among the test items in **JIS C 1102-9** the corresponding requirements are not specified in **JIS C 1102-1** to **C 1102-8**. These performances are normally agreed between the manufacturer and the user, but the items are included in **JIS C 1102-9** for standardization of test methods.

Tracking error

Variation due to simultaneous influence of voltage and power factor

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Direct acting indicating analogue electrical measuring instruments and their accessories

Part 9 : Recommended test methods

Introduction This Japanese Industrial Standard has been prepared based on IEC 51-9, *Direct acting indicating analogue electrical measuring instruments and their accessories Part 9 : Recommended test methods*, published in 1988 as the fourth edition, Amendment 1 (1994) and Amendment 2 (1995) without modification of technical contents.

Standards of JIS C 1102-2 to JIS C 1102-8 are referred to as "detail specifications" in this Standard.

1 Scope and general test conditions

1.1 Scope

This Standard contains recommended test methods for direct acting indicating analogue electrical measuring instruments and their accessories.

1.2 General test conditions

The test methods described in this Standard shall be applied under the following conditions unless otherwise specified.

1.2.1 Reference conditions

Reference conditions shall be according to Table I of JIS C 1102-1 to -8. Where a reference range is specified, tests shall be performed at both limits of the reference range.

1.2.2 Parallax

Note : Care should be taken to avoid the effect of parallax error when taking instrument readings.

For an edgewise instrument, the line of vision should be perpendicular to the instrument dial at the index tip.

For an instrument having a mirror scale, the line of vision should be such that the index tip is coincident with its reflection in the mirror.

1.2.3 Tapping

Immediately prior to taking a reading, either the instrument or its support shall be tapped lightly as with a finger or the eraser end of a pencil.

However, tapping is not permitted in certain tests such as those for determining intrinsic error, return to zero and the effects of shock and vibration, as stated in these test methods.

1.2.4 Thermal stability

All instruments shall be allowed to remain at the reference temperature long enough to eliminate temperature gradients.

Note : Two hours will usually be sufficient.

1.2.5 Preconditioning time

See Sub-clause 3.3.1 of JIS C 1102-1.

1.2.6 Zero adjustment (mechanical)

With the instrument disconnected from all supplies and before each set of readings is taken, the index shall be set on the zero scale mark or to an appropriate reference mark on the scale using the mechanical zero adjuster, as follows:

- 1) Operate the zero adjuster in a direction which will drive the index toward the zero mark of the instrument.
- 2) While continuing to drive the index in the direction selected in 1), set the index on the zero mark while tapping the instrument case. Once the direction of drive has been selected, do not change it until the index is on the zero mark.
- 3) With the index set on the zero mark, reverse the direction of motion of the zero adjuster, and drive it far enough to introduce mechanical freedom (play) in the zero adjuster, but not far enough to disturb the position of the index.

Exception : Instruments without zero adjuster or where the mechanical zero does not appear on scale shall not be reset.

1.2.7 Zero adjustment (electrical)

Before each set of readings, the index shall be set on the reference mark with the electrical zero adjuster. Refer to the manufacturer's instructions for details of this adjustment.

1.2.8 Test equipment errors

All tests shall be made using reference instruments having an intrinsic error no more than one-fourth of that corresponding to the accuracy class of the instrument under test. However, the use of reference instruments having an intrinsic error no more than one-tenth of that corresponding to the accuracy class of the instrument under test is strongly recommended.

When testing for variations avoid, if possible, applying the influence quantity (e.g. temperature) to the reference instrument. Otherwise, ensure that the reference instrument is not affected by more than one-fourth of the permissible variation of the instrument under test, where both are subjected to the same influence quantity (e.g. change of frequency).

Manufacturers shall make allowance for reference instrument uncertainty to ensure that all instruments are within their error limits at the time of shipment. In contrast, a user shall add the errors of his reference instrument to the permitted error when rechecking an instrument and the resulting sum shall be used for the limit for that test.

Nothing in these recommendations is intended to prevent the use of special test methods and/or specialized test equipment for making testing simpler and/or more accurate.

1.2.9 Reading methods

Whenever possible, tests shall be conducted by setting the instrument under test to a scale mark and reading the reference instrument.

Note : The reference instrument should have an adequate scale resolution (or number of digits) to enable readings to be taken with a resolution at least as good as that corresponding to one-fifth of the accuracy class of the instrument under test.

1.2.10 Polyphase testing

Polyphase instruments may be tested by connecting to an appropriate polyphase supply with properly measured and controlled voltages, currents and phase angles.

If single-phase testing of polyphase instruments is permitted by the manufacturer, the current coils may be connected in series and the voltage coils in parallel. In all cases, follow the manufacturer's instructions for details of connections and the application of calibration constants.

1.2.11 A.C. instrument testing on d.c.

Some a.c. instruments, for example electrodynamic, thermal or electrostatic instruments, may be tested on d.c. if permitted by the manufacturer. If this is the case, perform the tests as specified for the instrument but use a d.c. supply and neglect references to power factor and phase angle. For these cases, the errors are computed from the average of the results from testing with the reversal of polarity of each measuring circuit. Other tests relating to a.c. variations may not apply.

1.2.12 Multirange and multifunction instruments

All ranges and all functions shall be tested separately. Instruments with multiple supply voltage capability shall be tested separately on each supply connection.

1.2.13 Test leads

If test leads are specified by the manufacturer they shall be used for these tests. Otherwise, the size and placement of leads used in the performance of these tests shall be such that they do not influence the test results.

1.2.14 Ohmmeter testing

For high value test resistors, the insulation of the test leads shall be adequate to ensure that the test resistor is not shunted to cause errors greater than one-tenth of the rated intrinsic error of the ohmmeter.

For low value resistors, the total resistance of the test leads shall be allowed for unless it is negligible in comparison with the value of the test resistor.

Ohmmeters having special leads terminating in spikes may need special test resistors having terminals capable of accepting the spikes.

Ohmmeters measuring the values of 4-terminal resistors may need special test resistors.

Care shall be taken when testing high voltage ohmmeters that the voltage rating of the test resistor is not exceeded. This is necessary both because of the danger of insulation breakdown and because of the possibility of the test resistor having a significant voltage coefficient.

If an ohmmeter has a stated value of test voltage when measuring a stated value of test resistance (or an open circuit), the voltage should be measured using a voltmeter having a permissible error not exceeding 1 % of the test voltage. Where the voltage is to be measured at a definite value of test resistance, the voltmeter may be shunted to obtain this value. An electrostatic voltmeter, when shown to be adequately free from leakage, will be suitable for carrying out the open circuit voltage test.

Note : An electronic d.c. voltmeter may be used but care should be taken to avoid the effects of input offset voltage and current.

Care shall be taken that the test resistor will not be damaged by the current supplied by the ohmmeter.

When an ohmmeter has a hand-driven generator, it should be turned, as nearly as possible, at a uniform speed and at the speed stated by the manufacturer. If a slipping clutch is provided, the turning speed should be about 10 % higher than the clutch slipping speed.

2 Intrinsic error tests

2.1 Ammeters and voltmeters

2.1.1 Procedure

- 1) If relevant, set zero with tapping.
- 2) Apply sufficient slowly increasing excitation to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of excitation (B_R) as shown by the reference instrument.
- 3) Increase the excitation to 120 % of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less. Immediately and slowly reduce the excitation to bring the index sequentially to the same scale marks (B_X) as in step 2) without tapping. Record the values of excitation (B_R) as shown by the reference instrument.

Note : For instruments in which the zero is displaced within the scale, these tests should be performed on both sides of the zero scale mark as appropriate.

2.1.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.2 Wattmeters and varmeters

2.2.1 Procedure

- 1) If relevant, set zero with tapping.
- 2) Energize the voltage circuits at rated voltage within $\pm 2\%$.
- 3) Apply sufficient slowly increasing current to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of excitation (B_R) as shown by the reference instrument.
- 4) Increase the current to 120 % of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less. Immediately and slowly reduce the current to bring the index sequentially to the same scale marks (B_X) as in step 3) without tapping. Record the values of excitation (B_R) as shown by the reference instrument.

Note : For instruments in which the zero is displaced within the scale, these tests should be performed on both sides of the zero scale mark as appropriate.

2.2.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.3 Frequency meters (pointer type)

2.3.1 Procedure

- 1) If relevant, set zero with tapping.
- 2) Apply rated voltage or a voltage at one of the limits of the reference range at a low frequency and slowly increase the frequency to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of frequency (B_R) as shown by the reference instrument.
- 3) Increase the frequency to 120 % of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less. Immediately and slowly reduce the frequency to bring the index sequentially to the same scale marks (B_X) as in step 2) without tapping. Record the values of frequency (B_R) as shown by the reference instrument.

2.3.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.4 Frequency meters (vibrating reed type)

2.4.1 Procedure

- 1) Apply rated voltage or a voltage at one of the limits of the reference range at the frequency required to bring the reed with the highest rating in that row (B_X) to resonate at its greatest amplitude and record the value of the frequency (B_R) as shown by the reference instrument.
- 2) Decrease the frequency to bring the reed with the next highest rating in that row (B_X) to resonate at its greatest amplitude and record the value of the frequency (B_R) as shown by the reference instrument.
- 3) Repeat step 2) for each reed.
- 4) Repeat steps 1), 2) and 3) for each row if there is more than one row.

2.4.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each reed as follows:

$$\left(\frac{B_X - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.5 Phasemeters

2.5.1 Procedure

- 1) If relevant, set zero with tapping.
- 2) Connect one of the measuring circuits to a source complying with the requirements of Table I-1 of **JIS C 1102-1** and Table I-5 of **JIS C 1102-5**. Connect the other measuring circuit to a separate source. Both sources shall be set to the same frequency. The phase angle between the sources shall be adjustable and known.
- 3) Slowly adjust the phase difference between the two sources to zero and note the indication.
- 4) Carefully and slowly increase the phase difference to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of phase difference (B_R) as shown by the reference instrument.
- 5) Increase the phase difference to 120 % of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less, but only to the value corresponding to the upper

limit of the measuring ranges for instruments which cannot indicate beyond such limit. Immediately and slowly reduce the phase difference to bring the index sequentially to the same scale marks as in step 4) without tapping. Record the values of phase difference (B_R) as shown by the reference instrument.

For phasemeters capable of continuous 360° rotation, step 4) shall be conducted in a clockwise direction and shall then be repeated in a counterclockwise direction. Step 5) shall be omitted.

2.5.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.6 Power factor meters

2.6.1 Procedure

- 1) If relevant, set zero with tapping.
- 2) Connect the voltage circuit to a voltage source complying with the requirements of Table I-1 of **JIS C 1102-1** and Table I-5 of **JIS C 1102-5**. Connect the current circuit to a separate source of current. Both sources shall be set to the same frequency. The phase angle between the sources shall be adjustable and known.
- 3) Apply 100 % of rated current to the current circuit.
- 4) Carefully and slowly increase the phase difference to bring the index sequentially to at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range, without tapping. Record the values of power factor (B_R) as shown by the reference instrument.
- 5) Increase the phase difference to 120 % of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less, but only to the value corresponding to the upper limit of the measuring ranges for instruments which cannot indicate beyond such limit. Immediately and slowly reduce the phase difference to bring the index sequentially to the same scale marks as in step 4) without tapping. Record the values of phase difference (B_R) as shown by the reference instrument.
- 6) Repeat the test using 40 % of rated current in the current circuit.

For power factor meters capable of continuous 360° rotation, step 4) shall be conducted in a clockwise direction and then shall be repeated in a counterclockwise direction. Step 5) shall be omitted.

2.6.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.7 Synchrosopes

2.7.1 Procedure

- 1) Connect both the incoming and the running circuits to separate voltage sources equal to the rated voltages for the instrument at rated frequency.
- 2) Adjust the phase difference between the incoming and running circuits to bring the index to the synchronizing mark. Record the phase difference (B_D) as shown by the reference instrument.

Note : The “incoming circuit” is that circuit which, in use, is normally connected to a source whose phase relative to another circuit, “the running circuit”, is to be adjusted so as to enable them to be synchronized.

2.7.2 Computation

The intrinsic error, expressed as a percentage, shall be computed as follows:

$$\left(\frac{B_D}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.8 Ohmmeters

2.8.1 Procedure

- 1) The condition of the battery(ies), if any, shall be in accordance with the manufacturer's statements.
- 2) If relevant, set mechanical zero with tapping.
- 3) Carry out any preliminary adjustments that are specified by the manufacturer.
- 4) Determine the error of the ohmmeter by connecting it sequentially to known values of a test resistor. The uncertainty in the knowledge of the values of the test resistor should be preferably one-tenth or less of the permissible error of the ohmmeter at that value.

Where possible, use an adjustable resistor (for example, a multi-decade resistance box) as the test resistor and adjust it to bring the index sequentially to each of the numbered scale marks (B_X) without tapping. Record the values of the test resistor (B_R).

2.8.2 Computation

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_x - B_R}{A_F} \right) \times 100$$

where A_F is the fiducial value

2.9 Interchangeable shunts

2.9.1 Procedure

- 1) Connect high current leads to the shunt of a size suitable for the rated current using the connection method intended by the manufacturer. If the shunt is intended for installation in a busbar, the test installation shall include a similar busbar configuration with the shunt mounted in the intended position of use.
- 2) Apply rated current, or rated current adjusted for the current drawn by the measuring instrument, through the shunt and record the voltage drop (B), as shown by the reference instrument. The rated current shall be d.c. unless a frequency is stated. If the shunt may be used on both a.c. and d.c., separate tests shall be performed.

2.9.2 Computation

The intrinsic error, expressed as a percentage, shall be computed as follows:

$$\left(\frac{B - A_F}{A_F} \right) \times 100$$

where A_F is the fiducial value (rated value of voltage drop)

2.10 Interchangeable series resistors (impedances)

2.10.1 Procedure

- 1) Connect the resistor (impedance) in series with a suitable current measuring instrument whose internal impedance is negligible compared with the resistor (impedance) under test.
- 2) Apply rated voltage across the resistor (impedance) in series with the current measuring instrument. Record the value of the current (B), as shown by the reference instrument. The rated voltage shall be d.c. unless a frequency is stated. If the resistor (impedance) may be used on both a.c. and d.c., separate tests shall be performed.

2.10.2 Computation

The intrinsic error, expressed as a percentage, shall be computed as follows:

$$\left(\frac{A_F - B}{A_F} \right) \times 100$$

where A_F is the fiducial value (rated value of current)

3 Variation tests

3.1 Variation due to ferromagnetic supports for instruments not marked with symbols F-37, F-38 or F-39 (Table III-1 of JIS C 1102-1)

3.1.1 Fixed instruments

3.1.1.1 Procedure

- 1) Mount the instrument on a non-ferromagnetic panel of any thickness at least 1 m from any ferromagnetic material.
- 2) Record the values of the excitation (B_A), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.
- 3) Mount the instrument in a similar manner on a 2 ± 0.5 mm thick demagnetized ferrous panel. The cutout in the panel shall be of the dimensions specified by the manufacturer.
- 4) Record the values of the excitation (B_B) to bring the index to the same scale marks as in step 2) with tapping.

3.1.1.2 Computation

The variation, expressed as a percentage, due to ferromagnetic supports shall be computed at each selected scale mark as follows:

$$\left(\frac{B_A - B_B}{A_F} \right) \times 100$$

where A_F is the fiducial value

3.1.2 Portable instruments

3.1.2.1 Procedure

- 1) Place the instrument in the reference position on a non-ferromagnetic surface at least 1 m from any ferromagnetic material.
- 2) Record the values of the excitation (B_A), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.
- 3) Place the instrument, still in the reference position, on a demagnetized ferrous plate which is at least 6 mm thick, but for convenience limited to 10 mm and which extends at least 150 mm beyond the instrument on all sides.
- 4) Record the values of the excitation (B_B) to bring the index to the same scale marks as in step 2) with tapping.

Note : For instruments that may be used in multiple positions, the limit positions and the middle position of the range should be tested.

3.1.2.2 Computation

The variation, expressed as a percentage, due to a ferromagnetic platform shall be computed for each selected scale mark as follows:

$$\left(\frac{B_A - B_B}{A_F} \right) \times 100$$

where A_F is the fiducial value

3.2 Variation due to ambient temperature

3.2.1 Procedure

- 1) Set the zero and record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping. If a reference range for temperature is specified, the upper limit of the reference range shall be used.
- 2) Subject the instrument to a temperature equal to the upper limit of the nominal range of use above the reference temperature until thermal stability is attained but for not less than 2 h. Record the values of the excitation (B_X) to bring the index to the same scale marks as in step 1) with tapping.
- 3) Condition the instrument at the reference temperature until thermal stability is attained but for not less than 2 h. Record the values of the excitation (B_T) to bring the index to the same scale marks as in step 1) with tapping. If a reference range for temperature is specified, the lower limit of the reference range shall be used.
- 4) Subject the instrument to a temperature equal to the lower limit of the nominal range of use below the reference temperature until thermal stability is attained but for not less than 2 h. Record the values of the excitation (B_Y) to bring the index to the same scale marks as in step 1) with tapping.

3.2.2 Computation

The variation, expressed as a percentage, at the upper limit of the nominal range of use shall be computed for each selected scale mark as follows:

$$\left(\frac{B_R - B_X}{A_F} \right) \times 100$$

where A_F is the fiducial value

A similar computation shall be made for the readings at the lower limit of the nominal range of use, as follows:

$$\left(\frac{B_T - B_Y}{A_F} \right) \times 100$$

where A_F is the fiducial value

If the absolute values of the variations above and below the reference temperature are not equal, the greater absolute value together with the appropriate sign shall be considered to be the temperature variation.

3.3 Variation due to humidity

3.3.1 Procedure

- 1) Set zero and record the values of the excitation (B_A), as shown by the reference instrument, under reference conditions, to bring the index to at least five approximately equidistant scale marks, including the upper and lower limits of the measuring range, with tapping.
- 2) Subject the instrument to a relative humidity of 25 % to 30 % for at least 96 h.
- 3) Set zero and record the values of the excitation (B_B) to bring the index to each of the same scale marks as in step 1) with tapping.
- 4) Subject the instrument to a relative humidity of 75 % to 80 % for at least 96 h.
- 5) Set zero and record the values of the excitation (B_C) to bring the index to each of the same scale marks as in step 1) with tapping.

3.3.2 Computation

The variation, expressed as a percentage, due to humidity at each selected scale mark shall be the maximum absolute value of the variation together with the appropriate sign. Computation is as follows:

$$\left(\frac{B_A - B_B}{A_F} \right) \times 100 \quad \text{or} \quad \left(\frac{B_A - B_C}{A_F} \right) \times 100$$

where A_F is the fiducial value

3.4 Variation due to position

3.4.1 Instruments marked with symbols D-1 to D-6 (Table III-1 of JIS C 1102-1)

3.4.1.1 Procedure

- 1) Place the instrument in the marked position.
- 2) Record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.
- 3) Tilt the instrument forward 5° or the value marked. Set zero and record the values of the excitation (B_W) to bring the index to each of the same scale marks as in step 2) with tapping.
- 4) Tilt the instrument back 5° or the value marked. Set zero and record the values of the excitation (B_X) to bring the index to each of the same scale marks as in step 2) with tapping.
- 5) Tilt the instrument to the left 5° or the value marked. Set zero and record the values of the excitation (B_Y) to bring the index to each of the same scale marks as in step 2) with tapping.