

Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN IEC 62477-2:2018 sisaldab Euroopa standardi EN IEC 62477-2:2018 ingliskeelset teksti.	This Estonian standard EVS-EN IEC 62477-2:2018 consists of the English text of the European standard EN IEC 62477-2:2018.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 28.09.2018.	Date of Availability of the European standard is 28.09.2018.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 29.200

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:
Koduleht www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:

Homepage www.evs.ee; phone +372 605 5050; e-mail info@evs.ee

ICS 29.200

English Version

Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC
(IEC 62477-2:2018)

Exigences de sécurité applicables aux systèmes et matériels électroniques de conversion de puissance - Partie 2: Convertisseurs électroniques de puissance entre 1 000 V en courant alternatif ou 1 500 V en courant continu et 36 kV en courant alternatif ou 54 kV en courant continu
(IEC 62477-2:2018)

Sicherheitsanforderungen an Leistungshalbleiter-Umrichtersysteme und -Betriebsmittel - Teil 2: Leistungselektronik Umrichter von 1 000 V a.c. oder 1 500 V d.c. bis 36 kV a.c. oder 54 kV d.c.
(IEC 62477-2:2018)

This European Standard was approved by CENELEC on 2018-07-26. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 22/290/FDIS, future edition 1 of IEC 62477-2, prepared by IEC/TC 22 "Power electronic systems and equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62477-2:2018.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2019-04-26
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2021-07-26

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62477-2:2018 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60071-1:2006	NOTE Harmonized as EN 60071-1:2006 (not modified)
IEC 60071-2:1996	NOTE Harmonized as EN 60071-2:1997 (not modified)
IEC 60146-1-1	NOTE Harmonized as EN 60146-1-1
IEC 60243-1:2013	NOTE Harmonized as EN 60243-1:2013 (not modified)
IEC 60529:1989	NOTE Harmonized as EN 60529:1991 (not modified)
IEC 60721-3 series	NOTE Harmonized as EN 60721-3 series
IEC 60990:2016	NOTE Harmonized as EN 60990:2016 (not modified)
IEC 61936-1	NOTE Harmonized as EN 61936-1
IEC 62271-200:2011	NOTE Harmonized as EN 62271-200:2012 (not modified)
IEC 62271-201:2014	NOTE Harmonized as EN 62271-201:2014 (not modified)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60204-11	-	Safety of machinery - Electrical equipment- of machines - Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV		-
IEC 60417-DB	-	Graphical symbols for use on equipment	-	-
IEC 60617-DB	-	Graphical symbols for diagrams	-	-
IEC 60730-1	-	Automatic electrical controls - Part 1:EN 60730-1 General requirements		-
IEC 61230	-	Live working - Portable equipment for earthing or earthing and short-circuiting	EN 61230	-
IEC 62271-102	-	High-voltage switchgear and controlgear Part 102: Alternating current disconnectors and earthing switches	EN IEC 62271-102	-
IEC 62477-1	2012	Safety requirements for power electronic converter systems and equipment - Part 1: General	EN 62477-1	2012
-	-		+ A11	2014
+ A1	2016		+ A1	2017
IEC Guide 104	-	The preparation of safety publications and the use of basic safety publications and group safety publications		-
ISO/IEC Guide 51	2014	Safety aspects - Guidelines for their- inclusion in standards		-

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	11
3 Terms and definitions	11
4 Protection against hazards	12
4.1 General.....	12
4.2 Fault and abnormal conditions	13
4.3 Short-circuit and overload protection.....	14
4.3.1 General	14
4.3.2 Specification of input short-circuit withstand strength and output short-circuit current ability	14
4.3.3 Short-circuit coordination (backup protection)	14
4.3.4 Protection by several devices	14
4.3.5 Input ports short time withstand current, I_{CW}	14
4.4 Protection against electric shock.....	14
4.4.1 General	14
4.4.2 Decisive voltage class	15
4.4.3 Provision for basic protection.....	16
4.4.4 Provision for fault protection	17
4.4.5 Enhanced protection	18
4.4.6 Protective measures	18
4.4.7 Insulation.....	19
4.4.8 Compatibility with residual current-operated protective devices (RCD).....	24
4.4.9 Capacitor discharge.....	24
4.5 Protection against electrical energy hazards	26
4.5.1 Operator access areas.....	26
4.5.2 Service access areas.....	28
4.6 Protection against fire and thermal hazards	28
4.6.1 Circuits representing a fire hazard	28
4.6.2 Components representing a fire hazard	28
4.6.3 Fire enclosures.....	28
4.6.4 Temperature limits	29
4.6.5 Limited power sources	29
4.7 Protection against mechanical hazards	29
4.7.1 General	29
4.7.2 Specific requirements for liquid cooled PECS	29
4.8 Equipment with multiple sources of supply	30
4.9 Protection against environmental stresses	30
4.10 Protection against sonic pressure hazards	30
4.10.1 General	30
4.10.2 Sonic pressure and sound level	31
4.11 Wiring and connections.....	31
4.11.1 General	31
4.11.2 Routing.....	31
4.11.3 Colour coding	31
4.11.4 Splices and connections	31

4.11.5	Accessible connections	31
4.11.6	Interconnections between parts of the PECS	31
4.11.7	Supply connections	31
4.11.8	Terminals	31
4.12	Enclosures	31
4.12.1	General	31
4.12.2	Handles and manual controls	32
4.12.3	Cast metal	32
4.12.4	Sheet metal	32
4.12.5	Stability test for enclosure	32
5	Test requirements	32
5.1	General	32
5.1.1	Test objectives and classification	32
5.1.2	Selection of test samples	33
5.1.3	Sequence of tests	33
5.1.4	Earthing conditions	33
5.1.5	General conditions for tests	33
5.1.6	Compliance	33
5.1.7	Test overview	33
5.2	Test specifications	33
5.2.1	Visual inspections (type test, sample test and routine test)	33
5.2.2	Mechanical tests	34
5.2.3	Electrical tests	35
5.2.4	Abnormal operation and simulated faults tests	38
5.2.5	Material tests	42
5.2.6	Environmental tests (type tests)	42
5.2.7	Hydrostatic pressure test (type test and routine test)	43
6	Information and marking requirements	43
6.1	General	43
6.2	Information for selection	43
6.3	Information for installation and commissioning	43
6.3.1	General	43
6.3.2	Mechanical considerations	43
6.3.3	Environment	43
6.3.4	Handling and mounting	43
6.3.5	Enclosure temperature	43
6.3.6	Connections	43
6.3.7	Protection requirements	44
6.3.8	Commissioning	45
6.4	Information for use	45
6.4.1	General	45
6.4.2	Adjustment	45
6.4.3	Labels, signs and signals	45
6.5	Information for maintenance	45
6.5.1	General	45
6.5.2	Capacitor discharge	45
6.5.3	Auto restart/bypass connection	45
6.5.4	Other hazards	46
6.5.5	Equipment with multiple sources of supply	46

Annex A (normative) Additional information for protection against electric shock	47
A.1 General.....	47
A.2 Protection by means of DVC As	47
A.3 Protection by means of protective impedance	47
A.4 Protection by using limited voltages	47
A.5 Evaluation of working voltage and selection of DVC for touch voltage, PELV and SELV circuits	47
A.6 Evaluation of the working voltage of circuits.....	47
A.7 Examples of the use of elements of protective measures	47
Annex B (informative) Considerations for the reduction of the pollution degree	49
Annex C (informative) Symbols referred to in IEC 62477-1	50
Annex D (normative) Evaluation of clearance and creepage distances	51
Annex E (informative) Altitude correction for clearances	52
Annex F (normative) Clearance and creepage distance determination for frequencies greater than 30 kHz	53
Annex G (informative) Cross-sections of round conductors	54
Annex H (informative) Guidelines for RCD compatibility.....	55
H.1 Selection of RCD type.....	55
Annex I (informative) Examples of overvoltage category reduction.....	56
Annex J (informative) Burn thresholds for touchable surfaces	57
Annex K (informative) Table of electrochemical potentials	58
Annex L (informative) Measuring instrument for touch current measurements	59
L.1 Measuring instrument.....	59
Annex M (informative) Test probes for determining access	60
Annex N (informative) Guidance regarding short-circuit current.....	61
Annex AA (normative) Arc fault test and labelling requirements	62
AA.1 Overview.....	62
AA.2 References	62
AA.3 Terms and definitions.....	62
AA.4 Ratings	65
AA.4.1 General	65
AA.4.2 Internal arc classification	65
AA.5 Testing	70
AA.5.1 General	70
AA.5.2 Test preparation	71
AA.5.3 Test conditions	77
AA.5.4 Assessment.....	86
AA.6 Arc-prohibiting design	89
AA.6.1 General	89
AA.6.2 Requirements	90
AA.6.3 Testing	91
AA.7 Information and marking requirements	92
AA.7.1 General	92
AA.7.2 IAC rating plate	93
AA.7.3 Information in manuals	94
AA.7.4 Product marking – Internal protection	96
AA.8 Internal arc classification concepts	96

AA.8.1	General	96
AA.8.2	Discription of risk and selection of equipment	98
AA.8.3	Causes and preventative measures	98
AA.8.4	Protection	99
AA.8.5	Considerations for selection and installation	100
AA.8.6	Requirements for concepts 5 and 6.....	101
AA.8.7	Installation of PECS with general public access	101
Bibliography.....		103
Figure AA.1	– Mounting frame for vertical indicators	72
Figure AA.2	– Horizontal indicator.....	73
Figure AA.3	– Arrangement of indicators for different height of equipment	75
Figure AA.4	– Example for two adjacent accessible sides	75
Figure AA.5	– Examples for an accessible side to a non-accessible side	76
Figure AA.6	– General setup for testing – Details.....	78
Figure AA.7	– General setup for calibration.....	78
Figure AA.8	– General setup for testing	78
Figure AA.9	– General setup for user installation	79
Figure AA.10	– Power drive system with 12-pulse diode rectifier supplied by an external transformer and a motor at the output.....	80
Figure AA.11	– Power drive system with integrated transformer and a motor at the output	81
Figure AA.12	– Grid interconnection between 50 Hz and 60 Hz grids	82
Figure AA.13	– Example for test of sub-assemblies of a PECS	86
Figure AA.14	– Installation example of mix of accessibility types including 4a or 4b.....	102
Table 5	– Steady state voltage limits for the decisive voltage classes	15
Table 6	– Protection requirements for circuit under consideration	16
Table 101	– Impulse withstand voltage and temporary overvoltage versus system voltage from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC.....	20
Table 102	– Clearance distances for functional, basic or supplementary insulation	22
Table 103	– Creepage distances (in millimetres).....	23
Table 104	– Limits for power sources without an overcurrent protective device	27
Table 105	– Limits for power sources with an overcurrent protective device	28
Table 22	– Test overview	33
Table 23	– Pull values for handles and manual control securement.....	35
Table 106	– Impulse test voltage	36
Table 107	– AC or DC test voltage for circuits connected directly to HV mains supply.....	37
Table A.4	– Examples for protection against electrical shock	48
Table C.1	– Symbols used	50
Table AA.1	– Definition of accessibility types	67
Table AA.2	– Single phase-to-earth internal arc fault current depending on the network neutral earthing.....	69
Table AA.3	– Parameters for internal fault test according to compartment construction.....	85
Table AA.4	– Information requirements	92

Table AA.5 – Example for concepts 2 and 3 (see Clause AA.8).....	93
Table AA.6 – Example for concept 4 (see Clause AA.8)	93
Table AA.7 – Example for not tested or test failed for concepts 5 and 6 (see Clause AA.8)...	93
Table AA.8 – Example for concept 1 (see Clause AA.8)	94
Table AA.9 – Example for accessibility type 0+ for concepts 5 and 6 (see Clause AA.8)	94
Table AA.10 – Internal arc fault safety concepts	97
Table AA.11 – Locations, causes and examples of measures to decrease the probability of internal arc faults	99

This document is a preview generated by EVS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY REQUIREMENTS FOR POWER ELECTRONIC
CONVERTER SYSTEMS AND EQUIPMENT –**
**Part 2: Power electronic converters from 1 000 V AC or
1 500 V DC up to 36 kV AC or 54 kV DC**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62477-2 has been prepared by IEC technical committee 22: Power electronic systems and equipment.

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

FDIS	Report on voting
22/290/FDIS	22/293/RVD

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

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

It has the status of a group safety publication in accordance with IEC Guide 104.

This International Standard is to be used in conjunction with IEC 62477-1:2012 and IEC 62477-1:2012/AMD1:2016.

This document supplements or modifies the corresponding clauses in IEC 62477-1:2012 and IEC 62477-1:2012/AMD1:2016. Where this document states "addition", "modification" or "replacement", the relevant requirement, test specification or explanatory matter in IEC 62477-1:2012 and IEC 62477-1:2012/AMD1:2016 is adapted accordingly. Where no change is necessary, this document indicates that the relevant clause or subclause applies. Where this document states "does not apply" this clause of the mentioned version of IEC 62477-1 does not apply to any section of the equipment. Products that are designed to be compliant to IEC 62477-1:2012 and IEC 62477-1:2012/AMD1:2016 are acceptable as components within the equipment designed to this document. Additional subclauses, tables and figures are numbered starting at 101. Additional annexes are numbered with double capital characters, starting with AA.

A list of all the parts in the IEC 62477 series, published under the general title *Safety requirements for power electronic converter systems and equipment* can be found 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 "<http://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.

INTRODUCTION

This part of IEC 62477 relates to products that include power electronic converters, with a rated system voltage from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC. It specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, except functional safety as defined in IEC 61508 (all parts). The objectives of this document are to establish a common terminology and basis for the safety requirements of products that contain power electronic converters across several IEC technical committees.

This document has been developed with the intention

- to be used as a reference document for product committees inside TC 22 in the development of product standards for power electronic converter systems and equipment;
- to replace IEC 62103 as a product family standard providing minimum requirements for safety aspects of power electronic converter systems and equipment in apparatus for which no product standard exists, and

NOTE The scope of IEC 62103 contains reliability aspects, which are not covered by this document.

- to be used as a reference document for product committees outside TC 22 in the development of product standards of power electronic converter systems and equipment intended renewable energy sources. Especially TC 82, TC 88, TC 105 and TC 114 have been identified as relevant technical committees at the time of publication.

Technical committees using this document should carefully consider the relevance of each paragraph in this document for the product under consideration and reference, add, replace or modify requirement as relevant. Product specific topics not covered by this document are in the responsibility of the technical committees using this document as reference document.

This document will not take precedence on any product specific standard according to IEC Guide 104. IEC Guide 104 provides information about the responsibility of product committees to use group safety standards for the development of their own product standards.

The most significant differences compared to IEC 62477-1:2012 and IEC 62477-1:2012/AMD1:2016 are the following:

- this document extends the range of rated system voltages for high-voltage (HV) up to 36 kV AC or 54 kV DC;
- this document adds arc fault rating label requirements with testing instructions.

SAFETY REQUIREMENTS FOR POWER ELECTRONIC CONVERTER SYSTEMS AND EQUIPMENT –

Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC

1 Scope

This part of IEC 62477 applies to power electronic converter systems (PECS) and equipment, their components for electronic power conversion and electronic power switching, including the means for their control, protection, monitoring and measurement, such as with the main purpose of converting electric power, with rated system voltages from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC.

This document can also be used as a reference standard for product committees producing product standards for

- adjustable speed electric power drive systems (PDS),
- standalone uninterruptible power systems (UPS), and
- stabilized DC power supplies.

For PECS for which no product standard exists, this document provides minimum requirements for safety aspects.

This document has the status of a group safety publication in accordance with IEC Guide 104 for power electronic converter systems and equipment for solar, wind, tidal, wave, fuel cell or similar energy sources.

According to IEC Guide 104, one of the responsibilities of technical committees is, wherever applicable, to make use of basic safety publications and/or group safety publications in the preparation of their product standards.

This document

- establishes a common terminology for safety aspects relating to PECS and equipment,
- establishes minimum requirements for the coordination of safety aspects of interrelated parts within a PECS,
- establishes a common basis for minimum safety requirements for the PEC portion of products that contain PEC,
- specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, during use and operation and, where specifically stated, during service and maintenance,
- specifies minimum requirements to reduce risks with respect to pluggable and permanently connected equipment, whether it consists of a system of interconnected units or independent units, subject to installing, operating and maintaining the equipment in the manner prescribed by the manufacturer,
- establishes an arc fault rating label requirement with testing instructions for PEC and PECS, and
- covers power electronic converters and systems in open type design, which are catalog (pre-defined commercially available) power electronic converters and systems or engineered solutions from same.