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Interested committees:

Title: Draft BS EN 61869-1 Instrument transformers. Part 1: General requirements.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



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COMMITTEE DRAFT (CD)

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SECRETARIAT: Italy	SECRETARY: Mr Filippo Frugoni
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 10,TC 13,SC 17C,TC 33,TC 85,TC 95,TC 115	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☒ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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TITLE:
Instrument transformers - Part 1: General requirements

NOTE FROM TC/SC OFFICERS:
This third draft of IEC 61869-1 Edition 2 is the first issue of the integration of IEC 61869-1 Ed.1 and IEC 61869-6 Ed.1

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSTRUMENT TRANSFORMERS –

Part 1: General requirements

FOREWORD

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International Standard IEC 61869-1 has been prepared by IEC technical committee 38: Instrument transformers.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

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

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

A list of all parts in the IEC 61869 series, published under the general title *Instrument transformers*, can be found on the IEC website.

An overview of the planned set of standards at the date of publication of this document is given below. The updated list of standards issued by IEC TC 38 is available at the website: www.iec.ch

PRODUCT FAMILY STANDARD	PRODUCT STANDARD	PRODUCTS
61869-1 GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS	61869-2	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS
	61869-3	ADDITIONAL REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMERS
	61869-4	ADDITIONAL REQUIREMENTS FOR COMBINED TRANSFORMERS
	61869-5	ADDITIONAL REQUIREMENTS FOR CAPACITIVE VOLTAGE TRANSFORMERS
	61869-7	ADDITIONAL REQUIREMENTS FOR ELECTRONIC VOLTAGE TRANSFORMERS
	61869-8	ADDITIONAL REQUIREMENTS FOR ELECTRONIC CURRENT TRANSFORMERS
	61869-9	DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS
	61869-10	ADDITIONAL REQUIREMENTS FOR LOW-POWER PASSIVE CURRENT TRANSFORMERS
	61869-11	ADDITIONAL REQUIREMENTS FOR LOW POWER PASSIVE VOLTAGE TRANSFORMERS
	61869-12	ADDITIONAL REQUIREMENTS FOR COMBINED ELECTRONIC INSTRUMENT TRANSFORMER OR COMBINED PASSIVE TRANSFORMERS
	61869-13	STAND ALONE MERGING UNIT
	61869-14	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS FOR DC APPLICATIONS
	61869-15	ADDITIONAL REQUIREMENTS FOR VOLTAGE TRANSFORMERS FOR DC APPLICATIONS
	61869-16	TEDS (TRANSDUCER ELECTRONIC DATA SHEET) FOR INSTRUMENT TRANSFORMERS
	61869-99	GLOSSARY OF TERMS

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

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

The National Committees are requested to note that for this publication the stability date is **20XX**.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

This standard is the first revision of the standard IEC 61869-1, defining common requirements for instrument transformers, whatever the type (CT, VT ...) or the technology.

The revision has been decided by the TC38 general meeting in November 2014 and has been officialised by the review report 38/497/RR. Additionally, it has been decided to merge the IEC 61869-1 (General requirements) with the IEC 61869-6 (Additional general requirements for low-power instrument transformers) to have one single document and simplify the comprehension for the reader of LPIT specific standards.

In the document, technical modifications are marked with a red line on the left side of the page

- Scope: this document concerns only equipment for applications > 1 kV AC or 1,5 kv DC. LV equipment are covered by IEC 61869-201

- Definitions:

These definitions are intended to be transferred to the TC38 Glossary IEC 61869-99

- Import the definitions from IEC 61869-6 and check the applicability of all definitions to all kinds of instrument transformers;
- Remove definitions of terms not appearing in any of the standard of IEC 61869 series. If the explanation note was useful, it has been transferred to the relevant annex.
- some definitions related to CT's or VT's have been introduced, as they are common definitions for different documents in the IEC 61869 series;

- Normal service conditions

- Definition of temperature for storage conditions
- Definition of climatic conditions for transportation and storage

- Ratings:

- More logical clause repartition, between voltage ratings, current ratings (clause numbering has been prepared for the specific standard) and dielectric ratings.
- Table2: addition of the EHV levels to be consistent with other equipment
- System voltage and system earthing have been transferred from chapter 4 to chapter 5, as these are not service conditions
- Chopped lightning impulse test is now applicable for all kind of IT's with $U_m \geq 72,5$ kV. For gas-insulated IT's, it will be performed at rated filling pressure. This is critical to test voltage repartition on VT windings, voltage dividers as well as on graded insulation.
- Criteria for capacitance and $\tan\delta$ has been moved to the chapter 5 instead of chapter 6 for consistency of the dielectric requirement. A table 4 has been added for maximum values of $\tan\delta$ depending on the insulation technology.
- Insulation requirements for secondary terminals: additionally to the actual 3 kV AC withstand test, a measurement of the DC insulation resistance at 1 kV minimum is requested for $U_m \geq 72,5$ kV. This was introduced for consistency with IEEE and the request from many customers. It also gives a more accurate measurement of the quality of the insulation than the previous "pass or fail" criteria.

- Design and construction

- Table 8 (previously table 5) has been adapted to be consistent with revised IEC 60085. Note that, in accordance with previous standards, the maximum allowed temperature rise has been reduced by 5K to consider the fact that resistance measurement method gives an average temperature instead of hot spot.
- Pollution: instead of the former table 6 specifying creepage distance, we are now referring to the new edition of IEC TS 60815 series. This new edition refers to voltage phase-to-ground, and we need also to consider the correction factor according to the diameter. An Annex K defines some rules to calculate the equivalent average diameter in case of irregular shape of the insulating part.
- Mechanical requirement: the table 9 has been completed to consider EHV applications
- Multiple chopped impulse test: definition of maximum gas-in-oil level before and after test
- Transmitted overvoltage: both wave shapes are applicable for any type of insulation.
- EMC immunity requirements and emission requirements have been updated, with a close coherence with the IEC 60255-27 related to protection relays.
- Markings: add requirements for the terminal markings. This is needed for right structure of the specific requirements.
- Basic requirement for the pressure withstand of gas-filled enclosure, including rules for determination of the design pressure.
- EMC requirements have been updated to be consistent with IEC 60225
- Requirements for connector pin-out has been clarified, as defined in the IEC 61869-10 and 61869-11.
- Additional requirements: wake-up current and climatic conditions withstand capability

- Type of tests

- The definition of special test has been clarified.
- A new type of tests has been added: commissioning tests, to be carried out on-site.
- Transmitted overvoltage test and mechanical test have been moved from special tests to type tests. These requirements are considered as sufficiently important to validate the product design on a mandatory basis.
- Chopped wave impulse test is now a type test and is included in the dielectric tests. This is critical to test voltage repartition on VT windings, voltage dividers as well as on any graded insulation. As a conclusion, it is also applicable to GIS VT's. This is also needed to be consistent with IEC 61869-11, and certain other IEC and IEEE standards. Practically, this test is carried out together with the impulse test.
- Measurement of C and $\tan\delta$ has been moved from special tests to routine tests. When applicable, this is a basic test for measurement of the quality of insulation.

- Type tests

- A new annex J (informative) gives guidance for the extension of validity of type tests of an instrument transformer to another one of the same product range, but with a different set of ratings or different arrangements of components.
- Temperature rise test: more accurate definition of the test duration, consistent with IEC 61869-2:2012, applicable to all types of instrument transformers. If not applicable, it shall be specified in each specific standard.
- Lightning impulse test: same procedure (15 impulses) for all instrument transformers, whatever the voltage level. The previous specification of 3 impulses above 300 kV has no serious technical background and was specific for instrument transformer standard.
- Switching impulse test: to be performed in both polarities. This is needed to be consistent with other IEC standards and is necessary for testing of gas-insulated instrument transformers.

- Transmitted overvoltage test: moved to type test chapter. Small modification on the test circuit and some requirements about the provisions to be taken.
- Test for accuracy: the accuracy must be verified with regards to the temperature range and guaranteed for the whole frequency range and any transformer position.
- Verification of the degree of protection by enclosures: some clarifications on the test procedure.
- Mechanical test: moved to type test chapter. As the wind load on the IT represents 30 to 40% of the total load, it is permitted to apply this load directly on the transformer head instead of the terminals. Three possible test procedures are considered and detailed.
- EMC tests: clarification on the test requirements and conditions.
- Routine tests
 - Partial discharge measurement: definition of the voltage profile. The measurement of PD inception voltage and extinction voltage shall be recorded.
 - Insulation resistance measurement on secondary terminals (new clause): the measurement of the DC insulation resistance at 1 kV DC
 - Tightness test for liquid insulation: clarification of the test procedure. A test time of 24 h under pressure is defined to let time for the leakage to appear.
 - Measurement of C and $\tan\delta$: moved to routine test chapter. Definition of $\tan\delta$ criteria depending on the insulation material.
- Special tests
 - Addition of a new test for resin insulated instrument transformers operating at low temperature. This is needed to check for the absence of cracks or partial discharges after 5 temperature cycles between the ambient temperature and the minimum temperature.
- Commissioning tests (new clause)
 - some clarification on the responsibility for commissioning tests.
 - Include the installation inspection in the commissioning tests.
 - The gas dew point test has been moved to commissioning tests. The reason is that the measurement of gas humidity only makes sense with the final filling gas. After routine test, the transformers are transported with reduced pressure.
- Rules for transport, storage, erection, operation and maintenance:
 - All the important rules are mandatory and have been transferred from the informative annex to the standard requirements.
 - Conditions for transportation and storage have been specified.
 - Final installation inspection and tests: clarification of the responsibilities.
- Annexes
 - Add annex J (informative): guidance for the extension of validity of type tests or special tests of instrument transformers.
 - Add annex M (normative): Seismic qualification of instrument transformers.

INSTRUMENT TRANSFORMERS

Part 1: General requirements

1 Scope

This International Standard is applicable to newly manufactured instrument transformers with highest system voltage (U_{sys}) higher than 1 kV AC and 1,5 kV DC, with analogue or digital output for use with electrical measuring instruments or electrical protective devices, either for DC application, or having rated frequencies from 15 Hz to 400 Hz.

NOTE 1 a bushing type current transformer, although considered to have $U_{\text{m}} < 1$ kV AC is often placed on a system with a highest voltage > 1 kV. Example: CT's placed around a HV bushing.

The general requirements for instrument transformers for applications in LV systems are considered in the standard IEC 61869-201

This part of IEC 61869 is a product family standard and covers general requirements only. For each type of instrument transformer, the product standard is composed by this document and the relevant specific standard.

This part of IEC 61869 defines the errors in case of analogue or digital output. The other characteristics of a digital interface for instrument transformer are standardised in IEC 61869-9 as an application of the horizontal standard IEC 61850 series, which details layered substation communication architecture.

This part of IEC 61869 considers requirements concerning bandwidth. The accuracy requirements on harmonics and requirements for the anti-aliasing filter are given in the normative annex B.4.

In case of LPIT, the general block diagram of single-phase devices is given in Figure 1.

According to the technology, it is not absolutely necessary that all parts described in

Figure 1 are included in the instrument transformer.

As an example, for low-power passive transformers (LPITs without active electronic components) the blocks are composed of passive components only and there is no power supply.

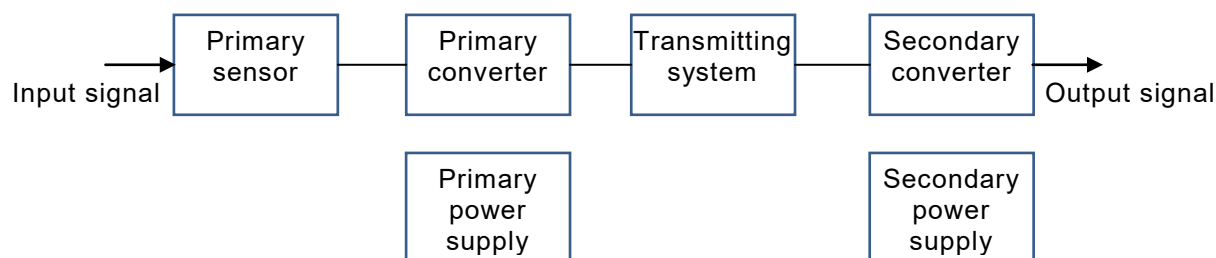


Figure 1 – General block diagram of single-phase devices

NOTE 2 A secondary power supply can be combined with a primary power supply or with a power supply of other instrument transformers.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50160:1994, *Voltage characteristics of electricity supplied by public distribution systems*

IEC 60060-1: *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-1: 2007, *Environmental testing - Part 2-1: Tests - Test A: Cold*

IEC 60068-2-2: 2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6:2007: *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*

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 60068-2-30: 2005, *Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-57: *Environmental testing – Part 2-57: Tests – Test Ff. Vibration – Time history method*

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

IEC 60068-3-3: *Environmental testing – Part 3: Guidance – Seismic test methods for equipments*

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

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

IEC 60085: *Electrical insulation – Thermal evaluation and designation*

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 sulphur hexafluoride (SF₆) for use in electrical equipment*

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

IEC 60480: *Guidelines for the checking and treatment of sulphur hexafluoride (SF₆) taken from electrical equipment and specification for its re-use*

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

- 674 IEC 60567: *Oil-filled electrical equipment – Sampling of gases and of oil for analysis of free*
675 *and dissolved gases – Guidance*
- 676 IEC 60603-7-1:2011, *Connectors for electronic equipment - Part 7-1: Detail specification for*
677 *8-way, shielded, free and fixed connectors*
- 678 IEC 60695-1-10: *Fire hazard testing – Part 1-10: Guidance for assessing the fire hazard of*
679 *electrotechnical products - General guidelines*
- 680 EC 60695-1-11: *Fire hazard testing - Part 1-11: Guidance for assessing the fire hazard of*
681 *electrotechnical products - Fire hazard assessment* IEC 60695-7-1: *Fire hazard testing – Part*
682 *7-1: Toxicity of fire effluent - General guidance*
- 683 IEC 60721-2-6: *Classification of environmental conditions – Part 2: Environmental conditions*
684 *appearing in nature – Earthquake vibration and shock*
- 685 IEC 60721-3-2: *Classification of environmental conditions – Part 3-2: Classification of groups*
686 *of environmental parameters and their severities - Transportation and Handling*
- 687 IEC 60721-3-3: *Classification of environmental conditions – Part 3-3: Classification of groups*
688 *of environmental parameters and their severities – Stationary use of weather protected*
689 *locations*
- 690 IEC 60794-2:2002, *Optical fibre cables – Part 2: Indoor cables - Sectional specification*
- 691 IEC 60794-3:2014, *Optical fibre cables - Part 3: Outdoor cables - Sectional specification*
- 692 IEC TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in*
693 *polluted conditions - Part 1: Definitions, information and general principles*
- 694 IEC TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in*
695 *polluted conditions - Part 2: Ceramic and glass insulators for a.c. systems*
- 696 IEC TS 60815-3, *Selection and dimensioning of high-voltage insulators intended for use in*
697 *polluted conditions - Part 3: Polymer insulators for a.c. systems*
- 698 IEC 60867: *Insulating liquids – Specifications for unused liquids based on synthetic aromatic*
699 *hydrocarbons*
- 700 IEC 61000-4-1:2006, *Electromagnetic compatibility (EMC) - Part 4-1: Testing and*
701 *measurement techniques - Overview of IEC 61000-4 series*
- 702 IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) - Part 4-2: Testing and*
703 *measurement techniques - Electrostatic discharge immunity test*
- 704 IEC 61000-4-3:2010, *Electromagnetic compatibility (EMC) - Part 4-3: Testing and*
705 *measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test*
- 706 IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) - Part 4-4: Testing and*
707 *measurement techniques - Electrical fast transient/burst immunity test*
- 708 IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) - Part 4-5: Testing and*
709 *measurement techniques - Surge immunity test*

- 710 IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) - Part 4-6: Testing and*
711 *measurement techniques - Immunity to conducted disturbances, induced by radio-frequency*
712 *fields*
- 713 IEC 61000-4-7:2009, *Electromagnetic compatibility (EMC) - Part 4-7: Testing and*
714 *measurement techniques - General guide on harmonics and interharmonics measurements*
715 *and instrumentation, for power supply systems and equipment connected thereto*
- 716 IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) - Part 4-8: Testing and*
717 *measurement techniques - Power frequency magnetic field immunity test*
- 718 IEC 61000-4-9:2001, *Electromagnetic compatibility (EMC) - Part 4-9: Testing and*
719 *measurement techniques - Pulse magnetic field immunity test*
- 720 IEC 61000-4-10:2001, *Electromagnetic compatibility (EMC) - Part 4-10: Testing and*
721 *measurement techniques - Damped oscillatory magnetic field immunity test*
- 722 IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) - Part 4-11: Testing and*
723 *measurement techniques - Voltage dips, short interruptions and voltage variations immunity*
724 *tests*
- 725 IEC 61000-4-13:2009, *Electromagnetic compatibility (EMC) - Part 4-13: Testing and*
726 *measurement techniques - Harmonics and interharmonics including mains signalling at AC*
727 *power port, low frequency immunity tests*
- 728 IEC 61000-4-16:2011, *Electromagnetic compatibility (EMC) - Part 4-16: Testing and*
729 *measurement techniques - Test for immunity to conducted, common mode disturbances in the*
730 *frequency range 0 Hz to 150 kHz*
- 731 IEC 61000-4-17:2009, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and*
732 *measurement techniques – Ripple on DC input power port immunity test*
- 733 IEC 61000-4-18:2011, *Electromagnetic compatibility (EMC) - Part 4-18: Testing and*
734 *measurement techniques - Damped oscillatory wave immunity test*
- 735 IEC 61000-4-29:2000, *Electromagnetic compatibility (EMC) - Part 4-29: Testing and*
736 *measurement techniques - Voltage dips, short interruptions and voltage variations on DC*
737 *input power port immunity tests*
- 738 IEC 61076-2-101:2012, *Connectors for electronic equipment - Product requirements - Part 2-*
739 *101: Circular connectors - Detail specification for M12 connectors with screw-locking*
- 740 IEC 61181: *Mineral oil-filled electrical equipment – Application of dissolved gas analysis*
741 *(DGA) to factory tests on electrical equipment*
- 742 IEC 61462: *Composite hollow insulators – Pressurized and unpressurized insulators for use in*
743 *electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods and*
744 *acceptance criteria and design recommendations*
- 745 IEC 61850-2:2003, *Communication networks and systems in substations - Part 2: Glossary*
- 746 IEC 61850-7-4:2010, *Communication networks and systems for power utility automation - Part*
747 *7-4: Basic communication structure - Compatible logical node classes and data object classes*
- 748 IEC 62271-1 *High-Voltage Switchgear and Controlgear - Part 1: Common specifications for*
749 *alternating current switchgear and controlgear*

750 IEC 62271-4 *High-voltage switchgear and controlgear – Use and handling of sulphur*
751 *hexafluoride (SF₆) in high-voltage switchgear and controlgear*

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

754 IEC 62262: *Degree of protection IK code*

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

757 ISO/IEC/IEEE 21451-4:2010, *Information technology -- Smart transducer interface for sensors*
758 *and actuators -- Part 4: Mixed-mode communication protocols and Transducer Electronic Data*
759 *Sheet (TEDS) formats*

760 CISPR 11:2010, *Industrial, scientific and medical equipment - Radio-frequency disturbance*
761 *characteristics - Limits and methods of measurement*

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

764 CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission*
765 *requirements*

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

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

769 **3 Terms and definitions**

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

771 ISO and IEC maintain terminological databases for use in standardization at the following
772 addresses:

- 773 • IEC Electropedia: available at <http://www.electropedia.org/>
- 774 • ISO Online browsing platform: available at <http://www.iso.org/obp>

775 **3.1 General definitions**

776 **3.1.1**

777 **instrument transformer**

778 **IT**

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

781 [SOURCE: IEC 321-01-01, modified – add “or similar apparatus”]

782 **3.1.2**

783 **current transformer**

784 **CT**

785 instrument transformer for current measurement with defined accuracy characteristics

3.1.3**voltage transformer****VT**

instrument transformer for voltage measurement with defined accuracy characteristics

3.1.4**bushing type current transformers**

current transformer without primary conductor and primary insulation of its own which can be fitted directly over an insulated bushing or conductor

Note 1 to entry: Bushing type current transformer is a generic definition which includes the cable type current transformer as defined in IEC 321-02-04

[SOURCE: IEC 321-02-02]

3.1.5**low-power instrument transformer****LPIT**

product arrangement, consisting of one or more current and/or voltage transformer(s) intended to transmit a low-power analogue or digital output signal to measuring instruments, meters and protective or control devices or similar apparatus

EXAMPLE: An arrangement consisting of three current sensors, three voltage sensors connected to one merging unit delivering one digital output is considered as an LPIT.

Note 1 to entry: output power produced by these devices is typically lower or equal to 1 VA.

3.1.6**low-power current transformer****LPCT**

low-power instrument transformer for current measurement

3.1.7**low-power voltage transformer****LPVT**

low-power instrument transformer for voltage measurement

3.1.8**measuring instrument transformer**

instrument transformer intended to transmit an output signal to measuring instruments and meters

3.1.9**protective instrument transformer**

instrument transformer intended to transmit an output signal to protective and control devices

3.1.10**multipurpose instrument transformer**

instrument transformer intended for both measurement and protection applications

3.1.11**electronic LPIT**

LPIT which cannot function without a source of energy other than the input signals

Note 1 to entry: the instrument transformers with electronics that are supplied from the primary circuit are also considered as electronic LPIT's

3.1.12**passive LPIT**

LPIT which functions without any source of energy other than the input signals

3.1.13**enclosure**

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

Note 1 to entry: This definition needs the following explanations under the scope of this standard:

1. Enclosures provide protection for persons or animals against access to hazardous parts;
2. Enclosures provide protection for equipment against the harmful effects of mechanical impacts;
3. Barriers, shapes of openings or any other means – whether attached to the enclosure or formed by the enclosed equipment – suitable to prevent or limit penetration, are considered as a part of the enclosure, except when they can be removed without the use of a key or tool.

[SOURCE: IEC 151-13-08, modified – Note to entry]

3.1.14**primary terminal**

terminal to which the voltage or current to be measured is applied

3.1.15**secondary terminals**

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

3.1.16**secondary circuit**

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

[SOURCE: IEC 321-01-08, modified – “winding” replaced by “terminals”]

3.1.17**section**

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

EXAMPLE: primary or secondary reconnectable windings, shielding to be externally grounded, temperature sensors

3.1.18**input signal**

signal corresponding to the current or to the voltage applied to the primary terminals of the instrument transformer

3.1.19**primary sensor**

electrical, optical or other device intended to provide information about the input signal in order to transmit it to the secondary converter, either directly or by means of a primary converter

3.1.20**primary converter**

electrical, optical or other arrangement that converts the signal coming from one or more primary sensors into a signal suitable for the transmitting system

3.1.21**primary power supply**

auxiliary power supply for the primary converter and/or primary sensor

Note 1 to entry: Can be combined with secondary power supply.

3.1.22**secondary power supply**

auxiliary power supply of the secondary converter

3.1.23**transmitting system**

short- or long-distance coupling arrangement between primary and secondary parts intended to transmit the signal

Note 1 to entry: Depending on the technology used, the transmitting system can also be used for power transmission.

3.1.24**output link**

short- or long-distance coupling arrangement intended to transmit the signal between the instrument transformer and the measuring instruments, meters and protective or control devices or similar apparatus

Note 1 to entry: Depending on the technology used, the transmitting system can also be used as output link.

3.1.25**secondary converter**

device that converts the signal transmitted through the transmitting system into a signal proportional to the input signal, to supply measuring instruments, meters and protective or control devices

Note 1 to entry: For analogue output, the secondary converter directly supplies measuring instruments, meters and protective or control devices. For digital output the secondary converter is connected to a merging unit before supplying the secondary equipment.

3.1.26**logical device merging unit**

logical device (in the meaning of IEC 61850-7-4) to do the time-coherent combination of logical nodes current transformer (TCTR) and/or logical nodes voltage transformer (TVTR) for building a standard digital output

3.1.27**Intelligent electronic device****IED**

any device incorporating one or more processors, with the capability to receive or send, data/control from, or to, an external source, for example electronic multi-function meters, digital relays, controllers

Device capable of executing the behaviour of one or more, specified logical nodes (in the meaning of IEC 61850-7-4) in a particular context and delimited by its interfaces.

3.1.28**merging unit****MU**

physical device (IED according to IEC 61850-2) in which a logical device merging unit is implemented

Note 1 to entry: The merging unit can be part of one of the instrument transformers in the field or may be a separate unit, for example, in the control room.

Note 2 to entry: The inputs of the merging unit may be proprietary or standardized.

3.1.29**stand-alone merging unit****SAMU**

merging unit with standardized inputs (analogue or digital)

925 EXAMPLE SAMU can be used with instrument transformers for retrofit purposes.

926 Note 1 to entry Digital input of the stand-alone merging unit could be specified according to former
927 IEC 60044-8 digital output or according to IEC 61869-9. This possibility ensures the backward compatibility
928 between IEC 60044-8 and the new IEC 61869 series.

929 3.1.30

930 merging unit clock input

931 electrical or optical input of the merging unit that can be used to synchronize several merging
932 units if required

933 3.1.31

934 output signal

935 analogue or digital signal at the secondary terminals

936 Note 1 to entry: In an electrical steady-state condition, the output signal is defined by the following equation:

937 a) For an analogue output:

$$938 y_s(t) = Y_s \sqrt{2} \sin(2\pi f t + \varphi_s) + Y_{\text{sdc}} + y_{\text{s res}}(t)$$

939 b) For a digital output:

$$940 y_s(n) = Y_s \sqrt{2} \sin(2\pi f t_n + \varphi_s) + Y_{\text{sdc}} + y_{\text{s res}}(n)$$

941 where

942 Y_s is the RMS value of secondary converter output, when $Y_{\text{sdc}} + y_{\text{s res}}(t) = 0$;

943 Y_{sdc} is the secondary direct signal (for LPIT);

944 $y_{\text{s res}}(t)$ is the secondary residual signal including harmonic and subharmonic components;

945 t is the instantaneous value of the time;

946 y_s is a digital number at the merging unit output representing the actual instantaneous value of
947 the primary signal;

948 Y_s is the RMS value of a certain merging unit output, when $Y_{\text{sdc}} + y_{\text{s res}}(n) = 0$;

949 f is the fundamental frequency;

950 φ_s is the phase of the secondary signal;

951 Y_{sdc} is the secondary direct output;

952 $y_{\text{s res}}(n)$ is the secondary residual output including harmonic, sub-harmonic and inter-harmonic
953 components;

954 n is the data sample counter;

955 t_n is the effective time where primary signal (current or voltage) of the n^{th} data set have been
956 sampled;

957 f, Y_s, φ_s being constant for steady-state condition.

958 Note 2 to entry: LPIT can exhibit specific characteristics as voltage offset, delay time, etc. Hence, while not
959 present within IEC 61869--2, -3 and -5, the above equations are important for an accurate presentation of the
960 requirements related to LPIT. The definitions of errors, while compatible with those of IEC 61869-2, -3 and -5, are
961 also improved.

962 3.1.32

963 steady state condition

964 the operating conditions in which the system state variables are considered to be sensibly
965 constant

966 3.1.33

967 transient condition

968 the operating condition in which at least one of the state variables is changing for a short
969 period

3.1.34**rated secondary output**

RMS value of the component at rated frequency of the secondary output (voltage or current) on which the performance of the instrument transformer is based

3.1.35**secondary voltage offset**

U_{sdco}

DC component of the secondary output of a low power instrument transformer when no input signal is applied

3.1.36**transient response**

response of the secondary output to a transient change of the primary signal

EXAMPLE. during short circuit or when reclosing with trapped charges

3.1.37**connecting point**

individual point of connection between the different low-voltage components of the instrument transformer.

3.1.38**low-voltage components**

all electric or electrical components of an LPIT separated from the primary circuit at the full rated withstand voltage level

EXAMPLE: Examples of low voltage components are the secondary converter, the merging unit, and the primary converter if placed at ground level.

3.1.39**wake-up time**

delay time needed by LPIT powered by the line current, in order to reach the normal operation, after the primary current has increased above the wake-up current

Note 1 to entry: During this delay, the output of the LPIT is zero.

3.1.40**wake-up current**

minimum value of the primary current necessary to wake up the LPIT (see 3.1.39)

3.1.41**electromagnetic compatibility****EMC**

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 161-01-07].

3.1.42**port**

particular interface of the specified equipment under test (EUT) with the external electromagnetic environment

See Figure 2

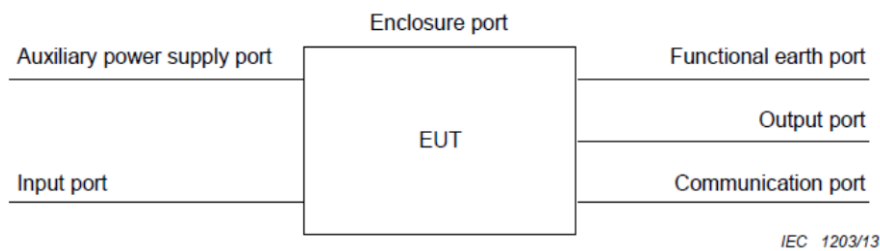


Figure 2 – Ports for LPIT

3.1.43

auxiliary power supply port

AC or DC auxiliary energizing input of the equipment under test

3.1.44

communication port

interface with a communication and/or control system permanently connected to the equipment under test

3.1.45

enclosure port

physical boundary of the equipment under test through which electromagnetic fields may radiate or impinge

3.1.46

functional earth port

port on the equipment under test which is connected to earth for purposes other than electrical safety

3.1.47

input port

port through which the equipment under test is energized or controlled in order to perform its function(s)

EXAMPLE Current and voltage transformer, binary input, etc.

3.2 Definitions related to voltage and insulation aspects

3.2.1

highest voltage of the system

U_{sys}

highest value of the line-to-line operating voltage (rms value) which occurs under normal operating conditions at any time and at any point in the system

[SOURCE: IEC 601-01-23, modified – add “line-to-line” and (rms value)]

3.2.2

highest voltage for equipment

U_{m}

greatest value of line-to-line voltage (RMS value) 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 under normal service conditions

[SOURCE: IEC 614-03-01]

3.2.3**rated primary voltage** U_{pr}

for voltage transformer, value of the primary voltage of the transformer and on which its performance is based

[SOURCE: IEC 321-01-12 modified – add “for voltage transformer” and remove “which appears in the designation”]

3.2.4**rated secondary voltage** U_{sr}

value of the secondary voltage on which the performance of the instrument transformer is based

3.2.5**rated voltage factor** F_V

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

[SOURCE: IEC 321-03-12]

3.2.6**rated insulation level**

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

3.2.7**isolated neutral system**

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

[SOURCE: IEC 601-02-24]

3.2.8**resonant earthed system**

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

Note 1 to entry 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.

[SOURCE: IEC 601-02-27 modified – note 1 to entry]

3.2.9**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

3.2.10**solidly earthed neutral system**

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

[SOURCE: IEC 601-02-25]

1092 **3.2.11**
1093 **impedance earthed neutral system**
1094 system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents

1095 [SOURCE: IEC 601-02-26]

1096 **3.2.12**
1097 **earth fault factor**
1098 at a given location of a three-phase system, and for a given system configuration, ratio of the
1099 highest RMS value of line-to-earth power frequency voltage on a healthy line conductor during
1100 an earth fault affecting one or more line conductors at any point on the system, to the RMS
1101 value of line-to-earth power frequency voltage which would be obtained at the given location
1102 in the absence of any such earth fault

1103 [SOURCE: IEC 614-03-06]

1104 **3.2.13**
1105 **voltages in transient condition**
1106 input signal and output signal of an instrument transformer during transients in the network

1107 **3.3 Definitions related to current ratings**

1108 **3.3.1**
1109 **rated primary current**
1110 I_{pr}
1111 value of the primary current on which the performance of the instrument transformer is based

1112 **3.3.2**
1113 **rated short-time thermal current**
1114 I_{th}
1115 maximum value of the primary current which a current transformer will withstand for a
1116 specified short time without suffering harmful effects

1117 [SOURCE: IEC 321-02-22 modified – reference to the secondary winding has been removed]

1118 **3.3.3**
1119 **rated dynamic current**
1120 I_{dyn}
1121 maximum peak value of the primary current which a current transformer will withstand, without
1122 being damaged electrically or mechanically by the resulting electromagnetic forces

1123 [SOURCE: IEC 321-02-24]

1124 **3.3.4**
1125 **rated continuous thermal current**
1126 I_{cth}
1127 value of the current which can be permitted to flow continuously in the primary terminals,
1128 without the temperature rise exceeding the values specified

1129 [SOURCE: IEC 321-02-25, modified – "primary winding" has been replaced by "primary
1130 terminals" and reference to the secondary winding has been removed]

1131 **3.3.5**
1132 **rated primary short-circuit current**
1133 I_{psc}
1134 rms value of the AC component of a transient primary short-circuit current on which the
1135 accuracy performance of a current transformer is based

1136 Note 1 to entry: While I_{th} is related to the thermal limit, I_{psc} is related to the accuracy limit. Usually, I_{psc} is smaller
 1137 than I_{th}

1138 3.3.6

1139 primary current in transient condition

1140 $i_p(t)$

1141 input signal of a low-power current transformer during transients in the network

1142 3.4 Definitions related to accuracy

1143 3.4.1

1144 actual transformation ratio

1145 ratio of the actual primary voltage or current to the actual secondary voltage or current

1146 3.4.2

1147 rated transformation ratio

1148 K_r

1149 ratio of the rated primary voltage or current to the rated secondary voltage or current

1150 3.4.3

1151 ratio error

1152 ε

1153 error which an instrument transformer introduces into the measurement and which arises from
 1154 the fact that the actual transformation ratio is not equal to the rated transformation ratio

1155 Note 1 to entry: The ratio error for current (ε_i) or voltage (ε_u) for analogue and for digital output is defined by the
 1156 following formula:

$$1157 \quad \varepsilon = \frac{K_r Y_s - X_p}{X_p} \times 100\%$$

1158 where

1159 K_r is the rated transformation ratio;

1160 X_p is the RMS value of the actual input signal;

1161 Y_s is the RMS value of actual output signal in case of analogue output;

1162 is the RMS value of the digital output in case of digital output.

1163 This definition is only related to components at rated burden and rated frequency of both primary signal and
 1164 secondary signal and does not consider direct signal components.

1165 3.4.4

1166 phase displacement

1167 $\Delta\phi$

1168 difference in phase between the primary voltage or current and the secondary voltage or
 1169 current phasors, the direction of the phasors being so chosen that the angle is zero for an
 1170 ideal transformer

1171 The phase displacement is said to be positive when the secondary voltage or current phasors
 1172 leads the primary voltage or current phasors. It is usually expressed in minutes or
 1173 centiradians.

1174 Note 1 to entry This definition is strictly correct for sinusoidal voltages or currents only.

1175 [SOURCE: IEC 321-01-23, modified – add “phasors” and the measurement units]

3.4.5**phase error** φ_e

difference between the actual phase displacement and the sum of rated phase offset related to the sensor technology and phase shift due to rated delay time related to the signal processing

Note 1 to entry: The phase error is calculated according to the following formula:

$$\varphi_e = \Delta\varphi - (\varphi_{or} + \varphi_{tdr})$$

with

$$\varphi_{tdr} = -2\pi f_{tdr}$$

where φ_{tdr} is the phase shift due to rated delay time

Note 2 to entry: For Instrument Transformers covered by IEC 61869-2, IEC 61869-3 and IEC 61869-5, phase displacement is equivalent to phase error

3.4.6**accuracy class**

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

[SOURCE: IEC 321-01-24, modified – replace “current” or “voltage” by “ratio” and “phase displacement” by “phase error”]

3.4.7**burden**

impedance of the secondary circuit

Note 1 to entry For conventional instrument transformers, the burden is usually expressed as the apparent power in volt-amperes absorbed in the secondary circuit at a specified power-factor and at the rated secondary voltage or current.

[SOURCE: IEC 321-01-25, modified – add “For conventional instrument transformer” in the note to entry]

3.4.8**rated burden**

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

[SOURCE: IEC 321-01-26]

3.4.9**rated output** S_r

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

[SOURCE: IEC 321-01-27 modified – add (“in Volt-amperes...”)]

3.4.10**delay time** t_d

actual time between an event taking place on the primary and its result(s) appearing in the output

Note 1 to entry: Delay time can result in low-power instrument transformers due to for instance band limiting filters and digital processing.

1222 Note 2 to entry: For instrument transformers with analogue output, delay time should be constant, and any
1223 deviation results in phase error.

1224 Note 3 to entry: For instrument transformers with digital output see IEC 61869-9.

1225 **3.4.11**

1226 **rated delay time**

1227 t_{dr}

1228 rated value of delay time for an LPIT with analogue output

1229 **3.4.12**

1230 **phase offset**

1231 φ_o

1232 phase displacement of an instrument transformer due to the technology employed and which
1233 is not affected by the frequency

1234 Note 1 to entry: An example of such technology is Rogowski Coil.

1235 **3.4.13**

1236 **rated phase offset**

1237 φ_{or}

1238 rated value of phase offset of an instrument transformer

1239 **3.4.14**

1240 **accuracy limit factor**

1241 K_{ALF}

1242 ratio of the rated accuracy limit primary current to the rated primary current

1243 [SOURCE IEC 321-02-30]

1244 **3.4.15**

1245 **composite error**

1246 ε_c

1247 under steady-state conditions, the RMS value of the difference between

1248 a) the instantaneous values of the primary current, and

1249 b) the instantaneous values of the actual secondary output multiplied by the rated
1250 transformation ratio,

1251 c) the positive signs of the primary current and secondary output corresponding to the
1252 convention for terminal markings

1253 Note 1 to entry: For analogue output, the composite error ε_c is expressed as a percentage of the RMS values of
1254 the primary current according to the formula:

$$1255 \quad \varepsilon_c (\%) = \frac{100}{I_p} \sqrt{\frac{1}{T} \int_0^T [k_r u_s(t) - i_p(t - t_{dr})]^2 dt}$$

1256 where

1257 K_r is the rated transformation ratio;

1258 I_p is the RMS value of the primary current;

1259 i_p is the primary current;

1260 u_s is the secondary voltage;

1261 T is the duration of one cycle;

1262 t is the instantaneous value of the time;

1263 t_{dr} is the rated delay time.

1264 For stand-alone Rogowski coils see IEC 61869-10.

1265 Note 2 to entry: For digital output, the composite error ε_c is expressed as a percentage of the RMS values of the
1266 primary current according to the formula:

$$1267 \quad \varepsilon_c(\%) = \frac{100}{I_p} \sqrt{\frac{T_s}{T} \sum_{n=1}^{T/T_s} [k_r i_s(n) - i_p(t_n)]^2}$$

1268 where

1269 K_r is the rated transformation ratio;

1270 I_p is the RMS value of the primary current;

1271 i_p is the primary current;

1272 i_s is the secondary digital output;

1273 T is the duration of one power cycle;

1274 n is the sample counter;

1275 t_n is the effective time where primary currents of the n^{th} data set have been sampled;

1276 T_s is the distance in time between two samples of the primary current.

1277 [SOURCE IEC 321-02-26, modified – replaced "secondary current" by "secondary output" –
1278 and modified note to the entry]

1279 3.4.16

1280 instantaneous error current

1281 $i_\varepsilon(t)$

1282 $i_\varepsilon(n)$

1283 difference between the instantaneous values of the secondary output multiplied by the rated
1284 transformation ratio and the primary current

1285 Note 1 to entry: For an analogue output, the instantaneous error current is defined by the following expression:

$$1286 \quad i_\varepsilon(t) = K_r \cdot u_s(t) - i_p(t - t_{dr})$$

1287 For stand-alone Rogowski coils see IEC 61869-10.

1288 Note 2 to entry: For digital output, the instantaneous error current is defined by the following expression:

$$1289 \quad i_\varepsilon(n) = K_r \cdot i_s(n) - i_p(t_n)$$

1290 3.4.17

1291 peak instantaneous current error

1292 $\hat{\varepsilon}$

1293 peak value ($\hat{i}_\varepsilon$) of instantaneous error current for the specified duty cycle, expressed as a
1294 percentage of the peak value of the rated primary short-circuit current

1295 Note 1 to entry: The peak instantaneous error is expressed by the following formula:

$$1296 \quad \hat{\varepsilon} = \frac{\hat{i}_\varepsilon}{\sqrt{2} \times I_{psc}} \times 100 \%$$

1297 3.4.18

1298 instantaneous voltage error

1299 $\varepsilon_u(t)$

1300 $\varepsilon_u(n)$

1301 ratio of the difference between the instantaneous values of the secondary output multiplied by
1302 the rated transformation ratio and the primary voltage to the peak of the primary voltage
1303 expressed in percent (%)

1304 **3.4.19**
1305 **power factor**
1306 under periodic conditions, ratio of the absolute value of the active power P to the apparent
1307 power S

1308 [SOURCE: IEC 131-11-46]

1309 **3.5 Definitions related to other ratings**

1310 **3.5.1**
1311 **rated frequency**
1312 f_r
1313 value of the frequency at which the Instrument transformer is designed to operate and on
1314 which the requirements of this standard are based

1315 **3.5.2**
1316 **rated frequency range**
1317 range of frequency for which the rated accuracy class is applicable

1318 **3.5.3**
1319 **rated auxiliary power supply voltage**
1320 U_{ar}
1321 auxiliary power supply voltage value on which the requirements of a specification are based

1322 **3.5.4**
1323 **nominal supply current**
1324 I_{ar}
1325 current required from the auxiliary power supply, including the MU power supply if required, in
1326 the nominal conditions

1327 **3.5.5**
1328 **maximum supply current**
1329 I_{amax}
1330 maximum current to be supplied by the auxiliary power supply, including the MU power supply
1331 if required, in the worst conditions

1332 **3.6 Definitions related to gas insulation**

1333 **3.6.1**
1334 **pressure relief device**
1335 device suitable to limit dangerous over-pressures inside the instrument transformer

1336 **3.6.2**
1337 **gas-insulated metal-enclosed instrument transformer**
1338 metal-enclosed instrument transformer intended to be mounted on Gas-Insulated Switchgear
1339 (GIS), inside or outside the switchgear enclosure

1340 **3.6.3**
1341 **closed pressure system**
1342 volume that is replenished only periodically by manual connection to an external gas source

1343 **3.6.4**
1344 **rated filling pressure**
1345 pressure referred to the standard atmospheric air conditions (20 °C and 101,3 kPa) to which
1346 the gas-insulated instrument transformer is filled before being put in service, or periodically
1347 replenished

1348 **3.6.5**1349 **minimum functional pressure**

1350 pressure referred to the standard atmospheric air conditions (20 °C and 101,3 kPa) at which,
1351 and above which, rated insulation and other characteristics of the gas-insulated instrument
1352 transformer are maintained and at which gas replenishment becomes necessary

1353 **3.6.6**1354 **absolute leakage rate**

1355 amount of gas escaped by time unit, expressed in Pa.m³/s

1356 **3.6.7**1357 **relative leakage rate**

1358 F_{rel}

1359 absolute leakage rate related to the total amount of gas in the instrument transformer at rated
1360 filling pressure (or density). It is expressed in percentage per year

3.7 Index of abbreviations

AIS	Air-Insulated Switchgear
CT	Current Transformer
EMC	Electromagnetic compatibility
F	Mechanical load
f_r	Rated frequency
F_{rel}	Relative leakage rate
GIS	Gas-Insulated Switchgear
I_{ar}	Nominal supply current
I_{amax}	Maximum supply current
I_{cth}	Rated continuous thermal current
I_{dyn}	Rated dynamic current
I_{pr}	Rated primary current
I_{psc}	Rated primary short-circuit current
I_{th}	Rated short-time thermal current
IED	Intelligent electronic device
IT	Instrument Transformer
K_r	Rated transformation ratio
LPCT	Low-power current transformer
LPIT	low-power instrument transformer
LPVT	Low-power voltage transformer
MU	Merging unit
U_{ar}	Rated auxiliary power supply voltage
U_m	Highest voltage for equipment
U_{pr}	Rated primary voltage
U_{sdco}	Secondary voltage offset
U_{sr}	Rated secondary voltage
U_{sys}	Highest voltage of a system
SAMU	Stand-alone merging unit
S_r	Rated output
t_d	Delay time
VT	Voltage Transformer
ε	Ratio error
$\Delta\varphi$	Phase displacement
φ_e	Phase error

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.

1367 If the actual service conditions differ from these normal service conditions, instrument
1368 transformers shall be designed to comply with any special service conditions required by the
1369 purchaser or appropriate arrangements shall be made.

1370 Detailed information concerning classification for environmental conditions is given in
1371 IEC 60721-3-3 (indoor) and IEC 60721-3-4 (outdoor).

1372 For instrument transformers for GIS application, Clause 2 of IEC 62271-203:2011 is
1373 applicable.

1374 **4.2 Normal service conditions**

1375 **4.2.1 Ambient air temperature**

1376 Instrument transformers are classified in three categories as given in Table 1.

1377 **Table 1 – Operating ambient temperature categories**

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

NOTE 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.

1378
1379 The possible normal storage temperatures (minimum and maximum) are indicated in Table 2.

1380 **Table 2 – Storage ambient temperatures**

Minimum temperature °C	Maximum temperature °C
–5	+40
–25	+55
–40	+70

1381

1382 **4.2.2 Altitude**

1383 The altitude does not exceed 1 000 m.

1384 **4.2.3 Vibrations or earth tremors**

1385 Vibrations can occur due to switchgear operations or short-circuit forces. Vibrations due to
1386 causes external to the instrument transformer (for example, switching operations of circuit-
1387 breakers, etc.) shall be regarded as normal service conditions. If additionally specified, tests
1388 shall be performed to prove the correct operations of the instrument transformer when
1389 subjected to such events. Vibrations due to earth tremors are considered as special service
1390 conditions.

1391 **4.2.4 Other service conditions for indoor instrument transformers**

1392 Other considered service conditions are as follows:

1393 a) the influence of solar radiation can be neglected;

- 1394 b) the ambient air is not significantly polluted by dust, smoke, corrosive gases, vapours or
1395 salt;
- 1396 c) the conditions of humidity are as follows:
- 1397 – the average value of the relative humidity measured for a period of 24 h does not
1398 exceed 95 %;
- 1399 – the average value of the water vapour pressure for a period of 24 h does not exceed
1400 2,2 kPa;
- 1401 – the average value of the relative humidity for a period of one month does not exceed
1402 90 %;
- 1403 – the average value of the water vapour pressure for a period of one month does not
1404 exceed 1,8 kPa.

1405 For these conditions, condensation can occasionally occur.

1406 NOTE 1 Condensation can be expected when sudden temperature changes occur in periods of high humidity.

1407 NOTE 2 Condensation can be prevented by special design of the housing, by suitable ventilation and heating, or
1408 using a dehumidifying device.

1409 **4.2.5 Other service conditions for outdoor instrument transformers**

1410 Other considered service conditions are as follows:

- 1411 a) the average value of the ambient air temperature, measured over a period of 24 h, does
1412 not exceed 35 °C;
- 1413 b) solar radiation up to a level of 1 000 W/m² (on a clear day at noon) shall be considered;
- 1414 c) the ambient air can be polluted by dust, smoke, corrosive gases, vapours or salt. The
1415 pollution does not exceed the pollution levels given in IEC TS 60815-1;
- 1416 d) the wind pressure does not exceed 700 Pa (corresponding to a 34 m/s wind speed);
- 1417 e) the presence of condensation or precipitation should be considered;
- 1418 f) the ice coating does not exceed 20 mm.

1419 **4.2.6 Partially outdoor LPIT**

1420 In the case of an LPIT of the type, which is partially indoors, partially outdoors, the
1421 manufacturer shall indicate which part of the equipment is indoors and which part of the
1422 equipment is outdoors.

1423 **4.2.7 Storage and transportation conditions**

1424 Instrument transformers are intended to be transported packaged or un-packaged, as defined
1425 by the manufacturer.

1426 If not otherwise specified, the standard classes of climatic conditions for transportation are:

- 1427 – class 2K12 in accordance with in IEC 60721-3-2 in case of weather-protected
1428 transportation;
- 1429 – class 2K13 in accordance with in IEC 60721-3-2 in case of non weather-protected
1430 transportation.

1431 During transportation, the standard mechanical conditions (vibration and shock) correspond to
1432 the class 2M4 according to IEC 60721-3-2. In specific conditions, class 2M5 can be more
1433 adapted.

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 can occur, resulting in condensation, even indoors.

For degrees of severity of service conditions under condensation and pollution, refer to the clause 3 of IEC 62271-304.

For electronics mounted inside an outdoor cabinet the preferred maximum temperature for very hot climates is increased to +55 °C (in accordance with IEC 62271-1). Temperatures up to +70 °C may also be specified (in accordance with IEC 60255-1).

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

Vibration level that are likely to occur shall be specified by the purchaser.

NOTE Earth tremors should not be confused with earthquakes.

4.3.5 Earthquakes

For installations where earthquakes are likely to occur, the relevant severity level in accordance with Annex N, clause N.3.2 shall be specified by the purchaser.

The compliance with such special requirements, if applicable, shall be demonstrated in accordance with Annex N.

5 Ratings

5.1 General

The ratings of instrument transformers, including their auxiliary equipment if existing, should be selected from the following (when applicable):

- a) highest voltage for equipment (U_m);
- b) rated insulation level;
- c) rated primary current (I_{pr}) or rated primary voltage (U_{pr});
- d) rated secondary current (I_{sr}) or rated secondary voltage (U_{sr}) or rated transformation ratio (K_r);
- e) rated short-time thermal current (for CT's) (I_{th});
- f) rated dynamic current (for CT's) (I_{dyn});
- g) rated continuous thermal current (for CT's) (I_{cth});
- h) rated primary short-circuit current (for CT's) (I_{psc});
- i) rated voltage factor (for VT's) (F_V);
- j) rated frequency (f_r);
- k) rated output (S_r);
- l) accuracy class.

The rating applies at the standardized reference atmosphere (temperature (20 °C), pressure (101,3 kPa) and humidity (11 g/m³)) specified in IEC 60071-1.

5.2 Voltage ratings

5.2.1 Highest voltage for equipment

Standard values shall be selected from Table 3.

Guidance for the selection of the rated Insulation level, is given in clause 5.5 of IEC 60071-1: 2011.

Table 3 – Rated primary terminal insulation levels for instrument transformers

Highest voltage for equipment U_m (RMS) kV	Rated power-frequency withstand voltage (RMS) kV	Rated lightning impulse withstand voltage (peak) kV	Rated switching withstand voltage (peak) kV
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 1 175	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
1100	1100	2250 2400 2550	1550 1675 1800
1200	1200	2250 2400 2700	1675 1800 1950

NOTE 1 For exposed installations (which is subject to overvoltage's of atmospheric origin), it is recommended to choose the highest insulation level.

NOTE 2 For alternative levels, refer to IEC 60071-1.

1494

1495 5.2.2 Highest voltage of the system (U_{sys})

1496 The highest voltage for equipment (U_{m}) shall be at least equal to the highest voltage of the
1497 system (U_{sys}).

1498 NOTE Bushing type CT's are sometimes intended to be installed on HV equipment. As the insulation is provided
1499 by the equipment itself, this requirement does not apply in this case.

1500 5.2.3 System earthing

1501 The considered system earthing can be:

- 1502 a) isolated neutral system (see 3.2.7);
- 1503 b) resonant earthed system (see 3.2.8);
- 1504 c) earthed neutral system (see 3.2.9):
 - 1505 1) solidly earthed neutral system (see 3.2.10);
 - 1506 2) impedance earthed neutral system (see 3.2.11):
 - 1507 – effectively earthed neutral characterized by an earth fault factor $\leq 1,4$;
 - 1508 – non-effectively earthed neutral characterized by an earth fault factor $> 1,4$.

1509 NOTE to entry This condition to be effectively earthed is obtained approximately when, for all system
1510 configurations, the ratio of zero-sequence reactance to the positive-sequence reactance is less than 3 and the ratio
1511 of zero-sequence resistance to positive sequence reactance is less than one.

1512 5.2.4 Rated auxiliary power supply voltage (U_{ar})

1513 5.2.4.1 General

1514 The rated auxiliary power supply voltage means the voltage measured at the power ports of
1515 the apparatus itself during its operation, including if necessary, the auxiliary resistors or

1516 accessories supplied or required by the manufacturer to be installed in series with it, but not
1517 including the conductors for the connection to the electricity supply.

1518 **5.2.4.2 AC voltage**

1519 The preferred rated values of AC voltages are given below:

1520 120 V – 230 V

1521 Preferred operating range is 80% to 110% of the rated voltage.

1522 The preferred values of the AC power supply frequency are:

1523 50 Hz – 60 Hz

1524 **5.2.4.3 DC voltage**

1525 The preferred rated values of DC voltages are given below:

1526 12 V - 24 V – 48 V – 60 V – 110 V – 125 V – 220 V – 250 V

1527 Preferred operating range is 80% to 110% of the rated voltage.

1528 NOTE In case of long distance between the control room and the instrument transformer electronics, a lower
1529 minimum supply voltage maybe specified.

1530 **5.2.4.4 Insulation requirements for power supply terminals**

1531 They shall be capable of meeting the requirements defined in the IEC 60255-27:2013, Table
1532 C7.

1533 **5.2.4.5 Power supply for LPIT supplied by IED**

1534 For LPIT supplied from IED in with DC power supply, the maximum power consumption shall
1535 be limited to 0.5 W. The standard voltage level of the power supply for this application is 24 V
1536 DC.

1537 **5.3 Current ratings**

1538 See specific standards.

1539 **5.4 Dielectric ratings**

1540 **5.4.1 General**

1541 For most of the values of highest voltage for equipment (U_m), several rated insulation levels
1542 exist to allow application of different performance criteria or overvoltage patterns. The choice
1543 should be made considering the degree of exposure to fast-front and slow-front overvoltage,
1544 the type of neutral earthing of the system and the type of overvoltage limiting devices.

1545 For the bushing type CT's, the insulation is not provided by the CT of its own, but through the
1546 HV device on which it is mounted (e.g. GIS, HV cable, HV bushing). No insulation level is
1547 applicable for these devices.

1548 **5.4.2 Rated primary terminal insulation level**

1549 The rated primary terminal insulation level of an instrument transformer shall be based on its
1550 highest voltage for equipment U_m in accordance with Table 3.

1551 Primary terminal intended to be earthed in service shall have a power-frequency withstand
1552 voltage of 3kV.

1553 For instrument transformers mounted on GIS, the rated insulation levels, testing procedures
1554 and acceptance criteria, are in accordance with IEC 62271-203. The applicable rated
1555 insulation levels are in accordance with IEC 62271-203:2011, Table 2 and 3, phase-to-earth
1556 insulation.

1557 5.4.3 Other requirements for primary terminals insulation

1558 5.4.3.1 Partial discharges

1559 Partial discharge requirements are applicable to instrument transformers having U_m greater
1560 than or equal to 7,2 kV.

1561 The partial discharge level shall not exceed the limits specified in Table 4. The test procedure
1562 is given in 7.3.2.2.

1563 **Table 4 – Partial discharge test voltages and permissible levels**

Type of earthing of the neutral system	Instrument transformer type	PD test voltage (rms) kV	Maximum permissible PD level pC	
			Type of insulation	
			immersed in liquid or gas	Solid
Earthed neutral system (earth fault factor $\leq 1,4$)	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.

1564

1565 5.4.3.2 Chopped lightning impulse

1566 Instrument transformers having $U_m \geq 72,5$ kV shall be capable to withstand a chopped
1567 lightning impulse voltage of negative polarity applied to its primary terminals having a peak
1568 value of 115 % of the rated lightning impulse withstand voltage.

1569 5.4.3.3 Capacitance and dielectric dissipation factor ($\tan \delta$)

1570 The main purpose of this measurement is to check the uniformity of the production.

1571 The measurement applies only to transformers having $U_m \geq 72,5$ kV, with

- 1572 – liquid immersed primary insulation;
- 1573 – solid-insulated instrument transformers;
- 1574 – gas-insulated instrument transformers with capacitance grading insulation system.

1575 NOTE Capacitance and $\tan \delta$ measurement can be difficult for many types of voltage transformers. Refer to the
1576 specific standards.

1577 The dielectric dissipation factor ($\tan \delta$) is dependent on the insulation design, and on both
 1578 voltage and temperature. Its value at ambient temperature shall not exceed the values
 1579 indicated in Table 5.

1580 **Table 5 – Maximum values of $\tan \delta$**

Type of insulation	Maximum value of $\tan \delta$ Measured at $U_m/\sqrt{3}$
Oil-impregnated paper	0,005
Oil-impregnated film	0,001
Gas-impregnated paper	0,003
Gas-impregnated film	0,001
Gas	0,001
Solid Insulation	0,015
Other (e.g.: new technologies)	^a
^a To be justified by the manufacturer	

1581 5.4.4 Between-section insulation requirements

1582 For interconnected terminals of each section, the rated power-frequency withstand voltage of
 1583 the insulation between sections shall be 3 kV.

1584 5.4.5 Insulation requirements for secondary terminals

1585 The rated power-frequency withstand voltage for secondary insulation shall be 3 kV.

1586 In case of LPIT, insulation requirements for secondary terminals and low voltage component
 1587 are given in Table 6.

1588 In cases where the total electrical cable length of the transmitting system up to the secondary
 1589 equipment does not exceed 10 m, and the associated earthing impedance is sufficiently low,
 1590 the common mode voltage is not supposed to exceed a safe value.

1591 **Table 6 – Secondary terminal and low voltage component withstand capability**

Transmitting system of the LPIT	Power frequency voltage withstand capability	Impulse voltage withstand capability
Electrical cable length < 10 m.	820 V	1,5 kV 1,2/50µs
Electrical cable length ≥ 10 m.	3 kV	5 kV 1,2/50µs
Optical connectors	NA	NA

1592 Note The first level for withstand capability of secondary terminal and the low voltage components are reduced to
 1593 a level consistent with the requirements defined in the IEC 60255-27:2013 Table C3. The insulation level meets
 1594 PEB (protection by equipotential bonding) system requirements for 150V working voltage.

1595 For Instrument transformers having $U_m \geq 72,5$ kV, the insulation resistance between the short-
 1596 circuited terminals of each secondary circuit and earth shall be higher or equal to 200 MΩ
 1597 when measured at a voltage of 1 kV DC. In case the withstand voltage is reduced below 1 kV
 1598 according to Table 6, the insulation measurement voltage shall be reduced to 500 V DC.

1599 NOTE if additionally specified for U_m lower than 72,5 kV, the same requirements apply.

1600 5.5 Rated frequency

1601 The standard values of the rated frequency for AC applications are

1602 16,7 Hz, 50 Hz, 60 Hz and 400 Hz.

1603 For measuring accuracy classes, the allowed frequency range is from 99 % to 101 % of the
1604 rated frequency (f_r).

1605 For protection accuracy classes, the allowed frequency range is from 96 % to 102 % of the
1606 rated frequency (f_r).

1607 The accuracy outside the rated frequency range, if requested is defined in Annex B.

1608 5.6 Output ratings

1609 5.6.1 Rated burden (R_{br})

1610 For conventional instrument transformers, the rated burden is expressed as the apparent
1611 power in volt-amperes absorbed in the secondary circuit at a specified power-factor and at the
1612 rated secondary voltage or current. See specific product standard.

1613 For LPIT's, the standard value of rated burden is defined by a resistance in parallel with a
1614 capacitance according to the following table:

Resistance	Capacitance
2 M Ω	50 pF

1615 For use on devices backward compatible with IEC 60044-8, 2 k Ω /5000 pF and 20 k Ω /500 pF
1616 are acceptable.

1617 The impact of the total burden impedance range on accuracy is covered under accuracy
1618 clauses.

1619 Attention should be paid to the parallel capacitance of electrical measuring Instruments or
1620 electrical protective devices. If the transmitting cable is not part of the sensor, the
1621 capacitance of the cable shall be considered as part of the burden. Typical cable capacitance
1622 is in the range from 15 to 100 pF/m.

1623 5.6.2 Standard values for the rated delay time (t_{dr})

1624 The standard values for rated delay time are:

1625 50 μ s, 100 μ s, 500 μ s

1626 5.7 Rated accuracy class

1627 See specific product standard.

1628 For LPIT's, harmonic requirements are defined in Annex B.

1629 6 Design and construction

1630 6.1 Requirements for liquids used in equipment

1631 6.1.1 General

1632 The manufacturer shall specify the type and the required quantity and quality of the liquid to
1633 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, new insulating oil shall comply with IEC 60867.

6.1.3 Liquid level indicator

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

6.1.4 Liquid tightness

No liquid loss is permitted. Any liquid loss represents a danger of insulation dielectric performance and is harmful for the environment.

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 SF₆ (sulphur hexafluoride) shall comply with IEC 60376, while used SF₆ shall comply with IEC 60480.

SF₆ handling shall be in accordance with IEC 62271-4.

The maximum allowed moisture content within instrument transformers filled with gas at rated filling pressure 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 for new SF₆ and IEC 60480 for used SF₆. This is applicable at any time in the life of the instrument transformer.

NOTE new insulating gases are under consideration and will be standardised in due time.

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 can 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 as an insulating medium, other than air at atmospheric pressure.

6.2.4.2 Closed pressure systems for gas

The tightness characteristic of a closed pressure system and the time between replenishments under normal service conditions shall be stated by the manufacturer. This time shall be at least 10 years for maintenance planning purposes.

1670 The tightness of closed pressure systems for gas is specified by the relative leakage rate F_{rel}
 1671 of each compartment.

1672 Standardized value is

1673 – for SF_6 and SF_6 mixtures, 0,5 % per year;

1674 – for other gases, 1 % per year.

1675 NOTE Lower leakage rates may be specified according to national regulations and regional practice.

1676 An increased leakage rate at extreme temperatures (if such tests are required in the relevant
 1677 standards) is acceptable, provided that this rate resets to a value not higher than the
 1678 maximum permissible value at normal ambient air temperature. The increased temporary
 1679 leakage rate shall not exceed the values given in Table 7.

1680 **Table 7 – 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	$6F_p$

1681 **6.2.5 Pressure relief device**

1682 The device shall be protected against any accidental damage.

1683 For GIS instrument transformers refer to IEC 62271-203:2011, clause 5.105.

1684 **6.3 Requirements for solid materials used in equipment**

1685 Specifications for organic material used for instrument transformers (i.e. epoxy resin,
 1686 polyurethane resin, epoxy-cycloaliphatic resin, composite material, etc.) either for indoor or
 1687 outdoor installations, are given in the IEC 60455 series.

1688 NOTE Tests on complete instrument transformers considering phenomena such as flammability and aging are not
 1689 yet standardized. IEC 60660 for indoor insulation, IEC 61109 for outdoor insulation and IEC 62217 for polymeric
 1690 HV insulators should be used as guidance.

1691 **6.4 Requirements for temperature rise of parts and components**

1692 **6.4.1 General**

1693 The temperature rise of windings, magnetic circuits and any other parts of instrument
 1694 transformers shall not exceed the appropriate value given in Table 8, when operating under
 1695 the specified rated conditions. These values are based on the service conditions given in
 1696 clause 4.2.1.

1697 The temperature rise of the windings is limited by the lowest thermal class either of the
 1698 winding itself or of the surrounding medium in which it is embedded.

1699 If the instrument transformers are used within enclosures, attention shall be paid to the
 1700 temperature reached by the surrounding cooling media within the enclosure.

1701 If ambient temperatures exceeding the values given in 4.2.1 are specified, the permissible
 1702 temperature rise given in Table 8 shall be reduced by an amount equal to the excess ambient
 1703 temperature.

1704
1705**Table 8 – Limits of temperature and temperature rise for various parts, materials and dielectrics of instrument transformers**

Part of instrument transformers	Maximum value	
	Temperature °C	Temperature rise at ambient air temperature not exceeding 40 °C K
1) Oil-insulated instrument transformers		
- top oil	90	50
- top oil, hermetically sealed	95	55
- winding average	100	60
- winding average, hermetically sealed	105	65
- other metallic parts in contact with oil	as for winding	as for winding
2) Solid-insulated or gas-insulated instrument transformers^a		
- winding (average) in contact with insulating materials of the following thermal classes (°C) ^b :		
• 90 (Y)	85	45
• 105 (A)	100	60
• 120 (E)	115	75
• 130 (B)	125	85
• 155 (F)	150	110
• 180 (H)	175	135
- other metallic parts in contact with insulation materials of the above thermal classes	as for windings	as for windings
3) Connection (including terminals), bolted or the equivalent	d)	e)
Bare-copper, bare-copper alloy or bare-aluminium alloy		
- in OG ^c	90	50
- in NOG ^d	115	75
- in oil	100	60
Silver-coated or nickel-coated		
- in OG ^c	115	75
- in NOG ^d	115	75
- in oil	100	60
Tin-coated		
- in OG ^c	105	65
- in NOG ^d	105	65
- in oil	100	60
^a Also applicable for bushing type CT's immersed in oil.		
^b Thermal class definitions in accordance with IEC 60085.		
^c OG: (Oxidizing Gas), is a reactive gas that can accelerate ageing of contacts either by corrosion phenomena (presence of humidity) or by oxidation phenomena (mostly due to ambient air medium like oxygen). Typical insulating OG gas is ambient air and dry air.		
^d NOG: (Not Oxidizing Gas), is a non-reactive gas that does not accelerate ageing of contacts by corrosion or oxidation, as purity of these gases is controlled. Typical NOG gases used today are SF ₆ , N ₂ , CO ₂ , CF ₄ . They can be used pure or as a mixture of various NOG.		

1706 NOTE compared to IEC 60085, the maximum temperature of windings has been reduced by 5K to consider the
1707 difference between the average temperature given by the method of resistance increase and the hot spot
1708 temperature.

1709 6.4.2 Influence of altitude on temperature rise

1710 If an instrument transformer is specified for service at an altitude higher than 1 000 m and
1711 tested at an altitude below 1 000 m, the limits of temperature rise ΔT given in Table 8 shall be