

# INTERNATIONAL STANDARD

---

**Railway applications – Communication, signalling and processing systems –  
Safety related electronic systems for signalling**



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2025 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

**About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search -**  
[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**  
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**  
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

**IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)**

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	6
INTRODUCTION .....	8
1 Scope.....	9
2 Normative references.....	10
3 Terms, definitions and abbreviated terms.....	11
3.1 Terms and definitions.....	11
3.2 Abbreviated terms.....	21
4 Overall framework of this document.....	22
5 Requirements for developing safety-related electronic systems .....	24
5.1 General .....	24
5.2 The quality management process .....	24
5.3 The safety management process .....	26
5.3.1 General.....	26
5.3.2 Guideline for structuring documentation .....	26
5.3.3 Safety life cycle .....	27
5.3.4 Safety organization .....	27
5.3.5 Safety plan.....	29
5.3.6 Hazard log .....	30
5.3.7 Safety requirements specification .....	30
5.3.8 System design for safety.....	30
5.3.9 Safety operation and maintenance plan.....	31
5.3.10 Safety verification .....	31
5.3.11 Safety validation .....	32
5.3.12 Safety qualification tests.....	33
5.3.13 Management of safety-related application conditions .....	34
5.3.14 Safety justification.....	35
5.3.15 Independent safety assessment .....	36
6 Requirements for elements following different life cycles .....	36
6.1 General .....	36
6.2 Use of pre-existing items .....	37
6.2.1 General.....	37
6.2.2 Requirements for use of complete pre-existing systems .....	38
6.2.3 Requirements for use of pre-existing equipment.....	38
6.3 Safety-related tools for electronic systems .....	39
6.4 Physical security and cybersecurity .....	40
7 The safety case: structure and content.....	41
7.1 The safety case structure .....	41
7.2 The technical safety report .....	43
7.3 Generic and specific safety cases .....	52
7.4 Provisions for the specific application safety case .....	52
7.5 Dependencies between safety cases .....	53
8 System safety acceptance and subsequent phases .....	54
8.1 System safety acceptance process.....	54
8.2 Operation, maintenance and performance monitoring .....	58
8.3 Modification and retrofit.....	58
8.4 Decommissioning and disposal .....	58

Annex A (normative) Safety integrity levels .....	59
A.1 General .....	59
A.2 Safety requirements.....	59
A.3 Safety integrity .....	60
A.4 Determination of safety integrity requirements .....	60
A.4.1 General.....	60
A.4.2 Risk assessment.....	62
A.4.3 Hazard control.....	64
A.4.4 Identification and treatment of new hazards arising from design.....	70
A.5 Allocation of SILs.....	71
A.5.1 General aspects.....	71
A.5.2 Relationship between SIL and associated TFFR.....	72
Annex B (normative) Management of faults for safety-related functions .....	74
B.1 General .....	74
B.2 General concepts .....	74
B.2.1 Detection and negation times .....	74
B.2.2 Composition of two independent items .....	75
B.3 Effects of faults .....	76
B.3.1 Effects of single faults .....	76
B.3.2 Independence of items .....	78
B.3.3 Detection of single faults .....	83
B.3.4 Action following detection (retention of safe state).....	86
B.3.5 Effects of multiple faults .....	87
B.3.6 Defence against systematic faults.....	90
Annex C (normative) Identification of hardware component failure modes.....	91
C.1 General .....	91
C.2 General procedure.....	91
C.3 Procedure for integrated circuits.....	91
C.4 Procedure for components with inherent physical properties .....	92
C.5 General provisions concerning component failure modes .....	92
Annex D (informative) Example of THR/TFFR/FR apportionment and SIL allocation .....	110
Annex E (normative) Techniques and measures for the avoidance of systematic faults and the control of random and systematic faults .....	112
E.1 General .....	112
E.2 Tables of techniques and measures.....	114
Annex F (informative) Guidance on User Programmable Integrated Circuits .....	122
F.1 General .....	122
F.1.1 Purpose .....	122
F.1.2 Terminology and context.....	122
F.2 UPIC life cycle.....	123
F.2.1 General.....	123
F.2.2 Organization, roles, responsibilities and personnel competencies .....	125
F.2.3 UPIC Requirements .....	125
F.2.4 UPIC Architecture and Design .....	126
F.2.5 Logic Component Design .....	127
F.2.6 Logic Component Coding.....	127
F.2.7 Logic Component Verification.....	127
F.2.8 UPIC Physical Implementation .....	127

F.2.9	UPIC Integration .....	127
F.2.10	UPIC Validation .....	127
F.2.11	Requirements for use of pre-existing logic components.....	127
F.3	Detailed technical requirements for UPIC .....	127
F.3.1	Guidance on safety architecture .....	127
F.3.2	Protection against random faults – architectural principles .....	128
F.3.3	Protection against systematic faults – techniques and measures.....	128
Annex G (informative)	Changes in this document compared to IEC 62425:2007 .....	137
Bibliography	.....	140
Figure 1	– Scope of the main IEC and CENELEC railway application standards .....	10
Figure 2	– Structure of IEC 62425 .....	23
Figure 3	– Example of system life cycle .....	25
Figure 4	– Example of design and validation portion of system life cycle .....	27
Figure 5	– Independence of roles for different SILs and BI, phases 5 to 10.....	29
Figure 6	– Structure of safety case .....	42
Figure 7	– Structure of technical safety report .....	44
Figure 8	– Examples of different usage of safety cases .....	54
Figure 9	– Examples of different safety acceptance processes .....	57
Figure A.1	– Safety requirements and safety integrity.....	59
Figure A.2	– The hourglass model.....	62
Figure A.3	– Definition of hazards with respect to the system boundary.....	64
Figure A.4	– Example of a hazard analysis process .....	66
Figure A.5	– Common cause failures (CCF) .....	68
Figure A.6	– Treatment of CCF by FTA.....	69
Figure A.7	– Relationship between SILs and techniques.....	72
Figure B.1	– Detection and negation times .....	74
Figure B.2	– Control of single and multiple faults .....	78
Figure B.3	– Influences affecting the independence of items .....	80
Figure B.4	– Detection and negation of single faults – composite fail-safety .....	86
Figure B.5	– Detection and negation of single faults – reactive fail-safety.....	87
Figure C.1	– Example of a 4-terminal resistor, using a hybrid thick layer technique .....	94
Figure D.1	– Example of THR/TFFR/FR breakdown and related SIL allocation.....	110
Figure F.1	– UPIC architecture.....	123
Figure F.2	– UPIC development context.....	123
Figure F.3	– Example of UPIC development life cycle.....	124
Figure F.4	– Example of UPIC development life cycle with pre-existing components.....	124
Figure F.5	– UPIC development techniques and measures .....	129
Table 1	– Example of SRAC template .....	35
Table 2	– Sections and contents of the technical safety report .....	44
Table A.1	– The SIL table.....	72
Table B.1	– Measures to detect faults in integrated circuits by means of periodic online testing.....	88

Table C.1 – Resistors .....	94
Table C.2 – Capacitors .....	95
Table C.3 – Electromagnetic components .....	96
Table C.4 – Diodes.....	99
Table C.5 – Transistors.....	100
Table C.6 – Controlled rectifiers.....	102
Table C.7 – Surge suppressors.....	103
Table C.8 – Opto-electronic components.....	104
Table C.9 – Filters.....	106
Table C.10 – Interconnection assemblies.....	107
Table C.11 – Fuses .....	108
Table C.12 – Switches and push/pull buttons .....	108
Table C.13 – Lamps.....	108
Table C.14 – Batteries .....	109
Table C.15 – Transducers and sensors (excluding those with internal electronic circuitry) .....	109
Table E.1 – Safety planning and quality assurance activities.....	114
Table E.2 – Safety requirements specification .....	115
Table E.3 – Safety organization .....	115
Table E.4 – Architecture of system, subsystem or equipment.....	116
Table E.5 – Design features .....	117
Table E.6 – Failure and hazard analysis methods .....	118
Table E.7 – Design and development of system, subsystem or equipment.....	119
Table E.8 – Safety verification and validation of the system, subsystem or equipment .....	120
Table E.9 – Application, operation and maintenance .....	121
Table F.1 – Example of documentation generated during each phase .....	125
Table F.2 – Simplified techniques and measures for protection against systematic failures.....	129
Table F.3 – Design and verification (including all activities before synthesis).....	130
Table F.4 – Synthesis .....	130
Table F.5 – Placement, routing and layout generation .....	131
Table F.6 – Description of techniques for design.....	132
Table F.7 – Description of techniques for synthesis.....	135
Table F.8 – Description of techniques for placement, routing and layout generation .....	136
Table G.1 – Clauses and subclauses – correspondence with IEC 62425:2007 .....	137
Table G.2 – Figures and tables – correspondence with IEC 62425:2007.....	139

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**RAILWAY APPLICATIONS –  
COMMUNICATION, SIGNALLING AND PROCESSING SYSTEMS –  
SAFETY RELATED ELECTRONIC SYSTEMS FOR SIGNALLING****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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62425 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways. It is an International Standard.

EN 50129:2018 has served as a basis for the development of this document.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

- a) a better alignment with the life cycle phases defined in IEC 62278-1 has been made;
- b) Clause 5 describes the requirements that apply to the development of safety-related electronic systems (until phase 9 of the life cycle);

- c) Clause 8 focuses on the requirements for safety acceptance and approval of safety-related electronic systems and subsequent phases;
- d) requirements and guidance have been added in Clause 6 on the following topics:
  - 1) reuse of pre-existing systems,
  - 2) safety-related tools,
  - 3) impact of cybersecurity threats on functional safety,
  - 4) specific application safety cases;
- e) requirements for the structure and content of the safety case are now defined in a dedicated Clause 7;
- f) Annex A has been updated for the specification and allocation of safety integrity requirements;
- g) the content of former Annex D has been merged with Annex B, and the content has been changed from informative to normative;
- h) the status of Annex E has been changed from informative to normative;
- i) an Annex F has been added as an informative annex on User Programmable Integrated Circuits.

A more detailed comparison of changes between IEC 62425:2007 and this document can be found in Annex G.

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

Draft	Report on voting
9/3113/FDIS	9/3141/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under [webstore.iec.ch](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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



## INTRODUCTION

This International Standard defines requirements for the development and acceptance of safety-related electronic systems in the railway signalling field.

Safety-related electronic systems for signalling include hardware and software aspects. To develop complete safety-related systems, both aspects need to be taken into account throughout the whole life cycle of the system. The requirements for the overall safety-related electronic system and for its hardware aspects are defined in this document. Other requirements are defined in associated IEC and CENELEC standards. For safety-related systems which include software, additional conditions are defined in IEC 62279:2015.

NOTE 1 IEC 62279:2015 is derived from the European Standard EN 50128:2011.

Additional requirements for safety-related communication are defined in IEC 62280:2014.

This document is the common base for safety acceptance and approval of electronic systems for railway signalling applications. The aim of railway authorities and railway industry is to develop railway systems based on common standards. The safety authorities having jurisdiction can apply this document to the relevant matters they choose. On this basis, cross-acceptance of safety approvals for sub-systems and equipment can be applied by the different national safety authorities.

Cross-acceptance is applicable to generic approval, not to specific applications.

This document is concerned with the evidence to be presented for the acceptance of safety-related systems. However, it specifies not only those life cycle activities which need to be completed before the acceptance stage, but also the additional planned activities to be carried out afterwards. In this way, safety justification will cover the whole life cycle.

This document is concerned with what evidence is to be presented. Except where considered appropriate, it does not specify who carries out the necessary work. The necessary work can be carried out by different people, in different circumstances or organisational structures, provided that independence of roles is respected.

This document consists of Clauses 1 to 8, which form the main part, and Annexes A, B, C, D, E, F and G. The requirements defined in Clauses 5 to 8 and in Annexes A, B, C and E are normative, whilst Annexes D, F and G are informative.

This document is in line with, and contain references to IEC 62278-1:—<sup>1</sup> and IEC 62278-2:—<sup>1</sup>.

NOTE 2 IEC 62278-1:— and IEC 62278-2:— are derived from the European Standards EN 50126-1:2017 and EN 50126-2:2017 respectively.

This document is based on the system life cycle described in IEC 62278 series and is in line with the IEC 61508 series. IEC 62278, IEC 62279 and IEC 62425 comprise the railway sector equivalent of the IEC 61508 series so far as railway communication, signalling and processing systems are concerned. Given that compliance with these documents has been demonstrated, there are no requirements in this document for further evaluation of compliance with the IEC 61508 series.

---

<sup>1</sup> Under preparation. Stage at the time of publication: IEC/FDIS 62278-1:2025 and IEC/FDIS 62278-2:2025.

## **RAILWAY APPLICATIONS – COMMUNICATION, SIGNALLING AND PROCESSING SYSTEMS – SAFETY RELATED ELECTRONIC SYSTEMS FOR SIGNALLING**

### **1 Scope**

This document is applicable to safety-related electronic systems (including subsystems and equipment) for railway signalling applications.

This document applies to generic systems (i.e. generic products or systems defining a class of applications), as well as to systems for specific applications.

The scope of this document, and its relationship with other IEC and CENELEC standards, are shown in Figure 1.

This document is applicable only to the functional safety of systems. It does not deal with other aspects of safety such as the occupational health and safety of personnel. While functional safety of systems clearly can have an impact on the safety of personnel, there are other aspects of system design which can also affect occupational health and safety and which are not covered by this document. Cybersecurity aspects of functional safety are addressed only to a limited extent.

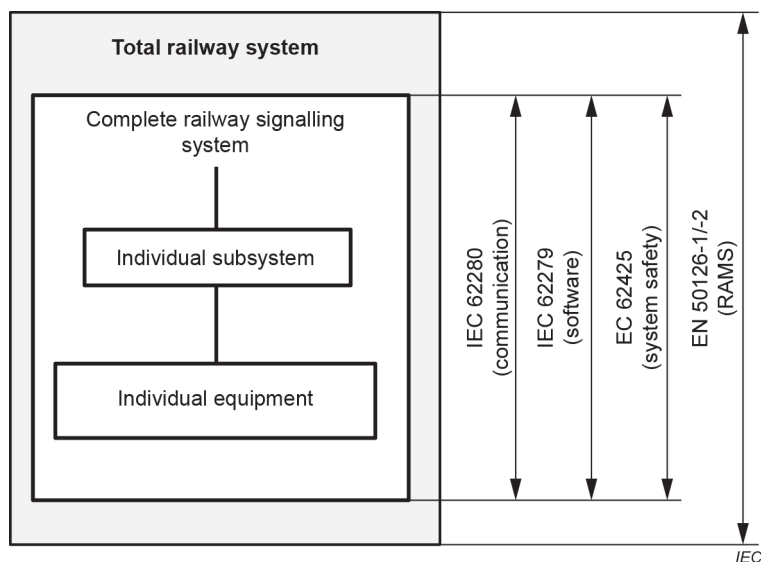
This document applies to all the phases of the life cycle of a safety-related electronic system, focusing in particular on phases 5 (architecture and apportionment of system requirements) to 10 (system acceptance) as defined in IEC 62278-1:—.

Requirements for systems which are not related to safety are outside the scope of this document.

This document is not applicable to existing systems, subsystems or equipment which had already been accepted prior to the development of this document. However, so far as reasonably practicable, it is applicable to modifications and extensions to existing systems, subsystems and equipment.

This document is primarily applicable to systems, subsystems or equipment which have been specifically designed and manufactured for railway signalling applications. It is also applicable, so far as reasonably practicable, to general-purpose or industrial equipment (e.g. power supplies, display screens or other commercial off the shelf items), which is procured for use as part of a safety-related electronic system.

This document is aimed at railway duty holders, railway suppliers, and assessors as well as at safety authorities, although it does not define an approval process to be applied by the safety authorities.



**Figure 1 – Scope of the main IEC and CENELEC railway application standards**

## 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 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 62278-1:—<sup>2</sup>, *Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part 1: Generic RAMS Process*

IEC 62278-2:—<sup>2</sup>, *Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part 2: Systems Approach to Safety*

IEC 62279:2015, *Railway applications – Communication, signalling and processing systems – Software for railway control and protection systems*

IEC 62280:2014, *Railway applications – Communication, signalling and processing systems – Safety related communication in transmission systems*

IEC 62497-1<sup>3</sup>:2010, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*  
IEC 62497-1:2010/AMD1:2013

IEC 62498-1:2010, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

IEC 62498-3:2010, *Railway applications – Environmental conditions for equipment – Part 3: Equipment for signalling and telecommunications*

<sup>2</sup> Under preparation. Stage at the time of publication: IEC/FDIS 62278-1:2025 and IEC/FDIS 62278-2:2025.

<sup>3</sup> There exists a consolidated edition 1.1:2013 that includes IEC 62497-1:2010 and its Amendment 1:2013.