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Date: 09 August 2024

Origin: International

Latest date for receipt of comments: 25 September 2024

Project No. 2024/02224

Responsible committee: PEL/38 Instrument transformers

Interested committees:

Title: BS EN IEC 61869-5 Instrument transformers

Part 5: Additional requirements for capacitor voltage transformers

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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UK Vote

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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.	



38/801/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC 61869-5 ED2

DATE OF CIRCULATION:

2024-08-02

CLOSING DATE FOR COMMENTS:

2024-10-25

SUPERSEDES DOCUMENTS:

38/784/RR

IEC TC 38 : INSTRUMENT TRANSFORMERS

SECRETARIAT:

Italy

SECRETARY:

Mr Filippo Frugoni

OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 13,SC 17C,TC 33,TC 85,TC 95

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

Electricity transmission and distribution

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TITLE:

Instrument transformers - Part 5: Additional requirements for capacitor voltage transformers

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSTRUMENT TRANSFORMERS –

Part 5: Specific requirements of capacitor voltage transformers

FOREWORD

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IEC 61869-5 has been prepared by IEC technical committee 38: Instrument transformers. It is an International Standard.

This second edition cancels and replaces the first edition published in 2011 . This edition constitutes a technical revision.

The text of this International Standard is based on the following documents:

Draft	Report on voting
38/XX/FDIS	38/XX/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

This standard is Part 5 of IEC 61869, published under the general title *Instrument transformers*.

This part 5 is to be read in conjunction with, and is based on, IEC 61869-1, *General Requirements* – second edition (2023) – however the reader is encouraged to use its most recent edition.

This Part 5 follows the structure of IEC 61869-1:2023 and supplements or modifies its corresponding clauses.

For additional clauses, subclauses, figures, tables, annexes or note, the following numbering system is used:

- clauses, subclauses, tables and figures and notes that are numbered starting from 501 are additional to those in Part 1;
- additional annexes are lettered 5A, 5B, etc.

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 or existing 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: <https://www.iec.ch>

Product family standard	Product standard	Title
61869-1 General requirements	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 low-power voltage transformers
	61869-8	Additional requirements for low-power current transformers
	61869-9	Digital interface for instrument transformers
	61869-10	Additional requirements for current sensors
	61869-11	Additional requirements for voltage sensors
	61869-12	Additional requirements for combined low-power instrument 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	Instrument transformers: Glossary

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

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INTRODUCTION

This document is the first revision of the standard IEC 61869-5, defining additional requirements for capacitor voltage transformers.

The main modifications of this revision are listed below:

- adaptation to the new structure and requirements of IEC 61869-1:2023, common requirements for instrument transformers
- definition of two ranges for standard values for rated secondary voltage
- accuracy class 3,0 excluded
- transient accuracy class simplified to two classes
- standard values of rated output limited to 25 VA with unity power factor
- clarification on simultaneous loading
- new rated thermal limiting output values
- simplification of temperature rise test
- updated criteria for short circuit tests
- transfer of the definitions to the TC 38 Glossary IEC 61869-99;
- new annexes:
 - Annex A (normative): Identification of test specimen;
 - Annex B (informative): Recommendation for contents of failure reports;
 - Annex C (informative): Fire hazard;
 - Annex D (informative): Sample test;
 - Annex E (informative): Technique used in temperature rise test of transformers to determine the thermal time constant by an experimental estimation;
 - Annex F (informative): guidance for the extension of validity of type tests and special tests;
 - Annex G (informative): Guidance for the calculation of equivalent diameter in case of irregular shape of insulating part;
 - Annex I (normative): seismic qualification of instrument transformers;
 - Annex 5C (informative): Information about residual voltage winding;
 - Annex 5D (informative): Accuracy measurements with more than one winding;
 - Annex 5E (informative): Assessment of accuracy for different burden and power factor from the measured data;
 - Annex 5F (normative): Legacy burden values and accuracy definitions;

INSTRUMENT TRANSFORMERS –

Part 5: Specific requirements for capacitor voltage transformers

1 Scope

Scope 1 of IEC 61869-1:2023 applies with the following addition:

This part of IEC 61869 applies to new single-phase capacitor voltage transformers connected between line and ground for system voltages $U_m \geq 72,5$ kV at power frequencies from 15 Hz to 400 Hz. They are intended to supply a low voltage for measurement, control and protective functions.

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

The base requirements for coupling capacitors and capacitors dividers are defined in IEC 60358 series. The transmission requirements for coupling devices for power line carrier (PLC) system are defined in IEC 60481.

The measurement application includes both indication measuring and revenue measuring.

NOTE 501 Diagrams of capacitor voltage transformer to which this standard applies are given in Figures 5J.501 and 5J.502.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

Clause 2 of IEC 61869-1:2023 is applicable with the following additions:

IEC 60028, *International standards for resistance of copper*

IEC 60038 ed7.0 – IEC standard voltages

IEC 61869-1:2023, *Instrument transformer – Part 1: General requirements*

IEC 60050-436, *International Electrotechnical Vocabulary (IEV) – Chapter 436: Power capacitors*

IEC 60050-601, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*

IEC 60050-604, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*

IEC 62641:2022, *Conductors for overhead lines - Aluminium and aluminium alloy wires for concentric lay stranded conductors*

IEC 60358-1, *Coupling capacitors and capacitor dividers – Part1: General rules*

IEC 60358-2, *Coupling capacitors and capacitor dividers – Part2: AC or DC single-phase coupling capacitor connected between line and ground for power line carrier-frequency (PLC) application*

IEC 60358-4, *Coupling capacitors and capacitor dividers – Part4: SC or AC single-phase capacitor dividers*

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

IEEE C93.4:2012, *IEEE Standard for Power-Line Carrier Line-Tuning Equipment (30 kHz to 500 kHz) Associated with Power Transmission Lines*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 61869-99 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>;
- ISO Online browsing platform: available at <https://www.iso.org/obp>.

3.2 Symbols and abbreviated terms

Clause 3.2 of IEC 61869-1:2023 is modified by the following:

AIS	air-insulated switchgear
CVT	capacitor voltage transformer
CVD	Capacitor voltage divider
EMC	electromagnetic compatibility
F	mechanical load
f_r	rated frequency
F_{rel}	relative leakage rate
F_V	rated voltage factor
IT	instrument transformer
K_r	rated transformation ratio
k_{se}	superelevation factor
PD	partial discharge
U_m	highest voltage for equipment
U_{pr}	rated primary voltage
U_{sr}	rated secondary voltage
U_{sys}	highest voltage of the system

S_r	rated output – rated output power
S_{sim}	rated simultaneous burden
S_{th}	rated thermal limiting output of the winding
S_{tth}	rated thermal limiting output of the equipment
Z_{br}	rated burden
ZPA	zero period acceleration
ε	ratio error
ε_c	composite error
$\Delta\varphi$	phase displacement
K	actual transformation ratio
C_1	high voltage capacitor (of a capacitive divider)
C_2	intermediate voltage capacitor (of a capacitive divider)
C_r	rated capacitance of a capacitor
K_C	voltage ratio (of a capacitive divider)
L	compensating inductance
$\tan \delta$	tangent of loss angle of a capacitor
T_C	temperature coefficient of capacitance
U_C	intermediate voltage of a capacitive divider
$U_P(t)$	actual primary voltage
$U_S(t)$	actual secondary voltage

4 Normal and special environmental conditions

Clause 4 of IEC 61869-1:2023 applies

5 Ratings

5.1 General

Clause 5.1 of IEC 61869-1:2023 applies with the following addition:

NOTE 501 Please note that additional voltage ratings, to be considered together with subclause 5.2: Highest voltage for equipment, are given in subclause 5.2.1: Standard values of rated voltages.

5.2 Voltage ratings

5.2.1 Highest voltage for equipment (U_m)

Subclause 5.2.1 of IEC 61869-1:2023 applies

5.2.2 Power system earthing

Subclause 5.2.2 of IEC 61869-1:2023 applies

5.2.3 Standard values for rated primary voltage (U_{pr})

The standard values of rated primary voltage of a capacitor voltage transformer connected between one line of a three-phase system and earth or between a system neutral point and earth shall be $1/\sqrt{3}$ times the values of nominal system voltage as described in IEC 60038.

Preferred values are given in Table 501 and are based on IEC 60038.

Table 501 – Rated primary voltage (U_{pr}) levels for capacitor voltage transformers for AC applications

Highest voltage for equipment U_m (r.m.s.) kV	Rated primary voltage U_{pr} phase to ground (r.m.s.) kV
3,6	$3,3/\sqrt{3}$
7,2	$6,6/\sqrt{3}$
12	$11/\sqrt{3}$
17,5	$15/\sqrt{3}$
24	$22/\sqrt{3}$
36	$33/\sqrt{3}$
52	$45/\sqrt{3}$
72,5	$66/\sqrt{3}$ $69/\sqrt{3}$
100	$95/\sqrt{3}$
123	$110/\sqrt{3}$ $115/\sqrt{3}$
145	$132/\sqrt{3}$ $138/\sqrt{3}$
170	$154/\sqrt{3}$
245	$220/\sqrt{3}$ $230/\sqrt{3}$
300	$275/\sqrt{3}$ $285/\sqrt{3}$
362	$345/\sqrt{3}$ $330/\sqrt{3}$
420	$380/\sqrt{3}$ $400/\sqrt{3}$
550	$525/\sqrt{3}$ $500/\sqrt{3}$
800	$765/\sqrt{3}$
1 100	$1 050/\sqrt{3}$
1 200	$1 140/\sqrt{3}$

The standard values for rated primary voltage U_{pr} given in Table 501 cover the individual country-dependent values with a tolerance of $\pm 10\%$ limited to U_m value. Within the range of $\pm 10\%$ limited to U_m value all country-dependent primary voltage levels are allowed to use.

NOTE501 The performance of a capacitor voltage transformer as a measuring or protection transformer is based on the rated primary voltage U_{pr} whereas the rated insulation level is based on one of the highest voltages for equipment U_m of IEC 60071-1.

5.2.4 Standard values for rated secondary voltage (U_{sr})

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

110 V, 220 V.

The standard value 110 V covers the former secondary voltage levels 100 V, 115 V and 120 V, as well as, 200 V, 220 V and 230 V within a range of $\pm 10\%$. Within the range of $\pm 10\%$ all secondary voltage levels are allowed to use.

NOTE 501: The actual secondary voltage level can vary in a range of $\pm 10\%$ based on the given values above. The value of $\pm 10\%$ has nothing to do with a tolerance of the given values! This approach allows to standardise future secondary voltages and consider given ratio factors between primary and secondary voltages.

NOTE 502: In order to accommodate fixed-ratio applications the following two ranges are permitted (99 V to 121 V) and (198 V to 242 V), respectively, and are covered by the range of $\pm 10\%$ of standard secondary voltages. This approach allows to standardise future secondary voltages and consider given ratio factors between primary and secondary voltages.

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

For secondary windings intended to be connected in open delta circuit with similar windings to generate a residual voltage, the rated secondary voltage can be divided by 1, $\sqrt{3}$, or 3. The division factor depends on the used application.

More information about residual voltage windings is in Annex 5C

5.2.5 Rated auxiliary power supply voltage (U_{ar})

Subclause 5.2.6 of IEC 61869-1:2023 is not applicable.

5.2.501 Standard values for rated voltage factor (F_v)

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

The standard voltage factors appropriate to the different earthing conditions are given in Table 502, together with the permissible duration of maximum operating voltage (i.e. rated time).

Table 502 – Standard values of rated voltage factors

Rated voltage factor	Rated time	Method of connecting the primary winding and system earthing conditions
1,2	Continuous	Between phases in any network Between transformer star-point and earth in any network

1,2	Continuous	Between phase and earth in an effectively earthed neutral system (IEC 61869-99:2022, 3.1.6) with an earth fault factor which does not exceed 1,4
1,5	30 s	
1,2	Continuous	Between phase and earth in a non-effectively earthed neutral system (IEC 61869-99:2022, 3.1.7) with an earth fault factor that may exceed 1,4 with automatic earth-fault tripping
1,9	30 s	
1,2	Continuous	Between phase and earth in an isolated neutral system (IEC 61869-99:2022, 3.1.9) without automatic earth-fault tripping or in a resonant earthed system (IEC 61869-99:2022, 3.1.8) without automatic earth-fault tripping
1,9	8 h	
NOTE 501 Reduced rated times are permissible by agreement between manufacturer and purchaser.		

The highest continuous operating voltage for a CVT is U_m (divided by $\sqrt{3}$ for transformers connected between a phase of a three-phase system and earth). The rated voltage factor 1,2 related to U_{pr} is defined for accuracy and temperature rise performances.

5.3 Current ratings

5.3.1 Standard values for rated primary current (I_{pr})

Subclause 5.3.1 of IEC 61869-1:2023 is not applicable.

5.3.2 Standard values for rated secondary current (I_{sr})

Subclause 5.3.2 of IEC 61869-1:2023 is not applicable.

5.3.3 Standard values for rated continuous thermal current (I_{cth})

Subclause 5.3.3 of IEC 61869-1:2023 is not applicable.

5.3.4 Short-time current ratings

5.3.4.1 Rated short-time thermal current (I_{th})

Subclause 5.3.4.1 of IEC 61869-1:2023 is not applicable.

5.3.4.2 Rated dynamic current (I_{dyn})

Subclause 5.3.4.2 of IEC 61869-1:2023 is not applicable.

5.3.4.3 Rated internal arc fault current (I_{arc})

Subclause 5.3.4.3 of IEC 61869-1:2023 is not applicable.

5.4 Dielectric ratings

5.4.1 General

Subclause 5.4.1 of IEC 61869-1:2023 applies

5.4.2 Rated primary terminal insulation level

Subclause 5.4.2 of IEC 61869-1:2023 applies

The rated power-frequency short-duration withstand voltage for the earthed terminal shall be 3 kV (r.m.s.).

5.4.3 Other requirements for primary terminal insulation**5.4.3.1 Partial discharges**

Subclause 5.4.3.1 of IEC 61869-1:2023 applies

5.4.3.2 Chopped lightning impulse

Subclause 5.4.3.2 of IEC 61869-1:2023 applies

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

Subclause 5.4.3.3 of IEC 61869-1:2023 is applicable with the following subclauses:

The capacitance C of a unit, a stack and a capacitor voltage divider, at U_{pr} , ambient temperature and rated frequency, shall not differ from the rated capacitance C_r by more than -5% to $+10\%$.
The ratio of the capacitances of any two units forming part of a capacitor stack shall not differ by more than 5% from the reciprocal ratio of the rated voltages of the units.

For more details, see standard IEC 60358 series.

The typical $\tan\delta$ values for dielectrics, which are impregnated with mineral oil or synthetic oil are at $+20\text{ }^{\circ}\text{C}$ (293 K) and rated voltage, are defined in IEC 60358-1.

NOTE 501: The given values in IEC 61869-1:2023 Table 5 differ from values specified in IEC 60358-1 due to possible requirements for measurement purposes.

5.4.4 Between-section insulation requirements

Subclause 5.4.4 of IEC 61869-1:2023 applies

5.4.5 Insulation requirements for secondary terminals and low-voltage components**5.4.5.1 General requirements**

Subclause 5.4.5.1 of IEC 61869-1:2023 applies

5.4.5.2 Special requirements for LPITs

Subclause 5.4.5.2 of IEC 61869-1:2023 is not applicable

5.4.5.3 DC insulation resistance requirement

Subclause 5.4.5.3 of IEC 61869-1:2023 applies

5.4.5.501 Low voltage terminal of the capacitor voltage divider

Capacitor voltage dividers with a low-voltage terminal shall be subjected for 1 min to a test voltage between the low-voltage and earth terminals. The test voltage shall be an a.c. voltage of 4 kV (r.m.s.).

If the low voltage terminal is exposed to the weather, it shall be subjected for 1 min to an a.c. voltage of 10 kV (r.m.s.) between the low-voltage and earth terminals.

– The electromagnetic unit shall be connected.

NOTE 501 The test voltages are applicable to capacitor voltage transformers with and without carrier-frequency accessories with overvoltage protection.

- If a protection gap between the low voltage terminal and earth is incorporated, it shall be prevented from functioning. The carrier-frequency accessories shall be disconnected.

5.4.5.502 Electromagnetic unit insulation requirements

- a) The rated lightning impulse withstand voltage (LIWV) of the electromagnetic unit shall be equal to the:

$$\text{LIWV of the CVT} \times \frac{C_1}{C_1 + C_2} \text{ (peak)}$$

- b) The rated short-duration power-frequency withstand voltage of the electromagnetic unit shall be equal to:

$$U_{pr} \times 3,3 \times \frac{C_1}{C_1 + C_2} \text{ (r.m.s.)}$$

NOTE 501 Testing the electromagnetic unit together with the capacitor divider, the resulting test voltage level will be reduced

NOTE 502 The factor 3,3 is fixed for all U_m values and covers the worst case. The factor is the correlation factor between a.c. test voltage and U_m . EXAMPLE: $\sqrt{3} \times \frac{140 \text{ kV}}{72,5 \text{ kV}} \approx \sqrt{3} \times \frac{275 \text{ kV}}{145 \text{ kV}} \approx 3,3$

5.5 Rated frequency (f_r)

Subclause 5.5 of IEC 61869-1:2023 applies

5.6 Output ratings

5.6.1 Rated output for inductive instrument transformers and CVT

5.6.1.1 General

Subclause 5.6.1.1 of IEC 61869-1:2023 applies

5.6.1.2 Rated output values

Subclause 5.6.1.2 of IEC 61869-1:2023 applies with the following addition:

The standard values of rated output, expressed in voltamperes, are:

$$1,0 - 10 - 25 \text{ VA}$$

The power factor shall be 1,0.

The rated output of a three-phase transformer shall be the rated output per phase.

For legacy burden definitions, see Annex 5F. If legacy burdens are specified, "Annex 5F" shall be mentioned in the enquiry and on the nameplate.

For information on simultaneous loading of multiple windings and its implications see Annex 5D.

For information on calculation methods for accuracy performance at different burdens and power factors, see Annex 5E.

The values listed above shall be assigned to each of the windings within a transformer, accompanied by its associated accuracy class.

For a given capacitor voltage transformer, provided one of the values of rated output is standard and associated with a standard accuracy class, the declaration of other rated outputs, which

may be non-standard values but associated with other standard accuracy classes, is not precluded.

5.6.1.2.1 Additional output values

5.6.1.2.1.501 Rated thermal limiting output

The rated thermal limiting output shall be specified in voltamperes; the standard values are:

25 – 50 – 100 VA

related to the rated secondary voltage with unity power factor.

Thermal limiting output shall be specified for each winding and as a total value the unit can thermally withstand.

For legacy burden definitions, see Annex 5F.

NOTE 501 In this condition the limits of error can be exceeded.

NOTE 502 In the case of more than one secondary winding, the thermal limiting output is to be given separately for each winding.

NOTE 503 The rated thermal limiting output is specified and tested on a single winding, with the other winding(s) open; therefore, when making use of thermal limiting output ratings, the simultaneous use of more than one winding can be carefully considered and/or agreed with the manufacturer. See also subclause 7.2.2.501.

5.6.1.2.1.502 Rated output values for residual voltage windings

The rated output of windings intended to be connected in open-delta with similar windings to produce a residual voltage shall be specified in voltamperes and the value shall be chosen from the values specified in subclause 5.6.1.2.

More information about residual voltage windings and open-delta connection is described in Annex 5C.

5.6.1.2.1.503 Rated thermal limiting output for residual voltage windings

The rated thermal limiting output of the residual voltage winding shall be specified in voltamperes; the standard values are:

100 - 250 - 500 VA

related to the rated secondary voltage with unity power factor.

Where a thermal limiting output is assigned to a residual voltage winding connected in an open-delta, it should be noted that these windings are only loaded under fault conditions and therefore for a limited duration. Deviating from the definition in subclause 5.6.1.2: the rated thermal output of the residual voltage winding should be referred to a duration of 8 h.

5.6.2 Rated burden for LPITs

Subclause 5.6.2 of IEC 61869:2023 is not applicable

5.6.3 Standard values for the rated delay time for EITs (t_{dr})

Subclause 5.6.3 of IEC 61869:2023 is not applicable

5.7 Accuracy requirements

5.7.1 General

Subclause 5.7.1 of IEC 61869-1:2023 applies

5.7.2 Rated accuracy classes

5.7.2.501 Accuracy requirements for capacitor measuring voltage transformers

5.7.2.501.1 Standard accuracy classes for capacitor measuring voltage transformers

For capacitor measuring voltage transformers, the accuracy class is designated by the highest permissible percentage voltage error at rated voltage and with rated output, prescribed for the accuracy class concerned.

The standard accuracy classes for single-phase capacitor measuring voltage transformers are:

0,2 – 0,5 – 1,0

5.7.2.501.2 Limits of voltage error and phase displacement for measuring voltage transformers

The voltage error and phase displacement at rated frequency shall not exceed the values given in Table 503 at any voltage between 80 % and 120 % of rated voltage.

The connected output of 0 VA and 100 % of the rated output, at a power factor equal to 1,0 shall be used for measurements.

For legacy burdens and accuracy class definition refer to Annex 5F.

For an output outside these ranges the accuracy of the capacitor voltage transformer is not guaranteed, even though it might be inherently achievable. For assessing expected accuracy performance at outputs and/or power factors exceeding the nominal range, see Annex 5E.

The errors shall be determined at the terminals of the transformer and shall include the effects of any fuses or resistors as an integral part of the transformer.

Table 503 – Limits of voltage error and phase displacement for capacitor measuring voltage transformers

Class	Voltage (ratio) error ε_u $\pm\%$	Phase displacement $\Delta\phi$	
		$\pm$ Minutes	$\pm$ Centiradians
0,2	0,20	10,0	0,30
0,5	0,50	20,0	0,60
1,0	1,00	40,0	1,20

NOTE 501 Voltage (ratio) error is considered with 2 digit measurement resolution.

5.7.2.502 Accuracy requirements for capacitor protective voltage transformers

5.7.2.502.1 Accuracy class designation for capacitor protective voltage transformers

All voltage transformers intended for protection application, with the exception of residual voltage windings, shall be assigned a measuring accuracy class in accordance with subclause 5.7.2.501. In addition, they shall be assigned one of the accuracy classes specified in subclause 5.7.2.502.

The accuracy class for a capacitor protective voltage transformer is designated by the highest permissible percentage voltage error prescribed for the accuracy class concerned, from 5 % of rated voltage to a voltage corresponding to the rated voltage factor (see subclause 5.2.501). This expression is followed by the letter P.

In subclause 6.503.3 two additional classes for transient performance are introduced: T1 and T2. This designation shall follow the designation of the accuracy class. Class 3PT1, for example, incorporates the performance of accuracy class 3P and transient performance class T1 (see Table 510).

5.7.2.502.2 Limits of voltage error and phase displacement for capacitor protective voltage transformers

The standard accuracy classes for capacitor protective voltage transformers are

3P – 6P

The same limits of voltage error and phase displacement will normally apply at both 5 % of rated voltage and at the voltage corresponding to the rated voltage factor.

The voltage error and phase displacement at rated frequency shall not exceed the values in Table 504 at 5 % of rated voltage and at rated voltage multiplied by the rated voltage factor (1,2, 1,5 or 1,9) with burdens of:

The connected output of 0 VA and 100 % of the rated output, at a power factor equal to 1 shall be used for measurements.

At 2 % of rated voltage, the limits of voltage error and phase displacement will be twice as high as those given in Table 504.

Where transformers have more than one secondary windings, allowance shall be made for the mutual interdependence. An output range, which may be different from the rated output, shall be specified for each winding under test and each shall meet the accuracy requirements within this range with the untested windings at any burden from zero to rated value (simultaneous output). The output of the residual winding shall not to be considered due to the occasional loading of the residual winding.

Table 504 – Limits of voltage error and phase displacement for capacitor protective voltage transformers

Protection classes	% of rated voltage											
	2	5	100	X	2	5	100	X	2	5	100	X
	Voltage (ratio) error ε_u ± %				Phase displacement, $\Delta\phi$ ± Minutes				Phase displacement, $\Delta\phi$ ± Centiradians			
3P	6,00	3,00	3,00	3,00	240,0	120,0	120,0	120,0	7,0	3,5	3,5	3,5
6P	12,00	6,00	6,00	6,00	480,0	240,0	240,0	240,0	14,0	7,0	7,0	7,0
NOTE 501 $X = F_V \times 100$ (rated voltage factor multiplied by 100).												
NOTE 502 Voltage (ratio) error is considered with 2 digit measurement resolution.												

5.7.2.502.3 Accuracy class for residual voltage windings

The accuracy class for a residual voltage winding shall be 6P or better, as defined in subclause 5.7.2.502.2.

689 If the residual voltage winding is used only for ferroresonance damping purposes, an accuracy
690 class designation is not mandatory.

691 **5.7.2.503 Accuracy of tapped windings**

692 The accuracy shall be specified for full and tapped windings. If not, the accuracy requirements
693 refer to full tap (i.e., lowest transformation ratio).

694 **5.7.2.504 Simultaneous loading of capacitor voltage transformer windings**

695 Transformers that have more than one secondary winding may have those windings loaded
696 simultaneously. A guaranteed simultaneous output range S_{sim} for each winding shall be
697 specified in VA and indicated on the nameplate if simultaneous loading is expected.

698 If a simultaneous output range is specified each winding shall meet the accuracy requirements
699 of the specified simultaneous output range, with the untested windings at any burden from zero
700 to rated value.

701 Alternatively, the test may be performed with the simultaneous output value applied to the
702 winding itself.

703 The output of the residual winding shall not to be considered due to the occasional loading of
704 the residual winding, present only in fault conditions.

705 For more information see Annex 5D and Annex 5F.

706 **5.7.3 Accuracy class extension for harmonics**

707 Subclause 5.7.3 of IEC 61869-1:2023 applies

708 **5.7.4 Accuracy requirements for harmonics**

709 Subclause 5.7.4 of IEC 61869-1:2023 applies

710 **5.7.5 Harmonic requirements for LPIT protection accuracy classes**

711 Subclause 5.7.5 of IEC 61869-1:2023 is not applicable

712 **5.7.6 Anti-aliasing filter for EIT using digital data processing**

713 Subclause 5.7.6 of IEC 61869-1:2023 is not applicable

714 **6 Design and construction**

715 **6.1 Requirements for liquids used in equipment**

716 **6.1.1 General**

717 Subclause 6.1.1 of IEC 61869-1:2023 applies

718 **6.1.2 Liquid level indicator**

719 Subclause 6.1.2 of IEC 61869-1:2023 applies

720 **6.1.3 Liquid tightness**

721 Subclause 6.1.3 of IEC 61869-1:2023 applies with the following addition:

No liquid leakage is permitted. Any liquid leakage represents a danger for insulation dielectric performance and can be harmful for the environment.

A capacitor unit or the complete assembled capacitor voltage divider shall be tight in the full temperature range specified for the applicable temperature category.

The electromagnetic unit shall be tight in the full temperature range specified for the applicable temperature category.

6.2 Requirements for gases used in equipment

Subclause 6.2 of IEC 61869-1:2023 applies

6.3 Requirements for solid materials used in equipment

Subclause 6.3 of IEC 61869-1:2023 applies

6.4 Requirements for temperature rise of parts and components

6.4.1 General

Subclause 6.4.1 of IEC 61869-1:2023 applies with the following additional text:

Unless otherwise specified, the temperature rise of a capacitor voltage transformer at the specified voltage, at rated frequency and at rated burden, or at the highest rated burden if there are several rated burdens, at any power factor between 0,8 lagging and unity, shall not exceed the appropriate value given in Table 12 of IEC 61869-1:2023.

When the electromagnetic unit is fitted with a conservator tank or has an inert gas above the oil, it is considered as hermetically sealed and the same limit applies as per Table 12 in IEC 61869-1:2023.

The temperature rise measured on the external surface of the core and other metallic parts where in contact with, or adjacent to, insulation shall not exceed the appropriate value in Table 12 of IEC 61869-1:2023.

6.4.2 Influence of altitude on temperature rise

Subclause 6.4.2 of IEC 61869-1:2023 applies

6.5 Requirements for earthing of equipment

6.5.1 General

Subclause 6.5.1 of IEC 61869-1:2023 applies

6.5.2 Earthing of the enclosure

6.5.2.1 GIS enclosure

Subclause 6.5.2.1 of IEC 61869-1:2023 is not applicable

6.5.2.2 Enclosure of low-voltage components

Subclause 6.5.2.2 of IEC 61869-1:2023 is not applicable

6.5.3 Electrical continuity

Subclause 6.5.3 of IEC 61869-1:2023 applies