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TECHNICAL REPORT

colour inside

Low-voltage switchgear and controlgear – Fire risk analysis and risk reduction measures

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – FIRE RISK ANALYSIS AND RISK REDUCTION MEASURES

FOREWORD

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IEC TR 63054, which is a technical report, 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 technical report is based on the following documents:

Enquiry draft	Report on voting
121A/115/DTR	121A/155/RVDTR

Full information on the voting for the approval of this technical report 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.

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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

As fire-ignition hazards are inherent with electricity, installation rules and product standards for electrical equipment are aimed at providing risk reduction measures and minimizing residual risk without compromising product safety and function.

Residual risk of low-voltage switchgear and controlgear compliant with IEC 60947 relevant publications is generally low and, when selected, installed and used according to manufacturer instruction and installation rules, do not ignite fire in normal operation or reasonably foreseeable fault conditions.

This document, in accordance to ISO/IEC Guide 51 and IEC Guide 116, describes the fire risk analysis of electrical equipment and risk reduction measures in IEC 60947 relevant publications. While intended to apply specifically to low voltage switchgear and controlgear, it is suggested that other product committees may find this information useful.

The fire hazards, namely the flame ignition mechanisms, relevant for low-voltage switchgear and controlgear are reviewed and discussed. The related risk reduction measures included in IEC 60947 relevant publications are subsequently reported for each of those mechanisms.

These measures are based on a system approach, not limited to construction materials requirements and include design rules and type testing to ensure equipment do not cause fires in normal operation or due to reasonably foreseeable faulty conditions.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – FIRE RISK ANALYSIS AND RISK REDUCTION MEASURES

1 Scope

This document applies to the fire risk analysis of low-voltage switchgear and controlgear (hereinafter referred to as "equipment") referring to the IEC 60947 relevant publications, where the following applies:

– only the case where a fire originates (typically under fault or misuse conditions) within the equipment;
– only equipment installed in normal environments. Hazardous environments, for example in presence of combustible materials, is not to be considered;
– only the case of products selected, installed and used according to the manufacturer instructions and installation rules.

In addition, the following cases are not considered:

– faults addressed by IEC TR 61641;
– risks due to smoke emissions;
– double faults, i.e. multiple phenomenon, potentially combined.

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 Guide 116:2010, *Guidelines for safety related risk assessment and risk reduction for low voltage equipment*

IEC 60695-1-10:2015, *Fire hazard testing – Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
IEC 60947-1:2007/AMD1:2010
IEC 60947-1:2007/AMD2:2014

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

IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-6-1, *Low-voltage switchgear and controlgear – Part 6-1: Multiple function equipment – Transfer switching equipment*

IEC 60947-7-1:2009, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors*

IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*

IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm² up to 300 mm² (included)*

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

3 Terms and definitions

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

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
fire risk
probability of a fire combined with a quantified measure of its consequence

[SOURCE: IEC 60695-1-10:2016, 3.5, modified – Note 1 to entry deleted.]

3.2
electrical fire
fire caused by electrical equipment or installation

3.3
spark
electric spark
small luminous electric arc of short duration

[SOURCE: IEC 60050-121:1998, 121-13-16]

3.4
electric arc
high-temperature luminous electric discharge across a gap or through a medium such as charred insulation

[SOURCE: NFPA 921:2014]

3.5
discharge
electric discharge
discontinuous movement of charge carriers through part of an otherwise insulating medium, initiated by electronic avalanche and supplemented by secondary processes

[SOURCE: IEC 60050-121:1998, 121-13-11]

3.6
tracking
progressive formation of conductive paths, which are produced on the surface or within a solid insulating material, due to the combined effects of electric stress and electrolytic contamination

[SOURCE: IEC 60050-212:2010, 212-11-56, modified – Note deleted.]

4 Ignition modes for electrical fires

4.1 General

Physical effects occurring in electrical equipment that can potentially cause fires are listed in Table 1 below, inspired by Table 1 of IEC 60695-1-10:2016.

Table 1 – Ignition phenomena in electrotechnical products

Phenomenon [a]	Origin	Consequential effects
Abnormal temperature rises	Overcurrent in a conductor Defective contacts Leakage currents (insulation loss and heating) Failure of a component, an internal part or an associated system (for example, ventilation) Mechanical distortions which modify electrical contacts or the insulation system Seizure of a motor shaft (locked rotor) Premature thermal ageing	The temperature rises are gradual and at times very slow[b]. Therefore a significant accumulation of heat and effluent in the vicinity of the product may result, sufficient to support fire as soon as ignition occurs Accumulation and diffusion of flammable gases in air may give rise to ignition or an explosion, especially inside hermetically sealed products
Short-circuit	Direct contact between conductive live parts at different potentials (stray conductors from loose terminals, ingress of conducting foreign bodies, etc.) Gradual degradation of some components causing changes in their insulation impedances After sudden failure of a component or an internal part	The rise in temperature is significant after a very short time[c] and is quite localized Possible arc-flash and emission of smoke and flammable gases Release of glowing materials or substances
Accidental sparks and arcs[e]	Cause external to the product (overvoltage of the system network, accidental mechanical action exposing live parts or bringing them together, etc.) Internal cause (switching operations with gradual degradation of internal components and/or ingress of moisture) After sudden failure of a component or an internal part	Possible emission and ignition of flammable gases[d], with consequent flames Ignition may occur locally in surrounding components
High transient peak current	Defect in the electrical circuit	The rise in temperature is significant after a very short time[d] and is quite localized However ignition or explosion are unlikely
NOTE The protective devices can include thermal, mechanical, electrical or electronic types. [a] Mechanical distortions and structural changes induced by anyone phenomenon may result in the occurrence of one or more of the others. [b] At start, protective devices may interrupt the current after a variable length of time according to a predefined tripping curve. [c] The protective devices are activated. [d] The protective devices may not always be activated. [e] Some products produce arcs and sparks in normal operation.		

A quantitative analysis of the probability of those phenomena and the severity of their consequences is overwhelming. An alternative approach is using fire statistics.