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STN	**Nízkonapäťové spínacie a riadiace zariadenia Časť 9-2: Aktívne systémy na zmierňovanie porúch s oblúkom Optické zariadenia na detekciu a zmierňovanie vnútorného oblúka**	**STN EN IEC 60947-9-2** 35 4101

Low-voltage switchgear and controlgear - Part 9-2: Active arc-fault mitigation systems - Optical-based internal arc-detection and mitigation devices

Táto norma obsahuje anglickú verziu európskej normy.
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 01/26

Obsahuje: EN IEC 60947-9-2:2025, IEC 60947-9-2:2021

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 60947-9-2

July 2025

ICS 29.120.40; 29.130.20

English Version

Low-voltage switchgear and controlgear - Part 9-2: Active arc-fault mitigation systems - Optical-based internal arc-detection and mitigation devices (IEC 60947-9-2:2021)

Appareillage à basse tension - Partie 9-2: Systèmes actifs de limitation des défauts d'arc - Dispositifs optiques de détection et de limitation d'arcs internes (IEC 60947-9-2:2021)

Niederspannungsschaltgeräte - Aktive Systeme zur Abschwächung von Störlichtbögen - Teil 9-2: Optische Geräte zur Erfassung und Abschwächung innerer Lichtbögen (IEC 60947-9-2:2021)

This European Standard was approved by CENELEC on 2021-05-31. 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.

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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

Ref. No. EN IEC 60947-9-2:2025 E

European foreword

The text of document 121A/406/FDIS, future edition 1 of IEC 60947-9-2, prepared by SC 121A "Low-voltage switchgear and controlgear" of IEC/TC 121 "Switchgear and controlgear and their assemblies for low voltage" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60947-9-2:2025.

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) 2026-07-31
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2028-07-31

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.

This document has been prepared under a standardization request addressed to CENELEC by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZZ, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60947-9-2:2021 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 standard indicated:

IEC 60079 (series)	NOTE	Approved as EN IEC 60079 (series)
IEC 60269 (series)	NOTE	Approved as EN 60269 (series)
IEC 60664-1:2020	NOTE	Approved as EN IEC 60664-1:2020 (not modified)
IEC 60947-3	NOTE	Approved as EN IEC 60947-3
IEC 61439 (series)	NOTE	Approved as EN IEC 61439 (series)
IEC 61439-1:2020	NOTE	Approved as EN IEC 61439-1:2021 (not modified)
IEC 61439-2:2020	NOTE	Approved as EN IEC 61439-2:2021 (not modified)
IEC 62474	NOTE	Approved as EN IEC 62474
IEC 62606	NOTE	Approved as EN 62606
IEC/TR 63201	NOTE	Approved as CLC IEC/TR 63201

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.cencenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60068-2-6	2007	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	2008
IEC 60068-2-27	2008	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	EN 60068-2-27	2009
IEC 60068-2-30	2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	EN 60068-2-30	2005
IEC 60255-27	2013	Measuring relays and protection equipment - Part 27: Product safety requirements	EN 60255-27	2014
IEC 60695-2-10	-	Fire hazard testing - Part 2-10: Glowing/hot-wire based test methods - Glow-wire apparatus and common test procedure	EN IEC 60695-2-10	2021
IEC 60695-2-11	2014	Fire hazard testing - Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products (GWEPT)	EN IEC 60695-2-11	2021
IEC 60695-2-12	-	Fire hazard testing - Part 2-12: Glowing/hot-wire based test methods - Glow-wire flammability index (GWFI) test method for materials	EN IEC 60695-2-12	2021
IEC 60715	2017	Dimensions of low-voltage switchgear and controlgear - Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories	EN 60715	2017
IEC 60947-1	2020	Low-voltage switchgear and controlgear - Part 1: General rules	EN IEC 60947-1	2021
IEC 60947-2	2016	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers	EN 60947-2	2017
+ A1	2019		+ A1	2020

EN IEC 60947-9-2:2025 (E)

Publication	Year	Title	EN/HD	Year
IEC 60947-9-1	2019	Low-voltage switchgear and controlgear - Part 9-1: Active arc-fault mitigation systems - Arc quenching devices	EN IEC 60947-9-1	2019
IEC 60990	2016	Methods of measurement of touch current and protective conductor current	EN 60990	2016
IEC 61482-1-2	2014	Live working - Protective clothing against the thermal hazards of an electric arc - Part 1-2: Test methods - Method 2: Determination of arc protection class of material and clothing by using a constrained and directed arc (box test)	EN 61482-1-2	2014
IEC 61557-2	-	Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. - Equipment for testing, measuring or monitoring of protective measures - Part 2: Insulation resistance	EN IEC 61557-2	2021
CISPR 11 (mod)	2015	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	2016
+ A1	2016		+ A1	2017
			+ A11	2020
CISPR 32	2015	Electromagnetic compatibility of multimedia equipment - Emission requirements	EN 55032	2015
			+ AC	2016
			+ A11	2020
ISO 3864-1	2011	Graphical symbols - Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings	-	-
ISO 3864-2	2016	Graphical symbols - Safety colours and safety signs – Part 2: Design principles for product safety labels	-	-

Annex ZZ
(informative)

Relationship between this European standard and the safety objectives of Directive 2014/35/EU [2014 OJ L96] aimed to be covered

This European standard has been prepared under a Commission's standardisation request relating to harmonised standards in the field of the Low Voltage Directive, M/511, to provide one voluntary means of conforming to safety objectives of Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits [2014 OJ L96].

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding safety objectives of that Directive, and associated EFTA regulations.

Table ZZ.1 — Correspondence between this European standard and the Annex I of Directive 2014/35/EU [2014 OJ L96]

Safety objectives of Directive 2014/35/EU	Clause(s) / sub-clause(s) of this EN	Remarks/note
1 a)	4, 6.1, 6.2, 6.3	
1 b)	4, 6.1, 6.3, 9.3.3, 9.3.4, A.5, B.5, E.2.7	
1 c)	4, 6, B.5	see 2 a) to 2 d) and 3 a) to 3 c) in this table
2 a)	4, 5, 6, 7, 8.1, 8.2, 9.2, 9.3, 9.4	
2 b)	4, 6, 8.1, 8.2, 9.3	
2 c)	4, 5, 8.1, 9	
2 d)	4, 5, 8.1, 9.1, 9.3, 9.4	
3 a)	4, 6.3, 7, 8.1, 9	
3 b)	4, 6, 8.3, 9.1, 9.3, 9.4	
3 c)	4, 5, 9.3	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

IEC 60947-9-2

Edition 1.0 2021-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Low-voltage switchgear and controlgear – Part 9-2: Active arc-fault mitigation systems – Optical-based internal arc-detection and mitigation devices

Appareillage à basse tension – Partie 9-2: Systèmes actifs de limitation des défauts d'arc – Dispositifs optiques de détection et de limitation d'arcs internes

IEC 60947-9-2:2021-04(en-fr)

IEC 60947-9-2

Edition 1.0 2021-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Low-voltage switchgear and controlgear – Part 9-2: Active arc-fault mitigation systems – Optical-based internal arc-detection and mitigation devices

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 9-2: Active arc-fault mitigation systems – Optical-based internal arc-detection and mitigation devices

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.
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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.

IEC 60947-9-2 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage. It is an International Standard.

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

Draft	Report on voting
121A/406/FDIS	121A/417/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.

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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

Low-voltage switchgear and controlgear, as well as complementary protective and measuring devices, are installed in assemblies according to IEC 61439 series standards and/or others, which provide rules and requirements for interface characteristics, service conditions, construction, performance and verification.

The main objective of these standards is to achieve the safe operation of low-voltage switchgear and controlgear assemblies under normal operating conditions as well as under abnormal operating conditions, e.g. occurrence of overvoltage, overload or short-circuit currents.

The case of an arc-fault inside a LV assembly is considered by the following publications:

– IEC TR 61641, which specify tests requirements for assemblies under internal arc-fault;
– IEC TR 61439-0:2013, which identifies arc-fault containment in its Annex C;
– IEC TS 63107, which specifies tests to verify correct integration of internal arc-fault mitigation systems in power switchgear and controlgear assemblies (PSC assemblies) according to IEC 61439-2.

Even in a Class I assembly according to IEC TR 61641, the occurrence of an internal arc cannot be completely excluded. Typically, internal arc-faults result from:

– conducting materials inadvertently left inside equipment during manufacture, installation or maintenance;
– failures in materials or workmanship;
– inadvertent contact with a live conductor;
– entry of small animals such as mice, snakes, ants, etc.;
– use of an incorrect assembly for the application resulting in overheating and subsequently an internal arcing fault;
– inappropriate operating conditions (for example water, fungus, or dust);
– incorrect operation; or,
– lack of maintenance or inappropriate maintenance (loose parts, paint, etc.).

The occurrence of arcs inside enclosed assemblies is associated with various physical phenomena. For example, the arc energy resulting from an arc developed in air at atmospheric pressure within the enclosure will cause an internal overpressure and local overheating which will result in mechanical and thermal stressing of the assembly. Moreover, the materials involved may produce hot decomposition products, either gases, metals or vapours, which may be discharged outside of the enclosure.

Due to the risk of personal injury, damage and loss of energy supply as consequences of internal arc-faults there is a growing demand for internal arc-fault sensing and mitigation. This is the reason why some standards have been drafted to give specifications including test protocol and acceptance criteria for corresponding devices. Arc-fault effects can be dramatically reduced by active arc-fault mitigation systems, combining fast detection of the internal arc-fault, and related actions on short-circuit protection devices and/or additional quenching devices. Therefore, the application of such devices can result in:

– reduction of incident/released energy;
– shortening of power outage/downtime (by minimizing damage to the enclosed equipment, switchgear and controlgear as well as other measuring and protective devices);
– limitation of side-effects to other systems, due to high and continuously increasing density of installed apparatus.

This document is intended to cover devices and functions dedicated to:

– detect an arc-fault internal to an assembly by processing optical effects of an internal arc-fault, and to signal and trigger devices intended to mitigate the internal arc-fault, and

– detect by processing optical effects of an internal arc-fault and mitigate the impact of the internal arc-fault by its extinction.

NOTE Even when both terms are related to assemblies in which an arc occurs between conductors, arc-flash is terminology mainly used in NFPA 70E, CSA Z462 and IEEE 1584, which usually describes effects of direct exposure of workers to thermal energy emitted, whereas the term "internal arc-fault" as used in this document describes the hot-gas flow phenomena which can injure people in the vicinity of the arcing current.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 9-2: Active arc-fault mitigation systems – Optical-based internal arc-detection and mitigation devices

1 Scope

This document covers internal arc-fault control devices, hereinafter referred to as IACD, which are intended to:

– detect internal arc-faults in low-voltage switchgear and controlgear assemblies, by processing (at a minimum) the optical effect of an internal arc-fault, and

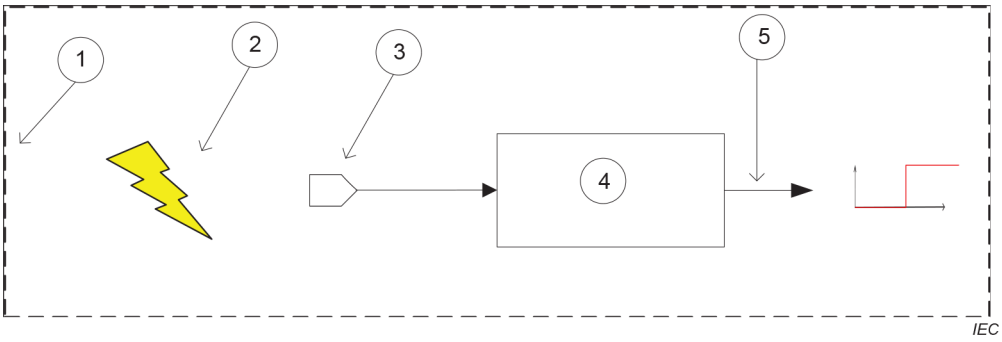
– operate mitigation device (either external or combined)

in order to minimize the effects of the internal arc-fault (see Figure 1).

For the purpose of this document the terms "light" or "optical" covers more than visible spectra. They may cover also, for example, infrared or ultraviolet electromagnetic radiations (see Annex D).

For combined-type IACD, this document is considered in addition to the relevant product standard for internal arc-fault mitigation devices (IARD per IEC TS 63107:2020). Compliance to the relevant product standard is mandatory and cannot be claimed by testing to this document alone.

NOTE 1 Low-voltage switchgear and controlgear assemblies are usually described by IEC 61439 series.



NOTE This figure displays a simplified IACD schematic with only one optical sensor and no other sensing means that can be used for secondary confirmation of an arcing fault, such as current sensing.

Key

1 assembly enclosure

2 internal arc-fault

3 optical sensor

4 processing unit

5 trigger output used to operate e.g. mitigation device

Figure 1 – Optical-based IACD schematic (stand-alone type and no secondary sensor)

Therefore, this document covers the following:

– internal arc-fault control device (stand-alone, multifunction or combined);

– one or more associated sensor(s) used to detect optical effect of the internal arc-fault;

– sensor(s), sensing another physical effect, to confirm the fault;

– associated or combined mitigation device.

An IACD is not intended to trigger under normal operation of low-voltage switchgear and controlgear (i.e. absence of internal arc-fault), including normal arcing associated with operation of disconnecting and switching devices.

This document only covers the following methods:

– optical detection of the light caused by an internal arc-fault;
– optional confirmation of internal arc-fault by line current measurement.

Many different conductive materials could be used in LV assemblies (e.g. steel, copper, aluminium). Nevertheless, tests specified in this document are deemed to represent the most critical and challenging conditions for arc-detection and cover all combinations of conductive materials.

NOTE 2 Compared to other materials (e.g. steel, aluminium), copper leads to a lower optical radiation energy.

The rated voltage of the assembly in which an IACD is installed does not exceed 1 000 V AC.

Such devices are designed to be operated and maintained by skilled persons only.

This document does not cover:

– DC internal arc-fault detection and control;
– overcurrent relays;
– AFDD (arc-fault detection devices) as defined by IEC 62606;
– guidance on installation within assemblies;

NOTE 3 The integration of an IACD into an assembly is described in IEC TS 63107.

– use with additional measures needed for installation and operation within explosive atmospheres. These are given in IEC 60079 series documents;
– requirements for embedded software and firmware design rules; for this subject, the manufacturer is responsible for taking additional safety measures;

NOTE 4 IEC TR 63201 describes rules for firmware and embedded software development preventing errors in software.

– cybersecurity aspects; for this subject, the manufacturer is responsible for taking additional safety measures;

NOTE 5 See IEC TS 63208.

– mobile applications.

NOTE 6 Even when addressing internal arc-fault mitigation devices, this document does not supersede any other relevant product standard (e.g. IEC 60947-2 or IEC 60947-9-1).

NOTE 7 DC arcing fault phenomena are under consideration. Further investigation is needed to comprehend DC arcing phenomena and required sensing.

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

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

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

IEC 60255-27:2013, *Measuring relays and protection equipment – Part 27: Product safety requirements*

IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-2-12, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 60715:2017, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

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

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2016/AMD1:2019

IEC 60947-9-1:2019, *Low-voltage switchgear and controlgear – Part 9-1: Active arc-fault mitigation systems – Arc quenching devices*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 61482-1-2:2014, *Live working – Protective clothing against the thermal hazards of an electric arc – Part 1-2: Test methods – Method 2: Determination of arc protection class of material and clothing by using a constrained and directed arc (box test)*

IEC 61557-2, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 2: Insulation resistance*

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
CISPR 11:2015/AMD1:2016

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

ISO 3864-1:2011, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

ISO 3864-2:2016, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*