

Instrument transformers —

Part 2: Inductive voltage transformers

The European Standard EN 60044-2:1999, with the incorporation of amendments A1:2000 and A2:2003 has the status of a British Standard

ICS 17.220.20; 29.180

National foreword

This British Standard is the English language version of EN 60044-2:1999, including amendments A1:2000 and A2:2003. It was derived by CENELEC from IEC 60044-2:1997, including amendments 1:2000 and 2:2002. It supersedes BS 7625:1993 which is withdrawn.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].

The UK participation in its preparation was entrusted to Technical Committee PEL/38, Instrument transformers, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Instrument transformers — Part 2: Inductive voltage transformers

(includes amendments A1:2000 and A2:2003)
(IEC 60044-2:1997 + A1:2000 + A2:2002, modified)

Transformateurs de mesure —
Partie 2: Transformateurs inductifs de tension
(inclut les amendements A1:2000 et A2:2003)
(CEI 60044-2:1997 + A1:2000 + A2:2002,
modifiée)

Meßwandler —
Teil 2: Induktive Spannungswandler
(enthält Änderungen A1:2000 und A2:2003)
(IEC 60044-2:1997 + A1:2000 + A2:2002,
modifiziert)

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CENELEC

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

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Foreword

The text of the International Standard IEC 60044-2:1997, 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 60044-2 on 1999-01-01.

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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 A1

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In this standard, Annex ZA is normative.

Annex ZA has been added by CENELEC.

Foreword to amendment A2

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1 General

1.1 Scope

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

Although this standard relates basically to transformers with separate windings, it is also applicable, where appropriate, to auto-transformers. This standard does not apply to transformers for use in laboratories.

NOTE Requirements specific to three-phase voltage transformers are not included in this standard but, so far as they are relevant, the requirements in Clauses 3 to 11 apply to these transformers and a few references to them are included in those clauses (e.g. see 2.1.4, 5.1.1, 5.2, and 11.2).

Clause 13 covers the requirements and tests, in addition to those in Clauses 3 to 12, that are necessary for single-phase inductive protective voltage transformers. The requirements of Clause 13 apply particularly to transformers which are required to have sufficient accuracy to operate protective systems at voltages that occur under fault conditions.

☐ 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 the EMC Directive. For a guidance of the test procedure EN 60694:1996, 6.3 might be followed.

Three-phase inductive voltages transformers are covered by HD 587 S1. ☐

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*.

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 60270:1981, *Partial discharge measurements*.

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

voltage transformer

an instrument transformer in which the secondary voltage, in normal conditions of use, is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections
[IEC 60321-03-01]

2.1.3

unearthed voltage transformer

a voltage transformer which has all parts of its primary winding, including terminals, insulated from earth to a level corresponding to its rated insulation level

2.1.4

earthed voltage transformer

a single-phase voltage transformer which is intended to have one end of its primary winding directly earthed or a three-phase voltage transformer which is intended to have the star-point of its primary winding directly earthed

2.1.5

primary winding

the winding to which the voltage to be transformed is applied

2.1.6

secondary winding

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

2.1.7

secondary circuit

the external circuit supplied by the secondary winding of a transformer

2.1.8

rated primary voltage

the value of the primary voltage which appears in the designation of the transformer and on which its performance is based
[IEV 321-01-12 modified]

2.1.9

rated secondary voltage

the value of the secondary voltage which appears in the designation of the transformer and on which its performance is based
[IEV 321-01-16 modified]

2.1.10

actual transformation ratio

the ratio of the actual primary voltage to the actual secondary voltage
[IEV 321-01-18 modified]

2.1.11

rated transformation ratio

the ratio of the rated primary voltage to the rated secondary voltage
[IEV 321-01-20 modified]

2.1.12

voltage error (ratio error)

the error which a transformer introduces into the measurement of a voltage and which arises when the actual transformation ratio is not equal to the rated transformation ratio
[IEV 321-01-22 modified]

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

$$\text{voltage error \%} = \frac{K_n U_s - U_p}{U_p} \times 100$$

where

K_n is the rated transformation ratio;

U_p is the actual primary voltage;

U_s is the actual secondary voltage when U_p is applied under the conditions of measurement.

2.1.13

phase displacement

the difference in phase between the primary voltage and the secondary voltage 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 voltage vector leads the primary voltage vector. It is usually expressed in minutes or centiradians.

NOTE This definition is strictly correct for sinusoidal voltages only.

2.1.14

accuracy class

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

2.1.15

burden

the admittance of the secondary circuit expressed in siemens and power factor (lagging or leading)

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

2.1.16

rated burden

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

2.1.17 output

2.1.17.1

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 voltage and with rated burden connected to it

[IEV 321-01-27 modified]

2.1.17.2

thermal limiting output

the value of the apparent power referred to rated voltage which can be taken from a secondary winding, at rated primary voltage applied, without exceeding the limits of temperature rise of **5.4**

NOTE 1 In this condition the limits of error may be exceeded.

NOTE 2 In the case of more than one secondary winding, the thermal limiting output is given separately.

NOTE 3 The simultaneous use of more than one secondary winding is not admitted unless there is an agreement between manufacturer and purchaser.

2.1.18

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 2.1.19**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

2.1.20**rated insulation level**

the combination of voltage values which characterizes the isolation of a transformer with regard to its capability to withstand dielectric stresses

2.1.21**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]

2.1.22**solidly earthed neutral system**

a system whose neutral point(s) is(are) earthed directly
[IEV 601-02-25]

2.1.23**impedance earthed (neutral) system**

a system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents
[IEV 601-02-26]

2.1.24**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 self-extinguishing.

2.1.25**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]

2.1.26**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 transient oscillations and to give a current sufficient for selective earth-fault protection:

- a) a three-phase 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 approximately when, for all system configurations, the ratio of zero-sequence reactance to the positive-sequence reactance is less than three and the ratio of zero-sequence resistance to positive-sequence reactance is less than one.

- b) a three-phase system with non-effectively earthed neutral at a given location is a system characterized by earth fault factor at this point that may exceed 1,4 **A₂**

A₂ 2.1.27**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.

2.1.28

non-exposed installation

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

NOTE Such installations are usually connected to underground cable networks.

2.1.29

rated frequency

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

2.1.30

rated voltage factor

the multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer must comply with the relevant thermal requirements for a specified time and with the relevant accuracy requirements

2.1.31

measuring voltage transformer

a voltage transformer intended to supply indicating instruments, integrating meters and similar apparatus **A₂**

2.2 Additional definitions for single-phase inductive protective voltage transformers

2.2.1

protective voltage transformer

a voltage transformer intended to provide a supply to electrical protective relays

2.2.2

residual voltage winding

the winding of a single-phase voltage transformer intended, in a set of three single-phase transformers, for connection in broken delta for the purpose of:

- a) producing a residual voltage under earth-fault conditions;
- b) damping of relaxation oscillations (ferro-resonances).

3 General requirements

All the transformers shall be suitable for measuring purposes, but, in addition, certain types may be suitable for protection purposes. Transformers for the dual purpose of measurement and protection shall comply with all clauses of this standard.

4 Normal and special service conditions

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

4.1 Normal service conditions**4.1.1 Ambient air temperature**

The voltage 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.

4.1.2 Altitude

The altitude does not exceed 1 000 m.

4.1.3 Vibrations or earth tremors

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

4.1.4 Other service conditions for indoor voltage transformers

Other considered service conditions 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, voltage 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.

4.1.5 Other service conditions for outdoor voltage transformers

Other considered service conditions are the following:

- 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 gases, vapours or salt. The pollution does not exceed the pollution levels given in Table 8;
- 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.

4.2 Special service conditions

When voltage transformers may be used under conditions different from the normal service conditions given in 4.1, the user's requirements should refer to standardized steps as follows.

4.2.1 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.

4.2.2 Ambient temperature

For installation in a place where the ambient temperature can be significantly outside the normal service condition range stated in 4.1.1, the preferred ranges of minimum and maximum temperature to be specified should be:

- a) -50 °C and 40 °C for very cold climates;
- b) -5 °C and 50 °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, in order not to exceed the specified temperature rises.

4.2.3 Earthquakes

Requirements and testing are under consideration.

4.3 System earthing

The considered system earthings are:

- a) isolated neutral system (see 2.1.21);
- b) resonant earthed system (see 2.1.24);
- c) earthed neutral system (see 2.1.26):
 - 1) solidly earthed neutral system (see 2.1.22);
 - 2) impedance earthed neutral system (see 2.1.23).

5 Ratings

5.1 Standard values of rated voltages

5.1.1 Rated primary voltages

The standard values of rated primary voltage of three-phase transformers and of single-phase transformers for use in a single-phase system or between lines in a three-phase system shall be one of the values of rated system voltage designated as being usual values in IEC 60038. The standard values of rated primary voltage of a single-phase transformer connected between one line of a three-phase system and earth or between a system neutral point and earth shall be $1/\sqrt{3}$ times one of the values of rated system voltage.

NOTE The performance of a voltage transformer as a measuring or protection transformer is based on the rated primary voltage, whereas the rated insulation level is based on one of the highest voltages for equipment of IEC 60038.

5.1.2 Rated secondary voltages

The rated secondary voltage shall be chosen according to the practice at the location where the transformer is to be used. The values given below are considered standard values for single-phase transformers in single-phase systems or connected line-to-line in three-phase systems and for three-phase transformers.

- a) Based on the current practice of a group of European countries:
 - 100 V and 110 V;
 - 200 V for extended secondary circuits.
- b) Based on the current practice in the United States and Canada:
 - 120 V for distribution systems;
 - 115 V for transmission systems;
 - 230 V for extended secondary circuits.

For single-phase transformers intended to be used phase-to-earth in three-phase systems where the rated primary voltage is a number divided by $\sqrt{3}$, the rated secondary voltage shall be one of the fore-mentioned values divided by $\sqrt{3}$, thus retaining the value of the rated transformation ratio.

NOTE 1 The rated secondary voltage for windings intended to produce a residual secondary voltage is given in 13.3.

NOTE 2 Whenever possible, the rated transformation ratio should be of a simple value. If one of the following values: 10 – 12 – 15 – 20 – 25 – 30 – 40 – 50 – 60 – 80 and their decimal multiples is used for the rated transformation ratio together with one of the rated secondary voltages of this subclause, the majority of the standard values of rated system voltage of IEC 60038 will be covered.

5.2 Standard values of rated output

The standard values of rated output at a power factor of 0,8 lagging, expressed in voltamperes, are:

10, 15, 25, 30, 50, 75, 100, 150, 200, 300, 400, 500 VA.

The values underlined are preferred values. The rated output of a three-phase transformer shall be the rated output per phase.

NOTE For a given transformer, provided one of the values of rated output is standard and associated with a standard accuracy class, the declaration of other rated outputs, which may be non-standard values but associated with other standard accuracy classes, is not precluded.

5.3 Standard values of rated voltage factor

The voltage factor is determined by the maximum operating voltage which, in turn, is dependent on the system and the voltage transformer primary winding earthing conditions.

The standard voltage factors appropriate to the different earthing conditions are given in Table 2 below, together with the permissible duration of maximum operating voltage (i.e. rated time).

Table 2 — Standard values of rated voltage factors

Rated voltage factor	Rated time	Method of connecting the primary winding and system earthing conditions
1,2	Continuous	Between phases in any network Between transformer star-point and earth in any network
1,2	Continuous	Between phase and earth in an effectively earthed neutral system [2.1.26a)]
1,5	30 s	
1,2	Continuous	Between phase and earth in a non-effectively earthed neutral system [2.1.26b)] with automatic earth-fault tripping
1,9	30 s	
1,2	Continuous	Between phase and earth in an isolated neutral system (2.1.21) without automatic earth-fault tripping or in a resonant earthed system (2.1.24) without automatic earth-fault tripping
1,9	8 h	
NOTE 1 The highest continuous operating voltage of an inductive voltage transformer is equal to the highest voltage for equipment (divided by $\sqrt{3}$ for transformers connected between a phase of a three-phase system and earth) or the rated primary voltage multiplied by the factor 1,2, whichever is the lowest.		
NOTE 2 Reduced rated times are permissible by agreement between manufacturer and user. A2		

5.4 Limits of temperature rise

Unless otherwise specified below, the temperature rise of a voltage transformer at the specified voltage, at rated frequency and at rated burden, or at the highest rated burden if there are several rated burdens, at any power factor between 0,8 lagging and unity, shall not exceed the appropriate value given in Table 3.

The voltage to be applied to the transformer shall be in accordance with item a), b) or c) below, as appropriate.

- a) All voltage transformers irrespective of voltage factor and time rating shall be tested at 1,2 times the rated primary voltage.

If a thermal limiting output is specified, the transformer shall be tested at rated primary voltage, at a burden corresponding to the thermal limiting output at a unity power factor without loading the residual voltage winding.

If a thermal limiting output is specified for one or more secondary windings, the transformer shall be tested separately with each of these windings connected, one at a time, to a burden corresponding to the relevant thermal limiting output at a unity power factor.

The test shall be continued until the temperature of the transformer has reached a steady state.

- b) Transformers having a voltage factor of 1,5 for 30 s or 1,9 for 30 s shall be tested at their respective voltage factor for 30 s starting after the application of 1,2 times rated voltage for a time sufficient to reach stable thermal conditions; the temperature rise shall not exceed by more than 10 K the value specified in Table 3.

Alternatively, such transformers may be tested at their respective voltage factor for 30 s starting from the cold condition; the winding temperature rise shall not exceed 10 K.

NOTE This test may be omitted if it can be shown by other means that the transformer is satisfactory under these conditions.

- c) Transformers having a voltage factor of 1,9 for 8 h shall be tested at 1,9 times the rated voltage for 8 h starting after the application of 1,2 times rated voltage for a time sufficient to reach stable thermal conditions; the temperature rise shall not exceed by more than 10 K the values specified in Table 3.

The values in Table 3 are based on the service conditions given in Clause 4.

If ambient temperatures in excess of the values given in 4.1 are specified, the permissible temperature rise in Table 3 shall be reduced by an amount equal to the excess ambient temperature.