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EN 60 051-9 : 1989
IEC 51-9 : 1988

UDC : 621.317.7.037.33 : 620.1

British Standard

Direct acting indicating analogue electrical measuring instruments and their accessories

Part 9. Recommended test methods

Appareils mesureurs électriques indicateurs analogiques à action directe et leurs accessoires
Neuvième partie. Méthodes d'essais recommandées

Direkt wirkende anzeigende elektrische Meßgeräte und ihr Zubehör Meßgeräte mit Skalanzeige
Teil 9. Empfohlene Prüfverfahren

This European Standard EN 60 051-9 : has the status of a British Standard

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National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee and is the English language version of EN 60 051-9 'Direct acting indicating analogue electrical measuring instruments and their accessories — Part 9 : Recommended test methods', published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC publication 51-9 published by the International Electrotechnical Commission (IEC).

This Part of BS 89 together with Parts 1, 2, 3, 4, 5, 6, 7 and 8 of this standard supersedes BS 89 : 1977, which is withdrawn. BS 89 comprises the following Parts, which will be the English language version of the listed European Standards.

European Standard	Corresponding Part of BS 89
EN 60 051-1	Part 1 Specification for definitions and general requirements common to all Parts
EN 60 051-2	Part 2 Specification for special requirements for ammeters and voltmeters
EN 60 051-3	Part 3 Specification for special requirements for wattmeters and varmeters
EN 60 051-4	Part 4 Specification for special requirements for frequency meters
EN 60 051-5	Part 5 Specification for special requirements for phase meters, power factor meters and synchrosopes
EN 60 051-6	Part 6 Specification for special requirements for ohmmeters (impedance meters) and conductance meters
EN 60 051-7	Part 7 Specification for special requirements for multi-function instruments
EN 60 051-8	Part 8 Specification for special requirements for accessories
EN 60 051-9	Part 9 Recommended test methods

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Amendment No. 1
published and effective from 15 December 1995
to BS 89 : Part 9 : 1990

Direct acting indicating analogue electrical measuring
instruments and their accessories

Part 9. Recommended test methods

NOTE. The English language version of European Standard
EN 60051-9 : 1989 was implemented in the United Kingdom by the
publication of BS 89 : Part 9 : 1990. This amendment implements
Amendments A1 and A2 to EN 60051-9 : 1989.

This amendment together with the European Standard EN 60051-9 :
1989 has the status of a British Standard.

Revised text

National foreword

In paragraph 1, line 4, after 'IEC Publication 51-9' insert 'including Amendments A1
and A2'.

At the end of paragraph 1 insert the following new paragraph.

In 1995 the European Committee for Electrotechnical Standardization (CENELEC)
accepted Amendment 1 : 1995 and Amendment 2 : 1995 to IEC 51-9 : 1988 as
Amendment A1 : 1995 and Amendment A2 : 1995 to EN 60051-9 : 1989, respectively.

At the end of paragraph 2, insert the following new paragraph.

The foreword of the EN amendments makes reference to 'date of withdrawal (dow)
of conflicting national standards' as 1996-02-15. In this case the relevant national
standard is BS 89 : Part 9 but the date of withdrawal relates only to those parts of
the British Standard subject to Amendments No. 1 and No. 2. Certificates and marks
will not be awarded after this date with respect to the British Standard not
incorporating Amendments No. 1 and No. 2. They will be awarded only to the
amended British Standard. However, such certificates and marks already awarded
with respect to the British Standard not incorporating Amendments No. 1 and No. 2
may continue to apply for production until 2001-02-15.

AMD 8832/December 1995

EN amendment title page and foreword

After the existing EN title page and foreword, insert the attached title page
(forewords on reverse).

AMD 8832/December 1995

Text of EN 60051-9

Amend the text of the European Standard in accordance with the details given on
the attached pages.

AMD 8832/December 1995

Descriptors: Electrical measuring instruments, analogue indicating instruments, direct acting measuring instruments, recommended test methods for direct acting measuring instruments

English version

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

(IEC 51-9 : 1988/A1 : 1994 + A2 : 1995)

Appareils mesureurs électriques
indicateurs analogiques à action directe
et leurs accessoires
Partie 9: Méthodes d'essai recommandées
(CEI 51-9 : 1988/A1 : 1994 + A2 : 1995)

Direkt wirkende anzeigende elektrische
Meßgeräte und ihr Zubehör
Meßgeräte mit Skalenanzeige
Teil 9: Empfohlene Prüfverfahren
(IEC 51-9 : 1988/A1 : 1994 + A2 : 1995)

These amendments A1 + A2 modify the European Standard EN 60051-9 : 1989; they were approved by CENELEC on 1995-05-15 and 1995-02-15 respectively. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This amendment exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword to Amendment A1

The text of amendment 1 : 1994 to the International Standard IEC 51-9 : 1988, prepared by IEC TC 85, Measuring equipment for electromagnetic quantities, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as Amendment A1 to EN 60051-9 : 1989 on 1995-05-15 without any modification.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1996-02-15
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1996-02-15

For products which have complied with EN 60051-9 : 1989 before 1996-02-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2001-02-15.

Foreword to Amendment A2

The text of document 85(CO)65 + 65A, future Amendment 2 to IEC 51-9 : 1988, prepared by IEC TC 85, Measuring equipment for electromagnetic quantities, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as Amendment A2 to EN 60051-9 : 1989 on 1995-02-15.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1996-02-15
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1996-02-15

For products which have complied with EN 60051-9 : 1989 before 1996-02-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2001-02-15.

After 4.6.1 4): Note 2 insert new sub-clauses 4.6.1 5) and 4.6.1 6).

- 5) While the overload specified in step 2) is applied, observe the indication and check that it is clearly beyond the upper extreme scale mark. (See part 17.3).
- 6) Where a value of the measurand would produce an indication below the lower extreme scale mark, such a value shall be applied. Check that the indication is clearly below the lower extreme scale mark.

NOTE – This check may be carried out at any time during the tests of 4.6.1.

Replacement:

4.14.1.1 Procedure

- 1) Condition the instrument and its non-interchangeable accessories under reference conditions, without excitation, for at least 4 h.
- 2) Apply a constant value of excitation with tapping that will bring the index to a scale mark as specified in 6.3.1 of Part 1. Record the value of the excitation (B_R) after at least 1 min but less than 3 min of excitation.
- 3) After at least 30 min but less than 35 min of excitation, readjust the excitation to bring the index to the same scale mark as in step 2) with tapping. Record the value of the excitation (B_X).

NOTE – In case of doubt, and by agreement between the supplier and the purchaser, the self-heating test may be extended. A maximum period of 6 h is suggested.

UDC : 621.317.7.037.33 : 620.1

Key words : Electrical measuring instruments; analogue indicating instruments; direct acting measuring instruments; recommended test methods for direct acting measuring instruments

English version

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

(IEC 51-9 (1988) edition 4)

Appareils mesureurs électriques indicateurs
analogiques à action directe et leurs accessoires
Neuvième partie: Méthodes d'essais recommandées
(CEI 51-9 (1988) édition 4)

Direkt wirkende anzeigende elektrische Meßgeräte
und ihr Zubehör Meßgeräte mit Skalenanzeige
Teil 9: Empfohlene Prüfverfahren
(IEC 51-9 (1988) Ausgabe 4)

This European Standard was ratified by CENELEC on 11 September 1989. CENELEC members are bound to comply with the requirements of the CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CENELEC Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French and German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to CENELEC Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: Rue Bréderode 2, B - 1000 Brussels

Brief history

The text of IEC-Publication 51-9 (4th edition – 1988) was submitted to the CENELEC members for unique acceptance.

Technical text

The text of the International Standard IEC 51-9 (4th edition – 1988) was approved by CENELEC on 11 September 1989 as a European Standard.

The following dates are applicable:

- latest date of announcement of
the EN at national level (doa) : 1990–03–01
- date of latest publication of a
new harmonized standard (dop) : 1990–09–01
- date of withdrawal of conflicting
national standards (dow) : 1990–09–01

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES

Part 9: Recommended test methods

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by IEC Technical Committee No. 85: Measuring equipment for basic electrical quantities (former Sub-Committee 13B: Electrical measuring instruments).

This fourth edition replaces the third edition of IEC Publication 51.

This standard constitutes Part 9.

The general layout for the revised Publication 51 is as follows:

- 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.

Part 9 is not complete in itself as it contains no requirements. The requirements are contained in Parts 1 to 8 and include references to the test sub-clauses of Part 9.

Three tests specified in Part 9 have no corresponding requirements in Parts 1 to 8 but are included to permit standardization of the test methods for characteristics that are normally specified by agreement between the manufacturer and the user. These tests are:

- Pull-in difference frequency
- Tracking error
- Simultaneous influence of voltage and power factor.

The text of this standard is based on the following documents:

Six Months' Rule	Report on Voting
13B(C0)105	85(C0)5

Full information on the voting for the approval of this standard can be found in the Voting Report indicated in the above table.

DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES

Part 9: Recommended test methods

1. Scope and general test conditions

1.1 Scope

Part 9 of Publication 51 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 part shall be applied under the following conditions unless otherwise specified.

1.2.1 Reference conditions

Reference conditions shall be according to Table I of the relevant part. 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 Part 1: Sub-clause 3.3.1.

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 Part 1 and Table I-5 of Part 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 Part 1 and Table I-5 of Part 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).