

INTERNATIONAL STANDARD



**High-voltage switchgear and controlgear –
Part 212: Compact Equipment Assembly for Distribution Substation (CEADS) for
AC voltages up to 52 kV**

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 212: Compact Equipment Assembly
for Distribution Substation (CEADS) for AC voltages up to 52 kV**

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 62271-212:2016. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 62271-212 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

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

- a) clause numbering aligned with IEC 62271-1:2017,
- b) rewording of title and scope of the document,
- c) implement changes on internal arc definition and testing following the evolution of prefabricated substation concept according to IEC 62271-202,
- d) general review of main test procedures such as temperature rise or dielectric test on interconnections, considering control equipment, communication, smart grid devices and integration of components,
- e) general review of installation, operation, safety and maintenance requirements.

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

Draft	Report on voting
17C/845/FDIS	17C/850/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/standardsdev/publications.

This International Standard should be read in conjunction with IEC 62271-1:2017, to which it refers and which is applicable unless otherwise specified. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1:2017. Amendments to these clauses and subclauses are given under the same numbering, whilst additional subclauses, are numbered from 101.

A list of all parts of the IEC 62271 series can be found, under the general title *High-voltage switchgear and controlgear*, on the IEC website.

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

Traditionally a high-voltage/low-voltage distribution substation has been constructed by installing the main electrical components – high-voltage switchgear and controlgear, ~~distribution power transformer(s)~~ and the corresponding low-voltage ~~distribution panel(s)~~ switchgear and controlgear- within a closed electrical operating area. It can be a room within a building intended for other ~~usages~~ (non electrical uses) or a separated housing (prefabricated or not) designed specifically to contain the electrical equipment of the substation or an open area limited by fences.

Some years ago in the search for a more standardized and compact substation, the concept of prefabricated substation was developed. IEC 62271-202 covers this type of substation. According to this document, the main electrical components (high-voltage switchgear and controlgear, power transformer and low-voltage switchgear and controlgear) are fully in compliance with their respective product standard, and the whole substation, including interconnections and enclosure is designed and type tested and later manufactured and routine tested in the factory. Correspondingly the quality of the substation is assured by the manufacturer.

Moreover, also other types of assemblies have been introduced in the market. These are assemblies comprising the main electrical active components of the substation and their interconnections, delivered as a single product. The product can therefore be type tested, manufactured, routine tested in the factory, transported and then installed in a closed electrical operating area.

This type of factory assembled and type-tested product is covered by this document receiving the generic name CEADS from Compact Equipment Assembly for Distribution Substation. Numerous arrangements are possible and this document provides guidance on basic types of assemblies, which might be envisaged.

A CEADS is not covered by IEC 61936-1. However, CEADS is intended to become part of a distribution substation.

Taking into account the closer proximity of the main electrical components that even can share some parts (enclosure, solid or fluid insulation...), it is very relevant to take notice of the potential interaction between them. Therefore, to cover CEADS is neither sufficient nor always applicable to refer to the relevant product standards. This document covers any additional design and construction requirements and test methods applicable to the different types of CEADS. In addition to the specified characteristics, particular attention has been paid to the specification concerning the protection of persons, both operators and general public.

The CEADS is also of interest to committee TC 14: Power transformers, and committee TC 121: Switchgear and controlgear and their assemblies for low voltage.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 212: Compact Equipment Assembly for Distribution Substation (CEADS) for AC voltages up to 52 kV

1 General

1 Scope

This part of IEC 62271 specifies the service conditions, rated characteristics, general structural requirements and test methods of the assemblies of the main electrical functional units of a ~~high-voltage/low-voltage distribution~~ high-voltage transformer substation, duly interconnected, for AC ~~of rated operating voltages above 1 kV and~~ up to and including 52 kV on the high-voltage side and service frequency 50 Hz or 60 Hz. ~~This assembly is to be cable-connected to the network, and intended for installation within an indoor or outdoor closed electrical operating area.~~ The CEADS is cable-connected to the high-voltage network for indoor and outdoor applications of restricted access.

A CEADS as defined in this document is designed and tested to be a single product with a single serial number and one set of documentation.

The functions of a CEADS are:

- ~~switching and control for the operation of the high-voltage circuit(s);~~
- ~~protection of the high-voltage/low-voltage transformer functional unit;~~
- ~~high-voltage/low-voltage transformation;~~
- ~~switching and control for the operation and protection of the low-voltage feeders.~~

~~However relevant provisions of this document are also applicable to designs where not all of these functions exist (e.g. equipment comprising only high-voltage/low-voltage transformation and switching and control for the operation and protection of the low-voltage feeder functions or equipment without switching and control for the operation of the high-voltage circuit(s)).~~

- high-voltage/high-voltage or high-voltage/low-voltage transformation;

and some or all the following:

- switching and control for the operation of the high-voltage circuit(s);
- switching and control for the operation of the low-voltage circuit(s);
- protection of the power transformer functional unit.

The main functions are integrated in the following functional units:

- high-voltage functional unit;
- power transformer functional unit;
- low-voltage functional unit.

NOTE For the purpose of this document a self-protected transformer is not considered as a CEADS, but as a functional unit, designed and type tested to its own product standard IEC 60076-13:2006.

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.

IEC 60050-441:~~1984~~, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at www.electropedia.org)

IEC 60050-461:~~2008~~, *International Electrotechnical Vocabulary (IEV) – Part 461: Electric cables* (available at www.electropedia.org)

IEC 60076 (all parts), *Power transformers*

IEC 60076-1:2011, *Power transformers – Part 1: General*

IEC 60076-2:2011, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3:2013, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*
IEC 60076-3:2013/AMD1:2018

IEC 60076-5:2006, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-7:2018, *Power transformers – Part 7: Loading guide for mineral-oil-immersed power transformers*

IEC 60076-10:2016, *Power transformers – Part 10: Determination of sound levels*

IEC 60076-11:~~2004~~2018, *Power transformers – Part 11: Dry-type transformers*

IEC 60076-12:2008, *Power transformers – Part 12: Loading guide for dry-type power transformers*

IEC 60076-15:2015, *Power transformers – Part 15: Gas-filled power transformers*

IEC 60243-1:2013, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

~~IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*~~

IEC 60721-1:1990, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*
IEC 60721-1:1990/AMD1:1992
IEC 60721-1:1990/AMD2:1995

IEC 60721-2-2:2012, *Classification of environmental conditions – Part 2-2: Environmental conditions appearing in nature – Precipitation and wind*

IEC 60721-2-4:19872018, *Classification of environmental conditions – Part 2-4: Environmental conditions appearing in nature – Solar radiation and temperature*

IEC TS 60815 (all parts), *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions*

IEC 60947-1:20072020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 61439 (all parts)¹, *Low-voltage switchgear and controlgear assemblies*

IEC 61439-1:20142020, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

~~IEC 62262:2002, Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)~~

IEC 62271-1:20072017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*
~~IEC 62271-1:2007/AMD1:2011~~

IEC 62271-200:20112021, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-201:2014, *High-voltage switchgear and controlgear – Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-202:20142022, *High-voltage switchgear and controlgear – Part 202: ~~High-voltage/low-voltage~~ Prefabricated substation*

~~ISO/IEC Guide 51:2014, Safety aspects – Guidelines for their inclusion in standards~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-441, ~~IEC 62271-1:2007 and in the standards mentioned in 1.2,~~ IEC 62271-202 and the following apply.

NOTE Some standard terms and definitions are recalled here for ease of reference.

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

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

¹ This series supersedes some parts of IEC 60439 series.

3.1 General terms and definitions

3.1.101

closed electrical operating area

room or location for operation of electrical installations and equipment to which access is intended to be restricted to skilled or instructed persons or to lay personnel under the supervision of skilled or instructed persons

[SOURCE: IEC 61936-1:2021, 3.2.1, modified – In the definition, "power installations" replaced with "installations", and "ordinary persons" replaced with "personnel".]

3.2 Assemblies of switchgear and controlgear

3.2.101

Compact Equipment Assembly for Distribution Substation

CEADS

factory assembled and type-tested equipment comprising functional units, described in Clause 1, duly interconnected

Note 1 to entry: Three types of CEADS are considered: grouped, associated and integrated (see Annex C for details).

3.2.101.1

grouped type CEADS

CEADS-G

CEADS with functional units are standalone equipment fully complying with their respective product standards, where these functional units are placed close to each other in a specified layout

3.2.101.2

associated type CEADS

CEADS-A

CEADS with functional units ~~may~~ can deviate from existing product standard but not in any aspect that could affect negatively safety and/or operation and where these functional units can either be independent or share part of their frames or enclosures

3.2.101.3

integrated type CEADS

CEADS-I

CEADS where all or part of high-voltage functional units and the high-voltage/low-voltage transformation functional unit are contained in a single enclosure, sharing the insulating medium

3.3 Parts of assemblies

3.3.101

functional unit

assembly of devices and components performing a given main function of the CEADS

Note 1 to entry: For the purpose of this document functional unit has a different meaning than the meaning in other standards. For example, in this document high-voltage functional unit (see 3.3.102) ~~may~~ can comprise several functional units as per IEC 62271-200:2014/2021.

3.3.102

high-voltage functional unit

assembly of the switching devices and other components performing the function of switching and control for the operation of the high-voltage side of the CEADS

Note 1 to entry: It ~~may~~ can include switching and control of the high-voltage main circuit of the network and the protection of the high-voltage/low-voltage transformation function.

3.3.103

high-voltage/low-voltage power transformer functional unit

assembly of elements that perform the function of high-voltage/high-voltage or high-voltage/low-voltage transformation of the CEADS

3.3.104

low-voltage functional unit

assembly of the switching devices and other components performing the function of switching and control for the operation and protection of the low-voltage feeders of the CEADS

3.103

closed electrical operating area

room or location for operation of electrical installations and equipment to which access is intended to be restricted to skilled or instructed persons or to lay personnel under the supervision of skilled or instructed persons

3.104

internal arc classified CEADS

IAC

CEADS which meet prescribed criteria, demonstrated by type tests, for the protection of persons in the event of internal arc at the high-voltage side

3.3.105

high-voltage interconnection

electrical connection between the terminals of the high-voltage functional unit and the high-voltage terminals of the high-voltage/low-voltage power transformer functional unit

3.3.106

low-voltage interconnection

electrical connection between the low-voltage terminals of the high-voltage/low-voltage power transformer functional unit and the incoming terminals of the low-voltage functional unit

3.4 Switching devices

3.5 Parts of switchgear and controlgear

3.6 Operational characteristics of switchgear and controlgear

3.6.101

internal arc classified CEADS

IAC

CEADS which meet prescribed criteria, demonstrated by type tests, for the protection of persons in the event of internal arc at the high-voltage side

3.7 Characteristic quantities

3.8 Index of definitions

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4 Normal and special service conditions

4.1 Normal service conditions

4.1.1 General

Subclause 4.1 of IEC 62271-1:2007/2017 is applicable with the following additions for CEADS. Following subclauses also refer to specific additions to other functional units according to their relevant standards.

Wave shape and symmetry of supply voltage are in accordance with 4.2 of IEC 60076-1:2011.

~~For high-voltage/low-voltage transformer functional unit, average ambient air temperature limits of 4.2 of IEC 60076-1:2011 for liquid-immersed type and 4.2.3 of IEC 60076-11:2004 shall also apply.~~

For indoor CEADS

- ~~the minimum air ambient temperature is 5 °C;~~
- equipment shall also be suitable for conditions of relative humidity and condensation in accordance with Table 15 of IEC 61439-1:2020.

~~For outdoor CEADS~~

- ~~the preferred values of minimum air ambient temperature are 10 °C, 25 °C.~~

NOTE 1 For air ambient below -25 °C, outdoor CEADS can be designed or used according to the relevant product standards, where applicable, or according to agreement between manufacturer and user.

NOTE 2 For higher ambient temperatures inside a room, the user ~~has to~~ can specify to the manufacturer the specific operating conditions in order to check whether de-rating is applicable for any of the functional units.

When two or more functional units share a common surrounding medium and in some cases, even the same enclosure, the real operating service conditions, in particular temperature, of those functional units can differ largely from the normal service conditions (ambient air) due to the interaction between them. This ~~has to~~ should be considered, where relevant, during type test (see e.g., 7.101.2).

4.1.2 Low-voltage switchgear and controlgear

Subclause 4.1 of IEC 62271-1:2017 is not applicable to low-voltage functional unit.

Subclause 7.1 of IEC 61439-1:2020 is applicable.

4.1.3 Power transformer

Subclause 4.1 of IEC 62271-1:2017 is not applicable to power transformer.

Subclause 4.2 of IEC 60076-1:2011 is applicable for liquid-immersed power transformers and 4.2 of IEC 60076-11:2018 for dry-type power transformers.

4.2 Special service conditions

4.2.1 General

Subclause 4.2 of IEC 62271-1:2007~~2017~~ is applicable to CEADS with the following additions.

Particular specifications for operation under abnormal conditions apart from those included in this subclause shall be subject to agreement between the manufacturer and user.

Refer to the relevant standards for the different functional units.

4.2.2 Altitude

4.2.2.1 General

Subclause 4.2.2 of IEC 62271-1:2017 is applicable for CEADS with the following additions.

For installation of CEADS at altitude, the main components temperature rise limits should be evaluated considering the recommendations of IEC TR 60943:1998 and IEC TR 60943:1998/AMD2009 [1]².

4.2.2.2 Power transformer

For installation at an altitude higher than 1 000 m, refer to 6.3 of IEC 60076-2:2011 or 10.3 of IEC 60076-11:2018.

4.2.3 Exposure to pollution

4.2.3.1 General

Subclause 4.2.3 of IEC 62271-1:2017 is applicable for CEADS with the following additions.

4.2.3.2 Low-voltage switchgear and controlgear

There are several degrees of pollution defined for the installation conditions. Refer to 7.1.2 of IEC 61439-1:2020 for the purpose of evaluating clearances and creepage distances of the low-voltage functional unit.

4.2.3.3 Power transformer

Refer to 5.5 of IEC 60076-1:2011, except for dry-type power transformers for which 4.2 f) and 12.2 of IEC 60076-11:2018 should be referred to select appropriate environmental class.

4.2.4 Temperature and humidity

Subclause 4.2.4 of IEC 62271-1:2017 is applicable for CEADS with following addition.

If the power transformer service conditions at the intended installation site do not fall within the limits of the normal cooling conditions, then the limits of temperature rise for the liquid-immersed power transformer shall be modified in accordance with 6.3 of IEC 60076-2:2011.

4.2.5 Exposure to abnormal vibrations, shock or tilting

Subclause 4.2.5 of IEC 62271-1:2017 is applicable.

² Numbers in square brackets refer to the Bibliography.

4.2.6 Wind speed

Subclause 4.2.6 of IEC 62271-1:2017 is applicable.

4.2.7 Other parameters

Subclause 4.2.7 of IEC 62271-1:2017 is applicable.

5 Ratings

5.1 General

Clause 5.1 of IEC 62271-1:2007/2017 is applicable with the following modifications.

The ratings of CEADS are the following:

- a) rated voltages (U_r , U_n);
- b) rated insulation levels;
- c) rated frequency (f_r);
- d) rated current for low-voltage assembly main circuits (I_{nA});
- e) rated ~~normal~~ continuous current for high-voltage main circuits (I_r , I_{nA});
- f) rated short-time withstand currents (I_k , I_{ke} , I_{cw}) for main and earthing circuits;
- i) rated peak withstand currents (I_p , I_{pe} , I_{pk}) for main and earthing circuits;
- j) rated durations of short circuit (t_k , t_{ke} , t_{cw}) for main and earthing circuits;
- k) rated supply voltage of closing and opening devices and of auxiliary and control circuits;
- l) rated supply frequency of closing and opening devices and of auxiliary and control circuits;
- m) rated power and total losses of CEADS;
- n) ratings of the internal arc classification (IAC), if assigned by the manufacturer.

The ratings of CEADS shall be assigned to ensure that operation of the equipment within its assigned ratings do not expose any individual functional unit to conditions which are outside its rated capabilities.

NOTE Functional units forming part of the CEADS can have other individual rated values in accordance with their relevant standards.

5.2 Rated voltage

Subclause 5.2 of IEC 62271-1:2007/2017 is not applicable.

Rated voltages of CEADS are defined by the rated voltages of its high-voltage functional unit (U_r), ~~high-voltage/low-voltage~~ power transformer functional unit and low-voltage functional unit (U_n).

Refer to subclause 5.2 of IEC 62271-1:2007/2017 for high-voltage functional unit.

Refer to IEC 60947-1:2007 and 5.2 of IEC 61439-1:2014/2020 for low-voltage functional unit.

Subclause 5.4.1 of IEC 60076-1:2011 is applicable for the ~~high-voltage/low-voltage~~ power transformer functional unit.

NOTE ~~These values are determined by the characteristics of the high-voltage/low-voltage transformer functional unit.~~ High-voltage and low-voltage ~~switchgear and controlgear~~ functional units can have rated voltages higher than the ~~high-voltage/low-voltage~~ power transformer functional unit rated voltages.

5.3 Rated insulation level

Subclause 5.3 of IEC 62271-1:2007/2017 is not applicable.

Rated insulation levels of CEADS are defined by the **lowest** rated insulation levels of any of its **components**, the high-voltage functional unit, the low-voltage functional unit or the power transformer.

For the high-voltage functional unit refer to 5.3 of IEC 62271-1:2007/2017.

For the low-voltage functional unit refer to 5.2 of IEC 61439-1:2011/2020 and 5.2 of IEC 60947-1:2007/2020.

For the rated insulation levels of the power transformer refer to 5.6 of IEC 60076-1:2011 about applicable insulation levels in relation with the highest voltage for the equipment (U_m).

The minimum rated ~~lightning~~ impulse ~~voltage~~ withstand **voltage** of the low-voltage functional unit shall be at least the value given for overvoltage category IV in ~~Table F.1 of IEC 60664-1:2007~~ Table G.1 of IEC 61439-1:2020. Depending on the network in different countries, it ~~may~~ can be ~~necessary~~ relevant to choose a higher insulation level.

5.4 Rated frequency (f_r)

Subclause 5.4 of IEC 62271-1:2007/2017 is not applicable.

The standard values of the rated frequency for CEADS are 50 Hz and 60 Hz.

~~4.4 Rated normal current and temperature rise~~

5.5 Rated ~~normal~~ continuous current (I_r , I_{nA})

Subclause 5.5 of IEC 62271-1:2007/2017 is not applicable for CEADS.

Rated currents of CEADS are defined by the rated **continuous** current of its high-voltage functional unit (I_r) and the rated current of its low-voltage functional unit (I_{nA}).

Subclause 5.5 of IEC 62271-1:2007/2017 is applicable for the high-voltage functional unit.

Subclause 5.3.1 of IEC 61439-1:2011/2020 is applicable for the low-voltage functional unit.

NOTE The high-voltage functional unit and the low-voltage functional unit have rated ~~normal~~ current values which are equal or higher than operating current values.

~~4.4.2 Temperature rise~~

~~Subclause 4.4.2 of IEC 62271-1:2007 is not applicable.~~

~~The temperature rise of CEADS is defined by the temperature rise of its functional units:~~

- ~~• limits of the high-voltage functional unit defined in 4.4.2 of IEC 62271-1:2007;~~
- ~~• limits of the high-voltage/low-voltage transformer functional unit are the ones defined in Clause 6 of IEC 60076-2:2011 for liquid filled type and in Clause 11 of IEC 60076-11:2004 for dry type, at rated voltages and rated normal currents for which the CEADS has been designed;~~

• ~~limits of the low-voltage functional unit defined in 9.2 of IEC 61439-1:2011.~~

5.6 Rated short-time withstand current (I_k , I_{ke} , I_{cw})

Subclause 5.6 of IEC 62271-1:20072017 is not applicable.

5.6.101 Rated short-time phase-to-phase and rated short-time phase-to-earth withstand currents of high-voltage functional unit and rated short-time withstand current of high-voltage interconnection (I_k , I_{ke})

For the rated short-time withstand currents I_k and/or I_{ke} of high-voltage functional unit, high-voltage interconnection and earthing circuit, 5.6 of IEC 62271-1:20072017 is applicable with the following additions:

Rated short-time withstand current (I_k) shall be assigned to high-voltage functional unit and also to high-voltage interconnection.

NOTE 1 In principle, the rated short-time withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

A rated short-time withstand phase-to-earth current (I_{ke}) shall be assigned to the earthing circuit of high-voltage functional unit and high-voltage interconnection. This value ~~may~~ can differ from that of the main circuit.

NOTE 2 The short-circuit current ratings applicable to the earthing circuit depend upon the type of system neutral earthing for which it is intended. Refer to Table 3 of IEC 62271-202:20142022.

5.6.102 Rated short-time withstand currents of low-voltage functional unit and low-voltage interconnection (I_{cw})

Refer to 5.3.5 of IEC 61439-1:20142020.

5.6.103 Short-time withstand currents of ~~high-voltage/low-voltage~~ power transformer functional unit

Refer to Clause 3 of IEC 60076-5:2006.

5.7 Rated peak withstand current (I_p , I_{pe} , I_{pk})

Subclause 5.7 of IEC 62271-1:20072017 is not applicable.

5.7.101 Rated peak phase-to-phase and rated peak phase-to-earth withstand currents of high-voltage functional unit and rated peak withstand current of high-voltage interconnection (I_p , I_{pe})

For the rated peak withstand currents I_p and/or I_{pe} of high-voltage functional unit, high-voltage interconnection and earthing circuit 5.7 of IEC 62271-1:20072017 is applicable with the following additions:

Rated peak withstand current (I_p) shall be assigned to high-voltage functional unit and also to high-voltage interconnection.

NOTE In principle, the rated peak withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

A rated peak withstand phase-to-earth current (I_{pe}) shall be assigned to the earthing circuit of high-voltage functional unit and high-voltage interconnection. This value ~~may~~ can differ from that of the main circuit.

5.7.102 Rated peak withstand currents of low-voltage and low-voltage interconnection (I_{pk})

Refer to 5.3.4 of IEC 61439-1:2014/2020.

5.7.103 Peak withstand currents of ~~high-voltage/low-voltage~~ power transformer functional unit

Refer to Clause 3 of IEC 60076-5:2006.

5.8 Rated duration of short circuit (t_k , ~~t_{ke}~~ , t_{cw})

Subclause 5.8 of IEC 62271-1:2007/2017 is not applicable.

5.8.101 Rated duration of phase-to-phase short circuit (t_k) and rated duration of phase-to-earth short circuit (t_{ke}) of high-voltage functional unit and rated duration of short-circuit of high-voltage interconnection

For the rated durations of short circuit t_k and t_{ke} for high-voltage functional unit, high-voltage interconnection and earthing circuit, subclause 5.8 of IEC 62271-1:2007/2017 is applicable with the following additions:

A rated duration of short circuit (t_k) shall be assigned to high-voltage ~~switchgear~~ functional unit and to high-voltage interconnection.

NOTE In principle, the rated duration of short circuit for a main circuit cannot exceed the corresponding rated value of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the duration of the short-circuit current, such as current-limiting fuses.

A rated duration of phase-to-earth short circuit (t_{ke}) shall also be assigned to the earthing circuit of high-voltage functional unit and high-voltage interconnection. This value ~~may~~ can differ from that of the main circuit.

5.8.102 Rated duration of short circuit (t_{cw}) for low-voltage functional unit and low-voltage interconnection

Refer to 5.3.4 of IEC 61439-1:2014/2020 for low-voltage functional unit and assign a rated duration of short-circuit (t_{cw}) to the low-voltage interconnection.

5.8.103 Duration of short circuit for ~~high-voltage/low-voltage~~ power transformer functional unit

Refer to 4.1.3 of IEC 60076-5:2006.

~~4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits~~

~~Subclause 4.8 of IEC 62271-1:2007 is not applicable.~~

~~For high-voltage functional unit refer to 4.8 of IEC 62271-1:2007; for low-voltage functional unit refer to 5.2.2 of IEC 61439-1:2011.~~

4.9 ~~Rated supply frequency of closing and opening devices and of auxiliary circuits~~

~~Subclause 4.9 of IEC 62271-1:2007 is not applicable.~~

~~For high-voltage functional unit refer to 4.9 of IEC 62271-1:2007; for low-voltage functional unit refer to 5.5 of IEC 61439-1:2011.~~

5.9 Rated supply voltage of auxiliary and control circuits (U_a)

Subclause 5.9 of IEC 62271-1:2017 is applicable for CEADS.

5.10 Rated supply frequency of auxiliary and control circuits

Subclause 5.10 of IEC 62271-1:2017 is applicable for CEADS.

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 5.11 of IEC 62271-1:2017 is not applicable to CEADS.

5.101 Rated power and total losses of CEADS

The rated power of CEADS is the rated power of the ~~high-voltage/low-voltage~~ power transformer functional unit at rated voltage as defined in IEC 60076-1:2011 for liquid-filled power transformer functional units or IEC 60076-11:2018 for dry-type power transformer functional units.

The total losses of CEADS is the sum of the losses of the high-voltage functional unit and high-voltage interconnection at its rated continuous current, the total losses (identifying load and no load losses) of the ~~high-voltage/low-voltage~~ power transformer functional unit at its rated voltage in accordance with IEC 60076-1:2011 for liquid-filled power transformer functional units or IEC 60076-11:2018 for dry-type power transformer functional units, and the losses of the low-voltage functional unit and low-voltage interconnection at the current determined by the ~~high-voltage/low-voltage~~ power transformer functional unit rated power.

5.102 Ratings of the internal arc classification (IAC)**5.102.1 General**

If an IAC classification is assigned by the manufacturer, several ratings shall be specified. These ratings are subdivided into type of accessibility, arc fault currents and arc fault durations.

5.102.2 Types of accessibility (A, B, AB)

Three types of ~~protection~~ accessibility in case of an internal arc are considered:

Accessibility type A: for CEADS providing protection to the operators ~~standing~~ during normal operations in ~~front of~~ the high-voltage operating side (or sides) of the CEADS.

NOTE In principle, operating at the high-voltage side and at the low-voltage operating side at the same time can be considered an unsafe procedure.

Accessibility type B: for CEADS providing protection to the general public in the vicinity of the equipment on all its sides at any time.

Accessibility type AB: for CEADS providing protection to both operators and the general public.

To qualify for this classification, these CEADS shall comply with the requirements for type A and type B with the same value of the test current in kA and duration in second(s).

5.102.3 Classified sides

For identification purposes of the different classified sides of the CEADS the following code shall be used:

- F for front side (defined by high-voltage operating side);
- L for lateral side;
- R for rear side.

The ~~front~~ high-voltage operating side(s) shall be clearly stated by the manufacturer before the test and identified in the test report.

5.102.4 Rated arc fault currents (I_A , I_{Ae})

The standard value of rated arc fault currents should be selected from the IEC 60059:1999 and IEC 60059:1999/AMD1:2009 [2] standard current ratings.

Two ratings of the arc fault currents are recognised:

- three-phase arc fault current (I_A),
- single phase-to-earth arc fault current (I_{Ae}), when applicable.

When only a three-phase rating is specified, the single-phase rating is by default 87 % of the three-phase rating, and ~~need~~ shall not be specified.

NOTE 1 The manufacturer specifies the compartments of the high-voltage functional unit to which the single phase-to-earth arc fault current rating applies. Such value is assigned to functional unit where its construction ~~will~~ can prevent the arc from becoming multiphase, as demonstrated during the internal arc test.

NOTE 2 Rationale for this 87 % is the arc fault test with 2-phase ignition; refer to 9.104.5 of IEC 62271-202:2014/2022.

In the case where all high-voltage compartments are only designed for single phase-to-earth arc faults, only single phase-to-earth arc fault current (I_{Ae}) ~~needs to~~ shall be assigned.

NOTE 3 Information about the relationship between type of neutral earthing and the single phase-to-earth arc fault current is provided in 9.104.5 and Table 3 of IEC 62271-202:2014/2022.

5.102.5 Rated arc fault duration (t_A , t_{Ae})

Standard recommended values for the three-phase arc fault duration (t_A) are 0,1 s, 0,5 s and 1 s.

If applicable, the test duration (t_{Ae}) of the single phase-to-earth arc fault shall be stated by the manufacturer.

NOTE It is in general not possible to calculate the permissible arc duration for a current which differs from that used in the test.

6 Design and construction

Clause 6 of IEC 62271-1:2017 is not applicable to CEADS.

CEADS shall be designed so that normal service, inspection and maintenance can be carried out safely. As CEADS are intended for installation within closed electrical operating areas, in principle general public is not allowed to approach the equipment. However, when a CEADS is installed in a factory, the employees not in charge of ~~the~~ its operation ~~of the equipment may~~

can be occasionally in the proximity of the CEADS. As they are not aware of the electrical features of the equipment they are considered as **general** public in the sense of this document.

NOTE If some parts of enclosures of a CEADS are intended to become part of the enclosure of a substation, the relevant requirements of IEC 62271-202 or IEC 61936-1, as applicable, are met.

The design of CEADS shall take into account the possible interactions (e.g., electrical, mechanical and thermal) in the performance of different functional units and the components used to interconnect these.

The complete assembly of a CEADS and the individual functional units forming part of it shall comply with the requirements of this document. For the individual functional units, reference is made to the following respective standards:

- High-voltage functional unit IEC 62271-200:2011/2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear;
- ~~High-voltage/low-voltage~~ Power transformer functional unit IEC 60076 (all parts);
- Low-voltage functional unit IEC 61439 (all parts) and IEC 60947-1.

The individual functional units of a CEADS-G shall comply with the requirements of their respective product standard listed above.

Concerning CEADS-A and CEADS-I, the individual functional units ~~may~~ can deviate in some aspects from those products standards. Due to that, specific testing procedures for individual functional units, where direct application of above-mentioned product standards is not possible, are described in this document.

6.1 Requirements for liquids in switchgear and controlgear

Subclause 6.1 of IEC 62271-1:2007/2017 is applicable.

6.2 Requirements for gases in switchgear and controlgear

Subclause 6.2 of IEC 62271-1:2007/2017 is applicable.

NOTE For the handling of SF₆ refer to IEC 62271-4 [3].

6.3 Earthing of switchgear and controlgear

Subclause 6.3 of IEC 62271-1:2007/2017 is applicable with the following additions:

A main earthing ~~conductor~~ circuit system shall be provided to connect to the earth all metallic parts of the CEADS not belonging to the main and/or secondary/auxiliary circuits of the equipment. It consists of a main earthing conductor to which each component is connected through a single circuit.

If the CEADS has a metallic frame, then it ~~may~~ can serve as, or form part of, the main earthing ~~conductor~~ circuit. In such a case, the fastening system, if any, used to join parts of the frame shall demonstrate its ability to carry the **phase-to-earth** rated current. The main earthing ~~conductor~~ circuit system shall be designed to withstand the rated short-time and peak withstand current under the neutral earthing condition of the system.

The cross-section of ~~the~~ any earthing conductor shall be not less than 30 mm². It shall be terminated by an adequate terminal intended for connection to the earth system of the installation. If any conductor or conducting part of the earthing ~~conductor~~ circuit is not made of copper, equivalent ~~thermal~~ conductive and mechanical requirements shall be met.

The continuity of the ~~earth-system~~ earthing circuit shall be ensured and corresponding measures preventing corrosion, loosening of bolts etc. shall be taken. The earthing circuit system shall take into account the thermal and mechanical stresses caused by the current ~~it may have to carry~~.

NOTE The user can establish procedures to check the integrity of all parts of the earthing ~~system~~ circuit (internal and external) either periodically or after a short-circuit current ~~has flown into the earthing system~~.

Components to be connected to the main earthing ~~conductor-system~~ circuit shall include:

- the enclosure, if metallic, of the high-voltage functional units from the terminal provided for that purpose;
- the tank of ~~liquid-filled high-voltage/low-voltage~~ liquid-immersed power transformer functional unit or the metallic non active parts of dry-type ~~high-voltage/low-voltage~~ power transformer functional unit;
- the frame and/or enclosure, if metallic, of the low-voltage functional unit;
- the earthing connection of automatic controls and remote-control devices;
- the metal shields and the earthing conductors of the high-voltage cables;
- the metallic frame of the CEADS, if any;
- earthing switches, if any.

6.4 Auxiliary and control equipment and circuits

Subclause 6.4 of IEC 62271-1:2007/2017 is ~~not~~ applicable with the following additions.

For the low-voltage installation embedded in the CEADS (for example, illumination, auxiliary supply, etc.), refer to IEC 60364-4-41:2005 for low-voltage electrical installations or IEC 61439-1:2014/2020 for low-voltage switchgear and controlgear assemblies, as appropriate.

6.5 Dependent power operation

Subclause 6.5 of IEC 62271-1:2007/2017 is ~~not~~ only applicable for high-voltage functional unit.

6.6 Stored energy operation

Subclause 6.6 of IEC 62271-1:2007/2017 is ~~not~~ only applicable for high-voltage functional unit.

6.7 Independent unlatched operation (independent manual or power operation) (~~independent unlatched operation~~)

Subclause 6.7 of IEC 62271-1:2007/2017 is ~~not~~ only applicable for high-voltage functional unit.

6.8 Manually operated actuators

Subclause 6.8 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.9 Operation of releases

Subclause 6.9 of IEC 62271-1:2007/2017 is ~~not~~ only applicable for high-voltage functional unit.

6.10 ~~Low and high pressure interlocking and monitoring devices~~ Pressure/level indication

Subclause 6.10 of IEC 62271-1:2007:2017 is ~~not~~ applicable.

6.11 Nameplates

Subclause 6.11 of IEC 62271-1:2007:2017 is not applicable, and it is replaced as follows:

Each CEADS shall be provided with a durable, clearly legible nameplate, visible in ~~normal service~~ operating condition, which shall contain at least the following information:

- manufacturer's name or trade mark;
- type designation;
- serial number;
- number of this document;
- year of manufacture;
- ratings of CEADS listed in Clause 5;
- internal arc classification designation, where applicable;
- instruction book reference.

The ratings of the functional units shall be listed on separate nameplates, clearly visible, or on the CEADS nameplate. Where functional units are independent, they shall be provided with separate nameplates as in their respective product standards.

Each nameplate shall have a unique serial number.

6.12 ~~Interlocking~~ Locking devices

Subclause 6.12 of IEC 62271-1:2007:2017 is not applicable and it is replaced as follows:

Interlocking can be necessary to ensure the correct sequence of operation of equipment, to minimise the risk to personnel and damage to the equipment. Interlocking can be achieved by electrical or mechanical methods. If non-mechanical interlocks are provided, the design shall be such that no improper situations can occur in case of lack of auxiliary power supply.

6.13 Position indication

Subclause 6.13 of IEC 62271-1:2007:2017 is not applicable to CEADS.

Subclause 6.13 of IEC 62271-1:2007:2017 for high-voltage functional unit and 8.1.6 of IEC 60947-1:2007:2020 for low-voltage functional unit are applicable.

6.14 Degrees of protection provided by enclosures

6.14.1 General

Subclause 6.14 of IEC 62271-1:2007:2017 is not applicable ~~for high-voltage functional unit~~ to CEADS.

~~Subclause 8.2 of IEC 61439-1:2011 is applicable for low-voltage functional unit.~~

6.14.2 Protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects (IP coding)

Degrees of protection in accordance with IEC 60529:1989 shall be as specified below.

The enclosures of high-voltage and low-voltage functional units shall provide at least the degree of protection IP2X for indoor application.

If non insulated conductors and/or bushings in low-voltage interconnections or non-screened conductors and/or bushings in high-voltage interconnections are used, suitable means to prevent direct contact with live parts shall be provided either by the manufacturer as part of the CEADS itself or alternatively by the user incorporating adequate protection in the installation site. In the first case, the minimum degree of protection should be IP1X. In the second case, the manufacturer shall include in the instruction manual clear information about the need to provide additional protection.

NOTE Additional safety measures for the protection of persons against approach to hazardous parts are described in Clause 8 of IEC 61936-1:2021 [4].

When dry-type ~~high-voltage/low-voltage~~ power transformer functional unit is used, a protection means around the ~~high-voltage/low-voltage~~ power transformer functional unit shall be provided with at least a degree of protection IP2X.

6.14.3 Protection against ingress of water (IP coding)

For outdoor application of CEADS the minimum degree of protection shall be IP23.

6.14.4 Protection against mechanical impact under normal service conditions (IK coding)

The enclosures shall have sufficient mechanical strength to withstand external mechanical impacts with energy of 2 J, corresponding to a degree of protection IK07 [5] for indoor application and 20 J corresponding to IK10 for outdoor application.

NOTE CEADS for indoor application is always installed within a closed electrical operating area. In case it is installed within a fence into an industrial facility, the user can consider increasing mechanical requirements of the fence to protect the integrity of the CEADS.

6.15 Creepage distances for outdoor insulators

Subclause 6.15 of IEC 62271-1:2007:2017 is only applicable for high-voltage outdoor insulators (if any) of the high-voltage functional unit and of the high-voltage side of the ~~high-voltage/low-voltage~~ power transformer functional unit.

6.16 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2007:2017 is only applicable for the high-voltage functional unit of the CEADS.

Subclause 5.11 of IEC 60076-15:2015 is applicable for the ~~high-voltage/low-voltage~~ power transformer functional unit if of gas-filled type.

6.17 ~~Liquid tightness~~ Tightness for liquid systems

Subclause 6.17 of IEC 62271-1:2007:2017 is only applicable for high-voltage functional unit.

For ~~high-voltage/low-voltage~~ power transformer functional unit relevant clauses of IEC 60076 (all parts) are applicable.

6.18 Fire hazard (flammability)

Subclause 6.18 of IEC 62271-1:2007:2017 is applicable for CEADS.

6.19 Electromagnetic compatibility (EMC)

Subclause 6.19 of IEC 62271-1:2007/2017 is not applicable.

Subclauses 6.19 of IEC 62271-1:2007/2017 for high-voltage functional unit and 9.4 and Annex J of IEC 61439-1:2014/2020 for low-voltage functional unit are respectively applicable to the high-voltage and low-voltage functional units of the CEADS.

6.20 X-ray emission

Subclause 6.20 of IEC 62271-1:2007/2017 is only applicable for the high-voltage functional unit.

6.21 Corrosion

Subclause 6.21 of IEC 62271-1:2007/2017 is applicable for CEADS.

6.22 Filling levels for insulation, switching and/or operation

Subclause 6.22 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.101 Protection against mechanical stresses

The enclosures shall have sufficient mechanical strength ~~and shall~~ to withstand the following loads and impacts:

- ~~a) external mechanical impacts with energy of 2 J, corresponding to a degree of protection IK07 for indoor application and 20 J corresponding to IK10 for outdoor application.~~
- a) for CEADS intended for outdoor installation, snow loads according to the local climatic conditions;
- b) for CEADS intended for outdoor installation, the mechanical effects of wind pressure according to 4.1.3 of IEC 62271-1:2007/2017. It ~~may~~ can be verified by calculation.

Any other mechanical stresses that can be expected to occur in service, depending on the intended application, ~~may~~ can be verified by calculation.

NOTE 1 Seismic stresses according to IEC TS 62271-210:2013 [6] can also be considered within this subclause.

The complete assembly lifting lugs shall be designed for the total weight of the CEADS. Although each component had been tested for inherent physical stability, when various components are attached together in a CEADS, instability ~~may~~ can result. The design shall ensure stability during delivery, installation and operation.

NOTE 2 The lifting lugs designed to lift the complete assembly can be painted yellow for easy identification.

6.102 Protection of the environment due to internal defects

In the event that internal defects ~~may~~ can lead to the escape of hazardous liquids from the equipment (for example: liquid from a ~~high-voltage/low-voltage~~ power transformer functional unit or a high-voltage functional unit), provision shall be made to retain the hazardous liquids in order to prevent the soil being polluted.

The capacity of the retention tank shall be at least equal to the biggest hazardous liquid containing part (for example, ~~high-voltage/low-voltage~~ power transformer functional unit, high-voltage functional unit, etc.), unless applicable national regulations have different requirements. The retention tank can be part of CEADS or provided in the installation site where the CEADS ~~is to~~ shall be installed.

Additional measures ~~may~~ can be taken by agreement between manufacturer and user.

6.103 Internal arc fault

A CEADS that satisfies the requirements of this document is designed, in principle, to prevent the occurrence of internal arc faults in the high-voltage side.

To achieve this objective, the manufacturer of the CEADS shall ensure the correct manufacture, verifying it by carrying out routine tests according to Clause 8. In turn, the user shall make a proper selection, according to the characteristics of the network, operating procedures and service conditions (refer to Clause 9).

There should be little probability that an internal arc occurs during the entire service life, provided that the CEADS is installed, operated and maintained following the instructions provided by the manufacturer and the cables are correctly installed; however, the possibility of an internal arc cannot be completely disregarded.

Failures can occur in any part of the CEADS. However, as no internal arc testing procedure for low-voltage functional unit and ~~high-voltage/low-voltage~~ power transformer functional unit is described in their respective relevant standards, only faults occurring within the enclosure of the high-voltage functional units and in the high-voltage interconnection are taken into consideration in this document (see 7.101).

NOTE If user and manufacturer agree on an internal arc test of the low-voltage part of the CEADS, IEC TR 61641:2014 [7] gives guidance for an internal arc test in enclosed low-voltage switchgear and controlgear assemblies.

Failure either due to a defect, an exceptional service condition or mal-operation on the high-voltage side ~~may~~ can initiate an internal arc within the high-voltage functional unit and/or in the high-voltage interconnection, which constitutes a hazard if persons are present.

6.104 Enclosures

The enclosures of the functional units shall comply with the relevant requirements of their respective product standards. In the case that an enclosure is shared by several functional units, it shall comply with the requirements of the products standards of those functional units (example: the tank of the ~~high-voltage/low-voltage~~ power transformer functional unit of a CEADS-I shall comply with the requirements of IEC 60076 (all parts), if applicable, and IEC 62271-200: ~~2014~~ 2021).

6.105 Sound emission

The ~~high-voltage/low-voltage~~ power transformer functional unit is the main source of sound. On the other hand, there is no requirement in high-voltage and low-voltage functional units' relevant standards on this matter and the direct contribution of the high-voltage and low-voltage functional units to the sound level of the CEADS is considered, in principle, negligible. However, the determination of CEADS sound level ~~is to~~ shall be made according to ~~IEC 60076-10:2016~~, Annex B, on the complete CEADS to take into account any possible interaction.

6.106 Electromagnetic fields

CEADS in service generate electromagnetic fields that may need assessment to:

- assist with planning, installation, operating instruction and service;
- take measures to meet requirements or regulations on electromagnetic fields.

If an evaluation of electromagnetic fields generated by a CEADS is required, the methodology described in IEC TR 62271-208:2009 should be followed.

6.107 Solar radiation

In the case of outdoor installation of CEADS, its performance during service conditions can be substantially affected due to solar radiation. In addition to the losses from the components, solar radiation could be a significant external source of heat that can affect the performance. Every outer part of the CEADS exposed to solar radiation produces an additional heat transfer that can lead to a de-rating of a functional unit due to exceeding the maximum temperature rise established by its specific product standard. As an example, the heat radiation on the high-voltage functional unit enclosure can require its de-rating and/or reduce the current carrying capacity. In some cases, it could lead to the premature malfunction or failure of temperature-sensitive electronic devices.

Annex G of IEC 62271-202:2022 provides guidance on how to assess the effect of solar radiation.

Additional measures, for example double roofing, lighter enclosure colours, double walls, alternative enclosure materials, etc. can be used in order to reduce the effect of solar radiation on the CEADS. Such additional measures are subject to an agreement between the manufacturer and user.

IEC 60721-2-4:2018 can be used to help select the appropriate level of solar radiation.

7 Type tests

7.1 General

7.1.1 Basics

Subclause 7.1.1 of IEC 62271-1:2007/2017 is applicable with the following additions.

In principle, the type tests shall be made on a representative configuration of the CEADS. The functional units and the interconnections contained in a CEADS shall be tested according to their relevant product standard.

Type tests shall be made on the complete CEADS, unless otherwise specified in this document.

Due to the design of the equipment it ~~may~~ can be practical to test more than one function at the same time. In that case it is not required to repeat those tests in which the test conditions applied are the same specified in their respective standards.

The aim of the type tests on a CEADS is to demonstrate the characteristics of the CEADS as a complete unit. The required tests on the complete CEADS, in addition to those required for the individual functional units, are listed below:

Mandatory type tests:	Subclause
a) Tests to verify the insulation level of the CEADS	7.2
b) Measurement of the resistance of the main circuit of the high-voltage functional unit	7.4
c) Test to prove the temperature rise of any part of the equipment	7.101
d) Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents	7.6
e) Tests to verify the degree of protection and resistance to mechanical impact	7.7
f) Additional tests on auxiliary and control circuits	7.10

g) Verification of making and breaking capacities of the high-voltage functional unit	7.103
h) Mechanical operation tests	7.104
Mandatory type tests, where applicable:	
i) Tightness tests	7.8
j) EMC compatibility tests	7.9
k) For CEADS intended to be classified IAC, tests to assess the effects of arcing due to an internal arc fault	7.102
l) Pressure withstand tests for gas-filled compartments	7.106
m) Measurements of leakage current of non-metallic enclosures	7.107
n) Tightness and mechanical strength for liquid-filled compartments	7.109
Special type tests (subject to agreement between manufacturer and user):	
o) Tests to verify the sound level of CEADS	Annex B
p) Mechanical stability test	7.105
q) Partial discharge test	7.2.10
r) Weatherproofing tests	7.108
s) Measurement or calculation of electromagnetic fields	7.110

Type tests ~~may~~ can impair the suitability of the tested parts for subsequent use in service. Therefore, test objects used for type test shall not be used in service without agreement between manufacturer and user.

~~6.1.1 Grouping of tests~~

~~Subclause 6.1.1 of IEC 62271-1:2007 is applicable with the following addition:~~

~~The mandatory type tests (not including items i) and j)) shall be carried out on a maximum of four test objects.~~

7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC 62271-1:20072017 is applicable.

7.1.3 Information to be included in type-test reports

Subclause 7.1.3 of IEC 62271-1:20072017 is applicable with the following addition to the list:

- the identification, including serial numbers as appropriate, of all functional units of the CEADS, together with the identification of the CEADS itself;
- details of the mechanical and electrical interconnections of the functional units as part of the CEADS;
- drawings and photographs to demonstrate that physical arrangement of the equipment during testing.

Internal arc type test report shall give the information detailed in 7.102.6.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2 of IEC 62271-1:2017 is applicable with the following additions.

When performing dielectric tests, ~~three situations can be considered~~, the following criteria are applicable in order to limit the number of required tests:

- a) in the case that each of the main components of the CEADS (high-voltage functional unit, ~~high-voltage/low-voltage~~ power transformer functional unit and low-voltage functional unit), ~~and the interconnections~~ have been all previously individually type-tested under the same conditions as in the CEADS, there is no need to conduct dielectric tests;
- b) the dielectric tests are not required on the high-voltage interconnection when it is made of high-voltage type-tested earth-shielded cables connected by type-tested earth-shielded connectors or by other types of terminations which have been type-tested on both the high-voltage switchgear and controlgear and the power transformer sides in the installation conditions of the prefabricated substation;
- c) in case the main components (high-voltage functional unit, ~~high-voltage/low-voltage~~ power transformer functional unit, low-voltage functional unit) are type tested according to their product standards, but the interconnections are not previously type tested, the tests as stated in 7.2.2 and 7.2.3 shall be carried out;
- d) in all other cases, dielectric tests as stated in 7.2.2, 7.2.3, 7.2.4, 7.2.5 and 7.2.6 shall be carried out.

7.2.2 Ambient air conditions during tests

Subclause 7.2.2 of IEC 62271-1:2017 is applicable.

7.2.3 Wet test procedure

In case a wet test is required for outdoor CEADS then 7.2.3 of IEC 62271-1:2017 is applicable.

7.2.4 Arrangement of the equipment

Subclause 7.2.4 of IEC 62271-1:2017 is not applicable. Refer instead to 7.2.101.

7.2.5 Criteria to pass the test

Subclause 7.2.5 of IEC 62271-1:2017 is applicable for the high-voltage tested components.

7.2.6 Application of the test voltage and test conditions

Subclause 7.2.6 of IEC 62271-1:2017 is not applicable. Refer instead to 7.2.101.2.

7.2.7 Tests of switchgear and controlgear of $U_r \leq 245$ kV

Subclause 7.2.7 of IEC 62271-1:2017 is applicable for the high-voltage functional unit.

7.2.8 Tests of switchgear and controlgear of $U_r > 245$ kV

Subclause 7.2.8 of IEC 62271-1:2017 is not applicable.

7.2.9 Artificial pollution tests for outdoor insulators

Subclause 7.2.9 of IEC 62271-1:2017 is only applicable for high-voltage outdoor insulators (if any) of the high-voltage functional unit and of the high-voltage side of the power transformer functional unit.

7.2.10 Partial discharge tests

Subclause 7.2.10 of IEC 62271-1:2017 is not applicable to CEADS.

Partial discharge test can be specified by some of the main components relevant product standards.

By agreement between the manufacturer and the user a test to evaluate the insulation of the high-voltage functional unit can be carried out following 7.2.10 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.2.9 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear, depending on the type of insulation.

7.2.11 Dielectric tests on auxiliary and control circuits

Subclause 7.2.11 of IEC 62271-1:2017 is applicable.

7.2.12 Voltage test as condition check

Subclause 7.2.12 of IEC 62271-1:2017 is not applicable for CEADS.

7.2.101 Dielectric tests on the high-voltage interconnection

7.2.101.1 General conditions

The tests ~~may~~ can be carried out with the power transformer replaced by a ~~mock-up~~ replica reproducing the field configuration of the transformer bushings.

For the tests, the high-voltage connection is connected to the test supply through the high-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

Voltage limiting devices shall be disconnected during dielectric tests.

Secondary terminals of current transformers shall be short-circuited and connected to earth.

Instrument transformers, power transformers or fuses ~~may~~ can be replaced by replicas reproducing the field configuration of the high-voltage connections.

~~6.2.2.2 Ambient air conditions during tests~~

~~Refer to 6.2.1 of IEC 62271-1:2007.~~

7.2.101.2 Application of test voltage

7.2.101.2.1 ~~On the high-voltage interconnection~~ General

The test voltages shall be applied connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply. All other conductors of the main circuit, the auxiliary circuits and all other metallic parts shall be connected to the earthing conductor of the frame, and to the earth terminal of the test supply.

Where ~~no~~-earth-shielded high-voltage connections are used, the non-conductive material shall likewise withstand the test voltages specified in 7.2.101.4. The methods specified in IEC 60243-1:2013 shall be applied to test ~~to~~ if the non-conductive material meets the relevant requirements.

7.2.101.2.2 Test voltage

Refer to 7.2.6 of IEC 62271-1: ~~2007~~2017.

7.2.101.3 Lightning impulse voltage tests

The high-voltage interconnection shall be subjected to lightning impulse voltage tests according to 7.2.7.3 of IEC 62271-1: ~~2007~~2017 with the following addition:

During the lightning impulse-voltage tests, the grounded terminal of the impulse generator shall be connected to the main earthing conductor system of the CEADS. **Overvoltage suppressing means shall be disconnected.**

7.2.101.4 Power-frequency voltage withstand tests

The high-voltage interconnection shall be subjected to 1 min power-frequency voltage withstand tests in dry conditions in accordance with 7.2.7.2 of IEC 62271-1:20072017 with the following addition.

During the power-frequency voltage test, one terminal of the test transformer shall be connected to earth and to the main earthing conductor system of the CEADS.

7.2.101.5 High-voltage interconnection covered by non-metallic enclosure

When the interconnection is totally or partially covered by a non-metallic enclosure accessible during normal operation, the enclosure shall meet the following requirements.

- The insulation between live parts of the main circuit and the accessible surface of insulating enclosure shall withstand the test voltages specified in 5.3 of IEC 62271-1:20072017 for voltage tests to earth and between poles.
- The insulating material shall withstand the power-frequency test voltage specified in item a). The appropriate test methods given in IEC 60243-1:2013 shall be applied **to test if the insulating material meets the relevant requirements.**
- The insulation between live parts of the main circuit and the inner surface of insulating enclosure facing these shall withstand at least 150 % of the rated voltage of the equipment **for one minute.** This shall be tested according to 6.104 of IEC 62271-201:2014 taking into account the selected protection category of the interconnection.
- If a leakage current ~~may~~ **can** reach the accessible side of the insulating enclosure by a continuous path over insulating surfaces, it shall be not greater than 0,5 mA under the specified test conditions (refer to 7.104).

For testing procedures see 7.2.101.2.2 of IEC 62271-202:20142022.

7.2.102 Dielectric tests on the low-voltage interconnection

7.2.102.1 General conditions

For the tests, the low-voltage interconnection is connected to the test supply through the low-voltage functional unit. One terminal of the voltage source shall be connected to the main earthing conductor system of the CEADS. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

When the low-voltage interconnection is partially or totally covered by a non-metallic enclosure, the enclosure shall be covered by a circular or square metal foil having an area as large as possible, but not exceeding 100 cm² connected to the earth. The foil shall be applied to all surfaces that can be touched by an operator.

7.2.102.2 Lightning impulse-voltage tests

The low-voltage interconnection shall be subjected to lightning impulse-voltage tests. ~~The test voltage is specified in Table F.5 of IEC 60664-1:2007, where~~ The rated impulse-voltage test is chosen in accordance with 5.3.

The 1,2/50 µs impulse voltage shall be applied three times for each polarity at intervals of 1 s minimum. **Voltage surge suppression devices shall be disconnected.**

The test voltage shall be applied connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply. All other conductors of the main circuit and the

auxiliary circuits shall be connected to the earthing conductor or the frame and to the earth terminal of the test supply.

There shall be no disruptive discharge during the tests.

7.2.102.3 Power-frequency voltage withstand test

The low-voltage interconnection shall be subjected to 1 min power-frequency voltage withstand tests in dry conditions in accordance with 10.9.2 of IEC 61439-1:2011/2020 with the following addition:

During the power-frequency voltage withstand test, one terminal of the test transformer shall be connected to earth and to the main earthing conductor system of the CEADS.

7.2.103 Dielectric tests on high-voltage functional unit

Subclause 7.2 of IEC 62271-200:2011/2021 for metal-enclosed switchgear and controlgear or 6.2 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable with the following addition:

In case that the design of CEADS does not allow to separate physically high-voltage/low-voltage power transformer functional unit and high-voltage functional unit, the tests of the high-voltage functional unit shall be carried out with the high-voltage/low-voltage power transformer functional unit isolated from the high-voltage functional unit (e.g. by removing the interconnection).

7.2.104 Dielectric tests on high-voltage/low-voltage power transformer functional unit

Tests prescribed in the IEC 60076 (all parts) will shall be applicable applied, with the following considerations:

Preferably the high-voltage/low-voltage power transformer functional unit should be disconnected from the high-voltage functional unit and the low-voltage functional unit. However, for practical reasons the test voltage can be applied through the high-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

7.2.105 Dielectric tests on low-voltage functional unit

Subclause 9.1 of IEC 61439-1:2011/2020 is applicable.

For practical reasons this test may can be performed on the low-voltage functional unit already installed in CEADS. In this case the low-voltage functional unit shall be isolated from the high-voltage/low-voltage power transformer functional unit.

6.2.7 Partial discharge test

~~By agreement between the manufacturer and the user a test to evaluate the insulation of the high-voltage functional unit can be carried out following 6.2.9 of IEC 62271-200:2011 or IEC 62271-201:2014, depending on the type of insulation.~~

7.3 Radio interference voltage (RIV) test

Subclause 7.3 of IEC 62271-1:2007/2017 is not applicable for CEADS.

7.4 Measurement of the resistance of circuits Resistance measurement

~~Subclause 6.4.1 of IEC 62271-200:2011 or IEC 62271-201:2014 is applicable.~~

Subclause 7.4 of IEC 62271-1:2017 is applicable with the following considerations.

When the power transformer functional unit cannot be disconnected from the high-voltage functional unit, the resistance measurement can be influenced by the power transformer high-voltage windings.

7.5 Continuous current tests

Subclause 7.5 of IEC 62271-1:2017 is applicable with the following considerations.

This test is applicable for CEADS-G and CEADS-A. For CEADS-I, when the power transformer functional unit cannot be disconnected from the high-voltage functional unit, this test is not applicable.

7.6 Short-time withstand current and peak withstand current tests

Subclause 7.6 of IEC 62271-1:2017 is not applicable to CEADS.

7.6.101 Short-time and peak withstand current tests on main circuit of high-voltage and low-voltage functional units

The high-voltage functional unit that has not been previously tested shall be submitted to test according to 7.6 of IEC 62271-200:20112021 for metal-enclosed switchgear and controlgear or 6.6 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear. The high-voltage functional unit shall be isolated from the ~~high-voltage/low-voltage~~ power transformer functional unit to perform the test.

The low-voltage functional unit that has not been previously tested shall be submitted to test according to IEC 61439-1:20112020. The low-voltage functional unit shall be isolated from the ~~high-voltage/low-voltage~~ power transformer functional unit to perform the test.

7.6.102 Short-time and peak withstand current tests on high-voltage and low-voltage interconnections

High-voltage interconnection shall be tested following the procedure described in 7.6.1 a) of IEC 62271-200:20112021 for metal-enclosed switchgear and controlgear or 6.6 a) of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear. The test current ~~will~~ shall be applied in such a manner that the complete connection to the power transformer is tested. All parts supporting the interconnection shall be maintained in place, as in service condition, during the test.

In particular, when the high-voltage interconnection is protected by current-limiting devices situated in the high-voltage switchgear, provisions of 7.6.1 a) of IEC 62271-200:20112021 for metal-enclosed switchgear and controlgear or 6.6 a) of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear are applicable.

If the high-voltage interconnection is not protected by current limiting devices, the test can be made, where appropriate, at the same time as the high-voltage functional unit is tested, provided that the conditions of 7.6.1 of IEC 62271-200:20112021 for metal-enclosed switchgear and controlgear or 6.6 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear are met.

Non type-tested low-voltage interconnections can be tested following the procedure described in IEC 61439-1:20112020 for low-voltage switchgear and controlgear assembly. Where appropriate this test can be made at the same time as the low-voltage functional unit is tested. The test current ~~will~~ shall be applied in such a manner that the complete connection to the power transformer functional unit is tested. All parts supporting the interconnection shall be maintained in place, as in service condition, during the test.

For safety reasons, the power transformer can be replaced by a replica for short-time and peak current type tests. To verify interconnections ability to withstand the test, a short-circuit is made at both sides of the power transformer replica terminals.

7.6.103 Short-time and peak withstand current tests on earthing circuits

The earthing ~~conductor system~~ circuit of the CEADS shall be tested according to 7.6 of IEC 62271-1:2007:2017 with the addition of the following paragraphs:

~~It is not required to repeat~~ The type tests shall not be repeated on the main earthing circuits of type-tested functional units.

After the test, some deformation of the main earthing conductor and of the connections to the functional units is permissible, but the continuity of the circuit shall be preserved.

~~Generally, no test of the connections of metallic covers and doors, if any, to the main earthing conductor is required, if adequate design is demonstrated. However, in case of doubt, they shall be tested at 30 A (DC). The voltage drop shall be lower than 3 V.~~

Test of connections of metallic covers and doors not belonging to the main earthing circuit is not required. However, they can be tested at 30 A (DC) to demonstrate the electrical continuity of earthed metallic parts. In this case, the voltage drop shall be lower than 3 V.

7.6.104 ~~Short time and peak withstand~~ Short-circuit current tests on ~~high-voltage/low-voltage~~ power transformer functional unit

By agreement between the manufacturer and the user a short circuit test according to IEC 60076-5:2006 on the ~~high-voltage/low-voltage~~ power transformer functional unit might be carried out.

Preferably the ~~high-voltage/low-voltage~~ power transformer functional unit should be disconnected from the high-voltage functional unit and the low-voltage functional unit. However, for practical reasons, the test voltage can be applied through the high-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

7.7 Verification of the protection

Subclause 7.7 of IEC 62271-1:2017 is applicable with the following addition.

Verification of the protection against mechanical stresses according to 6.14 and 6.101 shall be checked.

~~6.7.1 Verification of degree of protection (IP coding)~~

~~The degree of protection specified by the manufacturer for any enclosure within the CEADS shall be verified according to IEC 60529:1989.~~

~~6.7.2 Verification of resistance to mechanical impacts (IK coding)~~

~~In accordance with the requirements specified in IEC 62262:2002, test shall be performed on every enclosure as under service conditions. Testing values stated in 5.101 are applicable.~~

~~Verification of the resistance to mechanical impacts of other parts of the CEADS may be carried out by agreement between the user and the manufacturer.~~

7.8 Tightness tests

Subclause 7.8 of IEC 62271-1:2007/2017 is applicable for high-voltage functional unit ~~and it can be applicable to gas-filled type transformers.~~

7.9 Electromagnetic compatibility tests (EMC)

For high-voltage functional unit 7.9 of IEC 62271-1:2007/2017 is applicable with the exception of radio interference voltage test.

For low-voltage functional unit 10.12 of IEC 61439-1:2014/2020 is applicable.

A test on a CEADS is not necessary provided that the high-voltage functional unit and low-voltage functional unit have been tested according to their relevant standards.

7.10 Additional tests on auxiliary and control circuits

7.10.1 General

Subclause 7.10 of IEC 62271-1:2007/2017 is applicable, with the following addition:

These tests ~~will~~ shall be performed on the complete CEADS and are only applicable to the auxiliary and control low-voltage circuits. Low-voltage power circuits, i.e. secondary of power transformer, low-voltage interconnection and low-voltage functional unit, are excluded from the test.

7.10.2 Functional tests

A functional test of all low-voltage circuits shall be made to verify the proper functioning of auxiliary and control circuits in conjunction with the other parts of the CEADS.

The tests shall be performed with the upper and lower value limits of the supply voltage defined in 5.9.

For low-voltage circuits, sub-assemblies and components, operation tests ~~can~~ may be omitted if they have been fully performed during a test applied to similar CEADS.

~~6.10.3 Electrical continuity of earthed metallic parts test~~

~~Subclause 6.10.3 of IEC 62271-1:2007 is applicable.~~

7.10.3 Verification of the operational characteristics of auxiliary contacts

Subclause 7.10.3 of IEC 62271-1:2007/2017 is applicable.

7.10.4 Environmental tests

Subclause 7.10.4 of IEC 62271-1:2007/2017 is ~~partly~~ applicable on a representative sample of an auxiliary and control circuit with following limitations.

These tests do not apply for indoor switchgear and controlgear operated under normal service conditions as defined by Clause 4 of IEC 62271-1:2017.

When the tests as stated in 7.10.4 of IEC 62271-1:2007/2017 ~~are~~ have been performed on the separate components of a representative sample of an auxiliary and control circuit, no further environmental tests are needed.

Where this is not carried out, ~~the remaining subclauses of 6.10.5 of IEC 62271-1:2007 are~~ 7.10.4 of IEC 62271-1:2017 is applicable on a typical lay-out of the auxiliary and control circuits.

7.10.5 Dielectric test

Subclause 7.10.5 of IEC 62271-1:2007/2017 is applicable.

7.11 X-radiation test ~~procedure~~ for vacuum interrupters

Subclause 7.11 of IEC 62271-1:2007/2017 is applicable for high-voltage functional units where vacuum interrupters are used.

7.101 Temperature-rise tests

7.101.1 General

The purpose of this test is to check that the temperature increases of the components when adapted to the design of the CEADS in its entirety ~~operates correctly and~~ does not impair the life-time expectancy of the functional units and their interconnections. Their life-time expectancy ~~will~~ shall not be influenced if the acceptable limits of deterioration of insulation through thermal effects are not exceeded. As stated in Clause 4, the functional units, which form part of a CEADS, shall comply at least with the requirements of their respective standards. To ensure this compliance, the relevant type tests can be carried out on each functional unit, being alone or embedded in the CEADS. In addition, as stated in the introduction, potential interactions between devices ~~have to~~ shall be evaluated.

Two situations can be considered.

The temperature rise tests are previously performed on each functional unit alone. Then the purpose of the temperature-rise test on the complete CEADS is to assess the possible interactions, to define corresponding de-rating of the functional units if any, and to verify the temperature rise of the interconnections.

The temperature-rise tests are not previously performed on each functional unit alone. Then the purpose of the temperature-rise test on the complete CEADS is to verify the temperature rise of the functional units according to their respective standards and at the same time the temperature rise of the interconnections.

7.101.2 Test conditions

Main functional units and interconnections temperature-rise tests ~~will~~ shall be performed simultaneously on a complete CEADS. In the case of already type-tested high-voltage functional unit and where it is considered that there is no significant influence of the temperature-rise of the high-voltage functional unit on the other functional units, or vice-versa, the temperature-rise test ~~need~~ shall not ~~to~~ include the current flowing in the main circuit of the high-voltage functional unit (see Figure 1). If it cannot be demonstrated otherwise a complete test of the CEADS ~~has to~~ shall be performed (see Figure 2). For the high-voltage functional unit the procedure of 7.5 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.5 of ~~IEC 62271-200:2011 or~~ IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear shall be applied.

NOTE 1 Reasons for concern could be, for example, where the temperature-rise values reported during the type test are close to the acceptable limits, or the influence of other functional units on the power transformer feeder during the temperature-rise test of the complete CEADS is so high that can be estimated that the influence on the main circuit can compromise their rated values. In that case de-rating of the high-voltage functional unit is considered.

NOTE 2 It is a common practice that the high-voltage functional unit operates at much lower current (load) than its rated one. Taking this into account, the additional increase of temperature caused by operating as part of a CEADS in most cases has no relevant influence on the required current capability of the high-voltage functional unit. In cases where full load conditions are expected in the main circuit this assumption ~~would not~~ cannot be valid.

In case of high-voltage functional unit not previously type tested, a complete temperature-rise test of the CEADS ~~has to~~ shall be performed, according to Figure 2.

The distribution of current at the low-voltage functional unit feeders shall be chosen to be the worst condition in respect of heat generation.

NOTE 3 The low-voltage functional unit feeders comprise not only traditional electric distribution applications outgoing feeders but incoming feeders from back-feeding installations such as low voltage side generating plants.

If low-voltage functional unit feeders are equipped with fuses, these fuses shall be present during test and shall represent the service conditions. As an option, the feeders can be fitted with fuse-links instead of fuses. The rated power losses of the fuse-links used for the test shall be stated in the type test report. Fuse-link power loss shall be determined by measurement or alternatively as declared by the fuse-link manufacturer.

The test shall be carried out in a test room in which the dimensions and insulation ~~will~~ shall keep the ambient air temperature of the room ~~at less than 40 °C with a variation not exceeding 1 K in 1 h reading during the measurement test period~~ within the limits specified in 7.101.5.1.

The test room environment shall be substantially free from air currents, except those generated by heat from the equipment under test. In practice, this condition is reached when the air velocity does not exceed 0,5 m/s.

7.101.3 Test methods

7.101.3.1 General

Two different testing situations are considered (see 7.101.1).

- a) The temperature-rise test ~~need~~ shall not include the current flowing in the main circuit of the high-voltage functional unit because the temperature-rise test on the high-voltage functional unit has been previously carried out and the influence of the other functional units is deemed to be not significant for the temperature-rise of the high-voltage functional unit in the CEADS.
- b) The temperature-rise test ~~has to~~ shall include the current flowing in the main circuit of the high-voltage functional unit because the temperature-rise test on the high-voltage functional unit has not been previously carried out or the influence of the other functional units is deemed to be significant on the temperature-rise of the high-voltage functional unit when installed in the CEADS.

The following test methods ~~may~~ can be used:

- The preferred method requires the use of independent sources of current to supply the high-voltage and the low-voltage sides of the CEADS.
- An alternative method ~~may~~ can be used if the laboratory can provide only one source of current or the design of the CEADS makes the connection arrangements as described by Figure 1 impossible. The alternative method is applicable in case of situation a).

7.101.3.2 Preferred method

7.101.3.2.1 General

This method requires different connections of supply for the high-voltage and the low-voltage sides respectively.

7.101.3.2.2 Connection of supplies

a) High-voltage side

According to the two situations described above, the following testing procedures shall be used.

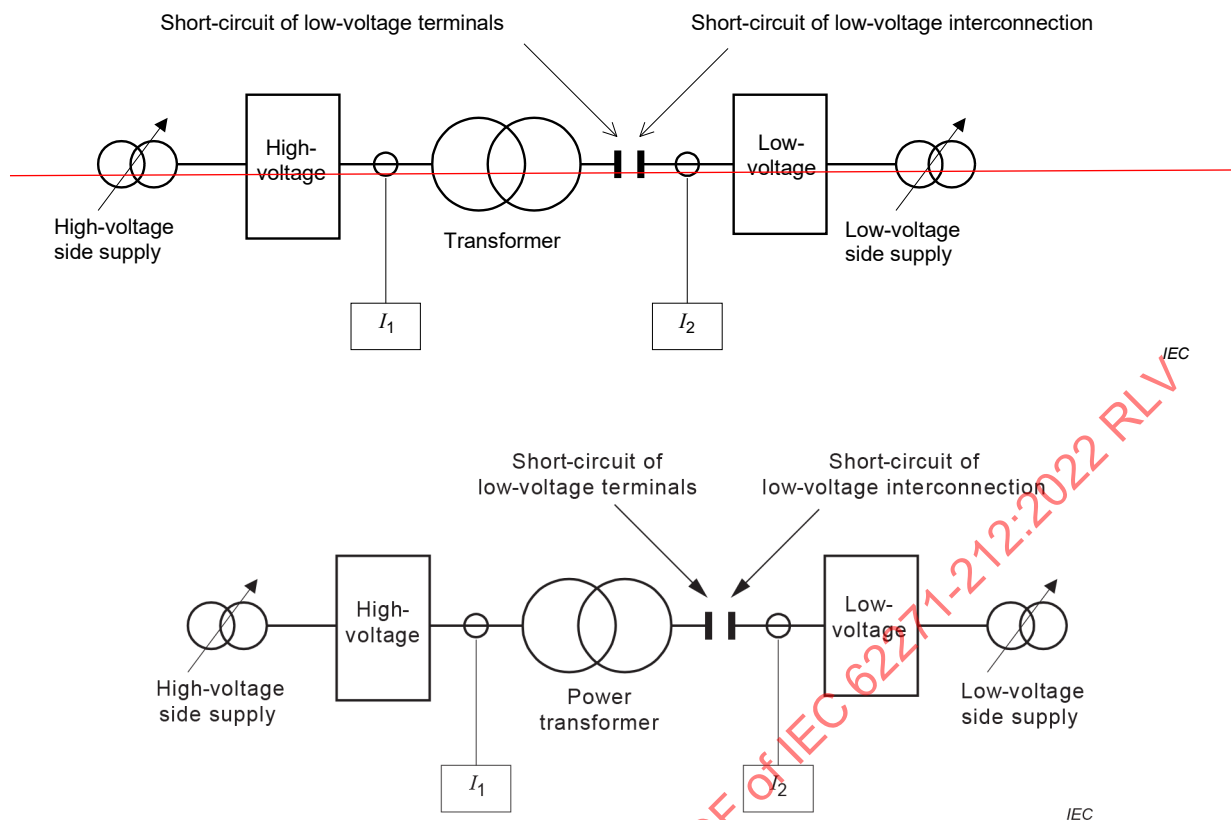
If the test does not require to include the current flowing in the main circuit of the high-voltage ~~/low-voltage~~ functional unit, the power transformer functional unit and the high-voltage functional unit shall be connected to one current supply and the low-voltage ~~outgoing~~ terminals of the ~~high-voltage / low-voltage~~ power transformer functional unit shall be short-circuited. The supply shall be connected to the incoming feeder of the high-voltage functional unit. Refer to Figure 1.

If the test requires to include the current flowing in the main circuit of the high-voltage functional unit, it ~~has to~~ shall be isolated ~~to~~ from the T-off (power transformer feeder) and two different supplies on the high-voltage side ~~are to~~ shall be used. The first one shall supply the high-voltage main ~~ring~~ circuit with its rated current. The second shall supply the high-voltage side of the ~~high-voltage / low-voltage~~ power transformer functional unit through the T-off of the high-voltage functional unit and the low-voltage ~~outgoing~~ terminals of the ~~high-voltage / low-voltage~~ power transformer functional unit shall be short-circuited. ~~Refer to Figure 2.~~ Figure 2 graphically explains the connection of supplies under an assembly with larger high-voltage main circuit.

b) Low-voltage side

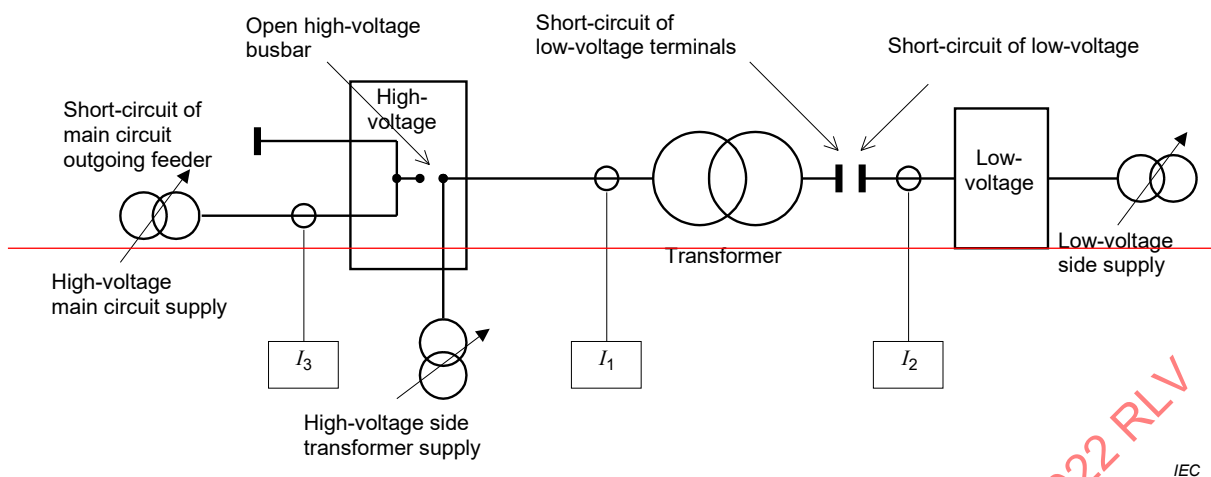
The temperature-rise test on the low-voltage side shall be carried out in accordance with 10.10 of IEC 61439-1: ~~2014~~ 2020 and the following specific requirements.

The low-voltage functional unit shall be isolated from the ~~high-voltage / low-voltage~~ power transformer functional unit, as close as practicable to the ~~high-voltage / low-voltage~~ power transformer functional unit terminals. At a convenient point adjacent to the ~~high-voltage / low-voltage~~ power transformer functional unit terminals, a short-circuit shall be applied to the connections between the ~~high-voltage / low-voltage~~ power transformer functional unit and the low-voltage functional unit. Test current shall be applied to the low-voltage functional unit via the ~~outgoing~~ feeders. ~~The distribution of this supply current at the low-voltage outgoing feeders shall be chosen to be the worst case in respect of heat generation. Refer to Figure 1 or Figure 2.~~

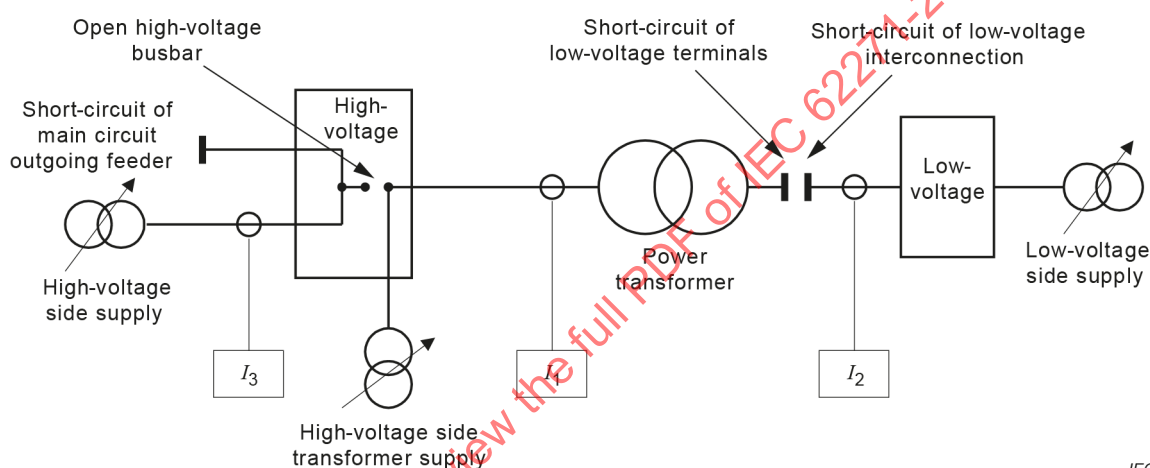
**Key**

- I_1 sufficient current to generate the total losses in accordance with Step 1 and Step 2 of 7.101.3.3.3 for liquid-filled high-voltage/low-voltage liquid-immersed power transformer functional unit or high-voltage rated current of dry-type high-voltage/low-voltage power transformer functional unit (see 7.101.4 step 2)
- I_2 Low-voltage rated current of high-voltage/low-voltage transformer functional unit
current determined by the power transformer functional unit rated power at its low-voltage side at the maximum current tapping

Figure 1 – Test diagram in case of type-tested high-voltage functional unit



IEC



IEC

Key

- I_1 sufficient current to generate the total losses of liquid-filled ~~high-voltage/low-voltage~~ power transformer functional unit or high-voltage rated current of dry-type ~~high-voltage/low-voltage~~ power transformer functional unit (see 7.101.4 step 2)
- I_2 ~~low-voltage rated current of high-voltage/low-voltage transformer functional unit~~ current determined by the power transformer functional unit rated power at its low-voltage side at the maximum current tapping
- I_3 rated continuous current of high-voltage main circuit

Figure 2 – Test diagram in case of non-type-tested high-voltage functional unit

7.101.3.2.3 Application of test currents

a) High-voltage side

For liquid filled ~~high-voltage/low-voltage~~ power transformer functional unit the circuit is supplied with sufficient current to generate the total losses of the ~~high-voltage/low-voltage~~ power transformer functional unit, at its reference temperature, using the method defined in IEC 60076-2:2011.

NOTE 1 ~~This test can require~~ A small percentage of current above the rated current flowing through the complete circuit ~~can be used~~ so as to compensate for the ~~high-voltage/low-voltage~~ power transformer functional unit no-load losses.

NOTE 2 During the test, the resistance ~~will~~ can vary according to the temperature of the ~~high-voltage/low-voltage~~ power transformer functional unit. Thus, the test supply current is varied accordingly to maintain the generated losses constant and equal to the total ~~high-voltage/low-voltage~~ power transformer functional unit losses throughout the test.

For dry type ~~high-voltage/low-voltage~~ power transformer functional units, the simulated load method described in IEC 60076-11:2004/2018 shall be followed (see 7.101.4).

b) Low-voltage side

The low-voltage circuit is supplied with the ~~rated low-voltage current of the tested high-voltage/low-voltage transformer functional unit~~ current determined by the power transformer functional unit rated power at its low-voltage side at the maximum current tapping.

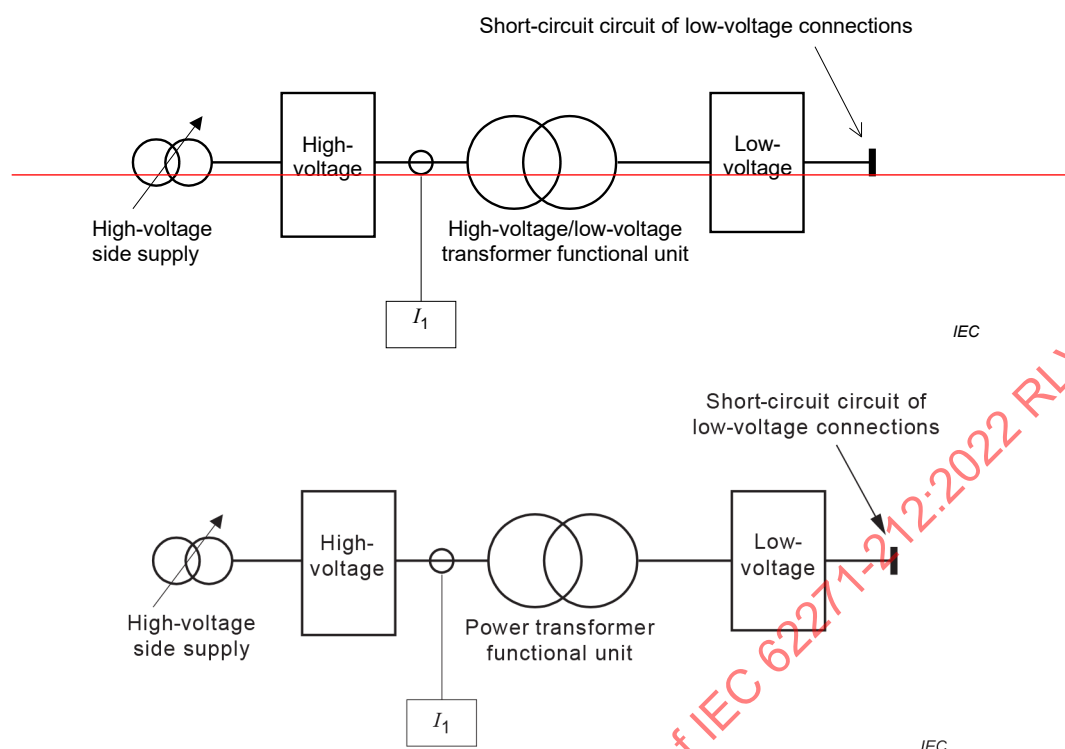
7.101.3.3 Alternative method

7.101.3.3.1 General

This method requires one single supply.

7.101.3.3.2 Connection of supply

The high-voltage functional unit and the ~~high-voltage/low-voltage~~ power transformer functional unit shall be connected and the ~~outgoing terminal~~ feeders of the low-voltage functional unit shall be short-circuited. The supply shall be connected to the incoming terminals of the high-voltage functional unit (see Figure 3).



Key

I_1 sufficient current to generate the total losses of liquid-filled ~~high-voltage/low-voltage transformer functional unit~~ or ~~high-voltage rated current of dry-type high-voltage/low-voltage~~ power transformer functional unit (see 7.101.3.3.3 step 1 and step 2)

Figure 3 – ~~Alternative diagram in case of type tested high-voltage functional unit~~
Diagram of the temperature-rise test alternative method

7.101.3.3.3 Application of test current

When the CEADS is equipped with a liquid-immersed power transformer functional unit, the application of test currents should follow the method as described in 7.3.2 of IEC 60076-2:2011 consisting of the two following consecutive steps.

Step 1:

The CEADS is supplied with sufficient current to generate the total losses of the ~~high-voltage/low-voltage~~ power transformer functional unit, at its reference temperature, using the method defined in ~~the relevant product standard~~ IEC 60076-2:2011.

NOTE The total power supplied to the complete prefabricated substation can be higher than the power transformer total rated losses due to the connection of the low-voltage switchgear assembly.

Step 2:

The supply current is reduced so that the high-voltage rated current of the power transformer is injected for 1 h in accordance with IEC 60076-2:2011.

At the end of the second step, the low-voltage and high-voltage switchgear temperature measurements shall be made in accordance with 7.101.5.3 and 7.101.5.4.

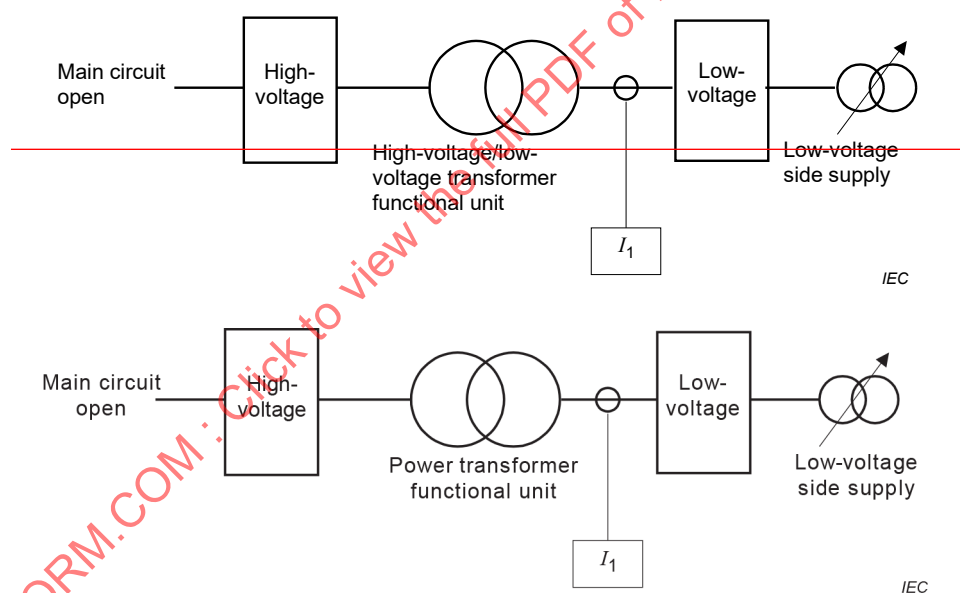
7.101.4 ~~Special case of dry-type high-voltage/low-voltage transformer functional unit~~ Test method for CEADS equipped with dry-type power transformer functional unit

For a temperature-rise test on a CEADS equipped with a dry-type ~~high-voltage/low-voltage~~ power transformer functional unit, the method for the temperature-rise test should follow the simulated load method as described in IEC 60076-11:2004/2018 consisting of two consecutive steps.

Step 1:

The open-circuit test shall be performed in such a manner that the rated operating voltage (three-phase) at rated frequency is applied to the low-voltage winding of the ~~high-voltage/low-voltage~~ power transformer functional unit via one of the ~~outgoing~~ feeders of the low-voltage functional unit. The high-voltage winding is connected to the high-voltage functional unit. High-voltage main circuit is open (see Figure 4). ~~After thermal equilibrium has been reached~~ Once the steady state condition of the windings and magnetic core ~~individual winding~~ has been reached (see 14.3.2.4 of IEC 60076-11:2018), the temperature-rise of each winding of the dry-type power transformer functional unit shall then be measured.

NOTE This test can also be made by feeding the high-voltage winding of the ~~high-voltage/low-voltage~~ power transformer functional unit via high-voltage functional unit. The low voltage winding is connected to the low-voltage functional unit. Low-voltage main circuit is open.



Key

I_1 no load current of the power transformer

Figure 4 – Diagram for the open-circuit test

Step 2:

The connection of supplies is made according to 7.101.3.3.2 (Figure 3) or 7.101.3.2.2 (Figure 1 or Figure 2).

~~The high-voltage side of the CEADS is supplied with the high-voltage rated current of the high-voltage/low-voltage transformer functional unit. The low-voltage side of the CEADS is supplied with the low-voltage rated current of the high-voltage/low-voltage transformer functional unit.~~

When the steady-state condition of the windings and magnetic core is achieved, the temperature rises of ~~the individual windings are~~ each winding of the dry-type power transformer functional unit shall be measured together with the temperature rises of the low-voltage functional unit and the interconnections and high-voltage functional unit for case b) of 7.101.3.1. For the steady-state conditions of dry-type ~~high-voltage/low-voltage~~ power transformer functional unit refer to 14.3.2.4 of IEC 60076-11:20042018.

After completion of the two steps above the temperature rise of the power transformer functional unit is calculated by the formula given in 14.3.2.2.2 of IEC 60076-11:20042018.

7.101.5 Measurements

7.101.5.1 Measurements of the ambient air temperature

The ambient air temperature is the average temperature of the air surrounding the CEADS. It shall be measured during the last ~~quarter~~ part of the test period or each test step (depending on test method) by means of at least four thermometers, thermocouples or other temperature-detecting measuring devices equally distributed around the CEADS at about the average height of its current-carrying parts and at a distance of about 1 m from the CEADS. The thermometers or thermocouples shall be protected against air currents and undue influence of heat.

In order to avoid indication errors because of rapid temperature changes, the thermometers or thermocouples ~~may~~ can be put into small bottles containing about half a litre of oil.

During the last ~~quarter~~ part of the test period or each test step (depending on test method), the change of ambient air temperature shall not exceed 1 K in 1 h. The ambient air temperature during tests shall be more than +10 °C but less than +40 °C. No correction of the temperature-rise values shall be made for ambient air temperatures within this range.

7.101.5.2 ~~High-voltage/low-voltage~~ Power transformer functional unit

In the case of already type-tested ~~high-voltage/low-voltage~~ power transformer functional unit, the top liquid temperature-rise for liquid-filled ~~high-voltage/low-voltage~~ power transformer functional units shall be measured as given in IEC 60076-2:2011, or the average winding temperature rises for dry-type ~~high-voltage/low-voltage~~ power transformer functional units shall be measured as given in IEC 60076-11:20042018.

In addition to this, in the case of non-type-tested ~~high-voltage/low-voltage~~ power transformer functional unit measurement of the temperature-rise of the windings shall be performed according to IEC 60076-2:2011 ~~or IEC 60076-11:2004~~ for liquid-filled power transformer functional units or IEC 60076-11:2018 for dry-type power transformer functional units. ~~For this measurement, the diagram of Figure 1 has to be preferably used, or Figure 3 if only one supply source is available.~~

7.101.5.3 Low-voltage functional unit

The low-voltage functional unit temperature-rise shall be measured as given in 10.10 of IEC 61439-1:20142020.

The air temperature in the location where electronic equipment ~~may~~ can be installed shall be measured. The temperature shall be within the service condition applicable to the contained electronic equipment.

7.101.5.4 High-voltage functional unit

If this test is considered to be necessary or in case of non-type-tested high-voltage functional unit ~~(see 6.5.2)~~, a complete measurement ~~is to~~ shall be performed according to IEC 62271-200:20142021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.

The air temperature in the location where electronic equipment ~~may~~ can be installed shall be measured. The temperature shall be within the service condition applicable to the contained electronic equipment.

7.101.5.5 Interconnections

The temperature of the high-voltage and low-voltage interconnections, their terminals and accessible parts expected to be touched in normal operation shall be measured according to 7.5.6 of IEC 62271-1:2017.

7.101.5.6 Acceptance criteria

The CEADS is deemed to pass the test if:

- a) the temperature-rise of the ~~high-voltage/low-voltage~~ power transformer functional unit does not exceed the requirements of Clause 6 of IEC 60076-2:2011 for liquid-filled ~~high-voltage/low-voltage~~ power transformer functional units or Clause 10 of IEC 60076-11:2004/2018 for dry-type ~~high-voltage/low-voltage~~ power transformer functional units. If the liquid-filled ~~high-voltage/low-voltage~~ power transformer functional unit has been tested previously only the top liquid temperature ~~needs to~~ shall be checked;
- b) the temperature-rise and temperatures of the high-voltage functional units and high-voltage interconnection do not exceed the requirements of 7.5.6 of IEC 62271-1:2007/2017;
- c) the temperature rises and temperatures of the low-voltage functional unit and low-voltage interconnection do not exceed the requirements of 9.2 of IEC 61439-1:2014/2020;
- d) for the accessible parts of CEADS the temperature-rise and temperatures do not exceed the requirements of 7.5.6 of IEC 62271-1:2007/2017 for accessible parts expected to be touched in normal operation.

NOTE If the values for accessible parts expected to be touched in normal operation are exceeded, additional precautions, covers, barriers and access limitation ~~should~~ can be taken on site to avoid the risk of burns.

7.101.6 Temperature-rise due to solar radiation

In case of outdoor installation of CEADS, the effect of solar radiation could affect its performance. In order to evaluate the influence, CEADS can be subjected to a temperature rise type test with the addition of a simulated solar radiation in accordance with Annex G of IEC 62271-202:2022. The purpose of the test is to determine the impact due to solar radiation in terms of additional temperature rise on main components of CEADS and on those accessible parts expected to be touched in normal operation. If necessary, the required de-rating of CEADS could then be determined.

7.102 Internal arc test

7.102.1 General

These tests are applicable to CEADS, intended to be qualified as class IAC with respect to protection of persons in the event of an internal arc at high-voltage functional unit side.

These tests cover the cases of faults resulting in an arc occurring inside the CEADS in the high-voltage functional unit and the high-voltage interconnection. The effectiveness of the design of the CEADS to provide protection to persons in case of an internal arc can be verified by testing according to Annex A.

CEADS are generally intended for installation in closed electrical operating areas, where, in principle, only authorised personnel can enter. However, the employees of ~~a factory~~ an industrial facility not in charge of the operation of the high-voltage functional unit, can stand occasionally in the proximity of a CEADS. As they are not aware of the risks involved, they are considered to be general public in the context of this document. Consequently, the document considers both accessibility types A and B, as in IEC 62271-200:2014/2021 for metal-enclosed

switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.

IAC-A is intended to verify the protection of operators when operating the CEADS and is based on a restriction to authorised persons only (Accessibility Type A, see 5.102.2).

IAC-B is intended to verify the protection of the general public around the CEADS with unrestricted access (Accessibility Type B, see 5.102.2).

The manufacturer shall indicate which parts of the CEADS are classified as accessible during an internal arc event and which are defined as high-voltage operating side(s) according to the tested IAC classification.

This IAC classification is intended to offer a tested level of protection to persons (including operators) around CEADS in the event of internal arcs in normal operating conditions and with its high-voltage functional unit in normal service position.

NOTE This document covers only internal arcs occurring in the high-voltage side of the CEADS, including high-voltage-interconnections (e.g. between high-voltage functional unit and ~~high-voltage/low-voltage~~ power transformer functional unit). Internal arcs within the ~~high-voltage/low-voltage~~ power transformer functional unit or the low-voltage functional unit are not taken into account (see 6.103 for explanation of this exclusion).

Internal arcs in a CEADS can occur in a number of locations and can cause various physical phenomena. For example, the energy resulting from an arc developed in open air within the CEADS or in any insulating fluid within the enclosure of any of the high-voltage functional units ~~will~~ can cause an internal overpressure and local overheating which ~~will~~ can result in mechanical and thermal stressing of room or the enclosure (if any) containing the CEADS. Moreover, the materials involved ~~may~~ can produce hot decomposition products, either gaseous or vaporous, which ~~may~~ can be discharged around the CEADS.

The Internal Arc Class (IAC) makes allowance for internal overpressure acting on covers, doors, floor(s), etc. It also takes into consideration the thermal effects of arc or its roots on the enclosure and of ejected hot gases and glowing particles, but not damage to internal partitions, shutters or other internal installations not being accessible in normal operating conditions.

The internal arc tests described below does not cover all effects that ~~may~~ can constitute a hazard, such as the presence of gases with potential toxic characteristics that can be present after the fault, or the hazard of propagation of fire after an internal arc to combustible materials or equipment placed in the proximity of the CEADS.

7.102.2 Test conditions

To be qualified as class IAC-A and/or IAC-B a CEADS shall be subjected to ~~two~~ a different test series, one on the high-voltage functional unit and ~~one~~, if applicable, on the high-voltage interconnections. To be qualified as class IAC-AB the CEADS shall be subjected to the test series for IAC-A and IAC-B.

For required tests, see Figure A.7, Figure A.8, Figure A.9 and Figure A.10, showing the principles for the selection of tests and the corresponding number and type of tests to be performed.

The internal arc test shall be performed on a complete CEADS to ensure that the influence of all devices is represented. If any device is used to limit the duration of the arc (for example protection relay, fuses), it ~~may~~ can be operative during the test but the part of the CEADS protected by the device shall be classified per the actual duration of the arc. The test current shall be maintained for the rated short-circuit duration of the main circuit.

As an exception, the test on high-voltage functional unit might be not necessary, provided that:

- this functional unit has been previously internal arc ~~tested~~ classified according to 5.103 of IEC 62271-200:2014:2021 for metal-enclosed switchgear and controlgear or 4.101 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear, in a test arrangement equal or more onerous than the actual installation conditions in the CEADS;
- it can be proven that the other components of the CEADS do not affect the behaviour.

In the case where open-air fuse-bases devices are used as high-voltage functional unit, a three-phase test shall be performed at the feeding side of the fuse-bases.

7.102.3 Arrangement of the equipment

The following points shall be observed:

- tests shall be carried out on a CEADS not previously subjected to arcing, or, if subjected, being in a condition which does not affect the result of the test;
- the CEADS shall be fully equipped, including high-voltage interconnection. Mock-ups of internal components that ~~will~~ shall not be exposed to the arc are permitted provided they have the same volume and external material as the original components;
- when the CEADS is connected to earth, the connection shall be at the point provided.

7.102.4 Test procedure

The method to verify the internal arc classification is defined in A.6.

7.102.5 Criteria to pass the test

A CEADS is qualified as class IAC (according to the relevant accessibility type) providing that:

- the five criteria as in 7.105.5 of IEC 62271-200:2014:2021 for metal-enclosed switchgear and controlgear or 6.105.5 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear have been met after the internal arc test on the high-voltage functional unit,

NOTE Where the design of the CEADS includes a space below the floor to receive the exhausting gases, the behaviour of the floor ~~should be~~ is assessed from the point of view of the safety of the operator standing on it.

- where applicable (see Figure A.9 and Figure A.10), the following criteria have been met after test on the high-voltage interconnections:

Criterion no.1 Barriers, obstacles or enclosures of the high-voltage interconnection, if any, are not moved or deformed further than the position of the indicators.

Criterion no.2 No material projections of an individual mass above 60 g or more falling to the floor in the immediate vicinity of the assembly (in the case of accessible sides, this means between the assembly and the indicator rack).

Criterion no.3 Arcing does not cause holes in the accessible side of the enclosure of the high-voltage interconnection, ~~if this side is completely closed.~~

Criterion no.4 Indicators do not ignite due to the effect of flames or hot gases.
Should they start to burn during the test, the assessment criterion ~~may~~ can be regarded as having been met, if proof is established of the fact that glowing particles rather than hot gases caused the ignition. Pictures taken by high-speed cameras, video or any other suitable means can be used by the test laboratory to establish evidence.

Indicators ignited as a result of paint or stickers burning are also excluded from the assessment.

Criterion no.5 If the high-voltage interconnection is protected by an enclosure connected to earth, this enclosure remains connected to its earthing point.

7.102.6 Test report

The following information shall be given in the test report:

- description of test object: comprehensive list of drawings and documents to identify critical aspects of the design regarding gas cooling, exhausting path or arrangement of cable ducts if used to exhaust gases;
- ratings and description of the CEADS with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief flaps and the method of fixing the CEADS to the floor and/or to the walls;
- high-voltage functional unit type and ratings, as well as a specific mention to high-voltage functional unit internal arc classification, if any;
- type of high-voltage interconnections;
- arrangement of the test connections;
- spatial dimensional arrangement of main components;
- the ceiling height for installation or the relative distance between the upper part of the test object and the ceiling of the room or building;
- point and method of initiation of the internal arc;
- drawings or photographs of test arrangement (room simulation, test object and mounting frame of indicators) with respect to the type of accessibility (A or B), operating side (F, L or R) and installation conditions;
- applied voltage and frequency;
- for the prospective or test current:
 - a) RMS value of the AC component during the first three half cycles;
 - b) highest peak value;
 - c) average value of the AC component over the actual duration of the test;
 - d) ~~test~~ duration of arc fault current;
- oscillogram(s) showing currents and voltages;
- assessment of the test results, including a record of the observations in accordance with 7.102.5;
- photographs of the test object under test, before and after test;
- other relevant remarks.

~~— arrangement of cable ducts if used to exhaust gases.~~

7.102.7 Extension of validity of test results

The validity of the results of a test carried out on a particular CEADS design or representative part of it can be ~~extended~~ transferred to another one, provided that the original test was equal or more onerous and that the ~~latter~~ design under consideration can be considered as similar to the one tested in all of the following ~~respects~~ characteristics:

- arc current and arcing time;
- directions of gas flow from the internal arc;
- dimensions of the tested compartments and layout of the CEADS;
- structure and mechanical strength of the compartments and partitions, if any;
- performance of the pressure release device, if any.

NOTE If applicable, the assessment of the high-voltage functional unit assembly of the CEADS can be done in accordance with IEC TR 62271-307 [8].

7.103 Verification of making and breaking capacities of high-voltage functional unit

Subclause 7.101 of IEC 62271-200:2011/2021 for metal-enclosed switchgear and controlgear or 6.101 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable with the following addition:

It is not required to repeat the type tests to verify making and breaking capability on previously type-tested components, provided that ~~the service conditions in the CEADS are similar to the testing conditions~~ mechanical, thermal and electrical conditions during test are representative of the service conditions when installed in the CEADS. ~~Possible mechanical, thermal and electrical influences have to be considered.~~

7.104 Mechanical operation tests

Subclauses 7.102 of IEC 62271-200:2011 ~~2021 and 10.13 of IEC 61439-1:2011~~ for metal-enclosed switchgear and controlgear and 6.102 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear are applicable ~~respectively~~ to high-voltage functional unit and 10.2.8 of IEC 61439-1:2020 is applicable for low-voltage functional unit, with the following addition:

Mechanical operation test ~~need~~ shall not be repeated if the functional units have been previously type tested, provided that the installation of the functional unit within the CEADS does not impose conditions that could influence negatively the operation. In case of doubt the test shall be repeated in the real installation conditions.

7.105 Mechanical stability test

~~The complete assembly lifting lugs shall be designed for the total weight of the CEADS.~~

The type tests for the complete assembly shall include a test for stability. The test shall be conducted with care to ensure that the equipment cannot topple in an uncontrolled manner. The complete CEADS shall be lifted, by the specified lifting lugs, to verify the assembly stability for safe handling and operations. ~~The~~ A second test shall comprise lifting one side of the equipment by 15° to check that there is no toppling. When agreed between manufacturer and user, this last test can be repeated to check stability lifting from any of the sides.

NOTE It is suggested that the equipment can be supported with a crane during the test.

7.106 Pressure withstand test for gas-filled compartments

Subclause 7.103 of IEC 62271-200:2011 ~~2021~~ is applicable with the following addition:

~~It is not required to repeat the pressure withstand test for gas-filled compartments on type tested components.~~

Pressure withstand test for gas-filled compartments shall not be repeated if the functional units have been previously type tested, provided that the installation of the functional unit within the CEADS does not impose conditions that could influence negatively the tightness. In case of doubt, the test shall be repeated in the real installation conditions.

7.107 Measurements of leakage currents of non-metallic enclosures

When the high-voltage interconnection is totally or partially covered by a non-metallic enclosure the following tests shall be made in order to check compliance with the requirement of item d) of 7.2.101.5.

At the discretion of the manufacturer, the main circuit shall be connected either to a three-phase supply of power-frequency voltage equal to the rated voltage of the high-voltage functional unit, with one phase connected to earth, or to a single-phase supply of a voltage equal to the rated voltage. The live parts of the main circuit ~~being~~ shall be connected together. For three-phase tests, three measurements shall be made with the different phases of the supply successively connected to earth. In the case of single-phase tests, only one measurement is necessary.

A metal foil shall be placed in the most unfavourable situation for the test on the accessible surface of the insulation providing the protection against contact with live parts. In case of doubt about the most unfavourable situation, the test shall be repeated with different situations.

The metal foil shall be approximately circular or square, having an area as large as possible but not exceeding 100 cm². The enclosure and the frame of the ~~metal-enclosed switchgear~~ **high-voltage functional unit** and ~~controlgear~~ the **power transformer** shall be earthed. The leakage current flowing through the metal foil to earth shall be measured with the insulation dry and clean.

If the value of the leakage current measured is more than 0,5 mA, the insulating surface does not provide the protection required in this document.

It is not necessary to measure leakage currents, if earthed metal parts are arranged in an appropriate manner to ensure that leakage currents cannot reach the accessible parts of the enclosure.

7.108 Weatherproofing test

When agreed between manufacturer and user, a weatherproofing test can be made on **outdoor** CEADS. A recommended method is given in Annex C of IEC 62271-1:2007/2017.

7.109 Tightness and mechanical strength for liquid filled compartments

If the enclosure is of hermetically sealed type and completely liquid filled, 11.8 of IEC 60076-1:2011 is applicable with the following addition:

The test shall be performed on a complete CEADS to ensure that the influence of all devices is represented.

NOTE Mechanical withstand tests specified in EN 50464-4 [9] and IEEE C57.12.00 [10] can be considered as alternative test method references for corrugated tanks of liquid filled ~~high-voltage/low-voltage~~ **power transformer functional unit**.

7.110 Measurement or calculation of electromagnetic fields

General guidance regarding the measurement or calculation of electromagnetic fields is given in IEC TR 62271-208:2009.

8 Routine tests

8.1 General

Clause 8 of IEC 62271-1:2017 is not applicable for CEADS.

The routine tests shall be made on each complete CEADS at the manufacturer's factory to ensure that the product **quality** is in accordance with the equipment on which the type tests have been carried out.

Due to the special design of this equipment it ~~may~~ **can** be practical to test more than one functional unit at the same time.

The routine tests comprise the following:

- dielectric test on the main circuit (8.2);
- tests on auxiliary and control circuits (8.3);
- measurement of the resistance of the main circuit (8.4);

- tightness test (8.5);
- design and visual checks (8.6);
- mechanical operation tests on high-voltage functional units (8.101);
- pressure tests of gas-filled compartments (8.102);
- tests of auxiliary electrical, pneumatic and hydraulic devices (8.103);
- measurement of the resistance of the windings (8.104);
- measurement of the voltage ratio (8.105);
- measurement of the short circuit impedance and load losses (8.106);
- measurement of non-load losses and current (8.107);
- inspection of the low-voltage functional unit, including inspection of wiring and, if necessary, electrical operation test (8.108);
- checking of protective measures and of the electrical continuity of the protective circuits of the low-voltage functional unit (8.109);
- tests after assembly onsite (8.110).

If the components of the CEADS have been routine tested before in accordance with their relevant standards, these tests shall not be repeated unless the characteristics of the components are modified during manufacturing of the CEADS.

8.2 Dielectric tests on the main circuit

8.2.101 General

Only parts of CEADS not previously routine tested shall be tested.

8.2.102 Dielectric tests on high-voltage functional unit

The tests ~~will~~ shall be carried out with the ~~high-voltage/low-voltage~~ power transformer functional unit isolated from the high-voltage functional unit. For this purpose, the switching device of the power transformer feeder circuit, if any, shall be in open position.

In this case, for practical reasons, the switching device of the power transformer feeder circuit ~~will~~ shall not be part of the tested equipment. Therefore it shall be tested together with the ~~high-voltage/low-voltage~~ power transformer functional unit as stated in 8.2.103. Test voltage values ~~will~~ shall be those of the ~~high-voltage/low-voltage~~ power transformer functional unit. A test with the switching device of the power transformer feeder circuit in open position shall be included according to 8.2 of IEC 62271-1:2017. ~~The following tests are applicable:~~

- ~~dielectric tests (7.1 of IEC 62271-1:2007).~~

Voltage limiting devices such as surge arresters and voltage transformers, if part of the high-voltage functional unit, shall be disconnected during routine dielectric tests.

8.2.103 Dielectric tests on ~~high-voltage/low-voltage~~ power transformer functional unit and high-voltage interconnection

If the ~~high-voltage/low-voltage~~ power transformer functional unit has not been previously routine tested, IEC 60076-1:2011 shall be followed.

The testing voltage ~~will~~ shall be applied through the high-voltage functional unit or the low-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed, all other switching devices are in open position. The following tests are applicable:

- Applied voltage test (AV) (Clause 10 of IEC 60076-3:2013);

- Induced voltage withstand test (IVW) (11.2 of IEC 60076-3:2013).

8.2.104 Dielectric tests on low-voltage functional unit and low-voltage interconnection

As the purpose of this test is to test only the low-voltage functional unit and low-voltage interconnection, the low-voltage interconnection ~~will~~ shall be disconnected from the ~~high-voltage/low-voltage~~ power transformer functional unit. The testing voltage ~~will~~ shall be applied at the ~~high-voltage/low-voltage~~ power transformer functional unit side of the low-voltage interconnection. The switching devices that are in series in the supply circuit are closed.

The following tests are applicable:

- dielectric tests (11.9 of IEC 61439-1:2014/2020);
- verification of insulation resistance (11.9 of IEC 61439-1:2014/2020).

8.3 Tests on auxiliary and control circuits

Subclause 8.3 of IEC 62271-1:2007/2017 is applicable.

8.4 Measurement of the resistance of the main circuit

~~This test shall be carried out on the main circuit as described in 7.3 of IEC 62271-200:2011.~~

Subclause 8.4 of IEC 62271-1:2017 is only applicable for high-voltage functional unit of CEADS-G.

8.5 Tightness test

In the case that they have been routine-tested according to their relevant standards, there is no need to conduct this test.

In other case, the following tests are applicable:

- a tightness test as stated in 8.5 of IEC 62271-1:2007/2017 shall be carried out for high-voltage functional unit.
- a leak test with pressure according to 11.8 of IEC 60076-1:2011 for liquid-filled ~~high-voltage/low-voltage~~ power transformer functional unit or a tightness test according to 11.3 of IEC 60076-15:2015 for gas-filled ~~high-voltage/low-voltage~~ power transformer functional unit.

8.6 Design and visual checks

Subclause 8.6 of IEC 62271-1:2007/2017 is applicable.

8.101 Mechanical operation tests on high-voltage functional unit

Subclause 8.102 of IEC 62271-200:2014/2021 for metal-enclosed switchgear and controlgear or 7.102 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable for the high-voltage functional unit.

8.102 Pressure tests of gas-filled compartments

Subclause 8.103 of IEC 62271-200:2014/2021 for metal-enclosed switchgear and controlgear or 7.103 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable ~~with the following addition~~ for the high-voltage functional unit.

~~Pressure test for a gas-filled high-voltage/low-voltage transformer functional unit tank shall be done according to subclause 11.4 of IEC 60076-15:2015.~~

8.103 Tests of auxiliary electrical, pneumatic and hydraulic devices

Subclause 7.104 of ~~IEC 62271-200:2011~~ or IEC 62271-201:2014 is applicable for solid-insulation high-voltage functional unit.

8.104 Measurement of the winding resistance

If the ~~high-voltage/low-voltage~~ power transformer functional unit has not been previously routine tested, 11.2 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.1 of IEC 60076-11:2004/2018 for dry-type power transformer shall be applied.

8.105 Measurement of the voltage ratio and check of phase displacement

If the ~~high-voltage/low-voltage~~ power transformer functional unit has not been previously routine tested, 11.3 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.2 of IEC 60076-11:2004/2018 for dry-type power transformer shall be applied.

8.106 Measurement of the short circuit impedance and load losses

If the ~~high-voltage/low-voltage~~ power transformer functional unit has not been previously routine tested, 11.4 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.3 of IEC 60076-11:2004/2018 for dry-type power transformer shall be applied.

8.107 Measurement of no-load loss and current

If the ~~high-voltage/low-voltage~~ power transformer functional unit has not been previously routine tested, 11.5 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.4 of IEC 60076-11:2004/2018 for dry-type power transformer shall be applied.

8.108 Inspection of the low-voltage functional unit, including inspection of wiring ~~and, if necessary, electrical operation test~~, operational performance and function

If the low-voltage functional unit has not been previously routine tested, 11.10 of IEC 61439-1:2011/2020 shall be applied.

8.109 Checking of protective measures and of the electrical continuity of the protective circuits of the low-voltage functional unit

If the low-voltage functional unit has not been previously routine tested, 11.4 of IEC 61439-1:2011/2020 shall be applied.

8.110 Tests after CEADS assembly on site

In the exceptional case where for practical reasons manufacturer and user agree to transport the CEADS unit dismantled, ~~additional tests may be made~~ some of these routine tests can be repeated on site by agreement between manufacturer and user, to assure that the assembly process has been carried out correctly.

9 Guide to the selection of CEADS (informative)

9.1 General

Subclause 9.1 of IEC 62271-1:2017 is not applicable to CEADS.

CEADS ~~may~~ can be constructed in various forms that have evolved with changing technologies and functional requirements. The selection of CEADS essentially involves an identification of the functional requirements for the service installation that best meets these requirements.

Such requirement should also take account of applicable legislation and user safety rules.

Table 3 to Table 5 provide a summary of the considerations for specifying CEADS.

9.2 Selection of rated values

Subclause 9.2 of IEC 62271-1:2017 is not applicable to CEADS.

For a given duty in service, the CEADS is selected by considering the individual rated values of its components required by normal load condition and in the case of fault conditions.

It is desirable that the rated values are chosen as suggested in this document regarding the characteristics of the system as well as its anticipated future development. The complete list of ratings is given in Clause 5. Other parameters, such as local atmospheric and climatic conditions and the use at altitudes exceeding 1 000 m, shall also be considered.

NOTE The power transformer rated total losses takes account of any local legislation regarding the amount of losses.

9.3 Cable-interface considerations

Subclause 9.3 of IEC 62271-1:2017 is applicable to CEADS.

9.4 Continuous or temporary overload due to changed service conditions

Subclause 9.4 of IEC 62271-1:2007-2017 is only applicable for high-voltage functional unit.

In case of variable load conditions, IEC 60076-7:2018 for ~~oil-immersed high-voltage/low-voltage~~ mineral oil-immersed power transformer functional unit and IEC 60076-12:2008 for dry-type ~~high-voltage/low-voltage~~ power transformer functional unit are applicable.

Under those changed conditions, possible interactions between functional units ~~may~~ can occur and their temperature rise limits, according to their individual standards, ~~may~~ can be exceeded even due to the interaction between them. Those interactions ~~have to~~ shall be considered when selecting the CEADS.

9.5 Environmental aspects

Subclause 9.5 of IEC 62271-1:2017 is applicable for CEADS.

9.101 Selection of internal arc classification

When selecting a CEADS, the probability of internal faults should be properly addressed, with the aim to provide an acceptable protection level for operators and for the general public.

This protection is achieved by reducing the risk to a tolerable level. According to ISO/IEC Guide 51:2014 [11], risk is the combination of the probability of occurrence of harm and the severity of the harm. (Refer to Clause 4 of ISO/IEC Guide 51:2014 on the concept of safety).

Therefore, the selection of a suitable CEADS, in relation to an internal fault leading to an arc, should be governed by a procedure to achieve a tolerable level of risk. Such a procedure is described in Clause 6 of ISO/IEC Guide 51:2014. This procedure is based on the assumption that the user has a role to play in the reduction of risk.

For guidance, Table 1 gives a list of locations where experience shows that faults are most likely to occur. It also gives possible causes of failure and possible measures to decrease the probability of internal arc faults. Other measures ~~may~~ can be adopted to provide the highest possible level of protection to persons in the case of an internal arc. These measures are aimed to limit the external consequences of such an event. Table 2 gives examples of measures limiting the consequences of internal arc faults.

For both ~~classes~~ types of accessibility, it is important to realise that the test for internal arc classification relates to a given configuration of the CEADS in respect of type and position of the ~~high-voltage/low-voltage~~ power transformer functional unit, high-voltage functional unit and low-voltage functional unit. The outcome of the test is dependent of the specific type of switchgear in the CEADS. The decision of an Internal Arc Classification restricts the free choice of high-voltage functional unit in the CEADS.

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Table 1 – Locations, causes and examples of measures decreasing the probability of internal arc faults

(1)	(2)	(3)
Locations where internal faults are most likely to occur	Possible causes of internal faults	Examples of possible preventive measures
Cable compartments	Inadequate design	Selection of adequate dimensions. Use of appropriate materials.
	Faulty installation	Avoidance of crossed cables connections. Checking of workmanship on site. Correct torque.
	Failure of solid or liquid insulation (defective or missing)	Checking of workmanship and/or dielectric test on site. Regular checking of liquid levels, where applicable.
Disconnectors Switches Earthing switches	Mal-operation	Interlocks. Delayed reopening. Independent manual operation. Making capacity for switches and earthing switches. Instructions to personnel.
Bolted connections and contacts	Corrosion	Use of corrosion inhibiting coating and/or greases. Use of plating. Encapsulation, where possible.
	Faulty assembly	Checking of workmanship by suitable means. Correct torque. Adequate locking means.
Instrument transformers	Ferroresonance	Avoidance of these electrical influences by suitable design of the circuit.
	Short circuit on low-voltage side of voltage transformer	Avoid short circuit by proper means e.g. protection cover, low-voltage fuses.
Circuit breakers	Insufficient maintenance	Regular programmed maintenance. Instructions to personnel.
All locations	Error by personnel	Limitation of access by compartmentalisation. Insulation embedded live parts. Instructions to personnel.
	Ageing under electric stresses	Partial discharge routine tests.
	Pollution, moisture, ingress of dust, vermin, etc.	Measures to ensure that the specified service conditions are achieved (refer to Clause 4). Use of gas-filled compartments.
	Overvoltages	Surge protection. Adequate insulation co-ordination. Dielectric tests on site.
Interconnections	Failure of insulation	Use of adequate clearances, phase-to-phase and phase-to-ground. Use of insulated interconnections, shielded type preferred.

Table 2 – Examples of measures limiting the consequences of internal arc faults

Rapid fault clearance times initiated by detectors sensitive to light, pressure or heat or by differential busbar protection.
Remote control.
Pressure relief devices, pressure resistant enclosure (including current limiting devices, arc eliminating devices, etc.).
Application of power transformer protection with individual circuit-breaker or suitable fuses in combination with switching devices limiting the let-through current and fault duration.
Gas flow control and gas flow cooling devices. (pressure relief ducts or chimneys, etc.).

As a guide for the selection of an adequate CEADS, with respect to internal arc faults, the following criteria ~~may~~ can be used:

- where the risk due to an internal arc fault is considered negligible: a CEADS class IAC-A and/or IAC-B is not necessary;
- where the risk due to an internal arc fault is considered to be relevant: only CEADS class IAC-A and/or IAC-B should be used.

For the second case, the selection should be made by taking into account the foreseeable maximum level of current and duration of the fault, in comparison with the rated values of the tested equipment.

Parts of a CEADS protected by devices that limit the duration of the fault ~~may~~ can be tested with such devices operative and then, after passing the test, IAC rated for the actual duration of the arc. If the remaining parts of the CEADS are rated to the maximum level of current and duration of the fault foreseeable in the network, it is admissible to take advantage of the operation of the protection and use the CEADS in this application by agreement between the user and the manufacturer.

In addition, the installation instructions of the manufacturer should be followed (refer to Clause 11).

~~The location of personnel during an internal arc event is important. The manufacturer should indicate which parts of the CEADS are accessible, according to the testing arrangement and the user should follow the instruction carefully. Allowing personnel to enter an area not designated as accessible may lead to the risk of personnel injury.~~

Internal arc classification gives a tested level of protection of persons under normal operating conditions as defined in 7.102.1. ~~It is not concerned with personnel protection under maintenance conditions with service continuity.~~ The location of personnel during an internal arc event is important. The user should consider with care when allowing personnel to enter an area not designated as accessible by the manufacturer that could lead to the risk of personnel injury.

9.102 Information Summary of technical requirements and ratings for CEADS

Table 3 to Table 5 provide a summary of the considerations for specifying CEADS ratings.

Table 3 – Summary of technical requirements, ratings for CEADS – Service conditions

Information		Clause of this document	Reference to	User requirements as appropriate
Ambient air temperature: Average Minimum Maximum	°C °C °C	4	High-voltage functional unit IEC 62271-1:2007:2017 Low-voltage functional unit IEC 61439-1 Power transformer functional unit IEC 60076-1 or IEC 60076-11 IEC 60721-2-4:1987:2018 high-voltage: IEC 62271-1:2007	
Solar radiation	W/m ²		IEC TS 60815 (all parts)	
Altitude	m		IEC 62271-1:2007:2017	
Pollution	level		IEC 60721-2-2:2012	
Ice coating			IEC 60721-2-2:2012	
Wind-driven sand			IEC 62271-1:2007	
Wind-driven snow			IEC 60721-2-2:2012	
Wind	m/s		IEC 60721-2-2:2012	
Condensation or precipitation				
Vibration			IEC 60721-1:1990, IEC 60721-1:1990/AMD:1:1992 and IEC 60721-1:1990/AMD2:1995	
Risk of earth tremors				
Risk of other vibrations				
Induced electromagnetic disturbance in secondary system	Class		IEC 62271-1:2007:2017	
^a For high-voltage functional unit in a CEADS installed in places where earthquakes are likely to occur, the severity level according with IEC 62271-210:2013 should be specified by the user.				

Table 4 – Summary of technical requirements, ratings for CEADS – Ratings of the CEADS

Information		Subclause of this document	Reference to	User to indicate requirement as appropriate
Rated voltages high-voltage low-voltage	kV V	5.2	High-voltage: functional unit IEC 62271 1:2017 Low-voltage functional unit IEC 61439-1 Power transformer functional unit IEC 60076-1:2011	
Nominal voltages high-voltage low-voltage	kV V	10.2		
Number of phases		10.2		
Type of high-voltage neutral earthing Maximum expected value of earth fault current	kA	10.2	User	
Type of low-voltage neutral earthing Maximum expected value of earth fault current	kA	10.2	User	

Information		Subclause of this document	Reference to	User to indicate requirement as appropriate
Rated power and total losses of CEADS	kVA kW	5.101	IEC 60076-1:2011	
Sound level	dB	Annex B	IEC 60076-10:2016	
Internal arc classification	IAC	5.102		Y/N
Classified sides	F/L/R			
Accessibility type A				
Fault current and duration	kA, s			
Accessibility type B				
Fault current and duration	kA, s			
Rated insulation levels		5.3	IEC 60076-3:2013	
Common value	kV or V			
Rated short-duration power-frequency withstand voltage	kV or V			
Rated lightning impulse withstand voltage	kV or V			
Across isolating distance				
high-voltage:	kV or V		IEC 62271-1:20072017	
low-voltage:	kV or V		IEC 61439-1:20112020	
			IEC 60947-1:20072020	
Rated short-duration power-frequency withstand voltage	kV or V			
Rated lightning impulse withstand voltage	kV or V			
Rated frequency	Hz	5.4		
Rated ~~normal~~ continuous current for main circuits		5.5		
high-voltage:	A		IEC 62271-1:20072017	
low-voltage:	A		IEC 61439-1:20112020	
Rated short-time withstand currents		5.6		
high-voltage:	kA		IEC 62271-1:20072017	
low-voltage:	kA		IEC 61439-1:20112020	
Earthing circuit:	kA		IEC 62271-1:20072017	
Rated peak withstand currents		5.7		
high-voltage:	kA		IEC 62271-1:20072017	
low-voltage:	kA		IEC 61439-1:20112020	
Earthing circuit:	kA		IEC 62271-1:20072017	
Rated durations of short-circuit		5.8		
high-voltage:	s		IEC 62271-1:20072017	
low-voltage:	s		IEC 61439-1:20112020	
Power transformer:	s		IEC 60076-5:2006 IEC 60076-11:20042018	
Earthing circuit:	s		IEC 62271-1:20072017	

Information		Subclause of this document	Reference to	User to indicate requirement as appropriate
Rated supply voltage of closing and opening devices and of auxiliary and control circuits	high-voltage	5.9	IEC 62271-1:20072017 IEC 61439-1:20112020	
Closing and tripping:	low-voltage			
Indication:	V			
Control:	V			
Rated supply frequency of closing and opening devices and of auxiliary and control circuits		5.10	IEC 62271-1:20072017 IEC 61439-1:20112020	
high-voltage:	Hz		IEC 62271-1:20072017	
low-voltage:	Hz		IEC 61439-1:20112020	
High-voltage/low-voltage transformer functional unit temperature rises	K	4.4.2	IEC 60076-2:2011 IEC 60076-11:2004	

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**Table 5 – Summary of technical requirements, ratings for CEADS –
Design and construction of the CEADS**

CEADS		(Sub)clause of this document	Reference to	User to indicate requirement as appropriate
~~Degree of protection of the high-voltage/low-voltage transformer functional unit for indoor application~~ ~~Degree of protection of the high-voltage/low-voltage transformer functional unit for outdoor application~~ ~~Degree of protection of the dry-type high-voltage/low-voltage transformer functional unit~~ Degree of protection of the CEADS for indoor application Degree of protection of the power transformer functional unit for indoor application (if different) Degree of protection of the low-voltage functional unit (if different) Degree of protection of the high-voltage functional unit (if different) Degree of protection of the CEADS for outdoor application Degree of protection of exposed conductors and/or bushings		6.14	IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013	
Type of CEADS Type of components: high-voltage switchgear and controlgear low-voltage switchgear and controlgear Power transformer	G/A/I	6.1	User	
Rated power and total losses of CEADS Power Load loss P_{cu} No-load loss P_0 ~~No-load current I_0~~ Short-circuit impedance Temperature rise ~~Insulation~~	kVA W W A % K	5.101	IEC 60076-1:2011 IEC 60076-11:2004:2018 IEC 60076-2:2011 ~~IEC 60076-3:2013~~	
Materials of the enclosures		6.104	IEC 60076 (all parts) IEC 62271-200:2011:2021 IEC 62271-201:2014	
Surface treatment of the enclosures		10.2		
Mechanical impact energy	J	6.101	~~IEC 62271-1:2007~~	
Mechanical stresses by snow load of the roof roof loads wind pressure	N/m ² N/m ² N/m ²	6.101 10.2	~~IEC 62271-202:2014~~	

CEADS		(Sub)clause of this document	Reference to	User to indicate requirement as appropriate
Dimensions and weights		10.3		
Length	mm			
Width	mm			
Height	mm			
Mass of each transport unit	kg			
Total mass of the CEADS	kg			

10 Information to be given with enquiries, tenders and orders (informative)

10.1 General

Clause 10 of IEC 62271-1:2007/2017 is not applicable.

This clause lists the information, which is necessary to enable the user to make an appropriate enquiry for a CEADS and the supplier to give an adequate tender.

10.2 Information with enquiries and orders

When enquiring about or ordering a CEADS, the scope of supply should be defined for all equipment and services. This ~~may~~ can include training, technical and layout studies and requirements for co-operation with the supplier. The following information should be supplied by the enquirer:

a) Particulars of the system:

Nominal and highest voltages, frequency, types of system neutral earthing.

b) Service conditions:

Minimum and maximum ambient air temperature; any condition deviating from the normal service conditions or affecting the satisfactory operation of the equipment, as, for example, altitudes higher than 1 000 m, rapidly changing temperatures, wind-driven sand, rain and snow, the unusual exposure to vapour, moisture, fumes, explosive gases, excessive dust or salt (e.g. caused by traffic or industrial pollution), the risk of earth tremors or other vibrations due to external causes to the equipment to be delivered.

c) Particulars and electrical characteristics of the CEADS:

- 1) rated voltages;
- 2) rated power of the CEADS;
- 3) rated frequency;
- 4) rated insulation levels;
- 5) rated short-time withstand currents;
- 6) rated duration of short-circuit (if different from 1 s);
- 7) rated peak withstand currents;
- 8) rated values of functional units (high-voltage functional unit, low-voltage functional unit, ~~high-voltage/low-voltage~~ power transformer functional unit and interconnections);
- 9) number of phases;
- 10) type of functional units (e.g. air or gas-insulated ~~cubicle~~ type switchgear and controlgear, liquid-immersed power transformer);
- 11) circuit diagrams;
- 12) degree of protection of the enclosures and partitions if any;

- 13) material and surface treatment of the enclosures;
- 14) mechanical stresses (e.g. snow loads, roof loads, wind pressure, etc.);
- 15) maximum admissible dimensions and special requirements affecting the layout of the CEADS (general arrangement);
- 16) the maximum expected value of earth-fault currents dependent upon the type of high-voltage and low-voltage systems neutral earthing employed or the short-circuit current ratings applicable to the earthing circuit(s);
- 17) internal arc classification (if any), including value of the test current and duration.

Beyond these items the enquirer should indicate every condition which might influence the tender or the order, as, for example, special mounting or erection conditions (e.g. vicinity of surrounding walls, elements that can affect ventilation, etc.), the location of the external high-voltage connections, local fire and sound regulations, and expected lifespan. Information should be supplied if special type tests are required. Special conditions in case of installation within a factory (e.g. installation in areas accessible to employees, the existence of areas not protected in case of internal arc above or below the installation place of the CEADS where employees can stay or walk, etc.).

10.3 Information with tenders

The following information should be given by the manufacturer with descriptive matters and drawings:

- a) rated values and characteristics as enumerated in items b) and c) of 10.2;
- b) list of type test, and the corresponding certificates or reports on request, including the justification of the selection of internal arc tests for IAC-A and/or IAC-B, where applicable;
- c) constructional features, for example:
 - 1) mass of each transport unit;
 - 2) total mass of the CEADS;
 - 3) overall dimensions and the layout (general arrangement) of the CEADS;
 - 4) information of the arrangement of the external connections;
 - 5) transport and installation requirements;
 - 6) information on operation and maintenance;
 - 7) information required by the relevant standard of the components;
 - 8) minimum recommended clearances around the CEADS;
 - 9) volume of the fluid retention tank (if any);
 - 10) accessible sides and particular installation instructions to prevent access to the ~~high-voltage/low-voltage~~ power transformer functional unit in case of a CEADS accessible to the general public (special case of installation inside a factory);
 - 11) type of gas-pressure or liquid-pressure system;
 - 12) specified filling level and minimum functional level.
- d) list of recommended spare parts that should be procured by the user on request;
- e) relevant characteristics of the functional units of the CEADS, and if applicable, the surface treatment or coating of the enclosures and the tests carried out to assess their performance under specified environmental conditions;
- f) statement declaring that the CEADS complies with this document.

11 ~~Rules for Transport, storage, installation, operation~~ operating instructions and maintenance

11.1 General

Clause 11 of IEC 62271-1:2007/2017 is ~~not~~ applicable with following additions for CEADS.

It is essential that the transport, storage and erection of a CEADS or its transport units, as well as their operation and maintenance in service, are performed in accordance with instructions given by the manufacturer.

Consequently, the manufacturer should provide instructions for the transport, storage, erection, operation and maintenance of a CEADS. The instructions for the transport and storage should be given at a convenient time before delivery, and the instructions for the erection, operation and maintenance should be given by the time of delivery at the latest.

Relevant standards for the different components define particular rules for their transport, erection, operation and maintenance, and these should be included in the general instructions for the CEADS, where applicable.

The following information is given to supplement these instructions with the most important additional instructions to be provided by the manufacturer of CEADS.

11.2 Conditions during transport, storage and installation

Installation instructions shall provide information or specifications about methods for transportation and requirements for prolonged storage before the first energisation, if needed.

A special agreement should be made between manufacturer and user if the service conditions specified in the order cannot be guaranteed during transport, storage and erection. In particular, instructions should be given to protect insulation against undue moisture absorption or irreversible pollution, if the environmental conditions prior to energizing are such that the enclosures cannot provide appropriate protection.

It might also be necessary to give guidance and/or provide special elements to secure components to avoid any damage due to foreseen vibration or shocks during transport.

11.3 Installation

11.3.1 General

For each type of CEADS, the instructions provided by the manufacturer should at least include the following points.

11.3.2 Unpacking and lifting

The mass of each transport unit, including details of any special lifting devices required for safe lifting and unpacking should be labelled on the equipment.

Instructions shall state clearly the preferred method of safely lifting the CEADS and the need to remove the brackets if they are not suitable for continuous outdoor use.

11.3.3 Assembly

In principle the CEADS are transported as a unit fully assembled. Therefore, there is no need to assemble at the installation on site. However, if by agreement between manufacturer and user the CEADS is not fully assembled for transport, all transport units should be clearly marked and drawings showing assembly of these units should be provided.

11.3.4 Mounting

The manufacturer should provide all necessary information to enable site preparation to be completed, as for example:

- required civil work;
- external earthing terminals;
- position of the cable access points;
- minimum recommended clearances around the CEADS.

NOTE CEADS can be used for power supply inside factories. In such plants it is likely to occur that employees not involved in operation of CEADS (general public) come in close vicinity, next to, above or below the CEADS, e.g. the CEADS is installed below a grid made steel staircase. In such cases access from top or below the CEADS is considered.

When CEADS is installed into a prefabricated substation, the expected increase of temperature into the enclosure or any of the compartments and its influence on equipment shall be considered. Specifically, this condition can affect the performance of temperature-sensitive components such as electronic and smart grid devices. Therefore, the internal air temperature in the compartment containing the CEADS should be taken into account, because increased temperatures, although occurring infrequently, can lead to premature aging and even a failure.

11.3.5 Connections

Subclause 11.3.5 of IEC 62271-1:2017 is applicable to CEADS.

11.3.6 Information about gas and gas mixtures for controlled and closed pressure systems

Subclause 11.3.6 of IEC 62271-1:2017 is applicable to CEADS.

11.3.7 Final installation inspection

Subclause 11.3.7 of IEC 62271-1:2017 is applicable to CEADS with the following addition.

In principle, the manufacturer should provide instructions for inspection and test of the CEADS after its installation and connection, which should include at least a list of recommended tests, made at site.

11.3.8 Basic input data by the user

Subclause 11.3.8 of IEC 62271-1:2017 is applicable to CEADS.

11.3.9 Basic input data by the manufacturer

Subclause 11.3.9 of IEC 62271-1:2017 is applicable to CEADS.

11.4 ~~Operation~~ Operating instructions

Subclause 11.4 of IEC 62271-1:2017 is applicable with the following addition.

A full installation and operating manual shall be provided for each component:

- high-voltage functional unit;
- low-voltage functional unit;
- power transformer;
- cable and cable terminations;
- RTU (Scada).

The operating manual shall describe normal and service conditions requirements to enable the unit to operate satisfactorily. The operating manual shall also include requirements to put into service the CEADS for the first time and testing required at site, if any.

Besides the particular operating instructions of each component, the manufacturer should provide the following additional information, so that the user can acquire an adequate understanding of the main principles involved:

- a description of the safety features of the CEADS, and a list of any special means or tools supplied for safety purposes and their instructions for use;
- the operation of interlocks and padlocking facilities;
- when fluids are used in CEADS, as far as practicable, instruction should be provided in order to allow the user to:
 - minimise the leakage rate;
 - control the handling of the new and used fluids.

11.5 Maintenance

Subclause 11.5 of IEC 62271-1:2017 is applicable with the following addition.

The manufacturer shall issue a maintenance manual, including at least the following information:

- complete maintenance instructions for main components, as required in relevant standards including frequency and procedure;
- instructions for adding gas or fluid to the equipment or getting samples for maintenance checks, and whether the unit should be de-energized for these operations;
- maintenance instructions, if any, for the enclosures; including frequency and procedure ~~for maintenance~~.

Instructions manual shall advice whether the unit shall be de-energized or any additional safety measure required during maintenance operations.

11.101 Dismantling, recycling and disposal at the end of service life

The manufacturer shall provide relevant information to allow the end user to carry out dismantling, recycling and disposal of the CEADS at the end of life. This information shall include instructions for disposal of the fluid at the end of life. This information shall take into account the protection of both the workers and the environment.

12 Safety

12.1 General

Clause 12 of IEC 62271-1:2007/2017 is applicable ~~for high-voltage functional unit~~ with the following additions for the complete CEADS.

A CEADS provides the specified level of protection to operators and general public only when installed and operated in accordance with the manufacturer's instructions and complying with the user's internal regulations. Additionally, the user ~~may~~ can set up specific procedures for installation and operation, as well as a list of any special tools required for normal operation and for maintenance requirements.

Safety aspects of functional units are covered by the relevant product standards.

When fluids are used in CEADS, instructions should be provided in order to allow the user to:

- provide the correct response if gas alarm is received;
- take measures to contain fluid in case of leakage;
- control the handling of the new and used fluids.

The following subclauses of this document describe additional features providing protection to operators and general public against various hazards:

12.101 Electrical aspects

- Earthing (indirect contact) (see 6.3).
- Degree of protection (direct contact) (see 6.14 and 7.7).

12.102 Mechanical aspects

- Degree of protection (see 6.14 and 7.7).
- Mechanical stresses (see 6.101 and 7.7).

12.103 Thermal aspects

- Maximum temperature of accessible parts (see 7.101.5.6).

12.104 Internal arc aspects

- Internal arc fault (see 6.103).

13 Influence of the product on the environment

Clause 13 of IEC 62271-1:2007/2017 is applicable with the following addition:

The following subclauses of this document contain provisions to protect the environment from potential negative influence of the CEADS:

- ~~operation~~ operating instructions (see 11.4);
- maintenance (see 11.5);
- dismantling, recycling and disposal at the end of service life (see 11.101).

Annex A (normative)

Method for testing CEADS under conditions of arcing due to an internal arc fault

A.1 General

This annex applies to CEADS of Class IAC.

For the purpose of this annex, normal operating conditions means the conditions of a CEADS required to carry out operations such as opening or closing high-voltage or low-voltage switching devices, reading of measuring instruments and monitoring equipment, etc. Therefore, if to perform any of such operations any cover has to be removed and/or any door has to be opened, the internal arc test shall be performed with the cover removed and/or door open. Change or replacement of high-voltage ~~HRC~~ fuses is not considered as a normal operation.

A.2 Room simulation

Internal arc tests aimed to verify the protection to operators should be carried out in a room simulating the electrical operating area provided that the conditions are not less onerous with respect to the direction of gas flow, strength of the enclosure and pressure release device(s). All other components or a valid mock-up of them ~~may~~ can be used, provided that they are installed as in service.

- a) CEADS designed for indoor installation. The test ~~will~~ shall be carried out in a simulated room following the principles described in A.1.1 of IEC 62271-200:2011 ~~2021~~ for metal-enclosed switchgear and controlgear or AA.1 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.
- b) CEADS designed for outdoor installation or an open area limited by fences into an industrial facility. In that case no room simulation around the CEADS is required for internal arc tests aimed to verify the degree of protection provided outside the equipment. However, where the ground around the CEADS is suspected to contribute to the performance of the CEADS, simulation of the ground surface might be required.

In all cases, if the manufacturer claims that the design of the CEADS requires that the cable access way and/or any other additional exhausting duct ~~need to~~ shall be used to evacuate gases generated during the internal arc, the installation conditions specified by the manufacturer shall be reproduced, and in particular all the means, if any, to direct and cool down the hot gases exhausted from the high-voltage functional unit.

This requirement shall be clearly stated, in particular in the instruction manual (see Clause 11), for IAC classification to be valid.

A.3 Indicators (for assessing the thermal effects of the gases)

A.3.1 General

Indicators are pieces of black cotton cloth and shall be so arranged that their cut edges do not point toward the test object.

Black cretonne (cotton fabric approximately 150 g/m²) shall be used for indicators for accessibility type A. Black cotton-interlining lawn (approximately 40 g/m²) shall be used for indicators for accessibility type B.

Care shall be taken to ensure that the vertical indicators cannot ignite each other. This is achieved by fitting them in a frame of sheet steel, with a depth of $2 \times 30 \text{ mm}$ ($^{+0}_{-3} \text{ mm}$), refer to Figure A.1.

With the horizontal indicators, care shall be taken that glowing particles do not accumulate. This is achieved if the indicators are mounted without a frame, refer to Figure A.2.

The indicator dimensions shall be $150 \text{ mm} \times 150 \text{ mm}$ ($^{+15}_{-0} \text{ mm}$).

A.3.2 Arrangement of indicators

Indicators shall be fitted ~~vertically~~ at each classified side of the CEADS, facing all points where gas is likely to be emitted (e.g. joints, inspection windows, doors) up to 2 m above the ground level in a checkerboard pattern covering 40 % to 50 % of the area.

The length of the mounting rack shall be larger than the corresponding area to be ~~tested~~ ~~assessed~~ to take into account the possibility of hot gases escaping at angles of up to 45° , from the surface under test. This means that the mounting frame shall be 100 mm longer in both sides than the test object under test in case of accessibility Type B, or 300 mm in both sides in case of accessibility Type A, provided that the test arrangement does not limit this extension.

NOTE 1 In all cases the distance from the indicators fitted vertically to the test object is measured from a virtual surface that envelopes the test object, disregarding protruding elements (e.g. handles, frame of apparatus and so on). Taking into account that this virtual surface ~~will~~ can be likely not regular, the indicators are placed to simulate as realistically as possible the position that an operator or person usually can adopt in front of the equipment, at indicated distance, according to type of accessibility.

a) Test to prove the level of protection to operators. Accessibility type A (restricted accessibility)

When performing the internal arc test within the high-voltage functional unit (see Figure A.3), arrangement of indicators shall follow the requirements of Annex A of IEC 62271-200:2014-2021 for metal-enclosed switchgear and controlgear or Annex AA of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear for accessibility type A, limited to the high-voltage operating side(s) declared accessible by the CEADS manufacturer.

When performing the internal arc test on high-voltage interconnection (see Figure A.3) the indicators shall be located ~~at any accessible side~~, at 300 mm from ~~the closest position the operator can reach in normal operating conditions~~ every high-voltage operating side(s) declared accessible by the CEADS manufacturer.

NOTE 2 Normally some kind of barrier or obstacle ~~should provide~~ provides an “out of reach” condition with respect to an open-air conductor or connector.

Indicators shall also be arranged horizontally at a height of 2 m above the ground level as described in Figure A.3 and covering the whole area between 300 mm and 800 mm from the CEADS. The indicators shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area.

Where the design of the CEADS includes a space below the floor to receive the exhausting gases, the behaviour of the floor shall be assessed from the point of view of the safety of the operator standing on it. Two situations are considered:

- if the design and construction of the floor makes possible the displacement of pieces of it or allows exhausting gases to escape through gaps or joints, another horizontal rack with indicators ~~will~~ shall be placed at a distance of 100 mm ~~from~~ above the floor. These indicators shall cover either the total length between 300 mm and 800 mm from the high-voltage functional unit or the total length of the pressure relief volume from the high-voltage functional unit plus 100 mm, whatever is the largest (see Figure A.5);
- in other cases this horizontal rack is not necessary.

- b) Test to prove level of protection to general public. Accessibility type B (unrestricted accessibility)

Indicators shall be fitted vertically at all ~~accessible~~ sides of the CEADS up to 2 m above the ground level. If the actual height of CEADS is lower than 1,9 m, vertical indicators shall be fitted up to a height 100 mm higher than the test object (see Figure A.4).

The indicators shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area.

The distance from the indicators to the CEADS shall be 100 mm ± 5 mm.

If the CEADS is higher than ~~2 m~~ 1,9 m, indicators shall also be arranged horizontally at a height above the ground level as described in Figure A.4, and covering the whole area between 100 mm and 800 mm from CEADS.

If the CEADS is lower than ~~2 m~~ 1,9 m, horizontal indicators shall be placed instead, in a checkerboard pattern, ~~above the equipment, if accessible,~~ at a distance of 100 mm ± 5 mm above the equipment.

For CEADS lower than 800 mm, the ~~entire~~ arrangement of indicators in a checkerboard pattern is not applicable as 100 % of the upper surface shall be covered.

Where the design of the CEADS includes a space below the floor to receive the exhausting gases, the behaviour of the floor shall be assessed from the point of view of the safety of the general public standing on it. Two situations are considered:

- if the design and construction of the floor makes possible the displacement of pieces of it or allows exhausting gases to escape through gaps or joints another horizontal rack with indicators ~~will~~ shall be placed at a distance of 100 mm ~~from~~ above the floor. These indicators shall cover either the total length between 100 mm and 800 mm from the high-voltage functional unit or the total length of the pressure relief volume from the high-voltage functional unit plus 100 mm, whatever is the largest (see Figure A.6);
- in other cases this horizontal rack is not necessary.

A.4 Tolerances for geometrical dimensions of test arrangements

Summary of tolerances for geometrical dimensions of test arrangements as given in the document (the values given there in brackets are tolerances only for the actual test arrangement and do not extend the required values):

- indicator dimensions: 0/+15 mm;
- depth of the steel frame for indicators: -3/0 mm;
- height of indicators ± 50 mm;
- distance between test object and indicators;
 - accessibility type A ± 30 mm;
 - accessibility type B ± 5 mm.

A.5 Test parameters

Clause A.4 of IEC 62271-200:2011/2021 for metal-enclosed switchgear and controlgear or Clause AA.4 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable.

A.6 Test procedure

The test procedures and the number of tests on high-voltage functional unit are dependent on whether the switchgear and controlgear has an IAC classification according to IEC 62271-200:2011/2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear or not. ~~Figures AA.4 and AA.5 provide selection criteria for high voltage compartment to be tested.~~ Figure A.7 and

Figure A.8 provide selection criteria for high-voltage compartment(s) of the high-voltage switchgear and controlgear to be tested.

The internal arc tests covering the case of a fault inside the high-voltage functional unit shall be performed according to Clause A.5 of IEC 62271-200:2011 for metal-enclosed switchgear class IAC or Clause AA.5 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear class IAC, including the point of initiation of the arc.

The test procedures and the number of tests on the high-voltage interconnection depend on the type of power transformer protection ~~in the switchgear~~ and type of interconnection. ~~Figures AA.6 and AA.7~~ Figure A.9 and Figure A.10 provide selection criteria for high-voltage interconnection to be tested.

The tests covering the case of a fault in the high-voltage interconnection shall be performed following, as applicable, the provisions of Annex A of IEC 62271-200:2011 for metal-enclosed switchgear and controlgear or Annex AA of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.

For each accessibility type of a CEADS, at least one internal arc test is mandatory on the high-voltage functional unit (see Figure A.7 and Figure A.8). The point of initiation of the arc shall be in the high-voltage compartment of the high-voltage functional unit having the highest arc energy determined during internal arc tests carried out in accordance with IEC 62271-200:2011 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear. However, if this data is not available, it is acceptable to select the high-voltage compartment with the largest clearance between the points where the arc was initiated. The number of arced phases, arc current and duration shall be the same for all the assessed compartments. In addition, if the high-voltage functional unit has more than one gas flow directions, a representative test shall be performed for each high-voltage compartment having a different gas flow direction (see Figure A.7 and Figure A.8). When more than one high-voltage compartments are the same in all the above-mentioned aspects, only one of these compartments shall be tested.

The tests covering the case of a fault in the high-voltage interconnection shall be performed following, as applicable, the provisions of Annex A of IEC 62271-200:2011 with the following additions to A.5.2 of IEC 62271-200:2011:

- The point of initiation shall be located at the furthest accessible point from the supply. The feeding direction shall be in accordance with the normal expected flow of the energy in service.

~~For each accessibility type of a CEADS the three-phase arc initiation within the switching compartment of the high voltage functional unit is mandatory (see Figures AA.7 and AA.8). Additionally, upon agreement between manufacturer and user the arc initiation within other compartments of the high voltage functional unit may be carried out.~~

- Internal arc testing on high-voltage insulated ~~ground~~ and earth-shielded ~~type tested~~ interconnections equipped with insulated earth shielded connections according to IEC 60050-461:2008, 461-10-15 is not mandatory (see ~~Figures AA.6 and AA.7~~ Figure A.9 and Figure A.10). However, a non mandatory test can be agreed between manufacturer and user. In that case A.5.2 of IEC 62271-200:2011 is applicable.
- Internal arc testing ~~need to~~ shall be performed on high-voltage solid insulated interconnections equipped with insulated connections according to IEC 60050-461:2008, 461-10-16 or IEC 60050-461:2008, 461-10-21. In that case A.5.2.3.1 of IEC 62271-200:2011 is applicable.

In case of equipment without high-voltage functional unit and having incoming cables directly connected to the bushings of the ~~high-voltage/low-voltage~~ power transformer functional unit, testing shall be carried out as follows:

- a three-phase test in case of connections uninsulated or fitted with site-made solid insulation;
- a single or two-phase test in the case of plug in insulated connections. For phase-to-ground test the current value to be stated by the manufacturer. For two-phase test current ~~will~~ shall be 87 % of the rated short time withstand current.

In case that fuse-base devices are used as the only high-voltage functional unit, a three-phase test shall be performed at the feeding side of the fuse-bases.

The test procedures and the number of tests on the interconnections depend on the type of power transformer protection in the switchgear and type of interconnections. Figure A.9 and Figure A.10 show the principles for selection of tests to be performed.

A.7 Designation of the internal arc classification

In case that class IAC-A, IAC-B or IAC-AB is proven by the tests, according to 7.102, the CEADS ~~will~~ shall be designated as follows:

- general: class IAC (initials of internal arc classified at the high-voltage side);
- class A if protection to operator is proven;
- class B if protection to general public is proven;
- class AB if protection of both operators and general public is proven;
- F, L, R: accessible sides;
- test ratings: RMS value of the test current in kA, and duration in second(s).

EXAMPLE 1

A CEADS tested for a fault current (RMS) of 16 kA for 0,5 s tested for protection to operators (5.102) declared accessible at ~~all~~ front and lateral operating sides.

Designation: Class IAC-~~AFLR~~AFL – 16 kA – 0,5 s.

EXAMPLE 2

A CEADS tested for a fault current (RMS) of 12,5 kA for 1 s ~~tested for protection to general public (4.102), accessible only at front side~~ providing protection to the general public in the vicinity of the equipment on all its sides at any time (5.102).

Designation: Class IAC-~~BFB~~B – 12,5 kA – 1 s.

Dimensions in millimetres

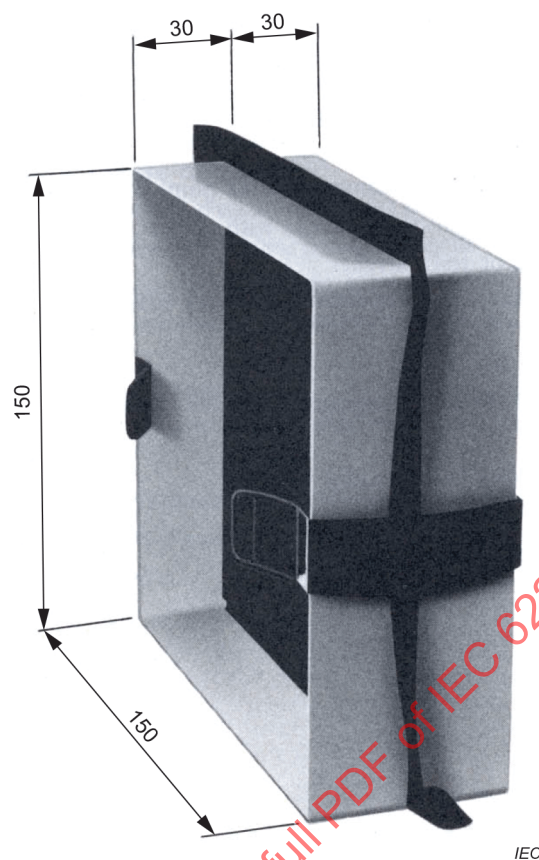


Figure A.1 – Mounting frame for vertical indicators

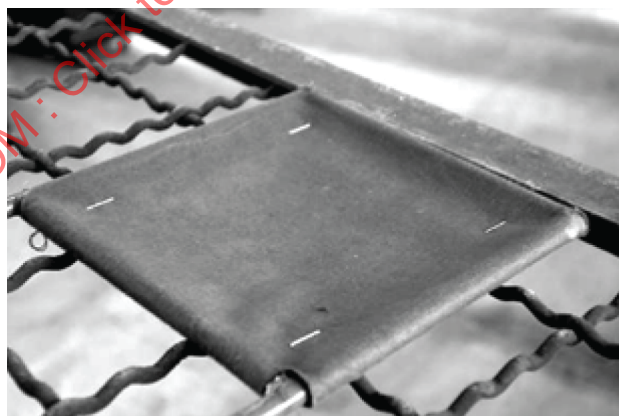
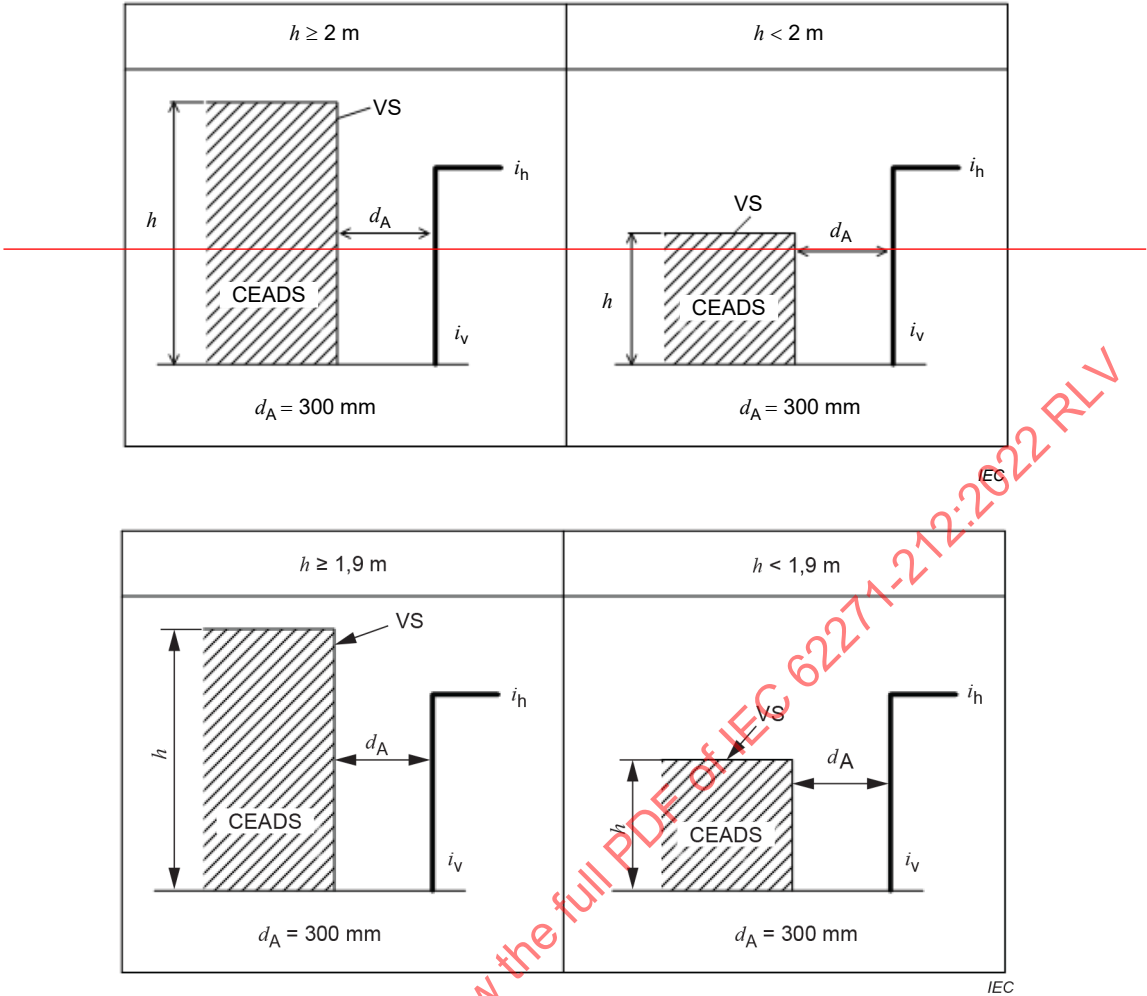
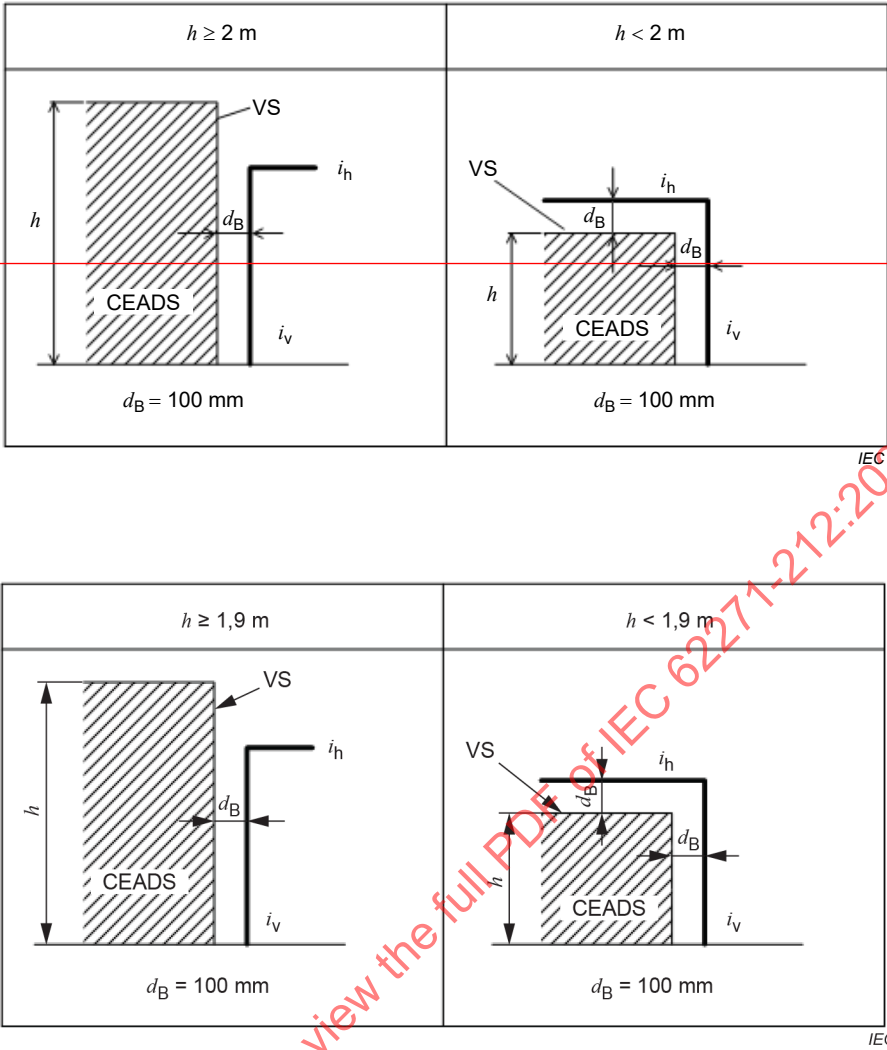


Figure A.2 – Horizontal indicators



- Key**
- i_h position of horizontal indicators
 - i_v position of vertical indicators
 - h height of the CEADS
 - d_A horizontal distance of indicators to the CEADS (classified side(s))
 - VS virtual surface that envelopes the CEADS

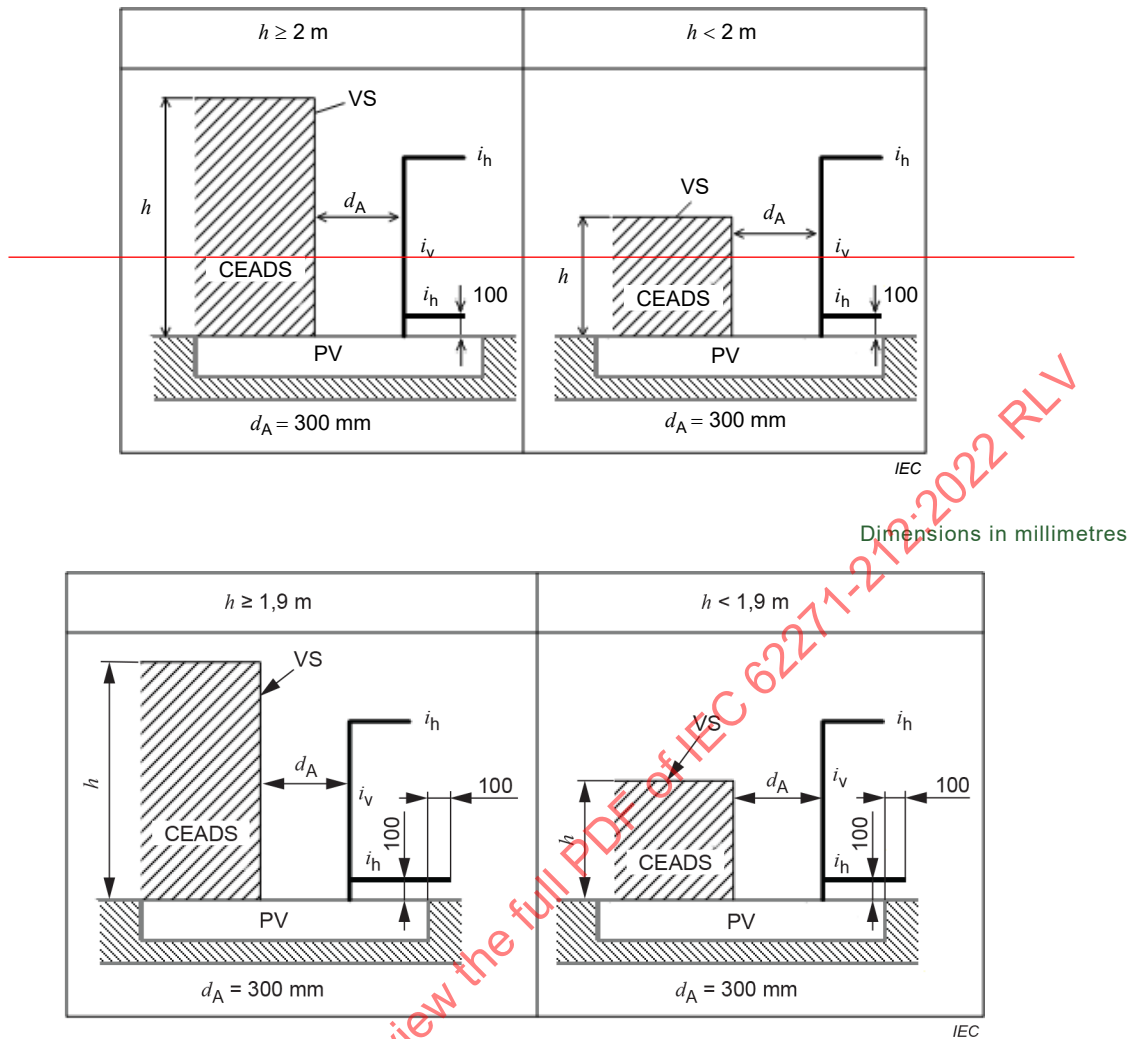
Figure A.3 – Protection of operators in front of classified side(s) of CEADS



Key

- i_h position of horizontal indicators
- i_v position of vertical indicators
- h height of the CEADS
- d_B horizontal distance of indicators to CEADS
- VS virtual surface that envelopes the CEADS

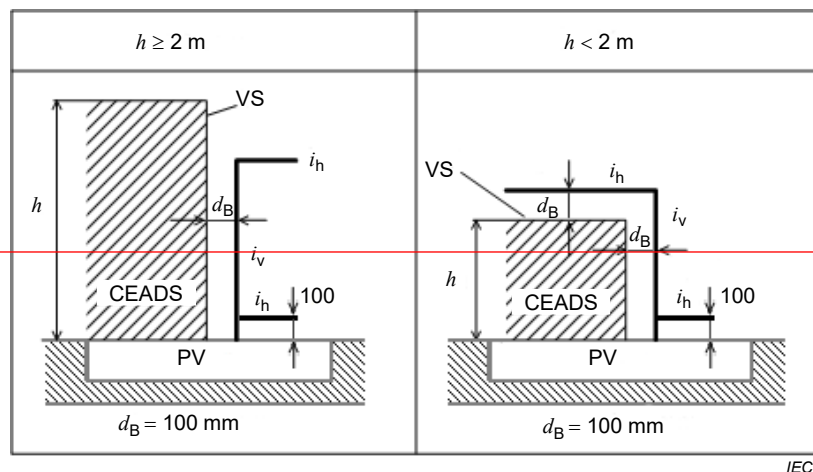
Figure A.4 – Protection of general public around the CEADS



Key

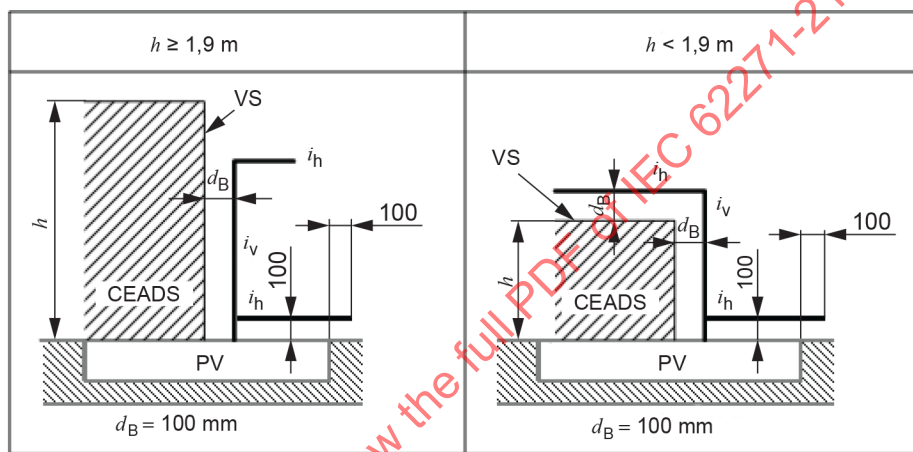
- i_h position of horizontal indicators
- i_v position of vertical indicators
- h height of the CEADS
- d_A horizontal distance of indicators to the CEADS (classified side(s))
- PV pressure relief volume to exhaust gases
- VS virtual surface that envelops the CEADS

Figure A.5 – Protection of operators in front of classified side(s) of CEADS having a pressure relief volume below the floor



IEC

Dimensions in millimetres

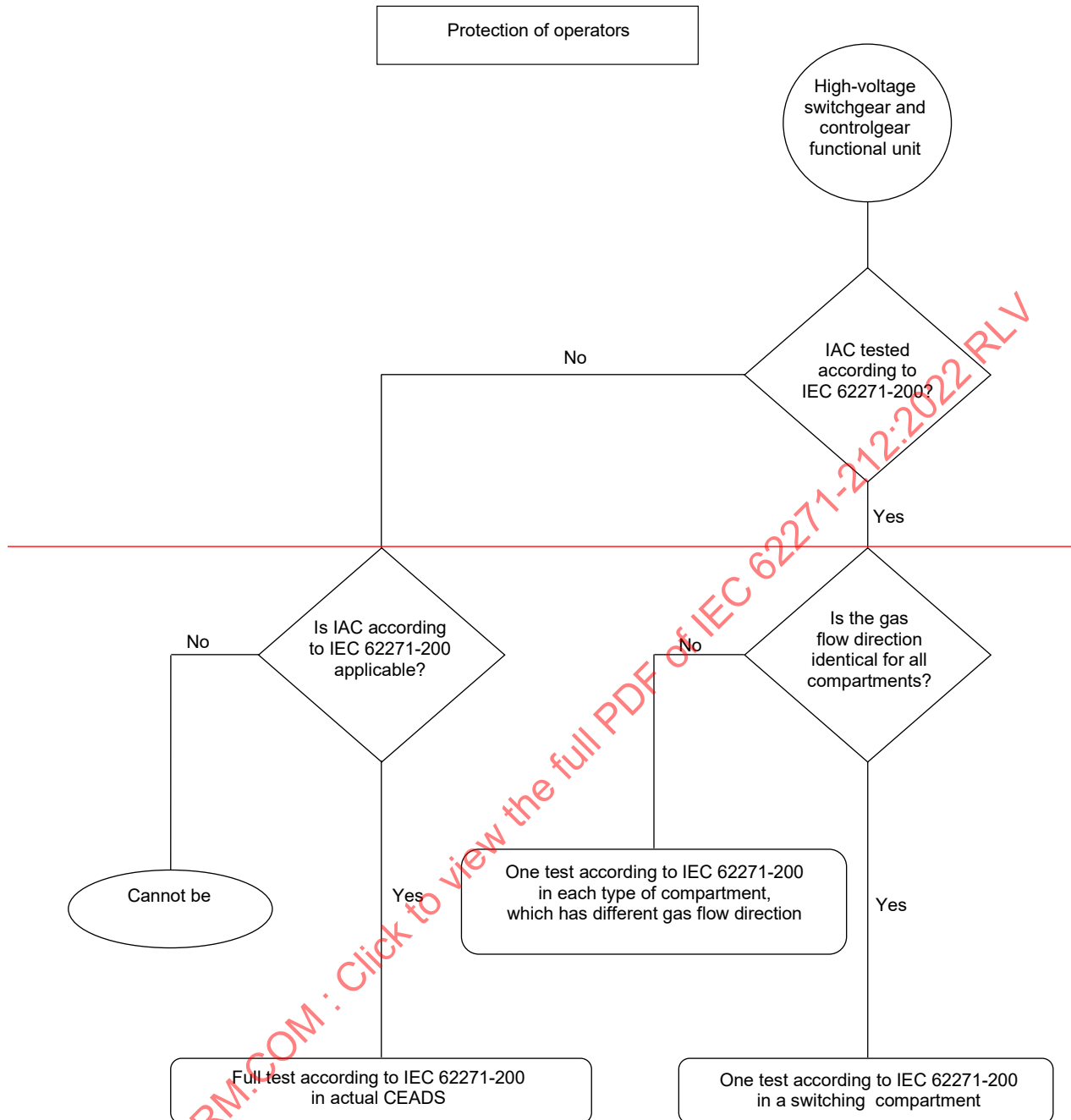


IEC

Key

- i_h position of horizontal indicators
- i_v position of vertical indicators
- h height of the CEADS
- d_B horizontal distance of indicators to CEADS
- VS virtual surface that envelopes the CEADS
- PV pressure relief volume to exhaust gases

Figure A.6 – Protection of the general public around the CEADS having a pressure relief volume below the floor



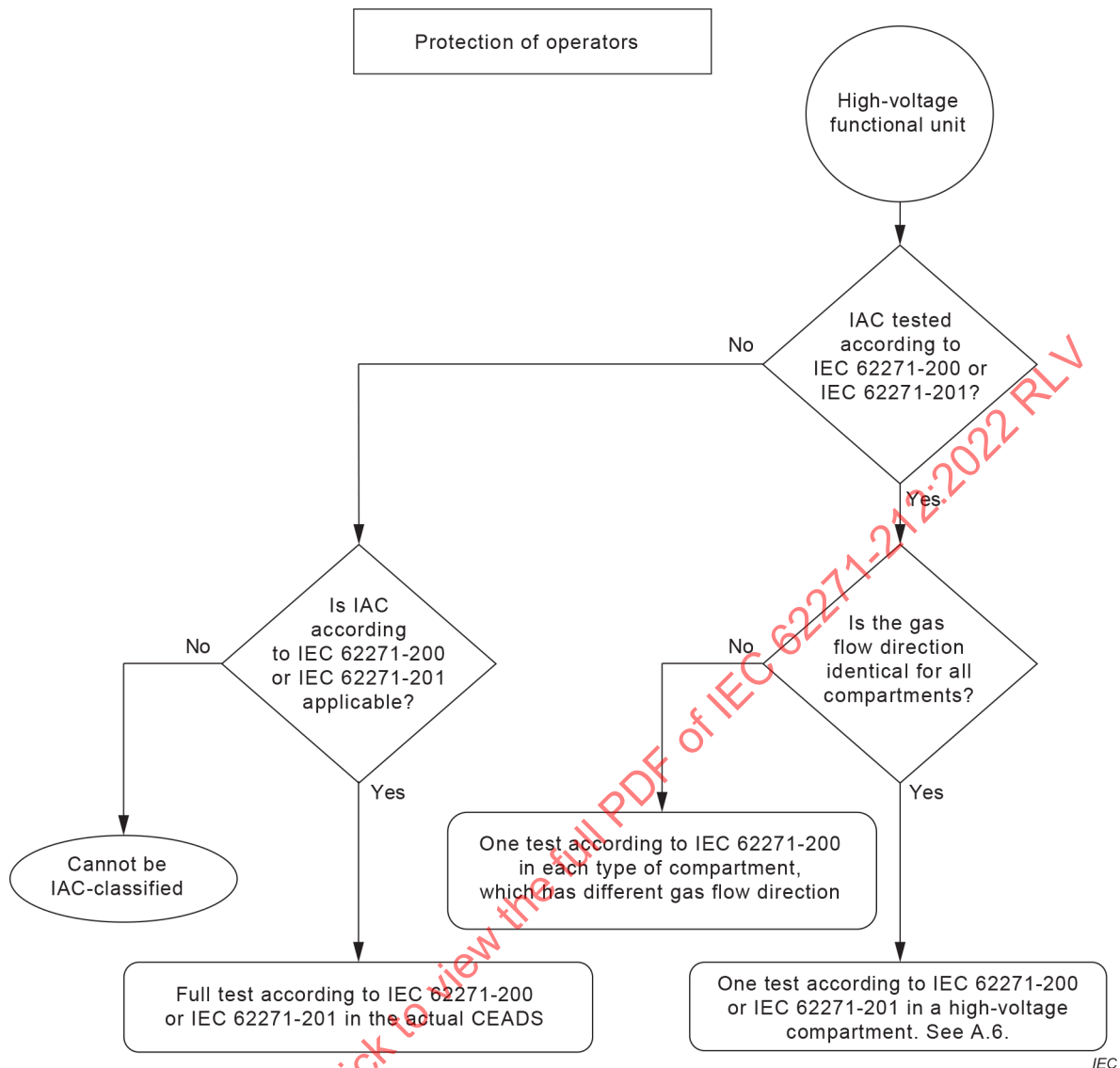
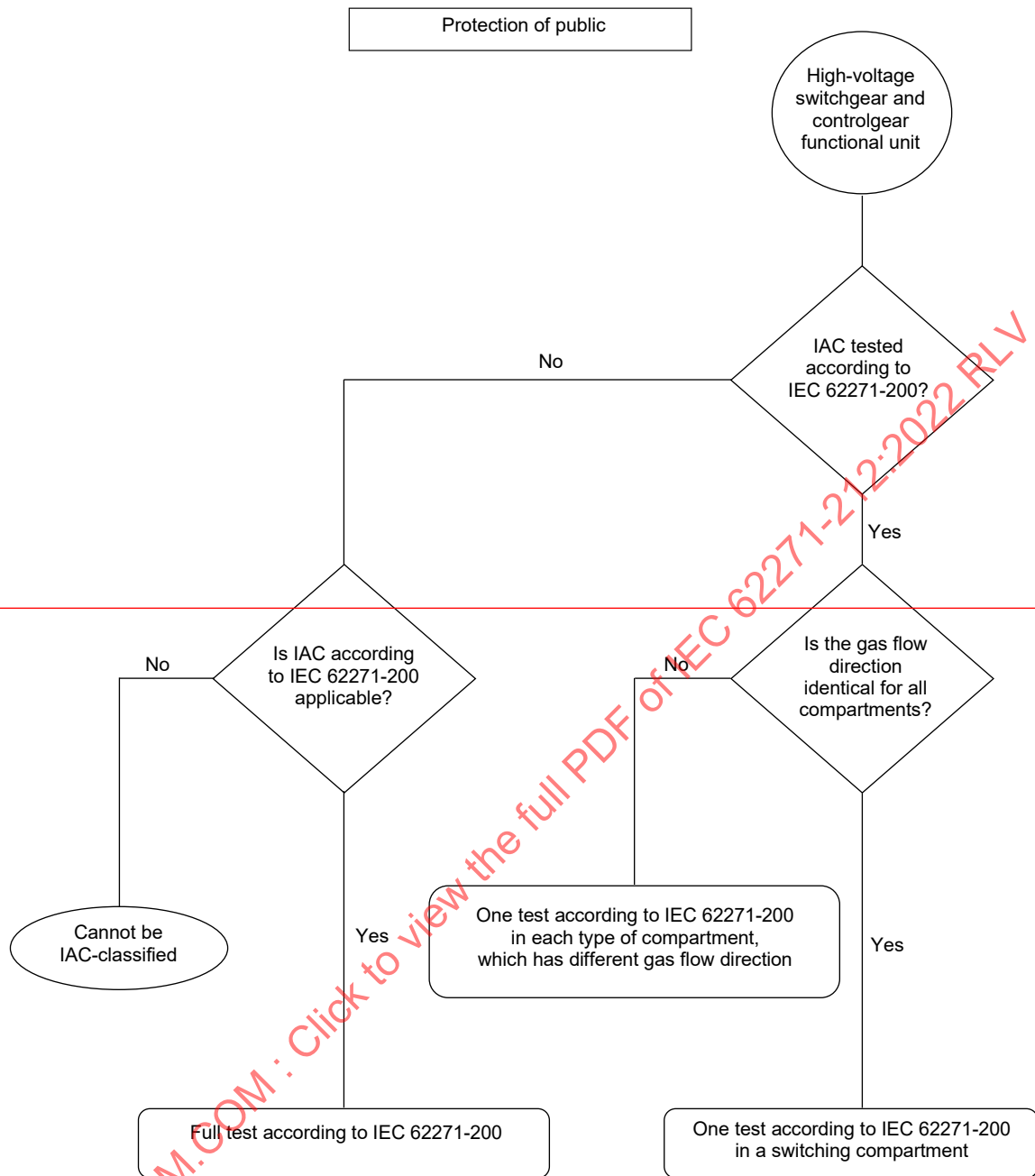


Figure A.7 – Selection of tests on high-voltage switchgear functional unit for class IAC-A



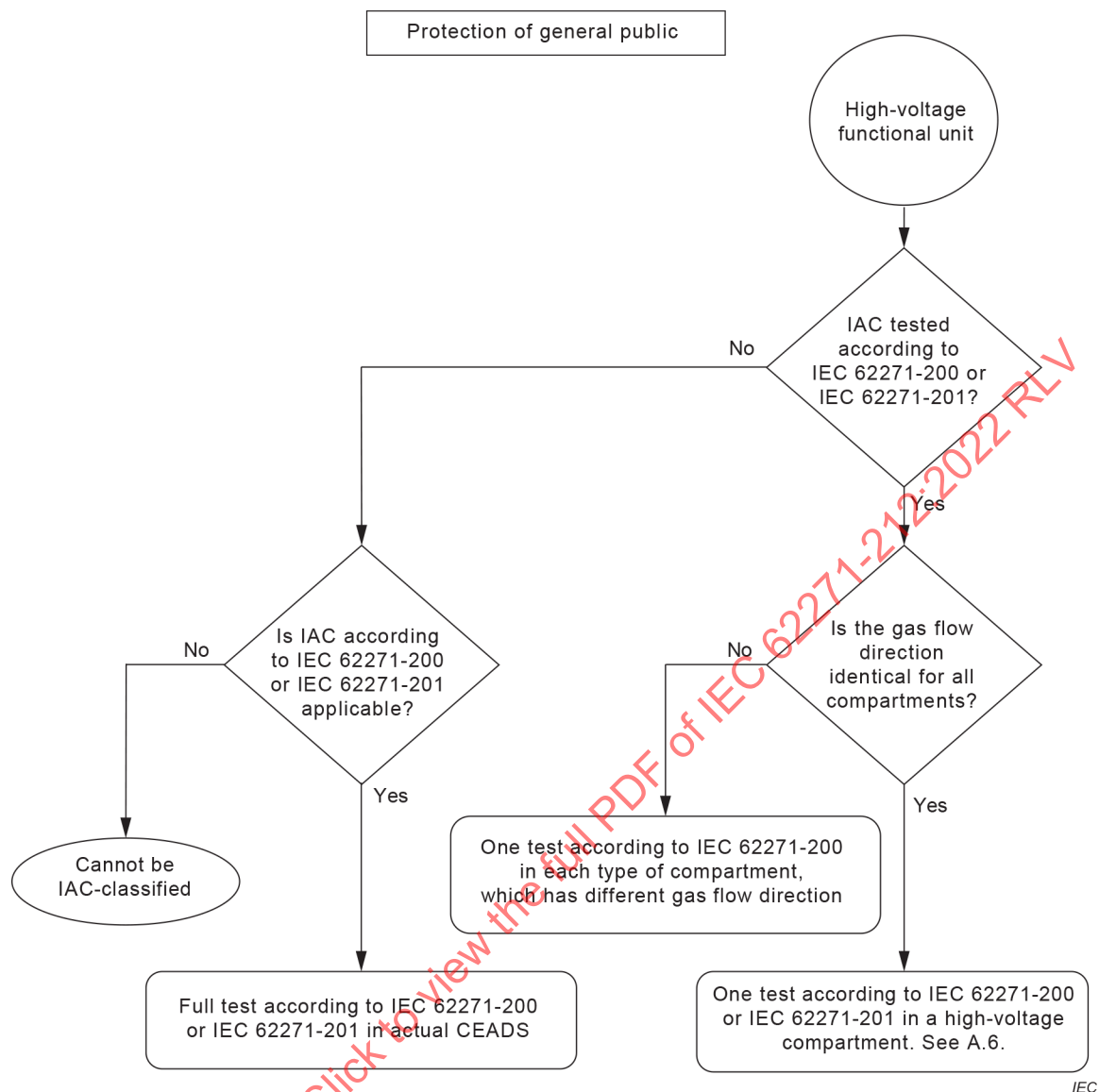
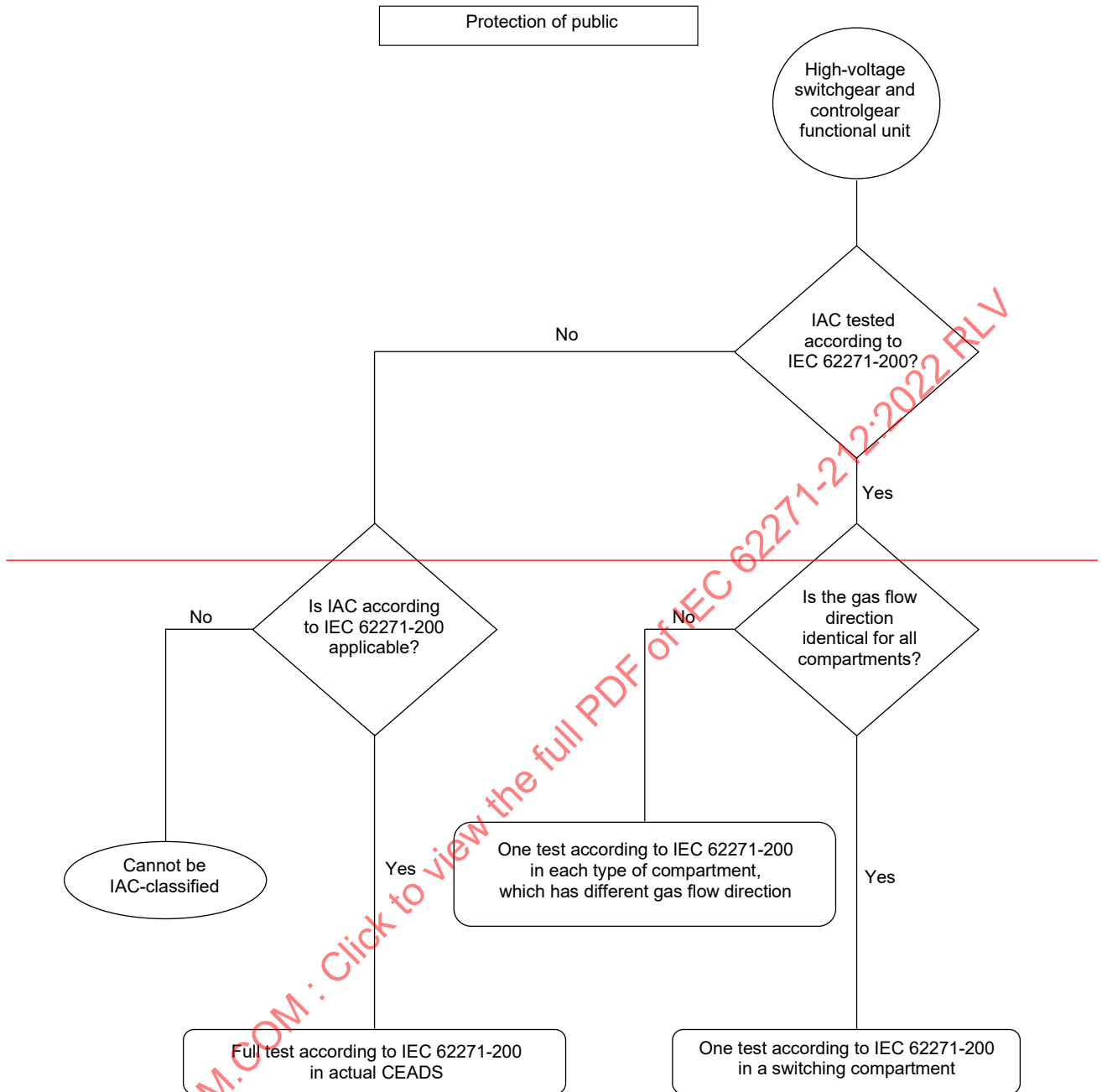


Figure A.8 – Selection of tests on high-voltage ~~switchgear~~ functional unit for class IAC-B



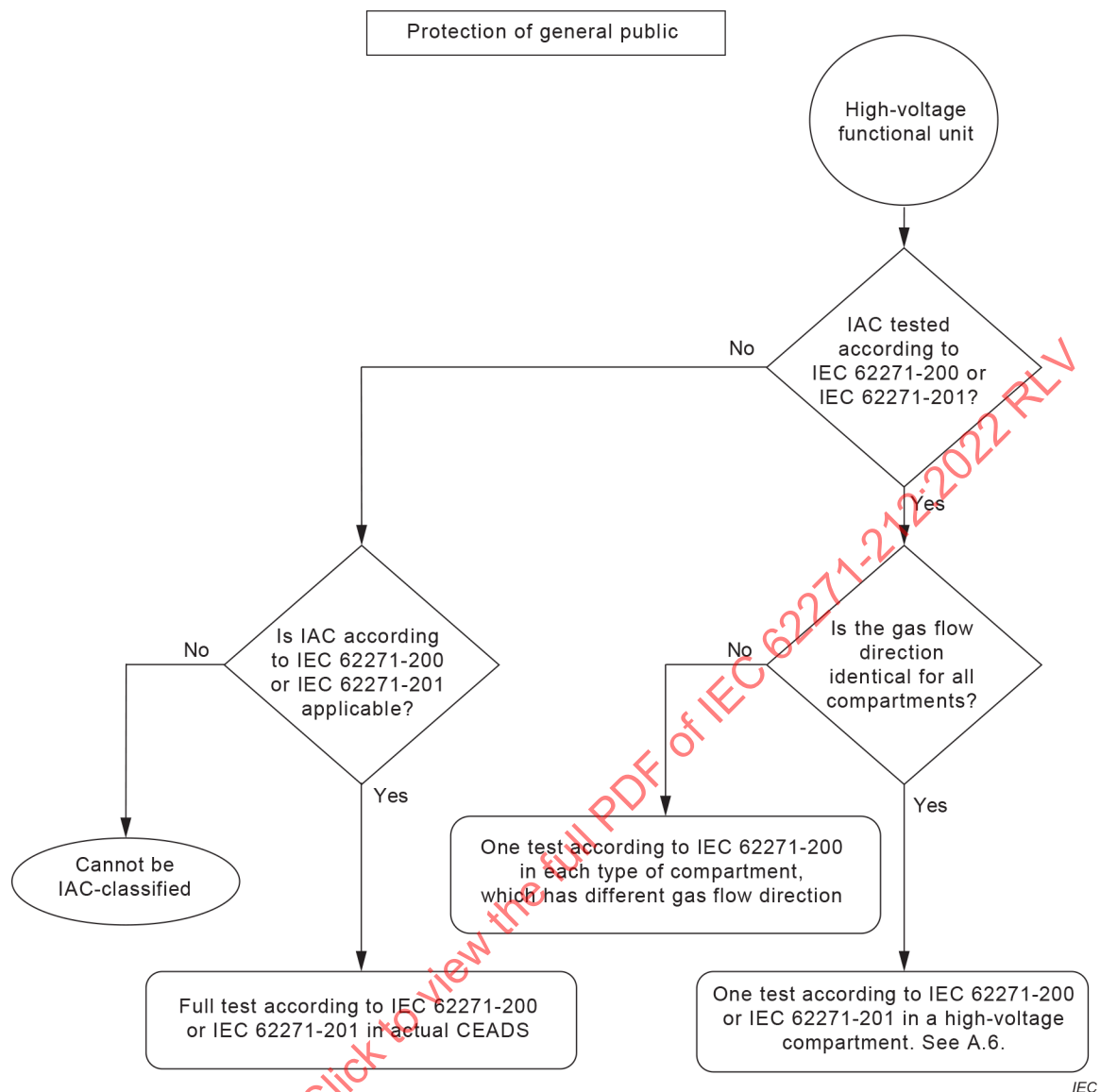
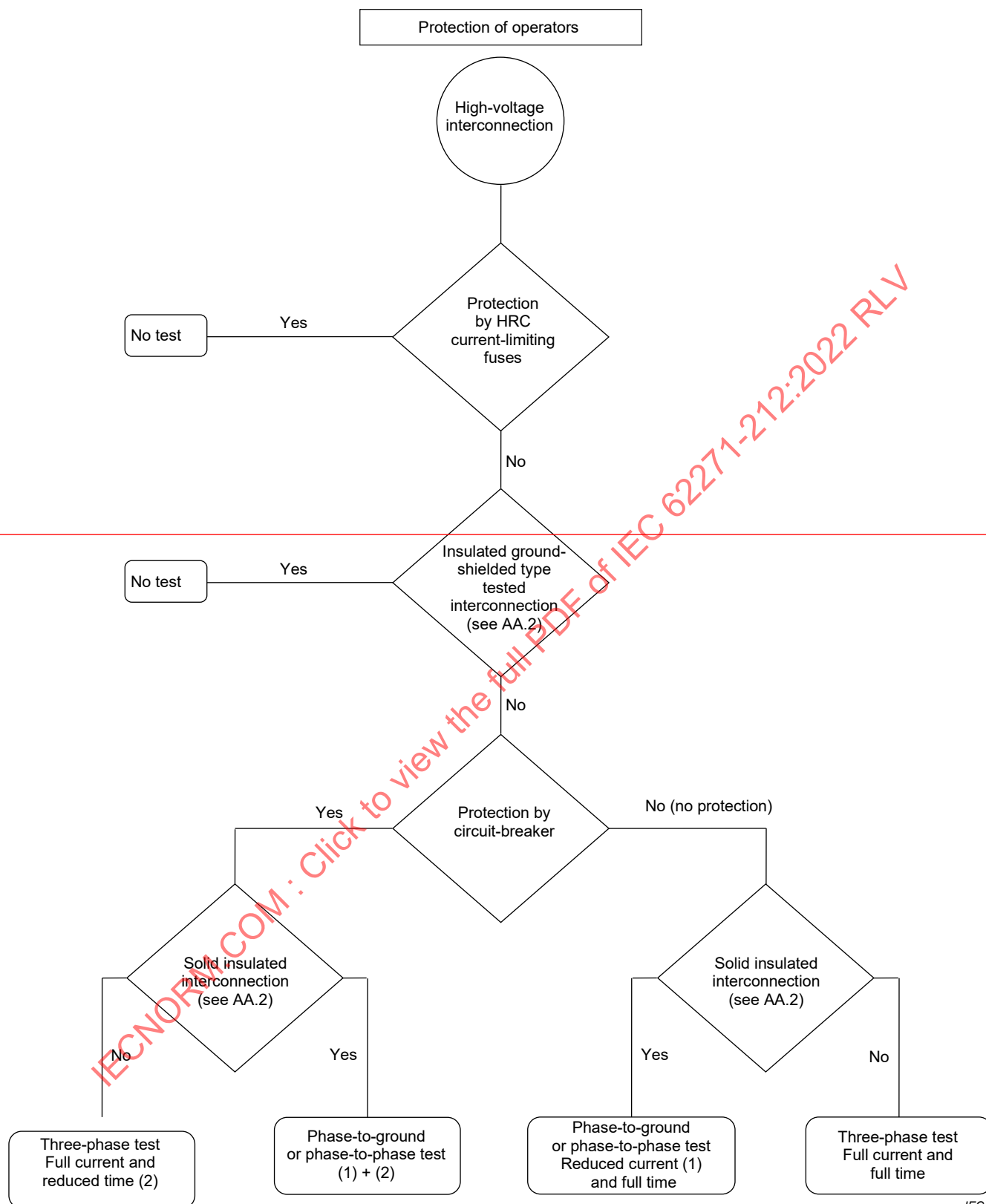
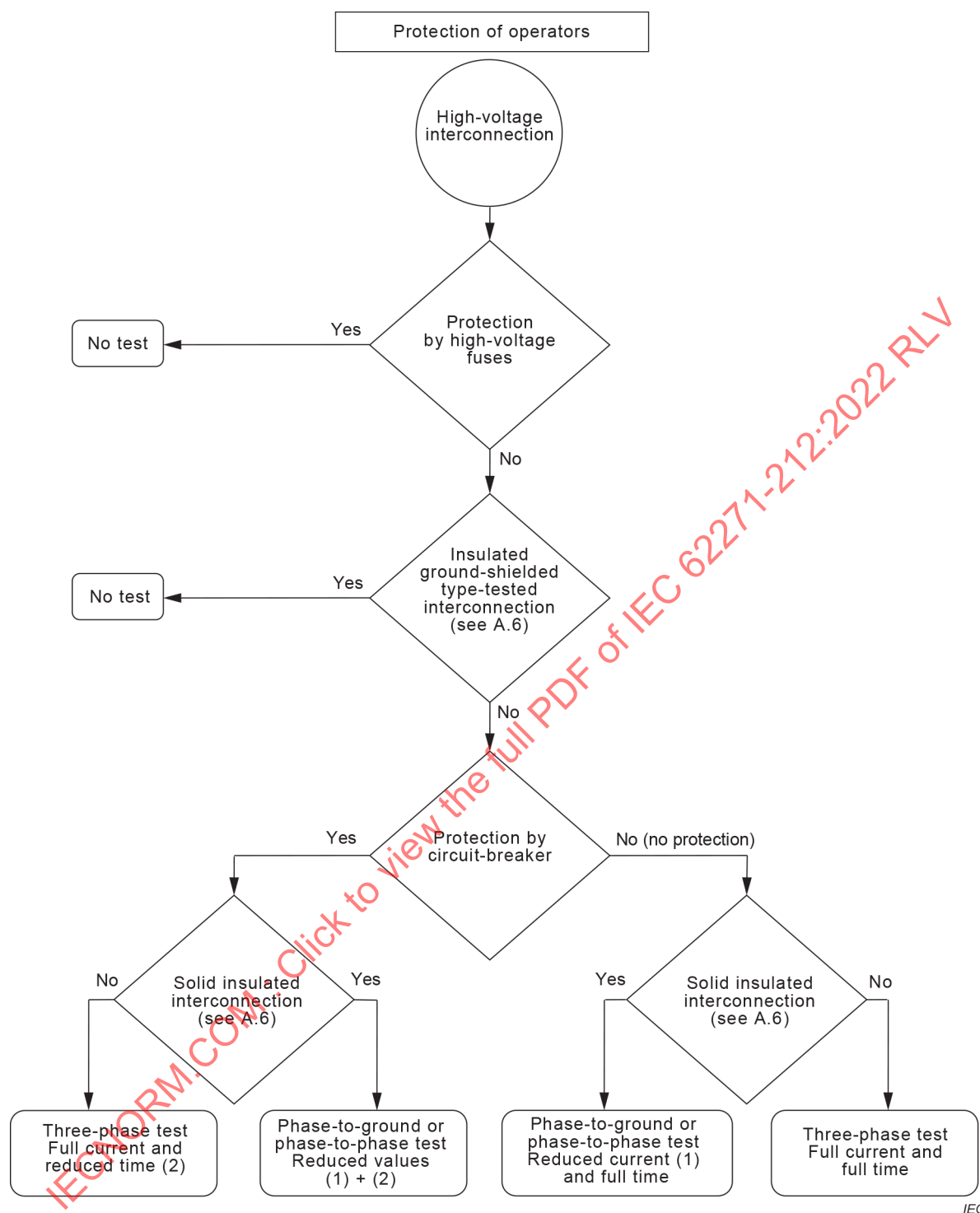


Figure A.9 – Selection of tests on high-voltage functional unit for class IAC-B





(1) ~~IEC 62271-200:2011.~~

* ~~For phase-to-ground test the current value to be stated by the manufacturer.~~

* ~~For phase-to-phase test the current will be 87% of the rated short-time withstand current.~~

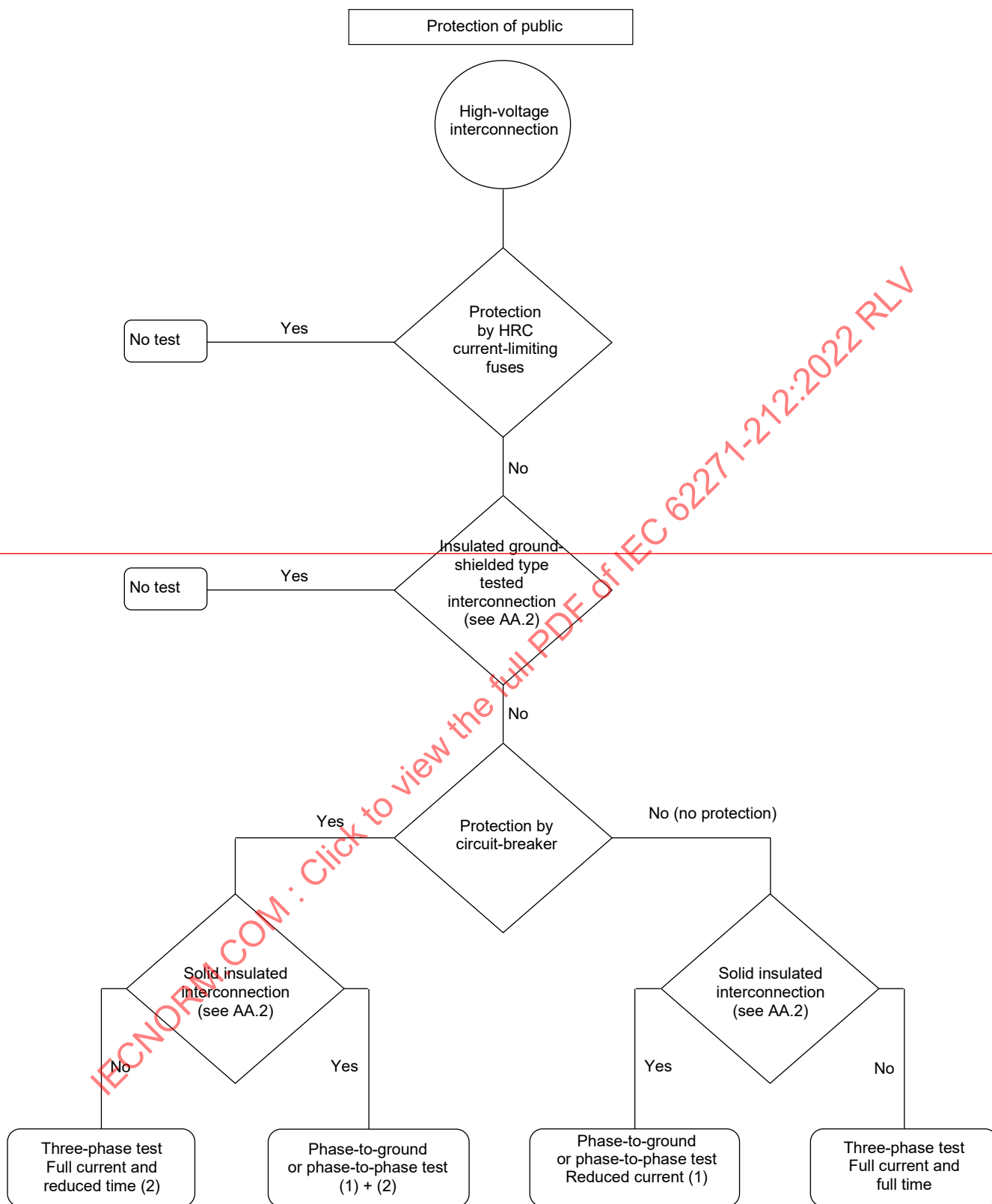
Applicability of phase-to-ground or phase-to-phase test according to the criteria in A.5.2.1 of IEC 62271-200:2021.

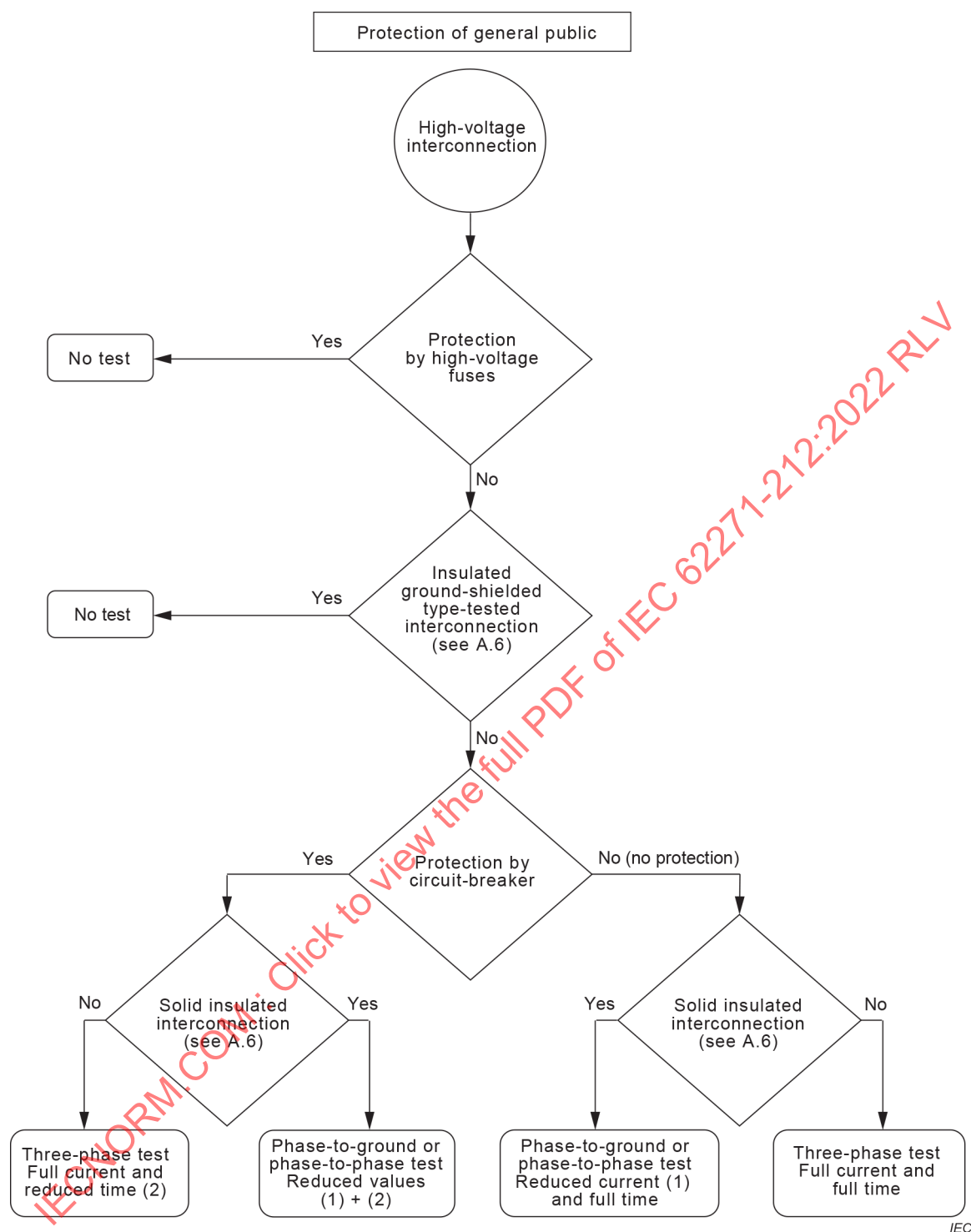
* For phase-to-ground test the current value to be stated by the manufacturer.

* For phase-to-phase test the current shall be 87 % of the rated short-time withstand current.

(2) The time can be stated by the manufacturers, taking into account the time-setting of the protection.

Figure A.10 – Selection of tests on high-voltage interconnection for class IAC-A





(1) Applicability of phase-to-ground or phase-to-phase test according to the criteria in A.5.2.1 of IEC 62271-200:2011 and 2021.

* For phase-to-ground test the current value to be stated by the manufacturer.

* For phase-to-phase test the current will shall be 87 % of the rated short-time withstand current.

(2) The time can be stated by the manufacturers, taking into account the time-setting of the protection.

Figure A.11 – Selection of tests on high-voltage interconnection for class IAC-B

Annex B (normative)

Test to verify the sound level of a CEADS

B.1 Purpose

The purpose of the test is to measure the sound level of a given CEADS in no-load condition. It is expected that the ~~high-voltage/low-voltage~~ power transformer functional unit ~~will~~ can be the main source of sound. However, even in the case that the ~~high-voltage/low-voltage~~ power transformer functional unit is manufactured as an individual power transformer according to IEC 60076 (all parts), the test could be considered relevant as the other components of the CEADS ~~might~~ can modify the sound level of the power transformer or significantly increase it by resonance phenomena.

NOTE Full-load noise level can be considered under special requirement.

The test values are only valid for the tested assembly at the rated ~~operating~~ voltage and frequency.

B.2 Test object

The CEADS tested shall be fully assembled, comprising all fittings and equipment.

B.3 Test method

The test shall be carried out according to IEC 60076-10:2016. IEC 60076-10:2016 defines the method of test and calculation of an A-weighted sound level along a prescribed contour around the power transformer functional unit.

The same method shall be used for measurements on the CEADS where a virtual surface that envelops the assembly (excluding protruding elements, e.g. handles) is considered to be the sound-emitting boundary. The method of measurement shall comply with Clause 5 of IEC 60076-10:2016 with the exception of the requirement for the measuring device, which shall be at 1,5 m above ground level as defined for the CEADS.

B.4 Measurements

These shall be in accordance with Clause 5 of IEC 60076-10:2016. For the purpose of positioning the measuring instruments, virtual surface defined in Clause B.3 shall be considered as principal radiating surface of the CEADS.

B.5 Presentation and calculation of the results

The sound level shall be calculated in accordance with Clause 12 of IEC 60076-10:2016.

The report of the test shall include all applicable information as given in Clause 15 of IEC 60076-10:2016. In addition, for the CEADS, the following information shall also be included:

- a) main design characteristics of the assembly, including materials used;
- b) dimensional drawing of the internal arrangement of the components inside CEADS and any other part that ~~may~~ can significantly influence the sound propagation.

NOTE If any sound measurement on any side of the CEADS differs substantially from those on the other sides, the test report records all values to enable the user to take account of the differences when installing the CEADS.

Annex C (informative)

Types and application of CEADS

C.1 Type of CEADS

C.1.1 General

The document classifies CEADS in three general types: grouped CEADS (CEADS-G), associated CEADS (CEADS-A) and integrated CEADS (CEADS-I). The three types of CEADS ~~may can~~ differ by the type of interconnections, layout and level of proximity and/or integration of the functional units, which –in some cases– include to share parts and/or dielectric medium between certain functions, etc.

C.1.2 CEADS-G

This type of CEADS is characterised by the fact that its functional units are manufactured as independent products, which fully comply with their respective product standard. Different layouts can be used (see a non-comprehensive example in Figure C.2) but in all cases the functional units are placed in proximity but not attached to each other. Interconnections between functional units are of conventional type (cables or bus-bar arrangements).

C.1.3 CEADS-A

In this type of CEADS some functional unit(s) ~~may can~~ be modified to obtain shorter interconnections or reduce the size of the assembly. Non conventional interfaces between the functional units ~~may can~~ be part of the design. ~~It may require that~~ Because of this, the functional units ~~can~~ deviate, to some extent from their product standard (e.g. the bushings of the power transformer ~~may can~~ be different from those mentioned in the relevant standard, or the order of phases can be modified). The functional units are manufactured as independent products or ~~may can~~ share part of their respective enclosures (see a non-comprehensive example in Figure C.3). However none of these special features are acceptable if they affect negatively the performance, functionality and safety of the product.

C.1.4 CEADS-I

This type of CEADS is characterised by the integration of high-voltage switchgear (totally or partially) and power transformer within a single enclosure, requiring sharing the insulating medium as well (see a non-comprehensive example in Figure C.4).

C.2 Application of CEADS

For industrial applications, such as factories, CEADS are intended for application in public distribution networks or at industrial sites.

For public distribution networks, CEADS are installed within an indoor or outdoor closed electrical operating area (see definition 3.1.101) forming part of a distribution substation.

CEADS can be installed outside a closed electrical operating area provided that safety regulations are fulfilled by additional measures adopted at the installation site under the responsibility of the designer of the installation.

Figure C.1, below, describes the application of CEADS to build different types of high-voltage ~~low-voltage distribution~~ substations.

Once manufactured, the CEADS (any of the different types) is ready to follow to the final alternative step of the erection of the substation by:

- transporting it to the site and install it into the closed electrical operating area. No additional internal installation works and interconnection are necessary there, except for special cases where the CEADS is delivered in several units due to transport and site access constraints, by agreement between the manufacturer and the user.
- introducing it into an enclosure in the factory and then the complete assembly been transported to the installation site.

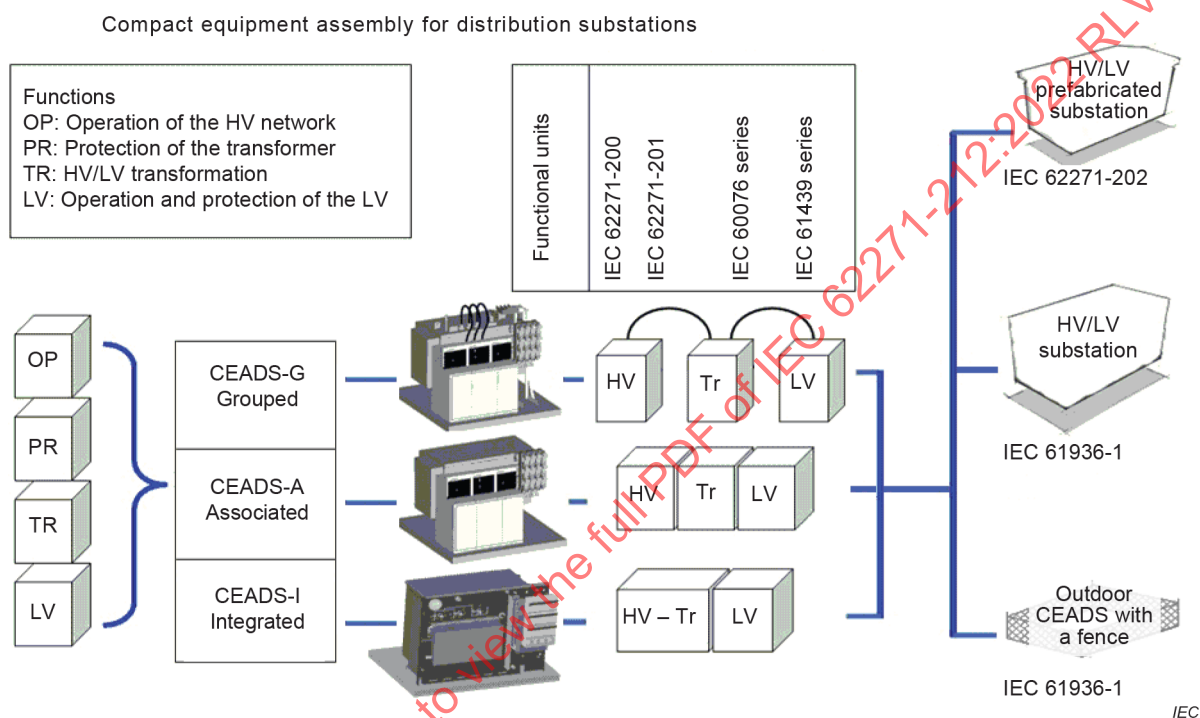
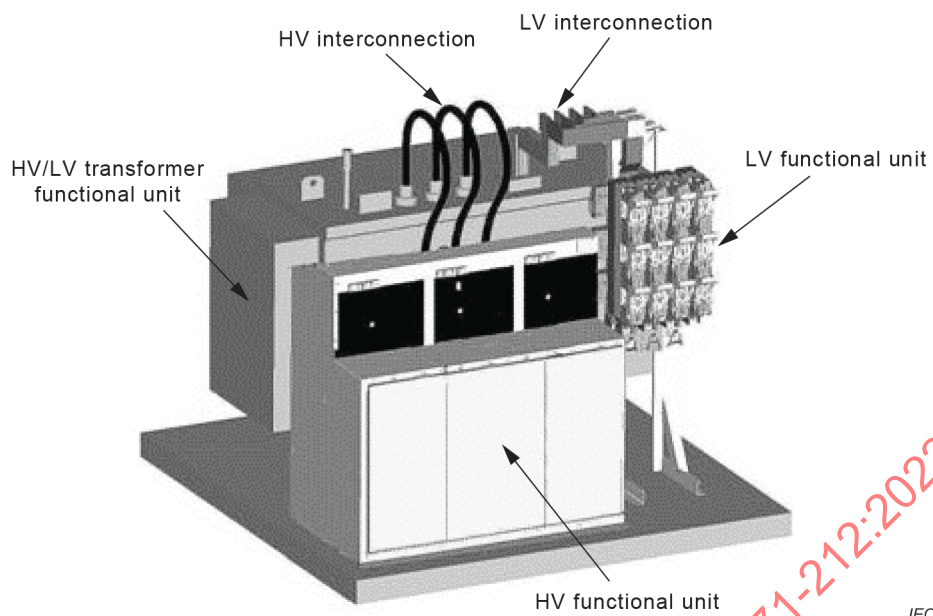
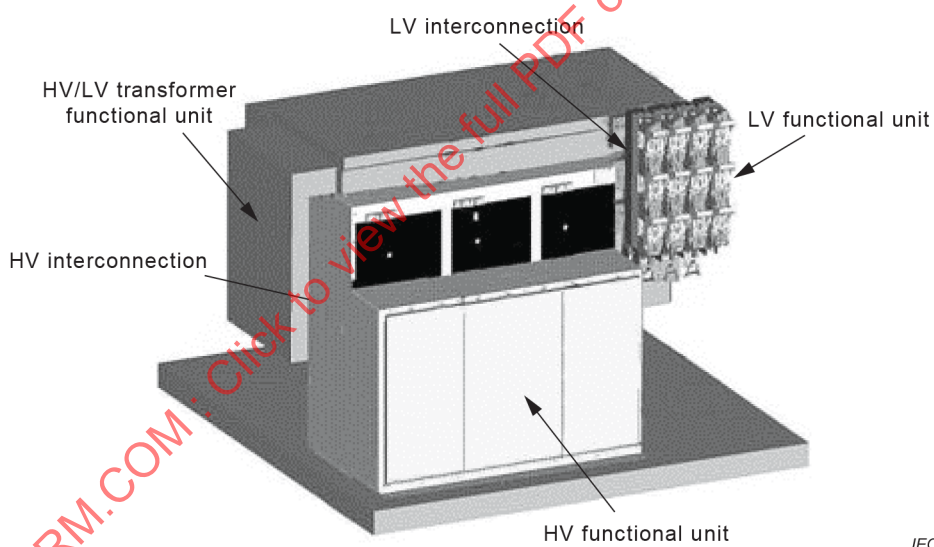


Figure C.1 – Application of CEADS

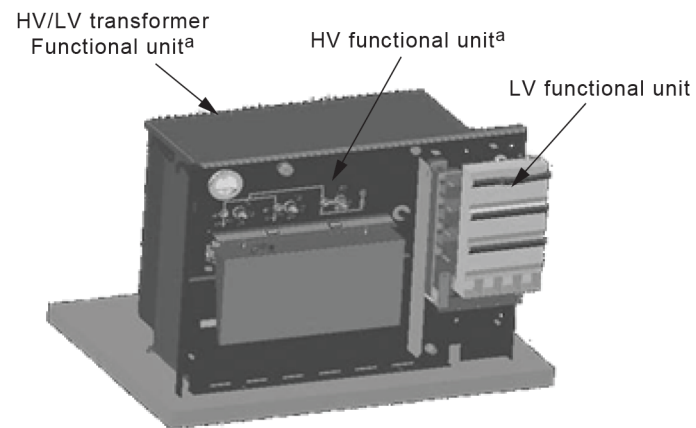


IEC

Figure C.2 – CEADS Type G

IEC

Figure C.3 – CEADS Type A



IEC

^a Functional units sharing the same enclosure

Figure C.4 – CEADS Type I

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- [14] IEC 62271-200:2011³, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

³ This publication was withdrawn and replaced with IEC 62271-200 :2021.

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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**High-voltage switchgear and controlgear –
Part 212: Compact Equipment Assembly for Distribution Substation (CEADS) for
AC voltages up to 52 kV**

**Appareillage à haute tension –
Partie 212: Ensemble compact d'équipement pour poste de distribution (ECEPD)
pour les tensions alternatives inférieures ou égales à 52 kV**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 212: Compact Equipment Assembly for Distribution Substation (CEADS) for AC voltages up to 52 kV

FOREWORD

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IEC 62271-212 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

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

- a) clause numbering aligned with IEC 62271-1:2017,
- b) rewording of title and scope of the document,
- c) implement changes on internal arc definition and testing following the evolution of prefabricated substation concept according to IEC 62271-202,
- d) general review of main test procedures such as temperature rise or dielectric test on interconnections, considering control equipment, communication, smart grid devices and integration of components,

e) general review of installation, operation, safety and maintenance requirements.

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

Draft	Report on voting
17C/845/FDIS	17C/850/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/standardsdev/publications.

This International Standard should be read in conjunction with IEC 62271-1:2017, to which it refers and which is applicable unless otherwise specified. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1:2017. Amendments to these clauses and subclauses are given under the same numbering, whilst additional subclauses, are numbered from 101.

A list of all parts of the IEC 62271 series can be found, under the general title *High-voltage switchgear and controlgear*, on the IEC website.

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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Traditionally a high-voltage/low-voltage distribution substation has been constructed by installing the main electrical components –high-voltage switchgear and controlgear, power transformer and the corresponding low-voltage switchgear and controlgear- within a closed electrical operating area. It can be a room within a building intended for other usages (non electrical uses) or a separated housing (prefabricated or not) designed specifically to contain the electrical equipment of the substation or an open area limited by fences.

Some years ago in the search for a more standardized and compact substation, the concept of prefabricated substation was developed. IEC 62271-202 covers this type of substation. According to this document, the main electrical components (high-voltage switchgear and controlgear, power transformer and low-voltage switchgear and controlgear) are fully in compliance with their respective product standard, and the whole substation, including interconnections and enclosure is designed and type tested and later manufactured and routine tested in the factory. Correspondingly the quality of the substation is assured by the manufacturer.

Moreover, also other types of assemblies have been introduced in the market. These are assemblies comprising the main electrical active components of the substation and their interconnections, delivered as a single product. The product can therefore be type tested, manufactured, routine tested in the factory, transported and then installed in a closed electrical operating area.

This type of factory assembled and type-tested product is covered by this document receiving the generic name CEADS from Compact Equipment Assembly for Distribution Substation. Numerous arrangements are possible and this document provides guidance on basic types of assemblies, which might be envisaged.

A CEADS is not covered by IEC 61936-1. However, CEADS is intended to become part of a distribution substation.

Taking into account the closer proximity of the main electrical components that even can share some parts (enclosure, solid or fluid insulation...), it is very relevant to take notice of the potential interaction between them. Therefore, to cover CEADS is neither sufficient nor always applicable to refer to the relevant product standards. This document covers any additional design and construction requirements and test methods applicable to the different types of CEADS. In addition to the specified characteristics, particular attention has been paid to the specification concerning the protection of persons, both operators and general public.

The CEADS is also of interest to committee TC 14: Power transformers, and committee TC 121: Switchgear and controlgear and their assemblies for low voltage.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 212: Compact Equipment Assembly for Distribution Substation (CEADS) for AC voltages up to 52 kV

1 Scope

This part of IEC 62271 specifies the service conditions, rated characteristics, general structural requirements and test methods of the assemblies of the main electrical functional units of a high-voltage transformer substation, duly interconnected, for AC voltages up to and including 52 kV on the high-voltage side and service frequency 50 Hz or 60 Hz. The CEADS is cable-connected to the high-voltage network for indoor and outdoor applications of restricted access.

A CEADS as defined in this document is designed and tested to be a single product with a single serial number and one set of documentation.

The functions of a CEADS are:

- high-voltage/high-voltage or high-voltage/low-voltage transformation;

and some or all the following:

- switching and control for the operation of the high-voltage circuit(s);
- switching and control for the operation of the low-voltage circuit(s);
- protection of the power transformer functional unit.

The main functions are integrated in the following functional units:

- high-voltage functional unit;
- power transformer functional unit;
- low-voltage functional unit.

NOTE For the purpose of this document a self-protected transformer is not considered as a CEADS, but as a functional unit, designed and type tested to its own product standard IEC 60076-13:2006.

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.

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at www.electropedia.org)

IEC 60050-461, *International Electrotechnical Vocabulary (IEV) – Part 461: Electric cables* (available at www.electropedia.org)

IEC 60076 (all parts), *Power transformers*

IEC 60076-1:2011, *Power transformers – Part 1: General*

IEC 60076-2:2011, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3:2013, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-3:2013/AMD1:2018

IEC 60076-5:2006, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-7:2018, *Power transformers – Part 7: Loading guide for mineral-oil-immersed power transformers*

IEC 60076-10:2016, *Power transformers – Part 10: Determination of sound levels*

IEC 60076-11:2018, *Power transformers – Part 11: Dry-type transformers*

IEC 60076-12:2008, *Power transformers – Part 12: Loading guide for dry-type power transformers*

IEC 60076-15:2015, *Power transformers – Part 15: Gas-filled power transformers*

IEC 60243-1:2013, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-41:2005/AMD1:2017

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 60721-1:1990, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

IEC 60721-1:1990/AMD1:1992

IEC 60721-1:1990/AMD2:1995

IEC 60721-2-2:2012, *Classification of environmental conditions – Part 2-2: Environmental conditions appearing in nature – Precipitation and wind*

IEC 60721-2-4:2018, *Classification of environmental conditions – Part 2-4: Environmental conditions appearing in nature – Solar radiation and temperature*

IEC TS 60815 (all parts), *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 61439 (all parts)¹, *Low-voltage switchgear and controlgear assemblies*

IEC 61439-1:2020, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

¹ This series supersedes some parts of IEC 60439 series.

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-200:2021, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-201:2014, *High-voltage switchgear and controlgear – Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-202:2022, *High-voltage switchgear and controlgear – Part 202: Prefabricated substation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-441, IEC 62271-202 and the following apply.

NOTE Some standard terms and definitions are recalled here for ease of reference.

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

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

3.1 General terms and definitions

3.1.101

closed electrical operating area

room or location for operation of electrical installations and equipment to which access is intended to be restricted to skilled or instructed persons or to lay personnel under the supervision of skilled or instructed persons

[SOURCE: IEC 61936-1:2021, 3.2.1, modified – In the definition, "power installations" replaced with "installations", and "ordinary persons" replaced with "personnel".]

3.2 Assemblies of switchgear and controlgear

3.2.101

Compact Equipment Assembly for Distribution Substation

CEADS

factory assembled and type-tested equipment comprising functional units, described in Clause 1, duly interconnected

Note 1 to entry: Three types of CEADS are considered: grouped, associated and integrated (see Annex C for details).

3.2.101.1

grouped type CEADS

CEADS-G

CEADS with functional units are standalone equipment fully complying with their respective product standards, where these functional units are placed close to each other in a specified layout

3.2.101.2 **associated type CEADS** **CEADS-A**

CEADS with functional units can deviate from existing product standard but not in any aspect that could affect negatively safety and/or operation and where these functional units can either be independent or share part of their frames or enclosures

3.2.101.3 **integrated type CEADS** **CEADS-I**

CEADS where all or part of high-voltage functional units and the high-voltage/low-voltage transformation functional unit are contained in a single enclosure, sharing the insulating medium

3.3 Parts of assemblies

3.3.101 **functional unit**

assembly of devices and components performing a given main function of the CEADS

Note 1 to entry: For the purpose of this document functional unit has a different meaning than the meaning in other standards. For example, in this document high-voltage functional unit (see 3.3.102) can comprise several functional units as per IEC 62271-200:2021.

3.3.102 **high-voltage functional unit**

assembly of the switching devices and other components performing the function of switching and control for the operation of the high-voltage side of the CEADS

Note 1 to entry: It can include switching and control of the high-voltage main circuit of the network and the protection of the high-voltage/low-voltage transformation function.

3.3.103 **power transformer functional unit**

assembly of elements that perform the function of high-voltage/high-voltage or high-voltage/low-voltage transformation of the CEADS

3.3.104 **low-voltage functional unit**

assembly of the switching devices and other components performing the function of switching and control for the operation and protection of the low-voltage feeders of the CEADS

3.3.105 **high-voltage interconnection**

electrical connection between the terminals of the high-voltage functional unit and the high-voltage terminals of the power transformer functional unit

3.3.106 **low-voltage interconnection**

electrical connection between the low-voltage terminals of the power transformer functional unit and the terminals of the low-voltage functional unit

3.4 Switching devices**3.5 Parts of switchgear and controlgear****3.6 Operational characteristics of switchgear and controlgear****3.6.101****internal arc classified CEADS****IAC**

CEADS which meet prescribed criteria, demonstrated by type tests, for the protection of persons in the event of internal arc at the high-voltage side

3.7 Characteristic quantities**3.8 Index of definitions****A-C**

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D-P

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power transformer functional unit	3.3.103

4 Normal and special service conditions**4.1 Normal service conditions****4.1.1 General**

Subclause 4.1 of IEC 62271-1:2017 is applicable with the following additions for CEADS. Following subclauses also refer to specific additions to other functional units according to their relevant standards.

Wave shape and symmetry of supply voltage are in accordance with 4.2 of IEC 60076-1:2011.

For indoor CEADS equipment shall also be suitable for conditions of relative humidity and condensation in accordance with Table 15 of IEC 61439-1:2020.

NOTE 1 For air ambient below -25 °C, outdoor CEADS can be designed or used according to the relevant product standards, where applicable, or according to agreement between manufacturer and user.

NOTE 2 For higher ambient temperatures inside a room, the user can specify to the manufacturer the specific operating conditions in order to check whether de-rating is applicable for any of the functional units.

When two or more functional units share a common surrounding medium and in some cases, even the same enclosure, the real operating service conditions, in particular temperature, of those functional units can differ largely from the normal service conditions (ambient air) due to the interaction between them. This should be considered, where relevant, during type test (see e.g., 7.101.2).

4.1.2 Low-voltage switchgear and controlgear

Subclause 4.1 of IEC 62271-1:2017 is not applicable to low-voltage functional unit.

Subclause 7.1 of IEC 61439-1:2020 is applicable.

4.1.3 Power transformer

Subclause 4.1 of IEC 62271-1:2017 is not applicable to power transformer.

Subclause 4.2 of IEC 60076-1:2011 is applicable for liquid-immersed power transformers and 4.2 of IEC 60076-11:2018 for dry-type power transformers.

4.2 Special service conditions

4.2.1 General

Subclause 4.2 of IEC 62271-1:2017 is applicable to CEADS with the following additions.

Particular specifications for operation under abnormal conditions apart from those included in this subclause shall be subject to agreement between the manufacturer and user.

Refer to the relevant standards for the different functional units.

4.2.2 Altitude

4.2.2.1 General

Subclause 4.2.2 of IEC 62271-1:2017 is applicable for CEADS with the following additions.

For installation of CEADS at altitude, the main components temperature rise limits should be evaluated considering the recommendations of IEC TR 60943:1998 and IEC TR 60943:1998/AMD2009 [1]².

4.2.2.2 Power transformer

For installation at an altitude higher than 1 000 m, refer to 6.3 of IEC 60076-2:2011 or 10.3 of IEC 60076-11:2018.

4.2.3 Exposure to pollution

4.2.3.1 General

Subclause 4.2.3 of IEC 62271-1:2017 is applicable for CEADS with the following additions.

² Numbers in square brackets refer to the Bibliography.

4.2.3.2 Low-voltage switchgear and controlgear

There are several degrees of pollution defined for the installation conditions. Refer to 7.1.2 of IEC 61439-1:2020 for the purpose of evaluating clearances and creepage distances of the low-voltage functional unit.

4.2.3.3 Power transformer

Refer to 5.5 of IEC 60076-1:2011, except for dry-type power transformers for which 4.2 f) and 12.2 of IEC 60076-11:2018 should be referred to select appropriate environmental class.

4.2.4 Temperature and humidity

Subclause 4.2.4 of IEC 62271-1:2017 is applicable for CEADS with following addition.

If the power transformer service conditions at the intended installation site do not fall within the limits of the normal cooling conditions, then the limits of temperature rise for the liquid-immersed power transformer shall be modified in accordance with 6.3 of IEC 60076-2:2011.

4.2.5 Exposure to abnormal vibrations, shock or tilting

Subclause 4.2.5 of IEC 62271-1:2017 is applicable.

4.2.6 Wind speed

Subclause 4.2.6 of IEC 62271-1:2017 is applicable.

4.2.7 Other parameters

Subclause 4.2.7 of IEC 62271-1:2017 is applicable.

5 Ratings

5.1 General

Clause 5.1 of IEC 62271-1:2017 is applicable with the following modifications.

The ratings of CEADS are the following:

- a) rated voltages (U_r , U_n);
- b) rated insulation levels;
- c) rated frequency (f_r);
- d) rated current for low-voltage assembly main circuits (I_{nA});
- e) rated continuous current for high-voltage main circuits (I_r);
- f) rated short-time withstand currents (I_k , I_{ke} , I_{cw}) for main and earthing circuits;
- g) rated peak withstand currents (I_p , I_{pe} , I_{pk}) for main and earthing circuits;
- h) rated durations of short circuit (t_k , t_{ke} , t_{cw}) for main and earthing circuits;
- i) rated supply voltage of closing and opening devices and of auxiliary and control circuits;
- j) rated supply frequency of closing and opening devices and of auxiliary and control circuits;
- k) rated power and total losses of CEADS;
- l) ratings of the internal arc classification (IAC), if assigned by the manufacturer.

The ratings of CEADS shall be assigned to ensure that operation of the equipment within its assigned ratings do not expose any individual functional unit to conditions which are outside its rated capabilities.

NOTE Functional units forming part of the CEADS can have other individual rated values in accordance with their relevant standards.

5.2 Rated voltage

Subclause 5.2 of IEC 62271-1:2017 is not applicable.

Rated voltages of CEADS are defined by the rated voltages of its high-voltage functional unit (U_r), power transformer functional unit and low-voltage functional unit (U_n).

Refer to subclause 5.2 of IEC 62271-1:2017 for high-voltage functional unit.

Refer to IEC 60947-1 and 5.2 of IEC 61439-1:2020 for low-voltage functional unit.

Subclause 5.4.1 of IEC 60076-1:2011 is applicable for the power transformer functional unit.

NOTE High-voltage and low-voltage functional units can have rated voltages higher than the power transformer functional unit rated voltages.

5.3 Rated insulation level

Subclause 5.3 of IEC 62271-1:2017 is not applicable.

Rated insulation levels of CEADS are defined by the lowest rated insulation levels of any of its components, the high-voltage functional unit, the low-voltage functional unit or the power transformer.

For the high-voltage functional unit refer to 5.3 of IEC 62271-1:2017.

For the low-voltage functional unit refer to 5.2 of IEC 61439-1:2020 and 5.2 of IEC 60947-1:2020.

For the rated insulation levels of the power transformer refer to 5.6 of IEC 60076-1:2011 about applicable insulation levels in relation with the highest voltage for the equipment (U_m).

The minimum rated impulse withstand voltage of the low-voltage functional unit shall be at least the value given for overvoltage category IV in Table G.1 of IEC 61439-1:2020. Depending on the network in different countries, it can be relevant to choose a higher insulation level.

5.4 Rated frequency (f_r)

Subclause 5.4 of IEC 62271-1:2017 is not applicable.

The standard values of the rated frequency for CEADS are 50 Hz and 60 Hz.

5.5 Rated continuous current (I_r)

Subclause 5.5 of IEC 62271-1:2017 is not applicable for CEADS.

Rated currents of CEADS are defined by the rated continuous current of its high-voltage functional unit (I_r) and the rated current of its low-voltage functional unit (I_{nA}).

Subclause 5.5 of IEC 62271-1:2017 is applicable for the high-voltage functional unit.

Subclause 5.3.1 of IEC 61439-1:2020 is applicable for the low-voltage functional unit.

NOTE The high-voltage functional unit and the low-voltage functional unit have rated current values which are equal or higher than operating current values.

5.6 Rated short-time withstand current (I_k)

Subclause 5.6 of IEC 62271-1:2017 is not applicable.

5.6.101 Rated short-time phase-to-phase and rated short-time phase-to-earth withstand currents of high-voltage functional unit and rated short-time withstand current of high-voltage interconnection (I_k , I_{ke})

For the rated short-time withstand currents I_k and/or I_{ke} of high-voltage functional unit, high-voltage interconnection and earthing circuit, 5.6 of IEC 62271-1:2017 is applicable with the following additions:

Rated short-time withstand current (I_k) shall be assigned to high-voltage functional unit and also to high-voltage interconnection.

NOTE 1 In principle, the rated short-time withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

A rated short-time withstand phase-to-earth current (I_{ke}) shall be assigned to the earthing circuit of high-voltage functional unit and high-voltage interconnection. This value can differ from that of the main circuit.

NOTE 2 The short-circuit current ratings applicable to the earthing circuit depend upon the type of system neutral earthing for which it is intended. Refer to Table 3 of IEC 62271-202:2022.

5.6.102 Rated short-time withstand currents of low-voltage functional unit and low-voltage interconnection (I_{cw})

Refer to 5.3.5 of IEC 61439-1:2020.

5.6.103 Short-time withstand currents of power transformer functional unit

Refer to Clause 3 of IEC 60076-5:2006.

5.7 Rated peak withstand current (I_p)

Subclause 5.7 of IEC 62271-1:2017 is not applicable.

5.7.101 Rated peak phase-to-phase and rated peak phase-to-earth withstand currents of high-voltage functional unit and rated peak withstand current of high-voltage interconnection (I_p , I_{pe})

For the rated peak withstand currents I_p and/or I_{pe} of high-voltage functional unit, high-voltage interconnection and earthing circuit 5.7 of IEC 62271-1:2017 is applicable with the following additions:

Rated peak withstand current (I_p) shall be assigned to high-voltage functional unit and also to high-voltage interconnection.

NOTE In principle, the rated peak withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

A rated peak withstand phase-to-earth current (I_{pe}) shall be assigned to the earthing circuit of high-voltage functional unit and high-voltage interconnection. This value can differ from that of the main circuit.

5.7.102 Rated peak withstand currents of low-voltage and low-voltage interconnection (I_{pk})

Refer to 5.3.4 of IEC 61439-1:2020.

5.7.103 Peak withstand currents of power transformer functional unit

Refer to Clause 3 of IEC 60076-5:2006.

5.8 Rated duration of short circuit (t_k)

Subclause 5.8 of IEC 62271-1:2017 is not applicable.

5.8.101 Rated duration of phase-to-phase short circuit (t_k) and rated duration of phase-to-earth short circuit (t_{ke}) of high-voltage functional unit and rated duration of short-circuit of high-voltage interconnection

For the rated durations of short circuit t_k and t_{ke} for high-voltage functional unit, high-voltage interconnection and earthing circuit, subclause 5.8 of IEC 62271-1:2017 is applicable with the following additions:

A rated duration of short circuit (t_k) shall be assigned to high-voltage functional unit and to high-voltage interconnection.

NOTE In principle, the rated duration of short circuit for a main circuit cannot exceed the corresponding rated value of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the duration of the short-circuit current, such as current-limiting fuses.

A rated duration of phase-to-earth short circuit (t_{ke}) shall also be assigned to the earthing circuit of high-voltage functional unit and high-voltage interconnection. This value can differ from that of the main circuit.

5.8.102 Rated duration of short circuit (t_{cw}) for low-voltage functional unit and low-voltage interconnection

Refer to 5.3.4 of IEC 61439-1:2020 for low-voltage functional unit and assign a rated duration of short-circuit (t_{cw}) to the low-voltage interconnection.

5.8.103 Duration of short circuit for power transformer functional unit

Refer to 4.1.3 of IEC 60076-5:2006.

5.9 Rated supply voltage of auxiliary and control circuits (U_a)

Subclause 5.9 of IEC 62271-1:2017 is applicable for CEADS.

5.10 Rated supply frequency of auxiliary and control circuits

Subclause 5.10 of IEC 62271-1:2017 is applicable for CEADS.

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 5.11 of IEC 62271-1:2017 is not applicable to CEADS.

5.101 Rated power and total losses of CEADS

The rated power of CEADS is the rated power of the power transformer functional unit at rated voltage as defined in IEC 60076-1:2011 for liquid-filled power transformer functional units or IEC 60076-11:2018 for dry-type power transformer functional units.

The total losses of CEADS is the sum of the losses of the high-voltage functional unit and high-voltage interconnection at its rated continuous current, the total losses (identifying load and no load losses) of the power transformer functional unit at its rated voltage in accordance with IEC 60076-1:2011 for liquid-filled power transformer functional units or IEC 60076-11:2018 for dry-type power transformer functional units, and the losses of the low-voltage functional unit and low-voltage interconnection at the current determined by the power transformer functional unit rated power.

5.102 Ratings of the internal arc classification (IAC)

5.102.1 General

If an IAC classification is assigned by the manufacturer, several ratings shall be specified. These ratings are subdivided into type of accessibility, arc fault currents and arc fault durations.

5.102.2 Types of accessibility (A, B, AB)

Three types of accessibility in case of an internal arc are considered:

Accessibility type A: for CEADS providing protection to the operators standing during normal operations in the high-voltage operating side (or sides) of the CEADS.

NOTE In principle, operating at the high-voltage side and at the low-voltage operating side at the same time can be considered an unsafe procedure.

Accessibility type B: for CEADS providing protection to the general public in the vicinity of the equipment on all its sides at any time.

Accessibility type AB: for CEADS providing protection to both operators and the general public.

To qualify for this classification, these CEADS shall comply with the requirements for type A and type B with the same value of the test current in kA and duration in second(s).

5.102.3 Classified sides

For identification purposes of the different classified sides of the CEADS the following code shall be used:

- F for front side (defined by high-voltage operating side);
- L for lateral side;
- R for rear side.

The high-voltage operating side(s) shall be clearly stated by the manufacturer before the test and identified in the test report.

5.102.4 Rated arc fault currents (I_A , I_{Ae})

The standard value of rated arc fault currents should be selected from the IEC 60059:1999 and IEC 60059:1999/AMD1:2009 [2] standard current ratings.

Two ratings of the arc fault currents are recognised:

- a) three-phase arc fault current (I_A),
- b) single phase-to-earth arc fault current (I_{Ae}), when applicable.

When only a three-phase rating is specified, the single-phase rating is by default 87 % of the three-phase rating, and shall not be specified.

NOTE 1 The manufacturer specifies the compartments of the high-voltage functional unit to which the single phase-to-earth arc fault current rating applies. Such value is assigned to functional unit where its construction can prevent the arc from becoming multiphase, as demonstrated during the internal arc test.

NOTE 2 Rationale for this 87 % is the arc fault test with 2-phase ignition; refer to 9.104.5 of IEC 62271-202:2022.

In the case where all high-voltage compartments are only designed for single phase-to-earth arc faults, only single phase-to-earth arc fault current (I_{Ae}) shall be assigned.

NOTE 3 Information about the relationship between type of neutral earthing and the single phase-to-earth arc fault current is provided in 9.104.5 and Table 3 of IEC 62271-202:2022.

5.102.5 Rated arc fault duration (t_A , t_{Ae})

Standard recommended values for the three-phase arc fault duration (t_A) are 0,1 s, 0,5 s and 1 s.

If applicable, the test duration (t_{Ae}) of the single phase-to-earth arc fault shall be stated by the manufacturer.

NOTE It is in general not possible to calculate the permissible arc duration for a current which differs from that used in the test.

6 Design and construction

Clause 6 of IEC 62271-1:2017 is not applicable to CEADS.

CEADS shall be designed so that normal service, inspection and maintenance can be carried out safely. As CEADS are intended for installation within closed electrical operating areas, in principle general public is not allowed to approach the equipment. However, when a CEADS is installed in a factory, the employees not in charge of its operation can be occasionally in the proximity of the CEADS. As they are not aware of the electrical features of the equipment they are considered as general public in the sense of this document.

NOTE If some parts of enclosures of a CEADS are intended to become part of the enclosure of a substation, the relevant requirements of IEC 62271-202 or IEC 61936-1, as applicable, are met.

The design of CEADS shall take into account the possible interactions (e.g., electrical, mechanical and thermal) in the performance of different functional units and the components used to interconnect these.

The complete assembly of a CEADS and the individual functional units forming part of it shall comply with the requirements of this document. For the individual functional units, reference is made to the following respective standards:

- High-voltage functional unit IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear;
- Power transformer functional unit IEC 60076 (all parts);
- Low-voltage functional unit IEC 61439 (all parts) and IEC 60947-1.

The individual functional units of a CEADS-G shall comply with the requirements of their respective product standard listed above.

Concerning CEADS-A and CEADS-I, the individual functional units can deviate in some aspects from those products standards. Due to that, specific testing procedures for individual functional units, where direct application of above-mentioned product standards is not possible, are described in this document.

6.1 Requirements for liquids in switchgear and controlgear

Subclause 6.1 of IEC 62271-1:2017 is applicable.

6.2 Requirements for gases in switchgear and controlgear

Subclause 6.2 of IEC 62271-1:2017 is applicable.

NOTE For the handling of SF₆ refer to IEC 62271-4 [3].

6.3 Earthing of switchgear and controlgear

Subclause 6.3 of IEC 62271-1:2017 is applicable with the following additions:

A main earthing circuit system shall be provided to connect to the earth all metallic parts of the CEADS not belonging to the main and/or secondary/auxiliary circuits of the equipment. It consists of a main earthing conductor to which each component is connected through a single circuit.

If the CEADS has a metallic frame, then it can serve as, or form part of, the main earthing circuit. In such a case, the fastening system, if any, used to join parts of the frame shall demonstrate its ability to carry the phase-to-earth rated current. The main earthing circuit system shall be designed to withstand the rated short-time and peak withstand current under the neutral earthing condition of the system.

The cross-section of any earthing conductor shall be not less than 30 mm². It shall be terminated by an adequate terminal intended for connection to the earth system of the installation. If any conductor or conducting part of the earthing circuit is not made of copper, equivalent conductive and mechanical requirements shall be met.

The continuity of the earthing circuit shall be ensured and corresponding measures preventing corrosion, loosening of bolts etc. shall be taken. The earthing circuit system shall take into account the thermal and mechanical stresses caused by the current.

NOTE The user can establish procedures to check the integrity of all parts of the earthing circuit (internal and external) either periodically or after a short-circuit current.

Components to be connected to the main earthing circuit shall include:

- the enclosure, if metallic, of the high-voltage functional units from the terminal provided for that purpose;
- the tank of liquid-immersed power transformer functional unit or the metallic non active parts of dry-type power transformer functional unit;
- the frame and/or enclosure, if metallic, of the low-voltage functional unit;
- the earthing connection of automatic controls and remote-control devices;
- the metal shields and the earthing conductors of the high-voltage cables;
- the metallic frame of the CEADS, if any;
- earthing switches, if any.

6.4 Auxiliary and control equipment and circuits

Subclause 6.4 of IEC 62271-1:2017 is applicable with the following additions.

For the low-voltage installation embedded in the CEADS (for example, illumination, auxiliary supply, etc.), refer to IEC 60364-4-41:2005 for low-voltage electrical installations or IEC 61439-1:2020 for low-voltage switchgear and controlgear assemblies, as appropriate.

6.5 Dependent power operation

Subclause 6.5 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.6 Stored energy operation

Subclause 6.6 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.8 Manually operated actuators

Subclause 6.8 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.9 Operation of releases

Subclause 6.9 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.10 Pressure/level indication

Subclause 6.10 of IEC 62271-1:2017 is applicable.

6.11 Nameplates

Subclause 6.11 of IEC 62271-1:2017 is not applicable, and it is replaced as follows:

Each CEADS shall be provided with a durable, clearly legible nameplate, visible in operating condition, which shall contain at least the following information:

- manufacturer's name or trade mark;
- type designation;
- serial number;
- number of this document;
- year of manufacture;

- ratings of CEADS listed in Clause 5;
- internal arc classification designation, where applicable;
- instruction book reference.

The ratings of the functional units shall be listed on separate nameplates, clearly visible, or on the CEADS nameplate. Where functional units are independent, they shall be provided with separate nameplates as in their respective product standards.

Each nameplate shall have a unique serial number.

6.12 Locking devices

Subclause 6.12 of IEC 62271-1:2017 is not applicable and it is replaced as follows:

Interlocking can be necessary to ensure the correct sequence of operation of equipment, to minimise the risk to personnel and damage to the equipment. Interlocking can be achieved by electrical or mechanical methods. If non-mechanical interlocks are provided, the design shall be such that no improper situations can occur in case of lack of auxiliary power supply.

6.13 Position indication

Subclause 6.13 of IEC 62271-1:2017 is not applicable to CEADS.

Subclause 6.13 of IEC 62271-1:2017 for high-voltage functional unit and 8.1.6 of IEC 60947-1:2020 for low-voltage functional unit are applicable.

6.14 Degrees of protection provided by enclosures

6.14.1 General

Subclause 6.14 of IEC 62271-1:2017 is not applicable to CEADS.

6.14.2 Protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects (IP coding)

Degrees of protection in accordance with IEC 60529 shall be as specified below.

The enclosures of high-voltage and low-voltage functional units shall provide at least the degree of protection IP2X for indoor application.

If non insulated conductors and/or bushings in low-voltage interconnections or non-screened conductors and/or bushings in high-voltage interconnections are used, suitable means to prevent direct contact with live parts shall be provided either by the manufacturer as part of the CEADS itself or alternatively by the user incorporating adequate protection in the installation site. In the first case, the minimum degree of protection should be IP1X. In the second case, the manufacturer shall include in the instruction manual clear information about the need to provide additional protection.

NOTE Additional safety measures for the protection of persons against approach to hazardous parts are described in Clause 8 of IEC 61936-1:2021 [4].

When dry-type power transformer functional unit is used, a protection means around the power transformer functional unit shall be provided with at least a degree of protection IP2X.

6.14.3 Protection against ingress of water (IP coding)

For outdoor application of CEADS the minimum degree of protection shall be IP23.

6.14.4 Protection against mechanical impact under normal service conditions (IK coding)

The enclosures shall have sufficient mechanical strength to withstand external mechanical impacts with energy of 2 J, corresponding to a degree of protection IK07 [5] for indoor application and 20 J corresponding to IK10 for outdoor application.

NOTE CEADS for indoor application is always installed within a closed electrical operating area. In case it is installed within a fence into an industrial facility, the user can consider increasing mechanical requirements of the fence to protect the integrity of the CEADS.

6.15 Creepage distances for outdoor insulators

Subclause 6.15 of IEC 62271-1:2017 is only applicable for high-voltage outdoor insulators (if any) of the high-voltage functional unit and of the high-voltage side of the power transformer functional unit.

6.16 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2017 is only applicable for the high-voltage functional unit of the CEADS.

Subclause 5.11 of IEC 60076-15:2015 is applicable for the power transformer functional unit if of gas-filled type.

6.17 Tightness for liquid systems

Subclause 6.17 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

For power transformer functional unit relevant clauses of IEC 60076 (all parts) are applicable.

6.18 Fire hazard (flammability)

Subclause 6.18 of IEC 62271-1:2017 is applicable for CEADS.

6.19 Electromagnetic compatibility (EMC)

Subclause 6.19 of IEC 62271-1:2017 is not applicable.

Subclauses 6.19 of IEC 62271-1:2017 for high-voltage functional unit and 9.4 and Annex J of IEC 61439-1:2020 for low-voltage functional unit are respectively applicable to the high-voltage and low-voltage functional units of the CEADS.

6.20 X-ray emission

Subclause 6.20 of IEC 62271-1:2017 is only applicable for the high-voltage functional unit.

6.21 Corrosion

Subclause 6.21 of IEC 62271-1:2017 is applicable for CEADS.

6.22 Filling levels for insulation, switching and/or operation

Subclause 6.22 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

6.101 Protection against mechanical stresses

The enclosures shall have sufficient mechanical strength to withstand the following loads and impacts:

- a) for CEADS intended for outdoor installation, snow loads according to the local climatic conditions;
- b) for CEADS intended for outdoor installation, the mechanical effects of wind pressure according to 4.1.3 of IEC 62271-1:2017. It can be verified by calculation.

Any other mechanical stresses that can be expected to occur in service, depending on the intended application, can be verified by calculation.

NOTE 1 Seismic stresses according to IEC TS 62271-210:2013 [6] can also be considered within this subclause.

The complete assembly lifting lugs shall be designed for the total weight of the CEADS. Although each component had been tested for inherent physical stability, when various components are attached together in a CEADS, instability can result. The design shall ensure stability during delivery, installation and operation.

NOTE 2 The lifting lugs designed to lift the complete assembly can be painted yellow for easy identification.

6.102 Protection of the environment due to internal defects

In the event that internal defects can lead to the escape of hazardous liquids from the equipment (for example: liquid from a power transformer functional unit or a high-voltage functional unit), provision shall be made to retain the hazardous liquids in order to prevent the soil being polluted.

The capacity of the retention tank shall be at least equal to the biggest hazardous liquid containing part (for example, power transformer functional unit, high-voltage functional unit, etc.), unless applicable national regulations have different requirements. The retention tank can be part of CEADS or provided in the installation site where the CEADS shall be installed.

Additional measures can be taken by agreement between manufacturer and user.

6.103 Internal arc fault

A CEADS that satisfies the requirements of this document is designed, in principle, to prevent the occurrence of internal arc faults in the high-voltage side.

To achieve this objective, the manufacturer of the CEADS shall ensure the correct manufacture, verifying it by carrying out routine tests according to Clause 8. In turn, the user shall make a proper selection, according to the characteristics of the network, operating procedures and service conditions (refer to Clause 9).

There should be little probability that an internal arc occurs during the entire service life, provided that the CEADS is installed, operated and maintained following the instructions provided by the manufacturer and the cables are correctly installed; however, the possibility of an internal arc cannot be completely disregarded.

Failures can occur in any part of the CEADS. However, as no internal arc testing procedure for low-voltage functional unit and power transformer functional unit is described in their respective relevant standards, only faults occurring within the enclosure of the high-voltage functional units and in the high-voltage interconnection are taken into consideration in this document (see 7.101).

NOTE If user and manufacturer agree on an internal arc test of the low-voltage part of the CEADS, IEC TR 61641:2014 [7] gives guidance for an internal arc test in enclosed low-voltage switchgear and controlgear assemblies.

Failure either due to a defect, an exceptional service condition or mal-operation on the high-voltage side can initiate an internal arc within the high-voltage functional unit and/or in the high-voltage interconnection, which constitutes a hazard if persons are present.

6.104 Enclosures

The enclosures of the functional units shall comply with the relevant requirements of their respective product standards. In the case that an enclosure is shared by several functional units, it shall comply with the requirements of the products standards of those functional units (example: the tank of the power transformer functional unit of a CEADS-I shall comply with the requirements of IEC 60076 (all parts), if applicable, and IEC 62271-200:2021).

6.105 Sound emission

The power transformer functional unit is the main source of sound. On the other hand, there is no requirement in high-voltage and low-voltage functional units' relevant standards on this matter and the direct contribution of the high-voltage and low-voltage functional units to the sound level of the CEADS is considered, in principle, negligible. However, the determination of CEADS sound level shall be made according to Annex B, on the complete CEADS to take into account any possible interaction.

6.106 Electromagnetic fields

CEADS in service generate electromagnetic fields that may need assessment to:

- assist with planning, installation, operating instruction and service;
- take measures to meet requirements or regulations on electromagnetic fields.

If an evaluation of electromagnetic fields generated by a CEADS is required, the methodology described in IEC TR 62271-208:2009 should be followed.

6.107 Solar radiation

In the case of outdoor installation of CEADS, its performance during service conditions can be substantially affected due to solar radiation. In addition to the losses from the components, solar radiation could be a significant external source of heat that can affect the performance. Every outer part of the CEADS exposed to solar radiation produces an additional heat transfer that can lead to a de-rating of a functional unit due to exceeding the maximum temperature rise established by its specific product standard. As an example, the heat radiation on the high-voltage functional unit enclosure can require its de-rating and/or reduce the current carrying capacity. In some cases, it could lead to the premature malfunction or failure of temperature-sensitive electronic devices.

Annex G of IEC 62271-202:2022 provides guidance on how to assess the effect of solar radiation.

Additional measures, for example double roofing, lighter enclosure colours, double walls, alternative enclosure materials, etc. can be used in order to reduce the effect of solar radiation on the CEADS. Such additional measures are subject to an agreement between the manufacturer and user.

IEC 60721-2-4:2018 can be used to help select the appropriate level of solar radiation.

7 Type tests

7.1 General

7.1.1 Basics

Subclause 7.1.1 of IEC 62271-1:2017 is applicable with the following additions.

In principle, the type tests shall be made on a representative configuration of the CEADS. The functional units and the interconnections contained in a CEADS shall be tested according to their relevant product standard.

Type tests shall be made on the complete CEADS, unless otherwise specified in this document.

Due to the design of the equipment it can be practical to test more than one function at the same time. In that case it is not required to repeat those tests in which the test conditions applied are the same specified in their respective standards.

The aim of the type tests on a CEADS is to demonstrate the characteristics of the CEADS as a complete unit. The required tests on the complete CEADS, in addition to those required for the individual functional units, are listed below:

Mandatory type tests:	Subclause
a) Tests to verify the insulation level of the CEADS	7.2
b) Measurement of the resistance of the main circuit of the high-voltage functional unit	7.4
c) Test to prove the temperature rise of any part of the equipment	7.101
d) Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents	7.6
e) Tests to verify the degree of protection and resistance to mechanical impact	7.7
f) Additional tests on auxiliary and control circuits	7.10
g) Verification of making and breaking capacities of the high-voltage functional unit	7.103
h) Mechanical operation tests	7.104
Mandatory type tests, where applicable:	
i) Tightness tests	7.8
j) EMC compatibility tests	7.9
k) For CEADS intended to be classified IAC, tests to assess the effects of arcing due to an internal arc fault	7.102
l) Pressure withstand tests for gas-filled compartments	7.106
m) Measurements of leakage current of non-metallic enclosures	7.107
n) Tightness and mechanical strength for liquid-filled compartments	7.109
Special type tests (subject to agreement between manufacturer and user):	
o) Tests to verify the sound level of CEADS	Annex B
p) Mechanical stability test	7.105
q) Partial discharge test	7.2.10
r) Weatherproofing tests	7.108
s) Measurement or calculation of electromagnetic fields	7.110

Type tests can impair the suitability of the tested parts for subsequent use in service. Therefore, test objects used for type test shall not be used in service without agreement between manufacturer and user.

7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC 62271-1:2017 is applicable.

7.1.3 Information to be included in type-test reports

Subclause 7.1.3 of IEC 62271-1:2017 is applicable with the following addition to the list:

- the identification, including serial numbers as appropriate, of all functional units of the CEADS, together with the identification of the CEADS itself;
- details of the mechanical and electrical interconnections of the functional units as part of the CEADS;
- drawings and photographs to demonstrate that physical arrangement of the equipment during testing.

Internal arc type test report shall give the information detailed in 7.102.6.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2 of IEC 62271-1:2017 is applicable with the following additions.

When performing dielectric tests, the following criteria are applicable in order to limit the number of required tests:

- a) in the case that each of the main components of the CEADS (high-voltage functional unit, power transformer functional unit and low-voltage functional unit) have been all previously individually type-tested under the same conditions as in the CEADS, there is no need to conduct dielectric tests;
- b) the dielectric tests are not required on the high-voltage interconnection when it is made of high-voltage type-tested earth-shielded cables connected by type-tested earth-shielded connectors or by other types of terminations which have been type-tested on both the high-voltage switchgear and controlgear and the power transformer sides in the installation conditions of the prefabricated substation;
- c) in case the main components (high-voltage functional unit, power transformer functional unit, low-voltage functional unit) are type tested according to their product standards, but the interconnections are not previously type tested, the tests as stated in 7.2.2 and 7.2.3 shall be carried out;
- d) in all other cases, dielectric tests as stated in 7.2.2, 7.2.3, 7.2.4, 7.2.5 and 7.2.6 shall be carried out.

7.2.2 Ambient air conditions during tests

Subclause 7.2.2 of IEC 62271-1:2017 is applicable.

7.2.3 Wet test procedure

In case a wet test is required for outdoor CEADS then 7.2.3 of IEC 62271-1:2017 is applicable.

7.2.4 Arrangement of the equipment

Subclause 7.2.4 of IEC 62271-1:2017 is not applicable. Refer instead to 7.2.101.

7.2.5 Criteria to pass the test

Subclause 7.2.5 of IEC 62271-1:2017 is applicable for the high-voltage tested components.

7.2.6 Application of the test voltage and test conditions

Subclause 7.2.6 of IEC 62271-1:2017 is not applicable. Refer instead to 7.2.101.2.

7.2.7 Tests of switchgear and controlgear of $U_r \leq 245$ kV

Subclause 7.2.7 of IEC 62271-1:2017 is applicable for the high-voltage functional unit.

7.2.8 Tests of switchgear and controlgear of $U_r > 245$ kV

Subclause 7.2.8 of IEC 62271-1:2017 is not applicable.

7.2.9 Artificial pollution tests for outdoor insulators

Subclause 7.2.9 of IEC 62271-1:2017 is only applicable for high-voltage outdoor insulators (if any) of the high-voltage functional unit and of the high-voltage side of the power transformer functional unit.

7.2.10 Partial discharge tests

Subclause 7.2.10 of IEC 62271-1:2017 is not applicable to CEADS.

Partial discharge test can be specified by some of the main components relevant product standards.

By agreement between the manufacturer and the user a test to evaluate the insulation of the high-voltage functional unit can be carried out following 7.2.10 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.2.9 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear, depending on the type of insulation.

7.2.11 Dielectric tests on auxiliary and control circuits

Subclause 7.2.11 of IEC 62271-1:2017 is applicable.

7.2.12 Voltage test as condition check

Subclause 7.2.12 of IEC 62271-1:2017 is not applicable for CEADS.

7.2.101 Dielectric tests on the high-voltage interconnection

7.2.101.1 General conditions

The tests can be carried out with the power transformer replaced by a replica reproducing the field configuration of the transformer bushings.

For the tests, the high-voltage connection is connected to the test supply through the high-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

Voltage limiting devices shall be disconnected during dielectric tests.

Secondary terminals of current transformers shall be short-circuited and connected to earth.

Instrument transformers, power transformers or fuses can be replaced by replicas reproducing the field configuration of the high-voltage connections.

7.2.101.2 Application of test voltage

7.2.101.2.1 General

The test voltages shall be applied connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply. All other conductors of the main circuit, the auxiliary circuits and all other metallic parts shall be connected to the earthing conductor of the frame, and to the earth terminal of the test supply.

Where no-earth-shielded high-voltage connections are used, the non-conductive material shall likewise withstand the test voltages specified in 7.2.101.4. The methods specified in IEC 60243-1:2013 shall be applied to test if the non-conductive material meets the relevant requirements.

7.2.101.2.2 Test voltage

Refer to 7.2.6 of IEC 62271-1:2017.

7.2.101.3 Lightning impulse voltage tests

The high-voltage interconnection shall be subjected to lightning impulse voltage tests according to 7.2.7.3 of IEC 62271-1:2017 with the following addition:

During the lightning impulse-voltage tests, the grounded terminal of the impulse generator shall be connected to the main earthing conductor system of the CEADS. Overvoltage suppressing means shall be disconnected.

7.2.101.4 Power-frequency voltage withstand tests

The high-voltage interconnection shall be subjected to 1 min power-frequency voltage withstand tests in dry conditions in accordance with 7.2.7.2 of IEC 62271-1:2017 with the following addition.

During the power-frequency voltage test, one terminal of the test transformer shall be connected to earth and to the main earthing conductor system of the CEADS.

7.2.101.5 High-voltage interconnection covered by non-metallic enclosure

When the interconnection is totally or partially covered by a non-metallic enclosure accessible during normal operation, the enclosure shall meet the following requirements.

- a) The insulation between live parts of the main circuit and the accessible surface of insulating enclosure shall withstand the test voltages specified in 5.3 of IEC 62271-1:2017 for voltage tests to earth and between poles.
- b) The insulating material shall withstand the power-frequency test voltage specified in item a). The appropriate test methods given in IEC 60243-1:2013 shall be applied to test if the insulating material meets the relevant requirements.
- c) The insulation between live parts of the main circuit and the inner surface of insulating enclosure facing these shall withstand at least 150 % of the rated voltage of the equipment for one minute. This shall be tested according to 6.104 of IEC 62271-201:2014 taking into account the selected protection category of the interconnection.
- d) If a leakage current can reach the accessible side of the insulating enclosure by a continuous path over insulating surfaces, it shall be not greater than 0,5 mA under the specified test conditions (refer to 7.104).

For testing procedures see 7.2.101.2.2 of IEC 62271-202:2022.

7.2.102 Dielectric tests on the low-voltage interconnection

7.2.102.1 General conditions

For the tests, the low-voltage interconnection is connected to the test supply through the low-voltage functional unit. One terminal of the voltage source shall be connected to the main earthing conductor system of the CEADS. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

When the low-voltage interconnection is partially or totally covered by a non-metallic enclosure, the enclosure shall be covered by a circular or square metal foil having an area as large as possible, but not exceeding 100 cm² connected to the earth. The foil shall be applied to all surfaces that can be touched by an operator.

7.2.102.2 Lightning impulse-voltage tests

The low-voltage interconnection shall be subjected to lightning impulse-voltage tests. The rated impulse-voltage test is chosen in accordance with 5.3.

The 1,2/50 µs impulse voltage shall be applied three times for each polarity at intervals of 1 s minimum. Voltage surge suppression devices shall be disconnected.

The test voltage shall be applied connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply. All other conductors of the main circuit and the auxiliary circuits shall be connected to the earthing conductor or the frame and to the earth terminal of the test supply.

There shall be no disruptive discharge during the tests.

7.2.102.3 Power-frequency voltage withstand test

The low-voltage interconnection shall be subjected to 1 min power-frequency voltage withstand tests in dry conditions in accordance with 10.9.2 of IEC 61439-1:2020 with the following addition:

During the power-frequency voltage withstand test, one terminal of the test transformer shall be connected to earth and to the main earthing conductor system of the CEADS.

7.2.103 Dielectric tests on high-voltage functional unit

Subclause 7.2 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.2 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable with the following addition:

In case that the design of CEADS does not allow to separate physically power transformer functional unit and high-voltage functional unit, the tests of the high-voltage functional unit shall be carried out with the power transformer functional unit isolated from the high-voltage functional unit (e.g. by removing the interconnection).

7.2.104 Dielectric tests on power transformer functional unit

Tests prescribed in the IEC 60076 (all parts) shall be applied, with the following considerations:

Preferably the power transformer functional unit should be disconnected from the high-voltage functional unit and the low-voltage functional unit. However, for practical reasons the test voltage can be applied through the high-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

7.2.105 Dielectric tests on low-voltage functional unit

Subclause 9.1 of IEC 61439-1:2020 is applicable.

For practical reasons this test can be performed on the low-voltage functional unit already installed in CEADS. In this case the low-voltage functional unit shall be isolated from the power transformer functional unit.

7.3 Radio interference voltage (RIV) test

Subclause 7.3 of IEC 62271-1:2017 is not applicable for CEADS.

7.4 Resistance measurement

Subclause 7.4 of IEC 62271-1:2017 is applicable with the following considerations.

When the power transformer functional unit cannot be disconnected from the high-voltage functional unit, the resistance measurement can be influenced by the power transformer high-voltage windings.

7.5 Continuous current tests

Subclause 7.5 of IEC 62271-1:2017 is applicable with the following considerations.

This test is applicable for CEADS-G and CEADS-A. For CEADS-I, when the power transformer functional unit cannot be disconnected from the high-voltage functional unit, this test is not applicable.

7.6 Short-time withstand current and peak withstand current tests

Subclause 7.6 of IEC 62271-1:2017 is not applicable to CEADS.

7.6.101 Short-time and peak withstand current tests on main circuit of high-voltage and low-voltage functional units

The high-voltage functional unit that has not been previously tested shall be submitted to test according to 7.6 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.6 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear. The high-voltage functional unit shall be isolated from the power transformer functional unit to perform the test.

The low-voltage functional unit that has not been previously tested shall be submitted to test according to IEC 61439-1:2020. The low-voltage functional unit shall be isolated from the power transformer functional unit to perform the test.

7.6.102 Short-time and peak withstand current tests on high-voltage and low-voltage interconnections

High-voltage interconnection shall be tested following the procedure described in 7.6.1 a) of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.6 a) of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear. The test current shall be applied in such a manner that the complete connection to the power transformer is tested. All parts supporting the interconnection shall be maintained in place, as in service condition, during the test.

In particular, when the high-voltage interconnection is protected by current-limiting devices situated in the high-voltage switchgear, provisions of 7.6.1 a) of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.6 a) of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear are applicable.

If the high-voltage interconnection is not protected by current limiting devices, the test can be made, where appropriate, at the same time as the high-voltage functional unit is tested, provided that the conditions of 7.6.1 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.6 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear are met.

Non type-tested low-voltage interconnections can be tested following the procedure described in IEC 61439-1:2020 for low-voltage switchgear and controlgear assembly. Where appropriate this test can be made at the same time as the low-voltage functional unit is tested. The test current shall be applied in such a manner that the complete connection to the power transformer functional unit is tested. All parts supporting the interconnection shall be maintained in place, as in service condition, during the test.

For safety reasons, the power transformer can be replaced by a replica for short-time and peak current type tests. To verify interconnections ability to withstand the test, a short-circuit is made at both sides of the power transformer replica terminals.

7.6.103 Short-time and peak withstand current tests on earthing circuits

The earthing circuit of the CEADS shall be tested according to 7.6 of IEC 62271-1:2017 with the addition of the following paragraphs:

The type tests shall not be repeated on the main earthing circuits of type-tested functional units.

After the test, some deformation of the main earthing conductor and of the connections to the functional units is permissible, but the continuity of the circuit shall be preserved.

Test of connections of metallic covers and doors not belonging to the main earthing circuit is not required. However, they can be tested at 30 A (DC) to demonstrate the electrical continuity of earthed metallic parts. In this case, the voltage drop shall be lower than 3 V.

7.6.104 Short-circuit current tests on power transformer functional unit

By agreement between the manufacturer and the user a short circuit test according to IEC 60076-5:2006 on the power transformer functional unit might be carried out.

Preferably the power transformer functional unit should be disconnected from the high-voltage functional unit and the low-voltage functional unit. However, for practical reasons, the test voltage can be applied through the high-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

7.7 Verification of the protection

Subclause 7.7 of IEC 62271-1:2017 is applicable with the following addition.

Verification of the protection against mechanical stresses according to 6.14 and 6.101 shall be checked.

7.8 Tightness tests

Subclause 7.8 of IEC 62271-1:2017 is applicable for high-voltage functional unit.

7.9 Electromagnetic compatibility tests (EMC)

For high-voltage functional unit 7.9 of IEC 62271-1:2017 is applicable with the exception of radio interference voltage test.

For low-voltage functional unit 10.12 of IEC 61439-1:2020 is applicable.

A test on a CEADS is not necessary provided that the high-voltage functional unit and low-voltage functional unit have been tested according to their relevant standards.

7.10 Additional tests on auxiliary and control circuits

7.10.1 General

Subclause 7.10 of IEC 62271-1:2017 is applicable, with the following addition:

These tests shall be performed on the complete CEADS and are only applicable to the auxiliary and control low-voltage circuits. Low-voltage power circuits, i.e. secondary of power transformer, low-voltage interconnection and low-voltage functional unit, are excluded from the test.

7.10.2 Functional tests

A functional test of all low-voltage circuits shall be made to verify the proper functioning of auxiliary and control circuits in conjunction with the other parts of the CEADS.

The tests shall be performed with the upper and lower value limits of the supply voltage defined in 5.9.

For low-voltage circuits, sub-assemblies and components, operation tests may be omitted if they have been fully performed during a test applied to similar CEADS.

7.10.3 Verification of the operational characteristics of auxiliary contacts

Subclause 7.10.3 of IEC 62271-1:2017 is applicable.

7.10.4 Environmental tests

Subclause 7.10.4 of IEC 62271-1:2017 is applicable on a representative sample of an auxiliary and control circuit with following limitations.

These tests do not apply for indoor switchgear and controlgear operated under normal service conditions as defined by Clause 4 of IEC 62271-1:2017.

When the tests as stated in 7.10.4 of IEC 62271-1:2017 have been performed on the separate components of a representative sample of an auxiliary and control circuit, no further environmental tests are needed.

Where this is not carried out, 7.10.4 of IEC 62271-1:2017 is applicable on a typical lay-out of the auxiliary and control circuits.

7.10.5 Dielectric test

Subclause 7.10.5 of IEC 62271-1:2017 is applicable.

7.11 X-radiation test for vacuum interrupters

Subclause 7.11 of IEC 62271-1:2017 is applicable for high-voltage functional units where vacuum interrupters are used.

7.101 Temperature-rise tests

7.101.1 General

The purpose of this test is to check that the temperature increases of the components when adapted to the design of the CEADS in its entirety does not impair the life-time expectancy of the functional units and their interconnections. Their life-time expectancy shall not be influenced if the acceptable limits of deterioration of insulation through thermal effects are not exceeded. As stated in Clause 4, the functional units, which form part of a CEADS, shall comply at least with the requirements of their respective standards. To ensure this compliance, the relevant type tests can be carried out on each functional unit, being alone or embedded in the CEADS. In addition, as stated in the introduction, potential interactions between devices shall be evaluated.

Two situations can be considered.

The temperature rise tests are previously performed on each functional unit alone. Then the purpose of the temperature-rise test on the complete CEADS is to assess the possible interactions, to define corresponding de-rating of the functional units if any, and to verify the temperature rise of the interconnections.

The temperature-rise tests are not previously performed on each functional unit alone. Then the purpose of the temperature-rise test on the complete CEADS is to verify the temperature rise of the functional units according to their respective standards and at the same time the temperature rise of the interconnections.

7.101.2 Test conditions

Main functional units and interconnections temperature-rise tests shall be performed simultaneously on a complete CEADS. In the case of already type-tested high-voltage functional unit and where it is considered that there is no significant influence of the temperature-rise of the high-voltage functional unit on the other functional units, or vice-versa, the temperature-rise test shall not include the current flowing in the main circuit of the high-voltage functional unit (see Figure 1). If it cannot be demonstrated otherwise a complete test of the CEADS shall be performed (see Figure 2). For the high-voltage functional unit the procedure of 7.5 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.5 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear shall be applied.

NOTE 1 Reasons for concern could be, for example, where the temperature-rise values reported during the type test are close to the acceptable limits, or the influence of other functional units on the power transformer feeder during the temperature-rise test of the complete CEADS is so high that can be estimated that the influence on the main circuit can compromise their rated values. In that case de-rating of the high-voltage functional unit is considered.

NOTE 2 It is a common practice that the high-voltage functional unit operates at much lower current (load) than its rated one. Taking this into account, the additional increase of temperature caused by operating as part of a CEADS in most cases has no relevant influence on the required current capability of the high-voltage functional unit. In cases where full load conditions are expected in the main circuit this assumption cannot be valid.

In case of high-voltage functional unit not previously type tested, a complete temperature-rise test of the CEADS shall be performed, according to Figure 2.

The distribution of current at the low-voltage functional unit feeders shall be chosen to be the worst condition in respect of heat generation.

NOTE 3 The low-voltage functional unit feeders comprise not only traditional electric distribution applications outgoing feeders but incoming feeders from back-feeding installations such as low voltage side generating plants.

If low-voltage functional unit feeders are equipped with fuses, these fuses shall be present during test and shall represent the service conditions. As an option, the feeders can be fitted with fuse-links instead of fuses. The rated power losses of the fuse-links used for the test shall be stated in the type test report. Fuse-link power loss shall be determined by measurement or alternatively as declared by the fuse-link manufacturer.

The test shall be carried out in a test room in which the dimensions and insulation shall keep the ambient air temperature of the room within the limits specified in 7.101.5.1.

The test room environment shall be substantially free from air currents, except those generated by heat from the equipment under test. In practice, this condition is reached when the air velocity does not exceed 0,5 m/s.

7.101.3 Test methods

7.101.3.1 General

Two different testing situations are considered (see 7.101.1).

- a) The temperature-rise test shall not include the current flowing in the main circuit of the high-voltage functional unit because the temperature-rise test on the high-voltage functional unit has been previously carried out and the influence of the other functional units is deemed to be not significant for the temperature-rise of the high-voltage functional unit in the CEADS.
- b) The temperature-rise test shall include the current flowing in the main circuit of the high-voltage functional unit because the temperature-rise test on the high-voltage functional unit has not been previously carried out or the influence of the other functional units is deemed to be significant on the temperature-rise of the high-voltage functional unit when installed in the CEADS.

The following test methods can be used:

- The preferred method requires the use of independent sources of current to supply the high-voltage and the low-voltage sides of the CEADS.
- An alternative method can be used if the laboratory can provide only one source of current or the design of the CEADS makes the connection arrangements as described by Figure 1 impossible. The alternative method is applicable in case of situation a).

7.101.3.2 Preferred method

7.101.3.2.1 General

This method requires different connections of supply for the high-voltage and the low-voltage sides respectively.

7.101.3.2.2 Connection of supplies

a) High-voltage side

According to the two situations described above, the following testing procedures shall be used.

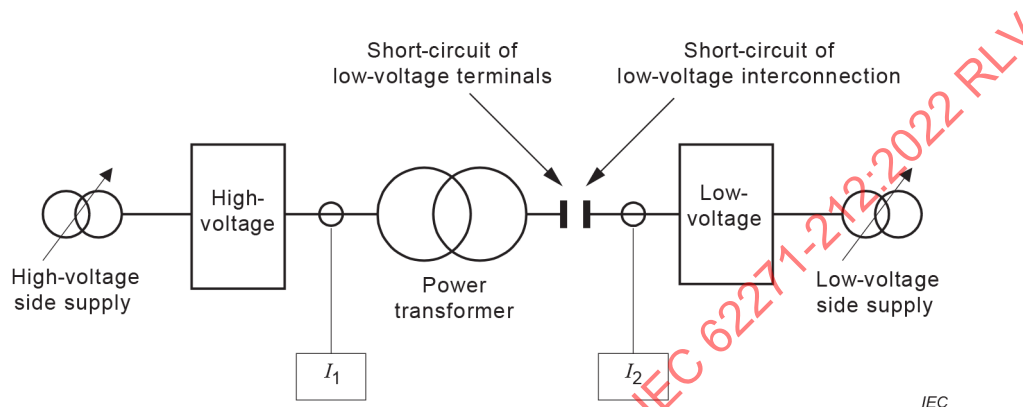
If the test does not require to include the current flowing in the main circuit of the high-voltage functional unit, the power transformer functional unit and the high-voltage functional unit shall be connected to one current supply and the low-voltage terminals of the power transformer functional unit shall be short-circuited. The supply shall be connected to the incoming feeder of the high-voltage functional unit. Refer to Figure 1.

If the test requires to include the current flowing in the main circuit of the high-voltage functional unit, it shall be isolated from the T-off (power transformer feeder) and two different supplies on the high-voltage side shall be used. The first one shall supply the high-voltage main circuit with its rated current. The second shall supply the high-voltage side of the power transformer functional unit through the T-off of the high-voltage functional unit and the low-voltage terminals of the power transformer functional unit shall be short-circuited. Figure 2 graphically explains the connection of supplies under an assembly with larger high-voltage main circuit.

b) Low-voltage side

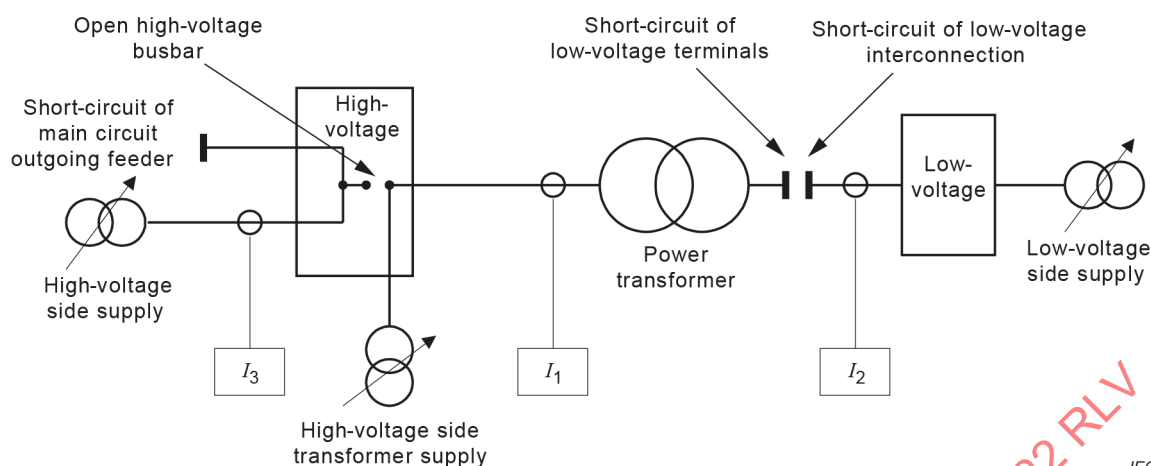
The temperature-rise test on the low-voltage side shall be carried out in accordance with 10.10 of IEC 61439-1:2020 and the following specific requirements.

The low-voltage functional unit shall be isolated from the power transformer functional unit, as close as practicable to the power transformer functional unit terminals. At a convenient point adjacent to the power transformer functional unit terminals, a short-circuit shall be applied to the connections between the power transformer functional unit and the low-voltage functional unit. Test current shall be applied to the low-voltage functional unit via the feeders.

**Key**

- I_1 sufficient current to generate the total losses in accordance with Step 1 and Step 2 of 7.101.3.3.3 for liquid-immersed power transformer functional unit or high-voltage rated current of dry-type power transformer functional unit (see 7.101.4 step 2)
- I_2 current determined by the power transformer functional unit rated power at its low-voltage side at the maximum current tapping

Figure 1 – Test diagram in case of type-tested high-voltage functional unit



Key

- I_1 sufficient current to generate the total losses of liquid-filled power transformer functional unit or high-voltage rated current of dry-type power transformer functional unit (see 7.101.4 step 2)
- I_2 current determined by the power transformer functional unit rated power at its low-voltage side at the maximum current tapping
- I_3 rated continuous current of high-voltage main circuit

Figure 2 – Test diagram in case of non-type-tested high-voltage functional unit

7.101.3.2.3 Application of test currents

a) High-voltage side

For liquid filled power transformer functional unit the circuit is supplied with sufficient current to generate the total losses of the power transformer functional unit, at its reference temperature, using the method defined in IEC 60076-2:2011.

NOTE 1 A small percentage of current above the rated current flowing through the complete circuit can be used so as to compensate for the power transformer functional unit no-load losses.

NOTE 2 During the test, the resistance can vary according to the temperature of the power transformer functional unit. Thus, the test supply current is varied accordingly to maintain the generated losses constant and equal to the total power transformer functional unit losses throughout the test.

For dry type power transformer functional units, the simulated load method described in IEC 60076-11:2018 shall be followed (see 7.101.4).

b) Low-voltage side

The low-voltage circuit is supplied with the current determined by the power transformer functional unit rated power at its low-voltage side at the maximum current tapping.

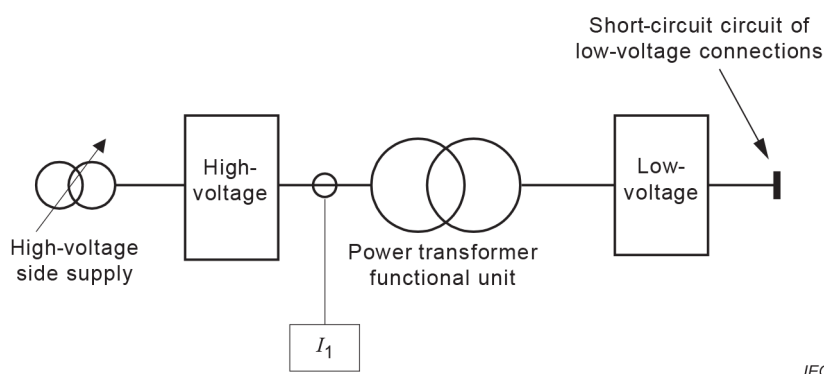
7.101.3.3 Alternative method

7.101.3.3.1 General

This method requires one single supply.

7.101.3.3.2 Connection of supply

The high-voltage functional unit and the power transformer functional unit shall be connected and the feeders of the low-voltage functional unit shall be short-circuited. The supply shall be connected to the incoming terminals of the high-voltage functional unit (see Figure 3).



IEC

Key

I_1 sufficient current to generate the total losses of liquid-filled power transformer functional unit (see 7.101.3.3.3 step 1 and step 2)

Figure 3 – Diagram of the temperature-rise test alternative method

7.101.3.3.3 Application of test current

When the CEADS is equipped with a liquid-immersed power transformer functional unit, the application of test currents should follow the method as described in 7.3.2 of IEC 60076-2:2011 consisting of the two following consecutive steps.

Step 1:

The CEADS is supplied with sufficient current to generate the total losses of the power transformer functional unit, at its reference temperature, using the method defined in IEC 60076-2:2011.

NOTE The total power supplied to the complete prefabricated substation can be higher than the power transformer total rated losses due to the connection of the low-voltage switchgear assembly.

Step 2:

The supply current is reduced so that the high-voltage rated current of the power transformer is injected for 1 h in accordance with IEC 60076-2:2011.

At the end of the second step, the low-voltage and high-voltage switchgear temperature measurements shall be made in accordance with 7.101.5.3 and 7.101.5.4.

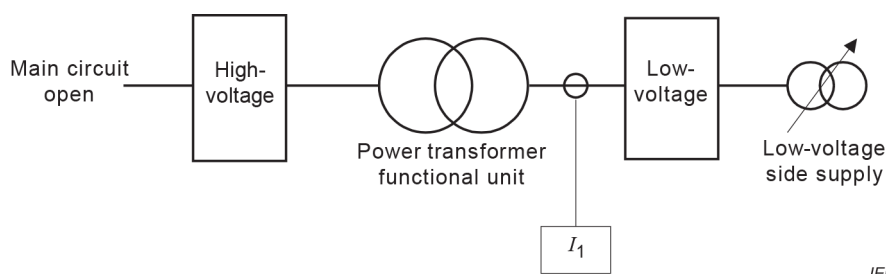
7.101.4 Test method for CEADS equipped with dry-type power transformer functional unit

For a temperature-rise test on a CEADS equipped with a dry-type power transformer functional unit, the method for the temperature-rise test should follow the simulated load method as described in IEC 60076-11:2018 consisting of two consecutive steps.

Step 1:

The open-circuit test shall be performed in such a manner that the rated operating voltage (three-phase) at rated frequency is applied to the low-voltage winding of the power transformer functional unit via one of the feeders of the low-voltage functional unit. The high-voltage winding is connected to the high-voltage functional unit. High-voltage main circuit is open (see Figure 4). Once the steady state condition of the windings and magnetic core has been reached (see 14.3.2.4 of IEC 60076-11:2018), the temperature-rise of each winding of the dry-type power transformer functional unit shall then be measured.

This test can also be made by feeding the high-voltage winding of the power transformer functional unit via high-voltage functional unit. The low voltage winding is connected to the low-voltage functional unit. Low-voltage main circuit is open.



Key

I_1 no load current of the power transformer

Figure 4 – Diagram for the open-circuit test

Step 2:

The connection of supplies is made according to 7.101.3.3.2 (Figure 3) or 7.101.3.2.2 (Figure 1 or Figure 2).

When the steady-state condition of the windings and magnetic core is achieved, the temperature rises of each winding of the dry-type power transformer functional unit shall be measured together with the temperature rises of the low-voltage functional unit and the interconnections and high-voltage functional unit for case b) of 7.101.3.1. For the steady-state conditions of dry-type power transformer functional unit refer to 14.3.2.4 of IEC 60076-11:2018.

After completion of the two steps above the temperature rise of the power transformer functional unit is calculated by the formula given in 14.3.2.2.2 of IEC 60076-11:2018.

7.101.5 Measurements

7.101.5.1 Measurements of the ambient air temperature

The ambient air temperature is the average temperature of the air surrounding the CEADS. It shall be measured during the last part of the test period or each test step (depending on test method) by means of at least four thermometers, thermocouples or other temperature-measuring devices equally distributed around the CEADS at about the average height of its current-carrying parts and at a distance of about 1 m from the CEADS. The thermometers or thermocouples shall be protected against air currents and undue influence of heat.

In order to avoid indication errors because of rapid temperature changes, the thermometers or thermocouples can be put into small bottles containing about half a litre of oil.

During the last part of the test period or each test step (depending on test method), the change of ambient air temperature shall not exceed 1 K in 1 h. The ambient air temperature during tests shall be more than +10 °C but less than +40 °C. No correction of the temperature-rise values shall be made for ambient air temperatures within this range.

7.101.5.2 Power transformer functional unit

In the case of already type-tested power transformer functional unit, the top liquid temperature-rise for liquid-filled power transformer functional units shall be measured as given in IEC 60076-2:2011, or the average winding temperature rises for dry-type power transformer functional units shall be measured as given in IEC 60076-11:2018.

In addition to this, in the case of non-type-tested power transformer functional unit measurement of the temperature-rise of the windings shall be performed according to IEC 60076-2:2011 for liquid-filled power transformer functional units or IEC 60076-11:2018 for dry-type power transformer functional units.

7.101.5.3 Low-voltage functional unit

The low-voltage functional unit temperature-rise shall be measured as given in 10.10 of IEC 61439-1:2020.

The air temperature in the location where electronic equipment can be installed shall be measured. The temperature shall be within the service condition applicable to the contained electronic equipment.

7.101.5.4 High-voltage functional unit

If this test is considered to be necessary or in case of non-type-tested high-voltage functional unit, a complete measurement shall be performed according to IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.

The air temperature in the location where electronic equipment can be installed shall be measured. The temperature shall be within the service condition applicable to the contained electronic equipment.

7.101.5.5 Interconnections

The temperature of the high-voltage and low-voltage interconnections, their terminals and accessible parts expected to be touched in normal operation shall be measured according to 7.5.6 of IEC 62271-1:2017.

7.101.5.6 Acceptance criteria

The CEADS is deemed to pass the test if:

- a) the temperature-rise of the power transformer functional unit does not exceed the requirements of Clause 6 of IEC 60076-2:2011 for liquid-filled power transformer functional units or Clause 10 of IEC 60076-11:2018 for dry-type power transformer functional units. If the liquid-filled power transformer functional unit has been tested previously only the top liquid temperature shall be checked;
- b) the temperature-rise and temperatures of the high-voltage functional units and high-voltage interconnection do not exceed the requirements of 7.5.6 of IEC 62271-1:2017;
- c) the temperature rises and temperatures of the low-voltage functional unit and low-voltage interconnection do not exceed the requirements of 9.2 of IEC 61439-1:2020;
- d) for the accessible parts of CEADS the temperature-rise and temperatures do not exceed the requirements of 7.5.6 of IEC 62271-1:2017 for accessible parts expected to be touched in normal operation.

NOTE If the values for accessible parts expected to be touched in normal operation are exceeded, additional precautions, covers, barriers and access limitation can be taken on site to avoid the risk of burns.

7.101.6 Temperature-rise due to solar radiation

In case of outdoor installation of CEADS, the effect of solar radiation could affect its performance. In order to evaluate the influence, CEADS can be subjected to a temperature rise type test with the addition of a simulated solar radiation in accordance with Annex G of IEC 62271-202:2022. The purpose of the test is to determine the impact due to solar radiation in terms of additional temperature rise on main components of CEADS and on those accessible parts expected to be touched in normal operation. If necessary, the required de-rating of CEADS could then be determined.

7.102 Internal arc test

7.102.1 General

These tests are applicable to CEADS, intended to be qualified as class IAC with respect to protection of persons in the event of an internal arc at high-voltage functional unit side.

These tests cover the cases of faults resulting in an arc occurring inside the CEADS in the high-voltage functional unit and the high-voltage interconnection. The effectiveness of the design of the CEADS to provide protection to persons in case of an internal arc can be verified by testing according to Annex A.

CEADS are generally intended for installation in closed electrical operating areas, where, in principle, only authorised personnel can enter. However, the employees of an industrial facility not in charge of the operation of the high-voltage functional unit, can stand occasionally in the proximity of a CEADS. As they are not aware of the risks involved, they are considered to be general public in the context of this document. Consequently, the document considers both accessibility types A and B, as in IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.

IAC-A is intended to verify the protection of operators when operating the CEADS and is based on a restriction to authorised persons only (Accessibility Type A, see 5.102.2).

IAC-B is intended to verify the protection of the general public around the CEADS with unrestricted access (Accessibility Type B, see 5.102.2).

The manufacturer shall indicate which parts of the CEADS are classified as accessible during an internal arc event and which are defined as high-voltage operating side(s) according to the tested IAC classification.

This IAC classification is intended to offer a tested level of protection to persons (including operators) around CEADS in the event of internal arcs in normal operating conditions and with its high-voltage functional unit in normal service position.

NOTE This document covers only internal arcs occurring in the high-voltage side of the CEADS, including high-voltage-interconnections (e.g. between high-voltage functional unit and power transformer functional unit). Internal arcs within the power transformer functional unit or the low-voltage functional unit are not taken into account (see 6.103 for explanation of this exclusion).

Internal arcs in a CEADS can occur in a number of locations and can cause various physical phenomena. For example, the energy resulting from an arc developed in open air within the CEADS or in any insulating fluid within the enclosure of any of the high-voltage functional units can cause an internal overpressure and local overheating which can result in mechanical and thermal stressing of room or the enclosure (if any) containing the CEADS. Moreover, the materials involved can produce hot decomposition products, either gaseous or vaporous, which can be discharged around the CEADS.

The Internal Arc Class (IAC) makes allowance for internal overpressure acting on covers, doors, floor(s), etc. It also takes into consideration the thermal effects of arc or its roots on the enclosure and of ejected hot gases and glowing particles, but not damage to internal partitions, shutters or other internal installations not being accessible in normal operating conditions.

The internal arc tests described below does not cover all effects that can constitute a hazard, such as the presence of gases with potential toxic characteristics that can be present after the fault, or the hazard of propagation of fire after an internal arc to combustible materials or equipment placed in the proximity of the CEADS.

7.102.2 Test conditions

To be qualified as class IAC-A and/or IAC-B a CEADS shall be subjected to a different test series, one on the high-voltage functional unit and, if applicable, on the high-voltage interconnections. To be qualified as class IAC-AB the CEADS shall be subjected to the test series for IAC-A and IAC-B.

For required tests, see Figure A.7, Figure A.8, Figure A.9 and Figure A.10, showing the principles for the selection of tests and the corresponding number and type of tests to be performed.

The internal arc test shall be performed on a complete CEADS to ensure that the influence of all devices is represented. If any device is used to limit the duration of the arc (for example protection relay, fuses), it can be operative during the test but the part of the CEADS protected by the device shall be classified per the actual duration of the arc. The test current shall be maintained for the rated short-circuit duration of the main circuit.

As an exception, the test on high-voltage functional unit might be not necessary, provided that:

- this functional unit has been previously internal arc classified according to 5.103 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 4.101 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear, in a test arrangement equal or more onerous than the actual installation conditions in the CEADS;
- it can be proven that the other components of the CEADS do not affect the behaviour.

In the case where open-air fuse-bases devices are used as high-voltage functional unit, a three-phase test shall be performed at the feeding side of the fuse-bases.

7.102.3 Arrangement of the equipment

The following points shall be observed:

- tests shall be carried out on a CEADS not previously subjected to arcing, or, if subjected, being in a condition which does not affect the result of the test;
- the CEADS shall be fully equipped, including high-voltage interconnection. Mock-ups of internal components that shall not be exposed to the arc are permitted provided they have the same volume and external material as the original components;
- when the CEADS is connected to earth, the connection shall be at the point provided.

7.102.4 Test procedure

The method to verify the internal arc classification is defined in A.6.

7.102.5 Criteria to pass the test

A CEADS is qualified as class IAC (according to the relevant accessibility type) providing that:

- the five criteria as in 7.105.5 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.105.5 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear have been met after the internal arc test on the high-voltage functional unit,

NOTE Where the design of the CEADS includes a space below the floor to receive the exhausting gases, the behaviour of the floor is assessed from the point of view of the safety of the operator standing on it.

- where applicable (see Figure A.9 and Figure A.10), the following criteria have been met after test on the high-voltage interconnections:

Criterion no.1 Barriers, obstacles or enclosures of the high-voltage interconnection, if any, are not moved or deformed further than the position of the indicators.

- | | |
|----------------|--|
| Criterion no.2 | No material projections of an individual mass above 60 g or more falling to the floor in the immediate vicinity of the assembly (in the case of accessible sides, this means between the assembly and the indicator rack). |
| Criterion no.3 | Arcing does not cause holes in the accessible side of the enclosure of the high-voltage interconnection. |
| Criterion no.4 | <p>Indicators do not ignite due to the effect of flames or hot gases.</p> <p>Should they start to burn during the test, the assessment criterion can be regarded as having been met, if proof is established of the fact that glowing particles rather than hot gases caused the ignition. Pictures taken by high-speed cameras, video or any other suitable means can be used by the test laboratory to establish evidence.</p> <p>Indicators ignited as a result of paint or stickers burning are also excluded from the assessment.</p> |
| Criterion no.5 | If the high-voltage interconnection is protected by an enclosure connected to earth, this enclosure remains connected to its earthing point. |

7.102.6 Test report

The following information shall be given in the test report:

- description of test object: comprehensive list of drawings and documents to identify critical aspects of the design regarding gas cooling, exhausting path or arrangement of cable ducts if used to exhaust gases;
- ratings and description of the CEADS with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief flaps and the method of fixing the CEADS to the floor and/or to the walls;
- high-voltage functional unit type and ratings, as well as a specific mention to high-voltage functional unit internal arc classification, if any;
- type of high-voltage interconnections;
- arrangement of the test connections;
- spatial dimensional arrangement of main components;
- the ceiling height for installation or the relative distance between the upper part of the test object and the ceiling of the room or building;
- point and method of initiation of the internal arc;
- drawings or photographs of test arrangement (room simulation, test object and mounting frame of indicators) with respect to the type of accessibility (A or B), operating side (F, L or R) and installation conditions;
- applied voltage and frequency;
- for the prospective or test current:
 - a) RMS value of the AC component during the first three half cycles;
 - b) highest peak value;
 - c) average value of the AC component over the actual duration of the test;
 - d) duration of arc fault current;
- oscillogram(s) showing currents and voltages;
- assessment of the test results, including a record of the observations in accordance with 7.102.5;
- photographs of the test object under test, before and after test;
- other relevant remarks.

7.102.7 Extension of validity of test results

The validity of the results of a test carried out on a particular CEADS design or representative part of it can be transferred to another one, provided that the original test was equal or more onerous and that the design under consideration can be considered as similar to the one tested in all of the following characteristics:

- arc current and arcing time;
- directions of gas flow from the internal arc;
- dimensions of the tested compartments and layout of the CEADS;
- structure and mechanical strength of the compartments and partitions, if any;
- performance of the pressure release device, if any.

NOTE If applicable, the assessment of the high-voltage functional unit assembly of the CEADS can be done in accordance with IEC TR 62271-307 [8].

7.103 Verification of making and breaking capacities of high-voltage functional unit

Subclause 7.101 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 6.101 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable with the following addition:

It is not required to repeat the type tests to verify making and breaking capability on previously type-tested components, provided that mechanical, thermal and electrical conditions during test are representative of the service conditions when installed in the CEADS.

7.104 Mechanical operation tests

Subclauses 7.102 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear and 6.102 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear are applicable to high-voltage functional unit and 10.2.8 of IEC 61439-1:2020 is applicable for low-voltage functional unit, with the following addition:

Mechanical operation test shall not be repeated if the functional units have been previously type tested, provided that the installation of the functional unit within the CEADS does not impose conditions that could influence negatively the operation. In case of doubt the test shall be repeated in the real installation conditions.

7.105 Mechanical stability test

The type tests for the complete assembly shall include a test for stability. The test shall be conducted with care to ensure that the equipment cannot topple in an uncontrolled manner. The complete CEADS shall be lifted, by the specified lifting lugs, to verify the assembly stability for safe handling and operations. A second test shall comprise lifting one side of the equipment by 15° to check that there is no toppling. When agreed between manufacturer and user, this last test can be repeated to check stability lifting from any of the sides.

NOTE It is suggested that the equipment can be supported with a crane during the test.

7.106 Pressure withstand test for gas-filled compartments

Subclause 7.103 of IEC 62271-200:2021 is applicable with the following addition:

Pressure withstand test for gas-filled compartments shall not be repeated if the functional units have been previously type tested, provided that the installation of the functional unit within the CEADS does not impose conditions that could influence negatively the tightness. In case of doubt, the test shall be repeated in the real installation conditions.

7.107 Measurements of leakage currents of non-metallic enclosures

When the high-voltage interconnection is totally or partially covered by a non-metallic enclosure the following tests shall be made in order to check compliance with the requirement of item d) of 7.2.101.5.

At the discretion of the manufacturer, the main circuit shall be connected either to a three-phase supply of power-frequency voltage equal to the rated voltage of the high-voltage functional unit, with one phase connected to earth, or to a single-phase supply of a voltage equal to the rated voltage. The live parts of the main circuit shall be connected together. For three-phase tests, three measurements shall be made with the different phases of the supply successively connected to earth. In the case of single-phase tests, only one measurement is necessary.

A metal foil shall be placed in the most unfavourable situation for the test on the accessible surface of the insulation providing the protection against contact with live parts. In case of doubt about the most unfavourable situation, the test shall be repeated with different situations.

The metal foil shall be approximately circular or square, having an area as large as possible but not exceeding 100 cm². The enclosure and the frame of the high-voltage functional unit and the power transformer shall be earthed. The leakage current flowing through the metal foil to earth shall be measured with the insulation dry and clean.

If the value of the leakage current measured is more than 0,5 mA, the insulating surface does not provide the protection required in this document.

It is not necessary to measure leakage currents, if earthed metal parts are arranged in an appropriate manner to ensure that leakage currents cannot reach the accessible parts of the enclosure.

7.108 Weatherproofing test

When agreed between manufacturer and user, a weatherproofing test can be made on outdoor CEADS. A recommended method is given in Annex C of IEC 62271-1:2017.

7.109 Tightness and mechanical strength for liquid filled compartments

If the enclosure is of hermetically sealed type and completely liquid filled, 11.8 of IEC 60076-1:2011 is applicable with the following addition:

The test shall be performed on a complete CEADS to ensure that the influence of all devices is represented.

NOTE Mechanical withstand tests specified in EN 50464-4 [9] and IEEE C57.12.00 [10] can be considered as alternative test method references for corrugated tanks of liquid filled power transformer functional unit.

7.110 Measurement or calculation of electromagnetic fields

General guidance regarding the measurement or calculation of electromagnetic fields is given in IEC TR 62271-208:2009.

8 Routine tests

8.1 General

Clause 8 of IEC 62271-1:2017 is not applicable for CEADS.

The routine tests shall be made on each complete CEADS at the manufacturer's factory to ensure that the product quality is in accordance with the equipment on which the type tests have been carried out.

Due to the special design of this equipment it can be practical to test more than one functional unit at the same time.

The routine tests comprise the following:

- dielectric test on the main circuit (8.2);
- tests on auxiliary and control circuits (8.3);
- measurement of the resistance of the main circuit (8.4);
- tightness test (8.5);
- design and visual checks (8.6);
- mechanical operation tests on high-voltage functional units (8.101);
- pressure tests of gas-filled compartments (8.102);
- tests of auxiliary electrical, pneumatic and hydraulic devices (8.103);
- measurement of the resistance of the windings (8.104);
- measurement of the voltage ratio (8.105);
- measurement of the short circuit impedance and load losses (8.106);
- measurement of non-load losses and current (8.107);
- inspection of the low-voltage functional unit, including inspection of wiring and, if necessary, electrical operation test (8.108);
- checking of protective measures and of the electrical continuity of the protective circuits of the low-voltage functional unit (8.109);
- tests after assembly onsite (8.110).

If the components of the CEADS have been routine tested before in accordance with their relevant standards, these tests shall not be repeated unless the characteristics of the components are modified during manufacturing of the CEADS.

8.2 Dielectric tests on the main circuit

8.2.101 General

Only parts of CEADS not previously routine tested shall be tested.

8.2.102 Dielectric tests on high-voltage functional unit

The tests shall be carried out with the power transformer functional unit isolated from the high-voltage functional unit. For this purpose, the switching device of the power transformer feeder circuit, if any, shall be in open position.

In this case, for practical reasons, the switching device of the power transformer feeder circuit shall not be part of the tested equipment. Therefore it shall be tested together with the power transformer functional unit as stated in 8.2.103. Test voltage values shall be those of the power transformer functional unit. A test with the switching device of the power transformer feeder circuit in open position shall be included according to 8.2 of IEC 62271-1:2017.

Voltage limiting devices such as surge arresters and voltage transformers, if part of the high-voltage functional unit, shall be disconnected during routine dielectric tests.

8.2.103 Dielectric tests on power transformer functional unit and high-voltage interconnection

If the power transformer functional unit has not been previously routine tested, IEC 60076-1:2011 shall be followed.

The testing voltage shall be applied through the high-voltage functional unit or the low-voltage functional unit. Only the switching devices that are in series in the supply circuit are closed, all other switching devices are in open position. The following tests are applicable:

- Applied voltage test (AV) (Clause 10 of IEC 60076-3:2013);
- Induced voltage withstand test (IVW) (11.2 of IEC 60076-3:2013).

8.2.104 Dielectric tests on low-voltage functional unit and low-voltage interconnection

As the purpose of this test is to test only the low-voltage functional unit and low-voltage interconnection, the low-voltage interconnection shall be disconnected from the power transformer functional unit. The testing voltage shall be applied at the power transformer functional unit side of the low-voltage interconnection. The switching devices that are in series in the supply circuit are closed.

The following tests are applicable:

- dielectric tests (11.9 of IEC 61439-1:2020);
- verification of insulation resistance (11.9 of IEC 61439-1:2020).

8.3 Tests on auxiliary and control circuits

Subclause 8.3 of IEC 62271-1:2017 is applicable.

8.4 Measurement of the resistance of the main circuit

Subclause 8.4 of IEC 62271-1:2017 is only applicable for high-voltage functional unit of CEADS-G.

8.5 Tightness test

In the case that they have been routine-tested according to their relevant standards, there is no need to conduct this test.

In other case, the following tests are applicable:

- a tightness test as stated in 8.5 of IEC 62271-1:2017 shall be carried out for high-voltage functional unit.
- a leak test with pressure according to 11.8 of IEC 60076-1:2011 for liquid-filled power transformer functional unit or a tightness test according to 11.3 of IEC 60076-15:2015 for gas-filled power transformer functional unit.

8.6 Design and visual checks

Subclause 8.6 of IEC 62271-1:2017 is applicable.

8.101 Mechanical operation tests on high-voltage functional unit

Subclause 8.102 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 7.102 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable for the high-voltage functional unit.

8.102 Pressure tests of gas-filled compartments

Subclause 8.103 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or 7.103 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable for the high-voltage functional unit.

8.103 Tests of auxiliary electrical, pneumatic and hydraulic devices

Subclause 7.104 of IEC 62271-201:2014 is applicable for solid-insulation high-voltage functional unit.

8.104 Measurement of the winding resistance

If the power transformer functional unit has not been previously routine tested, 11.2 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.1 of IEC 60076-11:2018 for dry-type power transformer shall be applied.

8.105 Measurement of the voltage ratio and check of phase displacement

If the power transformer functional unit has not been previously routine tested, 11.3 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.2 of IEC 60076-11:2018 for dry-type power transformer shall be applied.

8.106 Measurement of the short circuit impedance and load losses

If the power transformer functional unit has not been previously routine tested, 11.4 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.3 of IEC 60076-11:2018 for dry-type power transformer shall be applied.

8.107 Measurement of no-load loss and current

If the power transformer functional unit has not been previously routine tested, 11.5 of IEC 60076-1:2011 for liquid-immersed power transformer or 14.2.4 of IEC 60076-11:2018 for dry-type power transformer shall be applied.

8.108 Inspection of the low-voltage functional unit, including inspection of wiring, operational performance and function

If the low-voltage functional unit has not been previously routine tested, 11.10 of IEC 61439-1:2020 shall be applied.

8.109 Checking of protective measures and of the electrical continuity of the protective circuits of the low-voltage functional unit

If the low-voltage functional unit has not been previously routine tested, 11.4 of IEC 61439-1:2020 shall be applied.

8.110 Tests after CEADS assembly on site

In the exceptional case where for practical reasons manufacturer and user agree to transport the CEADS unit dismantled, some of these routine tests can be repeated on site by agreement between manufacturer and user, to assure that the assembly process has been carried out correctly.

9 Guide to the selection of CEADS (informative)

9.1 General

Subclause 9.1 of IEC 62271-1:2017 is not applicable to CEADS.

CEADS can be constructed in various forms that have evolved with changing technologies and functional requirements. The selection of CEADS essentially involves an identification of the functional requirements for the service installation that best meets these requirements.

Such requirement should also take account of applicable legislation and user safety rules.

Table 3 to Table 5 provide a summary of the considerations for specifying CEADS.

9.2 Selection of rated values

Subclause 9.2 of IEC 62271-1:2017 is not applicable to CEADS.

For a given duty in service, the CEADS is selected by considering the individual rated values of its components required by normal load condition and in the case of fault conditions.

It is desirable that the rated values are chosen as suggested in this document regarding the characteristics of the system as well as its anticipated future development. The complete list of ratings is given in Clause 5. Other parameters, such as local atmospheric and climatic conditions and the use at altitudes exceeding 1 000 m, shall also be considered.

NOTE The power transformer rated total losses takes account of any local legislation regarding the amount of losses.

9.3 Cable-interface considerations

Subclause 9.3 of IEC 62271-1:2017 is applicable to CEADS.

9.4 Continuous or temporary overload due to changed service conditions

Subclause 9.4 of IEC 62271-1:2017 is only applicable for high-voltage functional unit.

In case of variable load conditions, IEC 60076-7:2018 for mineral oil-immersed power transformer functional unit and IEC 60076-12:2008 for dry-type power transformer functional unit are applicable.

Under those changed conditions, possible interactions between functional units can occur and their temperature rise limits, according to their individual standards, can be exceeded even due to the interaction between them. Those interactions shall be considered when selecting the CEADS.

9.5 Environmental aspects

Subclause 9.5 of IEC 62271-1:2017 is applicable for CEADS.

9.101 Selection of internal arc classification

When selecting a CEADS, the probability of internal faults should be properly addressed, with the aim to provide an acceptable protection level for operators and for the general public.

This protection is achieved by reducing the risk to a tolerable level. According to ISO/IEC Guide 51:2014 [11], risk is the combination of the probability of occurrence of harm and the severity of the harm. (Refer to Clause 4 of ISO/IEC Guide 51:2014 on the concept of safety).

Therefore, the selection of a suitable CEADS, in relation to an internal fault leading to an arc, should be governed by a procedure to achieve a tolerable level of risk. Such a procedure is described in Clause 6 of ISO/IEC Guide 51:2014. This procedure is based on the assumption that the user has a role to play in the reduction of risk.

For guidance, Table 1 gives a list of locations where experience shows that faults are most likely to occur. It also gives possible causes of failure and possible measures to decrease the probability of internal arc faults. Other measures can be adopted to provide the highest possible level of protection to persons in the case of an internal arc. These measures are aimed to limit the external consequences of such an event. Table 2 gives examples of measures limiting the consequences of internal arc faults.

For both types of accessibility, it is important to realise that the test for internal arc classification relates to a given configuration of the CEADS in respect of type and position of the power transformer functional unit, high-voltage functional unit and low-voltage functional unit. The outcome of the test is dependent of the specific type of switchgear in the CEADS. The decision of an Internal Arc Classification restricts the free choice of high-voltage functional unit in the CEADS.

Table 1 – Locations, causes and examples of measures decreasing the probability of internal arc faults

(1)	(2)	(3)
Locations where internal faults are most likely to occur	Possible causes of internal faults	Examples of possible preventive measures
Cable compartments	Inadequate design	Selection of adequate dimensions. Use of appropriate materials.
	Faulty installation	Avoidance of crossed cables connections. Checking of workmanship on site. Correct torque.
	Failure of solid or liquid insulation (defective or missing)	Checking of workmanship and/or dielectric test on site. Regular checking of liquid levels, where applicable.
Disconnectors Switches Earthing switches	Mal-operation	Interlocks. Delayed reopening. Independent manual operation. Making capacity for switches and earthing switches. Instructions to personnel.
Bolted connections and contacts	Corrosion	Use of corrosion inhibiting coating and/or greases. Use of plating. Encapsulation, where possible.
	Faulty assembly	Checking of workmanship by suitable means. Correct torque. Adequate locking means.
Instrument transformers	Ferroresonance	Avoidance of these electrical influences by suitable design of the circuit.
	Short circuit on low-voltage side of voltage transformer	Avoid short circuit by proper means e.g. protection cover, low-voltage fuses.
Circuit breakers	Insufficient maintenance	Regular programmed maintenance. Instructions to personnel.
All locations	Error by personnel	Limitation of access by compartmentalisation. Insulation embedded live parts. Instructions to personnel.
	Ageing under electric stresses	Partial discharge routine tests.
	Pollution, moisture, ingress of dust, vermin, etc.	Measures to ensure that the specified service conditions are achieved (refer to Clause 4). Use of gas-filled compartments.
	Overvoltages	Surge protection. Adequate insulation co-ordination. Dielectric tests on site.
Interconnections	Failure of insulation	Use of adequate clearances, phase-to-phase and phase-to-ground. Use of insulated interconnections, shielded type preferred.

Table 2 – Examples of measures limiting the consequences of internal arc faults

Rapid fault clearance times initiated by detectors sensitive to light, pressure or heat or by differential busbar protection.
Remote control.
Pressure relief devices, pressure resistant enclosure (including current limiting devices, arc eliminating devices, etc.).

Application of power transformer protection with individual circuit-breaker or suitable fuses in combination with switching devices limiting the let-through current and fault duration.
Gas flow control and gas flow cooling devices. (pressure relief ducts or chimneys, etc.).

As a guide for the selection of an adequate CEADS, with respect to internal arc faults, the following criteria can be used:

- where the risk due to an internal arc fault is considered negligible: a CEADS class IAC-A and/or IAC-B is not necessary;
- where the risk due to an internal arc fault is considered to be relevant: only CEADS class IAC-A and/or IAC-B should be used.

For the second case, the selection should be made by taking into account the foreseeable maximum level of current and duration of the fault, in comparison with the rated values of the tested equipment.

Parts of a CEADS protected by devices that limit the duration of the fault can be tested with such devices operative and then, after passing the test, IAC rated for the actual duration of the arc. If the remaining parts of the CEADS are rated to the maximum level of current and duration of the fault foreseeable in the network, it is admissible to take advantage of the operation of the protection and use the CEADS in this application by agreement between the user and the manufacturer.

In addition, the installation instructions of the manufacturer should be followed (refer to Clause 11).

Internal arc classification gives a tested level of protection of persons under normal operating conditions as defined in 7.102.1. The location of personnel during an internal arc event is important. The user should consider with care when allowing personnel to enter an area not designated as accessible by the manufacturer that could lead to the risk of personnel injury.

9.102 Summary of technical requirements and ratings for CEADS

Table 3 to Table 5 provide a summary of the considerations for specifying CEADS ratings.

Table 3 – Summary of technical requirements, ratings for CEADS – Service conditions

Information		Clause of this document	Reference to	User requirements as appropriate
Ambient air temperature:		4	High-voltage functional unit IEC 62271-1:2017	
Average	°C		Low-voltage functional unit IEC 61439-1	
Minimum	°C		Power transformer functional unit IEC 60076-1 or IEC 60076-11	
Maximum	°C		IEC 60721-2-4:2018	
Solar radiation	W/m ²			
Altitude	m			
Pollution	level		IEC TS 60815 (all parts)	
Ice coating			IEC 62271-1:2017	
Wind-driven sand			IEC 60721-2-2:2012	
Wind-driven snow			IEC 60721-2-2:2012	
Wind	m/s			
Condensation or precipitation			IEC 60721-2-2:2012	
Vibration			^a	
Risk of earth tremors			^a	
Risk of other vibrations			IEC 60721-1:1990, IEC 60721-1:1990/AMD1:1992 and IEC 60721-1:1990/AMD2:1995	
Induced electromagnetic disturbance in secondary system	Class		IEC 62271-1:2017	
^a For high-voltage functional unit in a CEADS installed in places where earthquakes are likely to occur, the severity level according with IEC 62271-210:2013 should be specified by the user.				

Table 4 – Summary of technical requirements, ratings for CEADS – Ratings of the CEADS

Information		Subclause of this document	Reference to	User to indicate requirement as appropriate
Rated voltages		5.2	High-voltage: functional unit IEC 62271 1:2017 Low-voltage functional unit IEC 61439-1 Power transformer functional unit IEC 60076-1:2011	
high-voltage	kV			
low-voltage	V			
Nominal voltages		10.2		
high-voltage	kV			
low-voltage	V			
Number of phases		10.2		
Type of high-voltage neutral earthing		10.2	User	
Maximum expected value of earth fault current	kA			

Information		Subclause of this document	Reference to	User to indicate requirement as appropriate
Type of low-voltage neutral earthing		10.2	User	
Maximum expected value of earth fault current	kA			
Rated power and total losses of CEADS	kVA kW	5.101	IEC 60076-1:2011	
Sound level	dB	Annex B	IEC 60076-10:2016	
Internal arc classification	IAC	5.102		Y/N
Classified sides	F/L/R			
Accessibility type A				
Fault current and duration	kA, s			
Accessibility type B				
Fault current and duration	kA, s			
Rated insulation levels		5.3		
Common value	kV or V		IEC 60076-3:2013	
Rated short-duration power-frequency withstand voltage	kV or V			
Rated lightning impulse withstand voltage	kV or V			
Across isolating distance				
high-voltage:	kV or V		IEC 62271-1:2017	
low-voltage:	kV or V		IEC 61439-1:2020 IEC 60947-1:2020	
Rated short-duration power-frequency withstand voltage	kV or V			
Rated lightning impulse withstand voltage	kV or V			
Rated frequency	Hz	5.4		
Rated continuous current for main circuits		5.5		
high-voltage:	A		IEC 62271-1:2017	
low-voltage:	A		IEC 61439-1:2020	
Rated short-time withstand currents		5.6		
high-voltage:	kA		IEC 62271-1:2017	
low-voltage:	kA		IEC 61439-1:2020	
Earthing circuit:	kA		IEC 62271-1:2017	
Rated peak withstand currents		5.7		
high-voltage:	kA		IEC 62271-1:2017	
low-voltage:	kA		IEC 61439-1:2020	
Earthing circuit:	kA		IEC 62271-1:2017	
Rated durations of short-circuit		5.8		
high-voltage:	s		IEC 62271-1:2017	
low-voltage:	s		IEC 61439-1:2020	
Power transformer:	s		IEC 60076-5:2006 IEC 60076-11:2018	
Earthing circuit:	s		IEC 62271-1:2017	

Information		Subclause of this document	Reference to	User to indicate requirement as appropriate
Rated supply voltage of closing and opening devices and of auxiliary and control circuits	high-voltage low-voltage	5.9	IEC 62271-1:2017 IEC 61439-1:2020	
Closing and tripping:	V			
Indication:	V			
Control:	V			
Rated supply frequency of closing and opening devices and of auxiliary and control circuits		5.10		
high-voltage:	Hz		IEC 62271-1:2017	
low-voltage:	Hz		IEC 61439-1:2020	

**Table 5 – Summary of technical requirements, ratings for CEADS –
Design and construction of the CEADS**

CEADS		(Sub)clause of this document	Reference to	User to indicate requirement as appropriate
Degree of protection of the CEADS for indoor application Degree of protection of the power transformer functional unit for indoor application (if different) Degree of protection of the low-voltage functional unit (if different) Degree of protection of the high-voltage functional unit (if different) Degree of protection of the CEADS for outdoor application Degree of protection of exposed conductors and/or bushings		6.14	IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013	
Type of CEADS Type of components: high-voltage switchgear and controlgear low-voltage switchgear and controlgear Power transformer	G/A/I	C.1	User	
Rated power and total losses of CEADS Power Load loss P_{cu} No-load loss P_0 Short-circuit impedance Temperature rise	kVA W W % K	5.101	IEC 60076-1:2011 IEC 60076-11:2018 IEC 60076-2:2011	
Materials of the enclosures		6.104	IEC 60076 (all parts) IEC 62271-200:2021 IEC 62271-201:2014	
Surface treatment of the enclosures		10.2		

CEADS		(Sub)clause of this document	Reference to	User to indicate requirement as appropriate
Mechanical impact energy	J	6.101		
Mechanical stresses by snow load of the roof	N/m ²	6.101		
roof loads	N/m ²	10.2		
wind pressure	N/m ²			
Dimensions and weights		10.3		
Length	mm			
Width	mm			
Height	mm			
Mass of each transport unit	kg			
Total mass of the CEADS	kg			

10 Information to be given with enquiries, tenders and orders (informative)

10.1 General

Clause 10 of IEC 62271-1:2017 is not applicable.

This clause lists the information, which is necessary to enable the user to make an appropriate enquiry for a CEADS and the supplier to give an adequate tender.

10.2 Information with enquiries and orders

When enquiring about or ordering a CEADS, the scope of supply should be defined for all equipment and services. This can include training, technical and layout studies and requirements for co-operation with the supplier. The following information should be supplied by the enquirer:

a) Particulars of the system:

Nominal and highest voltages, frequency, types of system neutral earthing.

b) Service conditions:

Minimum and maximum ambient air temperature; any condition deviating from the normal service conditions or affecting the satisfactory operation of the equipment, as, for example, altitudes higher than 1 000 m, rapidly changing temperatures, wind-driven sand, rain and snow, the unusual exposure to vapour, moisture, fumes, explosive gases, excessive dust or salt (e.g. caused by traffic or industrial pollution), the risk of earth tremors or other vibrations due to external causes to the equipment to be delivered.

c) Particulars and electrical characteristics of the CEADS:

- 1) rated voltages;
- 2) rated power of the CEADS;
- 3) rated frequency;
- 4) rated insulation levels;
- 5) rated short-time withstand currents;
- 6) rated duration of short-circuit (if different from 1 s);
- 7) rated peak withstand currents;
- 8) rated values of functional units (high-voltage functional unit, low-voltage functional unit, power transformer functional unit and interconnections);

- 9) number of phases;
- 10) type of functional units (e.g. air or gas-insulated type switchgear and controlgear, liquid-immersed power transformer);
- 11) circuit diagrams;
- 12) degree of protection of the enclosures and partitions if any;
- 13) material and surface treatment of the enclosures;
- 14) mechanical stresses (e.g. snow loads, roof loads, wind pressure, etc.);
- 15) maximum admissible dimensions and special requirements affecting the layout of the CEADS (general arrangement);
- 16) the maximum expected value of earth-fault currents dependent upon the type of high-voltage and low-voltage systems neutral earthing employed or the short-circuit current ratings applicable to the earthing circuit(s);
- 17) internal arc classification (if any), including value of the test current and duration.

Beyond these items the enquirer should indicate every condition which might influence the tender or the order, as, for example, special mounting or erection conditions (e.g. vicinity of surrounding walls, elements that can affect ventilation, etc.), the location of the external high-voltage connections, local fire and sound regulations, and expected lifespan. Information should be supplied if special type tests are required. Special conditions in case of installation within a factory (e.g. installation in areas accessible to employees, the existence of areas not protected in case of internal arc above or below the installation place of the CEADS where employees can stay or walk, etc.).

10.3 Information with tenders

The following information should be given by the manufacturer with descriptive matters and drawings:

- a) rated values and characteristics as enumerated in items b) and c) of 10.2;
- b) list of type test, and the corresponding certificates or reports on request, including the justification of the selection of internal arc tests for IAC-A and/or IAC-B, where applicable;
- c) constructional features, for example:
 - 1) mass of each transport unit;
 - 2) total mass of the CEADS;
 - 3) overall dimensions and the layout (general arrangement) of the CEADS;
 - 4) information of the arrangement of the external connections;
 - 5) transport and installation requirements;
 - 6) information on operation and maintenance;
 - 7) information required by the relevant standard of the components;
 - 8) minimum recommended clearances around the CEADS;
 - 9) volume of the fluid retention tank (if any);
 - 10) accessible sides and particular installation instructions to prevent access to the power transformer functional unit in case of a CEADS accessible to the general public (special case of installation inside a factory);
 - 11) type of gas-pressure or liquid-pressure system;
 - 12) specified filling level and minimum functional level.
- d) list of recommended spare parts that should be procured by the user on request;
- e) relevant characteristics of the functional units of the CEADS, and if applicable, the surface treatment or coating of the enclosures and the tests carried out to assess their performance under specified environmental conditions;
- f) statement declaring that the CEADS complies with this document.

11 Transport, storage, installation, operating instructions and maintenance

11.1 General

Clause 11 of IEC 62271-1:2017 is applicable with following additions for CEADS.

It is essential that the transport, storage and erection of a CEADS or its transport units, as well as their operation and maintenance in service, are performed in accordance with instructions given by the manufacturer.

Consequently, the manufacturer should provide instructions for the transport, storage, erection, operation and maintenance of a CEADS. The instructions for the transport and storage should be given at a convenient time before delivery, and the instructions for the erection, operation and maintenance should be given by the time of delivery at the latest.

Relevant standards for the different components define particular rules for their transport, erection, operation and maintenance, and these should be included in the general instructions for the CEADS, where applicable.

The following information is given to supplement these instructions with the most important additional instructions to be provided by the manufacturer of CEADS.

11.2 Conditions during transport, storage and installation

Installation instructions shall provide information or specifications about methods for transportation and requirements for prolonged storage before the first energisation, if needed.

A special agreement should be made between manufacturer and user if the service conditions specified in the order cannot be guaranteed during transport, storage and erection. In particular, instructions should be given to protect insulation against undue moisture absorption or irreversible pollution, if the environmental conditions prior to energizing are such that the enclosures cannot provide appropriate protection.

It might also be necessary to give guidance and/or provide special elements to secure components to avoid any damage due to foreseen vibration or shocks during transport.

11.3 Installation

11.3.1 General

For each type of CEADS, the instructions provided by the manufacturer should at least include the following points.

11.3.2 Unpacking and lifting

The mass of each transport unit, including details of any special lifting devices required for safe lifting and unpacking should be labelled on the equipment.

Instructions shall state clearly the preferred method of safely lifting the CEADS and the need to remove the brackets if they are not suitable for continuous outdoor use.

11.3.3 Assembly

In principle the CEADS are transported as a unit fully assembled. Therefore, there is no need to assemble at the installation on site. However, if by agreement between manufacturer and user the CEADS is not fully assembled for transport, all transport units should be clearly marked and drawings showing assembly of these units should be provided.

11.3.4 Mounting

The manufacturer should provide all necessary information to enable site preparation to be completed, as for example:

- required civil work;
- external earthing terminals;
- position of the cable access points;
- minimum recommended clearances around the CEADS.

NOTE CEADS can be used for power supply inside factories. In such plants it is likely to occur that employees not involved in operation of CEADS (general public) come in close vicinity, next to, above or below the CEADS, e.g. the CEADS is installed below a grid made steel staircase. In such cases access from top or below the CEADS is considered.

When CEADS is installed into a prefabricated substation, the expected increase of temperature into the enclosure or any of the compartments and its influence on equipment shall be considered. Specifically, this condition can affect the performance of temperature-sensitive components such as electronic and smart grid devices. Therefore, the internal air temperature in the compartment containing the CEADS should be taken into account, because increased temperatures, although occurring infrequently, can lead to premature aging and even a failure.

11.3.5 Connections

Subclause 11.3.5 of IEC 62271-1:2017 is applicable to CEADS.

11.3.6 Information about gas and gas mixtures for controlled and closed pressure systems

Subclause 11.3.6 of IEC 62271-1:2017 is applicable to CEADS.

11.3.7 Final installation inspection

Subclause 11.3.7 of IEC 62271-1:2017 is applicable to CEADS with the following addition.

In principle, the manufacturer should provide instructions for inspection and test of the CEADS after its installation and connection, which should include at least a list of recommended tests, made at site.

11.3.8 Basic input data by the user

Subclause 11.3.8 of IEC 62271-1:2017 is applicable to CEADS.

11.3.9 Basic input data by the manufacturer

Subclause 11.3.9 of IEC 62271-1:2017 is applicable to CEADS.

11.4 Operating instructions

Subclause 11.4 of IEC 62271-1:2017 is applicable with the following addition.

A full installation and operating manual shall be provided for each component:

- high-voltage functional unit;
- low-voltage functional unit;
- power transformer;
- cable and cable terminations;
- RTU (Scada).

The operating manual shall describe normal and service conditions requirements to enable the unit to operate satisfactorily. The operating manual shall also include requirements to put into service the CEADS for the first time and testing required at site, if any.

Besides the particular operating instructions of each component, the manufacturer should provide the following additional information, so that the user can acquire an adequate understanding of the main principles involved:

- a description of the safety features of the CEADS, and a list of any special means or tools supplied for safety purposes and their instructions for use;
- the operation of interlocks and padlocking facilities;
- when fluids are used in CEADS, as far as practicable, instruction should be provided in order to allow the user to:
 - minimise the leakage rate;
 - control the handling of the new and used fluids.

11.5 Maintenance

Subclause 11.5 of IEC 62271-1:2017 is applicable with the following addition.

The manufacturer shall issue a maintenance manual, including at least the following information:

- complete maintenance instructions for main components, as required in relevant standards including frequency and procedure;
- instructions for adding gas or fluid to the equipment or getting samples for maintenance checks, and whether the unit should be de-energized for these operations;
- maintenance instructions, if any, for the enclosures; including frequency and procedure.

Instructions manual shall advice whether the unit shall be de-energized or any additional safety measure required during maintenance operations.

11.101 Dismantling, recycling and disposal at the end of service life

The manufacturer shall provide relevant information to allow the end user to carry out dismantling, recycling and disposal of the CEADS at the end of life. This information shall include instructions for disposal of the fluid at the end of life. This information shall take into account the protection of both the workers and the environment.

12 Safety

12.1 General

Clause 12 of IEC 62271-1:2017 is applicable with the following additions for the complete CEADS.

A CEADS provides the specified level of protection to operators and general public only when installed and operated in accordance with the manufacturer's instructions and complying with the user's internal regulations. Additionally, the user can set up specific procedures for installation and operation, as well as a list of any special tools required for normal operation and for maintenance requirements.

Safety aspects of functional units are covered by the relevant product standards.

When fluids are used in CEADS, instructions should be provided in order to allow the user to:

- provide the correct response if gas alarm is received;
- take measures to contain fluid in case of leakage;
- control the handling of the new and used fluids.

The following subclauses of this document describe additional features providing protection to operators and general public against various hazards:

12.101 Electrical aspects

- Earthing (indirect contact) (see 6.3).
- Degree of protection (direct contact) (see 6.14 and 7.7).

12.102 Mechanical aspects

- Degree of protection (see 6.14 and 7.7).
- Mechanical stresses (see 6.101 and 7.7).

12.103 Thermal aspects

- Maximum temperature of accessible parts (see 7.101.5.6).

12.104 Internal arc aspects

- Internal arc fault (see 6.103).

13 Influence of the product on the environment

Clause 13 of IEC 62271-1:2017 is applicable with the following addition:

The following subclauses of this document contain provisions to protect the environment from potential negative influence of the CEADS:

- operating instructions (see 11.4);
- maintenance (see 11.5);
- dismantling, recycling and disposal at the end of service life (see 11.101).

Annex A

(normative)

Method for testing CEADS under conditions of arcing due to an internal arc fault

A.1 General

This annex applies to CEADS of Class IAC.

For the purpose of this annex, normal operating conditions means the conditions of a CEADS required to carry out operations such as opening or closing high-voltage or low-voltage switching devices, reading of measuring instruments and monitoring equipment, etc. Therefore, if to perform any of such operations any cover has to be removed and/or any door has to be opened, the internal arc test shall be performed with the cover removed and/or door open. Change or replacement of high-voltage fuses is not considered as a normal operation.

A.2 Room simulation

Internal arc tests aimed to verify the protection to operators should be carried out in a room simulating the electrical operating area provided that the conditions are not less onerous with respect to the direction of gas flow, strength of the enclosure and pressure release device(s). All other components or a valid mock-up of them can be used, provided that they are installed as in service.

- a) CEADS designed for indoor installation. The test shall be carried out in a simulated room following the principles described in A.1.1 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or AA.1 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.
- b) CEADS designed for outdoor installation or an open area limited by fences into an industrial facility. In that case no room simulation around the CEADS is required for internal arc tests aimed to verify the degree of protection provided outside the equipment. However, where the ground around the CEADS is suspected to contribute to the performance of the CEADS, simulation of the ground surface might be required.

In all cases, if the manufacturer claims that the design of the CEADS requires that the cable access way and/or any other additional exhausting duct shall be used to evacuate gases generated during the internal arc, the installation conditions specified by the manufacturer shall be reproduced, and in particular all the means, if any, to direct and cool down the hot gases exhausted from the high-voltage functional unit.

This requirement shall be clearly stated, in particular in the instruction manual (see Clause 11), for IAC classification to be valid.

A.3 Indicators (for assessing the thermal effects of the gases)

A.3.1 General

Indicators are pieces of black cotton cloth and shall be so arranged that their cut edges do not point toward the test object.

Black cretonne (cotton fabric approximately 150 g/m²) shall be used for indicators for accessibility type A. Black cotton-interlining lawn (approximately 40 g/m²) shall be used for indicators for accessibility type B.

Care shall be taken to ensure that the vertical indicators cannot ignite each other. This is achieved by fitting them in a frame of sheet steel, with a depth of $2 \times 30 \text{ mm}$ ($^{+0}_{-3} \text{ mm}$), refer to Figure A.1.

With the horizontal indicators, care shall be taken that glowing particles do not accumulate. This is achieved if the indicators are mounted without a frame, refer to Figure A.2.

The indicator dimensions shall be $150 \text{ mm} \times 150 \text{ mm}$ ($^{+15}_{-0} \text{ mm}$).

A.3.2 Arrangement of indicators

Indicators shall be fitted at each classified side of the CEADS, facing all points where gas is likely to be emitted (e.g. joints, inspection windows, doors) up to 2 m above the ground level in a checkerboard pattern covering 40 % to 50 % of the area.

The length of the mounting rack shall be larger than the corresponding area to be assessed to take into account the possibility of hot gases escaping at angles of up to 45° , from the surface under test. This means that the mounting frame shall be 100 mm longer in both sides than the test object under test in case of accessibility Type B, or 300 mm in both sides in case of accessibility Type A, provided that the test arrangement does not limit this extension.

NOTE 1 In all cases the distance from the indicators fitted vertically to the test object is measured from a virtual surface that envelopes the test object, disregarding protruding elements (e.g. handles, frame of apparatus and so on). Taking into account that this virtual surface can be likely not regular, the indicators are placed to simulate as realistically as possible the position that an operator or person usually can adopt in front of the equipment, at indicated distance, according to type of accessibility.

a) Test to prove the level of protection to operators. Accessibility type A (restricted accessibility)

When performing the internal arc test within the high-voltage functional unit (see Figure A.3), arrangement of indicators shall follow the requirements of Annex A of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or Annex AA of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear for accessibility type A, limited to the high-voltage operating side(s) declared accessible by the CEADS manufacturer.

When performing the internal arc test on high-voltage interconnection (see Figure A.3) the indicators shall be located at 300 mm from every high-voltage operating side(s) declared accessible by the CEADS manufacturer.

NOTE 2 Normally some kind of barrier or obstacle provides an “out of reach” condition with respect to an open-air conductor or connector.

Indicators shall also be arranged horizontally at a height of 2 m above the ground level as described in Figure A.3 and covering the whole area between 300 mm and 800 mm from the CEADS. The indicators shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area.

Where the design of the CEADS includes a space below the floor to receive the exhausting gases, the behaviour of the floor shall be assessed from the point of view of the safety of the operator standing on it. Two situations are considered:

- if the design and construction of the floor makes possible the displacement of pieces of it or allows exhausting gases to escape through gaps or joints, another horizontal rack with indicators shall be placed at a distance of 100 mm above the floor. These indicators shall cover either the total length between 300 mm and 800 mm from the high-voltage functional unit or the total length of the pressure relief volume from the high-voltage functional unit plus 100 mm, whatever is the largest (see Figure A.5);
- in other cases this horizontal rack is not necessary.

- b) Test to prove level of protection to general public. Accessibility type B (unrestricted accessibility)

Indicators shall be fitted vertically at all sides of the CEADS up to 2 m above the ground level. If the actual height of CEADS is lower than 1,9 m, vertical indicators shall be fitted up to a height 100 mm higher than the test object (see Figure A.4).

The indicators shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area.

The distance from the indicators to the CEADS shall be $100 \text{ mm} \pm 5 \text{ mm}$.

If the CEADS is higher than 1,9 m, indicators shall also be arranged horizontally at a height above the ground level as described in Figure A.4, and covering the whole area between 100 mm and 800 mm from CEADS.

If the CEADS is lower than 1,9 m, horizontal indicators shall be placed instead, in a checkerboard pattern, at a distance of $100 \text{ mm} \pm 5 \text{ mm}$ above the equipment.

For CEADS lower than 800 mm, the arrangement of indicators in a checkerboard pattern is not applicable as 100 % of the upper surface shall be covered.

Where the design of the CEADS includes a space below the floor to receive the exhausting gases, the behaviour of the floor shall be assessed from the point of view of the safety of the general public standing on it. Two situations are considered:

- if the design and construction of the floor makes possible the displacement of pieces of it or allows exhausting gases to escape through gaps or joints another horizontal rack with indicators shall be placed at a distance of 100 mm above the floor. These indicators shall cover either the total length between 100 mm and 800 mm from the high-voltage functional unit or the total length of the pressure relief volume from the high-voltage functional unit plus 100 mm, whatever is the largest (see Figure A.6);
- in other cases this horizontal rack is not necessary.

A.4 Tolerances for geometrical dimensions of test arrangements

Summary of tolerances for geometrical dimensions of test arrangements as given in the document (the values given there in brackets are tolerances only for the actual test arrangement and do not extend the required values):

- indicator dimensions: $0/+15 \text{ mm}$;
- depth of the steel frame for indicators: $-3/0 \text{ mm}$;
- height of indicators $\pm 50 \text{ mm}$;
- distance between test object and indicators;
 - accessibility type A $\pm 30 \text{ mm}$;
 - accessibility type B $\pm 5 \text{ mm}$.

A.5 Test parameters

Clause A.4 of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or Clause AA.4 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear is applicable.

A.6 Test procedure

The test procedures and the number of tests on high-voltage functional unit are dependent on whether the switchgear and controlgear has an IAC classification according to IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear or not. Figure A.7 and Figure A.8 provide selection criteria for high-voltage compartment(s) of the high-voltage switchgear and controlgear to be tested.

The internal arc tests covering the case of a fault inside the high-voltage functional unit shall be performed according to Clause A.5 of IEC 62271-200:2021 for metal-enclosed switchgear class IAC or Clause AA.5 of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear class IAC, including the point of initiation of the arc.

The test procedures and the number of tests on the high-voltage interconnection depend on the type of power transformer protection and type of interconnection. Figure A.9 and Figure A.10 provide selection criteria for high-voltage interconnection to be tested.

The tests covering the case of a fault in the high-voltage interconnection shall be performed following, as applicable, the provisions of Annex A of IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or Annex AA of IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear.

For each accessibility type of a CEADS, at least one internal arc test is mandatory on the high-voltage functional unit (see Figure A.7 and Figure A.8). The point of initiation of the arc shall be in the high-voltage compartment of the high-voltage functional unit having the highest arc energy determined during internal arc tests carried out in accordance with IEC 62271-200:2021 for metal-enclosed switchgear and controlgear or IEC 62271-201:2014 for solid-insulation enclosed switchgear and controlgear. However, if this data is not available, it is acceptable to select the high-voltage compartment with the largest clearance between the points where the arc was initiated. The number of arced phases, arc current and duration shall be the same for all the assessed compartments. In addition, if the high-voltage functional unit has more than one gas flow directions, a representative test shall be performed for each high-voltage compartment having a different gas flow direction (see Figure A.7 and Figure A.8). When more than one high-voltage compartments are the same in all the above-mentioned aspects, only one of these compartments shall be tested.

The tests covering the case of a fault in the high-voltage interconnection shall be performed following, as applicable, the provisions of Annex A of IEC 62271-200:2021 with the following additions to A.5.2 of IEC 62271-200:2021:

- The point of initiation shall be located at the furthest accessible point from the supply. The feeding direction shall be in accordance with the normal expected flow of the energy in service.
- Internal arc testing on high-voltage insulated and earth-shielded interconnections equipped with insulated earth shielded connections according to IEC 60050-461:2008, 461-10-15 is not mandatory (see Figure A.9 and Figure A.10). However, a non mandatory test can be agreed between manufacturer and user. In that case A.5.2 of IEC 62271-200:2021 is applicable.
- Internal arc testing shall be performed on high-voltage solid insulated interconnections equipped with insulated connections according to IEC 60050-461:2008, 461-10-16 or IEC 60050-461:2008, 461-10-21. In that case A.5.2.3.1 of IEC 62271-200:2021 is applicable.

In case of equipment without high-voltage functional unit and having incoming cables directly connected to the bushings of the power transformer functional unit, testing shall be carried out as follows:

- a three-phase test in case of connections uninsulated or fitted with site-made solid insulation;
- a single or two-phase test in the case of plug in insulated connections. For phase-to-ground test the current value to be stated by the manufacturer. For two-phase test current shall be 87 % of the rated short time withstand current.

In case that fuse-base devices are used as the only high-voltage functional unit, a three-phase test shall be performed at the feeding side of the fuse-bases.

The test procedures and the number of tests on the interconnections depend on the type of power transformer protection in the switchgear and type of interconnections. Figure A.9 and Figure A.10 show the principles for selection of tests to be performed.

A.7 Designation of the internal arc classification

In case that class IAC-A, IAC-B or IAC-AB is proven by the tests, according to 7.102, the CEADS shall be designated as follows:

- general: class IAC (initials of internal arc classified at the high-voltage side);
- class A if protection to operator is proven;
- class B if protection to general public is proven;
- class AB if protection of both operators and general public is proven;
- F, L, R: accessible sides;
- test ratings: RMS value of the test current in kA, and duration in second(s).

EXAMPLE 1

A CEADS tested for a fault current (RMS) of 16 kA for 0,5 s tested for protection to operators (5.102) declared accessible at front and lateral operating sides.

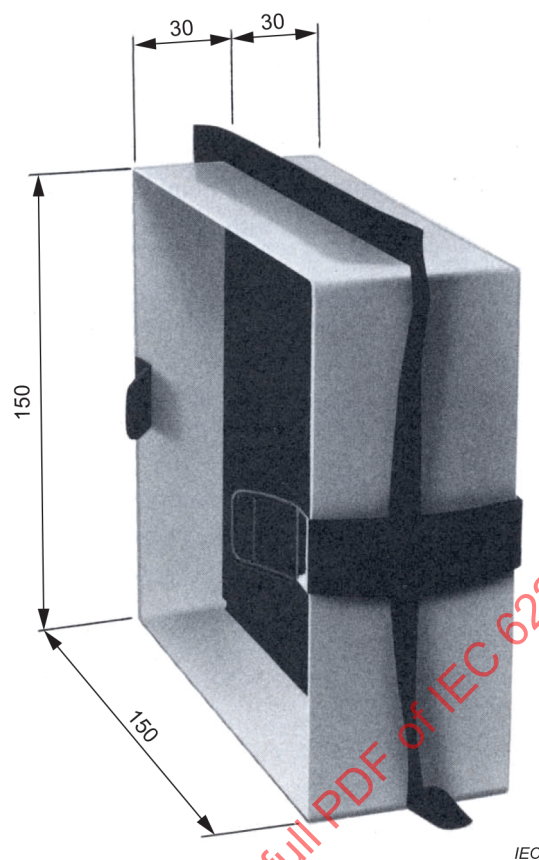
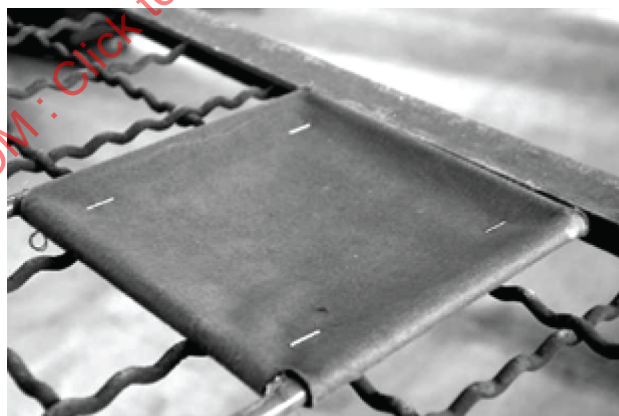
Designation: Class IAC-AFL – 16 kA – 0,5 s.

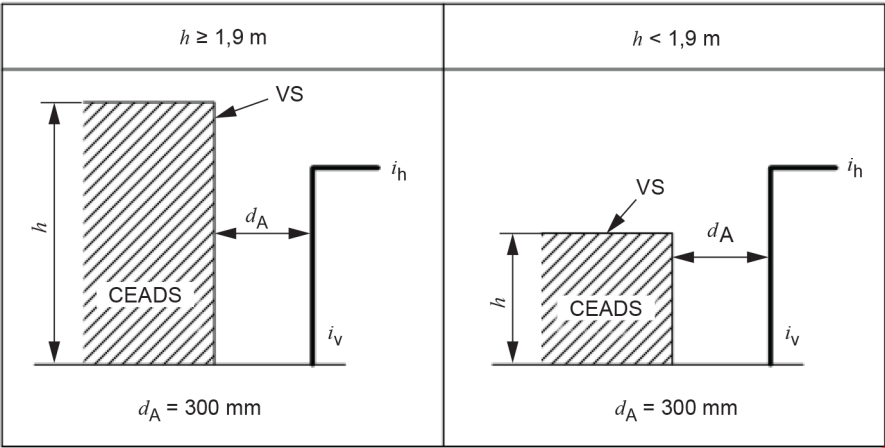
EXAMPLE 2

A CEADS tested for a fault current (RMS) of 12,5 kA for 1 s providing protection to the general public in the vicinity of the equipment on all its sides at any time (5.102).

Designation: Class IAC-B- 12,5 kA – 1 s.

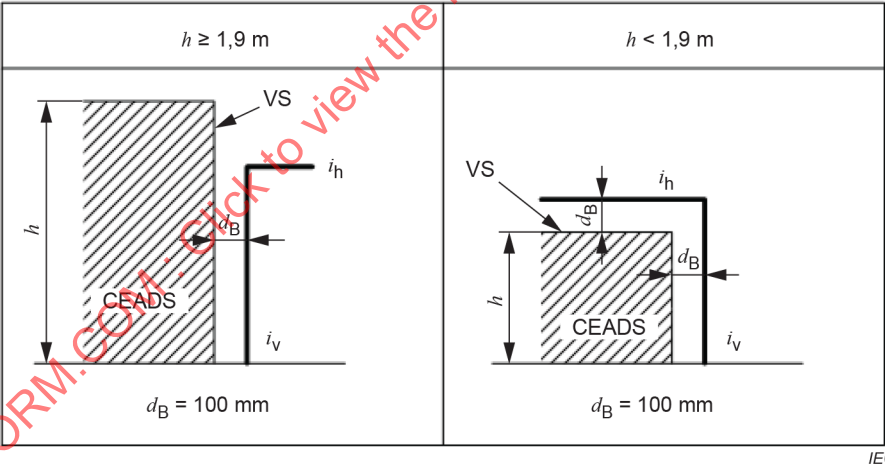
Dimensions in millimetres

**Figure A.1 – Mounting frame for vertical indicators****Figure A.2 – Horizontal indicators**



- Key**
- i_h position of horizontal indicators
 - i_v position of vertical indicators
 - h height of the CEADS
 - d_A horizontal distance of indicators to the CEADS (classified side(s))
 - VS virtual surface that envelopes the CEADS

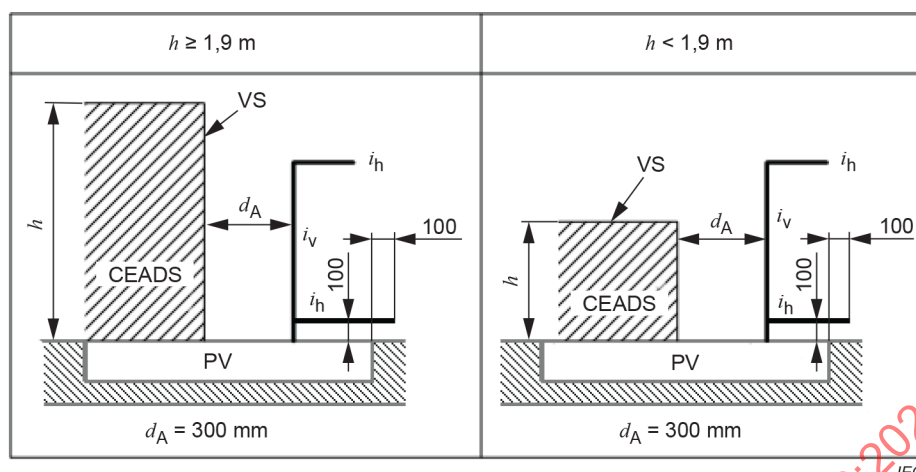
Figure A.3 – Protection of operators in front of classified side(s) of CEADS



- Key**
- i_h position of horizontal indicators
 - i_v position of vertical indicators
 - h height of the CEADS
 - d_B horizontal distance of indicators to CEADS
 - VS virtual surface that envelopes the CEADS

Figure A.4 – Protection of general public around the CEADS

Dimensions in millimetres

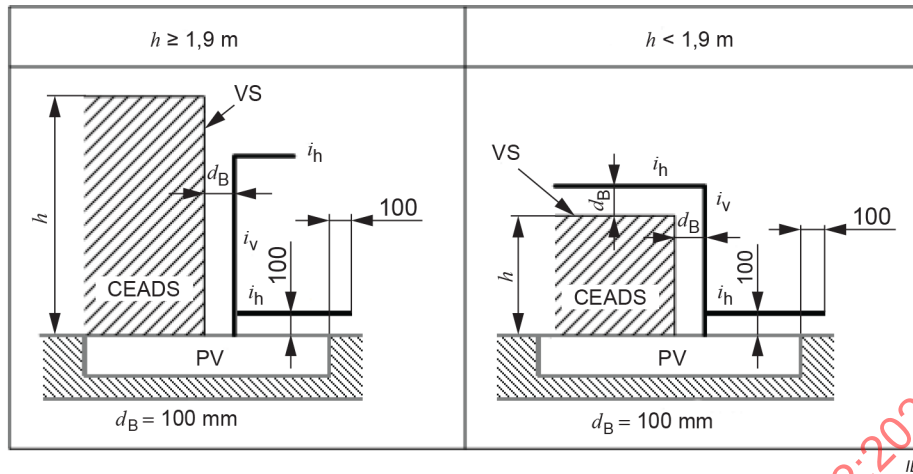
**Key** i_h position of horizontal indicators i_v position of vertical indicators h height of the CEADS d_A horizontal distance of indicators to the CEADS (classified side(s))

PV pressure relief volume to exhaust gases

VS virtual surface that envelopes the CEADS

Figure A.5 – Protection of operators in front of classified side(s) of CEADS having a pressure relief volume below the floor

Dimensions in millimetres



Key

- i_h position of horizontal indicators
- i_v position of vertical indicators
- h height of the CEADS
- d_B horizontal distance of indicators to CEADS
- VS virtual surface that envelopes the CEADS
- PV pressure relief volume to exhaust gases

Figure A.6 – Protection of the general public around the CEADS having a pressure relief volume below the floor

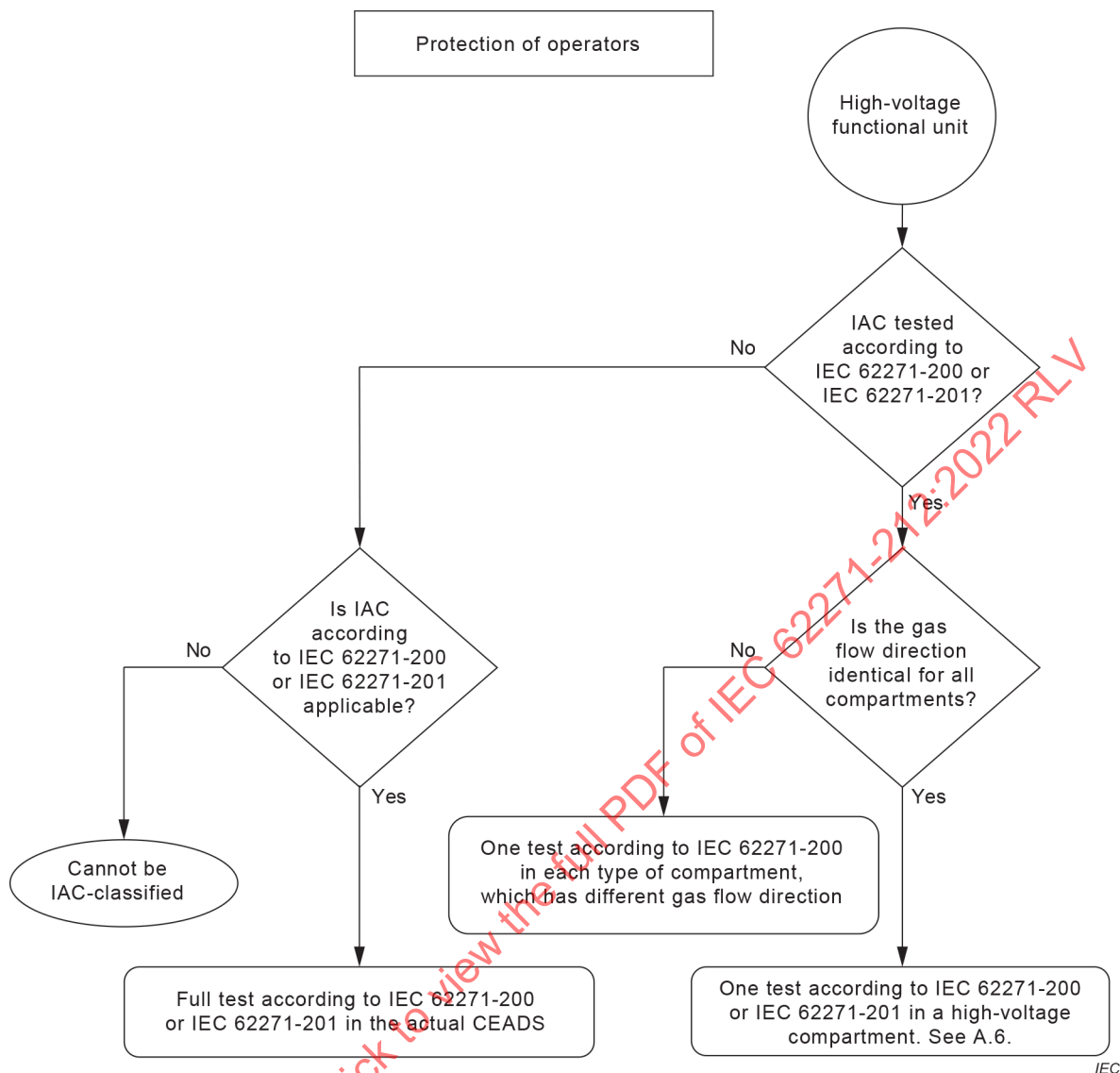


Figure A.7 – Selection of tests on high-voltage functional unit for class IAC-A

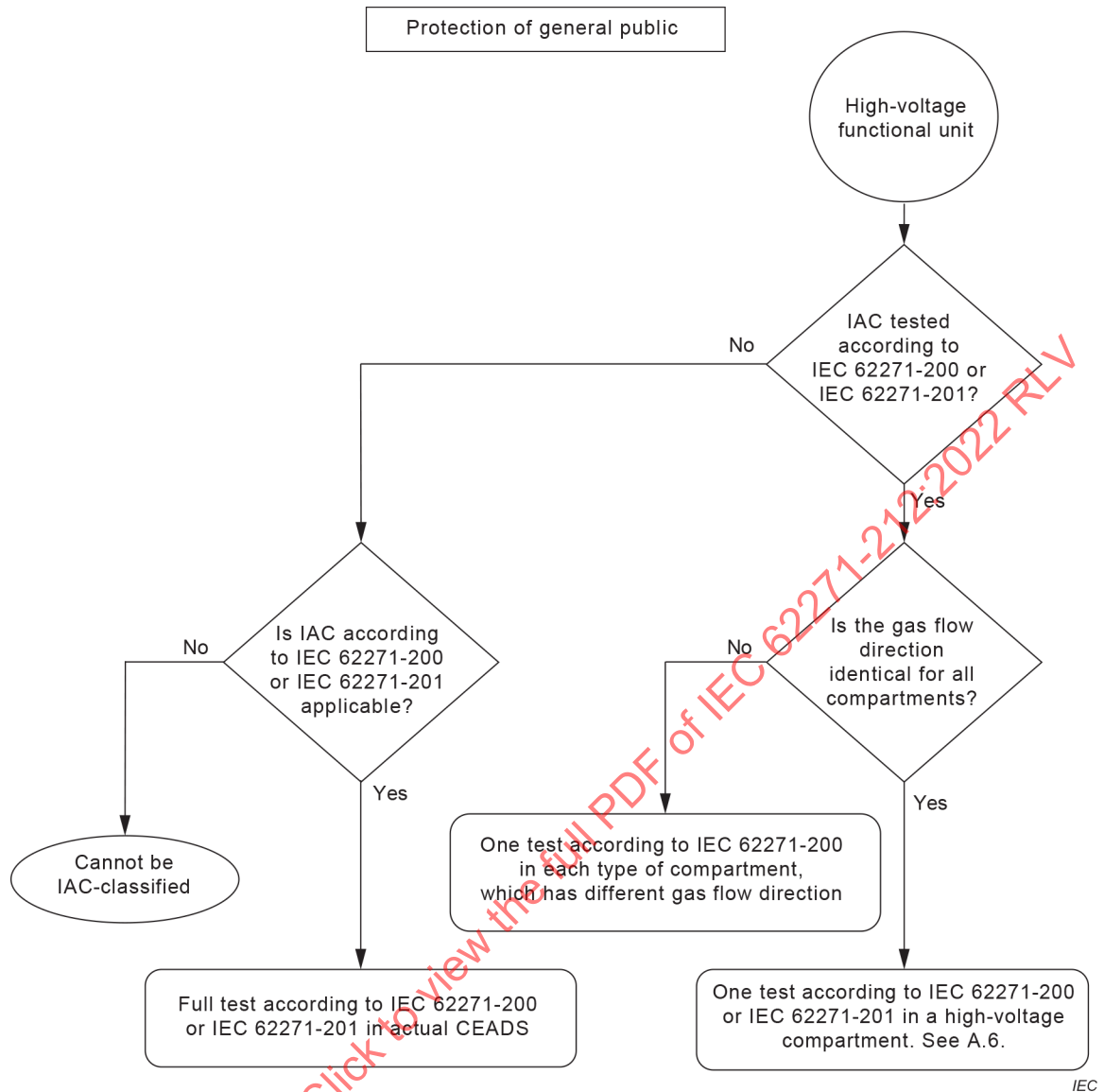
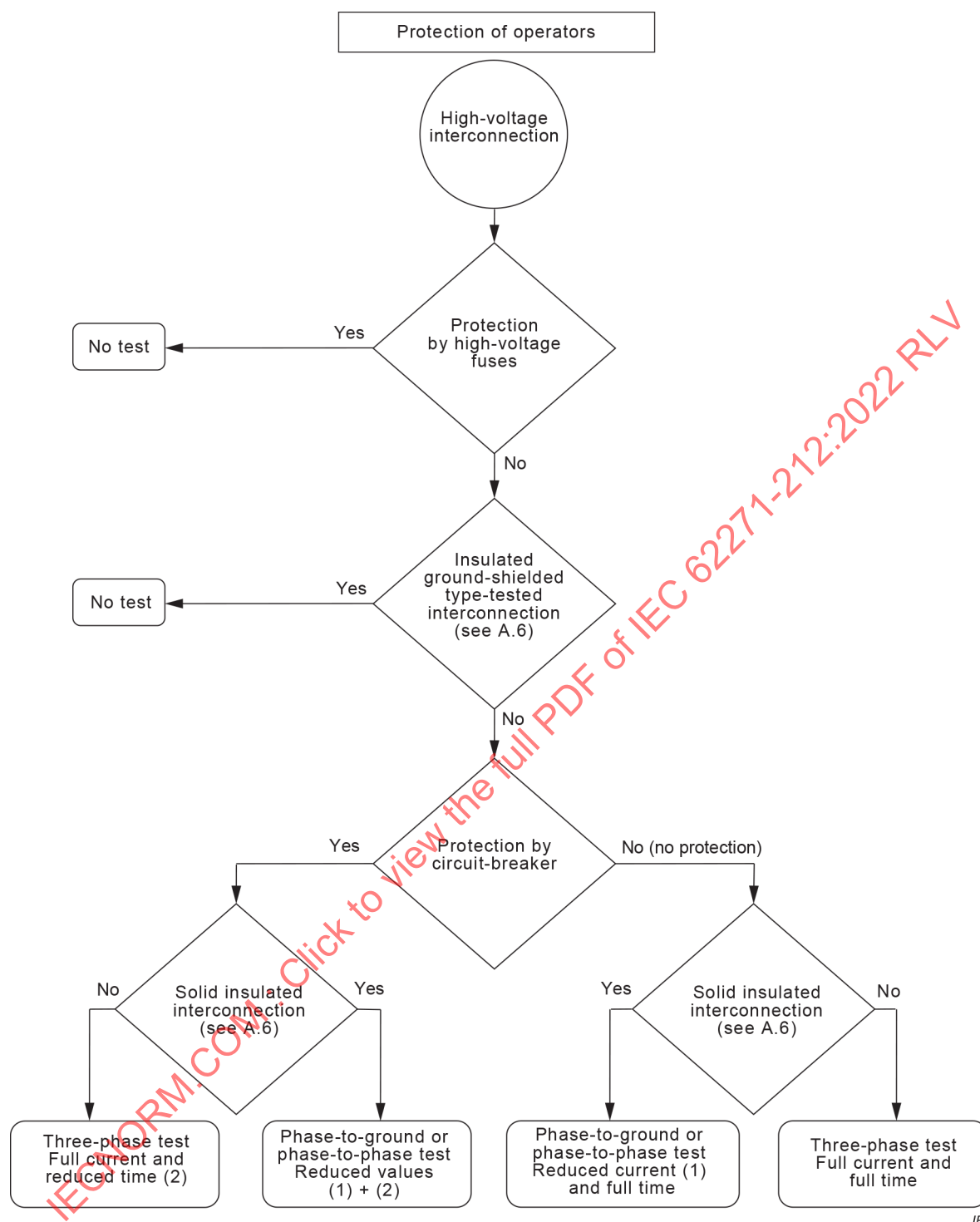


Figure A.8 – Selection of tests on high-voltage functional unit for class IAC-B



IEC

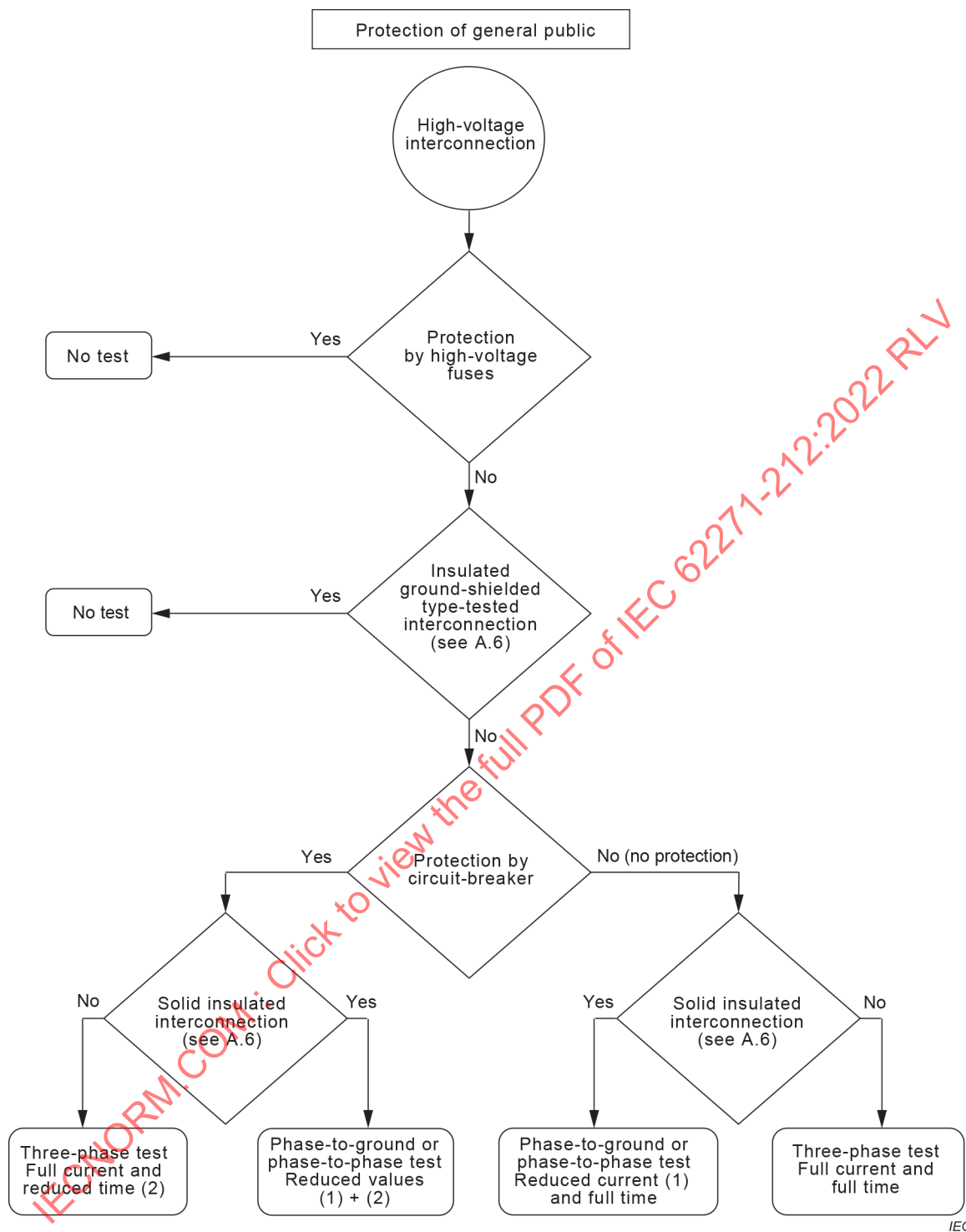
(1) Applicability of phase-to-ground or phase-to-phase test according to the criteria in A.5.2.1 of IEC 62271-200:2021.

* For phase-to-ground test the current value to be stated by the manufacturer.

* For phase-to-phase test the current shall be 87 % of the rated short-time withstand current.

(2) The time can be stated by the manufacturers, taking into account the time-setting of the protection.

Figure A.9 – Selection of tests on high-voltage interconnection for class IAC-A



(1) Applicability of phase-to-ground or phase-to-phase test according to the criteria in A.5.2.1 of IEC 62271-200:2021.

* For phase-to-ground test the current value to be stated by the manufacturer.

* For phase-to-phase test the current shall be 87 % of the rated short-time withstand current.

(2) The time can be stated by the manufacturers, taking into account the time-setting of the protection.

Figure A.10 – Selection of tests on high-voltage interconnection for class IAC-B

Annex B

(normative)

Test to verify the sound level of a CEADS

B.1 Purpose

The purpose of the test is to measure the sound level of a given CEADS in no-load condition. It is expected that the power transformer functional unit can be the main source of sound. However, even in the case that the power transformer functional unit is manufactured as an individual power transformer according to IEC 60076 (all parts), the test could be considered relevant as the other components of the CEADS can modify the sound level of the power transformer or significantly increase it by resonance phenomena.

NOTE Full-load noise level can be considered under special requirement.

The test values are only valid for the tested assembly at the rated voltage and frequency.

B.2 Test object

The CEADS tested shall be fully assembled, comprising all fittings and equipment.

B.3 Test method

The test shall be carried out according to IEC 60076-10:2016. IEC 60076-10:2016 defines the method of test and calculation of an A-weighted sound level along a prescribed contour around the power transformer functional unit.

The same method shall be used for measurements on the CEADS where a virtual surface that envelops the assembly (excluding protruding elements, e.g. handles) is considered to be the sound-emitting boundary. The method of measurement shall comply with Clause 5 of IEC 60076-10:2016 with the exception of the requirement for the measuring device, which shall be at 1,5 m above ground level as defined for the CEADS.

B.4 Measurements

These shall be in accordance with Clause 5 of IEC 60076-10:2016. For the purpose of positioning the measuring instruments, virtual surface defined in Clause B.3 shall be considered as principal radiating surface of the CEADS.

B.5 Presentation and calculation of the results

The sound level shall be calculated in accordance with Clause 12 of IEC 60076-10:2016.

The report of the test shall include all applicable information as given in Clause 15 of IEC 60076-10:2016. In addition, for the CEADS, the following information shall also be included:

- a) main design characteristics of the assembly, including materials used;
- b) dimensional drawing of the internal arrangement of the components inside CEADS and any other part that can significantly influence the sound propagation.

NOTE If any sound measurement on any side of the CEADS differs substantially from those on the other sides, the test report records all values to enable the user to take account of the differences when installing the CEADS.

Annex C (informative)

Types and application of CEADS

C.1 Type of CEADS

C.1.1 General

The document classifies CEADS in three general types: grouped CEADS (CEADS-G), associated CEADS (CEADS-A) and integrated CEADS (CEADS-I). The three types of CEADS can differ by the type of interconnections, layout and level of proximity and/or integration of the functional units, which –in some cases- include to share parts and/or dielectric medium between certain functions, etc.

C.1.2 CEADS-G

This type of CEADS is characterised by the fact that its functional units are manufactured as independent products, which fully comply with their respective product standard. Different layouts can be used (see a non-comprehensive example in Figure C.2) but in all cases the functional units are placed in proximity but not attached to each other. Interconnections between functional units are of conventional type (cables or bus-bar arrangements).

C.1.3 CEADS-A

In this type of CEADS some functional unit(s) can be modified to obtain shorter interconnections or reduce the size of the assembly. Non conventional interfaces between the functional units can be part of the design. Because of this, the functional units can deviate, to some extent from their product standard (e.g. the bushings of the power transformer can be different from those mentioned in the relevant standard, or the order of phases can be modified). The functional units are manufactured as independent products or can share part of their respective enclosures (see a non-comprehensive example in Figure C.3). However none of these special features are acceptable if they affect negatively the performance, functionality and safety of the product.

C.1.4 CEADS-I

This type of CEADS is characterised by the integration of high-voltage switchgear (totally or partially) and power transformer within a single enclosure, requiring sharing the insulating medium as well (see a non-comprehensive example in Figure C.4).

C.2 Application of CEADS

For industrial applications, such as factories, CEADS are intended for application in public distribution networks or at industrial sites.

For public distribution networks, CEADS are installed within an indoor or outdoor closed electrical operating area (see definition 3.1.101) forming part of a distribution substation.

CEADS can be installed outside a closed electrical operating area provided that safety regulations are fulfilled by additional measures adopted at the installation site under the responsibility of the designer of the installation.

Figure C.1, below, describes the application of CEADS to build different types of high-voltage substations.

Once manufactured, the CEADS (any of the different types) is ready to follow to the final alternative step of the erection of the substation by:

- transporting it to the site and install it into the closed electrical operating area. No additional internal installation works and interconnection are necessary there, except for special cases where the CEADS is delivered in several units due to transport and site access constraints, by agreement between the manufacturer and the user.
- introducing it into an enclosure in the factory and then the complete assembly been transported to the installation site.

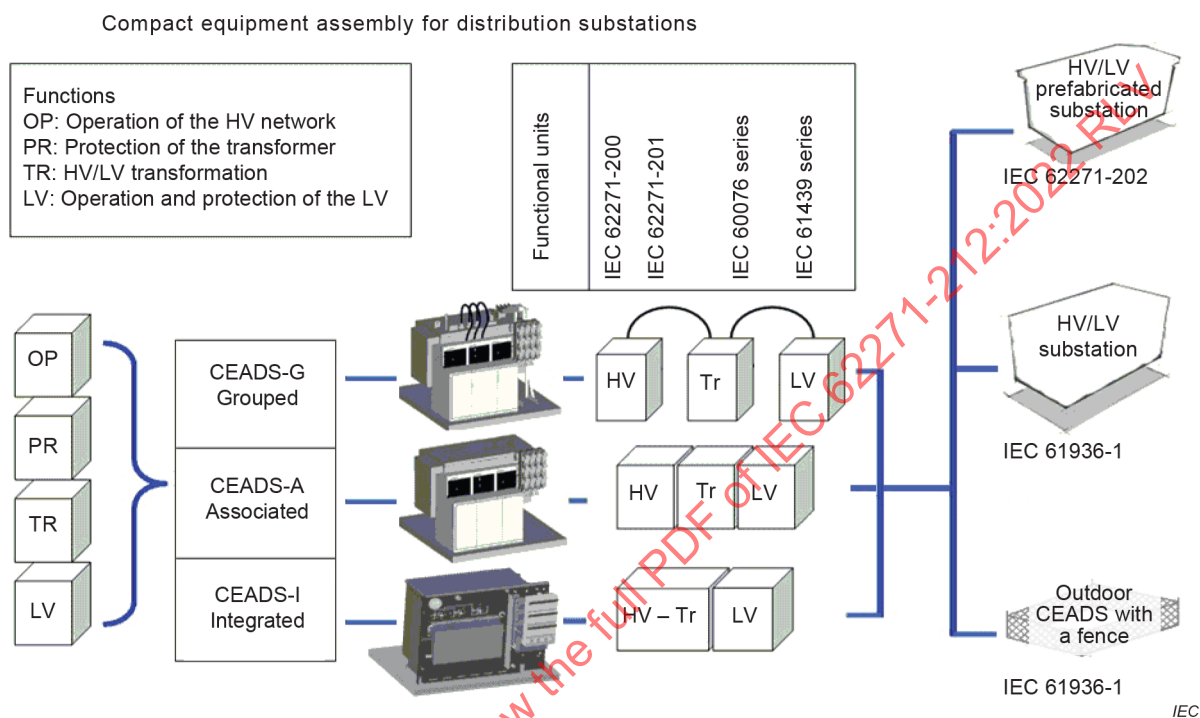


Figure C.1 – Application of CEADS

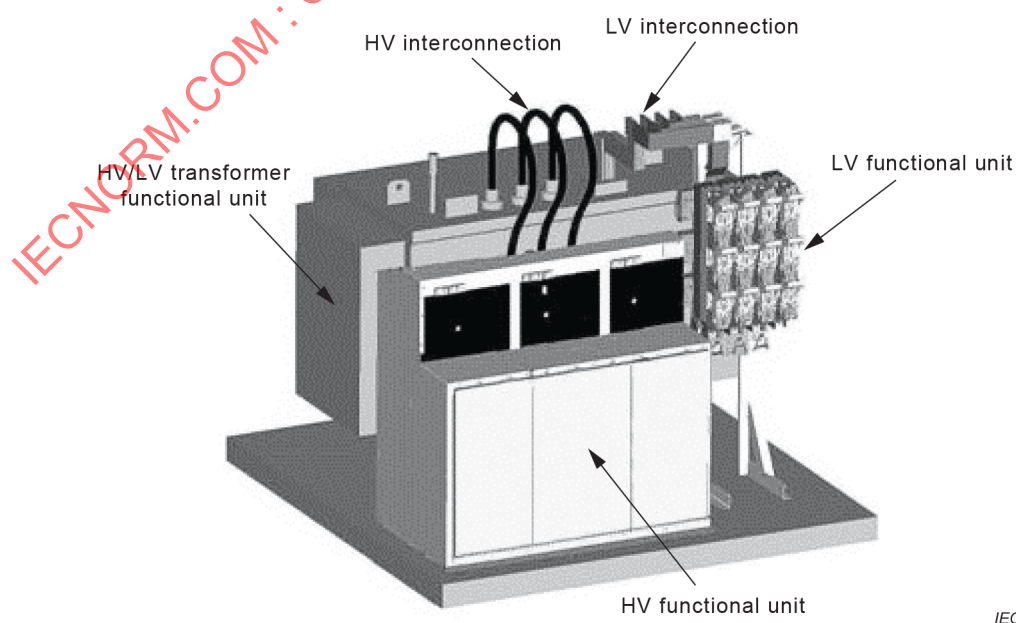
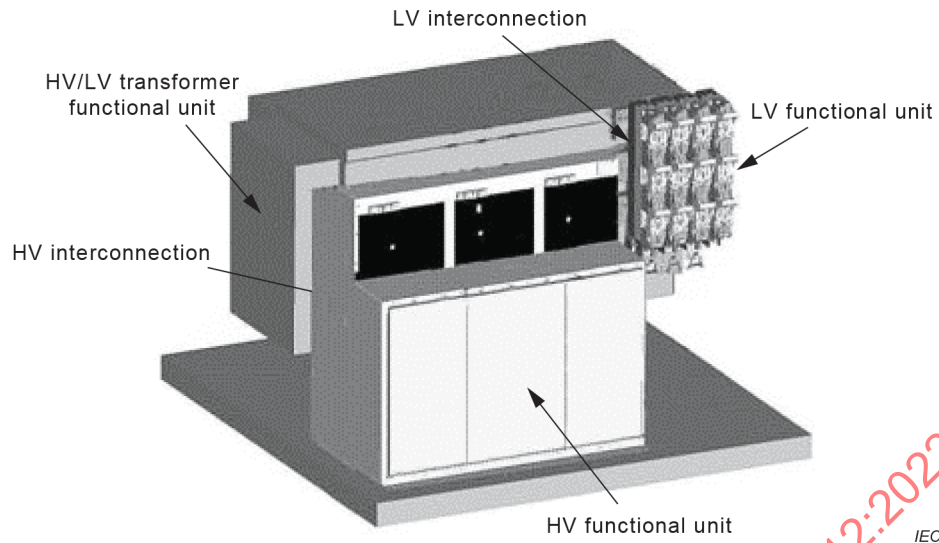
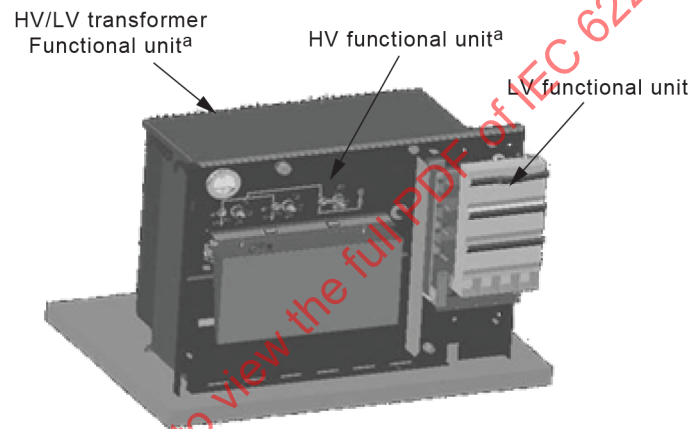


Figure C.2 – CEADS Type G



IEC

Figure C.3 – CEADS Type A



IEC

^a Functional units sharing the same enclosure

Figure C.4 – CEADS Type I

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

APPAREILLAGE À HAUTE TENSION –

**Partie 212: Ensemble compact d'équipement
pour poste de distribution (ECEPD) pour les tensions alternatives
inférieures ou égales à 52 kV**

AVANT-PROPOS

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L'IEC 62271-212 a été établie par le sous-comité 17C: Ensembles, du comité d'études de l'IEC 17: Appareillage à haute tension. Il s'agit d'une Norme internationale.

Cette deuxième édition annule et remplace la première édition parue en 2016. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) numérotation des articles alignée sur l'IEC 62271-1:2017;
- b) reformulation du titre et du domaine d'application du document;

- c) mise en œuvre des modifications relatives à la définition et aux essais d'arc interne en suivant l'évolution du concept de poste préfabriqué conformément à l'IEC 62271-202;
- d) examen général des principaux modes opératoires d'essai tels que l'échauffement ou l'essai diélectrique sur les interconnexions, compte tenu des équipements de commande, de la communication, des dispositifs de réseau intelligent et de l'intégration des composants;
- e) examen général des exigences d'installation, de fonctionnement, de sécurité et de maintenance.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
17C/845/FDIS	17C/850/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Le présent document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Il convient de lire cette Norme internationale conjointement avec l'IEC 62271-1:2017, à laquelle elle fait référence et qui est applicable, sauf spécification contraire. Pour faciliter le repérage des exigences correspondantes, cette norme utilise une numérotation identique des articles et des paragraphes à celle de l'IEC 62271-1:2017. Les modifications à ces articles et paragraphes sont indiquées sous la même numérotation, alors que les paragraphes additionnels sont numérotés à partir de 101.

Une liste de toutes les parties de la série IEC 62271, sous le titre général *Appareillage à haute tension* se trouve sur le site web de l'IEC.

Le comité a décidé que le contenu du présent document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

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- supprimé
- remplacé par une édition révisée, ou
- amendé.

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INTRODUCTION

Un poste de distribution haute tension/basse tension est traditionnellement construit par l'installation des principaux composants électriques – appareillage à haute tension, transformateur de puissance et appareillage à basse tension correspondant – dans un local électrique fermé. Il peut s'agir d'une salle dans un bâtiment destiné à d'autres utilisations (non électriques) ou un local séparé (préfabriqué ou non) conçu spécifiquement pour contenir le matériel électrique du poste ou une zone ouverte délimitée par des clôtures.

Il y a quelques années, dans le cadre de la recherche d'un poste plus normalisé et plus compact, le concept de poste préfabriqué a été développé. L'IEC 62271-202 couvre ce type de poste. Conformément au présent document, les principaux composants électriques (appareillage à haute tension, transformateur de puissance et appareillage à basse tension) sont totalement conformes à leur norme de produit respective, et le poste complet, interconnexions et enveloppe comprises, est conçu et soumis à des essais de type puis fabriqué et soumis à des essais individuels de série en usine. La qualité du poste est par conséquent assurée par le constructeur.

Par ailleurs, d'autres types d'ensembles ont également été introduits sur le marché. Il s'agit d'ensembles qui comprennent les principaux composants actifs électriques du poste et leurs interconnexions, livrés sous la forme d'un produit monobloc. Le produit peut par conséquent être soumis à des essais de type, fabriqué, soumis à des essais individuels de série en usine, transporté puis installé dans un local électrique fermé.

Ce type de produit soumis à des essais de type et assemblé en usine est couvert par le présent document sous le nom générique d'Ensemble Compact d'Équipement pour Poste de Distribution (ECEPD). De nombreux agencements sont possibles et le présent document spécifie des recommandations concernant les principaux types d'ensembles qui peuvent être envisagés.

Un ECEPD ne relève pas de l'IEC 61936-1. L'ECEPD est toutefois destiné à faire partie d'un poste de distribution.

Compte tenu de la proximité étroite des principaux composants électriques qui peuvent même partager certaines parties (enveloppe, isolation solide ou par fluide...), il est très pertinent d'être attentif à leur interaction potentielle. Par conséquent, pour un ECEPD, il n'est ni suffisant ni toujours applicable de se reporter aux normes de produits pertinentes. Le présent document couvre toutes les exigences de conception et de construction supplémentaires ainsi que les méthodes d'essai applicables aux différents types d'ECEPD. En plus des caractéristiques spécifiées, une attention particulière a été portée à la spécification concernant la protection des personnes, aussi bien les opérateurs que le grand public.

L'ECEPD est aussi un sujet d'intérêt du comité d'études 14: Transformateurs de puissance, et du comité d'études 121: Appareillages et ensembles d'appareillages basse tension.

APPAREILLAGE À HAUTE TENSION –

Partie 212: Ensemble compact d'équipement pour poste de distribution (ECEPD) pour les tensions alternatives inférieures ou égales à 52 kV

1 Domaine d'application

La présente partie de l'IEC 62271 spécifie les conditions de service, les caractéristiques assignées, les exigences structurelles générales et les méthodes d'essai des ensembles des principales unités fonctionnelles électriques d'un poste de transformation haute tension, dûment interconnecté, pour les tensions alternatives inférieures ou égales à 52 kV du côté haute tension, et avec une fréquence de service de 50 Hz ou 60 Hz. L'ECEPD est raccordé par câble au réseau à haute tension pour des applications à l'intérieur et à l'extérieur à accès restreint.

Un ECEPD tel que défini dans le présent document est conçu et soumis à des essais comme un produit unique avec un numéro de série unique et un ensemble de documentation.

Les fonctions d'un ECEPD sont les suivantes:

- la transformation haute tension/haute tension ou haute tension/basse tension;

et tout ou partie des fonctions suivantes:

- la connexion et la commande pour le fonctionnement du ou des circuits à haute tension;
- la connexion et la commande pour le fonctionnement du ou des circuits à basse tension;
- la protection de l'unité fonctionnelle du transformateur de puissance.

Les principales fonctions sont intégrées aux unités fonctionnelles suivantes:

- unité fonctionnelle haute tension;
- unité fonctionnelle de transformateur de puissance;
- unité fonctionnelle basse tension.

NOTE Pour les besoins du présent document, un transformateur autoprotégé n'est pas considéré comme un ECEPD, mais comme une unité fonctionnelle, conçue et soumise à un essai de type conformément à sa propre norme de produit IEC 60076-13:2006.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-441, *Vocabulaire électrotechnique international (IEV) – Partie 441: Appareillage et fusibles* (disponible sous www.electropedia.org)

IEC 60050-461, *Vocabulaire électrotechnique international (IEV) – Partie 461: Câbles électriques* (disponible sous www.electropedia.org)

IEC 60076 (toutes les parties), *Transformateurs de puissance*

IEC 60076-1:2011, *Transformateurs de puissance – Partie 1: Généralités*

IEC 60076-2:2011, *Transformateurs de puissance – Partie 2: Échauffement des transformateurs immergés dans le liquide*

IEC 60076-3:2013, *Transformateurs de puissance – Partie 3: Niveaux d'isolement, essais diélectriques et distances d'isolement dans l'air*
IEC 60076-3:2013/AMD1:2018

IEC 60076-5:2006, *Transformateurs de puissance – Partie 5: Tenue au court-circuit*

IEC 60076-7:2018, *Power transformers – Partie 7: Loading guide for mineral-oil-immersed power transformers* (disponible en anglais seulement)

IEC 60076-10:2016, *Transformateurs de puissance – Partie 10: Détermination des niveaux de bruit*

IEC 60076-11:2018, *Transformateurs de puissance – Partie 11: Transformateurs de type sec*

IEC 60076-12:2008, *Transformateurs de puissance – Partie 12: Guide de charge pour transformateurs de puissance de type sec*

IEC 60076-15:2015, *Transformateurs de puissance – Partie 15: Transformateurs de puissance à isolation gazeuse*

IEC 60243-1:2013, *Rigidité électrique des matériaux isolants – Méthodes d'essai – Partie 1: Essais aux fréquences industrielles*

IEC 60364-4-41:2005, *Installations électriques à basse tension – Partie 4-41: Protection pour assurer la sécurité – Protection contre les chocs électriques*
IEC 60364-4-41:2005/AMD1:2017

IEC 60529:1989, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 60721-1:1990, *Classification des conditions d'environnement – Partie 1: Agents d'environnement et leurs sévérités*

IEC 60721-1:1990/AMD1:1992

IEC 60721-1:1990/AMD2:1995

IEC 60721-2-2:2012, *Classification des conditions d'environnement – Partie 2-2: Conditions d'environnement présentes dans la nature – Précipitations et vent*

IEC 60721-2-4:2018, *Classification des conditions d'environnement – Partie 2-4: Conditions d'environnement présentes dans la nature – Rayonnement solaire et température*

IEC TS 60815 (toutes les parties), *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions* (disponible en anglais seulement)

IEC 60947-1:2020, *Appareillage à basse tension – Partie 1: Règles générales*

IEC 61439 (toutes les parties)¹, *Ensembles d'appareillages à basse tension*

IEC 61439-1:2020 *Ensembles d'appareillages à basse tension – Partie 1: Règles générales*

IEC 62271-1:2017 *Appareillage à haute tension – Partie 1: Spécifications communes pour appareillage à courant alternatif*

IEC 62271-200:2021 *Appareillage à haute tension – Partie 200: Appareillage sous enveloppe métallique pour courant alternatif de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV*

IEC 62271-201:2014 *Appareillage à haute tension – Partie 201: Appareillage sous enveloppe isolante solide pour courant alternatif de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV*

IEC 62271-202:2022, *High-voltage switchgear and controlgear – Part 202: Prefabricated substation* (disponible en anglais seulement)

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 60050-441, l'IEC 62271-202, ainsi que les suivants s'appliquent.

NOTE Certains termes et définitions normalisés sont rappelés ici à titre de référence.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

3.1 Termes et définitions à caractère général

3.1.101

local électrique fermé

salle ou local destiné à l'exploitation des installations électriques et des matériels électriques dont l'accès est réservé aux personnes qualifiées ou instruites ou aux autres personnes sous la surveillance de personnes qualifiées ou instruites

[SOURCE: IEC 61936-1:2021, 3.2.1, modifié – Remplacement du terme "installation électrique fermée" par "local électrique fermé"; dans la définition remplacement de "lieu" par "local"; suppression de "ordinaires".]

3.2 Ensembles d'appareillages

3.2.101

ensemble compact d'équipement pour poste de distribution

ECEPD

équipement assemblé en usine et soumis à un essai de type qui comprend des unités fonctionnelles, décrites à l'Article 1, dûment interconnectées

Note 1 à l'article: Trois types d'ECEPD sont pris en compte: groupé, associé et intégré (voir l'Annexe C pour des informations détaillées).

¹ Cette série remplace certaines parties de la série IEC 60439.

3.2.101.1**ECEPD de type groupé****ECEPD-G**

ECEPD dont les unités fonctionnelles sont des équipements autonomes en totale conformité avec leurs normes de produits respectives, dans lequel ces unités fonctionnelles sont placées à proximité les unes des autres selon un agencement spécifié

3.2.101.2**ECEPD de type associé****ECEPD-A**

ECEPD dont les unités fonctionnelles peuvent s'écarter de leur norme de produit existante, en dehors de tout aspect susceptible de nuire à la sécurité et/ou au fonctionnement, et dans lequel ces unités fonctionnelles peuvent être indépendantes ou partager une partie de leurs structures ou de leurs enveloppes

3.2.101.3**ECEPD de type intégré****ECEPD-I**

ECEPD dans lequel tout ou partie des unités fonctionnelles haute tension et l'unité fonctionnelle de transformation haute tension/basse tension sont contenues dans une enveloppe unique, qui partage le milieu isolant

3.3 Parties d'ensembles**3.3.101****unité fonctionnelle**

ensemble d'appareils et de composants qui exécutent une fonction principale donnée de l'ECEPD

Note 1 à l'article: Pour les besoins du présent document, l'unité fonctionnelle a une signification différente de celle des autres normes. Par exemple, dans le présent document, l'unité fonctionnelle haute tension (voir 3.3.102) peut comprendre plusieurs unités fonctionnelles selon l'IEC 62271-200:2021.

3.3.102**unité fonctionnelle haute tension**

ensemble des appareils de connexion et d'autres composants qui exécutent la fonction de connexion et de commande pour le fonctionnement du côté haute tension de l'ECEPD

Note 1 à l'article: Elle peut inclure la connexion et la commande du circuit principal haute tension du réseau et la protection de la fonction de transformation haute tension/basse tension.

3.3.103**unité fonctionnelle de transformateur de puissance**

ensemble d'éléments qui exécutent la fonction de transformation haute tension/haute tension ou haute tension/basse tension de l'ECEPD

3.3.104**unité fonctionnelle basse tension**

ensemble des appareils de connexion et d'autres composants qui exécutent la fonction de connexion et de commande pour le fonctionnement et la protection des réseaux d'alimentation à basse tension de l'ECEPD

3.3.105**interconnexion haute tension**

connexion électrique entre les bornes de l'unité fonctionnelle haute tension et les bornes haute tension de l'unité fonctionnelle de transformateur de puissance

3.3.106**interconnexion basse tension**

connexion électrique entre les bornes basse tension de l'unité fonctionnelle de transformateur de puissance et les bornes de l'unité fonctionnelle basse tension

3.4 Appareils de connexion

3.5 Parties d'appareillages

3.6 Caractéristiques opérationnelles de l'appareillage

3.6.101

ECEPD de classe de tenue à l'arc interne

IAC

ECEPD qui répond aux critères spécifiés, démontrés par des essais de type, pour la protection des personnes en cas d'arc interne du côté haute tension

Note 1 à l'article: L'abréviation "IAC" est dérivée du terme anglais développé correspondant "internal arc classified".

3.7 Grandeurs caractéristiques

3.8 Index des définitions

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4 Conditions normales et spéciales de service

4.1 Conditions normales de service

4.1.1 Généralités

Le paragraphe 4.1 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants pour les ECEPD. Les paragraphes suivants font également référence à des ajouts spécifiques aux autres unités fonctionnelles selon leurs normes correspondantes.

La forme d'onde et la symétrie de la tension d'alimentation sont conformes au 4.2 de l'IEC 60076-1:2011.

Pour un ECEPD d'intérieur, les équipements doivent également être adaptés aux conditions d'humidité relative et de condensation conformément au Tableau 15 de l'IEC 61439-1:2020.

NOTE 1 Pour une température ambiante inférieure à -25 °C, un ECEPD d'extérieur peut être conçu ou utilisé selon les normes de produits pertinentes, le cas échéant, ou selon un accord entre le constructeur et l'utilisateur.

NOTE 2 Pour une température ambiante supérieure à l'intérieur d'une salle, l'utilisateur peut spécifier au constructeur les conditions de service spécifiques afin de vérifier si un déclassement est applicable pour toute unité fonctionnelle.

Lorsque plusieurs unités fonctionnelles partagent un milieu environnant commun et dans certains cas la même enveloppe, il est possible que les conditions de service réelles, en particulier la température, de ces unités fonctionnelles diffèrent grandement des conditions normales de service (air ambiant) du fait de l'interaction entre elles. Il convient de prendre en considération ce phénomène, le cas échéant, pendant un essai de type (voir par exemple 7.101.2).

4.1.2 Appareillage à basse tension

Le paragraphe 4.1 de l'IEC 62271-1:2017 ne s'applique pas à l'unité fonctionnelle basse tension.

Le paragraphe 7.1 de l'IEC 61439-1:2020 est applicable.

4.1.3 Transformateur de puissance

Le paragraphe 4.1 de l'IEC 62271-1:2017 ne s'applique pas au transformateur de puissance.

Le paragraphe 4.2 de l'IEC 60076-1:2011 est applicable aux transformateurs de puissance immergés dans le liquide et le paragraphe 4.2 de l'IEC 60076-11:2018 est applicable aux transformateurs de puissance de type sec.

4.2 Conditions spéciales de service

4.2.1 Généralités

Le paragraphe 4.2 de l'IEC 62271-1:2017 est applicable à l'ECEPD avec les ajouts suivants.

Les spécifications particulières de fonctionnement dans des conditions anormales différentes de celles incluses dans ce paragraphe doivent être soumises à un accord entre le constructeur et l'utilisateur.

Se reporter aux normes concernées pour les différentes unités fonctionnelles.

4.2.2 Altitude

4.2.2.1 Généralités

Le paragraphe 4.2.2 de l'IEC 62271-1:2017 est applicable à l'ECEPD avec les ajouts suivants.

Pour l'installation d'un ECEPD en altitude, il convient d'évaluer les limites d'échauffement des principaux composants compte tenu des recommandations de l'IEC TR 60943:1998 et de l'IEC TR 60943:1998/AMD2009 [1]².

4.2.2.2 Transformateur de puissance

Pour une installation à une altitude supérieure à 1 000 m, se reporter au 6.3 de l'IEC 60076-2:2011 ou au 10.3 de l'IEC 60076-11:2018.

4.2.3 Exposition à la pollution

4.2.3.1 Généralités

Le paragraphe 4.2.3 de l'IEC 62271-1:2017 est applicable à l'ECEPD avec les ajouts suivants.

² Les chiffres entre crochets renvoient à la Bibliographie.

4.2.3.2 Appareillage à basse tension

Plusieurs degrés de pollution sont définis pour les conditions d'installation. Se reporter au 7.1.2 de l'IEC 61439-1:2020 à des fins d'évaluation des distances d'isolement et des lignes de fuite de l'unité fonctionnelle basse tension.

4.2.3.3 Transformateur de puissance

Se reporter au 5.5 de l'IEC 60076-1:2011, sauf pour les transformateurs de puissance de type sec pour lesquels il convient de se reporter au 4.2 f) et au 12.2 de l'IEC 60076-11:2018 pour sélectionner la classe environnementale appropriée.

4.2.4 Température et humidité

Le paragraphe 4.2.4 de l'IEC 62271-1:2017 est applicable à l'ECEPD avec l'ajout suivant.

Lorsque les conditions de service d'un transformateur de puissance au site d'installation prévu ne relèvent pas des limites des conditions normales de refroidissement, les limites d'échauffement du transformateur de puissance immergé dans le liquide doivent alors être modifiées conformément au 6.3 de l'IEC 60076-2:2011.

4.2.5 Exposition aux vibrations, chocs ou basculements anormaux

Le paragraphe 4.2.5 de l'IEC 62271-1:2017 est applicable.

4.2.6 Vitesse du vent

Le paragraphe 4.2.6 de l'IEC 62271-1:2017 est applicable.

4.2.7 Autres paramètres

Le paragraphe 4.2.7 de l'IEC 62271-1:2017 est applicable.

5 Caractéristiques assignées

5.1 Généralités

Le paragraphe 5.1 de l'IEC 62271-1:2017 est applicable avec les modifications suivantes.

Les caractéristiques assignées d'un ECEPD sont les suivantes:

- a) tensions assignées (U_r , U_n);
- b) niveaux d'isolement assignés;
- c) fréquence assignée (f_r);
- d) courant assigné pour les circuits principaux d'un ensemble basse tension (I_{nA});
- e) courant permanent assigné pour les circuits principaux haute tension (I_r);
- f) courants de courte durée admissibles assignés (I_k , I_{ke} , I_{cw}) pour les circuits principaux et les circuits de mise à la terre;
- g) valeurs de crête des courants admissibles assignées (I_p , I_{pe} , I_{pk}) pour les circuits principaux et les circuits de mise à la terre;
- h) durées de court-circuit assignées (t_k , t_{ke} , t_{cw}) pour les circuits principaux et les circuits de mise à la terre;
- i) tension assignée d'alimentation des dispositifs de fermeture et d'ouverture et des circuits auxiliaires et de commande;

- j) fréquence assignée d'alimentation des dispositifs de fermeture et d'ouverture et des circuits auxiliaires et de commande;
- k) puissance assignée et pertes totales de l'ECEPD;
- l) caractéristiques assignées de la classe de tenue à l'arc interne (IAC), lorsqu'elles sont attribuées par le constructeur.

Les caractéristiques assignées de l'ECEPD doivent être attribuées pour vérifier que l'utilisation des équipements dans le cadre de ses caractéristiques assignées n'expose aucune unité fonctionnelle individuelle à des conditions hors de ses capacités assignées.

NOTE Les unités fonctionnelles qui font partie de l'ECEPD peuvent avoir d'autres valeurs assignées individuelles conformément à leurs normes pertinentes.

5.2 Tension assignée

Le paragraphe 5.2 de l'IEC 62271-1:2017 ne s'applique pas.

Les tensions assignées de l'ECEPD sont définies par les tensions assignées de son unité fonctionnelle haute tension (U_r), son unité fonctionnelle de transformateur de puissance et son unité fonctionnelle basse tension (U_n).

Se reporter au 5.2 de l'IEC 62271-1:2017 pour l'unité fonctionnelle haute tension.

Se reporter à l'IEC 60947-1 et au 5.2 de l'IEC 61439-1:2020 pour l'unité fonctionnelle basse tension.

Le paragraphe 5.4.1 de l'IEC 60076-1:2011 est applicable à l'unité fonctionnelle de transformateur de puissance.

NOTE Les unités fonctionnelles haute tension et basse tension peuvent avoir des tensions assignées supérieures aux tensions assignées de l'unité fonctionnelle de transformateur de puissance.

5.3 Niveau d'isolement assigné

Le paragraphe 5.3 de l'IEC 62271-1:2017 ne s'applique pas.

Les niveaux d'isolement assignés de l'ECEPD sont définis par les niveaux d'isolement assignés les plus faibles de l'un de ses composants, quels qu'ils soient, de l'unité fonctionnelle haute tension, de l'unité fonctionnelle basse tension ou du transformateur de puissance.

Pour l'unité fonctionnelle haute tension, se reporter au 5.3 de l'IEC 62271-1: 2017.

Pour l'unité fonctionnelle basse tension, se reporter au 5.2 de l'IEC 61439-1: 2020 et au 5.2 de l'IEC 60947-1:2020.

Pour les niveaux d'isolement assignés du transformateur de puissance, se reporter au 5.6 de l'IEC 60076-1:2011 concernant les niveaux d'isolement applicables en rapport avec la tension la plus élevée des équipements (U_m).

La tension assignée de tenue aux chocs minimale de l'unité fonctionnelle basse tension doit avoir au moins la valeur donnée pour la catégorie IV de surtension dans le Tableau G.1 de l'IEC 61439-1:2020. Selon le réseau des différents pays, il peut être pertinent de choisir un niveau d'isolement supérieur.

5.4 Fréquence assignée (f_r)

Le paragraphe 5.4 de l'IEC 62271-1:2017 ne s'applique pas.

Les valeurs normales de la fréquence assignée pour l'ECEPD sont 50 Hz et 60 Hz.

5.5 Courant permanent assigné (I_r)

Le paragraphe 5.5 de l'IEC 62271-1:2017 ne s'applique pas à l'ECEPD.

Les courants assignés de l'ECEPD sont définis par le courant permanent assigné de son unité fonctionnelle haute tension (I_r) et le courant assigné de son unité fonctionnelle basse tension (I_{nA}).

Le paragraphe 5.5 de l'IEC 62271-1:2017 est applicable à l'unité fonctionnelle haute tension.

Le paragraphe 5.3.1 de l'IEC 61439-1:2020 est applicable à l'unité fonctionnelle basse tension.

NOTE L'unité fonctionnelle haute tension et l'unité fonctionnelle basse tension ont des valeurs de courant assigné qui sont supérieures ou égales aux valeurs de courant de fonctionnement.

5.6 Courant de courte durée admissible assigné (I_k)

Le paragraphe 5.6 de l'IEC 62271-1:2017 ne s'applique pas.

5.6.101 Courants de courte durée admissibles assignés phase-phase et phase-terre de l'unité fonctionnelle haute tension et courant de courte durée admissible assigné de l'interconnexion haute tension (I_k , I_{ke})

Pour les courants de courte durée admissibles assignés I_k et/ou I_{ke} de l'unité fonctionnelle haute tension, l'interconnexion haute tension et le circuit de mise à la terre, le 5.6 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

Le courant de courte durée admissible assigné (I_k) doit être attribué à l'unité fonctionnelle haute tension, ainsi qu'à l'interconnexion haute tension.

NOTE 1 En principe, le courant de courte durée admissible assigné d'un circuit principal ne peut pas dépasser les valeurs assignées correspondantes des plus faibles de ses composants connectés en série. Toutefois, pour chaque circuit ou compartiment haute tension, il est possible de bénéficier d'appareils qui limitent le courant de court-circuit, tels que des fusibles limiteurs de courant, des bobines d'inductance, etc.

Un courant de courte durée admissible assigné phase-terre (I_{ke}) doit être attribué au circuit de mise à la terre de l'unité fonctionnelle haute tension, ainsi qu'à l'interconnexion haute tension. Cette valeur peut différer de celle du circuit principal.

NOTE 2 Les caractéristiques assignées de courant de court-circuit s'appliquent au circuit de mise à la terre en fonction du type de mise à la terre du neutre du système auquel il est destiné. Se reporter au Tableau 3 de l'IEC 62271-202:2022.

5.6.102 Courants de courte durée admissibles assignés de l'unité fonctionnelle basse tension et de l'interconnexion basse tension (I_{cw})

Se reporter au 5.3.5 de l'IEC 61439-1:2020.

5.6.103 Courants de courte durée admissibles de l'unité fonctionnelle de transformateur de puissance

Se reporter à l'Article 3 de l'IEC 60076-5:2006.

5.7 Valeur de crête du courant admissible assignée (I_p)

Le paragraphe 5.7 de l'IEC 62271-1:2017 ne s'applique pas.

5.7.101 Valeurs de crête des courants admissibles assignés phase-phase et phase-terre de l'unité fonctionnelle haute tension et valeur de crête du courant admissible assignée de l'interconnexion haute tension (I_p , I_{pe})

Pour les valeurs de crête des courants admissibles assignées I_p et/ou I_{pe} de l'unité fonctionnelle haute tension, de l'interconnexion haute tension et du circuit de mise à la terre, le 5.7 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

La valeur de crête du courant admissible assignée (I_p) doit être attribuée à l'unité fonctionnelle haute tension, ainsi qu'à l'interconnexion haute tension.

NOTE En principe, la valeur de crête du courant admissible assignée d'un circuit principal ne peut pas dépasser les valeurs assignées correspondantes des plus faibles de ses composants connectés en série. Toutefois, pour chaque circuit ou compartiment haute tension, il est possible de bénéficier d'appareils qui limitent le courant de court-circuit, tels que des fusibles limiteurs de courant, des bobines d'inductance, etc.

Une valeur de crête du courant admissible assignée phase-terre (I_{pe}) doit être attribuée au circuit de mise à la terre de l'unité fonctionnelle haute tension, ainsi qu'à l'interconnexion haute tension. Cette valeur peut différer de celle du circuit principal.

5.7.102 Valeurs de crête des courants admissibles assignés de basse tension et de l'interconnexion basse tension (I_{pk})

Se reporter au 5.3.4 de l'IEC 61439-1:2020.

5.7.103 Valeurs de crête des courants admissibles de l'unité fonctionnelle de transformateur de puissance

Se reporter à l'Article 3 de l'IEC 60076-5:2006.

5.8 Durée de court-circuit assignée (t_k)

Le paragraphe 5.8 de l'IEC 62271-1:2017 ne s'applique pas.

5.8.101 Durée de court-circuit phase-phase assignée (t_k) et durée de court-circuit phase-terre assignée (t_{ke}) de l'unité fonctionnelle haute tension et durée de court-circuit assignée de l'interconnexion haute tension

Pour les durées de courts-circuits assignées t_k et t_{ke} pour l'unité fonctionnelle haute tension, l'interconnexion haute tension et le circuit de mise à la terre, le 5.8 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

Une durée de court-circuit assignée (t_k) doit être attribuée à l'unité fonctionnelle haute tension et l'interconnexion haute tension.

NOTE En principe, la durée de court-circuit assignée pour un circuit principal ne peut pas dépasser la valeur assignée correspondante du plus faible de ses composants connectés en série. Toutefois, pour chaque circuit ou compartiment haute tension, il est possible de bénéficier d'appareils qui limitent la durée du courant de court-circuit, tels que des fusibles limiteurs de courant.

Une durée de court-circuit phase-terre assignée (t_{ke}) doit également être attribuée au circuit de mise à la terre de l'unité fonctionnelle haute tension, ainsi qu'à l'interconnexion haute tension. Cette valeur peut différer de celle du circuit principal.

5.8.102 Durée de court-circuit assignée (t_{cw}) pour l'unité fonctionnelle basse tension et l'interconnexion basse tension

Se reporter au 5.3.4 de l'IEC 61439-1:2020 pour l'unité fonctionnelle basse tension et attribuer une durée de court-circuit assignée (t_{cw}) à l'interconnexion basse tension.

5.8.103 Durée de court-circuit pour l'unité fonctionnelle de transformateur de puissance

Se reporter au 4.1.3 de l'IEC 60076-5:2006.

5.9 Tension d'alimentation assignée des circuits auxiliaires et de commande (U_a)

Le paragraphe 5.9 de l'IEC 62271-1:2017 est applicable à l'ECEPD.

5.10 Fréquence d'alimentation assignée des circuits auxiliaires et de commande

Le paragraphe 5.10 de l'IEC 62271-1:2017 est applicable à l'ECEPD.

5.11 Pression d'alimentation assignée en gaz comprimé pour les systèmes à pression entretenue

Le paragraphe 5.11 de l'IEC 62271-1:2017 n'est pas applicable à l'ECEPD.

5.101 Puissance assignée et pertes totales de l'ECEPD

La puissance assignée de l'ECEPD est la puissance assignée de l'unité fonctionnelle de transformateur de puissance à la tension assignée telle que définie dans l'IEC 60076-1:2011 pour les unités fonctionnelles de transformateur de puissance rempli de liquide ou dans l'IEC 60076-11:2018 pour les unités fonctionnelles de transformateur de puissance de type sec.

Les pertes totales de l'ECEPD représentent la somme des pertes de l'unité fonctionnelle haute tension et de l'interconnexion haute tension à son courant permanent assigné, des pertes totales (avec identification des pertes en charge et des pertes à vide) de l'unité fonctionnelle de transformateur de puissance à sa tension assignée, conformément à l'IEC 60076-1:2011 pour les unités fonctionnelles de transformateur de puissance rempli de liquide ou à l'IEC 60076-11:2018 pour les unités fonctionnelles de transformateur de puissance de type sec, et des pertes de l'unité fonctionnelle basse tension et de l'interconnexion basse tension au courant déterminé par la puissance assignée de l'unité fonctionnelle de transformateur de puissance.

5.102 Caractéristiques assignées de la classe de tenue à l'arc interne (IAC)

5.102.1 Généralités

Lorsqu'une classification IAC est attribuée par le constructeur, plusieurs caractéristiques assignées doivent être spécifiées. Ces caractéristiques assignées sont subdivisées en type d'accessibilité, courants de défaut d'arc et durées de défaut d'arc.

5.102.2 Types d'accessibilité (A, B, AB)

Trois types d'accessibilité en cas d'arc interne sont pris en compte:

Accessibilité de type A: pour un ECEPD qui assure la protection des opérateurs en position debout pendant les opérations normales du ou des côtés commande de l'ECEPD.

NOTE En principe, toute intervention simultanée au niveau des côtés commande haute tension et basse tension peut être considérée comme une procédure non sécurisée.

Accessibilité de type B: pour un ECEPD qui assure la protection du grand public aux alentours de l'équipement de tous ses côtés et à tout moment.

Accessibilité de type AB: pour un ECEPD qui assure la protection à la fois des opérateurs et du grand public.

Pour pouvoir obtenir cette classification, ces ECEPD doivent satisfaire aux exigences du type A et du type B avec la même valeur de courant d'essai en kA et la même durée en secondes.

5.102.3 Côtés classifiés

À des fins d'identification des différents côtés classifiés de l'ECEPD, le code suivant doit être utilisé:

- F pour le côté avant (défini par le côté commande haute tension);
- L pour le côté latéral;
- R pour le côté arrière.

Le ou les côtés commande haute tension doivent être clairement indiqués par le constructeur avant l'essai et identifiés dans le rapport d'essai.

5.102.4 Courants assignés de défaut d'arc (I_A , I_{Ae})

Il convient de sélectionner la valeur normale des courants assignés de défaut d'arc parmi les caractéristiques assignées des courants normaux (IEC 60059:1999 et IEC 60059:1999/AMD1:2009 [2]).

Deux caractéristiques assignées de courants de défaut d'arc sont reconnues:

- a) courant de défaut d'arc triphasé (I_A);
- b) courant de défaut d'arc monophasé-terre (I_{Ae}), le cas échéant.

Lorsque seule une caractéristique assignée triphasée est spécifiée, la caractéristique assignée monophasée représente par défaut 87 % de la caractéristique assignée triphasée et elle ne doit pas être spécifiée.

NOTE 1 Le constructeur spécifie les compartiments de l'unité fonctionnelle haute tension auxquels s'applique la caractéristique assignée du courant de défaut d'arc monophasé-terre. Une telle valeur est assignée à l'unité fonctionnelle lorsque sa construction peut empêcher l'arc de devenir polyphasé, comme cela est démontré pendant l'essai d'arc interne.

NOTE 2 Cette valeur de 87 % se justifie par l'essai de défaut d'arc avec allumage biphasé; se reporter au 9.104.5 de l'IEC 62271-202:2022.

Dans le cas où tous les compartiments haute tension sont uniquement conçus pour les défauts d'arc monophasé-terre, seul le courant de défaut d'arc monophasé-terre (I_{Ae}) doit être assigné.

NOTE 3 Des informations sur la relation entre le type de mise à la terre du neutre et le courant de défaut d'arc monophasé-terre sont fournies en 9.104.5 et dans le Tableau 3 de l'IEC 62271-202:2022.

5.102.5 Durée de défaut d'arc assignée (t_A , t_{Ae})

Les valeurs normales recommandées pour la durée de défaut d'arc triphasé (t_A) sont 0,1 s, 0,5 s et 1 s.

Le cas échéant, la durée d'essai (t_{Ae}) du défaut d'arc monophasé-terre doit être indiquée par le constructeur.

NOTE Il n'est en général pas possible de calculer la durée d'arc admissible pour un courant qui diffère de celui utilisé dans l'essai.

6 Conception et construction

L'Article 6 de l'IEC 62271-1:2017 ne s'applique pas aux ECEPD.

Les ECEPD doivent être conçus pour que les opérations normales d'exploitation, d'inspection et de maintenance puissent être effectuées en toute sécurité. Comme les ECEPD sont destinés à être utilisés dans des locaux électriques fermés, il n'est en principe pas permis au grand public d'approcher l'équipement. Toutefois, lorsqu'un ECEPD est installé dans une usine, les employés qui ne sont pas chargés de son fonctionnement peuvent parfois se trouver à proximité de l'ECEPD. Comme ils ne connaissent pas les caractéristiques électriques de l'équipement, ils sont considérés comme étant du grand public au sens du présent document.

NOTE Lorsque certaines parties des enveloppes d'un ECEPD sont destinées à faire partie de l'enveloppe d'un poste, les exigences pertinentes de l'IEC 62271-202 ou de l'IEC 61936-1, le cas échéant, sont satisfaites.

La conception de l'ECEPD doit prendre en compte les interactions possibles (par exemple, électriques, mécaniques et thermiques) dans la performance des différentes unités fonctionnelles et des composants utilisés pour leurs interconnexions.

L'ensemble complet d'un ECEPD et les unités fonctionnelles individuelles qui le composent doivent satisfaire aux exigences du présent document. Pour les unités fonctionnelles individuelles, il est fait référence aux normes respectives suivantes:

- Unité fonctionnelle haute tension IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou IEC 62271-201:2014 pour l'appareillage sous enveloppe isolante solide;
- Unité fonctionnelle de transformateur de puissance IEC 60076 (toutes les parties);
- Unité fonctionnelle basse tension IEC 61439 (toutes les parties) et IEC 60947-1.

Les unités fonctionnelles individuelles d'un ECEPD-G doivent satisfaire aux exigences de leurs normes de produits respectives indiquées ci-dessus.

Pour les ECEPD-A et ECEPD-I, les unités fonctionnelles individuelles peuvent s'écarter de ces normes de produits pour certains aspects. Par conséquent, des modes opératoires d'essai spécifiques pour les unités fonctionnelles individuelles, lorsque l'application directe des normes de produits mentionnées ci-dessus n'est pas possible, sont décrits dans le présent document.

6.1 Exigences pour les liquides utilisés dans l'appareillage

Le paragraphe 6.1 de l'IEC 62271-1:2017 est applicable.

6.2 Exigences pour les gaz utilisés dans l'appareillage

Le paragraphe 6.2 de l'IEC 62271-1:2017 est applicable.

NOTE Pour la manipulation du SF₆, se reporter à l'IEC 62271-4 [3].

6.3 Raccordement à la terre de l'appareillage

Le paragraphe 6.3 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

Un système de circuit principal de mise à la terre doit être disponible pour raccorder à la terre toutes les parties métalliques de l'ECEPD qui n'appartiennent pas aux circuits principaux et/ou secondaires/auxiliaires de l'équipement. Ce système se compose d'un conducteur de mise à la terre principal auquel chaque composant est raccordé par l'intermédiaire d'un circuit unique.

Lorsque l'ECEPD est équipé d'un cadre métallique, celui-ci peut alors servir de, ou faire partie du, circuit principal de mise à la terre. Dans ce cas, le système de fixation, s'il existe, utilisé pour joindre les pièces du cadre doit démontrer sa capacité à transporter le courant phase-terre assigné. Ce système de circuit principal de mise à la terre doit être conçu pour supporter le courant de courte durée admissible assigné et sa valeur de crête selon la condition de mise à la terre du neutre de l'installation.

La section de tout conducteur de mise à la terre ne doit pas être inférieure à 30 mm². Elle doit se terminer par une borne appropriée prévue pour être raccordée au réseau de terre de l'installation. Lorsque tout conducteur ou toute partie conductrice du circuit de mise à la terre n'est pas en cuivre, des exigences conductrices et mécaniques équivalentes doivent être satisfaites.

La continuité du circuit de mise à la terre doit être assurée et des mesures correspondantes qui empêchent la corrosion, le desserrement des boulons, etc. doivent être prises. Le réseau de circuits de mise à la terre doit tenir compte des contraintes thermiques et mécaniques provoquées par le courant.

NOTE L'utilisateur peut définir des modes opératoires pour vérifier l'intégrité de toutes les parties du circuit de mise à la terre (internes et externes) périodiquement ou après un courant de court-circuit.

Les composants à raccorder au circuit principal de mise à la terre doivent inclure:

- l'enveloppe, lorsqu'elle est métallique, des unités fonctionnelles haute tension à partir de la borne prévue à cet effet;
- le bac de l'unité fonctionnelle de transformateur de puissance immergé dans le liquide ou les parties métalliques non actives de l'unité fonctionnelle de transformateur de puissance de type sec;
- le cadre et/ou l'enveloppe, lorsqu'ils sont métalliques, de l'unité fonctionnelle basse tension;
- la connexion de mise à la terre des commandes automatiques et des appareils de commande à distance;
- les écrans métalliques et les conducteurs de mise à la terre des câbles haute tension;
- le cadre métallique de l'ECEPD, s'il existe;
- les sectionneurs de terre, s'ils existent.

6.4 Équipements et circuits auxiliaires et de commande

Le paragraphe 6.4 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

Pour l'installation basse tension intégrée dans l'ECEPD (par exemple, éclairage, alimentation auxiliaire, etc.), se reporter à l'IEC 60364-4-41:2005 pour les installations électriques basse tension ou l'IEC 61439-1:2020 pour les ensembles d'appareillages à basse tension, selon le cas.

6.5 Manœuvre dépendante à source d'énergie extérieure

Le paragraphe 6.5 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.6 Manœuvre à accumulation d'énergie

Le paragraphe 6.6 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.7 Manœuvre indépendante sans accrochage mécanique (manœuvre indépendante manuelle ou manœuvre indépendante à source d'énergie extérieure)

Le paragraphe 6.7 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.8 Organes de commande à manœuvre manuelle

Le paragraphe 6.8 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.9 Fonctionnement des déclencheurs

Le paragraphe 6.9 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.10 Indication de la pression / du niveau

Le paragraphe 6.10 de l'IEC 62271-1:2017 est applicable.

6.11 Plaques signalétiques

Le paragraphe 6.11 de l'IEC 62271-1:2017 ne s'applique pas, et est remplacé comme suit:

Chaque ECEPD doit être fourni avec une plaque signalétique durable, clairement lisible, visible dans des conditions de fonctionnement, qui doit contenir au moins les informations suivantes:

- nom ou marque commerciale du constructeur;
- désignation du type;
- numéro de série;
- numéro du présent document;
- année de fabrication;
- caractéristiques assignées de l'ECEPD énumérées dans l'Article 5;
- désignation de la classe de tenue à l'arc interne, le cas échéant;
- référence au manuel d'instructions.

Les caractéristiques assignées des unités fonctionnelles doivent être énumérées sur des plaques signalétiques séparées, clairement visibles, ou sur la plaque signalétique de l'ECEPD. Lorsque les unités fonctionnelles sont indépendantes, elles doivent être livrées avec des plaques signalétiques séparées comme dans leurs normes de produits respectives.

Chaque plaque signalétique doit porter un numéro de série unique.

6.12 Dispositifs de verrouillage

Le paragraphe 6.12 de l'IEC 62271-1:2017 ne s'applique pas, et est remplacé comme suit:

Le verrouillage peut être nécessaire pour assurer la séquence correcte de fonctionnement de l'équipement, afin de réduire le plus possible les risques pour le personnel et les dommages pour l'équipement. Le verrouillage peut être réalisé par des méthodes électriques ou mécaniques. Lorsque des verrouillages non mécaniques sont fournis, la conception doit être

telle qu'aucune situation incorrecte ne puisse survenir en cas d'absence d'alimentation auxiliaire.

6.13 Indicateur de position

Le paragraphe 6.13 de l'IEC 62271-1:2017 n'est pas applicable à l'ECEPD.

Le paragraphe 6.13 de l'IEC 62271-1:2017 pour l'unité fonctionnelle haute tension et le paragraphe 8.1.6 de l'IEC 60947-1:2020 pour l'unité fonctionnelle basse tension sont applicables.

6.14 Degrés de protection procurés par les enveloppes

6.14.1 Généralités

Le paragraphe 6.14 de l'IEC 62271-1:2017 n'est pas applicable à l'ECEPD.

6.14.2 Protection des personnes contre l'accès aux parties dangereuses et protection du matériel contre la pénétration de corps solides étrangers (codification IP)

Les degrés de protection conformément à l'IEC 60529 doivent être tels que spécifiés ci-dessous.

Les enveloppes des unités fonctionnelles haute tension et basse tension doivent assurer un degré minimal de protection IP2X pour une application à l'intérieur.

Lorsque des conducteurs et/ou des traversées non isolés sont utilisés pour les interconnexions basse tension ou lorsque des conducteurs et/ou des traversées non blindés sont utilisés pour les interconnexions haute tension, des moyens adaptés pour empêcher le contact direct avec les parties actives doivent être fournis soit par le constructeur en tant que partie intégrante de l'ECEPD lui-même, soit par l'utilisateur en incorporant la protection adéquate sur le site d'installation. Dans le premier cas, il convient que le degré minimal de protection soit IP1X. Dans le second cas, le constructeur doit inclure dans le manuel d'instructions des informations claires sur la nécessité de fournir une protection supplémentaire.

NOTE Des mesures de sécurité complémentaires pour la protection des personnes contre toute approche des parties dangereuses sont décrites à l'Article 8 de l'IEC 61936-1:2021 [4].

Lorsqu'une unité fonctionnelle de transformateur de puissance de type sec est utilisée, un moyen de protection autour de l'unité fonctionnelle de transformateur de puissance doit être fourni avec un degré minimal de protection IP2X.

6.14.3 Protection contre la pénétration d'eau (codification IP)

Pour une application à l'extérieur de l'ECEPD, le degré minimal de protection doit être IP23.

6.14.4 Protection contre les impacts mécaniques dans les conditions normales de service (codification IK)

Les enveloppes doivent avoir une résistance mécanique suffisante pour résister aux impacts mécaniques externes d'une énergie de 2 J, correspondant à un degré de protection IK07 [5] pour une application à l'intérieur et une énergie de 20 J correspondant à un degré de protection IK10 pour une application à l'extérieur.

NOTE Un ECEPD pour une application à l'intérieur est toujours installé dans un local électrique fermé. En cas d'installation de l'ECEPD à l'intérieur d'une clôture au sein d'un site industriel, l'utilisateur peut envisager de renforcer les exigences mécaniques de la clôture afin de protéger l'intégrité de l'ECEPD.

6.15 Lignes de fuite pour les isolateurs d'extérieur

Le paragraphe 6.15 de l'IEC 62271-1:2017 est applicable uniquement aux isolateurs d'extérieur haute tension (lorsqu'ils existent) de l'unité fonctionnelle haute tension et du côté haute tension de l'unité fonctionnelle de transformateur de puissance.

6.16 Étanchéité au gaz et au vide

Le paragraphe 6.16 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension de l'ECEPD.

Le paragraphe 5.11 de l'IEC 60076-15:2015 est applicable à l'unité fonctionnelle de transformateur de puissance lorsque celle-ci est de type à isolation gazeuse.

6.17 Étanchéité des systèmes de liquide

Le paragraphe 6.17 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

Pour une unité fonctionnelle de transformateur de puissance, les articles pertinents de l'IEC 60076 (toutes les parties) sont applicables.

6.18 Risque de feu (inflammabilité)

Le paragraphe 6.18 de l'IEC 62271-1:2017 est applicable à l'ECEPD.

6.19 Compatibilité électromagnétique (CEM)

Le paragraphe 6.19 de l'IEC 62271-1:2017 ne s'applique pas.

Le paragraphe 6.19 de l'IEC 62271-1:2017 pour l'unité fonctionnelle haute tension, ainsi que le 9.4 et l'Annexe J de l'IEC 61439-1:2020 pour l'unité fonctionnelle basse tension sont applicables respectivement aux unités fonctionnelles haute tension et basse tension de l'ECEPD.

6.20 Émission de rayons X

Le paragraphe 6.20 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.21 Corrosion

Le paragraphe 6.21 de l'IEC 62271-1:2017 est applicable à l'ECEPD.

6.22 Niveaux de remplissage pour l'isolement, la coupure et/ou la manœuvre

Le paragraphe 6.22 de l'IEC 62271-1:2017 est applicable uniquement à l'unité fonctionnelle haute tension.

6.101 Protection contre les contraintes mécaniques

Les enveloppes doivent avoir une résistance mécanique suffisante pour supporter les charges et les impacts suivants:

- a) pour un ECEPD destiné à une installation à l'extérieur, des charges de neige selon les conditions climatiques locales;
- b) pour un ECEPD destiné à une installation à l'extérieur, les effets mécaniques de la pression du vent selon 4.1.3 de l'IEC 62271-1:2017. Ces dispositions peuvent être vérifiées par calcul.

Toutes les autres contraintes mécaniques susceptibles de se produire en service, selon l'application prévue, peuvent être vérifiées par calcul.

NOTE 1 Les contraintes sismiques conformément à l'IEC TS 62271-210:2013 [6] peuvent aussi être prises en considération dans ce paragraphe.

Les pattes de levage de l'ensemble complet doivent être conçues pour supporter le poids total de l'ECEPD. Bien que chaque composant ait été soumis à un essai de stabilité physique intrinsèque, lorsque différents composants sont fixés ensemble dans un ECEPD, il peut en résulter une instabilité. La conception doit assurer la stabilité pendant la livraison, l'installation et le fonctionnement.

NOTE 2 Les pattes de levage conçues pour soulever l'ensemble complet peuvent être peintes en jaune pour faciliter l'identification.

6.102 Protection de l'environnement du fait de défauts internes

Dans le cas où des défauts internes peuvent entraîner l'échappement de liquides dangereux de l'équipement (par exemple, un liquide qui s'échappe d'une unité fonctionnelle de transformateur de puissance ou d'une unité fonctionnelle haute tension), des dispositions doivent être prises pour retenir les liquides dangereux afin d'empêcher la pollution des sols.

La capacité du bac de rétention doit être au moins égale à celle du plus grand conteneur de liquide dangereux (par exemple, unité fonctionnelle du transformateur de puissance, unité fonctionnelle haute tension, etc.), à moins que les réglementations nationales applicables n'expriment des exigences différentes. Le bac de rétention peut faire partie de l'ECEPD ou être fourni sur le site d'installation sur lequel l'ECEPD doit être installé.

Des mesures supplémentaires peuvent être prises par accord entre le constructeur et l'utilisateur.

6.103 Défaut d'arc interne

Un ECEPD qui satisfait aux exigences du présent document est en principe conçu pour empêcher l'apparition de défauts d'arc interne du côté haute tension.

Pour atteindre cet objectif, le constructeur de l'ECEPD doit assurer la fabrication correcte, en la vérifiant à l'aide d'essais individuels de série selon l'Article 8. L'utilisateur doit à son tour faire un choix approprié, selon les caractéristiques du réseau, les modes opératoires de fonctionnement et les conditions de service (se reporter à l'Article 9).

Il convient que la probabilité d'apparition d'un arc interne pendant toute la durée de vie en service soit faible, sous réserve d'une installation, d'une utilisation et d'une maintenance de l'ECEPD suivant les instructions fournies par le constructeur et d'une installation correcte des câbles. La possibilité d'un arc interne ne peut toutefois pas être complètement négligée.

Des défaillances peuvent survenir dans toute partie de l'ECEPD. Toutefois, comme aucun mode opératoire d'essai d'arc interne pour l'unité fonctionnelle basse tension et l'unité fonctionnelle de transformateur de puissance n'est décrit dans leurs normes pertinentes respectives, seuls les défauts dans l'enveloppe des unités fonctionnelles haute tension et dans l'interconnexion haute tension sont pris en considération dans le présent document (voir 7.101).

NOTE Lorsque l'utilisateur et le constructeur conviennent d'un essai d'arc interne de la partie basse tension de l'ECEPD, l'IEC TR 61641:2014 [7] fournit des recommandations pour un essai d'arc interne dans les ensembles d'appareillages à basse tension sous enveloppe.

Une défaillance due à un défaut, à des conditions de service exceptionnelles ou à un dysfonctionnement du côté haute tension peut être à l'origine d'un arc interne dans l'unité fonctionnelle haute tension et/ou dans l'interconnexion haute tension, ce qui constitue un danger lorsque des personnes sont présentes.

6.104 Enveloppes

Les enveloppes des unités fonctionnelles doivent satisfaire aux exigences pertinentes de leurs normes de produits respectives. En cas de partage de l'enveloppe par plusieurs unités fonctionnelles, elle doit satisfaire aux exigences des normes de produits de ces unités fonctionnelles (exemple: le bac de l'unité fonctionnelle de transformateur de puissance d'un ECEPD-I doit satisfaire aux exigences de l'IEC 60076 (toutes les parties), le cas échéant, et de l'IEC 62271-200:2021).

6.105 Émission de bruit

L'unité fonctionnelle de transformateur de puissance est la principale source de bruit. Il n'existe cependant aucune exigence à ce propos dans les normes pertinentes des unités fonctionnelles haute tension et basse tension et la contribution directe des unités fonctionnelles haute tension et basse tension au niveau de bruit de l'ECEPD est, en principe, considérée comme négligeable. Toutefois, la détermination du niveau de bruit de l'ECEPD doit être réalisée selon l'Annexe B sur l'ECEPD complet pour prendre en compte les interactions éventuelles.

6.106 Champs électromagnétiques

L'ECEPD en service génère des champs électromagnétiques qui peuvent nécessiter une évaluation pour:

- aider à la planification, à l'installation, aux instructions d'utilisation et à l'entretien;
- prendre des mesures pour satisfaire aux exigences ou aux réglementations sur les champs électromagnétiques.

Lorsqu'une évaluation des champs électromagnétiques générés par un ECEPD est exigée, il convient de suivre la méthodologie décrite dans l'IEC TR 62271-208:2009.

6.107 Rayonnement solaire

Les performances d'un ECEPD installé à l'extérieur peuvent, pendant les conditions de service, être considérablement altérées du fait du rayonnement solaire. Outre les pertes issues des composants, le rayonnement solaire peut constituer une source de chaleur externe importante qui peut altérer les performances. Chaque partie extérieure de l'ECEPD exposée au rayonnement solaire produit un transfert de chaleur supplémentaire qui peut entraîner un déclassement d'une unité fonctionnelle en raison du dépassement de l'échauffement maximal établi par sa norme de produit spécifique. À titre d'exemple, le rayonnement thermique sur l'enveloppe de l'unité fonctionnelle haute tension peut exiger son déclassement et/ou réduire le courant maximal admissible. Dans certains cas, ce rayonnement peut entraîner le dysfonctionnement ou une défaillance prématurés des dispositifs électroniques sensibles à la température.

L'Annexe G de l'IEC 62271-202:2022 fournit des recommandations concernant le mode d'évaluation de l'effet du rayonnement solaire.

Il peut être nécessaire d'envisager des mesures complémentaires, par exemple, double toiture, enveloppes à couleurs plus claires, doubles parois, matériaux d'enveloppe alternatifs, etc. pour réduire l'effet du rayonnement solaire sur l'ECEPD. Ces mesures complémentaires sont soumises à un accord entre le constructeur et l'utilisateur.

L'IEC 60721-2-4:2018 peut être utilisée pour faciliter la sélection du niveau approprié de rayonnement solaire.

7 Essais de type

7.1 Généralités

7.1.1 Principes fondamentaux

Le paragraphe 7.1.1 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

En principe, les essais de type doivent être réalisés sur une configuration représentative de l'ECEPD. Les unités fonctionnelles et les interconnexions contenues dans un ECEPD doivent être soumises à l'essai selon leur norme de produit pertinente.

Les essais de type doivent être réalisés sur l'ECEPD complet, sauf spécification contraire dans le présent document.

Du fait de la conception de l'équipement, il peut être pratique de soumettre à l'essai plusieurs fonctions en même temps. Dans ce cas, il n'est pas exigé de répéter les essais dont les conditions d'application sont identiques dans leurs normes respectives.

L'objectif des essais de type sur un ECEPD est de démontrer les caractéristiques de l'ECEPD en tant qu'unité complète. Les essais exigés sur l'ECEPD complet, en plus de ceux exigés pour les unités fonctionnelles individuelles, sont énumérés ci-dessous:

Essais de type obligatoires:	Paragraphe
a) Essais de vérification du niveau d'isolement de l'ECEPD	7.2
b) Mesurage de la résistance du circuit principal de l'unité fonctionnelle haute tension	7.4
c) Essai de vérification de l'échauffement de toute partie de l'équipement	7.101
d) Essais de vérification de l'aptitude des circuits principaux et de mise à la terre à supporter des valeurs de crête de courants admissibles assignées et des courants de courte durée admissibles assignés	7.6
e) Essais de vérification du degré de protection et de résistance aux impacts mécaniques	7.7
f) Essais complémentaires sur les circuits auxiliaires et de commande	7.10
g) Vérification des pouvoirs de fermeture et de coupure de l'unité fonctionnelle haute tension	7.103
h) Essais de fonctionnement mécanique	7.104
Essais de type obligatoires, le cas échéant:	
i) Essais d'étanchéité	7.8
j) Essais de compatibilité électromagnétique (CEM)	7.9
k) Pour un ECEPD destiné à être classifié IAC, essais pour évaluer les effets d'un arc dû à un défaut interne	7.102
l) Essais de tenue à la pression pour les compartiments à remplissage de gaz	7.106
m) Mesurages du courant de fuite des enveloppes non métalliques	7.107
n) Étanchéité et résistance mécanique des compartiments remplis de liquide	7.109
Essais de type spéciaux (soumis à un accord entre le constructeur et l'utilisateur):	
o) Essais de vérification du niveau de bruit de l'ECEPD	Annexe B
p) Essai de stabilité mécanique	7.105
q) Essai de décharges partielles	7.2.10

- | | |
|---|-------|
| r) Essais de protection contre les intempéries | 7.108 |
| s) Mesurage ou calcul des champs électromagnétiques | 7.110 |

Les essais de type peuvent altérer la capacité des parties soumises à l'essai pour un usage ultérieur en service. Par conséquent, les objets d'essai utilisés pour un essai de type ne doivent pas être utilisés en service sans un accord entre le constructeur et l'utilisateur.

7.1.2 Informations pour l'identification des objets d'essai

Le paragraphe 7.1.2 de l'IEC 62271-1:2017 est applicable.

7.1.3 Informations à inclure dans les rapports d'essais de type

Le paragraphe 7.1.3 de l'IEC 62271-1:2017 est applicable avec l'ajout suivant à la liste:

- l'identification, y compris les numéros de série selon le cas, de toutes les unités fonctionnelles de l'ECEPD, avec l'identification de l'ECEPD lui-même;
- les informations détaillées des interconnexions mécaniques et électriques des unités fonctionnelles partie intégrante de l'ECEPD;
- des plans et photographies qui illustrent ce montage physique de l'équipement pendant les essais.

Le rapport d'essai de type d'arc interne doit fournir les informations détaillées en 7.102.6.

7.2 Essais diélectriques

7.2.1 Généralités

Le paragraphe 7.2 de l'IEC 62271-1:2017 est applicable avec les ajouts suivants:

Lors de la réalisation des essais diélectriques, les critères suivants s'appliquent afin de limiter le nombre d'essais exigés:

- a) dans le cas où chacun des principaux composants de l'ECEPD (unité fonctionnelle haute tension, unité fonctionnelle de transformateur de puissance et unité fonctionnelle basse tension) a été préalablement soumis à un essai de type individuel dans les mêmes conditions que dans l'ECEPD, il n'est pas nécessaire de réaliser des essais diélectriques;
- b) les essais diélectriques ne sont pas exigés pour l'interconnexion haute tension lorsqu'elle est constituée de câbles à blindage métallique haute tension soumis à un essai de type et raccordés au moyen de connecteurs également à blindage métallique et soumis à un essai de type, ou par d'autres types de terminaisons soumises à l'essai sur l'appareillage à haute tension et les côtés du transformateur de puissance dans les conditions d'installation du poste préfabriqué;
- c) dans le cas où les principaux composants (unité fonctionnelle haute tension, unité fonctionnelle de transformateur de puissance et unité fonctionnelle basse tension) sont soumis à des essais de type selon leurs normes de produits, mais que les interconnexions ne sont pas soumises préalablement à un essai de type, les essais indiqués en 7.2.2 et 7.2.3 doivent être effectués;
- d) dans tous les autres cas, les essais diélectriques indiqués en 7.2.2, 7.2.3, 7.2.4, 7.2.5 et 7.2.6 doivent être effectués.

7.2.2 Conditions de l'air ambiant pendant les essais

Le paragraphe 7.2.2 de l'IEC 62271-1:2017 est applicable.

7.2.3 Modalités des essais sous pluie

Dans le cas où un essai sous pluie est exigé pour un ECEPD d'extérieur, le paragraphe 7.2.3 de l'IEC 62271-1:2017 est alors applicable.

7.2.4 Disposition de l'appareil

Le paragraphe 7.2.4 de l'IEC 62271-1:2017 ne s'applique pas. Se reporter en revanche au 7.2.101.

7.2.5 Conditions de réussite des essais

Le paragraphe 7.2.5 de l'IEC 62271-1:2017 est applicable aux composants soumis à un essai à haute tension.

7.2.6 Application de la tension d'essai et conditions d'essai

Le paragraphe 7.2.6 de l'IEC 62271-1:2017 ne s'applique pas. Se reporter en revanche au 7.2.101.2.

7.2.7 Essais de l'appareillage de $U_r \leq 245$ kV

Le paragraphe 7.2.7 de l'IEC 62271-1:2017 est applicable à l'unité fonctionnelle haute tension.

7.2.8 Essais de l'appareillage de $U_r > 245$ kV

Le paragraphe 7.2.8 de l'IEC 62271-1:2017 ne s'applique pas.

7.2.9 Essais de pollution artificielle pour les isolateurs d'extérieur

Le paragraphe 7.2.9 de l'IEC 62271-1:2017 est applicable uniquement aux isolateurs d'extérieur haute tension (lorsqu'ils existent) de l'unité fonctionnelle haute tension et du côté haute tension de l'unité fonctionnelle de transformateur de puissance.

7.2.10 Essais de décharges partielles

Le paragraphe 7.2.10 de l'IEC 62271-1:2017 n'est pas applicable à l'ECEPD.

Un essai de décharges partielles peut être spécifié par certaines des normes de produits relatives aux composants principaux.

Par accord entre le constructeur et l'utilisateur, un essai d'évaluation de l'isolation de l'unité fonctionnelle haute tension peut être effectué en suivant le 7.2.10 de l'IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou le 6.2.9 de l'IEC 62271-201:2014 pour l'appareillage sous enveloppe isolante solide, selon le type d'isolation.

7.2.11 Essais diélectriques sur les circuits auxiliaires et de commande

Le paragraphe 7.2.11 de l'IEC 62271-1:2017 est applicable.

7.2.12 Essais de tension comme essai de vérification d'état

Le paragraphe 7.2.12 de l'IEC 62271-1:2017 n'est pas applicable à l'ECEPD.

7.2.101 Essais diélectriques de l'interconnexion haute tension

7.2.101.1 Conditions générales

Les essais peuvent être effectués avec le transformateur de puissance remplacé par une réplique qui reproduit la configuration de champ des traversées du transformateur.

Pour les essais, la connexion haute tension est raccordée à l'alimentation d'essai par l'intermédiaire de l'unité fonctionnelle haute tension. Seuls les appareils de connexion qui sont en série dans le circuit d'alimentation sont fermés. Tous les autres appareils de connexion sont ouverts.

Les dispositifs limiteurs de tension doivent être déconnectés pendant les essais diélectriques.

Les bornes secondaires des transformateurs de courant doivent être mises en court-circuit et raccordées à la terre.

Les transformateurs de mesure, les transformateurs de puissance ou les fusibles peuvent être remplacés par des répliques qui reproduisent la configuration de champ des connexions haute tension.

7.2.101.2 Application de la tension d'essai

7.2.101.2.1 Généralités

Les tensions d'essai doivent être appliquées par la connexion tour à tour de chaque conducteur de phase du circuit principal à la borne haute tension de l'alimentation d'essai. Tous les autres conducteurs du circuit principal, des circuits auxiliaires et de toutes les autres parties métalliques doivent être raccordés au conducteur de terre du cadre, et à la borne de terre de l'alimentation d'essai.

Lorsque des connexions haute tension sans blindage métallique sont utilisées, le matériau non conducteur doit résister de même aux tensions d'essai spécifiées en 7.2.101.4. Les méthodes spécifiées dans l'IEC 60243-1:2013 doivent être appliquées à l'essai lorsque le matériau non conducteur satisfait aux exigences concernées.

7.2.101.2.2 Tension d'essai

Se reporter au 7.2.6 de l'IEC 62271-1:2017.

7.2.101.3 Essais de tension de choc de foudre

L'interconnexion haute tension doit être soumise à des essais de tension de choc de foudre selon 7.2.7.3 de l'IEC 62271-1:2017 avec l'ajout suivant:

Pendant les essais de tension de choc de foudre, la borne mise à la terre du générateur de choc doit être connectée au système de conducteur de mise à la terre principal de l'ECEPD. Les dispositifs de suppression de la surtension doivent être déconnectés.

7.2.101.4 Essais de tenue à la tension à fréquence industrielle

L'interconnexion basse tension doit être soumise à des essais de tenue à la tension à fréquence industrielle de 1 min dans des conditions sèches conformément au 7.2.7.2 de l'IEC 62271-1:2017 avec l'ajout suivant:

Pendant l'essai de tension à fréquence industrielle, une borne du transformateur d'essai doit être raccordée à la terre et connectée au système de conducteur de mise à la terre principal de l'ECEPD.

7.2.101.5 Interconnexion haute tension recouverte d'une enveloppe non métallique

Lorsque l'interconnexion est entièrement ou partiellement recouverte d'une enveloppe non métallique accessible pendant le fonctionnement normal, cette enveloppe doit satisfaire aux exigences suivantes.

- a) L'isolation entre les parties actives du circuit principal et la surface accessible de l'enveloppe isolante doit résister aux tensions d'essai spécifiées au 5.3 de l'IEC 62271-1:2017 pour les essais de tension à la terre et entre les pôles.
- b) Le matériau isolant doit résister à la tension d'essai à fréquence industrielle spécifiée au point a). Les méthodes d'essai appropriées indiquées dans l'IEC 60243-1:2013 doivent être appliquées à l'essai lorsque le matériau isolant satisfait aux exigences concernées.
- c) L'isolation entre les parties actives du circuit principal et la surface interne de l'enveloppe isolante qui leur fait face doit résister à au moins 150 % de la tension assignée de l'équipement pendant une minute. Cette disposition doit être vérifiée par essai selon 6.104 de l'IEC 62271-201:2014 compte tenu de la catégorie de protection sélectionnée de l'interconnexion.
- d) Lorsqu'un courant de fuite peut atteindre le côté accessible de l'enveloppe isolante par un cheminement continu sur les surfaces isolantes, il ne doit pas être supérieur à 0,5 mA dans les conditions d'essai spécifiées (se reporter à 7.104).

Pour les modes opératoires d'essai, voir 7.2.101.2.2 de l'IEC 62271-202:2022.

7.2.102 Essais diélectriques de l'interconnexion basse tension

7.2.102.1 Conditions générales

Pour les essais, l'interconnexion basse tension est connectée à l'alimentation d'essai par l'intermédiaire de l'unité fonctionnelle basse tension. Une borne de la source de tension doit être connectée au système de conducteur de mise à la terre principal de l'ECEPD. Seuls les appareils de connexion qui sont en série dans le circuit d'alimentation sont fermés. Tous les autres appareils de connexion sont ouverts.

Lorsque l'interconnexion basse tension est partiellement ou totalement recouverte d'une enveloppe non métallique, cette enveloppe doit être recouverte d'une feuille métallique circulaire ou carrée d'une surface aussi grande que possible, mais qui ne dépasse pas toutefois 100 cm², reliée à la terre. La feuille doit être appliquée sur toutes les surfaces susceptibles d'être touchées par un opérateur.

7.2.102.2 Essais de tension de choc de foudre

L'interconnexion basse tension doit être soumise à des essais de tension de choc de foudre. L'essai de tension de choc assignée est choisi selon 5.3.

La tension de choc de 1,2/50 µs doit être appliquée trois fois pour chaque polarité à des intervalles de 1 s au minimum. Les dispositifs de suppression de la surtension doivent être déconnectés.

La tension d'essai doit être appliquée par la connexion tour à tour de chaque conducteur de phase du circuit principal à la borne haute tension de l'alimentation d'essai. Tous les autres conducteurs du circuit principal et des circuits auxiliaires doivent être raccordés au conducteur de terre ou au cadre, ainsi qu'à la borne de terre de l'alimentation d'essai.

Il ne doit pas y avoir de décharge disruptive pendant les essais.

7.2.102.3 Essais de tenue à la tension à fréquence industrielle

L'interconnexion basse tension doit être soumise à des essais de tenue à la tension à fréquence industrielle de 1 min dans des conditions sèches conformément au 10.9.2 de l'IEC 61439-1:2020 avec l'ajout suivant:

Pendant l'essai de tenue à la tension à fréquence industrielle, une borne du transformateur d'essai doit être raccordée à la terre et connectée au système de conducteur de mise à la terre principal de l'ECEPD.

7.2.103 Essais diélectriques sur l'unité fonctionnelle haute tension

Le paragraphe 7.2 de l'IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou 6.2 de l'IEC 62271-201:2014 pour l'appareillage sous enveloppe isolante solide est applicable avec l'ajout suivant:

Dans le cas où la conception de l'ECEPD ne permet pas de séparer physiquement l'unité fonctionnelle de transformateur de puissance et l'unité fonctionnelle haute tension, les essais de l'unité fonctionnelle haute tension doivent être effectués avec l'unité fonctionnelle de transformateur de puissance isolée de l'unité fonctionnelle haute tension (par exemple, par retrait de l'interconnexion).

7.2.104 Essais diélectriques sur l'unité fonctionnelle de transformateur de puissance

Les essais stipulés dans l'IEC 60076 (toutes les parties) doivent être appliqués, avec les considérations suivantes:

Il convient de préférence de déconnecter l'unité fonctionnelle de transformateur de puissance de l'unité fonctionnelle haute tension et de l'unité fonctionnelle basse tension. Toutefois, pour des raisons pratiques, la tension d'essai peut être appliquée par l'intermédiaire de l'unité fonctionnelle haute tension. Seuls les appareils de connexion qui sont en série dans le circuit d'alimentation sont fermés. Tous les autres appareils de connexion sont ouverts.

7.2.105 Essais diélectriques sur l'unité fonctionnelle basse tension

Le paragraphe 9.1 de l'IEC 61439-1:2020 est applicable.

Pour des raisons pratiques, cet essai peut être réalisé sur l'unité fonctionnelle basse tension déjà installée dans l'ECEPD. Dans ce cas, l'unité fonctionnelle basse tension doit être isolée de l'unité fonctionnelle de transformateur de puissance.

7.3 Essai de tension de perturbation radioélectrique

Le paragraphe 7.3 de l'IEC 62271-1:2017 ne s'applique pas à l'ECEPD.

7.4 Mesurage de la résistance

Le paragraphe 7.4 de l'IEC 62271-1:2017 est applicable avec les considérations suivantes.

Lorsque l'unité fonctionnelle de transformateur de puissance ne peut pas être déconnectée de l'unité fonctionnelle haute tension, le mesurage de la résistance peut être influencé par les enroulements haute tension du transformateur de puissance.

7.5 Essais au courant permanent

Le paragraphe 7.5 de l'IEC 62271-1:2017 est applicable avec les considérations suivantes.

Cet essai est applicable à l'ECEPD-G et à l'ECEPD-A. Pour l'ECEPD-I, cet essai n'est pas applicable lorsque l'unité fonctionnelle de transformateur de puissance ne peut pas être déconnectée de l'unité fonctionnelle haute tension.

7.6 Essais au courant de courte durée admissible et à la valeur de crête du courant admissible

Le paragraphe 7.6 de l'IEC 62271-1:2017 n'est pas applicable à l'ECEPD.

7.6.101 Essais au courant de courte durée et à la valeur de crête du courant admissible du circuit principal des unités fonctionnelles haute tension et basse tension

L'unité fonctionnelle haute tension qui n'a pas encore été soumise à l'essai doit être soumise à l'essai selon 7.6 de l'IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou selon 6.6 de l'IEC 62271-201:2014 pour l'appareillage sous enveloppe à isolation solide. L'unité fonctionnelle haute tension doit être isolée de l'unité fonctionnelle de transformateur de puissance pour réaliser l'essai.

L'unité fonctionnelle basse tension qui n'a pas encore été soumise à l'essai doit être soumise à l'essai conformément à l'IEC 61439-1:2020. L'unité fonctionnelle basse tension doit être isolée de l'unité fonctionnelle de transformateur de puissance pour réaliser l'essai.

7.6.102 Essais au courant de courte durée et à la valeur de crête du courant admissible des interconnexions haute tension et basse tension

L'interconnexion haute tension doit être soumise à l'essai suivant le mode opératoire décrit en 7.6.1 a) de l'IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou en 6.6 a) de l'IEC 62271-201:2014 pour l'appareillage sous enveloppe à isolation solide. Le courant d'essai doit être appliqué de manière à soumettre à l'essai la connexion complète au transformateur de puissance. Toutes les pièces de support de l'interconnexion doivent être maintenues en place dans les conditions de service pendant l'essai.

Plus particulièrement, lorsque l'interconnexion haute tension est protégée par des dispositifs limiteurs de courant au sein de l'appareillage à haute tension, les dispositions du 7.6.1 a) de l'IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou du 6.6 a) de l'IEC 62271-201:2014 pour l'appareillage sous enveloppe à isolation solide s'appliquent.

Lorsque l'interconnexion haute tension n'est pas protégée par des dispositifs limiteurs de courant, l'essai peut être réalisé, le cas échéant, en même temps que l'essai de l'unité fonctionnelle haute tension, sous réserve que les conditions du 7.6.1 de l'IEC 62271-200:2021 pour l'appareillage sous enveloppe métallique ou du 6.6 de l'IEC 62271-201:2014 pour l'appareillage sous enveloppe à isolation solide soient satisfaites.

Les interconnexions basse tension non soumises à un essai de type peuvent être soumises à l'essai en suivant le mode opératoire décrit dans l'IEC 61439-1:2020 pour l'ensemble d'appareillages à basse tension. Cet essai peut être réalisé, le cas échéant, en même temps que l'essai de l'unité fonctionnelle basse tension. Le courant d'essai doit être appliqué de manière à soumettre à l'essai la connexion complète à l'unité fonctionnelle de transformateur de puissance. Toutes les pièces de support de l'interconnexion doivent être maintenues en place dans les conditions de service pendant l'essai.

Pour des raisons de sécurité, le transformateur de puissance peut être remplacé par une réplique pour les essais de type de courte durée et à courant de crête. Afin de vérifier la capacité de résistance des interconnexions à l'essai, un court-circuit est réalisé des deux côtés des bornes de la réplique du transformateur de puissance.

7.6.103 Essais au courant de courte durée et à la valeur de crête du courant admissible des circuits de mise à la terre

Le circuit de mise à la terre de l'ECEPD doit être soumis à l'essai selon 7.6 de l'IEC 62271-1:2017 avec l'ajout des alinéas suivants:

Les essais de type ne doivent pas être répétés sur les circuits principaux de mise à la terre des unités fonctionnelles soumises à un essai de type.

Après l'essai, une certaine déformation du conducteur de mise à la terre principal et des connexions aux unités fonctionnelles est admissible, mais la continuité du circuit doit être préservée.

Un essai des connexions des capots et des portes métalliques qui n'appartiennent pas au circuit principal de mise à la terre n'est pas exigé. Toutefois, ces capots et ces portes peuvent être soumis à l'essai à un courant continu de 30 A afin de démontrer la continuité électrique des parties métalliques reliées à la terre. Dans ce cas, la chute de tension doit être inférieure à 3 V.

7.6.104 Essais de courant de court-circuit sur l'unité fonctionnelle de transformateur de puissance

Par accord entre le constructeur et l'utilisateur, un essai de court-circuit conformément à l'IEC 60076-5:2006 peut être effectué sur l'unité fonctionnelle de transformateur de puissance.

Il convient de préférence de déconnecter l'unité fonctionnelle de transformateur de puissance de l'unité fonctionnelle haute tension et de l'unité fonctionnelle basse tension. Toutefois, pour des raisons pratiques, la tension d'essai peut être appliquée par l'intermédiaire de l'unité fonctionnelle haute tension. Seuls les appareils de connexion qui sont en série dans le circuit d'alimentation sont fermés. Tous les autres appareils de connexion sont ouverts.

7.7 Vérification de la protection

Le paragraphe 7.7 de l'IEC 62271-1:2017 est applicable avec l'ajout suivant:

La protection contre les contraintes mécaniques selon 6.14 et 6.101 doit être vérifiée.

7.8 Essais d'étanchéité

Le paragraphe 7.8 de l'IEC 62271-1:2017 est applicable à l'unité fonctionnelle haute tension.

7.9 Essais de compatibilité électromagnétique (CEM)

Pour l'unité fonctionnelle haute tension, le paragraphe 7.9 de l'IEC 62271-1:2017 est applicable à l'exception de l'essai de tension de perturbation radioélectrique.

Pour l'unité fonctionnelle basse tension, le paragraphe 10.12 de l'IEC 61439-1:2020 est applicable.

Un essai sur un ECEPD n'est pas nécessaire, à condition que l'unité fonctionnelle haute tension et l'unité fonctionnelle basse tension aient été soumises à l'essai selon leurs normes respectives.