BS EN 61869-1:2009

BSI Standards Publication

Instrument transformers —

Part 1: General requirements

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National foreword

This British Standard is the UK implementation of EN 61869-1:2009. It was derived by CENELEC from IEC 61869-1:2007.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by tags (e.g. [C〉 〈C]).

The UK participation in its preparation was entrusted to Technical Committee PEL/38, Instrument transformers.

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

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Instrument transformers -
Part 1: General requirements
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Messwandler -
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(IEC 61869-1:2007, modifiziert)

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

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 38/360/FDIS, future edition 1 of IEC 61869-1, prepared by IEC TC 38, Instrument transformers, was submitted to the IEC-CENELEC parallel vote and, together with a number of editorial modifications drafted by the Technical Committee CENELEC TC 38X, Instrument transformers, to answer the EMC Consultant's remarks, it was approved by CENELEC as EN 61869-1 on 2009-07-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2010-04-01

– latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2012-07-01

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 2004/108/EC. See Annex ZZ.

IEC TC 38 decided to restructure the whole set of stand-alone standards in the IEC 60044 series and transform it into a new set of standards composed of general requirements documents and specific requirements documents.

This standard is the first issue of this new series and can be regarded as a Product Family standard. It contains the general requirements for instrument transformers and shall be read in conjunction with the relevant specific requirements standard for the instrument transformer concerned.

An overview of the planned set of standards is given below:

<table>
<tr><th colspan="2">PRODUCT FAMILY STANDARDS</th><th>PRODUCT STANDARD</th><th>PRODUCTS</th><th>OLD STANDARD</th></tr>
<tr><td rowspan="8">61869-1
GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS</td><td rowspan="5"></td><td>61869-2</td><td>CURRENT TRANSFORMERS</td><td>60044-1</td></tr>
<tr><td>61869-3</td><td>INDUCTIVE VOLTAGE TRANSFORMERS</td><td>60044-2</td></tr>
<tr><td>61869-4</td><td>COMBINED TRANSFORMERS</td><td>60044-3</td></tr>
<tr><td>61869-5</td><td>CAPACITIVE VOLTAGE TRANSFORMERS</td><td>60044-5</td></tr>
<tr><td>61869-6</td><td>CURRENT TRANSFORMERS FOR TRANSIENT PERFORMANCE</td><td>60044-6</td></tr>
<tr><td rowspan="2">61869-9
ADDITIONAL REQUIREMENTS AND DIGITAL INTERFACE FOR ELECTRONIC INSTRUMENT TRANSFORMERS</td><td>61869-7</td><td>ELECTRONIC VOLTAGE TRANSFORMERS</td><td>60044-7</td></tr>
<tr><td>61869-8</td><td>ELECTRONIC CURRENT TRANSFORMERS</td><td rowspan="2">60044-8</td></tr>
<tr><td></td><td>61869-10</td><td>LOW-POWER STAND-ALONE CURRENT SENSORS</td></tr>
</table>

This standard covers all general requirements formerly found in the stand-alone standards of the EN 60044 series. Additionally, it introduces some technical innovations:

– requirements for gas-insulated instrument transformers,
– additional special tests,
– requirements for internal arc fault protection,
– requirements for degrees of protection by enclosure,
– requirements for resistance to corrosion,
– requirements for safety and environmental concerns.

Annexes ZA and ZZ have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61869-1:2007 was approved by CENELEC as a European Standard with agreed common modifications.

CONTENTS

INSTRUMENT TRANSFORMERS –

Part 1: General requirements

1 Scope

This International Standard is applicable to newly manufactured instrument transformers with analogue or digital output for use with electrical measuring instruments or electrical protective devices having rated frequencies from 15 Hz to 100 Hz.

This standard is a product family standard and covers general requirements only. For each kind of instrument transformer the product standard is composed by this standard and the relevant specific standard.

2 Normative references

The following referenced documents are essential for the application 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 60060-1: *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-11: *Basic environmental testing procedures – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-17: *Basic environmental testing procedures – Part 2: Tests - Test Q: Sealing*

IEC 60068-2-75: *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests.*

IEC 60071-1: *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60085: *Electrical insulation – Thermal classification*

IEC 60270: *High-voltage test techniques – Partial discharge measurements*

IEC 60296: *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60376: *Specification of technical grade sulfur hexafluoride (SF_6) for use in electrical equipment*

IEC 60417: *Graphical symbols for use on equipment*

IEC 60455 (all parts): *Resin based reactive compounds used for electrical insulation*

IEC 60480: *Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use*

IEC 60529: *Degrees of protection provided by enclosures (IP code)*

IEC 60567: *Oil-filled electrical equipment – Sampling of gases and of oil for analysis of free and dissolved gases – Guidance*

IEC 60694: *Common specifications for high-voltage switchgear and controlgear standards*

IEC 60695-1-1: *Fire hazard testing – Part 1-1: Guidance for assessing the fire hazard of electrotechnical products - General guidelines*

IEC 60695-1-30: *Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Use of preselection testing procedures*

IEC 60695-7-1: *Fire hazard testing – Part 7-1: Toxicity of fire effluent - General guidance*

IEC 60721-3-3: *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use of weatherprotected locations*

IEC 60721-3-4: *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations*

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

IEC 60867: *Insulating liquids – Specifications for unused liquids based on synthetic aromatic hydrocarbons*

IEC 61462: *Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater that 1 000 V – Definitions, test methods and acceptance criteria and design recommendations*

IEC 61634: *High-voltage switchgear and controlgear – Use and handling of sulphur hexafluoride (SF_6) in high-voltage switchgear and controlgear*

IEC 62155: *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*

IEC 62262: *Degree of protection IK code*

IEC 62271-2: *High-voltage switchgear and controlgear – Part 2: Seismic qualification for rated voltages of 72,5 kV and above.*

IEC 62271-203: *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

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

IEC Guide 109: *Environmental aspects – Inclusion in electrotechnical product standards*

ISO 3231: *Paints and varnishes – Determination of resistance to humid atmospheres containing sulphur dioxide*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General definitions

3.1.1
instrument transformer
transformer intended to transmit an information signal to measuring instruments, meters and protective or control devices or similar apparatus

[IEV 321-01-01, modified]

3.1.2
enclosure
housing affording the type and degree of protection suitable for the intended application

[IEV 826-12-20]

3.1.3
primary terminals
terminals to which the voltage or current to be transformed is applied

3.1.4
secondary terminals
terminals which transmit an information signal to measuring instruments, meters and protective or control devices or similar apparatus

3.1.5
secondary circuit
the external circuit receiving the information signals supplied by the secondary terminals of an instrument transformer

[IEV 321-01-08, modified]

3.1.6
section
electrically conductive part of an instrument transformer insulated from other similar parts and equipped with terminals

3.2 Definitions related to dielectric ratings

3.2.1
highest voltage of a system (U_{sys})
highest value of the phase-to-phase operating voltage (r.m.s. value) which occurs under normal operating conditions at any time and at any point in the system

[IEV 601-01-23, modified]

3.2.2
highest voltage for equipment (U_m)
the highest r.m.s. value of phase-to-phase voltage for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards

[IEV 604-03-01]

3.2.3
rated insulation level
combination of voltage values which characterizes the insulation of a transformer with regard to its capability to withstand dielectric stresses

3.2.4
isolated neutral system
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]

3.2.5
resonant earthed system (a system earthed through an arc-suppression coil)
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.

3.2.6
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. value of 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]

3.2.7
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.

3.2.8
solidly earthed neutral system
system whose neutral point(s) is(are) earthed directly

[IEV 601-02-25]

3.2.9
impedance earthed neutral system
system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents

[IEV 601-02-26]

3.2.10
exposed installation
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.

3.2.11
non-exposed installation
installation in which the apparatus is not subject to overvoltages of atmospheric origin

NOTE Such installations are usually connected to underground cable networks.

3.3 Definitions related to current ratings

See specific requirements standard.

3.4 Definitions related to accuracy

3.4.1
actual transformation ratio *(k)*
ratio of the actual primary voltage or current to the actual secondary voltage or current

3.4.2
rated transformation ratio *(k_r)*
ratio of the rated primary voltage or current to the rated secondary voltage or current

3.4.3
ratio error *(ε)*
the error which an instrument transformer introduces into the measurement and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio

3.4.4
phase displacement *(Δφ)*
difference in phase between the primary voltage or current and the secondary voltage or current phasors, the direction of the phasors being so chosen that the angle is zero for an ideal transformer.

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

NOTE 1 This definition is strictly correct for sinusoidal voltages or currents only.

NOTE 2 Electronic instrument transformers may introduce a delay time due to a digital data transmission and by digital signal processing.

[IEV 321-01-23, modified]

3.4.5
accuracy class
a designation assigned to an instrument transformer, the ratio error and phase displacement of which remain within specified limits under prescribed conditions of use

[IEV 321-01-24, modified]

3.4.6
burden
admittance (or impedance) of the secondary circuit expressed in siemens (or ohms) and power factor

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 or current.

3.4.7
rated burden
value of the burden on which the accuracy requirements of this specification are based.

3.4.8
rated output *(S_r)*
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 or current and with rated burden connected to it

3.5 Definitions related to other ratings

3.5.1
rated frequency *(f_R)*
value of the frequency on which the requirements of this standard are based

3.5.2
mechanical load *(F)*
forces on different parts of the instrument transformer as a function of four main forces:

– forces on the terminals due to the line connections,
– forces due to the wind,
– seismic forces,
– electro dynamic forces due to short circuit current

3.5.3
internal arc fault protection instrument transformer
instrument transformer designed in such a way to ensure an assigned protection level against internal arc fault

3.6 Definitions related to gas insulation

3.6.1
pressure relief device
a device suitable to limit dangerous over-pressures inside the instrument transformer

3.6.2
gas-insulated metal-enclosed instrument transformer
metal-enclosed instrument transformer intended to be mounted on Gas-Insulated Switchgear (GIS), inside or outside the switchgear enclosure

3.6.3
closed pressure system
volume that is replenished only periodically by manual connection to an external gas source

3.6.4
rated filling pressure
pressure referred to the standard atmospheric air conditions (20 °C and 101,3 kPa) to which the gas-insulated instrument transformer is filled before being put in service, or periodicaly replenished

3.6.5
minimum functional pressure
pressure referred to the standard atmospheric air conditions (20 °C and 101,3 kPa) at which, and above which, rated insulation and other characteristics of the gas-insulated instrument transformer are maintained and at which gas replenishment becomes necessary

3.6.6
design pressure of the enclosure
pressure used to determine the thickness of the enclosure. It is at least equal to the maximum pressure of the enclosure at the highest temperature that the gas used for insulation can reach under maximum service conditions.

3.6.7
design temperature of the enclosure
highest temperature that can be reached by the enclosure under service conditions

3.6.8
absolute leakage rate
amount of gas escaped by time unit, expressed in Pa.m^3/s

3.6.9
relative leakage rate (F_{rel})
absolute leakage rate related to the total amount of gas in the instrument transformer at rated filling pressure (or density). It is expressed in percentage per year.

3.7 Index of abbreviations

IT	Instrument Transformer
CT	Current Transformer
CVT	Capacitive Voltage Transformer
VT	Voltage Transformer
AIS	Air-Insulated Switchgear
GIS	Gas-Insulated Switchgear
k	actual transformation ratio
k_r	rated transformation ratio
ε	ratio error
$\Delta\varphi$	phase displacement
S_r	rated output
U_{sys}	highest voltage for system
U_m	highest voltage for equipment
f_R	rated frequency
F	mechanical load
F_{rel}	relative leakage rate

4 Normal and special service conditions

4.1 General

Unless otherwise specified, instrument transformers are intended to be used at their rated characteristics under the normal service conditions listed in 4.2.

If the actual service conditions differ from these normal service conditions, instrument transformers shall be designed to comply with any special service conditions required by the purchaser, or appropriate arrangements shall be made (see 4.3).

Detailed information concerning classification for environmental conditions is given in IEC 60721-3-3 (indoor) and IEC 60721-3-4 (outdoor).

For gas-insulated metal-enclosed instrument transformers, Clause 2 of IEC 62271-203 is applicable.

4.2 Normal service conditions

4.2.1 Ambient air temperature

Instrument 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 1 In the choice of the temperature category, storage and transportation conditions should also be considered.

NOTE 2 In case of instrument transformers integrated within other equipment (e.g. GIS, circuit breaker) the instrument transformer should be specified for the temperature conditions for the respective equipment.

4.2.2 Altitude

The altitude does not exceed 1 000 m.

4.2.3 Vibrations or earth tremors

Vibrations due to causes external to the instrument transformers or earth tremors are negligible.

4.2.4 Other service conditions for indoor instrument transformers

Other considered service conditions are as follows:

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 for 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 may be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 In order to withstand the effects of high humidity and condensation, such as the breakdown of insulation or the corrosion of metallic parts, instrument 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 a dehumidifying device.

4.2.5 Other service conditions for outdoor instrument transformers

Other considered service conditions are as follows:

a) the 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/m^2 (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 IEC 60815;

d) the wind pressure does not exceed 700 Pa (corresponding to a 34 m/s wind speed);

e) the presence of condensation or precipitation should be taken into account;

f) the ice coating does not exceed 20 mm.

4.3 Special service conditions

4.3.1 General

When instrument transformers are intended to be used under conditions different from the normal service conditions given in 4.2, the purchaser's requirements should refer to standardised criteria given hereinafter.

4.3.2 Altitude

4.3.2.1 Influence of altitude on external insulation

At an altitude >1 000 m, the disruptive discharge voltage for external insulation is affected by the reduction of air density. Refer to 6.6.2.

4.3.2.2 Influence of altitude on temperature-rise

At an altitude >1 000 m, the thermal behaviour of an instrument transformer is affected by the reduction of air density. Refer to 6.4.2.

4.3.3 Ambient temperature

For installations located in a place where the ambient temperature can be significantly outside the normal service condition range stated in 4.2.1, 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 a 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. Alternatively, derating may be used.

4.3.4 Vibrations or earth tremors

Vibrations may occur due to switchgear operations or short circuit forces.

For an instrument transformer integrated within assembled equipment (GIS or AIS) the vibration produced by the assembled equipment shall be considered.

4.3.5 Earthquakes

For installations where earthquakes are likely to occur, the relevant severity level in accordance with IEC 62271-2 shall be specified by the purchaser.

The compliance with such special requirements, if applicable, has to be demonstrated either by calculation or by testing as defined by relevant standards.

4.4 System earthing

The considered system earthings are:

a) isolated neutral system (see 3.2.4);
b) resonant earthed system (see 3.2.5);
c) earthed neutral system (see 3.2.7).
   1) solidly earthed neutral system (see 3.2.8),
   2) impedance earthed neutral system (see 3.2.9).

5 Ratings

5.1 General

The common ratings of instrument transformers, including their auxiliary equipment if applicable, should be selected from the following:

a) highest voltage for equipment (U_m);
b) rated insulation level;
c) rated frequency (f_R),
d) rated output;
e) rated accuracy class.

The rating applies at the standardized reference atmosphere (temperature (20 °C), pressure(101,3 kPa) and humidity (11 g/m^3)) specified in IEC 60071-1.

5.2 Highest voltage for equipment

Standard values shall be selected from Table 2.

The highest voltage for equipment is chosen as the next standard value of U_m equal to or higher than the highest voltage of the system where the equipment will be installed.

For equipment to be installed under normal environmental conditions relevant to insulation, U_m shall be at least equal to U_{sys}.

For equipment to be installed outside of the normal environmental conditions relevant to insulation, U_m may be selected higher than the next standard value of U_m equal to or higher than U_{sys} according to the special needs involved.

NOTE As an example, the selection of a U_m value higher than the next standard value of U_m equal to or higher than U_{sys} may arise when the equipment has to be installed at an altitude higher than 1 000 m in order to compensate the decrease of withstand voltage of the external insulation.

Table 2 – Rated primary terminal insulation levels for instrument transformers

Highest voltage for equipment U_m (r.m.s.) kV	Rated power-frequency withstand voltage (r.m.s.) kV	Rated lightning impulse withstand voltage (peak) kV	Rated switching withstand voltage (peak) kV
0,72	3	---	
1,2	6	---	
3,6	10	20 40	
7,2	20	40 60	
12	28	60 75	
17,5	38	75 95	
24	50	95 125	
36	70	145 170	
52	95	250	
72,5	140	325	
100	185	450	
123	185 230	450 550	
145	230 275	550 650	
170	275 325	650 750	
245	395 460	950 1 050	
300	395 460	950 1 050	750 850
362	460 510	1 050 1175	850 950
420	570 630	1 300 1 425	950 1 050
550	630 680	1 425 1 550	1 050 1 175
800	880 975	1 950 2 100	1 425 1 550

NOTE 1 For exposed installations it is recommended to choose the highest insulation level.

NOTE 2 In the case of instrument transformers intended to be installed in GIS, the rated power frequency withstand voltage levels according to IEC 62271-203 may be different.

NOTE 3 For alternative levels, see IEC 60071-1.

5.3 Rated insulation levels

5.3.1 General

For most of the values of highest voltage for equipment (U_m), several rated insulation levels exist to allow application of different performance criteria or overvoltage patterns. The choice should be made considering the degree of exposure to fast-front and slow-front overvoltage, the type of neutral earthing of the system and the type of overvoltage limiting devices.

5.3.2 Rated primary terminal insulation level

The rated primary terminal insulation level of an instrument transformer shall be based on its highest voltage for equipment U_m according to Table 2.

Primary terminal intended to be earthed in service has U_m equal to 0,72 kV

For instrument transformers mounted on gas-insulated substations, the rated insulation levels, testing procedures and acceptance criteria, are according to IEC 62271-203. The applicable rated insulation levels are according to IEC 62271-203, Table 102 and 103, phase-to-earth insulation.

5.3.3 Other requirements for primary terminals insulation

5.3.3.1 Partial discharges

Partial discharge requirements are applicable to instrument transformers having U_m greater than or equal to 7,2 kV.

The partial discharge level shall not exceed the limits specified in Table 3. The test procedure is given in 7.3.2.2.

Table 3 – Partial discharge test voltages and permissible levels

Type of earthing of the neutral system	Instrument transformer type	PD test voltage (r.m.s.) kV	Maximum permissible PD level pC	
			Type of insulation	
			immersed in liquid or gas	solid
Earthed neutral system (earth fault factor≤1,4)	CT and earthed VT	U_m $1,2\ U_m/\sqrt{3}$	10 5	50 20
	Unearthed VT	$1,2\ U_m$	5	20
Isolated or non effectively earthed neutral system (earth fault factor>1,4)	CT and earthed VT	$1,2\ U_m$ $1,2\ U_m/\sqrt{3}$	10 5	50 20
	Unearthed VT	$1,2\ U_m$	5	20

NOTE 1 If the neutral system is not defined, the values given for isolated or non-effectively earthed neutral systems are valid.

NOTE 2 The maximum permissible PD level is also valid for frequencies different from rated frequency.

NOTE 3 CT for current transformer and VT for voltage transformer.

5.3.3.2 Chopped lightning impulse

If additionally specified, instrument transformers other than GIS devices shall be capable to withstand a chopped lightning impulse voltage applied to its primary terminals having a peak value of 115 % of the rated lightning impulse withstand voltage.

5.3.3.3 Capacitance and dielectric dissipation factor

These requirements apply only to transformers having $U_m \geq 72{,}5$ kV, with liquid immersed primary insulation or gas insulated instrument transformers with capacitance grading insulation system.

5.3.4 Between-section insulation requirements

For interconnected terminals of each section, the rated power-frequency withstand voltage of the insulation between sections shall be 3 kV.

5.3.5 Insulation requirements for secondary terminals

The rated power-frequency withstand voltage for secondary insulation shall be 3 kV.

5.4 Rated frequency

The standard values of the rated frequency are 16 2/3 Hz, 25 Hz, 50 Hz and 60 Hz.

5.5 Rated output

See specific product standard.

5.6 Rated accuracy class

See specific product standard.

6 Design and construction

6.1 Requirements for liquids used in equipment

6.1.1 General

The manufacturer shall specify the type and the required quantity and quality of the liquid to be used in equipment.

6.1.2 Liquid quality

For oil-filled equipment, new insulating oil shall comply with IEC 60296.

For synthetic liquid-filled equipment refer to IEC 60867.

6.1.3 Liquid level device

If supplied, the device for checking the liquid level shall indicate whether the liquid level is within the operating range, during operation.

6.1.4 Liquid tightness

No liquid loss is permitted. Any liquid loss represents a danger of insulation contamination.

6.2 Requirements for gases used in equipment

6.2.1 General

The manufacturer shall specify the type and the required quantity and quality of the gas to be used in equipment.

6.2.2 Gas quality

New SF_6 (sulphur hexafluoride) shall comply with IEC 60376, while used SF_6 shall comply with IEC 60480.

SF_6 handling shall be in accordance with IEC 61634.

The maximum allowed moisture content within instrument transformers filled with gas at rated filling density for insulation shall be such that the dew-point is not higher than – 5 °C for a measurement at 20 °C. Adequate correction shall be applied for measurement at other temperatures. For the measurement and determination of the dew point, refer to IEC 60376 and IEC 60480.

6.2.3 Gas monitoring device

Gas-insulated instrument transformers having a minimum functional pressure above 0,2 MPa shall be provided with pressure or density monitoring device. Gas monitoring devices may be provided alone or together with the associated equipment.

6.2.4 Gas tightness

6.2.4.1 General

The following specifications apply to all instrument transformers that use gas, other than air at atmospheric pressure, as an insulating medium.

6.2.4.2 Closed pressure systems for gas

The tightness characteristic of a closed pressure system stated by the manufacturer shall be consistent with a minimum maintenance and inspection philosophy.

The tightness of closed pressure systems for gas is specified by the relative leakage rate F_{rel} of each compartment.

Standardized value is 0,5 % per year, for SF_6 and SF_6-mixtures.

Means shall be provided to enable gas systems to be safely replenished whilst the equipment is in service.

NOTE Lower leakage rates can be specified according to national regulations and regional practice.

An increased leakage rate at extreme temperatures (if such tests are required in the relevant standards) is acceptable, provided that this rate resets to a value not higher than the maximum permissible value at normal ambient air temperature. The increased temporary leakage rate shall not exceed the values given in Table 4.

In general, for the application of an adequate test method, reference is made to IEC 60068-2-17.

Table 4 – Permissible temporary leakage rates for gas systems

Temperature class °C	**Permissible temporary leakage rate**
+40 and +50	$3F_p$
ambient temperature	F_p
–5 /–10 /–15 /–25 /–40	$3F_p$
–50	$6F_p$

6.2.5 Pressure relief device

The device shall be protected against any accidental damage.

For GIS instrument transformers refer to IEC 62271-203, Clause 5.105.

6.3 Requirements for solid materials used in equipment

Specifications for organic material used for instrument transformers (i.e. epoxy resin, polyurethane resin, epoxy-cycloaliphatic resin, composite material, etc.) either for indoor or outdoor installations are given in the IEC 60455 series.

NOTE Tests on complete instrument transformers taking into account phenomena such as sudden change of temperature, flammability and aging are not yet standardized. IEC 60660 for indoor insulation and IEC 61109 for outdoor insulation can be used as guidance.

6.4 Requirements for temperature rise of parts and components

6.4.1 General

The temperature-rise of windings, magnetic circuits and any other parts of instrument transformers shall not exceed the appropriate value given in Table 5, when operating under the specified rated conditions. These values are based on the service conditions given in clause 4.2.1.

The temperature rise of the windings is limited by the lowest class of insulation either of the winding itself or of the surrounding medium in which it is embedded.

If the instrument transformers are used within enclosures, attention shall be paid to the temperature reached by the surrounding cooling media within the enclosure.

If ambient temperatures in excess of the values given in 4.2.1 are specified, the permissible temperature rise given in Table 5 shall be reduced by an amount equal to the excess ambient temperature.

Table 5 – Limits of temperature rise for various parts, materials and dielectrics of instrument transformers

Part of instrument transformers	Temperature-rise limit K
1. Oil-immersed instrument transformers	
– top oil	50
– top oil, hermetically sealed	55
– winding average	60
– winding average, hermetically sealed	65
– other metallic parts in contact with oil	as for winding
2. Solid or gas insulated instrument transformers	
– winding (average) in contact with insulating materials of the following classes[a]:	
• Y	45
• A	60
• E	75
• B	85
• F	110
• H	135
– other metallic parts in contact with the above insulating material classes	as for windings
3. Connection, bolted or the equivalent	
– Bare-copper, bare-copper alloy or bare-aluminium alloy	
• in air	50
• in SF_6	75
• in oil	60
– Silver-coated or nickel-coated	
• in air	75
• in SF_6	75
• in oil	60
– Tin-coated	
• in air	65
• in SF_6	65
• in oil	60

[a] Insulating class definitions according to IEC 60085.

6.4.2 Influence of altitude on temperature-rise

If an instrument 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 5 shall be reduced by the following amounts for each 100 m that the altitude at the operating site exceeds 1 000 m (see Figure 1):

a) oil-immersed instrument transformers: 0,4 %;

b) dry-type and gas insulated instrument transformers: 0,5 %.

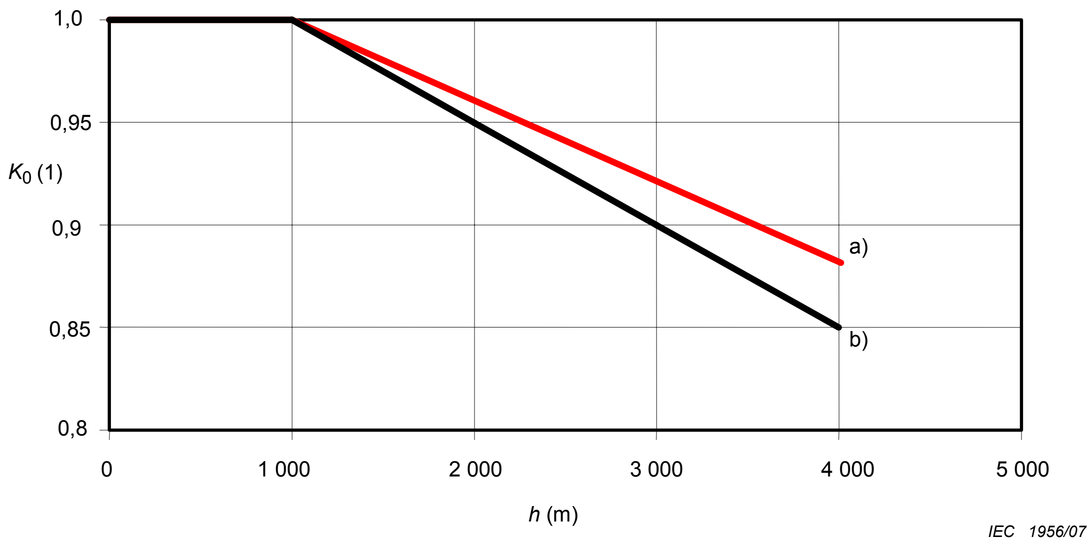


Figure 1 – Altitude correction factor for the temperature rise

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

– ΔT_h temperature rise at altitude $h > 1\,000$ m and

– ΔT_{ho} limits of temperature rise ΔT specified in Table 4 at altitudes ho ≤1 000 m.

6.5 Requirements for earthing of equipment

6.5.1 General

The frame of each equipment device, if intended to be earthed, shall be provided with a reliable earthing terminal for connection to an earthing conductor suitable for specified fault conditions. The connecting point shall be marked with the "earth" symbol, as indicated by symbol No 5019 of IEC 60417.

6.5.2 Earthing of the enclosure

The enclosure of instrument transformers for gas-insulated switchgear (GIS) shall be connected to earth. All metal parts which do not belong to a main or an auxiliary circuit, shall be earthed.

6.5.3 Electrical continuity

The continuity of the earthing circuits shall be ensured taking into account the thermal and electrical stresses caused by the current they may have to carry.

For the interconnection of enclosures, frames, etc., fastening (e.g. bolting or welding) is acceptable for providing electrical continuity.

6.6 Requirements for the external insulation

6.6.1 Pollution

For outdoor instrument transformers with ceramic insulators susceptible to contamination, the creepage distances for given pollution levels are given in Table 6. Creepage distances for polymeric or composite insulators are under consideration (by TC36).

Table 6 – Creepage distances

Pollution level	Mínimum nominal specific creepage distance mm/kV [a, b]	Ratio = creepage distance divided by arcing distance
I Light	16	≤3,5
II Medium	20	
III Heavy	25	≤4,0
IV Very heavy	31	

[a] Ratio of the creepage distance between phase and earth over the r.m.s. phase-to-phase value of the highest voltage for the equipment (see IEC 60071-1).

[b] For further information and manufacturing tolerances on the creepage distance, see IEC 60815.

NOTE 1 It is recognized that the performance of surface insulation is greatly affected by insulator shape.

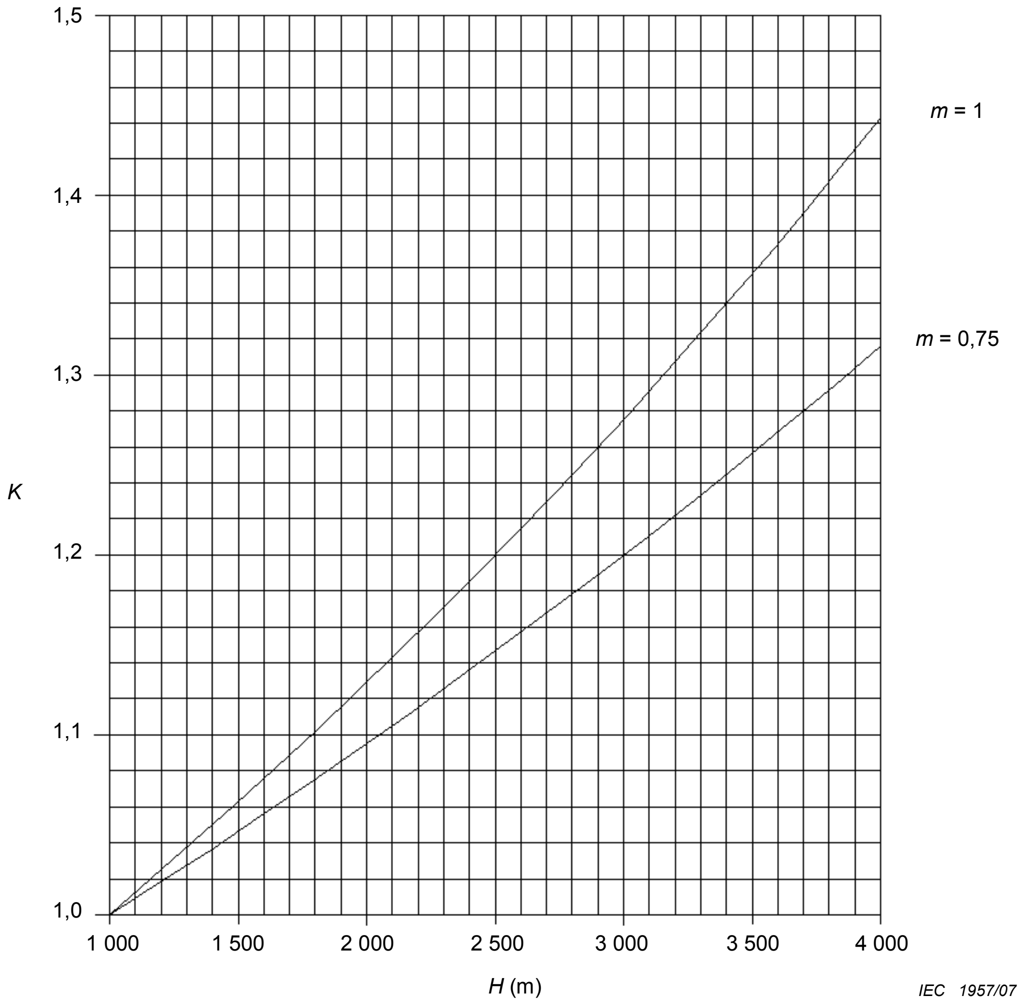
NOTE 2 In very lightly polluted areas, specific nominal creepage distances lower than 16 mm/kV can be used depending on service experience. A commonly adopted lower limit is 12 mm/kV.

NOTE 3 In cases of exceptional pollution severity, a specific nominal creepage distance of 31 mm/kV may not be adequate. Depending on service experience and/or on laboratory test results, a higher value of specific creepage distance can be used, but in some cases the practicability of washing may have to be considered.

6.6.2 Altitude

For installations at an altitude higher than 1000 m, the arcing distance under the standardised reference atmospheric conditions shall be determined by multiplying the withstand voltages required at the service location by a factor k in accordance with Figure 2.

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



Key

These factors can be calculated with the following equation:

$k = e^{m\,(H - 1\,000)/8\,150}$

where

H	is the altitude in metres
m = 1	for power-frequency and lightning impulse voltage
m = 0,75	for switching impulse voltage

Figure 2 – Altitude correction factor

6.7 Mechanical requirements

These requirements apply only to instrument transformers having a highest voltage for equipment of 72,5 kV and above.

The guidance for static loads that instrument transformers shall be capable of withstanding is given in Table 7. The figures include loads due to wind and ice.

The specified test loads are intended to be applied in any direction to the primary terminals.

Table 7 – Static withstand test loads

Highest voltage for equipment U_m kV	Static withstand test load F_R N		
	Instrument transformers with:		
	voltage terminals	current terminals	
		Load class I	Load class II
72,5 to 100	500	1 250	2 500
123 to 170	1 000	2 000	3 000
245 to 362	1 250	2 500	4 000
≥ 420	1 500	4 000	5 000

NOTE 1 The sum of the loads acting in routinely operating conditions should not exceed 50 % of the specified withstand test load.

NOTE 2 In some applications instrument transformers with through current terminals should withstand rarely occurring extreme dynamic loads (e.g. short circuits) not exceeding 1,4 times the static test load.

NOTE 3 For some applications it may be necessary to establish the resistance to rotation of the primary terminals. The moment to be applied during the test has to be agreed between manufacturer and purchaser.

NOTE 4 In the case of transformers integrated within other equipment (e.g.: switchgear assemblies) the static withstand test loads of the respective equipment should not be diminished by the integration process.

6.8 Multiple chopped impulse on primary terminals

If additionally specified, the primary terminals of oil-immersed instrument transformers having U_m≥300 kV shall withstand multiple chopped impulses in accordance with 7.4.2.

NOTE Requirements and tests relate to the behaviour of the internal shields and connections carrying high frequency transient currents, mainly due to disconnect switching operations. The test may also be applied to ratings below this level.

6.9 Internal arc fault protection requirements

These requirements apply to oil-immersed and gas-insulated free-standing instrument transformers having U_m ≥ 72,5 kV, for which internal arc fault protection class is additionally specified.

NOTE 1 This test is not a guarantee against containment under all short-circuit conditions, but a test to demonstrate conformance to an agreed level of safety.

NOTE 2 This test is a new test and therefore the test procedure may be improved in the future.

If additionally specified, the instrument transformer shall be able to withstand an internal arc of the specified current and duration.

The applied current is an asymmetrical current. The r.m.s. current value should be selected from the standard symmetrical single-phase values of R10 range according to 4.5 of IEC 60694. The first peak value of the current shall be 1,7 times the r.m.s. current.

NOTE 3 Reduced internal arc test levels should be agreed between the manufacturer and the purchaser. Experience has shown that selection of test currents equal to 100 % system fault level, statistically requires a degree of over-design of the transformer, since local fault levels are usually significantly lower.

The arc fault duration shall be according to Table 8.

It shall be considered that compliance with these requirements is achieved if the instrument transformer passes the test described in 7.4.6.

Table 8 – Arc fault duration and performance criteria

Internal arc fault current r.m.s. value kA	Protection stage	Arc fault duration s	Internal arc fault protection class I	Internal arc fault protection class II
< 40	1	0,2	Fracture of the housing and fire permitted, but all projected parts to be confined within the containment area	No external effect other than the operation of suitable pressure relief device
	2	0,5		No fragmentation (burn-through or fire acceptable)
≥40	1	0,1		No external effect other than the operation of suitable pressure relief device
	2	0,3		No fragmentation (burn-through or fire acceptable)

6.10 Degrees of protection by enclosures

6.10.1 General

Degrees of protection according to IEC 60529 shall be specified, if applicable, for all enclosures of instrument transformers containing parts of the main circuit allowing penetration from outside, as well as for enclosures for appropriate low-voltage control and/or auxiliary circuits.

6.10.2 Protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects

The degree of protection of persons provided by an enclosure against access to hazardous parts of the main circuit, control and/or auxiliary circuits shall be indicated by means of a designation specified in IEC 60529.

The first characteristic numeral indicates the degree of protection provided by the enclosure with respect to persons, as well as of protection of the instrument transformers inside the enclosure against ingress of solid foreign bodies.

IEC 60529 gives details of objects which will be “excluded” from the enclosure for each of the degrees of protection. The term “excluded” implies that solid foreign objects will not fully enter the enclosure and that a part of the body or an object held by a person, either will not enter the enclosure or, if it enters, that adequate clearance will be maintained and no hazardous part will be touched.

NOTE Generally the degree of protection of persons against access to hazardous parts of the main circuit, or control or auxiliary circuit of instrument transformers, and the protection of the instrument transformers against foreign objects, may be provided by the immediate surroundings of the instrument transformers, such as substation fence, building, module enclosure, and so on. Further protection may be required as a feature of the instrument transformers as a whole or parts of it.

6.10.3 Protection against ingress of water

The degree of protection provided by an enclosure against ingress of water shall be indicated by means of a designation specified in IEC 60529.

The second characteristic numeral indicates the degree of protection provided by the enclosure with respect to the dangerous effects of water, either of atmospheric origin or other.

6.10.4 Indoor instrument transformers

For instrument transformers for indoor installation, no degree of protection against harmful ingress of water according to the second characteristic numeral of the IP-code is specified (second characteristic numeral X).

The recommended minimum degree of protection for low-voltage control and/or auxiliary enclosures for indoor instrument transformers is IP20 according to IEC 60529. This requirement is not applicable to installations where personnel cannot gain access to the instrument transformer without firstly de-energising the transformer and making it safe through some controlled means (i.e. interlocking, documented operating instructions, etc.). In this case the need for such external safety measures to the instrument transformer should be clearly stated in the product documentation.

6.10.5 Outdoor instrument transformers

The recommended minimum degree of protection for low-voltage control and/or auxiliary enclosures for outdoor instrument transformers is IP44 according to IEC 60529.

Instrument transformers for outdoor installation provided with additional protection features against rain and other weather conditions shall be specified by means of the supplementary letter W placed after the second characteristic numeral, or after the additional letter, if any.

6.10.6 Protection of equipment against mechanical impact under normal service conditions

Enclosures of instrument transformers shall be of sufficient mechanical strength.

Corresponding tests are specified in 7.2.7.2. Porcelain insulators are excluded from impact test.

For indoor installation, the recommended level of protection against effects of mechanical impacts is impact level IK7 according to IEC 62262.

For outdoor installation without additional mechanical protection, users may specify higher impact levels.

6.11 Electromagnetic Compatibility (EMC)

6.11.1 General

EMC is the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment [IEV 161-01-07].

For instrument transformers the following EMC requirements and tests are specified:

[C› – requirements for emission, Radio Interference Voltage (RIV) included for high voltage parts of the equipment.;

– requirements for immunity, only applicable to electronic parts of the equipment;

– requirements for transmitted overvoltages. ‹C]

6.11.2 Requirement for Radio Interference Voltage (RIV)

The RIV requirement applies to instrument transformers having $U_m \geq 123$ kV to be installed in air-insulated substations.

The radio interference voltage shall not exceed 2 500 µV at 1,1 $U_m/\sqrt{3}$.

[C] *Text deleted* [C]

6.11.3 Requirements for immunity

The electromagnetic immunity requirements and tests are specified only for parts of instrument transformers containing active electronic components.

[C] Refer to specific product standards for details. [C]

6.11.4 Requirement for transmitted overvoltages

These requirements apply to instruments transformers having $U_m \geq 72{,}5$ kV.

The overvoltages transmitted from the primary to the secondary terminals shall not exceed the values given in Table 9, under the test and measuring conditions described in 7.4.4.

Type A impulse requirement applies to instrument transformers for air-insulated switchgear, while impulse B requirement applies to instrument transformers installed in gas insulated metal-enclosed switchgear (GIS). Type A and B impulses are depicted in Figure 3.

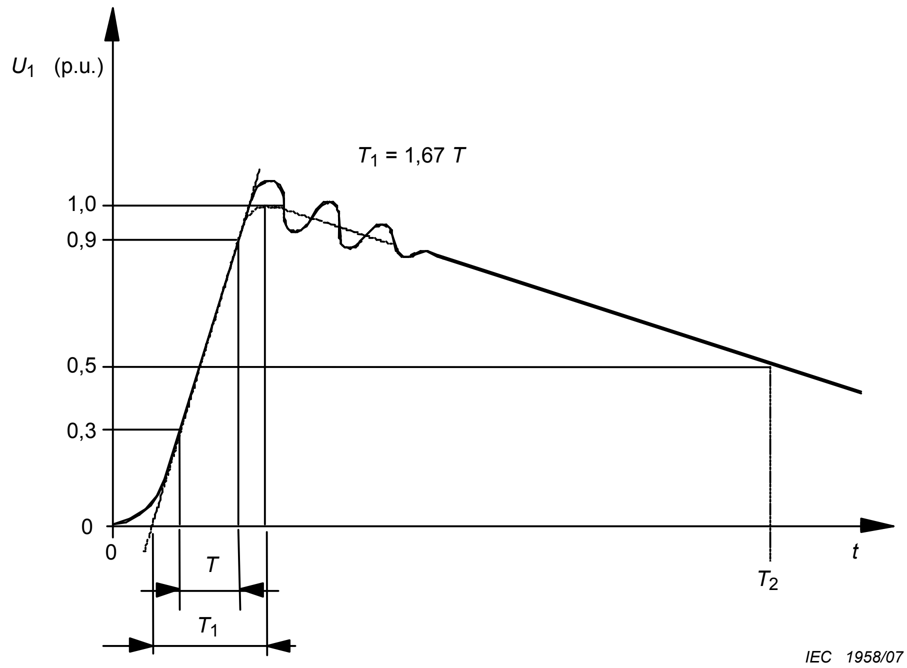
The transmitted overvoltage peak limits given in Table 9 and measured in accordance with the methods specified in 7.4.4 should ensure sufficient protection of electronic equipment connected to the secondary winding.

Table 9 – Transmitted overvoltage limits

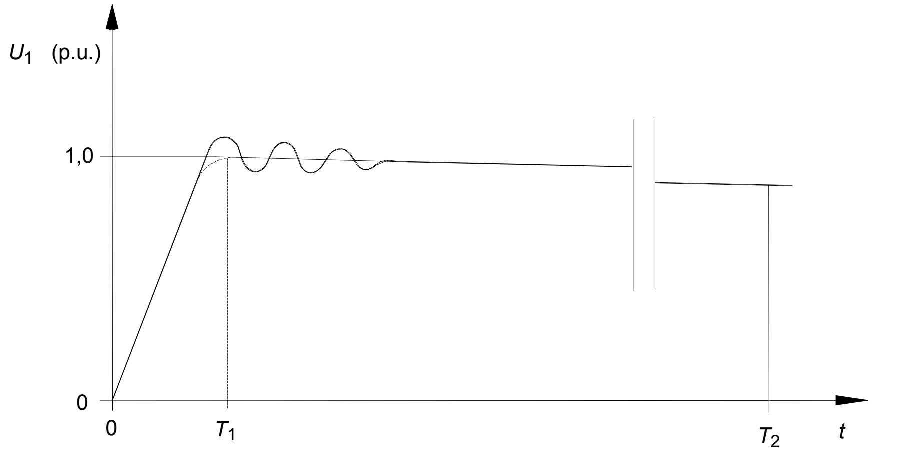
Type of impulse	A	B
Peak value of the applied voltage (U_p)	$1{,}6 \times \frac{\sqrt{2}}{\sqrt{3}} \times U_m$	$1{,}6 \times \frac{\sqrt{2}}{\sqrt{3}} \times U_m$
Wave shape characteristics:		
– conventional front time (T_1)	0,50 µs ± 20 %	-
– time to half-value (T_2)	≥ 50 µs	-
– front time (T_1)	-	10 ns ± 20 %
– tail length (T_2)	-	>100 ns
Transmitted overvoltage peak value limits (U_s)	1,6 kV	1,6 kV

NOTE 1 The wave-shape characteristics are representative of voltage oscillations due to switching operations.

NOTE 2 See Figure 3.



Waveshape A



Waveshape B

Figure 3 – Transmitted overvoltages measurement: Test impulse waveforms

6.12 Corrosion

Caution has to be taken against corrosion of the equipment during the service life.

All bolted or screwed parts of the main circuit and of the enclosure shall remain easily demountable.

Galvanic corrosion between materials in contact shall be considered because it can lead to the loss of tightness.

Oxidation can be considered as self-protection against corrosion.

Visual appearance shall remain acceptable.

6.13 Markings

All instrument transformers shall carry at least the following markings:

a) the manufacturer's name or other mark by which he may be readily identified;
b) the year of manufacture and a serial number or a type designation, preferably both,
c) rated frequency;
d) highest voltage of equipment;
e) rated insulation level;
f) temperature category;
g) mass in kg (when ≥ 25);
h) class of mechanical requirements (for U_m≥72kV).

NOTE The two items d) and e) may be combined into one marking (e.g. 72,5/140/325 kV).

All information shall be marked in an indelible manner on the instrument transformer itself or on a rating plate securely attached to the transformer.

In addition, the following information should be marked:

i) class of insulation if different from Class A;

   NOTE If several classes of insulating material are used, the one, which limits the temperature rise of the windings, should be indicated. On transformers with more than one secondary winding, the use of each winding and its corresponding terminals should be indicated.

j) all indications relative to the measuring characteristics (see specific standard);
k) type of the insulating fluid;
l) rated filling pressure;
m) minimum functional pressure;
n) insulating fluid volume (or mass) contained in the instrument transformer.

6.14 Fire hazard

See Annex C.

7 Tests

7.1 General

7.1.1 Classification of tests

The tests specified in this standard are classified as follows:

- Type test: a test made on equipment to demonstrate that all equipment made to the same specification complies with the requirements not covered by routine tests.
- Routine test: a test to which each individual piece of equipment is subjected. Routine tests are for the purpose of revealing manufacturing defects. They do not impair the properties and reliability of the test object.
- Special test: a test other than a type test or a routine test, agreed on by manufacturer and purchaser.

- Sample test: A selected type or special test performed on one or more complete instrument transformers out of a specified production batch.

7.1.2 List of tests

The list of tests is given in Table 10.

Table 10 – List of tests

Tests	Subclause
Type tests	**7.2**
Temperature-rise test	7.2.2
Impulse voltage test on primary terminals	7.2.3
Wet test for outdoor type transformers	7.2.4
Electromagnetic Compatibility tests	7.2.5
Test for accuracy	See specific requirements standard
Verification of the degree of protection by enclosures	7.2.7
Enclosure tightness test at ambient temperature	7.2.8
Pressure test for the enclosure	7.2.9
Routine tests	**7.3**
Power-frequency voltage withstand tests on primary terminals	7.3.1
Partial discharge measurement	7.3.2
Power-frequency voltage withstand tests between sections	7.3.3
Power-frequency voltage withstand tests on secondary terminals	7.3.4
Test for accuracy	7.3.5
Verification of markings	7.3.6
Enclosure tightness test at ambient temperature	7.3.7
Pressure test for the enclosure	7.3.8
Special tests	**7.4**
Chopped impulse voltage withstand test on primary terminals	7.4.1
Multiple chopped impulse test on primary terminals	7.4.2
Measurement of capacitance and dielectric dissipation factor	7.4.3
Transmitted overvoltage test	7.4.4
Mechanical tests	7.4.5
Internal arc fault test	7.4.6
Enclosure tightness test at low and high temperatures	7.4.7
Gas dew point test	7.4.8
Corrosion test	7.4.9
Fire hazard test	7.4.10
Sample tests	**7.5**

For the testing of gas-insulated instrument transformers, the type and pressure of the gas shall be according to Table 11.

Table 11 – Gas type and pressure during type, routine and special tests

Test	Gas type	Pressure
Dielectric, RIV [a] Accuracy Temperature rise	Same fluid as in service	Minimum functional pressure
Internal arc Short-circuit Mechanical Tightness Gas dew point	Same fluid as in service	Rated filling pressure
Transmitted overvoltages	Not applicable	Reduced pressure

[a] For gas-insulated instrument transformers installed on GIS, the wet test and RIV test are not applicable.

7.1.3 Sequence of tests

After the instrument transformer has been subjected to the dielectric type tests detailed in 7.2, it shall be subjected to all routine tests detailed in 7.3.

For different types of instrument transformers, refer to product specific standards for further test sequence and routine testing.

If special tests have to be carried out, they may have an influence on the sequence of tests.

7.2 Type tests

7.2.1 General

All the dielectric type tests shall be carried out on the same instrument transformer, unless otherwise specified.

All the type tests shall be carried out on a maximum of two specimens.

NOTE A type test may also be considered valid if it is made on a transformer that has minor constructional deviations from the instrument transformer under consideration. Such deviations should be subject to agreement between manufacturer and purchaser.

All the type tests shall be carried out at ambient temperature between 10 °C and 30 °C.

7.2.1.1 Information for identification of specimen

The manufacturer shall submit to the testing laboratory drawings and other data containing sufficient information to unambiguously identify by type the essential details and parts of the equipment presented for test. Each drawing or data schedule shall be uniquely referenced and shall contain a statement to the effect that the manufacturer guarantees that the drawings or data schedules truly represent the equipment to be tested.

After completion of verification, detail drawings and other data shall be returned to the manufacturer for storage.

The manufacturer shall maintain detailed design records of all component parts of the equipment tested and shall ensure that these may be identified from information included in the drawings and data schedules.

NOTE 1 Manufacturers whose production systems have been certified for compliance with ISO 9001 do satisfy the previously mentioned requirements.

The testing laboratory shall check that drawings and data schedules adequately represent the essential details and parts of the equipment to be tested, but shall not be responsible for the accuracy of the detailed information.

Particular drawings or data required to be submitted by the manufacturer to the test laboratory for identification of essential parts of equipment have to be specified by the relevant standards.

NOTE 2 An individual type test need not be repeated for a change of construction detail, if the manufacturer can demonstrate that this change does not influence the result of that individual type test.

Annex A gives a list of drawings to be submitted

7.2.1.2 Information to be included in type test reports

The results of all type tests shall be recorded in type-test reports containing:

a) Identification file as prescribed in 7.2.1.1 and Annex A.

b) Test arrangement

   details of the testing arrangements (including diagram of test circuit);

   general details of the supporting structure of the device used during the test;

   photographs to illustrate the condition of equipment before and after test.

c) Test data to prove compliance with the specification;

   test program;

   records of the test quantities during each test, as specified in the relevant IEC standard;

   statements of the behavior of the equipment during tests, its condition after tests and, if applicable, any parts renewed or reconditioned during the tests;

   conclusion.

7.2.2 Temperature-rise test

A test shall be made to prove compliance with 6.4.

For this test, the transformer shall be mounted in a manner representative of the mounting in service.

The temperature rise of windings shall, when practicable, be measured by the increase in resistance method, but for windings of very low resistance, thermocouples may be employed.

The temperature rise of parts other than windings may be measured by thermometers or thermocouples.

Instrument transformers shall be considered to have attained a steady-state temperature when the rate of temperature rise does not exceed 1 K/h.

For identification of any key components on which temperature measurements are to be made and for further information regarding test arrangements and procedures, refer to product specific standards.

7.2.3 Impulse voltage withstand test on primary terminals

7.2.3.1 General

The impulse test shall be performed in accordance with IEC 60060-1, and, if any, in accordance with the relevant instrument transformer specific standards.

The frame, case (if any) and core (if intended to be earthed) and all terminals of the secondary system shall be connected to earth.

The impulse tests generally consist of voltage application at reference and rated voltage levels. The reference impulse voltage shall be between 50 % and 75 % of the rated impulse withstand voltage. The peak value and the wave shape of the impulse shall be recorded.

Evidence of insulation failure due to the test may be given by variation in the wave shape at both reference and rated withstand voltages.

Improvements in failure detection may be obtained by recording of the current(s) to earth as a complement to the voltage record.

The test voltage shall have the appropriate value, given in Table 2 depending on the highest voltage for equipment and the specified insulation level.

7.2.3.2 Lightning impulse voltage test on primary terminals

7.2.3.2.1 Instrument transformers having U_m < 300 kV

The test shall be performed with both positive and negative polarities. Fifteen consecutive impulses of each polarity, not corrected for atmospheric conditions, shall be applied.

The following test procedure B of IEC 60060-1, adapted for HV equipment that has self-restoring and non-restoring insulation, is the preferred test procedure. The instrument transformer shall be considered to have passed the impulse tests for each polarity if the following conditions are fulfilled:

– each series (+ and –) has at least 15 impulses;
– no disruptive discharges on non-self restoring insulation shall occur. This is confirmed by 5 consecutive impulse withstands following the last disruptive discharge.
– the number of disruptive discharges shall not exceed two for each series.

This procedure leads to a maximum possible number of 25 impulses per series.

No evidence of insulation failure shall be detected (e.g variation of the wave shape of the recorded quantities on routine tests which serve as verification tests).

If disruptive discharges occur and evidence cannot be given during testing that the disruptive discharges were on self-restoring insulation, the IT shall be dismantled and inspected after the completion of the dielectric test series. If damage to non-self-restoring insulation is observed, the instrument transformer shall be considered to have failed the test.

NOTE The application of 15 positive and 15 negative impulses is specified for testing the external insulation. If other tests are agreed between manufacturer and purchaser in order to check the external insulation, then, the number of lightning impulses may be reduced to three of each polarity, not corrected for atmospheric conditions.

7.2.3.2.2 Instrument transformers having $U_m \geq$ 300 kV

The test shall be performed with both positive and negative polarities. Three consecutive impulses of each polarity, not corrected for atmospheric conditions, shall be applied.

The transformer shall be considered to have passed the test if:

– no disruptive discharge occurs;
– no other evidence of insulation failure is detected (e.g. variations in the wave shape of the recorded quantities on routine tests which serve as verification tests).

7.2.3.3 Switching impulse voltage test

7.2.3.3.1 General

The test shall be performed with positive polarity. Fifteen consecutive impulses, corrected for atmospheric conditions, shall be applied.

For outdoor-type transformers the test shall be performed under wet conditions. The wetting procedure shall be in accordance with IEC 60060-1.

The following test procedure B of IEC 60060-1, adapted for HV equipment that has self-restoring and non-restoring insulation, is the preferred test procedure. The instrument transformer shall be considered to have passed the impulse tests if the following conditions are fulfilled:

– the test has at least 15 impulses;
– no disruptive discharges on non-self restoring insulation shall occur. This is confirmed by 5 consecutive impulse withstands following the last disruptive discharge;
– the number of disruptive discharges shall not exceed two.

This procedure leads to a maximum possible number of 25 impulses.

No evidence of insulation failure shall be detected (e.g variation of the wave shape of the recorded quantities).

If disruptive discharges occur and evidence cannot be given during testing that the disruptive discharges were on self-restoring insulation, the IT shall be dismantled and inspected after the completion of the dielectric test series. If damage to non-self-restoring insulation is observed, the instrument transformer shall be considered to have failed the test.

Impulses with flashover to the walls or ceilings of the laboratory shall be disregarded.

7.2.4 Wet test for outdoor type transformers

The wetting procedure shall be in accordance with IEC 60060-1.

For instrument transformers having U_m < 300 kV, the test shall be performed with power-frequency voltage of the appropriate value given in Table 2 depending on the highest voltage for equipment applying corrections for atmospheric conditions.

For instrument transformers having U_m ≥ 300 kV, the test shall be performed with switching impulse voltage of positive polarity, of the appropriate value given in Table 2, depending on the highest voltage for equipment and the rated insulation level.

7.2.5 Electromagnetic Compatibility (EMC) tests

7.2.5.1 RIV test

As the radio interference voltage level may be affected by fibers or dust settling on the insulators, it is permitted to wipe the insulators with a clean cloth before taking a measurement.

The following test procedure shall be followed:

The instrument transformer, complete with accessories, shall be dry and clean and at approximately the same temperature as the laboratory room in which the test is made.

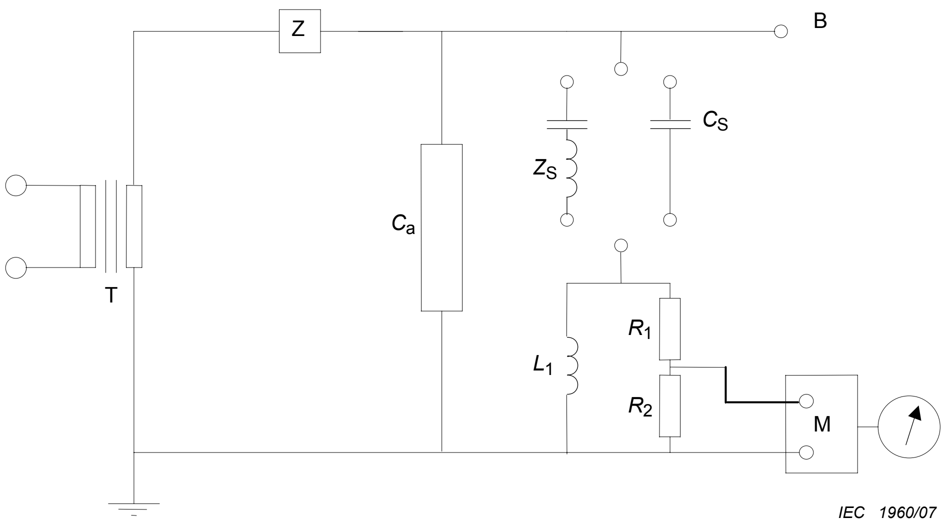
The test should be performed under the following atmospheric conditions:

– Temperature: from 10 °C to 30 °C;
– Pressure: from $0{,}870 \times 10^5$ Pa to $1{,}070 \times 10^5$ Pa;
– Relative humidity: from 45 % to 75 %.

NOTE 1 No correction factors for atmospheric conditions in accordance with IEC 60060-1 are applicable to radio interference tests.

The test connections and their ends shall not be a source of radio interference voltage.

Shielding of primary terminals simulating the operation condition should be provided to prevent spurious discharges. The use of sections of tube with spherical terminations is recommended.



Key
T test transformer
C_a test object
Z filter
B corona-free termination
M measuring set with input resistance R_M

$$Z_S + \left(R_1 + \frac{R_2 \cdot R_M}{R_2 + R_M} \right) = 300\ \Omega$$

Z_S, C_S, L_1, R_1, R_2 see CISPR 18-2

Figure 4 – RIV measuring circuit

The test voltage shall be applied between one of the terminals of the primary winding of the test object (C_a) and earth. The frame, case (if any), core (if intended to be earthed) and one terminal of each secondary winding shall be connected to earth.

The measuring circuit (see Figure 4) shall comply with CISPR 18-2. The measuring circuit shall preferably be tuned to a frequency in the range of 0,5 MHz to 2 MHz, the measuring frequency being recorded. The results shall be expressed in microvolts.

The impedance between the test conductor and earth, (Z_S + (R_1 + R_2 // R_M)) in Figure 4, shall be 300 Ω ± 40 Ω with a phase angle not exceeding 20° at the measuring frequency.

A capacitor, C_S, may also be used in place of the filter Z_S and a capacitance of 1 000 pF is generally adequate.

NOTE 2 A specially designed capacitor may be necessary in order to avoid too low a resonant frequency.

The filter Z shall have a high impedance at the measuring frequency in order to decouple the power frequency source from the measuring circuit. A suitable value for this impedance has been found to be 10 000 Ω to 20 000 Ω at the measuring frequency.

The radio interference background level (radio interference caused by external field and by the high-voltage transformer) shall be at least 6 dB (preferably 10 dB) below the specified radio interference level.

NOTE 3 Care should be taken to avoid disturbances caused by nearby objects to the instrument transformer and to the test and measuring circuits.

Calibration methods for the measuring instruments and for the measuring circuit are given in CISPR 18-2.

A pre-stress voltage of $1{,}5 \times U_m/\sqrt{3}$ shall be applied and maintained for 30 s.

The voltage shall then be decreased to $1{,}1 \times U_m/\sqrt{3}$ in about 10 s and maintained to this value for 30 s before measuring the radio interference voltage.

The instrument transformer shall be considered to have passed the test if the radio interference level at $1{,}1 \times U_m/\sqrt{3}$ is in accordance with 6.11.2.

7.2.5.2 Immunity test

[C Refer to specific product standards for details. C]

7.2.6 Test for accuracy

See specific standards.

7.2.7 Verification of the degree of protection by enclosures

7.2.7.1 Verification of the IP coding

In accordance with the requirements specified in 6.10, tests shall be performed in accordance with IEC 60529 on the enclosures of all parts of the fully assembled equipment as under service conditions.

7.2.7.2 Mechanical impact test

In accordance with the requirements specified in 6.10.6, enclosures shall be subjected to an impact test. Three blows are applied to points of the enclosure that are likely to be the weakest points. Devices such as connectors, displays, etc. are exempt from this test.

The use of a spring-operated impact test apparatus as defined in IEC 60068-2-75 is recommended.

After the test, the enclosure shall show no breaks, the deformation of the enclosure shall not affect the normal function of the instrument transformer, and shall not reduce the specified degree of protection. Superficial damage, such as removal of paint, breaking of cooling ribs or similar parts, or minor indentations can be ignored.

7.2.8 Enclosure tightness test at ambient temperature

7.2.8.1 Closed pressure systems for gas

The tightness test on the enclosure of gas-insulated instrument transformers shall prove compliance with the requirements given in 6.2.4.2 and shall be performed on a complete transformer at ambient temperature (20 ± 10) °C.

The method shall be the cumulative method for closed pressurised systems as specified by IEC 60068-2-17 (test method 1 of Qm test).

Every opening present on the transformer enclosure shall be sealed with the original sealing device.

The transformer shall be filled with the same gas mixture as used in service at the rated filling pressure at 20 °C ambient temperature.

The sensitivity of the leakage measurement shall be such as to detect a leakage rate corresponding to about 0,25 %/year.

NOTE 1 The sensitivity of a leakage measurement changes with the sensitivity of the leakage meter, with the capacity of the volume of measurement and with the time between two concentration measurements.

The test shall be started after at least 1 h from the completion of the filling of the instrument transformer, in order to allow stabilisation of the leakage flow.

NOTE 2 The tightness type test is not necessary if the routine tightness test is performed using the cumulative method (test method 1 of Qm test)

7.2.9 Pressure test for the enclosure

For gas-insulated, metal-enclosed instrument transformers, refer to 6.103 of IEC 62271-203.

For insulators of gas-insulated instrument transformers, refer to IEC 62155 and IEC 61462-2.

7.3 Routine tests

7.3.1 Power-frequency voltage withstand tests on primary terminals

The power-frequency withstand test shall be performed in accordance with IEC 60060-1.

The test voltage shall have the appropriate value given in Table 2, depending on the highest voltage for equipment. The duration shall be 60 s, unless otherwise specified.

The test voltage shall be applied:

- between the primary terminals and earth,
- between primary terminals, where applicable.

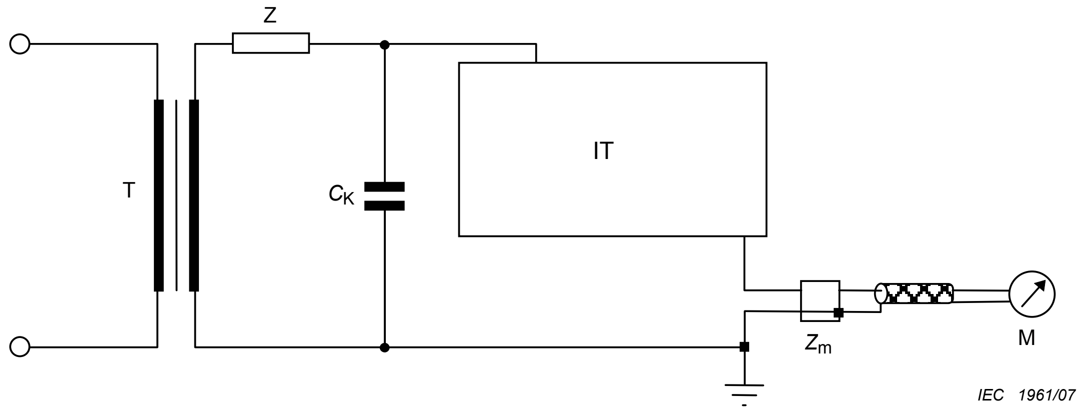
The secondary terminals, the frame, case (if any) and core (if there is a special earth terminal) shall be connected to earth.

Repeated power-frequency tests on primary terminals should be performed at 80 % of the specified test voltage.

7.3.2 Partial discharge measurement

7.3.2.1 Test circuit and instrumentation

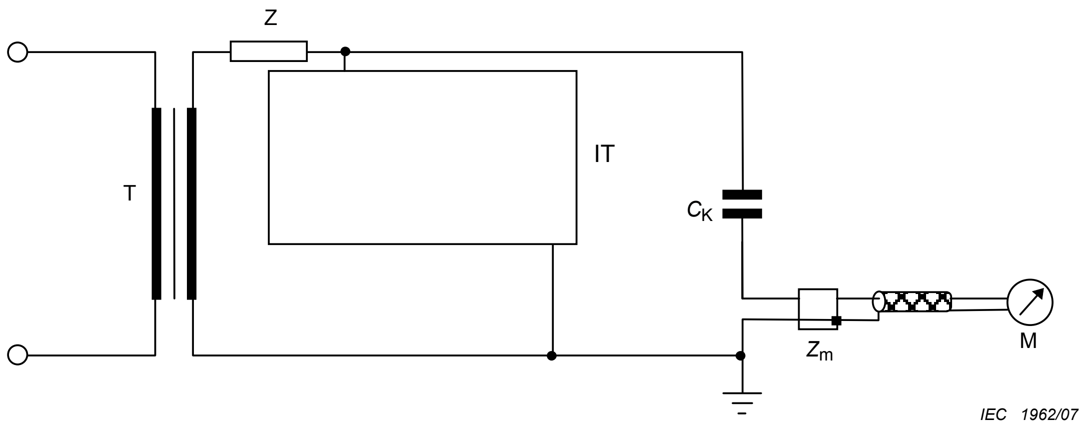
The test circuit and the instrumentation used shall be in accordance with IEC 60270. Some examples of test circuits are shown in Figures 5 to 7.



Key

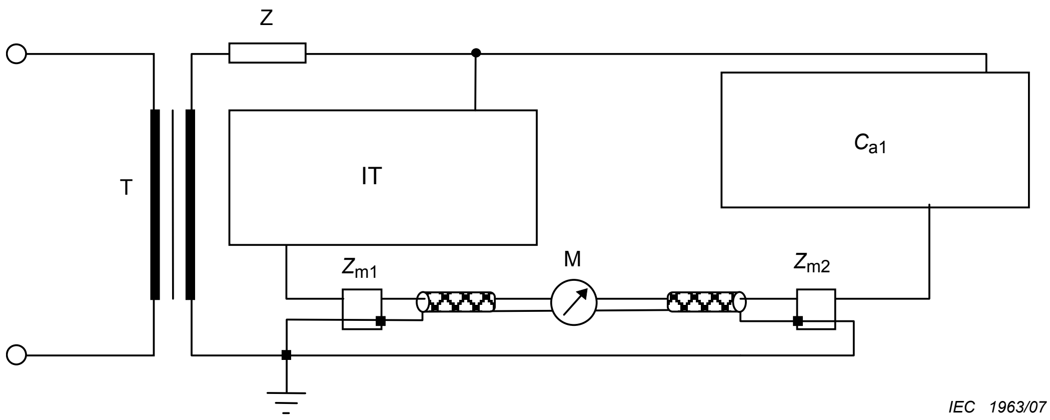
T	test transformer
IT	instrument transformer to be tested
C_k	coupling capacitor
M	PD measuring instrument
Z_m	measuring impedance
Z	filter

Figure 5 – Test circuit for partial discharge measurement



Key: see Figure 5.

Figure 6 – Alternative circuit for partial discharge measurement



Key

Symbols as in Figure 5

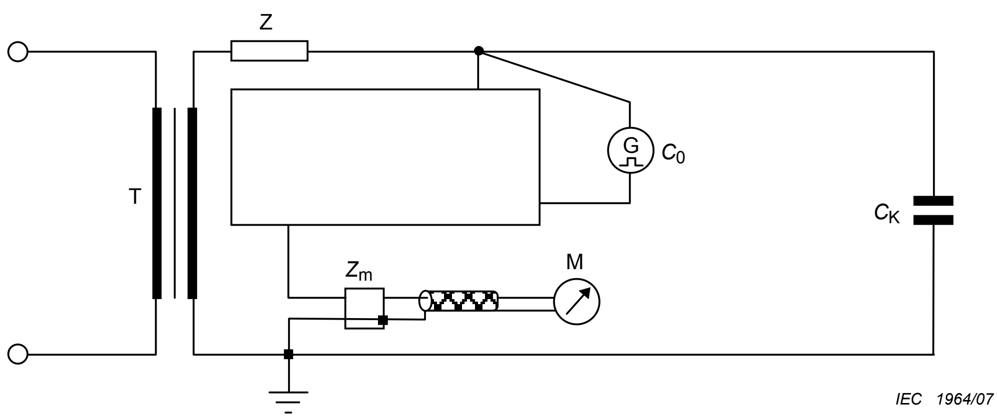
Z filter (not present if C_k is the capacitance of the test transformer)

C_{a1} auxiliary PD free object

Z_{m1} and Z_{m2} measuring impedances

Figure 7 – Example of balanced test circuit for partial discharge measurement

The instrument used shall measure the apparent charge *q* expressed in picocoulomb (pC). Its calibration shall be performed in the test circuit (see an example in Figure 8).



Key

Symbols as in Figure 5

G impulse generator with capacitance C_0

T test transformer for partial discharge measurement

Figure 8 – Example of calibration circuit for partial discharge measurement

A wide-band instrument shall have a bandwidth of at least 100 kHz with an upper cut-off frequency not exceeding 1,2 MHz.

Narrow-band instruments shall have their resonance frequency in the range 0,15 to 2 MHz. Preferred values should be in the range from 0,5 to 2 MHz but, if feasible, the measurement should be performed at the frequency which gives the highest sensitivity.

The sensitivity shall allow detection of a partial discharge level of 5 pC.

NOTE 1 The noise must be sufficiently lower than the sensitivity. Pulses that are known to be caused by external disturbances may be disregarded.

NOTE 2 For the suppression of external noise, the balanced test circuit (see Figure 7) is appropriate.

NOTE 3 When electronic signal processing and recovery are used to reduce the background noise, this must be demonstrated by varying its parameters so that it allows the detection of repeatedly occurring pulses.

7.3.2.2 Partial discharge test procedure

After a prestressing performed according to procedures A or B, the partial discharge test voltages specified in Table 3 are reached, and the corresponding partial discharge levels are measured in a time within 30 s.

The measured partial discharge shall not exceed the limits specified in Table 3.

Procedure A: the partial discharge test voltages are reached while decreasing the voltage after the power-frequency withstand test.

Procedure B: the partial discharge test is performed after the power-frequency withstand test. The applied voltage is raised to 80 % of the power-frequency withstand voltage, maintained for not less than 60 s, then reduced without interruption to the specified partial discharge test voltages.

If not otherwise specified, the choice of the procedure is left to the manufacturer. The test method used shall be indicated in the test report.

7.3.3 Power-frequency voltage withstand tests between sections

This test is applicable only to instrument transformers having more than one section.

The test voltage according to 5.3.4 shall be applied for 60 s in turn between the short circuited terminals of each section.

The frame, case (if any), core (if there is a special earth terminal), and the terminals of all the other terminals or sections shall be connected together and to earth.

7.3.4 Power-frequency voltage withstand tests on secondary terminals

The test voltage according to 5.3.5 shall be applied for 60 s in turn between the short circuited terminals of each winding and earth.

The frame, case (if any), core (if there is a special earth terminal), and all the other terminals shall be connected to earth.

7.3.5 Test for accuracy

See specific standards.

7.3.6 Verification of markings

It shall be verified that the nameplate and terminal markings are correct.

7.3.7 Enclosure tightness test at ambient temperature

7.3.7.1 Closed pressure systems for gas

The tightness test on the enclosure of gas-insulated instrument transformers shall prove compliance with the requirements given in 6.2.4 and shall be performed on a complete transformer at ambient temperature (20 ± 10) °C.

If possible, the method will be the cumulative method for closed pressurised systems as specified by IEC 60068-2-17 (test method 1 of Qm test). Leakage detection using a sniffing device may be used. If a leak is detected with the leakage detector, then the leakage shall be quantified using the cumulative method.

The test should be started at least 1 h after the filling of the transformer in order to reach a stabilised leakage flow.

The sensitivity of the leakage measurement shall be such as to detect a leakage rate corresponding to about 0,25 %/year.

7.3.7.2 Liquid systems

The purpose of tightness tests is to demonstrate that there is no leakage.

The object under test shall be assembled as in the service condition with all its accessories and its normal fluid, mounted as close as possible to that in service (i.e. framework, fixing etc.).

7.3.8 Pressure test for the enclosure

Refer to 7.2.9.

7.4 Special tests

7.4.1 Chopped impulse voltage withstand test on primary terminals

The test shall be carried out with negative polarity only and combined with the negative polarity lightning impulse test in the manner described below.

The voltage shall be a standard lightning impulse as defined in IEC 60060-1, chopped between 2 µs and 5 µs. The chopping circuit shall be so arranged that the amount of over swing of opposite polarity of the recorded impulse shall be limited to approximately 30 % of the peak value.

The test voltage of the full impulses shall have the appropriate value, given in Table 2 depending on the highest voltage for equipment and the specified insulation level.

The chopped impulse test voltage shall be in accordance with 5.3.3.2.

The sequence of impulse applications shall be as following:

a) for instrument transformers having U_m < 300 kV:
   - one full impulse;
   - two chopped impulses (four chopped impulses for unearthed voltage transformers);
   - fourteen full impulses.

   For unearthed voltage transformers, two chopped impulses and approximately half of the 15 full impulses shall be applied to each terminal.

b) for instrument transformers having $U_m \geq$ 300 kV:

– one full impulse;
– two chopped impulses;
– two full impulses.

Differences in the wave shape of full-wave applications before and after the chopped impulses are an indication of an internal fault.

Flashovers during chopped impulses along self-restoring external insulation shall be disregarded in the evaluation of the behavior of the insulation.

7.4.2 Multiple chopped impulse test on primary terminals

The test should be made to prove compliance with 6.8.

The test shall be performed by applying multiple impulses of negative polarity chopped close to the crest.

The test voltage shall be applied between the primary terminals (connected together) and earth for CT's, and between the primary high voltage terminals and the primary earth terminals for earthed voltage transformers. The frame, case (if any), core (if intended to be earthed) and all the terminals of the secondary winding(s) shall be connected to earth.

- The prescribed peak value of the test voltage shall be 70 % of the rated lightning impulse withstand voltage. The impulse front of the test voltage should be 1,2/50 µs wave.
- The virtual duration of voltage collapse, measured according to IEC 60060-1, shall not exceed 0,5 µs and the circuit shall be so arranged that the over swing to opposite polarity of the impulse shall be approximately 30 % of the prescribed peak voltage.

600 consecutive impulses shall be applied, approximately at a rate of 1 impulse/min.

NOTE The number of impulses could be reduced to 100 by agreement between the manufacturer and the purchaser.

The wave shape shall be recorded at the beginning and at the end of the test, as well as after a minimum of every 100 impulses.

The criteria for evaluating the result should be based on the following requirements:

– the comparison of the impulse voltages recorded at the beginning and after each 100 impulses should not give evidence of any modification which could be attributed to internal discharges;
– the level of the partial discharges measured should not exceed the values of Table 3;
– the measurement of capacitance and dielectric dissipation factor measured before and after at least 24 h from the conclusion of the test. The results should be the same, apart from the uncertainty attributed to the test method used and to the effects of negligible quantities that may influence the result (e. g., temperature of the insulating materials);
– the increase of the dissolved gases in oil, measured 72 h after the test, shall not exceed the following values:
  – hydrogen (H_2): 20 µl/l (minimum detectable level 3 µl/l),
  – methane (CH_4): 5 µl/l (minimum detectable level: 0,1 µl/l)
  – acetylene (C_2H_2): 1 µl/l (minimum detectable level: 0,1 µl/l).

  Oil sampling procedure should be in accordance with IEC 60567.

When any of the indicated requirements is not met, the instrument transformer shall be considered to have failed the test.

7.4.3 Measurement of capacitance and dielectric dissipation factor

The main purpose is to check the uniformity of the production. Limits for the permissible variations may be the subject of an agreement between manufacturer and purchaser.

The test shall be carried out after the power-frequency withstand test on the primary terminals. For a CVT this test shall be applied both before and after.

The dielectric dissipation factor is dependent on the insulation design, and on both voltage and temperature. Its value at $U_m/\sqrt{3}$ and ambient temperature normally does not exceed 0,005.

The test shall be performed with the instrument transformer at ambient temperature, the value of which shall be recorded.

The values of capacitance and dielectric dissipation factor (tan δ) shall be referred to the rated frequency and to a voltage level in the range from 10 kV to $U_m/\sqrt{3}$.

NOTE The dielectric dissipation factor test is not applicable to gas-insulated instrument transformers.

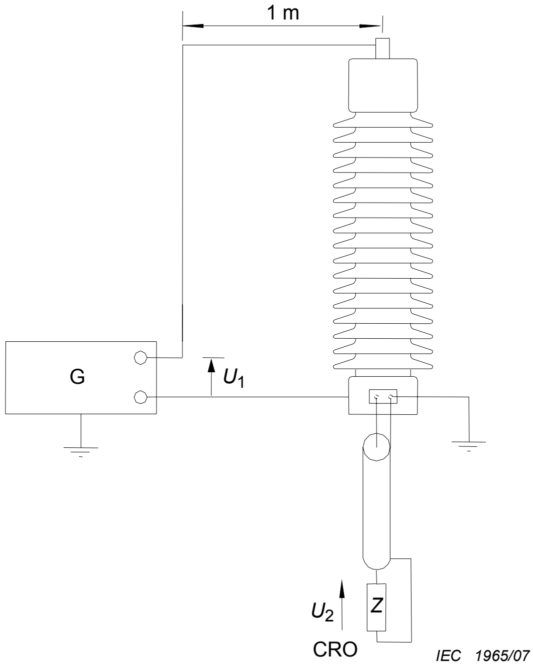
7.4.4 Transmitted overvoltage test

This test is made to prove compliance with 6.11.4.

A low voltage impulse (U_1) shall be applied between one of the primary terminals and earth (see Figure 9).

For instrument transformers for GIS, the impulse shall be applied through a 50 Ω coaxial cable adapter according to Figure 10. The enclosure of the GIS section shall be connected to earth as planned in service.

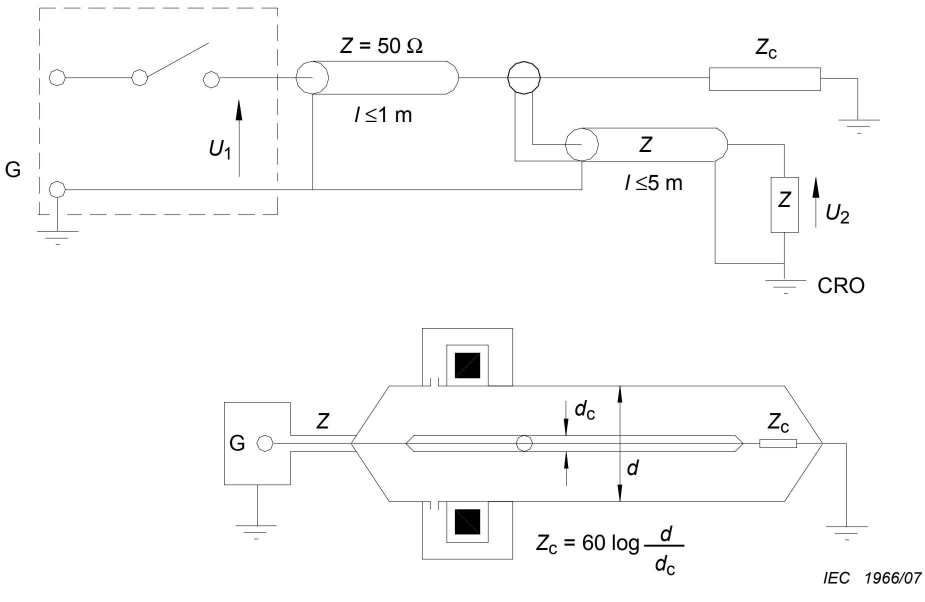
For other applications, the test circuit shall be as described in Figure 9.



Key

G	Test generator
U_1	Test voltage
U_2	Transmitted voltage
CRO	Oscilloscope

Figure 9 – Transmitted overvoltages measurement: general test configuration



Key

G	Test generator
Z	50 Ω coaxial feed-through terminator
CRO	Cathode Ray Oscilloscope
U_1	Test voltage
U_2	Transmitted voltage
Z	50 Ω coaxial cable
Z_C	Load

Figure 10 – Transmitted overvoltages measurement: test circuit and GIS Test configuration (CT)

The terminal(s) of the secondary winding(s) intended to be earthed shall be connected to the frame and to earth.

The transmitted voltage (U_2) shall be measured at the open secondary terminals through a 50 Ω coaxial cable terminated with the 50 Ω input impedance of an oscilloscope having a bandwidth of 100 MHz or higher which reads the peak value.

NOTE 1 Other test methods to avoid the intrusion of the instrumentation may be agreed between manufacturer and purchaser.

If the instrument transformer comprises more than one secondary winding, the measurement shall be successively performed on each one of the windings.

In the case of secondary windings with intermediate tappings, the measurement shall be performed only on the tapping corresponding to the full winding.

The overvoltages transmitted to the secondary winding (U_s) for the specified overvoltages (U_p) applied to the primary winding shall be calculated as follows:

$$U_s = U_p x U_2 / U_1$$

In case of oscillations on the crest, a mean curve should be drawn, and the maximum amplitude of this curve is considered as the peak value U_1 for the calculation of the transmitted voltage.

NOTE 2 Amplitude and frequency of the oscillation on the voltage wave may affect the transmitted voltage.

The instrument transformer is considered to have passed the test if the value of the transmitted overvoltage does not exceed the limits given in Table 9.

7.4.5 Mechanical tests

The tests are carried out to demonstrate that an instrument transformer is capable of complying with the requirements specified in 6.7.

The instrument transformer shall be completely assembled, installed in a vertical position with the frame rigidly fixed.

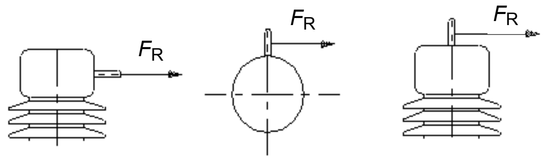
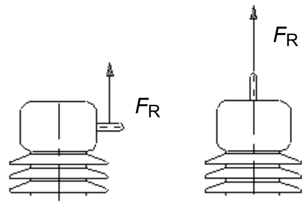
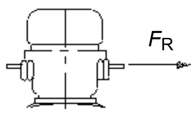
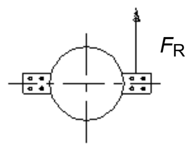
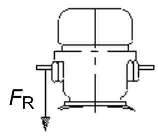
Liquid-immersed instrument transformers shall be filled with the specified insulation medium and submitted to the operating pressure.

Gas insulated free-standing instrument transformers shall be filled with specified gas or gas mixture at rated filling pressure.

For each of the conditions indicated in Table 12, the test loads shall be increased smoothly within 30 s to 90 s to the test load values according to Table 7. When the value is reached, it will be maintained for at least 60 s. During this time the deflection shall be measured. The test load shall then be released smoothly and the residual deflection shall be recorded.

The instrument transformer shall be considered to have passed the test if there is no evidence of damage (deformation, rupture or leakage).

Table 12 – Modalities of application of the test loads to be applied to the line primary terminals

Instrument transformer type	Modality of application	
With voltage terminal	Horizontal	
	Vertical	
With through current terminals	Horizontal to each terminal	
		
	Vertical to each terminal	
The test load shall be applied to the centre of the terminal.		

7.4.6 Internal arc fault test

The test should be made to prove compliance with 6.9. The instrument transformer shall be equipped with all accessories and shall be mounted to simulate service conditions.

The base of the transformer shall be mounted on a pedestal of at least 500 mm high. For gas-insulated instrument transformers, the filling pressure shall not be less than the rated filling pressure at 20 °C.

For the internal arc fault test, a containment area encircling the object under test for projected parts shall be defined. The diameter of this area shall be equal to the transformer diameter (largest dimension) plus twice the specimen height, with a minimum diameter of 2 m.

The test shall be carried out with the transformer initially at ambient temperature.

The test current frequency shall be between 48 Hz to 62 Hz.

The test current shall be the one specified in 6.9.

The tolerances admitted are the following:

- ±5 % on the r.m.s. value;
- ±5 % on the duration.

The power of the supply shall be sufficient to practically maintain the sinusoidal arc fault current throughout the entire duration of the test.

The arc inside the test object can be incepted by a wire of 1 mm to 3 mm diameter placed between the high and low voltage shield through the main insulation or by means of an equivalent device.

For gas insulated instrument transformers, the arc inception shall be located in the highest dielectric stressed area.

For oil-immersed instrument transformers, the location of the arc inception shall be agreed between the manufacturer and the purchaser.

NOTE For top core oil-immersed current transformers, in many cases the area in which failure in service is initiated is located in the upper part of the main insulation. For hair pin oil-immersed instrument transformers this area is generally located in the bottom part of the main insulation.

The instrument transformer is considered to have successfully passed the test if the performance criteria described in 6.9 are met.

In the event that an instrument transformer of similar design is already qualified, the manufacturer shall provide the documents demonstrating the ability of the non-qualified instrument transformer to withstand an internal arc fault without performing any additional test.

7.4.7 Enclosure tightness tests at low and high temperatures

The tightness test on the enclosure of gas-insulated instrument transformers shall prove compliance with the requirements given in 6.2.4.2 and shall be performed on a complete transformer at the specified extreme limits of the temperature category.

The method shall be the cumulative method for closed pressurised systems as specified by IEC 60068-2-17 (test method 1 of Qm test).

Every opening present on the transformer enclosure shall be sealed with the original sealing device.

The position of the transformer may be different from the service position due to physical limitations of the environmental chamber.

The ambient temperature shall be measured with a minimum of three sensors located at approximately 0,3 m from the transformer and equally distributed along its height.

The test shall be started after at least 1 h from the completion of the filling of the instrument transformer, in order to allow stabilisation of the leakage flow.

The two series of tests shall be performed as follows:

- the measurement of the leakage rate shall be performed at ambient temperature (20 ± 10) °C;

- the temperature of the environmental chamber shall be decreased (or increased) to the lower (or higher) limit corresponding to the temperature category of the transformer at an average rate of ±10 K/h;
- the transformer shall be maintained at the minimum (or maximum) temperatures for at least 24 h, with a tolerance of ±5 K, before taking the measurement of the leakage rate;
- the measurement of the leakage rate is carried out at low (or high) temperature;
- the temperature of the environmental chamber shall be increased (or decreased) to the ambient temperature at an average rate of ±10 K/h;
- the measurement of the leakage rate after the transformer has stabilised at ambient temperature (20 ± 10) °C.

7.4.8 Gas dew point test

The gas dew-point shall be determined 24 h after gas filling, as a routine or a sample test, in order to prove compliance with the requirements given in 6.2.2.

The dew-point determination shall be carried out in accordance with IEC 60376 or IEC 60480 24 h after refilling.

If not otherwise agreed, the choice of the test modality is left to the manufacturer.

7.4.9 Corrosion test

7.4.9.1 Test procedure

A specific corrosion test should be performed according to the relevant IEC standard; reference is made to IEC 60068-1.

The test may be performed on representative models using the same materials as the instrument transformer under consideration.

EXAMPLE

– The tested equipment shall be submitted to environmental testing Ka (salt mist) according to IEC 60068-2-11. The duration of the test is 168 h.
– In addition, for painted surfaces, the resistance to humid atmospheres containing sulphur dioxide shall be tested according to ISO 3231.

7.4.9.2 Criteria to pass the test

– The tightness of the representative model shall not be affected by corrosion, either by visual inspection or by measurement.
– If the surface is painted, no trace of degradation shall be noticed.
– The concerned functionality of the representative model shall not be affected.
– The dismantling of the assemblies shall not be affected.
– The degree of corrosion, if any, should be indicated in the test report.

7.4.10 Fire hazard test

See Annex C.

7.5 Sample tests

See Annex D.

8 Rules for transport, storage, erection, operation and maintenance

See Annex B.

9 Safety

High-voltage equipment can be safe only when installed in accordance with the relevant installation rules, and used and maintained in accordance with the manufacturer's instructions in terms of:

– electrical aspects;
– mechanical aspects;
– thermal aspects.

High-voltage equipment shall only be operated and maintained by competent persons. Where possible it shall only be accessible to such competent persons but where unrestricted access is available to instrument transformers, additional safety features may be required.

10 Influence of products on the natural environment

The need to minimize the impact of instrument transformers during all phases of their life on the natural environment is now recognized.

IEC guide 109 gives guidance with regard to life cycle impacts, recycling and disposal at the end of life.

The manufacturer should specify information regarding any environmental aspects of the instrument transformer during service life, dismantling of the equipment and disposal.

Annex A
(normative)

Identification of test specimen

A.1 General

The following data and drawings, as applicable, shall be submitted by the manufacturer to the testing laboratory, in respect of each test and sample (but not necessarily included in the test report). Information to be included in the test report is given in 7.2.1.2.

A.2 Data

– manufacturer's name;
– type designation, ratings and serial number of IT;
– outline description of IT;
– rated characteristics of fuse links and protective devices, if any.

A.3 Drawings

Example of drawing to be submitted

Drawings to be submitted	Drawing content (as applicable)
Circuit diagram	Type designation of principal components
General layout	Overall dimensions Enclosure (s) Pressure-relief devices Conducting parts of main circuit Earthing connections Electrical clearances to earth, Liquid or gas insulation type and level Location and type designation of insulators
Detailed drawings of insulators	Material Dimensions (including profile and creepage distances)
Detailed drawings of parts of the main circuit and associated components	Dimensions and material of principal parts Details of terminals (dimensions, primary and secondary materials)
Electrical diagram of auxiliary and control circuits (if applicable)	Type designation of all components

Annex B
(informative)

Rules for transport, storage, erection, operation and maintenance

B.1 General

It is essential that the transport, storage and installation of instrument transformers, as well as their operation and maintenance in service, be performed in accordance with instructions given by the manufacturer.

Consequently, the manufacturer should provide on time instructions for the transport, storage, installation, operation and maintenance of instrument transformers.

B.2 Conditions during transport, storage and installation

A special agreement should be made between manufacturer and purchaser if the service conditions defined in the order cannot be guaranteed during transport and storage. Special precautions may be essential for the protection of insulation during transport, storage and installation, and prior to energising, to prevent moisture absorption due, for instance, to rain, snow or condensation. Vibrations during transport should be considered. Appropriate instructions should be given.

Gas insulated instrument transformers should be filled to a pressure sufficient to maintain positive pressure during transportation. A factory filling pressure of 1,3 x 10^5 Pa abs at 20 °C is appropriate for all IEC instrument transformer temperature categories.

B.3 Installation

B.3.1 General

For each type of instrument transformer the installation instructions provided by the manufacturer should at least include the items listed below.

B.3.2 Unpacking and lifting

Required information for unpacking and lifting safely, including details of any special lifting and positioning devices which are necessary, should be given.

At the arrival on site and before the final filling, the instrument transformer should be checked according to the manufacturer’s instructions. For gas insulated instrument transformers, the gas pressure measured at ambient temperature should be above the atmospheric pressure.

B.3.3 Assembly

When the instrument transformer is not fully assembled for transport, all transport units should be clearly marked. Drawings showing assembly of these parts should be provided with the instrument transformer.

B.3.4 Mounting

Instructions for the mounting of instrument transformers, operating devices and auxiliary equipment should include sufficient details of locations and foundations to enable site preparation to be completed.

B.3.5 Connections

Instructions should include information on:

a) connection of conductors, comprising the necessary advice to prevent overheating and unnecessary strain on the instrument transformers and to provide adequate clearance distances;
b) connection of auxiliary circuits;
c) connection of liquid or gas systems, if any, including size and arrangement of piping;
d) connection for earthing;
e) type of cable to be connected at the secondary terminals: the manufacturer should indicate a recommended cable.

B.3.6 Final installation inspection

Instruction should be provided for inspection and tests which should be made after the instrument transformer has been installed and all connections have been completed.

These instructions should include:

– a schedule of recommended site tests to establish correct operation;
– procedures for carrying out any adjustment that may be necessary to obtain correct operation;
– recommendations for any relevant measurements that should be made and recorded to help with future maintenance decisions;
– instructions for final inspection and putting into service.

NOTE When an optical system is used, it is important to verify its integrity and to perform functional tests during final inspection to ensure that no physical damage has occurred to the fibre during installation.

The results of the tests and inspection should be recorded in a commissioning report.

Gas insulated instrument transformers should be submitted to the following final checking:

– Measurement of gas pressure

  The pressure of the gas measured at the end of filling and standard atmospheric air conditions (20 °C and 101,3 kPa) should be not less than the rated filling pressure.
– Measurement of the dew point

  The gas dew point at rated filling pressure should not exceed –5 °C when measured at 20 °C. Adequate corrections should be applied for measurement at the other temperatures.
– Enclosure tightness check

  The check should be performed with the probing method for closed pressurized systems as specified for the routine test (7.3.7.1). The check should be started at least 1 h after the filling of the transformer in order to reach a stabilized leakage flow. The check can be limited to gaskets, over pressure devices, valves, terminals, manometers, temperature sensors, etc., using a suitable leak detector.

B.4 Operation

The instructions given by the manufacturer should contain the following information:

– a general description of the equipment with particular attention to the technical description of its characteristics and all operational features provided, so that the purchaser has an adequate understanding of the main principles involved;
– the minimum wake up current (when applicable);

– a description of the safety features of the equipment and their operation;
– as relevant, a description of the action to be taken to manipulate the equipment for maintenance and testing.

B.5 Maintenance

General

The effectiveness of maintenance depends mainly on the way instructions are prepared by the manufacturer and implemented by the purchaser

Recommendation for the manufacturer

a) The manufacturer should issue a maintenance manual including the following information:
   1) maintenance frequency and active time;
   2) detailed description of the maintenance work;
      – recommended place for the maintenance work (indoor, outdoor, in factory, on site, etc.);
      – procedures for inspection, diagnostic tests, examination, overhaul, check of functionality (limits of values and tolerances, for example, optoelectrical component operating efficiency);
      – reference to drawings;
      – reference to part numbers (when applicable);
      – use of special equipment or tools (cleaning and degreasing agents);
      – precautions to be observed (e.g; cleanliness).
   3) Comprehensive drawings of the details of the instrument transformers important for maintenance, with clear identification (part number and description) of assemblies, sub -assemblies and significant parts.

      NOTE Expanded detailed drawings which indicate the relative position of components in assemblies and sub-assemblies are a recommended illustration method.

   4) List of recommended spare-parts (description, reference number, quantities, etc.) and advice for storage.
   5) Estimate of active scheduled maintenance time.
   6) How to proceed with the equipment at the end of its operating life, taking into consideration environmental requirements.
b) The manufacturer should inform the users about corrective actions required by possible systematic defects and failures where necessary.
c) Availability of spares: The manufacturer should be responsible for ensuring the continued availability of recommended spare parts required for maintenance for a period not less than 10 years from the date of the final manufacture of the instrument transformer.

Recommendations for the purchaser

a) If the purchaser wishes to do his own maintenance, he should ensure that his staff are suitably qualified and have a detailed knowledge of the instrument transformer.
b) The purchaser should record the following information:
   – the serial number and the type of the instrument transformer;
   – the date when the instrument transformer is put in service;
   – the results of all measurements and tests including diagnostic tests carried out during the life of the instrument transformer;
   – dates and extent of the maintenance work carried out;

- the service history, including records of the instrument transformers measurement during and following a special operating condition (e.g. fault and post fault operating state);
- references to any failure report.

c) In case of failure and defects, the purchaser should make a failure report and should inform the manufacturer by stating the special circumstances and measures taken. Depending upon the nature of the failure, an analysis of the failure should be made in collaboration with the manufacturer.

d) In case of disassembling for reinstallation in the future, the purchaser shall record the time and storage conditions.

B.6 Failure report

The purpose of the failure report is to standardize the recording of the instrument transformers failures with the following objectives:

- to describe the failure using a common terminology;
- to provide data for the purchaser statistics;
- to provide a meaningful feedback to the manufacturer;

The following gives guidance on how to make a failure report.

A failure report should include the following whenever such data is available:

a) Identification of the instrument transformers which failed:	
– substation name;	
– identification of the instrument transformer (manufacturer, type, serial number, ratings);	
– Instrument transformer construction (oil or SF_6 insulation, self-supported or busbar supported, mechanical coupled to a circuit breaker or not);	
– Instrument transformers technology used; (air core coil, iron core coil, optical)	
– location (indoor, outdoor);	
– enclosure.	
b) History of the instrument transformers:	
– history of the storage;	
– date of commissioning of the equipment	
– date of failure/defect;	
– date of last maintenance;	
– date of the last visual check of the oil level indicator	
– details of any changes made to the equipment since manufacture;	
– condition of the instrument transformers when the failure/defect was discovered (in service, maintenance, etc.).	
c) Identification of the sub-assembly/component responsible for the primary failure/defect:	
– high-voltage stressed components;	
– electrical control and auxiliary circuits;	
– other components.	
d) Stresses presumed to contribute to the failure/defect	
– environmental conditions (temperature, wind, snow, ice, pollution, lightning, etc.).	
– grid conditions (switching operations, failure of other equipment, etc.)	
– others	
e) Classification of the failure/defect	
– major failure;	

– minor failure;	
– defect.	
f) Origin and cause of the failure/defect	
– origin (mechanical, electrical, electronic, tightness if applicable);	
– cause in the opinion of the person having established the report (design, manufacture, inadequate instructions, incorrect mounting, incorrect maintenance, stresses beyond those specified, etc.).	
g) Consequences of the failures or defect	
– instrument transformers down-time;	
– time consumption for repair;	
– labor cost;	
– spare parts cost.	

A failure report may include the following information:

- drawings, sketches;
- photographs of defective components;
- single-line station diagram;
- records or plots;
- reference to maintenance manual.

Annex C
(informative)

Fire hazard

C.1 Fire hazard

As the risk of fire is present, the likelihood of fire should be reduced under conditions of normal use, and even in the event of foreseeable abnormal use, malfunction or failure.

The first objective is to prevent ignition due to an electrically energized part. The second objective is to limit the impact of the fire.

When possible, materials should be chosen or the parts designed in such a way that they retard the propagation of fire in the equipment and reduce harmful effects on the local environment.

In the case where product performance requires the use of flammable materials, product design should take flame retardation into account, where possible.

The information supplied by the manufacturer should enable the purchaser to make risk evaluation during normal and abnormal operation.

Guidance is given in Table C.1.

Table C.1 – Fire hazard of electrotechnical products

Guidance for assessing the fire hazard	Minimization of toxic hazards due to fires
IEC 60695-1-1	IEC 60695-7-1

C.2 Fire hazard test

If requested, based on IEC 60695-1- 30 and IEC 60695-7-1.

Annex D
(informative)

Sample test

D.1 Sample test definition

A selected type or special test performed on one or more complete instrument transformers out of a specified production batch.

D.2 Sample tests

In order to monitor the required adequacy of the production series, the manufacturer should define, execute and document the sample test program according to the production quantities (e.g. every 300 units of the same type defined by the same type test reports).

The recommended sample test is the lightning impulse test on the primary terminals.

Bibliography

IEC 60028: *International standard of resistance for copper*

IEC 60038: *IEC standard voltages*

NOTE Harmonized as HD 472 S2:1989 (modified), with the following title "*Nominal voltages for low-voltage public electricity supply systems*"

IEC 60068-2: *Environmental testing – Part 2: tests A: Cold*

NOTE Harmonized in EN 60068-2 series (not modified).

IEC 60071-2: *Insulation co-ordination – Part 2: Application guide*

NOTE Harmonized as EN 60071-2:1997 (not modified).

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

IEC 60255-22-1: *Electrical relays – Part 22-1: Electrical disturbance tests for measuring relays and protection equipment – 1 MHz burst immunity tests*

NOTE Harmonized as EN 60255-22-1:2008 (not modified).

IEC 60565: *Underwater acoustics – Hydrophones – Calibration in the frequency range 0,01 Hz to 1 MHz*

NOTE Harmonized as EN 60565:2007 (not modified).

IEC 60599:*Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis*

NOTE Harmonized as EN 60599:1999 (not modified).

IEC 60660: *Insulators – Tests on indoor post insulators of organic material for systems with nominal voltages greater than 1 kV up to but not including 300 kV*

NOTE Harmonized as EN 60660:1999 (not modified).

IEC 60664-1: *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

NOTE Harmonized as EN 60664-1:2007 (not modified).

IEC 60869: *Fibre optic attenuators*

NOTE Harmonized in EN 60869 series (not modified).

IEC 60943: *Guidance concerning the permissible temperature rise for parts of electrical equipment in particular for terminals*

IEC 61000 (all parts): *Electromagnetic compatibility (EMC)*

NOTE Harmonized in EN 61000 series (modified).

IEC 61109: *Composite insulation for a.c. overhead lines with a nominal voltage greater than 1000 V. Definitions, test methods and acceptance criteria*

NOTE Harmonized as EN 61109:2008 (not modified).

IEC 61161: *Ultrasonics – Power measurement – Radiation force balances and performance requirements*

NOTE Harmonized as EN 61161:2007 (not modified).

IEC 61181: *Mineral oil-filled electrical equipment – Application of dissolved gas analysis (DGA) to factory tests on electrical equipment*

NOTE Harmonized as EN 61181:2007 (not modified).

IEC 62271-100: *High-voltage switchgear and controlgear – Part 100: High-voltage alternating-current circuit-breakers*

NOTE Harmonized as EN 62271-100:2009 (not modified).

CISPR 11: *Industrial, scientific and medical (ISM) radio frequency equipment – Electromagnetic disturbance characteristics – Limits and method of measurement*

NOTE Harmonized as EN 55011:2007 (modified).

CISPR 16-1-1: *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

NOTE Harmonized as EN 55016-1-1:2007 (not modified).

ISO 9001: *Quality management systems – Requirements*

NOTE Harmonized as EN ISO 9001:2008 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60060-1	- [1]	High-voltage test techniques - Part 1: General definitions and test requirements	HD 588.1 S1	1991 [2]
IEC 60068-2-11	- [1]	Environmental testing - Part 2: Tests - Test Ka: Salt mist	EN 60068-2-11	1999 [2]
IEC 60068-2-17	- [1]	Environmental testing - Part 2: Tests - Test Q: Sealing	EN 60068-2-17	1994 [2]
IEC 60068-2-75	- [1]	Environmental testing - Part 2-75: Tests - Test Eh: Hammer tests	EN 60068-2-75	1997 [2]
IEC 60071-1	- [1]	Insulation co-ordination - Part 1: Definitions, principles and rules	EN 60071-1	2006 [2]
IEC 60085	- [1]	Electrical insulation - Thermal evaluation and designation	EN 60085	2008 [2]
IEC 60270	- [1]	High-voltage test techniques - Partial discharge measurements	EN 60270	2001 [2]
IEC 60296	- [1]	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear	EN 60296 + corr. September	2004 [2] 2004
IEC 60376	- [1]	Specification of technical grade sulfur hexafluoride (SF_6) for use in electrical equipment	EN 60376	2005 [2]
IEC 60417	Data-base	Graphical symbols for use on equipment	-	-
IEC 60455	Series	Resin based reactive compounds used for electrical insulation	EN 60455	Series
IEC 60480	- [1]	Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use	EN 60480	2004 [2]
IEC 60529	- [1]	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 [2] 1993
IEC 60567	- [1]	Oil-filled electrical equipment - Sampling of gases and of oil for analysis of free and dissolved gases - Guidance	EN 60567	2005 [2]

[1] Undated reference.

[2] Valid edition at date of issue.

Publication	Year	Title	EN/HD	Year
IEC 60694	- [1)]	Common specifications for high-voltage switchgear and controlgear standards	EN 60694 + corr. May	1996 [3)] 1999
IEC 60695-1-1	- [1)]	Fire hazard testing - Part 1-1: Guidance for assessing the fire hazard of electrotechnical products - General guidelines	EN 60695-1-1	2000 [2)]
IEC 60695-1-30	- [1)]	Fire hazard testing - Part 1-30: Guidance for assessing the fire hazard of electrotechnical products - Preselection testing process - General guidelines	EN 60695-1-30	2008 [2)]
IEC 60695-7-1	- [1)]	Fire hazard testing - Part 7-1: Toxicity of fire effluent - General guidance	EN 60695-7-1	2004 [2)]
IEC 60721-3-3	- [1)]	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 3: Stationary use at weatherprotected locations	EN 60721-3-3	1995 [2)]
IEC/TR 60815	- [1)]	Guide for the selection of insulators in respect of polluted conditions	-	-
IEC 60867	- [1)]	Insulating liquids - Specifications for unused liquids based on synthetic aromatic hydrocarbons	EN 60867	1994 [2)]
IEC 61462	- [1)]	Composite hollow insulators - Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V - Definitions, test methods, acceptance criteria and design recommendations	EN 61462	2007 [2)]
IEC/TR 61634	- [4)]	High-voltage switchgear and controlgear - Use and handling of sulphur hexafluoride (SF_6) in high-voltage switchgear and controlgear	-	-
IEC 62155 (mod)	- [1)]	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V	EN 62155	2003 [2)]
IEC 62262	- [1)]	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)	EN 62262	2002 [2)]
IEC 62271-2	- [1)]	High-voltage switchgear and controlgear - Part 2: Seismic qualification for rated voltages of 72,5 kV and above	EN 62271-2	2003 [5)]
IEC 62271-203	- [1)]	High-voltage switchgear and controlgear - Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	EN 62271-203	2004 [2)]

[3)] EN 60694:1996 is superseded by EN 62271-1:2008, which is based on IEC 62271-1:2007.

[4)] IEC/TR 61643 is superseded by IEC/TR 62271-303:2008, which is harmonized as CLC/TR 62271-303:2009.

[5)] EN 62271-2:2003 is superseded by EN 62271-207:2007, which is based on IEC 62271-207:2007.

Publication	Year	Title	EN/HD	Year
CISPR 18-2	- [1)]	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 2: Methods of measurement and procedure for determining limits	-	-
IEC Guide 109	- [1)]	Environmental aspects - Inclusion in electrotechnical product standards	-	-
ISO 3231	- [1)]	Paints and varnishes - Determination of resistance to humid atmospheres containing sulphur dioxide	-	-

Annex ZZ
(informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Article 1 of Annex I of the EC Directive 2004/108/EC.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directives concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

NOTE EN 61869-1:2009 does not give presumption of conformity without another part of the standard.

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