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BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

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Responsible Committee Secretary: Mr Peter Slot (BSI)
Direct tel: 020 8996 7147
E-mail: peter.slot@bsigroup.com

Full document details: 19/30391672 DC

Introduction

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

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

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

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



121A/279/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

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2019-05-03

SUPERSEDES DOCUMENTS:

121A/193/CD, 121A/216A/CC

IEC SC 121A : LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR

SECRETARIAT:

France

SECRETARY:

Mr Eric Bettega

OF INTEREST TO THE FOLLOWING COMMITTEES:

SC 23E, SC 121B

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☒ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

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

NOTE FROM TC/SC OFFICERS:

SC121A Officers support circulation of CD2 for project IEC 60947-9-2 ED1.

Secretary note: NC experts are kindly requested to refer their comments to line numbers.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR

ACTIVE ARC-FAULT MITIGATION SYSTEMS –

Part 2:

OPTICAL-BASED INTERNAL ARC DETECTION AND MITIGATION DEVICES

FOREWORD

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International Standard 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

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

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

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

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

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

- 254 • reconfirmed,
- 255 • withdrawn,
- 256 • replaced by a revised edition, or
- 257 • amended.

258

259 The National Committees are requested to note that for this publication the stability date
260 is 2023

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

263

264

INTRODUCTION

265 Low-voltage switchgear and controlgear, as well as complementary protective and measuring
266 devices, are essentially installed in assemblies, which are usually complying to standards (for
267 example IEC 61439 series) which gives rules and requirements for interface characteristics,
268 service conditions, construction, performance and verification.

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

273 The case of an arc-fault inside LV assembly is currently considered only by the following
274 publications:

- 275 – IEC TR 61641 (Enclosed low-voltage switchgear and controlgear assemblies – Guide for
276 testing under conditions of arcing due to internal fault), which specify tests requirements
277 for assemblies under internal arc-fault;
- 278 – IEC TR 61439-0 (Low-voltage switchgear and controlgear assemblies – Part 0: Guidance
279 to specifying assemblies), which identify arc-fault containment in Annex C.

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

- 282 – conducting materials inadvertently left in during manufacture, installation or maintenance;
- 283 – faults in materials or workmanship;
- 284 – inadvertent contact with a live conductor;
- 285 – entry of small animals such as mice, snakes, ants, etc.;
- 286 – use of an incorrect assembly for the application resulting in overheating and subsequently
287 an internal arcing fault;
- 288 – inappropriate operating conditions (for example water, fungus, or dust);
- 289 – incorrect operation; or,
- 290 – lack of maintenance or inappropriate maintenance (loose parts, paints, etc.).

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

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

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

309 This document is intended to cover devices and functions dedicated to detect an arc-fault
310 internal to an assembly by processing optical effects of an internal arc-fault, and to signal and
311 trigger devices intended to mitigate the internal arc-fault, or (alternatively) to detect and
312 mitigate the effects of the internal arc-fault.

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

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR

ACTIVE ARC-FAULT MITIGATION SYSTEMS –

Part 2:

OPTICAL-BASED INTERNAL ARC-DETECTION AND MITIGATION DEVICES

1 Scope

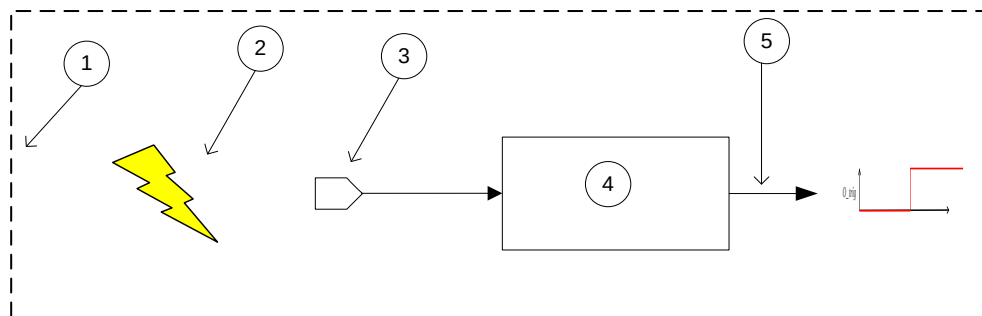
This document covers internal arc-fault control devices, hereinafter referred to as IACD, which are intended to:

- detect internal arc-faults in low-voltage assemblies, by processing (at least) 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 “light” or “optical” is covering more than visible spectra. They may cover also, for example, infrared or ultraviolet.

For combined-types IACD, this document shall be considered in addition to any other product standard. Preliminary compliance to the relevant product standard is mandatory and cannot be claimed regarding this document.

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



NOTE this figure display 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 boundary
- 2 internal arc-fault
- 3 optical sensor
- 4 processing unit
- 5 trigger output

Figure 1 – IACD schematic (stand-alone type, no secondary sensor)

Therefore, this document covers the following:

- arc-detection unit (stand-alone, multifunction or combined);
- (at least one) associated sensor 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 conditions for arc-detection and cover all combination of materials.

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

The rated voltage of the assembly in which IACD is installed shall 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 assemblies¹;
- use with additional measure within explosive atmosphere. These are given in IEC 60079 series;
- requirements for embedded software and firmware design rules²;
- cybersecurity aspects. See IEC TS 63208^{3,4}

NOTE 3 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 4 DC arcing fault phenomena are under consideration. However, further study 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 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

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

¹ Under consideration, future IEC TS 63107 ED1 (*Integration of arcing fault mitigation devices into power switchgear and controlgear assemblies (PSC-ASSEMBLIES) according to IEC 61439-2*).

² For this subject, the manufacturer is responsible for taking additional safety measures. See also IEC TR 63201 (under development).

³ For this subject, the manufacturer is responsible for taking additional safety measures.

⁴ Under development. Stage at the date of circulation: ADTS.

- 383 IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
384 IEC 60947-1:2007/AMD1:2010
385 IEC 60947-1:2007/AMD2:2014
- 386 IEC 60947-2:2016, *Low-voltage switchgear and controlgear - Part 2: Circuit-breakers*
- 387 IEC 60947-9-1:2019, *Low-voltage switchgear and controlgear - Part 9-1: Arc quenching device*
388
- 389 IEC 61439 (series), *Low-voltage switchgear and controlgear assemblies*
- 390 IEC 61439-1:2011, *Low-voltage switchgear and controlgear assemblies - Part 1: General rules*
391
- 392 IEC 61439-2:2011, *Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies*
393
- 394 IEC TR 61641:2014, *Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault*
395
- 396 IEC 61482-1-2, *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)*
397
398
- 399 IEC 61557-2:2007, *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*
400
401
- 402 ISO 3864-1:2011, *Graphical symbols -- Safety colours and safety signs -- Part 1: Design principles for safety signs and safety markings*
403
- 404 ISO 3864-2:2016, *Graphical symbols -- Safety colours and safety signs -- Part 2: Design principles for product safety labels*
405

406 3 Terms and definitions

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

408 ISO and IEC maintain terminological databases for use in standardization at the following addresses:
409

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

412 3.1

413 arc

414 current through air arising from a fault between live parts of different potential and/or between
415 live parts and other conductive parts within an ASSEMBLY

416 [SOURCE: IEC TR 61641, 3.5, modified – “Free-burning short-circuit” replaced by “current”]

417 Note 1 to entry: this phenomenon is accompanied (for example) by thermal, magnetic, radiation and luminescent effects.
418

419 3.2

420 (internal) arc-fault

421 unintentional arc arising from a short-circuit between live parts of different potential and/or
422 between live parts and other conductive parts within an assembly

423 Note to entry 1: Within IEEE 1584:2002 there is a different term and definition for the same current phenomenon:
424 arcing fault current: “A fault current flowing through an electrical arc plasma, also called arc fault current and arc
425 current”.

426 3.3

427 internal arc-fault control device

428 IACD

429 device intended to detect an internal arc-fault, which provides a signal for operation of a
430 separate mitigation device, or automatically mitigates the arc-fault

431 Note 1 to entry: IACD with mitigation capability combines in the same device arc-fault detection and breaking or
432 making capabilities.

433 Note 2 to entry: in the United States of America, these devices are commonly named AFR (arc-flash relays).

434 **3.4**

435 **arc-fault detection time**

436 interval of time between the ignition of the internal arc-fault, and the transition of the IACD
437 output signal to “triggered” state

438 **3.5**

439 **arc-fault mitigation time**

440 interval of time between the ignition of the internal arc-fault and the complete extinction of the
441 same

442 Note 1 to entry: mitigation time can be determined by measuring upstream line current and IACD current,
443 alternatively downstream line current.

444 **3.6**

445 **(arc-fault) current sensitivity**

446 value of fault-current an IACD is able to detect

447 Note 1 to entry: this value shall be declared by the manufacturer and expressed in ampere or kA.

448 **3.7 mitigation device**

449 device intended to reduce the effects of the internal arc-fault

450 Note 1 to entry: mitigation devices can be fuses (IEC 60209 series), circuit-breakers (IEC 60947-2), switches
451 (IEC 60947-3), arc-quenching device (IEC 60947-9-1), or a combination of any of these devices.

452 **3.8**

453 **arc quenching device**

454 device intended to eliminate arcing faults, by creating a lower impedance current path, to
455 cause the arcing current to transfer to the new current path

456 **3.9**

457 **prospective short circuit current**

458 current expected to flow when the arc electrodes are shunted by a conductor of negligible
459 impedance (available short-circuit current of supply)

460 Note 1 to entry Prospective short circuit current is expressed in Ampere RMS.

461 Note 2 entry There is in general a difference between the actual arc current and the current as defined. The actual
462 arc current flowing during the arc duration is smaller and fluctuates due to the non-linear arc impedance
463 stochastically varying with time. Reproducible test conditions may only be defined by means of the prospective
464 short-circuit current to be expected in case of short-circuited arc electrodes.

465 [SOURCE: 3.2.5 of IEC 61482-1-2:2007, modified – Application to IACD]

466 **3.10**

467 **optical sensor**

468 sensor used to detect the optical emission of an internal arc-fault

469 **3.11**

470 **secondary sensor**

471 sensor used in addition to optical sensor(s) to confirm indication by sensing another physical
472 effect of the arc, and to support additional function

473 Note 1 to entry: secondary sensor(s) are optional.

474 Note 2 to entry: current sensors are the only secondary sensor-type considered in this document.

475 Note 3 to entry: current sensors shall be selected according to manufacturer's instructions.

476 **3.12**

477 **latch-up time**

478 steady-state duration value of the output (triggering) signal value after detection

479 Note 1 to entry: not applicable to combined-type IACD.

480 **3.13**

481 **arc-setting current (I_{as})**

482 rated current pickup value enabling arc-detection

483 Note 1 to entry: this value can be expressed as an absolute value (in ampere) or as a ratio of current value.

3.14**arc-setting current range**

current setting range between the minimum and maximum values over which the arc-detection current function is enabled

Note 1 to entry: this setting can be expressed as an absolute value (in ampere) or as a ratio of current value.

3.15**design break**

significant difference in design between IACD of the same type, requiring additional type testing

EXAMPLE: Different arc-detection algorithm, different conditioning of optical sensor signal.

3.16**Overvoltage category****OVC**

numeral defining a transient overvoltage condition

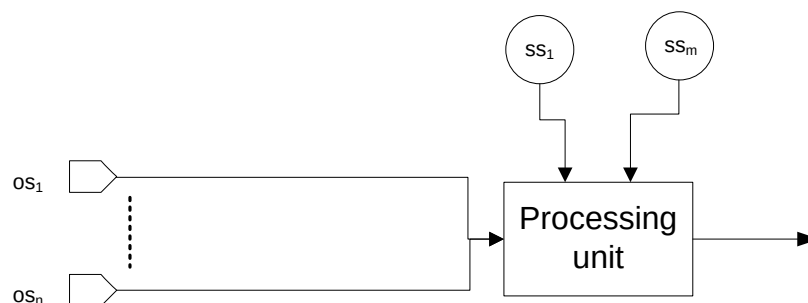
[SOURCE: IEC 60664-1:2007, 3.10, modified – Alternative term “OVC” added, reference in Note 1 to entry modified]

Note 1 to entry: Overvoltage categories I, II, III and IV are used, see 4.3.3.2 of IEC 60661-1:2007.

Note 2 to entry: The term ‘overvoltage category’ in this standard is synonymous with ‘impulse withstand category’ used in IEC 60364-4-44, Clause 443.

4 Classification**4.1 According to the IACD type****4.1.1 Stand-alone type IACD**

IACD with no function other than internal arc-fault detection and signalling (see Figure 2).

**Key**

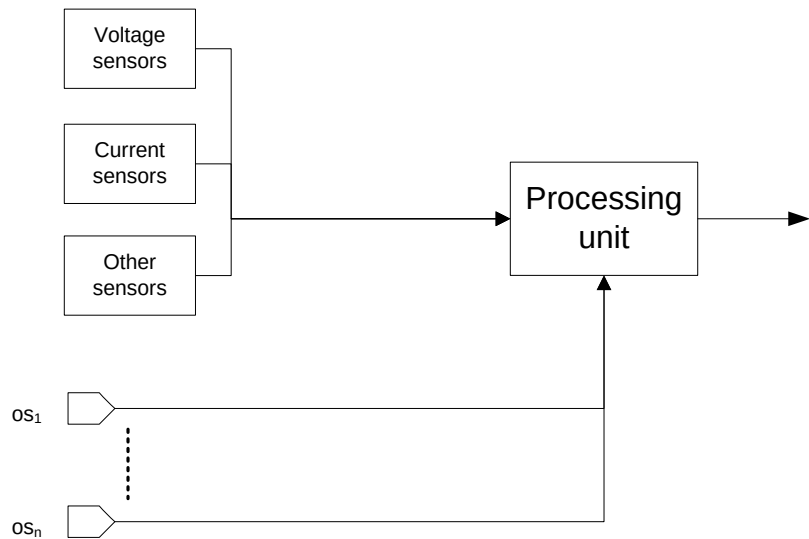
os1 to osn Optical sensor 1 to n
ss1 to ssm (Optional) secondary current sensor 1 to m

Figure 2 - Stand-alone type IACD architecture overview

NOTE Essential performance of such class of IACD is arc-fault detection time.

4.1.2 Multifunction-type IACD

A device in which an IACD is an integrated function of a measurement or protective device or relay (see Figure 3).



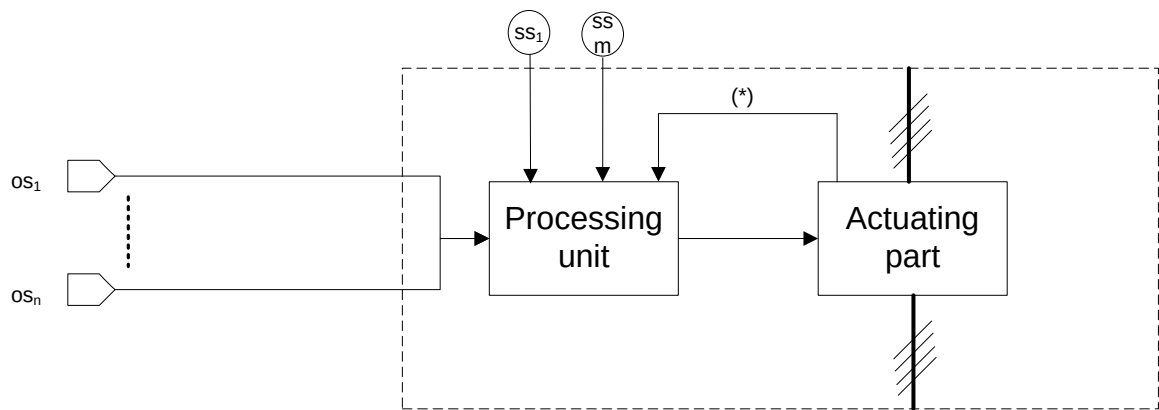
Key
os1 to osn Optical sensor 1 to n

Figure 3 – Multifunction-type IACD architecture overview

NOTE Essential performance of such class of IACD is arc-fault detection time.

4.1.3 Combined-type IACD

Device or combination of devices, including IACD function, designed to detect and mitigate internal arc-fault (see Figure 4).



Key
os1 to osn Optical sensor 1 to n
ss1 to ssm (Optional) secondary sensor 1 to m, or alternatively (*) current data value from embedded sensors
Actuating part Mitigation subset of associated device (i.e. Fuse, circuit-breaker-, switch, arc-quenching device, or a combination of any)

Figure 4 – Combined-type IACD architecture overview

Architecture as per Figure 4 is theoretical, and any other combination is acceptable, if the IACD essential functions are fulfilled, for example:

- Arc-fault detection can be a function of mitigation device, meaning there does exist only one common processing unit;
- Processing unit can be separated, and associated in a specific and unique combination to mitigation device.

NOTE Arc-fault detection time is not relevant for such class of IACD, because it is a part of the arc-fault mitigation time, manufacturer's claimed performance.

For combined-types IACD:

- this document shall be considered in addition to any other relevant product standard (i.e. IEC 60947-2, IEC 60947-9-1);
- compliance to the relevant product standard is mandatory and cannot be claimed regarding this document only;
- relevant tests of product standard shall have been done with additional features (software and hardware) mandatory for IACD functions (e.g. EMC tests including optical sensors, unless purely fiber-type).

When the former condition is not fulfilled, additional test sequences apply (see Clause 8).

4.2 According to the combination of sensors

4.2.1 Optical sensors-only type

IACD which is designed and intended to operate with optical sensor(s) only.

Optical sensors are considered as part of the product, and therefore provided by the same manufacturer, or approved by the manufacturer.

4.2.2 Optical sensors and secondary sensors type

IACD which is designed and intended to operate with both optical sensor(s) and secondary sensor(s).

NOTE 1 Secondary sensors can be separated from, or integrated into IACD.

NOTE 2 Secondary sensors may be embedded in the actuating part.

5 Characteristics

5.1 Maximum arc-fault detection time (respectively arc-fault mitigation time)

The maximum arc-fault detection time of an IACD is the maximum time from ignition of the arc-fault to the steady-state of the output signal.

The maximum arc-fault mitigation time of an IACD is the maximum time from ignition of the arc-fault to its complete extinguishing (see C.4 and C.6).

See Annex C for definition and identification of ignition-time of the arc-fault.

NOTE Manufacturer can express a set of detection time (respectively mitigation time) dependent upon rated supply voltage or prospective current, when relevant.

5.2 Minimum arc-fault detection current value capability

The value declared by the manufacturer, in prospective current, that indicates the minimum level of detection.

All IACDs shall be capable of sensing the arcing current corresponding to a 10 kA prospective current.

Preferred lower values that may be offered are: 5 kA – 7 kA.

NOTE 1 Higher sensitivity increases the risk of undesired operation.

NOTE 2 Values of 1 kA and 3 kA are under consideration.

NOTE 3 By pickup value capability, more than one preferred value can be covered.

NOTE 4 Minimum values of combined type IACD can be expressed as a ratio of rated or nominal current.

5.3 Maximum prospective short-circuit current value

The maximum prospective short-circuit current value is the value an IACD can successfully sustain and/or mitigate as claimed by the manufacturer.

Preferred values shall be selected within the followings:

10 kA – 30 kA – 50 kA – 65 kA – 85 kA – 100 kA

NOTE 1 By pickup value capability, more than one preferred value can be covered.

568 NOTE 2 Preferred values above are comparable to the usual short-circuit values of assemblies, and therefore
569 cannot be compared to values stated in IEC TR 61641, which are only used to create maximum stress to the
570 assembly.

571 **5.4 Nature of information**

572 Subclause 5.1 of IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010 and IEC 60947-
573 1:2007/AMD2:2014 applies, as far as appropriate.

574 **5.5 Markings**

575 Markings shall be done accordingly to Table 1.

Table 1 – Markings and indications for IACD ^d

Item	Information	Marking location
1	Indication of the status of arc-detection function	Visible ^a
2	Manufacturer's name or trade mark	Marked
3	Type designation or serial number	Marked
4	"IEC 60947-9-2", if the manufacturer claims compliance with the document	Marked
5	Need for auxiliary power supply ^e , as well as its characteristics, such as voltage, frequency, current, etc.	Literature
6	Characteristics of any output signal ^{b, c} (e.g. voltage, current or energy, duration)	Literature
7	Characteristics of any input signal ^{b, c}	Literature
8	Maximum detection time (respectively mitigation time) ^f	Literature
9	For IACD with no provisions for secondary sensors, the following warning: WARNING This is an IACD with optical sensors only – Non-arc light may unintentionally trigger device	Literature
10	Immunity to ambient light (yes/no), and associated ambient-light level max value (in lux), when greater than 500 lx	Literature
11	Minimum sensing capability in prospective short-circuit (bolted-fault) and associated distance	Literature
12	Prospective maximum short-circuit current value	Literature
14	Rated operational voltage (when combined-type)	Literature
15	Current-inhibit value and range setting (when relevant)	Literature
16	Optical sensitivity value and range setting (when relevant)	Literature
17	Marking of terminals ^g	Marked
18	IP code ^h	Literature
19	Overvoltage category (OVC) at connecting point ^{i, k}	Literature
NOTE Visible visible from the front when the IACD is installed as in service and the operator controls are accessible Marked marked on the exterior of the product Literature in the manufacturer literature		
^a Marking can be replaced with display for some operation information. Display shall return to essential information after a short delay. ^b The manufacturer shall define the ratings for each binary input/output. For example, when optical output offered, wavelength, connector type, mode, diameter, optical power shall be specified. ^c The manufacturer shall define the ratings for each analogue input/output, unless proprietary. ^d In addition to upper list, an additional marking of the assembly is required (see 8.2.3.2). ^e Auxiliary power supply shall be reliable relative to the application. ^f When the manufacturer claims for different performances with regards to conditions (e.g. for different auxiliary powering conditions), each-one shall to be tested. ^g In accordance with IEC 60255-27 or alternatively 7.1.8.4 and Annex L of IEC 60947-1:2007. ^h When multiple (e.g. due to different mounting cases), all shall be listed. ⁱ With rated voltage and type of system (see Table B.1 of IEC 60634-4-44:2007). ^k OVC can be replaced by U_{imp} , in accordance with 3.10 of IEC 60664-1:2007 and Table 44.B of IEC 60634-4-44:2007.		

The markings defined in upper Table 1 shall be considered as mandatory additional markings, when applied to combined-type IACD, for which all other relevant product standards marking requirements also apply.

5.6 Instructions for installation, operation, maintenance, decommissioning and dismantling

Subclause 5.3 of IEC 60947-1:2007 applies with the following addition.

The following items shall be specified in manufacturer's literature:

- type and reference of optical sensors to be used;
- maximum distances from sensors(s) to IACD shall be specified;
- type and reference of CTs to be used (when relevant);
- installation rules for optical sensors and any guidance required for proper installation;
- operating temperature range.

NOTE Upper list is including all accessories (e.g. optical fiber splices and holders).

Rail mounting of IACD shall be specified according to IEC 60715:2017, when relevant.

Additional information for the maintenance, decommissioning and dismantling of the equipment shall be made available to the user in case of foreseeable hazardous condition of the device, for example due to stored energy, instability or falling of objects, etc.

6 Normal service, mounting and transport conditions

Clause 6 of IEC 60947-1:2007 applies.

7 Constructional and performance requirements

7.1 Constructional requirements

7.1.1 General

Unless complying with protection class II, stand alone or multifunction-type IACD with metallic touchable parts shall be fitted with earthing terminal or earthing rails according to IEC 60715:2017.

Annex O of IEC 60947-1:2007, IEC 60947-1:2007/AMD2:2014 should be considered carefully especially for substitution or reduction in use of hazardous substances, or if not possible for providing measures to prevent emission and contact with them.

7.1.2 Creepages and clearances

Creepages and clearances shall fulfil the requirements of Table 13 and Table 15 of IEC 60947-1:2007.

7.1.3 Material requirement

7.1.3.1 General

Subclause 7.1.2.1 of IEC 60947-1:2007 applies with the following addition.

Special attention shall be called to humidity resisting qualities, and to the necessity to protect certain insulating materials against humidity.

7.1.3.2 Glow-wire testing

The suitability of materials used is verified by:

- a. making tests on the equipment; or
- b. making tests on sections taken from the equipment; or
- c. making tests on any parts of identical material having representative thickness; or
- d. providing data from the insulating material supplier fulfilling the requirements according to IEC 60695-2-12.

The suitability shall be determined with respect to resistance to abnormal heat and fire. The manufacturer shall indicate which methods, amongst a), b), c) and d) shall be used.

If an identical material having representative cross-sections has already satisfied the requirements of any of the tests of 8.2.1 of IEC 60947-1:2007/AMD1:2010, then those tests need not be repeated.

Tests on equipment shall be made by the glow-wire end-product test of IEC 60695-2-10 and IEC 60695-2-11.

NOTE For parts with a mass lower than 2 g and for small parts, as specified in IEC 60695-2-11, no other test is required

7.1.3.3 Test based on flammability category

Subclause 7.1.2.3 of IEC 60947-1:2007/AMD1:2010 applies.

7.2 Performance requirements

7.2.1 General

For stand-alone or multifunction type IACD, the maximum arc-fault detection time and the minimum arc-fault detection capability shall comply with the values as stated by the manufacturer.

For combined-type IACD, the maximum arc-fault mitigation time, minimum arc-fault detection capability and maximum arc-fault mitigation capability shall comply with the values as stated by the manufacturer.

7.2.2 Operating conditions

7.2.1 of IEC 60947-1:2007 applies.

7.2.3 Temperature-rise

The temperature-rises of the several parts of IACD measured during a test carried out under the conditions specified in 8.1.2 shall not exceed the limiting values stated in Table 2 and Table 3 of IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010.

NOTE According to engineering judgement the manufacturer can decide which part(s) are to be measured.

7.3 Electromagnetic compatibility (EMC)

Subclause 7.3 of IEC 60947-1:2007, IEC 60947-1:2007/AMD2:2014 applies.

8 Tests

8.1 General - Kind of tests

The tests to verify the characteristics of IACD are:

- type tests (done on representative samples for each design break);
- routine tests (on each product).

The tests are grouped together in a sequence and shall be run in the order listed.

The sample is a combination of one optical sensor and the IACD.

8.2 Type tests

8.2.1 General

An IACD shall be subjected to the following type tests:

- temperature-rise tests: to verify that temperature will not exceed some limits considering material performances and operator safety;
- arc-detection tests (for stand-alone or multifunction-type) to ensure that the sensing system is able to detect the minimum and sustain the maximum arc-fault currents specified by the manufacturer;
- arc-mitigation tests (for combined-type): to ensure that IACD is able to mitigate minimum and maximum arc-fault current values specified by the manufacturer;
- light-immunity tests: to insure the sensing is not activated by normal ambient light or light from common artificial sources, when claimed by manufacturer. Immunity to light from nearby arcing devices may need additional measures not addressed in this document;

NOTE 1 Ambient light values as specified in Annex E are considered as a minimum immunity level. Manufacturers can claim for higher immunity levels.

- environmental tests (e.g. EMC, vibration, damp heat).

When IACD has more than one identical output, each one shall be evaluated during the same test sequence, all results being recorded in test report. Normally open outputs may be tested together in series, and normally close may be tested together in parallel.

When different sets of contacts are functionally different, each set shall be tested independently.

Connection of optical sensors and secondary current sensors (when any) shall be done according to manufacturer's instruction.

NOTE 2 Optical fiber digital output are not deemed to be verified, unless agreement between manufacturer and user. Rationale is that test laboratories usually cannot handle optical fiber, for which interface to logic is proprietary.

A stand-alone or multifunction type IACD shall be subjected to the following type tests grouped together in a sequence and shall be run preferentially in the order listed in Table 2 below. For practical reasons, order can be changed under agreement between manufacturer and user.

Table 2 – Functional tests sequence for standalone-type or multifunction-type IACD

Test sequence	Type test	Subclause
1	Light immunity tests	8.2.3
	Arc-detection tests:	8.2.4
	- Reduced energy arcs	8.2.4.3
	- High energy arcs	8.2.4.4
	Dielectric properties	8.2.5
	Functional tests ^a	8.2.8
2	EMC test:	8.2.6
	- Emission	8.2.6.3
	- Immunity	8.2.6.2
3	Damp heat	8.2.7.2
	Vibration and shock	8.2.7.3
	Dielectric properties	8.2.4
	Functional tests	8.2.8
^a Can be omitted when same test sample for the whole test sequence.		

Upon manufacturer request, each test sequence of Table 2 can be performed with a new sample.

When combined-type IACD already passed all EMC and environmental tests as defined in its mitigation device standard, it shall only be subjected to the following additional type tests grouped together in one sequence listed in Table 3 below. When not, additional sequences 2 and/or 3 or Table 2 applies as well.

Table 3 – Functional tests sequence for combined-type IACD

Test sequence	Type test	Subclause
1	Light immunity tests	8.2.3
	Arc-mitigation tests:	8.2.4
	- Reduced energy arcs	8.2.4.3
	- High energy arcs	8.2.4.4
	Dielectric properties	8.2.5
	Functional tests	8.2.8

NOTE 3 Optical sensor replacement is not to be considered as a new sample.

NOTE 4 Some tests cannot be relevant if the device does not have a corresponding operational mode, e.g. 8.2.3 when not claimed by manufacturer.

The details of test arrangements such as type, length, size of conductors, distance of the sensor(s) to the arc or live parts or to the detection unit shall be given in the test report.