

Australian Standard™

Instrument transformers

Part 5: Capacitor voltage transformers



This Australian Standard was prepared by Committee EL-013, Measurement and Protection Transformers. It was approved on behalf of the Council of Standards Australia on 25 November 2003 and published on 30 January 2004.

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Australian Standard™

Instrument transformers

Part 5: Capacitor voltage transformers

Originated as part of AS C45—1928.
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PREFACE

This Standard was prepared by the Standards Australia Committee EL-013, Measurement and Protection Transformers to partially supersede AS 1243—2982 for capacitor voltage transformers one year after publication. During this period, it is anticipated that regulatory authorities will approve current transformers to either Standard. AS 1243—1982 will continue to apply to three-phase voltage transformers only.

The objective of this Standard is to provide users and manufacturers of capacitor voltage transformers with definitions of terms, safety requirements, methods of specifying performance and methods of test.

This Standard is Part Five of a series covering instrument transformers. The series consists of the following Standards:

AS

- 60044 Instrument transformers
- 60044.1 Part 1: Current transformers
- 60044.2 Part 2: Single-phase inductive voltage transformers
- 60044.3 Part 3: Combined transformers
- 60044.5 Part 5: Capacitor voltage transformers (this Standard)

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STANDARDS AUSTRALIAN

Australian Standard**Instrument transformers****Part 5: Capacitor voltage transformers****1 Scope**

This PAS which is a part of International Standard IEC 60044 applies to new single-phase capacitor voltage transformers connected between line and ground for system voltages $U_m \geq 72,5$ kV at power frequencies from 15 Hz to 100 Hz. They are intended to supply a low voltage for measurement, control and protective functions.

The capacitor voltage transformer can be equipped with or without carrier-frequency accessories for power line carrier-frequency (PLC) application at carrier frequencies from 30 kHz to 500 kHz.

The future standard that should supersede the present PAS will replace the IEC 60186 regarding capacitor voltage transformers.

Three standards formed the basis for this IEC-PAS 60044-5:

- IEC 60044-2; concerning inductive voltage transformers;
- IEC 60358, concerning coupling capacitors and capacitor dividers;
- IEC 60481, concerning coupling devices for power line carrier (PLC) systems.

The application measurement function includes both indication measuring and revenue measuring.

NOTE Diagrams of capacitor voltage transformer to which this document applies are given in figures A.1 and A.2.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

IEC 60028:1925, *International standard of resistance for copper*

~~IEC 60038:1983, IEC Standard voltages~~

AS 60038—2000, *Standard voltages*

~~IEC 60044-2:1997, Instrument transformers—Part 2: Inductive voltage transformers~~

AS 60044.2—2003, *Instrument transformers—voltage transformers* (identical to IEC 60044.2:1997 and Amendment 1:2000)

~~IEC 60050-321:1986, International Electrotechnical Vocabulary—Chapter 321: Instrument transformers~~

AS 1852.321—1988, *International Electrotechnical Vocabulary, Part 321: Instrument transformers* (identical to IEC 60050-321:1986)

IEC 60050-436:1990, *International Electrotechnical Vocabulary – Chapter 436: Power capacitors*

~~IEC 60050-601:1985, International Electrotechnical Vocabulary—Chapter 601: Generation, transmission and distribution of electricity—General~~

AS 1852.601—1988, *International Electrotechnical Vocabulary, Part 601: Generation, transmission and distribution of electricity—General* (identical to IEC 60050-601:1985)

~~IEC 60050-604:1987, International Electrotechnical Vocabulary—Chapter 604: Generation, transmission and distribution of electricity—Operation~~

AS 1852.604—1988, *International Electrotechnical Vocabulary, Part 604: Generation, transmission and distribution of electricity—Operation* (identical to IEC 60050-604:1987)

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

AS 1931—1996, *High-voltage test techniques—General definitions and test requirements* (Identical to IEC 60061-1:1989 and its corrigendum:1992)

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

AS 1824.1—1995, *Insulation co-ordination, Part 1: Definitions, principles and rules* (identical to IEC 60071-1:1993)

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

IEC 60233:1974, *Tests on hollow insulators for use in electrical equipment*

~~IEC 60270:1981, Partial discharge measurements~~

AS 60270—2001, *High-voltage test techniques – Partial discharge measurements*

IEC 60358:1990, *Coupling capacitors and capacitor dividers*

IEC 60481:1974, *Coupling devices for power line carrier systems*

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

AS 4436—1996, *Guide for the selection of insulators in respect of polluted conditions* (identical to IEC 60815:1986)

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*

3 Definitions

For the purpose of this part of IEC 60044, the following definitions shall apply. Some of these definitions are identical with or are similar to those of IEC 60050, Chapters 321, 436, 601 and 604. These are indicated by the relevant IEV reference number in brackets.

3.1 General definitions

3.1.1 capacitor voltage transformer (CVT)

a voltage transformer comprising a capacitor divider unit and an electromagnetic unit so designed and interconnected that the secondary voltage of the electromagnetic unit 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 and rated frequency. [IEV 321-03-14 modified]

3.1.2 rated frequency of a capacitor voltage transformer (f_R)

the frequency for which the capacitor voltage transformer has been designed.

3.1.3 standard reference range of frequency

the range of frequency for which the rated accuracy is applicable.

3.1.4 rated primary voltage (U_{PR})

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

3.1.5 rated secondary voltage (U_{SR})

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

3.1.6 secondary winding

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

3.1.7 secondary circuit

the external circuit supplied by the secondary winding of a transformer.

3.1.8 actual transformation ratio

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

3.1.9 rated transformation ratio (K_R)

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

3.1.10 voltage error (ratio error) for steady state conditions (ε_u)

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

NOTE This definition is only related to components at rated frequency of both primary and secondary voltages, and does not take into account direct voltage components and residual voltages.

$$\text{Voltage error } \varepsilon_u = \frac{K_R U_S - U_P}{U_P} 100 \%$$

where: K_R is the rated transformation ratio,

U_P is the actual primary voltage and

U_S is the actual secondary voltage when U_P is applied under the conditions of measurement.

3.1.11 phase displacement (ϕ_U)

the difference in phase between the primary and the secondary voltage phasors:

$$\phi_U = (\phi_S - \phi_P)$$

The direction of the phasors being so chosen that the angle (ϕ_U) is zero for a perfect transformer. The phase displacement is said to be positive when the secondary voltage phasor (ϕ_S) leads the primary voltage phasor (ϕ_P). It is usually expressed in minutes or centiradians. [IEV 321-01-23 modified]

NOTE This definition is strictly correct for sinusoidal voltages only.

3.1.12 accuracy class

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

3.1.13 burden

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

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

3.1.14 rated burden

value of the burden on which the accuracy requirements of this document are based.

3.1.15 output

a) rated output

the value of the apparent power (in volt-amperes at a specified power factor), which the capacitor voltage 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]

b) thermal limiting output

the value of the apparent power in volt-amperes 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 6.5.

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 to be given separately for each winding.

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

3.1.16 highest voltage for equipment (U_m)

the highest r.m.s. value of phase-to-phase voltage for which the equipment is designed and may be used in respect of its insulation.

3.1.17 rated insulation level

the combination of voltage values which characterises the insulation of a transformer with regard to its capability to withstand dielectric stresses.

3.1.18 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]

3.1.19 solidly earthed neutral system

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

3.1.20 impedance earthed (neutral) system

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

3.1.21 resonant earthed (neutral) system

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.

3.1.22 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]

3.1.23 earthed neutral system

system in which the neutral is connected to earth either solidly or through a resistance or reactance of sufficiently low 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 3 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 an earth fault factor at this point that may exceed 1,4.

3.1.24 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.

3.1.25 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.

3.1.26 measuring capacitor voltage transformer

a capacitor voltage transformer intended to supply indicating instruments, integrating meters and similar apparatus.

3.1.27 protective capacitor voltage transformer

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

3.1.28 residual voltage winding

the winding of a single-phase capacitor voltage transformer intended, in a set of three single-phase transformers, for connection in broken delta for the purpose of producing a residual voltage under earth-fault conditions.

3.1.29 rated voltage factor (F_V)

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

3.1.30 rated temperature category of a capacitor voltage transformer

the range of temperature of the ambient air or of the cooling medium for which the capacitor voltage transformer has been designed.

3.1.31 high voltage terminal

terminal intended for connection to a line conductor of a network. [IEV 436-03-01]

3.1.32 ferro-resonance

sustained resonance of a circuit consisting of a capacitance with a non-linear saturable magnetic inductance.

NOTE The ferro-resonance can be initiated by switching operations on the primary side or secondary side.

3.1.33 transient response

the measured fidelity of the secondary-voltage waveform, compared with the voltage waveform at the high-voltage terminal under transient conditions.

3.1.34 mechanical stress

the stresses on different parts of the capacitor voltage transformer as a function of four main forces:

- forces on the terminals due to the line connections,
- forces due to the wind on the cross-section of the capacitor voltage transformer with and without line trap mounted on the top of the coupling capacitor,
- seismic forces and
- electro dynamic forces due to short circuit current.

3.1.35 voltage-connected CVT

the CVT is voltage-connected when there is only one connection to the high voltage line.

NOTE Under normal conditions the top connection carries only the current of the capacitor voltage transformer.

3.1.36 current-connected CVT

the CVT is current-connected when there are two connections to the high voltage line.

NOTE The terminals and the top connection are designed to carry under normal conditions the line current.

3.1.37 line trap-connected CVT

the CVT is line trap-connected when it supports a line trap on its top. In this case, the two connections to the line trap carry the HV line current and one connection from the line trap to the CVT carries the CVT current.

NOTE The pedestal mounting line traps in two phases are generating additional forces during a short circuit in more than one phase.

3.2 Capacitor voltage divider definitions

3.2.1 capacitor voltage divider

a capacitor stack forming an alternating voltage divider. [IEV 436-02-10]

3.2.2 capacitor element

a device consisting essentially of two electrodes separated by a dielectric. [IEV 436-01-03]

3.2.3 capacitor unit

an assembly of one or more capacitor elements in the same container with terminals brought out. [IEV 436-01-04]

NOTE A common type of unit for coupling capacitors has a cylindrical housing of insulating material and metallic flanges which serve as terminals.

3.2.4 capacitor stack

an assembly of capacitor units connected in series. [IEV 436-01-05]

NOTE The capacitor units are usually mounted in a vertical array.

3.2.5 capacitor

a general term used when it is not necessary to state whether reference is made to a capacitor unit or to a capacitor stack.

3.2.6 rated capacitance of a capacitor (C_R)

the capacitance value for which the capacitor has been designed.

NOTE This definition applies:

- for a capacitor unit, to the capacitance between the terminals of the unit;
- for a capacitor stack, to the capacitance between line and low voltage terminals or between line and earth terminals of the stack;
- for a capacitor divider, to the resultant capacitance: $C_R = C_1 C_2 / (C_1 + C_2)$.

3.2.7 coupling capacitor

a capacitor used for the transmission of signals in a power system. [IEV 436-02-11]

3.2.8 high voltage capacitor (of a capacitor divider) (C_1)

the capacitor connected between the line terminal and the intermediate voltage terminal of a capacitor divider. [IEV 436-02-12 modified]

3.2.9 intermediate voltage capacitor (of a capacitor divider) (C_2)

the capacitor connected between the intermediate voltage and the low voltage terminals of a capacitor divider. [IEV 436-02-13]

3.2.10 intermediate voltage terminal of a capacitor divider

a terminal intended for connection to an intermediate circuit, such as the electromagnetic unit of a capacitor voltage transformer. [IEV 436-03-03]

3.2.11 low voltage terminal of a capacitor divider

a terminal (N) intended for connection to earth either directly or via a drain coil of negligible value of impedance, at rated frequency, for power line carrier (PLC) application. [IEV 436-03-04 modified]

3.2.12 capacitance tolerance

the permissible difference between the actual capacitance and the rated capacitance under specified conditions. [IEV 436-04-01]

3.2.13 equivalent series resistance of a capacitor

virtual resistance which, if connected in series with an ideal capacitor of capacitance value equal to that of the capacitor in question, would have a power loss equal to the active power dissipated in that capacitor under specified operating conditions at a given high frequency.

3.2.14 high frequency capacitance

the effective capacitance at a given frequency resulting from the joint effect of the intrinsic capacitance and the self-inductance of a capacitor. [IEV 436-04-03]

3.2.15 intermediate voltage of a capacitor divider (U_C)

the voltage between the intermediate voltage terminal of the capacitor divider and the low voltage terminal, when the primary voltage is applied between the high and low voltage terminals or high voltage terminal and earth terminal.

3.2.16 rated voltage ratio of a capacitor divider (K_{CR})

the ratio of the voltage applied to the capacitor divider to the open-circuit intermediate voltage. [IEV 436-04-05]

NOTE 1 This ratio corresponds to the sum of the capacitances of the high voltage and intermediate voltage capacitors divided by the capacitance of the high voltage capacitor: $(C_1 + C_2) / C_1 = K_{CR}$.

NOTE 2 C_1 and C_2 include the stray capacitances, which are generally negligible.

3.2.17 capacitor losses

the active power dissipated in the capacitor. [IEV 436-04-10]

3.2.18 tangent of the loss angle ($\tan\delta$) of a capacitor

the ratio between the active power P_a and the reactive power P_r : $\tan\delta = P_a/P_r$.

3.2.19 temperature coefficient of capacitance (T_C)

the fractional change of the capacitance for a given change in temperature:

$$T_C = \frac{\frac{\Delta C}{\Delta T}}{C_{20\text{ }^\circ\text{C}}} \left[\frac{1}{\text{K}} \right]$$

ΔC represents the observed change in capacitance over the temperature interval ΔT

$C_{20\text{ }^\circ\text{C}}$ represents the capacitance measured at 20 °C.

NOTE The term $\Delta C/\Delta T$ according to this definition is usable only if the capacitance is an approximate linear function of the temperature in the range under consideration. If not, the temperature dependency of the capacitance should be shown in a graph or a table.

3.2.20 stray capacitance of the low voltage terminal

the stray capacitance between the low voltage terminal and the earth terminal.

3.2.21 stray conductance of the low voltage terminal

the stray conductance between the low voltage terminal and the earth terminal.

3.2.22 dielectric of a capacitor

the insulating material between the electrodes.

3.3 Electromagnetic unit definitions

3.3.1 electromagnetic unit

the component of a capacitor voltage transformer, connected between the intermediate voltage terminal and the earth terminal of the capacitor divider (or possibly directly connected to earth when a carrier-frequency coupling device is used) which supplies the secondary voltage.

NOTE An electromagnetic unit essentially comprises a transformer to reduce the intermediate voltage to the required value of secondary voltage, and a compensating inductance approximately equal, at rated frequency to the capacitive reactance of the two parts of the divider connected in parallel ($C_1 + C_2$). The compensating inductance may be incorporated wholly or partially in the transformer.

3.3.2 intermediate transformer

a voltage transformer in which the secondary voltage, in normal conditions of use, is substantially proportional to the primary voltage.

3.3.3 compensating inductance

an inductance which is usually connected between the intermediate terminal and the high voltage terminal of the primary winding of the intermediate transformer or between earth terminal and the earth-side terminal of the primary winding of the intermediate transformer or incorporated in the primary and secondary windings of the intermediate transformer.

NOTE The design value L of the inductance is $L = \frac{1}{(C_1 + C_2) \cdot (2\pi f_R)^2}$

3.3.4 damping device

devices incorporated in the electromagnetic unit for the purposes of:

- a) limiting overvoltages which may appear across one or more components;
- b) and/or to prevent sustained ferro-resonance;
- c) and/or to achieve a higher performance of the transient response of the capacitor voltage transformer.

3.4 Carrier-frequency accessories definitions

3.4.1 carrier-frequency accessories

circuit element intended to permit the injection of carrier frequency signal and which is connected between the low voltage terminal of a capacitor divider unit and earth, having an impedance which is insignificant at power frequency, but appreciable at the carrier frequency. (see figure A.2)

3.4.2 drain coil

an inductance which is connected between the low voltage terminal of a capacitor divider and earth. The impedance of the drain coil is insignificant at power frequency, but has a high value at the carrier frequency.

3.4.3 voltage limitation element

an element connected across the drain coil or between low voltage terminal of the capacitor voltage divider and earth to limit the overvoltages which appear across the drain coil:

- a) at a short circuit between the high-voltage terminal and earth;
- b) in the case where an impulse voltage is applied between the high voltage terminal and earth.

3.4.4 carrier earthing switch

a switch for earthing, when necessary, of the low voltage terminal.

4 General requirements

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

5 Service conditions

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

5.1 Normal service conditions

5.1.1 Ambient air temperature

The capacitor voltage transformers are classified in three categories as given in table 1.

Table 1 – Rated ambient 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.		

5.1.2 Altitude

The altitude does not exceed 1 000 m.

5.1.3 Vibrations or earth tremors

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

5.1.4 Other service conditions for indoor capacitor 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 %; 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 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, capacitor 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.

5.1.5 Other service conditions for outdoor capacitor 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 6;
- 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.

5.2 Special service conditions

When capacitor voltage transformers may be used under conditions different from the normal service conditions given in 5.1, the user's requirements should refer to standardized steps as follows.

5.2.1 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 factor k in accordance with figure 1.

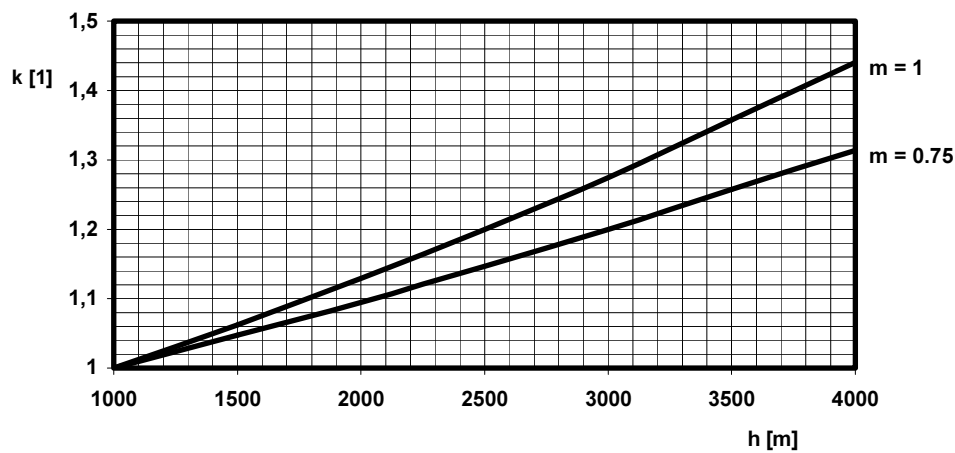


Figure 1 – Altitude correction factor for the insulation

These factors can be calculated with the following equation:

$$k = e^{m (H - 1000)/8150}$$

where

H is the altitude in metres;

$m = 1$ for power-frequency and lightning impulse voltage;

$m = 0,75$ for switching impulse voltage.

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.

5.2.2 Ambient temperature

For installation in a place where the ambient temperature can be significantly outside the normal service condition range stated in 5.1.1, the preferred ranges of minimum and maximum temperature to be specified should be:

- a) $-50\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$ for very cold climates;
- b) $-5\text{ }^{\circ}\text{C}$ 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, in order not to exceed the specified temperature rises.

5.2.3 Earthquakes

Requirements and testing are under consideration.

5.3 System earthing

The considered system earthings are:

- a) isolated neutral system (see 3.1.18);
- b) resonant earthed system (see 3.1.21);
- c) earthed neutral system (see 3.1.23):
 - 1) solidly earthed neutral system (see 3.1.19)
 - 2) impedance earthed (neutral) system (see 3.1.20).

6 Ratings

6.1 Standard values of rated frequency

Standard values are 50 and 60 Hz.

6.2 Standard values of rated voltages

6.2.1 Rated primary voltages U_{PR}

The standard values of rated primary voltage of a capacitor voltage 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 the values of rated system voltage.

Preferred values are given in IEC 60038.

NOTE The performance of a capacitor voltage transformer as a measuring or protection transformer is based on the rated primary voltage U_{PR} whereas the rated insulation level is based on one of the highest voltages for equipment U_m of IEC 60071-1.

6.2.2 Rated secondary voltages

The rated secondary voltage U_{SR} 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 capacitor voltage transformers connected between one phase and earth in three-phase systems.

- 1) $\frac{100}{\sqrt{3}}$ V and $\frac{110}{\sqrt{3}}$ V;
- 2) Based on the current practice in some countries:
 - a) $\frac{120}{\sqrt{3}}$ V for distribution systems;
 - b) $\frac{115}{\sqrt{3}}$ V for transmission systems.

NOTE 1 The rated secondary voltage for windings intended to produce a residual voltage is given in 15.6.1.

NOTE 2 Whenever possible, the rated transformation ratio should be of a simple value.

6.3 Standard values of rated output

The standard values of rated output at a power factor of 1, expressed in volt-amperes, are: 1,0; 1,5; 2,5; 3,0; 5,0; 7,5 VA (burden range I, in 9.8).

The standard values of rated output at a power factor of 0.8 lagging, expressed in volt-amperes, are: 10; 15; 25; 30; 40; 50; 100 VA (burden range II, in 9.8).

The values underlined are preferred values.

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 classes, is not precluded.

6.4 Standard values of rated voltage factor

The voltage factor is determined by the maximum operating voltage which, in turn, is dependent on the system 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 for accuracy and thermal requirements

Rated voltage factor F_v	Rated time	Method of connecting the primary terminal and system earthing conditions
1,2	Continuous	Between phase and earth in an effectively earthed neutral system (3.1.23 a)
1,5	30 s	
1,2	Continuous	Between phase and earth in a non-effectively earthed neutral system (3.1.23 b) with automatic earth-fault tripping.
1,9	30 s	
1,2	Continuous	Between phase and earth in an isolated neutral system (3.1.18) without automatic earth-fault tripping or in a resonant earthed system (3.1.21) without automatic earth-fault tripping.
1,9	8 h	

NOTE 1 Reduced rated times are permissible by agreement between manufacturer and user.

NOTE 2 The thermal and accuracy requirements of a capacitor voltage transformer are based on the primary rated voltage whereas the rated insulation level is based on the highest voltage for equipment U_m (IEC 60071-1).

NOTE 3 The maximum operating voltage of a capacitor voltage transformer must be lower or equal to the highest voltage of equipment $\frac{U_m}{\sqrt{3}}$ or the rated primary voltage U_{PR} multiplied with the rated voltage factor 1.2 for continuous service, whichever is the lowest.

6.5 Limits of temperature rise

Unless otherwise specified, the temperature rise ΔT of a capacitor 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.

If ambient temperatures in excess of the values given in 5.1 are specified, the permissible temperature rise ΔT in table 3 shall be reduced by an amount equal to the excess ambient temperature.

If a capacitor voltage transformer is specified for service at an altitude in excess of 1 000 m and tested at an altitude below 1 000 m, the limits of temperature rise ΔT given in table 3 shall be reduced by the following amounts for each 100 m that the altitude at the operating site exceeds 1 000 m:

- a) oil-immersed magnetic units: 0,4 %;

b) dry-type magnetic units: 0,5 %.

The altitude correction factor for the temperature rise $K_o = \frac{\Delta T_h}{\Delta T_{ho}}$ with

ΔT_h temperature rise at altitude $h > 1000$ m and

ΔT_{ho} limits of temperature rise ΔT specified in table 3 at altitudes $h_o \leq 1000$ m.

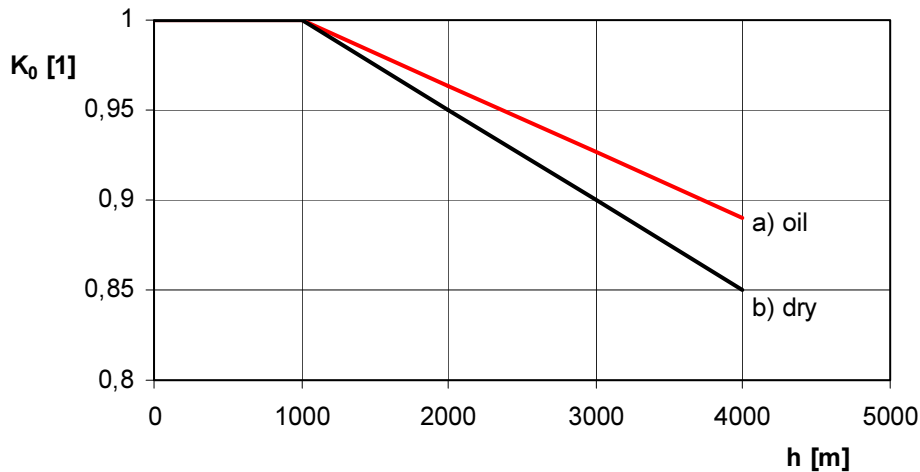


Figure 2 – Altitude correction factor for the temperature rise

The temperature rise ΔT of the windings is referred to the lowest class of insulation either of the winding itself or of the surrounding medium in which it is embedded. The maximum temperature rises of the insulation classes are as given in table 3.

Table 3 – Limits of temperature rise of windings

Class of insulation (in accordance with IEC 60085)	Maximum temperature rise ΔT in K
All classes, immersed in oil When the magnetic unit is not so fitted or arranged, the temperature rise ΔT of the oil at the top of the housing shall not exceed 50 K.	60
All classes, immersed in oil and hermetically sealed When the magnetic unit has an inert gas above the oil, or is hermetically sealed, the temperature rise ΔT of the oil at the top of the housing shall not exceed 55 K.	65
All classes, immersed in bituminous compound	50
Classes not immersed in oil or bituminous compound:	
Y	45
A	60
E	75
B	85
F	110
H	135
The temperature rise ΔT measured on the external surface of the core and other metallic parts which are in contact with, or adjacent to, insulation shall not exceed the appropriate values.	
NOTE For some materials (e.g. resin) the manufacturer should specify the relevant insulation class.	