

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Direct acting indicating analogue electrical measuring instruments and their accessories –

Part 2: Special requirements for ammeters and voltmeters

Appareils mesureurs électriques indicateurs analogiques à action directe et leurs accessoires –

Partie 2: Exigences particulières pour les ampèremètres et les voltmètres



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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International Standard IEC 60051-2 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

This fifth edition cancels and replaces the fourth edition published in 1984. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) updating of content in line with new editions of IEC 60051-1 and IEC 60051-9;
- b) addition of Annex A to specify the nonconformity classification of test items.

The text of this International Standard is based on the following documents:

CDV	Report on voting
85/555/CDV	85/578A/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

This International Standard is to be used in conjunction with IEC 60051-1:2016.

A list of all parts in the IEC 60051 series, published under the general title *Direct acting indicating analogue electrical measuring instruments and their accessories*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

IEC 60051 is published in separate parts according to the following structure and under the general 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

IEC 60051-2 is not complete in itself and is read in conjunction with IEC 60051-1.

All of these parts are arranged in the same format and a standard relationship between subject and clause number is maintained throughout these parts. This arrangement will assist the reader of IEC 60051 to distinguish information relating to the different types of instruments.

DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES –

Part 2: Special requirements for ammeters and voltmeters

1 Scope

This part of IEC 60051 applies to direct acting indicating ammeters and voltmeters having an analogue display.

NOTE For multi-function instruments, see IEC 60051-7.

It also applies to:

- direct acting indicating ammeters and voltmeters whose scale marks do not correspond directly to their electrical input quantity, provided that the relationship between them is known;
- direct acting indicating ammeters and voltmeters and accessories having electronic devices in their measuring and/or auxiliary circuits.

This document does not apply to:

- special purpose instruments which are covered by their own IEC standards;
- special purpose devices which are covered by their own IEC standards when they are used as accessories.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60051-1:2016, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts*

IEC 60051-9, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 9: Recommended test methods*

IEC 61869-2, *Instrument transformers – Part 2: Additional requirements for current transformers*

3 Terms and definitions

See IEC 60051-1:2016.

4 Description, classification and compliance

See IEC 60051-1:2016.

5 Requirements

5.1 Reference conditions

See IEC 60051-1:2016.

5.2 Limits of intrinsic uncertainty, fiducial value

5.2.1 Limits of intrinsic uncertainty

See IEC 60051-1:2016.

5.2.2 Correspondence between intrinsic uncertainty and accuracy class

See IEC 60051-1:2016.

5.2.3 Fiducial value

5.2.3.1 The fiducial value for an ammeter or a voltmeter corresponds to the following.

5.2.3.2 The upper limit of the measuring range for the following:

- instruments with the mechanical and/or electrical zero at one end of the scale;
- instruments with the mechanical zero outside the scale irrespective of the position of the electrical zero;
- instruments with the electrical zero outside the scale irrespective of the position of the mechanical zero.

The class index is marked using Symbol E-1 given in Table 6 of IEC 60051-1:2016 (see Clause 6 of IEC 60051-1:2016).

5.2.3.3 The sum of the electrical values:

The sum of the absolute values of the upper and lower limit of the measuring range when both the mechanical and the electrical zeros are displaced within the scale.

The class index is marked using Symbol E-1 given in Table 6 of IEC 60051-1:2016 (see Clause 6 of IEC 60051-1:2016).

5.2.3.4 The span for an instrument:

The span for an instrument whose scale marks do not correspond directly to its electrical input quantity.

The class index is marked using Symbol E-4 given in Table 6 of IEC 60051-1:2016 (see Clause 6 of IEC 60051-1:2016).

Subclause 5.2.3.4 does not apply to a voltmeter or ammeter designed to be used in conjunction with a shunt, a series resistor (impedance) or an instrument transformer. These instruments are to be treated in accordance with 5.2.3.2 or 5.2.3.3, as appropriate.

5.2.3.5 The fiducial value for an ammeter with overload scale or an expanded scale voltmeter:

The fiducial value for an ammeter with overload scale or an expanded scale voltmeter corresponds to 5.2.3.2 or 5.2.3.3, as appropriate. The measuring range of an ammeter with overload scale is the upper limit of the non-overload part. The measuring range of an expanded scale voltmeter is the lower limit of the expanded part.

5.2.3.6 The fiducial value for an instrument with a special arrangement of scale marks:

For an instrument whose scale has been arranged to produce a special arrangement of scale marks, the fiducial value shall be as agreed between manufacturer and user. The fiducial value does not have to be the same at all points on the scale.

5.3 Nominal range of use and variations

5.3.1 Nominal range of use

See Table 1.

Table 1 – Limits of the nominal range of use and permissible variations in addition to those given in Table 3 of IEC 60051-1:2016

Influence quantity		Limits of nominal range of use unless otherwise marked	Permissible variation expressed as a percentage of class index	
Ripple (45 Hz to 65 Hz and 90 Hz to 130 Hz) on DC measured quantity for other than RMS responding instruments ^a		20 %	50 %	
Distortion of AC measured quantity for other than rectifier instruments ^b	Distortion factor	Instruments without electronic devices in their measuring circuits: 20 %	100 %	
	Peak factor	Instruments having electronic devices in their measuring circuits: 1 to 3 ^c	100 %	
Frequency of AC measured quantity		Reference frequency ± 10 % or lower limit of reference range for frequency - 10 % and upper limit of reference range for frequency + 10 %	100 %	
Magnetic field of external origin	0,4 kA/m		Class indices 0,3 and smaller	Class indices 0,5 and greater
		Moving magnet, moving iron and electrodynamic instruments if not astatic and/or not having a magnetic screen	3 % of the fiducial value ^d	6 % of the fiducial value ^d
		Ferrodynamic instruments if not astatic and/or not having a magnetic screen	1,5 % of the fiducial value ^d	3 % of the fiducial value ^d
		All other instruments	0,75 % of the fiducial value ^d	1,5 % of the fiducial value ^d

^a For an RMS-responding instrument which also responds to DC, no permissible variation can be stated because the ripple is then part of the measured quantity.

^b For AC quantities, the requirements for instruments relate to RMS values irrespective of the principle of operation of the instrument. However, instruments incorporating rectifier(s) (except r.m.s.-responding instruments) usually respond to the rectified (mean) value of the waveform but are scaled to indicate the RMS value of a sinusoidal waveform .If the waveform is not sinusoidal, the indicated value may be seriously in uncertainty. However, if the waveform can be adequately characterized, this uncertainty is calculable.

Requirements for the influence of a distorted waveform on rectified (mean) and peak-sensing instruments are therefore not specified.

^c The permissible variation due to a peak factor of other than $\sqrt{2}$ (corresponding to a sine wave) is included in the permissible variation due to distortion of the measured quantity.

For instruments having a peak factor capability greater than 3, the manufacturer shall state:

- 1) the instrument peak factor capability producing a variation of 100 % of the class index;
- 2) the upper and lower limits of the frequency response (bandwidth) to 0,707 times the indication at the reference frequency;
- 3) the effective maximum rate of change of internal instrument AC amplifier response (slew rate), expressed in volts per second using appropriate SI prefixes.

Peak factor relates to the total peak factor capability of the instrument and includes both the peak factor due to a distorted waveform and the peak factor due to spurious impulses (which may be random or harmonically related to the fundamental frequency) containing negligible average power.

^d Not as a percentage of the class index.

5.3.2 Limits of variations

See IEC 60051-1:2016.

5.3.3 Conditions for the determination of variations

See IEC 60051-1:2016.

5.4 Operating uncertainty, overall system uncertainty and variations

See IEC 60051-1:2016.

5.5 Electrical requirements

5.5.1 Electrical safety requirements

See IEC 60051-1:2016.

For a fixed ammeter having the upper limit of its measuring range of 1 A to 10 A and intended for use with a current transformer having a high over-current capability (Class P protective current transformers as specified in IEC 61869-2), the measuring circuit shall not open when the ammeter is subjected to 30 times the nominal secondary current of the associated current transformer for a period of 2 s.

A portable ammeter intended for similar use shall withstand 15 times the upper limit of its measuring range for a period of 2 s.

These ammeters need not be functional after application of this overload but shall not then be open-circuit.

For the recommended test, see IEC 60051-9.

5.5.2 Self-heating

See IEC 60051-1:2016.

5.5.3 Permissible overloads

5.5.3.1 Continuous overload

Ammeters and voltmeters, together with their non-interchangeable accessory(ies), if any, except for instruments fitted with a non-locking switch, shall be subjected to a continuous overload of 120 % of the upper limit of the electrical input quantity for a period of 2 h. The upper limit of the electrical input quantity of an ammeter with overload scale is the upper limit of the non-overload part. The upper limit of the electrical input quantity of an expanded scale voltmeter is the upper limit of the expanded part.

After removal of the excitation, the sum of the temporary and any permanent residual deflections shall not exceed 1 % of the scale length.

After having cooled to the reference temperature, the instrument, together with its non-interchangeable accessory(ies), if any, shall comply with its accuracy requirements; however the overload shall not be repeated.

The continuous overload test shall be carried out under reference conditions.

For the recommended test, see IEC 60051-9.

5.5.3.2 Overloads of short duration

Ammeters and voltmeters, together with their non-interchangeable accessory(ies), if any, shall be subjected to overloads of short duration.

However, these requirements do not apply to:

- thermocouple instruments,
- electrostatic instruments,
- instruments having a freely suspended moving element,

unless these instruments are internally protected against overloads of short duration.

The values of current and voltage for the overloads of short duration shall be the product of the relevant factor given in Table 2 and the value of the upper limit of the electrical input quantity unless other values are stated by the manufacturer.

The full duration of each overload shall be applied except when an automatic cut-out (fuse) fitted to the instrument has interrupted the circuit in less than the time specified in Table 2.

The automatic cut-out shall be reset (or the fuse replaced) before the application of the next overload.

After having been subjected to the overloads of short duration and after having cooled to the reference temperature, ammeters and voltmeters whose mechanical zero is within the scale, together with their non-interchangeable accessory(ies), if any, shall comply with both of the following requirements:

- a) the deviation of the index from the zero scale mark, expressed as a percentage of the scale length, shall not exceed the following value:
 - 1) 0,5 for instruments of class indices 0,3 and smaller,
 - 2) the class index for instruments of class indices 0,5 and greater;
- b) the ammeter or voltmeter together with its non-interchangeable accessory(ies), if any, after adjustment of the zero (if necessary) shall comply with the accuracy requirements; however, the overloads shall not be repeated.

An ammeter or voltmeter whose mechanical zero is outside the scale is considered to have complied with this requirement if, after having cooled to the reference temperature, it has errors not exceeding those relating to its class index; however, the overloads shall not be repeated.

Table 2 – Overloads of short duration for ammeters and voltmeters

Instrument	Current factor	Voltage factor	Number of overloads	Duration of each overload (s)	Interval between successive overloads (s)
Instruments of class indices 0,5 and smaller					
Ammeters	2	–	5	0,5	15
Voltmeters	–	2	5	0,5	15
Instruments of class indices are greater than 0,5					
Ammeters	10	–	9	0,5	60
	10	–	1	5	–
Voltmeters	–	2	9	0,5	60
	–	2	1	5	–
Where two series of tests are specified, they should both be carried out, in the order given.					

For the recommended tests, see IEC 60051-9.

5.5.4 Limiting range of temperature

See IEC 60051-1:2016.

5.5.5 Deviation from zero

If an ammeter or a voltmeter has a zero position marked on the scale, it shall be tested for return to zero when de-energized. The test shall be carried out under reference conditions.

After a period of energization of 30 s at the upper limit of the measuring range, the deviation of the index from the zero scale mark, expressed as a percentage of the scale length, shall not exceed a value corresponding to 50 % of the class index.

For the recommended tests, see IEC 60051-9.

5.5.6 Electromagnetic compatibility (EMC)

See IEC 60051-1:2016.

5.6 Constructional requirements

5.6.1 General constructional requirements

See IEC 60051-1:2016.

5.6.2 Damping

5.6.2.1 General

See IEC 60051-1:2016.

5.6.2.2 Overshoot

See IEC 60051-1:2016.

However, these requirements do not apply to:

- thermal instruments;
- electrostatic instruments;
- instruments having a freely suspended moving element;
- instruments having a material pointer longer than 150 mm;
- instruments in which the current or voltage corresponding to the upper limit of the measuring range is less than 200 μ A or 20 mV;
- special-purpose instruments where other response times may be required. Such instruments will be the subject of agreement between manufacturer and user.

5.6.2.3 Response time

See IEC 60051-1:2016.

However, these requirements do not apply to:

- thermal instruments;
- electrostatic instruments;
- instruments having a freely suspended moving element;
- instruments having a material pointer longer than 150 mm;
- instruments in which the current or voltage corresponding to the upper limit of the measuring range is less than 200 μ A or 20 mV;
- special-purpose instruments where other response times may be required. Such instruments will be the subject of agreement between manufacturer and user.

5.6.2.4 Impedance of the external measuring circuit

See IEC 60051-1:2016.

However, if the impedance of the external measuring circuit is not stated, it shall be assumed to be, at the reference frequency:

- more than 50 times the impedance of the instrument for ammeters;
- less than 1/50 of the impedance of the instrument for voltmeters.

5.6.3 Sealing to prevent access

See IEC 60051-1:2016.

5.6.4 Scales

See IEC 60051-1:2016.

5.6.5 Stopper

See IEC 60051-1:2016.

5.6.6 Preferred values

The upper limit of the measuring range for ammeters and voltmeters shall preferably be one of the following values:

1, 1,2, 1,5, 2, 2,5, 3, 4, 5, 6, 7,5, 8 or their decimal multiples and sub-multiples.

For multi-range instruments, at least one of the ranges shall comply with this requirement.

The voltage drop at the upper limit of the measuring range for an ammeter intended for use with an external shunt shall preferably be one of the following values:

50 mV, 60 mV, 75 mV, 100 mV, 300 mV.

If, to achieve the correct performance of an instrument, it is necessary to use calibrated instrument leads (i.e. leads having a specified value of resistance) to connect it to a shunt, the manufacturer shall state the value of the lead resistance.

Unless otherwise stated by the manufacturer, the value of the total resistance of the calibrated instrument leads shall not exceed 70 mΩ at the reference temperature.

The value of the lead resistance shall not differ from the stated value by more than 10 % at the reference temperature.

5.6.7 Adjusters, mechanical and/or electrical

See IEC 60051-1:2016.

5.6.8 Effects of vibration and shock

See IEC 60051-1:2016.

5.6.9 Degrees of protection provided by enclosure

See IEC 60051-1:2016.

5.6.10 Terminals

See IEC 60051-1:2016.

6 Information, markings and symbols

6.1 Information

See IEC 60051-1:2016.

6.2 Markings, symbols and their locations

See IEC 60051-1:2016.

6.3 Markings relating to the reference values and nominal ranges of use of influence quantities

See IEC 60051-1:2016.

6.4 The symbols for marking instruments and accessories

See IEC 60051-1:2016.

6.5 Markings and symbols for terminals

6.5.1 Requirements for markings

See IEC 60051-1:2016.

6.5.2 Earthing (grounding) terminals

See IEC 60051-1:2016.

6.5.3 Measuring circuit terminals

See IEC 60051-1:2016.

6.5.4 Special markings for terminals

6.5.4.1 General

All terminals shall be marked so that they can be uniquely identified.

6.5.4.2 Single range DC ammeters and voltmeters

The positive terminal shall be marked using Symbol F-39 (+) given in Table 6 of IEC 60051-1:2016.

6.5.4.3 Multi-range DC ammeters and voltmeters

The range-selecting terminals shall be marked with the value corresponding to the upper limit of the relevant measuring range. If those terminals are positive terminals, they shall also be marked using Symbol F-39 (+) given in Table 6 of IEC 60051-1:2016. This marking shall follow the marking for the value of the range. If the common terminal is the positive terminal, it shall be marked using Symbol F-39 (+) given in Table 6 of IEC 60051-1:2016.

6.5.4.4 Single range AC ammeters and voltmeters

In the absence of special requirements, no markings are needed.

6.5.4.5 Multi-range AC ammeters and voltmeters

The range-selecting terminals shall be marked with the value corresponding to the upper limit of the measuring range.

6.6 Instructions for use

See IEC 60051-1:2016.

7 Package

See IEC 60051-1:2016.

8 Test rules

See IEC 60051-1:2016.

The recommended nonconformity classification of tests is given in Annex A.

The method of acceptance inspection may be agreed between the manufacturer and the customer.

Annex A

(normative)

Nonconformity classification of tests

The recommended nonconformity classification of tests is listed in Table A.1

Table A.1 – Nonconformity classification of tests

Test	Nonconformity class
Limits of intrinsic uncertainty (5.2.1)	A
Limits of variations (5.3.2)	B
Electrical safety requirements (5.5.1)	A
Self-heating (5.5.2)	B
Permissible overloads (5.5.3)	B
Limiting range of temperature (5.5.4)	B
Deviation from zero (5.5.5)	B
Electromagnetic compatibility (EMC) (5.5.6)	B
Damping (5.6.2)	B
Adjusters, mechanical and/or electrical (5.6.7)	B
Effects of vibration and shock (5.6.8)	B
Degrees of protection provided by enclosure (5.6.9)	B
Terminals (5.6.10)	B

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