

Instrument transformers —

Part 1: Current transformers

The European Standard EN 60044-1:1999, with the incorporation of amendments A1:2000 and A2:2003, has the status of a British Standard

ICS 17.220.20

National foreword

This British Standard is the English language version of EN 60044-1:1999, including amendments A1:2000 and A2:2003. It was derived by CENELEC from IEC 60044-1:1996, including amendments 1:2000 and 2:2002. It supersedes BS 7626:1993 which is withdrawn.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags [C] [C].

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1] [A1]. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by [A1] [A1].

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 - monitor related international and European developments and promulgate them in the UK.
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(including amendments A1:2000 and A2:2003)
(IEC 60044-1:1996 + A1:2000 + A2:2002, modified)

Transformateurs de mesure —
Partie 1: Transformateurs de courant
(inclut les amendements A1:2000 et A2:2003)
(CEI 60044-1:1996 + A1:2000 + A2:2002, modifiée)

Meßwandler —
Teil 1: Stromwandler
(enthält Änderungen A1:2000 und A2:2003)
(IEC 60044-1:1996 + A1:2000 + A2:2002, modifiziert)

This European Standard was approved by CENELEC on 1999-08-01. Amendment A1 was approved by CENELEC on 2000-09-01 and amendment A2 was approved by CENELEC on 2002-12-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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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

The text of the International Standard IEC 60044-1:1996, prepared by IEC TC 38, Instrument transformers, together with common modifications prepared by the Technical Committee CENELEC TC 38X, Instrument transformers, was submitted to the formal vote and was approved by CENELEC as EN 60044-1 on 1999-08-01.

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Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex A and Annex ZA are normative and Annex B is informative. Annex ZA has been added by CENELEC.

Foreword to amendment A1

The text of document 38/245/FDIS, future amendment 1 to IEC 60044-1:1996, prepared by IEC TC 38, Instrument transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60044-1:1999 on 2000-09-01.

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Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative. Annex ZA has been added by CENELEC.

Foreword to amendment A2

The text of document 38/285/FDIS, future amendment 2 to IEC 60044-1:1996, prepared by IEC TC 38, Instrument transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 60044-1:1999 on 2002-12-01.

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1 General

1.1 Scope

This part of IEC 60044 applies to newly manufactured current transformers for use with electrical measuring instruments and electrical protective devices at frequencies from 15 Hz to 100 Hz.

Although the requirements relate basically to transformers with separate windings, they are also applicable, where appropriate, to autotransformers.

Clause 11 covers the requirements and tests, in addition to those in Clauses 3, 4, 5, 6, 7, 8, 9 and 10, that are necessary for current transformers for use with electrical measuring instruments.

Clause 12 covers the requirements and tests, in addition to those in Clauses 3, 4, 5, 6, 7, 8, 9 and 10, that are necessary for current transformers for use with electrical protective relays, and in particular for forms of protection in which the prime requirement is the maintenance of accuracy up to several times the rated current.

A1 For certain protective systems, where the current transformer characteristics are dependant on the overall design of the protective equipment (for example, high-speed balanced systems and earth-fault protection in resonant earthed networks), additional requirements are given in Clause 13 for class PR transformers and in Clause 14 for class PX transformers.

Clause 13 covers the requirements and tests in addition to those in Clause 3, 4, 5, 6, 7, 8, 9 and 10 that are necessary for current transformers for use with electrical protective relays, and in particular for forms of protection in which the prime requirement is the absence of remanent flux.

Clause 14 covers the requirements and tests in addition to those in Clauses 3, 4, 5, 6, 7, 8, 9 and 10 that are necessary for current transformers for use with electrical protective relays, and in particular for forms of protection for which knowledge of the transformer's secondary excitation characteristic, secondary winding resistance, secondary burden resistance and turns ratio is sufficient to assess its performance in relation to the protective relay system with which it is to be used. **A1**

Current transformers intended for both measurement and protection shall comply with all the clauses of this standard.

C Instrument transformers (ITs) are considered to be passive elements.

NOTE For outdoor ITs having voltages ≥ 123 kV the RIV measurements are suitable to cover the requirements of EMC Directive. For guidance of the test procedure EN 60694:1996, § 6.3 might be followed. **C**

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60044. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60044 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60028:1925, *International Standard of resistance for copper*.

IEC 60038:1983, *IEC standard voltages*.

A1 IEC 60044-6:1992, *Instrument transformers — Part 6: Requirements for protective current transformers for transient performance*. **A1**

IEC 60050(321):1986, *International Electrotechnical Vocabulary — Chapter 321: Instrument transformers*.

IEC 60060-1:1989, *High-voltage test techniques — Part 1: General definitions and test requirements*.

IEC 60071-1:1993, *Insulation co-ordination — Part 1: Definitions, principles and rules*.

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*.

IEC 60121:1960, *Recommendation for commercial annealed aluminium electrical conductor wire*.

IEC 60270:1981, *Partial discharge measurements*.

IEC 60567:1992, *Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases*.

IEC 60599:1978, *Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service*.

IEC 60721, *Classification of environmental conditions*.

IEC 60815:1986, *Guide for the selection of insulators in respect of polluted conditions*.

Ⓐ CISPR 18-2:1986, *Radio interference characteristics of overhead power lines and high-voltage equipment — Part 2: Methods of measurement and procedure for determining limits*. Ⓐ

2 Definitions

For the purpose of this part of IEC 60044, the following definitions apply.

2.1 General definitions

2.1.1

instrument transformer

a transformer intended to supply measuring instruments, meters, relays and other similar apparatus
[IEV 321-01-01 modified]

2.1.2

current transformer

an instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections
[IEV 321-02-01]

2.1.3

primary winding

the winding through which flows the current to be transformed

2.1.4

secondary winding

the winding which supplies the current circuits of measuring instruments, meters, relays or similar apparatus

2.1.5

secondary circuit

the external circuit supplied by the secondary winding of a transformer

2.1.6

rated primary current

the value of the primary current on which the performance of the transformer is based
[IEV 321-01-11 modified]

2.1.7

rated secondary current

the value of the secondary current on which the performance of the transformer is based
[IEV 321-01-15 modified]

2.1.8

actual transformation ratio

the ratio of the actual primary current to the actual secondary current
[IEV 321-01-17 modified]

2.1.9

rated transformation ratio

the ratio of the rated primary current to the rated secondary current
[IEV 321-01-19 modified]

2.1.10**current error (ratio error)**

the error which a transformer introduces into the measurement of a current and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio
[IEV 321-01-21 modified]

The current error expressed in per cent is given by the formula:

$$\text{Current error \%} = \frac{(K_n I_s - I_p) \times 100}{I_p}$$

where

K_n is the rated transformation ratio;

I_p is the actual primary current;

I_s is the actual secondary current when I_p is flowing, under the conditions of measurement.

2.1.11**phase displacement**

the difference in phase between the primary and secondary current vectors, the direction of the vectors being so chosen that the angle is zero for a perfect transformer
[IEV 321-01-23 modified]

The phase displacement is said to be positive when the secondary current vector leads the primary current vector. It is usually expressed in minutes or centiradians.

NOTE This definition is strictly correct for sinusoidal currents only.

2.1.12**accuracy class**

a designation assigned to a current transformer the errors of which remain within specified limits under prescribed conditions of use

2.1.13**burden**

the impedance of the secondary circuit in ohms and power-factor

The burden is usually expressed as the apparent power in voltamperes absorbed at a specified power-factor and at the rated secondary current.

2.1.14**rated burden**

the value of the burden on which the accuracy requirements of this specification are based

2.1.15**rated output**

the value of the apparent power (in voltamperes at a specified power-factor) which the transformer is intended to supply to the secondary circuit at the rated secondary current and with rated burden connected to it

2.1.16**highest voltage for equipment**

the highest r.m.s. phase-to-phase voltage for which a transformer is designed in respect of its insulation

[A₂] 2.1.17**highest voltage of a system**

highest value of operating voltage which occurs under normal operating conditions at any time and at any point in the system

2.1.18**rated insulation level**

the combination of voltage values which characterizes the insulation of a transformer with regard to its capability to withstand dielectric stresses [A₂]

2.1.19

isolated neutral system

a system where the neutral point is not intentionally connected to earth, except for high impedance connections for protection or measurement purposes

[IEV 601-02-24]

2.1.20

solidly earthed neutral system

a system whose neutral point(s) is(are) earthed directly

[IEV 601-02-25]

2.1.21

impedance earthed (neutral) system

a system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents

[IEV 601-02-26]

2.1.22

resonant earthed (neutral) system

a system in which one or more neutral points are connected to earth through reactances which approximately compensate the capacitive component of a single-phase-to-earth fault current

[IEV 601-02-27]

NOTE With resonant earthing of a system, the residual current in the fault is limited to such an extent that an arcing fault in air is usually self-extinguishing.

2.1.23

earth fault factor

at a given location of a three-phase system, and for a given system configuration, the ratio of the highest r.m.s. phase-to-earth power frequency voltage on a healthy phase during a fault to earth affecting one or more phases at any point on the system to the r.m.s. phase-to-earth power frequency voltage which would be obtained at the given location in the absence of any such fault

[IEV 604-03-06]

2.1.24

earthed neutral system

a system in which the neutral is connected to earth, either solidly, or through a resistance or reactance of low enough value to reduce materially transient oscillations and to give a current sufficient for selective earth fault protection:

- a) a system with effectively-earthed neutral at a given location is a system characterized by an earth fault factor at this point which does not exceed 1,4;

NOTE This condition is obtained in general when, for all system configurations, the ratio of zero-sequence reactance to positive sequence reactance is less than 3 and the ratio of zero-sequence resistance to positive-sequence reactance is less than 1.

- b) a system with non-effectively earthed neutral at a given location is a system characterized by an earth fault factor at this point that may exceed 1,4

2.1.25

exposed installation

an installation in which the apparatus is subject to overvoltages of atmospheric origin

NOTE Such installations are usually connected to overhead transmission lines, either directly, or through a short length of cable.

2.1.26

non-exposed installation

an installation in which the apparatus is not subject to overvoltages of atmospheric origin

NOTE Such installations are usually connected to cable networks.

2.1.27

rated frequency

the value of the frequency on which the requirements of this standard are based 

[A₂] 2.1.28**rated short-time thermal current (I_{th})**

the r.m.s. value of the primary current which a transformer will withstand for one second without suffering harmful effects, the secondary winding being short-circuited

[C] Rated times other than one second, such as 0,5 s, 2 s and 3 s may be agreed. **[C]**

2.1.29**rated dynamic current (I_{dyn})**

the peak value of the primary current which a transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, the secondary winding being short-circuited

2.1.30**rated continuous thermal current (I_{cth})**

the value of the current which can be permitted to flow continuously in the primary winding, the secondary winding being connected to the rated burden, without the temperature rise exceeding the values specified

2.1.31**exciting current**

the r.m.s. value of the current taken by the secondary winding of a current transformer, when a sinusoidal voltage of rated frequency is applied to the secondary terminals, the primary and any other windings being open-circuited

2.1.32**composite error¹⁾**

under steady-state conditions, the r.m.s. value of the difference between:

- a) the instantaneous values of the primary current; and
- b) the instantaneous values of the actual secondary current multiplied by the rated transformation ratio, the positive signs of the primary and secondary currents corresponding to the convention for terminal markings

The composite error ϵ_c is generally expressed as a percentage of the r.m.s. values of the primary current according to the formula:

$$\epsilon_c = \frac{100}{I_p} \sqrt{\frac{1}{T} \int_0^T (K_n i_s - i_p)^2 dt}$$

where

- K_n is the rated transformation ratio;
- I_p is the r.m.s. value of the primary current;
- i_p is the instantaneous value of the primary current;
- i_s is the instantaneous value of the secondary current;
- T is the duration of one cycle.

[A₁] 2.1.33**rated resistive burden (R_b)**

rated value of the secondary connected resistive burden in ohms

2.1.34**secondary winding resistance (R_b)**

secondary winding d.c. resistance in ohms corrected to 75 °C or such other temperature as may be specified **[A₁]**

2.1.35**multi-ratio current transformer**

current transformer on which more ratios are obtained by connecting the primary winding sections in series or parallel or by means of taps on the secondary winding **[A₂]**

¹⁾ See Annex A.

2.2 Additional definitions for measuring current transformers

2.2.1

measuring current transformer

a current transformer intended to supply indicating instruments, integrating meters and similar apparatus

2.2.2

rated instrument limit primary current (*IPL*)

the value of the minimum primary current at which the composite error of the measuring current transformer is equal to or greater than 10 %, the secondary burden being equal to the rated burden

NOTE The composite error should be greater than 10 %, in order to protect the apparatus supplied by the instrument transformer against the high currents produced in the event of system fault.

2.2.3

instrument security factor (*FS*)

the ratio of rated instrument limit primary current to the rated primary current

A2 NOTE 1 Attention should be paid to the fact that the actual instrument security factor is affected by the burden.

NOTE 2 In the event of system fault currents flowing through the primary winding of a current transformer, the safety of the apparatus supplied by the transformer is greatest when the value of the rated instrument security factor (*FS*) is small. **A2**

2.2.4

secondary limiting e.m.f.

the product of the instrument security factor *FS*, the rated secondary current and the vectorial sum of the rated burden and the impedance of the secondary winding

NOTE 1 The method by which the secondary limiting e.m.f. is calculated will give a higher value than the real one. It was chosen in order to apply the same test method as in 11.6 and 12.5 for protective current transformers. Other methods may be used by agreement between manufacturer and purchaser.

NOTE 2 For calculating the secondary limiting e.m.f., the secondary winding resistance should be corrected to a temperature of 75 °C.

2.3 Additional definitions for protective current transformers

2.3.1

protective current transformer

a current transformer intended to supply protective relays

2.3.2

rated accuracy limit primary current

the value of primary current up to which the transformer will comply with the requirements for composite error

2.3.3

accuracy limit factor

the ratio of the rated accuracy limit primary current to the rated primary current

2.3.4

secondary limiting e.m.f.

the product of the accuracy limit factor, the rated secondary current and the vectorial sum of the rated burden and the impedance of the secondary winding

A2 2.3.5

class PR protective current transformer

a current transformer with limited remanence factor for which, in some cases, a value of the secondary loop time constant and/or a limiting value of the winding resistance may also be specified

2.3.6

saturation flux (Ψ_s)

that peak value of the flux which would exist in a core in the transition from the non-saturated to the fully saturated condition and deemed to be that point on the B-H characteristic for the core concerned at which a 10 % increase in B causes H to be increased by 50 %

2.3.7**remanent flux (Ψ_r)**

that value of flux which would remain in the core 3 min after the interruption of an exciting current of sufficient magnitude to induce the saturation flux (Ψ_s) defined in 2.3.6

2.3.8**remanence factor (K_r)**

the ratio $K_r = 100 \times \Psi_r/\Psi_s$, expressed as a percentage (%)

2.3.9**rated secondary loop time constant (T_s)**

value of the time constant of the secondary loop of the current transformer obtained from the sum of the magnetizing and the leakage inductance (L_s) and the secondary loop resistance (R_s)

$$T_s = L_s/R_s$$

2.3.10**excitation characteristic**

a graphical or tabular presentation of the relationship between the r.m.s value of the exciting current and a sinusoidal r.m.s e.m.f. applied to the secondary terminals of a current transformer, the primary and other windings being open-circuited, over a range of values sufficient to define the characteristics from low levels of excitation up to the rated knee point e.m.f.

2.3.11**class PX protective current transformer**

a transformer of low leakage reactance for which knowledge of the transformer secondary excitation characteristic, secondary winding resistance, secondary burden resistance and turns ratio is sufficient to assess its performance in relation to the protective relay system with which it is to be used

2.3.12**rated knee point e.m.f. (E_k)**

that minimum sinusoidal e.m.f. (r.m.s.) at rated power frequency when applied to the secondary terminals of the transformer, all other terminals being open-circuited, which when increased by 10 % causes the r.m.s. exciting current to increase by no more than 50 %

NOTE The actual knee point e.m.f. will be $\geq$ the rated knee point e.m.f.

2.3.13**rated turns ratio**

the required ratio of the number of primary turns to the number of secondary turns

EXAMPLE 1 1/600 (one primary turn with six hundred secondary turns).

EXAMPLE 2 2/1 200 (a current transformer of similar ratio to example 1 but employing two primary turns).

2.3.14**turns ratio error**

the difference between the rated and actual turns ratios, expressed as a percentage

$$\text{Turns ratio error} = \frac{\text{actual turns ratio} - \text{rated turns ratio}}{\text{rated turns ratio}} \times 100$$

2.3.15**dimensioning factor (K_x)**

a factor assigned by the purchaser to indicate the multiple of rated secondary current (I_{sn}) occurring under power system fault conditions, inclusive of safety factors, up to which the transformer is required to meet performance requirements $\triangleq$

3 Normal and special service conditions

Detailed information concerning classification of environmental conditions is given in the IEC 60721 series.

3.1 Normal service conditions

3.1.1 *Ambient air temperature*

The current transformers are classified in three categories as given in Table 1.

Table 1 — Temperature categories

Category	Minimum temperature °C	Maximum temperature °C
–5/40	–5	40
–25/40	–25	40
–40/40	–40	40

NOTE In the choice of the temperature category, storage and transportation conditions should also be considered.

3.1.2 *Altitude*

The altitude does not exceed 1 000 m.

3.1.3 *Vibrations or earth tremors*

Vibrations due to causes external to the current transformer or earth tremors are negligible.

3.1.4 *Other service conditions for indoor current transformers*

Other service conditions considered are the following:

- a) the influence of solar radiation may be neglected;
- b) the ambient air is not significantly polluted by dust, smoke, corrosive gases, vapours or salt;
- c) the conditions of humidity are as follows:
 - 1) the average value of the relative humidity, measured during a period of 24 h, does not exceed 95 %;
 - 2) the average value of the water vapour pressure for a period of 24 h does not exceed 2,2 kPa;
 - 3) the average value of the relative humidity, for a period of one month, does not exceed 90 %;
 - 4) the average value of the water vapour pressure, for a period of one month, does not exceed 1,8 kPa.

For these conditions, condensation may occasionally occur.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 To withstand the effects of high humidity and condensation, such as breakdown of insulation or corrosion of metallic parts, current transformers designed for such conditions should be used.

NOTE 3 Condensation may be prevented by special design of the housing, by suitable ventilation and heating or by the use of dehumidifying equipment.

3.1.5 *Other service conditions for outdoor current transformers*

Other service conditions considered are:

- a) average value of the ambient air temperature, measured over a period of 24 h, does not exceed 35 °C;
- b) solar radiation up to a level of 1 000 W/m² (on a clear day at noon) should be considered;
- c) the ambient air may be polluted by dust, smoke, corrosive gas, vapours or salt.

The pollution levels are given in Table 7:

- d) the wind pressure does not exceed 700 Pa (corresponding to 34 m/s wind speed);
- e) account should be taken of the presence of condensation or precipitation.

3.2 Special service conditions

When current transformers may be used under conditions different from the normal service conditions given in 3.1, the user's requirements should refer to standardized steps as follows.

3.2.1 Ambient air temperature

For installation in a place where the ambient temperature can be significantly outside the normal service condition range stated in 3.1.1, the preferred ranges of minimum and maximum temperature to be specified should be:

- $-50\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$ for very cold climates;
- $-5\text{ }^{\circ}\text{C}$ and $50\text{ }^{\circ}\text{C}$ for very hot climates.

In certain regions with frequent occurrence of warm humid winds, sudden changes of temperature may occur, resulting in condensation even indoors.

NOTE Under certain conditions of solar radiation, appropriate measures e.g. roofing, forced ventilation, etc. may be necessary, or derating may be used, in order not to exceed the specified temperature rises.

3.2.2 Altitude

For installation at an altitude higher than 1 000 m, the arcing distance under the standardized reference atmospheric conditions shall be determined by multiplying the withstand voltages required at the service location by a factor k in accordance with Figure 1.

NOTE As for the internal insulation, the dielectric strength is not affected by altitude. The method for checking the external insulation shall be agreed between manufacturer and purchaser.

3.2.3 Earthquakes

Requirements and testing are under consideration.

3.3 System earthing

The considered system earthings are:

- a) isolated neutral system (see 2.1.19);
- b) resonant earthed system (see 2.1.22);
- c) earthed neutral system (see 2.1.32):
 - 1) solidly earthed neutral system (see 2.1.20);
 - 2) impedance earthed (neutral) system (see 2.1.21).

4 Ratings

4.1 Standard values of rated primary currents

4.1.1 Single-ratio transformers

The standard values of rated primary currents are:

10 – 12,5 – 15 – 20 – 25 – 30 – 40 – 50 – 60 – 75 A,
and their decimal multiples or fractions.

The preferred values are those underlined.

4.1.2 Multi-ratio transformers

The standard values given in 4.1.1 refer to the lowest values of rated primary current.

4.2 Standard values of rated secondary currents

The standard values of rated secondary currents are 1 A, 2 A and 5 A, but the preferred value is 5 A.

NOTE For transformers intended for delta-connected groups, these ratings divided by $\sqrt{3}$ are also standard values.

4.3 Rated continuous thermal current

I_{A2} The standard value of rated continuous thermal current is the rated primary current.

When a rated continuous thermal current greater than rated primary current is specified, the preferred values should be 120 % to 150 % and 200 % of rated primary current. I_{A2}