



BSI Standards Publication

Railway applications - Rolling stock - Electronic equipment

National foreword

This British Standard is the UK implementation of EN 50155:2017. It supersedes BS EN 50155:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/9/2, Railway Electrotechnical Applications - Rolling stock.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Date	Text affected
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English Version

Railway applications - Rolling stock - Electronic equipment

Applications ferroviaires - Équipements électroniques
utilisés sur le matériel roulant

Bahnanwendungen - Elektronische Einrichtungen auf
Schienenfahrzeugen

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Contents

Page

European foreword.....	9
Introduction.....	11
1 Scope.....	12
2 Normative references.....	12
3 Terms, definitions and abbreviations	14
3.1 Terms and definitions.....	14
3.2 Abbreviations	19
4 General requirements	20
4.1 Performance requirements	20
4.2 Performance criteria.....	20
4.2.1 General	20
4.2.2 Performance criterion A	20
4.2.3 Performance criterion B	20
4.2.4 Performance criterion C	21
4.3 Environmental service conditions	21
4.3.1 Altitude	21
4.3.2 Operating temperature.....	21
4.3.3 Switch-on extended operating temperature.....	22
4.3.4 Rapid temperature variations.....	23
4.3.5 Shock and vibration	23
4.3.6 Electromagnetic compatibility	23
4.3.7 Relative humidity.....	23
4.4 Special service conditions.....	24
4.4.1 General	24
4.4.2 Atmospheric pollutants	24
5 Electrical service conditions.....	24
5.1 Power supply.....	24
5.1.1 DC Supply.....	24
5.1.2 Supply by a specified source other than the main power source	28
5.1.3 Supply change-over	28
5.1.4 Supply with overhead line or third rail.....	28
5.2 Installation requirements	29
5.2.1 Power supply	29
5.2.2 Thermal compatibility	29
5.2.3 Electromagnetic compatibility	29
5.2.4 Cabling	29
5.2.5 Installation instruction	29

5.2.6	Insulation.....	29
6	Reliability, maintainability and expected useful life	29
6.1	Equipment reliability	29
6.1.1	Predicted reliability.....	29
6.1.2	Proof of reliability	31
6.2	Useful life	32
6.3	Maintainability	33
6.3.1	General	33
6.3.2	Preventive Maintenance	33
6.3.3	Corrective Maintenance	33
6.4	Built-in diagnostics	34
6.5	Automatic test equipment.....	34
6.6	Purpose built test equipment and special tools	34
7	Design.....	34
7.1	General.....	34
7.1.1	Equipment.....	34
7.1.2	Quality management.....	34
7.1.3	System Life-cycle.....	34
7.2	Detailed practices - Hardware.....	35
7.2.1	Insulation coordination.....	35
7.2.2	Interfacing	35
7.2.3	Fault protection	37
7.2.4	Referencing power supplies	37
7.2.5	Interchangeability.....	37
7.2.6	Reduction of supply voltage and ON/OFF phases	37
7.2.7	Polarity reversal	37
7.2.8	Inrush currents	37
7.2.9	Energetic transient pulses	37
7.2.10	Capacitance to ground/earth	38
7.2.11	Spare capacity	38
7.2.12	Programmable Component.....	38
7.3	Detailed practices - Software	38
7.3.1	General	38
7.3.2	Life-cycle.....	38
7.4	Features of software controlled equipment.....	38
7.4.1	General	38
7.4.2	Self-test.....	38
7.4.3	Watchdog.....	38
7.4.4	Failure indication.....	38
7.4.5	Recovery.....	38
8	Non-railway designed electronic equipment.....	39

9	Components	39
9.1	General.....	39
9.2	Procurement.....	39
9.3	Application.....	39
10	Construction	40
10.1	Equipment construction	40
10.1.1	General	40
10.1.2	Mechanical protection	40
10.1.3	Polarization or coding	40
10.1.4	Dimensional requirements	40
10.1.5	Sockets and edge connectors	40
10.1.6	Cabling inside cubicles	40
10.2	Component mounting	41
10.2.1	General	41
10.2.2	Layout	41
10.2.3	Fixing	41
10.2.4	Component lead terminations	41
10.2.5	Pre-set control.....	41
10.2.6	Select on test components	41
10.3	Electrical connections.....	41
10.3.1	General	41
10.3.2	Soldered connections	41
10.3.3	Crimped connections	42
10.3.4	Wire wrap connections	42
10.3.5	Other connections.....	42
10.4	Internal flexible wiring (electrical and optical).....	42
10.5	Flexible printed wiring.....	42
10.6	Printed boards - flexible and rigid	43
10.6.1	Printed board	43
10.6.2	PCB acceptability.....	43
10.6.3	Layout	43
10.6.4	Materials	43
10.7	Protective coatings for printed board assemblies	43
10.8	Identification	44
10.8.1	Bare PCB identification.....	44
10.8.2	Identification of subracks and printed board assemblies.....	44
10.8.3	Mounting position of subracks and printed board assemblies.....	44
10.8.4	Fuse and battery identification.....	44
10.9	Mounting.....	44
10.10	Cooling and ventilation	45
10.11	Materials and finishes.....	45

10.12	Reworking, modification and repair of electronic assemblies	45
11	Safety	45
11.1	General	45
11.2	Requirements	45
11.3	Fire behaviour requirements	45
11.4	Functional safety	46
11.5	Personnel safety	46
12	Documentation.....	46
12.1	General	46
12.2	Supply and storage of documentation.....	46
12.3	Datasheet	46
12.4	User manual	49
12.5	Equipment integration/installation documentation.....	49
12.6	Commissioning documentation	50
12.7	Design documentation.....	50
12.7.1	General	50
12.7.2	Block diagrams	51
12.7.3	Wiring diagrams	51
12.7.4	Interface specification	51
12.7.5	Internal interface specification	51
12.7.6	Equipment drawings	51
12.7.7	Documentation – Hardware	51
12.7.8	Non repairable items list	52
12.7.9	Repair and Maintenance Documentation	52
12.7.10	Documentation – Software	53
12.7.11	Documentation – System	54
13	Testing	54
13.1	General	54
13.2	Categories of tests.....	54
13.2.1	General	54
13.2.2	Type tests	55
13.2.3	Routine tests	55
13.2.4	Investigation tests	55
13.3	Tests summary	55
13.4	Test specification.....	56
13.4.1	Visual inspection	56
13.4.2	Performance test.....	56
13.4.3	Power supply test.....	57
13.4.4	Low temperature start-up test.....	60
13.4.5	Dry heat test.....	61
13.4.6	Low temperature storage test	64

13.4.7	Cyclic damp heat test	65
13.4.8	Electromagnetic compatibility test	67
13.4.9	Insulation test.....	67
13.4.10	Salt mist test.....	68
13.4.11	Vibration and shock test.....	69
13.4.12	Enclosure protection test (IP code).....	69
13.4.13	Stress screening test.....	70
13.4.14	Rapid Temperature variation test.....	70
Annex A (informative) List of default requirements of EN 50155 and related clauses		71
Annex B (informative) Testing approach.....		72
B.1	General.....	72
B.2	Situation of applicability.....	72
B.3	General methodology.....	72
B.4	Equipment Specific Methodology.....	74
B.5	Equipment integration design review	74
B.6	Equipment integration type test	74
B.7	Equipment installation design review	74
B.8	Equipment installation type test	75
B.9	Equipment installation routine test	75
B.10	Equipment periodic re-verification	75
B.11	Replacement of items and ancillary components.....	75
Annex C (informative) Severity of the service conditions in different rolling stock locations ...		76
C.1	General.....	76
C.2	Severity of service conditions in different rolling stock types.....	76
C.3	Intended use of rolling stock	76
C.4	Location of equipment on board rolling stock	76
C.5	Severity of the service conditions in different rolling stock locations	78
Annex D (informative) Example of test report compliance summary.....		80
Annex E (informative) Life cycle model examples — Programmable component life cycle example		82
Annex F (informative) Design guidelines for electronic hardware used on board of rolling stock		83
F.1	Purpose of this annex	83
F.2	Design Rules.....	83
F.2.1	Pollutants	83
F.2.2	Methods against ageing regarding energetic transient pulses	83
F.2.3	Capacitor to ground/earth	84
F.2.4	Inside cabling for equipment.....	84
F.2.5	Earthing configuration.....	84
F.2.6	Prototype testing	85
F.2.7	Interfacing	85

F.2.8	Solder joint on PBA.....	85
F.2.9	Derating	85
Annex G	(informative) Non-railway designed electronic equipment.....	96
Annex H	(informative) Paragraphs with Agreements between the involved Parties	98
Annex ZZ	(informative) Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC	102
Bibliography		104

Tables

Table 1	— Operating temperature classes.....	22
Table 2	— Switch-on extended Operating temperature classes	22
Table 3	— Temperature variation classes.....	23
Table 4	— Continuous Voltage range.....	25
Table 5	— Fluctuation Voltage ranges	25
Table 6	— Interruption voltage supply classes	27
Table 7	— Maximum Peak to Peak Voltages with a DC Ripple Factor of 5 %	28
Table 8	— Supply change-over classes	28
Table 9	— Useful life classes	32
Table 10	— Protective coating classes	43
Table 11	— List of required documentation according to the class	52
Table 12	— List of tests	56
Table 13	— Interruptions of voltage supply classes	59
Table 14	— Test voltages of voltage withstand test	68
Table A.1	— Default requirements	71
Table C.1	— Example of typical equipment locations on board rolling stock	77
Table C.2	— Minimum severity of service conditions in different rolling stock locations	78
Table D.1	— Test report compliance summary	80
Table F.1	— Type and concentration of pollutants	83
Table F.2	— Derating factor.....	86
Table ZZ.1	— Correspondence between this European Standard, the TSI “Locomotives and Passenger Rolling Stock” (REGULATION (EU) No 1302/2014 of 18 November 2014) and Directive 2008/57/EC	102
Table ZZ.2	— Correspondence between this European Standard, the CCS TSI (COMMISSION REGULATION (EU) 2016/919 of 27 May 2016) and Directive 2008/57/EC.....	103

Figures

Figure 1	— Roles and relationship of user and/or supplier	11
Figure 2	— DC Power supply voltage range.....	25
Figure 3	— Temporary DC power supply voltage fluctuation requirements.....	26
Figure 4	— Styles of Test Plans	31
Figure 5	— System interfacing with the typical EMC-areas A, B and C	36
Figure 6	— Temporary supply overvoltages (a)	57

Figure 7 — Temporary supply overvoltages (b).....	58
Figure 8 — Temporary supply dips	58
Figure 9 — Interruption of supply voltage	59
Figure 10 — Supply change-over Class C1	60
Figure 11 — Supply change-over Class C2	60
Figure 12 — Low temperature start-up test	61
Figure 13 — Dry heat thermal test — Cycle A	62
Figure 14 — Dry heat thermal test — Cycle B	63
Figure 15 — Dry heat thermal test — Cycle C	64
Figure 16 — Cyclic damp heat test: Description of the first 24-h cycle	65
Figure 17 — Cyclic damp heat test: Recovery period	66
Figure B.1 — Testing stages	74
Figure C.1 — Typical equipment locations on board rolling stock.....	76
Figure C.2 — Integration of the equipment into the vehicle cabinet	79
Figure E.1 — Programmable component life cycle example	82

European foreword

This document (EN 50155:2017) has been prepared by CLC/SC 9XB, “Electrical, electronic and electromechanical material on board rolling stock, including associated software”.

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2018-04-13
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2020-10-13

This document supersedes EN 50155:2007.

EN 50155:2017 includes the following significant technical changes with respect to EN 50155:2007:

- a) revision of Clause 1, Scope;
- b) revision of Clause 2, Normative references;
- c) revision of Clause 3, Terms, definitions and abbreviations, with reorganisation of subclauses;
- d) improvement of Clause 4, General requirements, in terms of better wording, requirement expansion and reorganisation of subclauses;
- e) revision of Clause 5, Electrical service conditions, with reorganisation of subclauses;
- f) improvement of Clause 6, Reliability, maintainability and expected useful life, with reorganization of subclauses and introduction of explicative figures;
- g) revision of Clause 7, Design;
- h) introduction of a new Clause 8, Non-railway designed electronic equipment;
- i) renumbering of previous Clause 8 to Clause 9, Components, and revision;
- j) renumbering of previous Clause 9 to Clause 10, Construction, and introduction of new requirements;
- k) renumbering of previous Clause 10 to Clause 11, Safety, and improving of the wording;
- l) renumbering of previous Clause 11 to Clause 12, Documentation, and introduction of new requirements also considering new technologies;
- m) renumbering of previous Clause 12 to Clause 13, Testing, text improvement with a particular attention to table “List of tests” and introduction of explaining figures;
- n) introduction of the following informative Annexes:
 - 1) Annex A - List of default requirements of EN 50155 and related clauses;
 - 2) Annex B - Testing approach;

- 3) Annex C - Severity of the service conditions in different rolling stock locations;
- 4) Annex D - Example of test report compliance summary;
- 5) Annex E - Life cycle model examples;
- 6) Annex F - Design guidelines for electronic hardware used on board of rolling stock;
- 7) Annex G - Non-railway designed electronic equipment;
- o) Bibliography (extended and corrected).

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 mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive 2008/57/EC amended by Commission Directive 2011/18/EU, see informative Annex ZZ, which is an integral part of this document.

Introduction

This standard is applied in the design, manufacturing, testing of any electronic equipment installed on board rolling stock.

It also describes the electrical and environmental operating conditions.

There are not correlations between the operating temperature classes listed in Table 1 and the air temperature classes listed in EN 50125-1:2014, Table 2.

The aim of this standard is not to be a detailed guideline for the design of the electronic equipment; the design is made under the responsibility of the supplier. The supplier should take into account the requirements resulting from the specific location of the on board installation (see Annex C).

This standard contains the design, the documentation and the testing requirements.

The roles of user and/or supplier are shown in Figure 1 below.

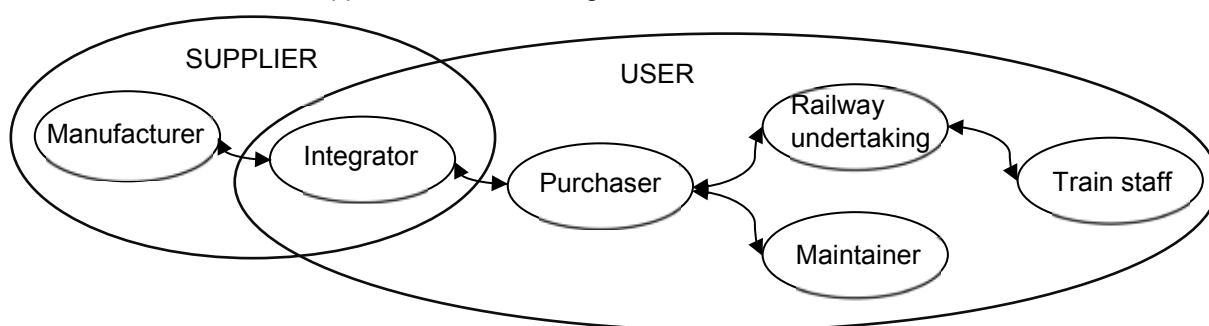


Figure 1 — Roles and relationship of user and/or supplier

1 Scope

This European Standard applies to all electronic equipment for control, regulation, protection, diagnostic, energy supply, etc. installed on rail vehicles.

For the purpose of this European Standard, electronic equipment is defined as equipment mainly composed of semiconductor devices and recognized associated components. These components will mainly be mounted on printed boards.

Sensors (current, voltage, speed, etc.) and Semiconductor drive unit (SDU) for power electronic devices are covered by this standard. Complete Semiconductor drive unit (SDU) and power converters are covered by EN 61287-1.

This European Standard covers the conditions of operation, design requirements, documentation, and testing of electronic equipment, as well as basic hardware and software requirements considered necessary for compliant and reliable equipment.

Specific requirements related to practices necessary to ensure defined levels of functional safety will be determined in accordance with relevant railway safety standards.

The software requirements for on board railway equipment are specified by EN 50657.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 45545 (all parts), *Railway applications — Fire protection on railway vehicles*

EN 45545-2:2013+A1:2015, *Railway applications — Fire protection on railway vehicles — Part 2: Requirements for fire behaviour of materials and components*

EN 50121-3-2:2016, *Railway applications — Electromagnetic compatibility — Part 3-2: Rolling stock - Apparatus*

EN 50124-1:2017, *Railway applications — Insulation coordination — Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment*

EN 50125-1:2014, *Railway applications — Environmental conditions for equipment — Part 1: Rolling stock and on-board equipment*

EN 50126-1:2017, *Railway Applications — The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) — Part 1: Generic RAMS Process*

EN 50153:2014, *Railway applications — Rolling stock — Protective provisions relating to electrical hazards*

EN 50163:2004, *Railway applications — Supply voltages of traction systems (IEC 60850:2000, not equivalent)*

EN 50657:2017, *Railway applications — Rolling stock applications — Software onboard of rolling stock*

EN 60068-2-1:2007, *Environmental testing — Part 2-1: Tests — Test A: Cold (IEC 60068-2-1:2007)*

EN 60068-2-2:2007, *Environmental testing — Part 2-2: Tests — Test B: Dry heat (IEC 60068-2-2:2007)*

EN 60068-2-11:1999, *Environmental testing — Part 2: Tests — Test Ka: Salt mist (IEC 60068-2-11:1981)*

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

EN 60297 (all parts), *Mechanical structures for electrical and electronic equipment — Dimensions of mechanical structures of the 482,6 mm (19 in) series (IEC 60297 series)*

EN 60352-1:1997, *Solderless connections — Part 1: Wrapped connections — General requirements, test methods and practical guidance (IEC 60352-1:1997)*

EN 60352-2:2006, *Solderless connections — Part 2: Crimped connections — General requirements, test methods and practical guidance (IEC 60352-2:2004)*

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN 61249-2-7:2001, *Materials for printed boards and other interconnecting structures — Part 2-7: Reinforced base materials, clad and unclad — Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad (IEC 61249-2-7:2002)*

EN 61249-2-22:2005, *Materials for printed boards and other interconnecting structures — Part 2-22: Reinforced base materials, clad and unclad — Modified non-halogenated epoxide woven E-glass laminated sheets of defined flammability (vertical burning test), copper-clad (IEC 61249-2-22:2003)*

EN 61373:2010, *Railway applications — Rolling stock equipment — Shock and vibration tests (IEC 61373:2010)*

EN 62326 (all parts), *Printed boards (IEC 62326 series)*

EN ISO 13732-1:2008, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces (ISO 13732-1:2006)*

ISO/IEC 90003, *Software engineering — Guidelines for the application of ISO 9001:2008 to computer software*

ISO/IEC/IEEE 15289:2017, *Systems and software engineering — Content of life-cycle information items (documentation)*

IPC-A-600 (H):2010, *Acceptability of Printed Boards*

IPC-A-610 (E):2010, *Acceptability of Electronic Assemblies*

IPC-2220:2010 series, *Family of Design Documents*

IPC-2221 (B):2012, *Generic Standard on Printed Board Design*

IPC-2222 (A):2010, *Sectional Design Standard for Rigid Organic Printed Boards*

IPC-2223 (C):2011, *Sectional Design Standard for Flexible Printed Boards*

IPC-2581 (B):2013, *Generic Requirements for Printed Board Assembly Products Manufacturing Description Data and Transfer Methodology*

IPC-4101 (D):2014, *Specification for Base Materials for Rigid and Multilayer Printed Boards*

IPC-6013 (C):2013, *Qualification and Performance Specification for Flexible Printed Boards*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1

printed boards

base materials which are cut to size containing all required holes and bearing at least one conductive pattern, and which are typically subdivided according to:

- their structure (e.g. single and double sided, multilayers);
- the nature of the base material (e.g. rigid, flexible)

[SOURCE: IEC ref.541-01-03, modified — The definition was grammatically modified.]

3.1.2

printed board assembly

printed board with electrical and mechanical components and/or other printed boards attached to it with all manufacturing processes, soldering, coating, etc., completed

3.1.3

operating temperature

temperature range in which the electronic equipment will operate (e.g. cubicle temperature, rack temperature, roof box temperature) in full conformity with his performance criteria, and outside which there can be temporary or permanent degradation of the equipment performances

3.1.4

plug-in unit

unit which plugs into a subrack and is supported by guides

Note 1 to entry: Plug-in units can be of various types, ranging from a printed board with components inserted, to a frame or box-type unit designed with a plug-in connection.

[SOURCE: IEC ref 581-25-04]

3.1.5

subrack

structural unit for housing printed boards with components inserted, and plug-in units

[SOURCE: IEC ref 581-25-01]

3.1.6

rack

free-standing or fixed structure for housing electrical and electronic equipment

[SOURCE: IEC ref 581-25-03]

3.1.7

cubicle

enclosure for housing electrical and/or electronic equipment

3.1.8

line replaceable unit

modular component that is designed to be removed and replaced at the field level to restore the system to an operational ready condition

3.1.9**performance test**

test in which the equipment is stimulated and measured to verify the conformance to the specified functional requirements, and which will verify all functionalities

Note 1 to entry: The performance test is carried out according to the Performance test specification and Performance test procedure provided by the supplier.

3.1.10**operational check**

tailored performance test which is carried out during and/or after environmental tests or stress screening sufficient to prove that the equipment is within its operational limits, and that it has survived the environmental/stress screening test

Note 1 to entry: Every environmental test or stress screening can use a different operational check.

Note 2 to entry: Operational checks are carried out according to Operational check specifications and Operational check procedures provided by the supplier.

3.1.11**system voltage supply**

voltage supply used to power the electronic equipment

3.1.12**vehicle wiring**

all wiring which can be connected to the system voltage supply, wherever located, and all other wiring external to the electronic equipment under consideration

3.1.13**supply overvoltage**

electrical disturbance to the control system voltage supply (e.g. caused by equipment controlling that supply, load drop)

Note 1 to entry: A supply overvoltage will occur as an increase in the level of the control system voltage supply.

3.1.14**energetic transient pulses**

non-periodic and relatively short positive or negative (or both) rapid change(s) of voltage and/or current between two steady states

3.1.15**failure**

termination of the ability of an item to perform a required function

Note 1 to entry: "Failure" is an event, as distinguished from "fault", which is a state.

Note 2 to entry: Attention is drawn to the possibility of a consequential failure of a second item of equipment resulting from a temporary malfunction of an item of equipment connected to it.

Note 3 to entry: A temporary malfunction will not be considered as a failure provided that the equipment recovers normal operation automatically following malfunction.

3.1.16**damage**

change in visual appearance or alteration of electrical or mechanical integrity

3.1.17

useful life

useful life, <of an item>

time interval, from first use until user requirements are no longer met, due to economics of operation and maintenance, or obsolescence

Note 1 to entry: In this context, “first use” excludes testing activities prior to hand-over of the item to the end-user.

[SOURCE: IEC 60050-192-02-27]

Note 2 to entry: For a repairable item the individual useful life may be ended by a failure which is not considered as repairable for any reason.

3.1.18

fault

state of an item characterized by its inability to perform a required function

Note 1 to entry: A fault is often the result of a failure of the item itself, but may exist without prior failure (e.g. in the case of a design fault).

3.1.19

performance criteria

performance specification for the operation of the electronic equipment throughout the environmental test conditions stated in this standard

3.1.20

minimum performance level

defined level of deviation from normal operation

3.1.21

user

person or organization that receives and specifies equipment or software for further use, and that can be:

- a system integrator in relationship to the manufacturer;
- a purchaser;
- a maintainer;
- a railway undertaking

3.1.22

manufacturer

party who develops and manufactures the electronic equipment

3.1.23

system integrator

party who is responsible for the specification and/or the integration of the electronic equipment into the railway vehicle or vehicle component

3.1.24**system**

set of interrelated elements considered in a defined context as a whole and separated from their environment

[SOURCE: IEV ref.351-42-08, modified — The original Notes to the definition have not been reproduced here.]

3.1.25**equipment**

single apparatus or set of devices or apparatuses, or the set of main devices of an installation, or all devices necessary to perform a specific task

[SOURCE: IEV ref.151-11-25, modified — The original Note to the definition has not been reproduced here.]

3.1.26**apparatus**

device or assembly of devices which can be used as an independent unit for specific functions

Note 1 to entry: In English, the term “apparatus” sometimes implies use by skilled persons for professional purposes.

[SOURCE: IEV ref.151-11-22]

3.1.27**component**

constituent part of a device which cannot be physically divided into smaller parts without losing its particular function

[SOURCE: IEV ref.151-11-21]

3.1.28**device**

material element or assembly of such elements intended to perform a required function

Note 1 to entry: A device may form part of a larger device.

[SOURCE: IEV ref.151-11-20]

3.1.29**item**

part, component, device, subsystem, functional unit, equipment or system that can be individually considered

Note 1 to entry: An item may consist of hardware, software or both, and may also in particular cases, include people.

[SOURCE: IEV ref.192-01-01, modified — The definition itself and the Note have been made more precise and the other Notes in the original definition have not been reproduced here.]

3.1.30**event**

something that occurs in a certain place during a particular interval of time

3.1.31

supplier

organization which has the responsibility for the supply of individual item of equipment or groups of the equipment to the user, and which can be:

- a manufacturer;
- a system integrator in relation to railway undertaking or maintainer

3.1.32

performance classes

classification applied to an electronic equipment and specifying different performance levels for a performance requirement

3.1.33

commercial off-the-shelf equipment/components

item purchased from a supplier's catalogue, available on the domestic and foreign market, according to a supplier reference, and for which the user has no control over the design definition or on the production

Note 1 to entry: This item may be modified; the manufacturing discontinued or may no longer be maintained without the user being notified and has no right to be so. A single supplier or multiple suppliers may exist for the same item.

3.1.34

equipotential area

area of electronic components/equipment and electric connections referenced to the same potential and without insulation between the components

3.1.35

performance specification

document that specifies the functions that a system or component is to perform (often part of a requirements specification)

3.1.36

DC ripple factor

ratio of half the difference between the maximum and minimum value of a pulsating direct current to the mean value of this current

Note 1 to entry: With low values of the DC ripple factor this quantity is approximately equal to the ratio of the difference to the sum of the maximum and the minimum values.

[SOURCE: IEC 551-17-29]

3.1.37

Extra Low Voltage (ELV) circuit

secondary circuit with voltages between any two conductors of the circuit, and between any one such conductor and earth, not exceeding 25 V AC or 60 V DC, under normal operating conditions, which is separated from hazardous voltage by basic insulation

Note 1 to entry: The values 25 V AC and 60 V DC are taken from band I of EN 50153.

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

AC	Alternating Current
ASIC	Application Specific Integrated Circuit,
ATE	Automatic Test Equipment
CAN	Controller Area Network bus
CMRR	Common Mode Rejection Ratio
CPLD	Complex Programmable Logic Device
CPU	Central Processing Unit
CTR	Current Transfer Ratio
DC	Direct Current
ELV	Extra Low Voltage
EMC	Electromagnetic compatibility
EN	European Standard (Norm)
ESD	Electrostatic discharge
FPGA	Field Programmable Gate Array
GBWP	Gain–bandwidth product
HR	Relative Humidity
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEV	International Electrotechnical Vocabulary
I/O	Input Output
IP code	International Protection Code
IPC	Association Connecting Electronics Industries
LED	Light Emitting Diode
LRU	Line Replaceable Unit
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
MVB	Multifunction Vehicle Bus
NA	Not Applicable
PBA	Printed Board Assembly
PCB	Printed Circuit Board
PLD	Programmable Logic Device
PoE	Power over Ethernet
PPS	Polyphenylene sulfide
PTE	Portable Test Equipment
RAMS	Reliability Availability Maintainability Safety
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals

RF	Radio Frequency
rms	Root Mean Square (value of a quantity)
RoHS	Restriction of the Use of Hazardous Substances
SOT	Select On Test
TCMS	Train Control and Monitoring System
TFT	Thin-Film-Transistor
TTL	Transistor-Transistor Logic
TVS	Transient Voltage Suppressor
UV	Ultraviolet

4 General requirements

4.1 Performance requirements

The electronic equipment performance requirements (e.g. functional, electrical, mechanical, appearance, interfaces) shall be defined.

The standard specifies a set of default performance classes of requirements; different classes may be requested at tender stage.

4.2 Performance criteria

4.2.1 General

The normal performance level of the electronic equipment may be replaced by a permissible loss of performance. In the text below if performance criteria A, B or C are used in Clauses 4 to 12 the word “test” shall be replaced by “event”.

The minimum performance level shall be defined.

If the minimum performance level or the permissible loss of performance is not specified by the supplier, either of these may be derived from the product description and documentation and what the user may reasonably expect from the apparatus if used as intended.

No damage to any connected equipment is allowed when the electronic equipment does not operate as intended during or after the test. Possible causes of failure are incorrect timing of output signals, overvoltage outside specifications, etc.

4.2.2 Performance criterion A

The apparatus shall continue to operate as intended during and after the test/event. No degradation of performance or loss of function is allowed.

Changes of actual operating state or stored data are not allowed.

If agreed between the involved parties, the normal performance level (all functions are working as specified) can be replaced by a minimum performance level.

4.2.3 Performance criterion B

The apparatus shall continue to operate as intended after the test/event.

During the test/event, degradation of performance is however allowed.

Changes of actual operating state or stored data are not allowed.

4.2.4 Performance criterion C

During the test/event temporary loss of function is allowed. The equipment could:

- automatically restart. The normal performance shall be obtained within a maximum defined time. After this time the equipment shall retain the previous operating state and shall work as intended. The loss of significant data is not allowed; or
- manually restart or process controlled restart. In this case this shall be agreed between user and supplier and/or clearly defined in the user manual. In this case the user manual shall be available to the user at the tender stage.

NOTE Significant stored data are application dependent and stated into the Performance specifications.

4.3 Environmental service conditions

4.3.1 Altitude

The altitude at which the equipment is normally to function does not exceed the values called for in EN 50125-1:2014, Table 1 "Classes of altitude range". In case of required altitude above the EN 50125-1:2014, Table 1 class A1, compliance with the requirements shall be agreed between the involved parties.

Unless otherwise specified, the requirements of EN 50125-1:2014, Table 1 class A1 apply.

4.3.2 Operating temperature

Electronic equipment shall be designed and manufactured to meet the full performance specification requirement for the selected temperature classes as stated in Table 1.

The supplier of the electronic equipment shall specify its power dissipation and the thermal integration constraints (e.g. natural convection cooling, forced air cooling, cooled plate, mounting position, free space inside integration volume, preheating, air outlet) to respect a correct integration of this electronic equipment into their operating environment.

The user of the electronic equipment shall respect the thermal integration constraints specified by the supplier and shall design the integration environment in order to ensure an operational temperature compliant with the operational temperature class of the integrated electronic equipment.

The requirements for active or assisted cooling system shall be described according to Subclause 12.5 Equipment integration/installation documentation

"Electronic equipment" and "Integration environment" are generic designations applicable to several levels; some examples are listed below:

- an "Enclosed" or "Open frame" complex component integrated on a PCB;
- a "Single electronic board" or a "Plug-In unit" integrated into a "Sub-rack";
- a "Single electronic board" integrated into an "Enclosure";
- a "Sub-rack" integrated into a "Cubicle" or "Cabinet" or "Case";
- a "Rack" or a "Case" integrated into a "Vehicle".

The ambient temperatures outside vehicle are defined into the EN 50125-1:2014, Table 2, column 1.

Table 1 — Operating temperature classes

Class	Equipment operating temperature range (°C)
OT1	–25 to +55
OT2	–40 to +55
OT3	–25 to +70
OT4	–40 to +70
OT5	–25 to +85
OT6	–40 to +85

Class OT5 and OT6 cannot be used as a general specification for temperature in vehicle requirement (e.g. can be used for Semiconductor Drive Unit (SDU), combustion engine control unit).

Temperature classes OT1 and OT2 should be used for passenger compartments and driver's cab with a reference permanent temperature of 25 °C for which the effects on the material ageing are equivalent to those of the climatic temperature during lifetime. OT3 and OT4 should be used for equipment in technical cabinet with a reference permanent temperature of 45 °C for which the effects on the material ageing are equivalent to those of the climatic temperature during lifetime.

Unless otherwise specified, the requirements of category OT3 apply.

4.3.3 Switch-on extended operating temperature

The design shall take into account temperature rises within cubicles to ensure that the components do not exceed their specified temperature ratings. For example, it is expected, that the air temperature surrounding the individual printed boards rises about 15 °C (this temperature rise depends significantly on the power dissipation of the board itself and on the power dissipation of other boards in the vicinity of it, on the natural or forced air flow, etc.). This shall be taken into account for the design of the PBA, particularly when individual PBA's are intended to be horizontally or vertically juxtaposed or when sub-racks containing the PBAs are superposed.

The supplier should take into account the requirements resulting from the specific on board installation (see Annex C).

In some special cases (e.g. cubicle, effect of sun, assisting cooling system shutdown) an extra operational check at the equipment switched on at short-term thermal conditions is carried out according to the classes ST1 or ST2 of Table 2.

Table 2 — Switch-on extended Operating temperature classes

Class	Switch-on extended operating temperature (duration: 10 min)	Thermal test cycle See 13.4.5
ST0	No switch-on extended operating temperature	Test cycle A
ST1	OTx +15 °C	Test cycle B
ST2	OTx +15 °C	Test cycle C

NOTE "OTx +15 °C" corresponds to (maximum temperature of "OTx" operating temperature range of Table 1) + (15 °C) and only for "OTx" with "x" = 1, 2, 3 or 4.

Class ST1 and ST2 do not apply to classes OT5 and OT6.

Unless otherwise specified, the requirements of class ST1 apply.

4.3.4 Rapid temperature variations

Special operation conditions as rapid temperature variations during train running through tunnels shall be taken into account.

The temperature variation seen by the equipment depends on installation location (see Table C.1; locations 4, 5, 6, 7 are particularly exposed).

The following classes are defined for the equipment and they define the requirements that the equipment shall fulfil:

Table 3 — Temperature variation classes

Class	Column 1	Column 2	Column 3
	Cold air temperature surrounding the equipment	Hot air temperature surrounding the equipment	Temperature gradient °C/s
H1	No requirements	No requirements	No requirements
H2	–25 °C	15 °C / 95 %RH	±3
	10 °C	40 °C / 60 %RH	±3

NOTE The H2 class take into account the situation of a vehicle entering into a tunnel from low temperature environment (from –25°C to 15°C) or exiting from a tunnel into a hot and wet environment (from 10°C to 40°C). Condensation phenomena occur in both cases.

The values given in Table 3, Class H2 are worst case values which will typically not occur regularly throughout the year. Both directions of the rapid temperature change shall be taken into account.

Class H2 cannot be used as a general specification for temperature and humidity change in vehicle requirements (e.g. can be used for equipment mounted outside vehicle body).

If class H2 is specified the duration of column 1 and column 2 shall be specified (typical and worst case).

Furthermore, the frequency of occurrence of the rapid temperature change shall be specified.

Unless otherwise specified, the requirements of class H1 apply.

4.3.5 Shock and vibration

The equipment shall be able to withstand, without deterioration or malfunction, vibrations and shocks that occur in service.

The level of shock and vibration that the equipment can withstand in normal operation shall be specified. This shall be done using the Categories and Classes as specified by EN 61373. The supplier shall specify the permitted orientation for mounting the equipment on the vehicle according to the definitions of EN 61373.

Unless otherwise specified, the requirements of EN 61373 category 1 class B apply.

4.3.6 Electromagnetic compatibility

All electronic equipment shall comply with EN 50121-3-2.

4.3.7 Relative humidity

Electronic equipment shall be designed for the humidity conditions described in EN 50125-1.

The external humidity levels and time periods to consider are specified by the EN 50125-1.

NOTE The temperature class to apply, in relation with the psychometric charts of EN 50125–1, is the class of air temperatures as defined in EN 50125–1:2014, Table 2.

The service condition (e.g. pollution degree of EN 50124-1) shall be taken into account in order to avoid malfunction or failure due to condensation (see Annex C).

4.4 Special service conditions

4.4.1 General

Special arrangements shall be agreed between the appropriate parties involved when service conditions can be proved to be different from those mentioned in Subclause 4.3 (e.g. electronic equipment mounted on the bogie or integrated within a power converter, etc.). Checks for the effectiveness of such arrangements can, if required, form the subject of optional type tests which can be carried out on the vehicle itself in accordance with methods to be agreed between the involved parties.

4.4.2 Atmospheric pollutants

The equipment may be expected to be exposed throughout its life to various pollutants (e.g. oil mist, salt spray, conductive dust, sulfur dioxide.). The types of pollutants, their concentration, test procedures and test specifications should be defined in the tender documents.

5 Electrical service conditions

5.1 Power supply

5.1.1 DC Supply

5.1.1.1 General

The nominal voltage of equipment (U_n) shall be selected from amongst the following values:

24 V, 28 V, 36 V, 48 V, 72 V, 96 V, 110 V

The recommended values are the following: 24 V, 72 V, 110 V.

These nominal voltage values are given only as standardizing values for the design of equipment. They should not be considered as the off load battery voltages since these are determined by the types of battery, the number of cells and the operating conditions.

The supply may be derived from a vehicle battery. The battery may be charged from battery chargers, auxiliary inverters and motor-alternator or motor-generator sets with associated electronic regulations.

The grouping of power supply nominal voltage ranges is allowed for equipment designed to be compliant with a wide input voltage range.

In this case, the principle (for performance and power supply type test compliance) is to consider the most stringent values in the voltage range; it means that the minimum continuous voltage shall be $0,7 U_n$ the lowest nominal power supply voltage and that the maximum continuous voltage shall be $1,25 U_n$ the highest nominal power supply voltage (i.e. an equipment can be designed to be compliant with the nominal power supply voltages of 24 V up to 48 V; the minimum continuous voltage to consider is $0,7 \times 24V$ and the maximum continuous voltages to consider ($1,25 \times 48$) V). See Figure 2 for other example of “DC Power supply voltage range”.

For thermal compliance and EMC tests, the most stringent values in the voltage range shall be considered.

For DC voltage supply fluctuation tests, the most stringent values in the voltage range shall be considered (see Figure 3 for other example of “DC Power supply voltage fluctuation requirements”).

For the interruption of voltage supply the equipment shall be validated for the minimum nominal power supply voltage for which he is designed for operation (i.e. for equipment designed to be

operated with minimum power supply voltages of 24 V, 48 V, 72 V or 110 V the interruption of voltage supply compliance test shall be performed at 24 V).

The grouping is not relevant for vibration and shock tests.

All requirements related to power supply (with possible exception for Subclause 5.1.1.4 and Subclause 5.1.3) shall be applied to all I/O ports referenced to the power supply line.

5.1.1.2 DC power supply range

Electronic equipment shall operate satisfactorily for all the values of the DC power supply voltage within the range defined in Table 4 measured at the terminals of the equipment, see also Figure 2.

In case of variation of the power supply voltage from zero to the maximum (e.g. intervention of circuit breaker) the equipment shall neither fail, nor be the cause of failure of other equipment. The equipment shall restart in normal operating mode when the power supply voltage is within the continuous voltage range.

Table 4 — Continuous Voltage range

Nominal voltage U_n	Limits
Minimum continuous voltage:	$0,7 U_n$
Maximum continuous voltage:	$1,25 U_n$

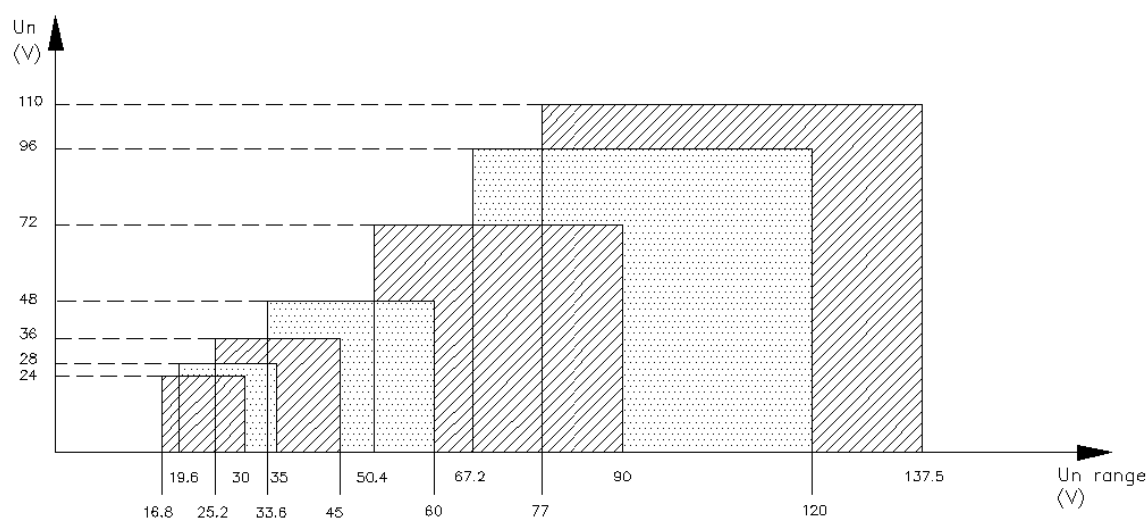


Figure 2 — DC Power supply voltage range

It is permitted to group different DC power supply voltages.

5.1.1.3 Temporary DC power supply fluctuation

Electronic equipment shall operate for the values of the DC power supply voltage within the fluctuation range defined in Table 5 measured at the terminals of the equipment, see also Figure 3.

Table 5 — Fluctuation Voltage ranges

Nominal voltage U_n	Limits
Minimum fluctuation voltage	$0,6 U_n$
Maximum fluctuation voltage	$1,4 U_n$

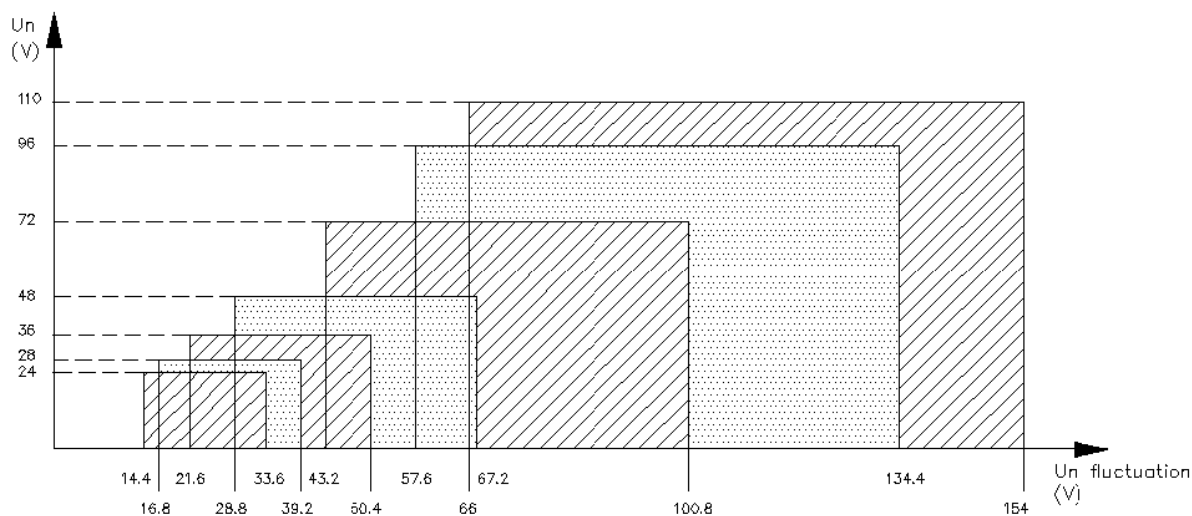


Figure 3 — Temporary DC power supply voltage fluctuation requirements

Voltage fluctuation can be either positive (overvoltage) or negative (dips).

Temporary supply overvoltages lying between U_n and $1,4 U_n$ and not exceeding 0,1 s shall not cause deviation of function (performance criterion A).

Temporary supply overvoltages lying between $1,25 U_n$ and $1,4 U_n$ and not exceeding 1 s shall fulfil performance criterion B.

Temporary supply dips lying between U_n down to $0,6 U_n$ and not exceeding 0,1 s shall not cause deviation of function (performance criterion A).

Temporary supply overvoltages shall be assumed to be generated with respect to the control system voltage supply return potential and to be present only as an increase to the level of the control system voltage, which shall be assumed to be present before and after the application of the overvoltage. Overvoltage of opposite polarity to the control system voltage supply need not be considered.

Overvoltage exceeding in duration or amplitude the specified voltage fluctuation shall be assumed to occur only in the case of a failure in the control system voltage supply.

Voltage dips are mainly caused by faults in the DC distribution system, or by sudden large changes of load.

In the case of combustion engines, see also 5.1.1.5.

5.1.1.4 Interruptions of voltage supply

Due to a short circuit on a DC supply distribution line and subsequent operation of fuse/circuit breakers, input voltage may reduce to 0 V for a short period.

The classes of interruptions on supply voltage, are listed in Table 6:

During a short interruption, the DC distribution system presents a “low impedance” (short circuit) condition due to the clearing of an overload or fault condition on the supply bus. This condition can cause reverse current (negative peak inrush current) from the load.

Regarding interruptions on supply voltage, there are three classes of interruption:

Table 6 — Interruption voltage supply classes

Class	Requirements
S1	In case of voltage interruption, no performance criterion is requested but the equipment shall continue to operate as specified after the voltage interruption.
S2	In case of voltage interruption up to 10 ms the equipment shall behave according to performance criterion A.
S3	In case of voltage interruption up to 20 ms the equipment shall behave according to performance criterion A.

For a voltage interruption longer than specified in Table 6, the behaviour of the equipment shall be agreed between the involved parties.

This classification is valid for nominal voltage.

The choice of class should be defined by the system integrator; unless otherwise specified, the requirements of class S2 apply.

Unless otherwise specified, the requirements for interruption of voltage supply apply to the power supply input ports only; the behaviour of the I/O ports, not functionally associated to the power supply of the equipment, but referenced to the same supply distribution line, shall be handled as described in the specification of the equipment.

5.1.1.5 Variations of voltage supply for rolling stock powered by combustion engine

At start-up of combustion engines the voltage supply system shall be designed to guarantee the supply to the essential electronic equipment during the whole starting sequence.

5.1.1.6 DC ripple factor

The DC ripple voltage, and frequency, on a DC supply is dependent on the type of power generator or converter that produces the controlled DC supply. The DC ripple normally consists of a small AC waveform superimposed on the DC supply once the generator or converter output has been rectified and filtered. In practise there are three common ways to produce a stable DC supply as follows:

- rectified single phase AC (50 Hz or 60 Hz) that produces a DC ripple at frequencies of 100 Hz and 120 Hz;
- rectified 3 phase AC (50 Hz or 60 Hz) that produces a DC ripple at frequencies of 300 Hz and 360 Hz;
- rectified inverter produced single phase AC (1 kHz and higher) that produces a DC ripple of twice the inverter switching frequency, i.e. 2 kHz and higher.

A peak to peak ripple voltage that gives a DC ripple factor no greater than 5 % is shown in Table 7. The formula to calculate the DC ripple factor is given below where $U_{\max}$ is the maximum voltage peak at the nominal voltage (U_n) and $U_{\min}$ is the minimum voltage peak at U_n .

$$\text{DC Ripple Factor (\%)} = \frac{U_{\max} - U_{\min}}{2U_n} \times 100 \quad \text{approximately} \quad \frac{U_{\max} - U_{\min}}{2U_{\max} + U_{\min}} \times 100$$

The equipment shall be able to work properly when its DC power supply has a periodic function ripple with a peak to peak value stated in Table 7.

The supplier shall specify in the documentation the limits of the ripple with which the equipment will operate normally.

Table 7 — Maximum Peak to Peak Voltages with a DC Ripple Factor of 5 %

Nominal Voltage (U_n)	Maximum Peak to Peak ripple allowed (V)	U _{max} (V)	U _{min} (V)	DC Ripple factor (%)
24	2,4	25,2	22,8	5 %
36	3,6	37,8	34,2	5 %
48	4,8	50,4	45,6	5 %
72	7,2	75,6	68,4	5 %
96	9,6	100,8	91,2	5 %
110	11	115,5	104,5	5 %

5.1.2 Supply by a specified source other than the main power source

In the case of equipment supplied by a specified source, not directly connected to the vehicles power supply (e.g. stabilized DC-DC-converter, PoE) the specification of this local source (e.g. voltages, currents, tolerances) shall be met.

Characteristics (e.g. range, fluctuation, ripple factor) of the output voltage of the stabilized supply and input voltage of the equipment shall fit together.

The specification shall be agreed between the involved parties.

5.1.3 Supply change-over

When the equipment supply is switched between different sources (e.g. redundancy switching), the equipment shall operate satisfactorily under the conditions stated in Subclauses 5.1.1.1, 5.1.1.2, 5.1.1.3, 5.1.1.6.

Table 8 — Supply change-over classes

Class	Requirements
C1	at 0,6 U_n duration 100 ms (without interruptions). Performance criterion A
C2	during a supply break of 30 ms starting at U_n . Performance criterion B

The supply break is an open circuit and not a short circuit.

Unless otherwise specified, the requirements of class C1 apply.

Unless otherwise specified, the requirements for interruption of voltage supply apply to the power supply input ports only; the behaviour of the I/O ports, not functionally associated to the power supply of the equipment, but referenced to the same supply distribution line, shall be handled as described in the specification of the equipment.

5.1.4 Supply with overhead line or third rail

In the case of electronic equipment with a supply derived directly from the overhead line or third rail (e.g. control electronics of a self-starting static converter), the equipment shall operate satisfactorily (Performance Criterion A) for values of contact line voltage as described in EN 50163.

5.2 Installation requirements

5.2.1 Power supply

The power supply to the electronic equipment should be provided by a separate conductor connected as directly as possible to the source or the main battery line. The separated conductor should be used only for the supply to electronic circuits.

Calculations for the battery cabling and current protection shall take into account the power consumption and inrush current specified by the datasheet or by the Equipment Integration Manual.

If one pole of the battery of the vehicle is connected to the vehicle body, this shall be specified.

5.2.2 Thermal compatibility

The integration of the electronic equipment into its operational environment shall respect the thermal integration constraints specified by the datasheet or by the Equipment Integration Manual and the integration environment shall be designed in order to ensure an operational temperature compliant with the operational temperature class of the integrated electronic equipment.

5.2.3 Electromagnetic compatibility

The installation of the electronic equipment shall be arranged to reduce, as far as possible, the effects of electrical disturbances to the electronic equipment and as far as possible the effect of emissions by the equipment to the electrical/electronic system of the rolling stock according to EN 50121-3-2.

The assembly of the equipment into the complete vehicle will give adequate immunity, provided that an EMC plan has been prepared and implemented, taking into account the limits in EN 50121-3-2.

5.2.4 Cabling

The cabling to connect the equipment on the vehicle should be done according to EN 50343.

5.2.5 Installation instruction

The equipment integration/installation instruction shall contain the specific installation requirements, (e.g. thermal requirements, handling, cable length).

5.2.6 Insulation

The insulation coordination requirements are defined in EN 50124-1. For voltage withstand test, the minimum value of the test voltage shall be selected from Table 14.

6 Reliability, maintainability and expected useful life

6.1 Equipment reliability

6.1.1 Predicted reliability

Failure rate data of components are published in several well-known reliability handbooks. Usually the data published are obtained from equipment in specific applications e.g. telephone exchanges. In some cases the source of the data are unspecified and is not principally obtained from field data. Due to this reason failure rate predictions often differ significantly from field observations and can often lead to false consequences.

Failure rate predictions are based on the following assumptions (the list could be not fully comprehensive):

- The prediction model uses a simple reliability series system of all components, in other words, a failure of any component is assumed to lead to a system failure.
- Component failure rates needed for the prediction are assumed to be constant for the time period considered. This is known to be realistic for electronic components after burn-in.

- Component failures are independent.
- No distinction is made between complete failures and drift failures.
- Components are faultless and are used within their specifications.
- Design and manufacturing processes of the item under consideration are faultless.
- Process weaknesses have been eliminated, or if not, screened by burn-in.

Limitations of failure rate predictions are:

- a) Provide only information whether reliability goals can be reached.
- b) Results are dependent on the trustworthiness of failure rate data.
- c) The assumption of constant component failure rates may not always be true. In such cases this method can lead to pessimistic results.
- d) Failure rate data may not exist for new component types.
- e) In general redundancies cannot be modelled.
- f) Other stresses can predominate and influence the reliability.
- g) Improper design and process weaknesses can cause major deviations.
- h) Different reliability calculation methods applied to the same circuit, although based on well-known reliability handbooks, (e.g. IEC/TR 62380) can lead to completely different results.

However reliability prediction methods can be useful at design stage to compare different designs in order to choose the design that probably will have the lowest failure rate.

The user can require from the supplier a reliability prediction calculation.

The user may require the manufacturer to predict his reliability figure or meet the user's reliability target.

The method of calculation shall be agreed at the time of tendering between the manufacturer and the user, and shall be in accordance with a recognized standard.

Failure rates used in the calculation can be either the failure rate from a supplier database or the failure rate from a well-known reliability handbook.

The supplier shall provide to the user a reference mission profile and the information needed to understand and to verify calculations.

The following list is an example of a reference mission profile:

- i) environment: ground mobile;
- j) average operating temperature: 45 °C;

NOTE For reliability calculation, the yearly average temperature is conventionally taken as 45 °C for all classes (EN 50125–1).

- k) average operating hours per day: 18 h;
- l) ON/OFF cycles per day: 16;
- m) average operating days per year: 350 d;

n) stress derating design rules applied to the component types (see Annex F).

Reliability prediction results are never directly comparable with actual failure rates and cannot be used to predict field failure rates.

6.1.2 Proof of reliability

The user may require the supplier to reach a target level for field reliability.

Demonstrations which are required to establish whether one or more reliability characteristic of the equipment is better, or not, than a specified level, with some stated degree of confidence are conducted on a sample of the series of a given system or type of equipment.

The pass/fail criteria for statistical tests are generally known as plans. Two styles of plans can be applied:

- fixed time/failure test;
- sequential test.

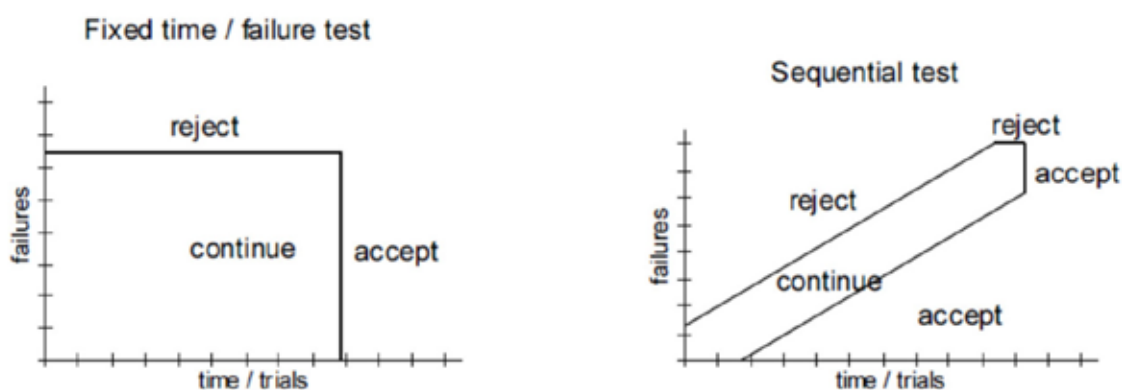


Figure 4 — Styles of Test Plans

The Reliability Demonstration Plan shall be agreed between supplier and user.

The Reliability Demonstration Plan shall specify the following:

- a) the reference mission profile;
- b) the target reliability and availability;
- c) monitoring and recording criteria;
- d) acceptance-rejection criteria;
- e) the maximum duration time;
- f) the cumulative test duration;
- g) numerosity of the specimen;
- h) specimen insertion/cancellation criteria;
- i) failure analysis criteria.