

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Railway applications - DC surge arresters and voltage limiting devices -
Part 2: Voltage limiting devices**

**Applications ferroviaires - Parafoudres et appareils limiteurs de tension pour
réseaux à courant continu -
Partie 2: Appareils limiteurs de tension**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**RAILWAY APPLICATIONS –
DC SURGE ARRESTERS AND VOLTAGE LIMITING DEVICES –**
Part 2: Voltage limiting devices

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This document is based on EN 50526-2:2014.

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

| | |
|-------------|------------------|
| FDIS | Report on voting |
| 9/2492/FDIS | 9/2503/RVD |

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

A list of all parts in the IEC 62848 series, published under the general title *Railway applications – DC surge arresters and voltage limiting devices*, can be found on the IEC website.

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

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RAILWAY APPLICATIONS – DC SURGE ARRESTERS AND VOLTAGE LIMITING DEVICES –

Part 2: Voltage limiting devices

1 Scope

This document applies to Voltage Limiting Devices (VLDs) to be applied in DC traction systems in order to comply with protective provisions against electric shock from DC, and combined AC – DC voltages, in accordance with the IEC 62128 series, taking into account stray current provisions.

VLDs operate in such a way as to connect the track return circuit of DC railway systems to the earthing system or to conductive parts within the overhead contact line zone or current collector zone.

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 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

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

IEC 60850:2014, *Railway applications – Supply voltages of traction systems*

IEC 61643-311, *Components for low-voltage surge protective devices – Part 311: Performance requirements and test circuits for gas discharge tubes (GDT)*

IEC 61992-1:2006, *Railway applications – Fixed installations – DC switchgear – Part 1: General*
IEC 61992-1:2006/AMD1:2014

IEC 61992-7:2006 (all parts), *Railway applications – Fixed installations – DC switchgear – Part 7-x: Measurement, control and protection devices for specific use in d.c. traction systems*

IEC 62128-1:2013, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*

IEC 62128-3:2013, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 3: Mutual Interaction of a.c. and d.c. traction systems*

IEC 62497-1, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

IEC 62498-2, *Railway applications – Environmental conditions for equipment – Part 2: Fixed electrical installations*

IEC 62848-1:2016, *Railway applications – DC surge arresters and voltage limiting devices – Part 1: Metal-oxide surge arresters without gaps*

ISO 4287:1997, *Geometrical Product Specifications (GPS) -Surface texture: Profile method – Terms, definitions and surface texture parameters*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

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 voltage-limiting device VLD

protective device whose function is to prevent existence of an impermissible high touch voltage

[SOURCE: IEC 60050-811:2017, 811-29-41]

3.2 recoverable VLD

VLD that recovers after triggering

3.3 non-recoverable VLD

VLD remaining in its low resistance state permanently after triggering

3.4 welding shut spark gap

VLD which is triggered by electrical discharge across a gap causing a permanent short-circuit by welding shut of metallic parts

Note 1 to entry: Sometimes the term voltage fuse is used for this type of VLD.

3.5 rated current

I_r

<for a voltage-limiting device> maximum value of the direct current that may flow for the specified long term through the VLD in specified environmental conditions without exceeding the temperature rise limits

3.6 short time withstand current

I_W

current that a VLD can carry in closed status, during a specified short time under prescribed conditions of use and behaviour

3.7 making capacity

I_{NSS}

<of a switching device or a fuse> value of prospective making current that a switching device is capable of making at a stated voltage under prescribed conditions of use and behaviour

Note 1 to entry: The conditions to be prescribed are dealt with in the relevant specifications.

[SOURCE: IEC 60050-441:1984, 441-17-09, modified – The beginning of the Note has been changed.]

3.8 breaking capacity

<of a voltage-limiting device> maximum current that a recoverable VLD can interrupt at a stated voltage

3.9 leakage current

I_L

<of a voltage-limiting device> current which flows through the terminals when the VLD is in open status

3.10 lightning current impulse

I_{imp-n}

8/20 μ s current impulse with limits on the adjustment of equipment such that the measured values are from 7 μ s to 9 μ s for the virtual front time and from 18 μ s to 22 μ s for the time to half value on the tail

Note 1 to entry: The time to half-value on the tail is not critical and may have any tolerance during the residual voltage type tests.

[SOURCE: IEC 60099-4:2014, 3.31]

3.11 high current impulse

$I_{imp-high}$

peak value of discharge current having a 4/10 μ s or 8/20 μ s impulse shape which is used to test the ability of the VLD to withstand direct lightning strikes from the dielectric point of view

3.12 high charge impulse

I_{imp-hc}

crest value of a high charge impulse through the VLD with specified charge transfer Q and specified energy W/R in the specified time

Note 1 to entry: A crest value of a high charge impulse having a 10/350 μ s waveshape is also a commonly known expression.

3.13 triggering voltage

U_T

voltage at which a VLD becomes conductive

**3.14
nominal triggering voltage** U_{Tn}

voltage at which the VLD becomes conductive when a DC voltage is applied for long term

Note 1 to entry: This voltage is used to identify the VLD.

**3.15
instantaneous triggering voltage** U_{Ti}

minimum triggering voltage at which the VLD becomes conductive shortly after its application

Note 1 to entry: A maximum delay of 5 ms is taken in this document.

**3.16
non-triggering voltage** U_W

maximum voltage below which the VLD will not trigger for any duration of the applied voltage

**3.17
residual voltage of a VLD** U_{res}

<of a voltage-limiting device> value of voltage that appears between the terminals of the VLD during the passage of a specified current

**3.18
combined voltage**

voltage having significant AC and DC components

**3.19
response time** T_R

<of a voltage-limiting device> time between the application of a voltage until VLD becomes conductive

**3.20
degree of protection**

extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water and verified by standardized test methods

[SOURCE: IEC 60529:1989, 3.3]

**3.21
IP Code**

coding system to indicate the degree of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give an additional information in connection with such protection

[SOURCE: IEC 60529:1989, 3.4]

4 Classes of VLD

This document identifies the properties and the technology of a VLD using the classes of VLD which are defined in Table 1.

Table 1 – Classes of voltage-limiting device

| Class | Method for switching between the high and low resistance status | Auxiliary power supply necessary for normal operation | Polarity | Maximum response time T_R | Recoverable or not | Able to interrupt the current in the VLD |
|---|---|---|----------------|--|--|---|
| 1 | Welding shut of metallic parts | No | Bidirectional | 5 ms | Can be recoverable in some conditions ^a | No |
| 2.1 | Triggering of thyristors | No | Unidirectional | 5 ms (for voltages equal to or higher than U_{TI}) | Yes | Passive at natural zero crossing of current |
| 2.2 | Triggering of thyristors | No | Bidirectional | 5 ms (for voltages equal to or higher than U_{TI}) | Yes | Passive at natural zero crossing of current |
| 3.1 | Contactor only | Yes | Bidirectional | Voltage dependent and not exceeding the limits given in IEC 62128-1:2013, 9.3.2.2 or IEC 62128-3:2013, 7.2 through 7.5 | Yes | Yes |
| 3.2 | Contactor only | Yes | Bidirectional | Voltage dependent and not exceeding the limits given in IEC 62128-1:2013, 9.3.2.3, IEC 62128-3:2013, 7.6 | Yes | Yes |
| 3.3 | Contactor only | Yes | Bidirectional | Specified by the manufacturer or the purchaser | Yes | Yes |
| 4.1 | Combination of thyristors and contactor | Yes | Bidirectional | For voltages up to U_{TI} , voltage dependent and not exceeding the limits given in IEC 62128-1:2013, 9.3.2.2 or IEC 62128-3:2013, 7.2 through 7.5. For voltages equal to or higher than U_{TI} , 5 ms. | Yes | Yes |
| 4.2 | Combination of thyristors and contactor | Yes | Bidirectional | For voltages up to U_{TI} , voltage dependent and not exceeding the limits given in IEC 62128-1:2013, 9.3.2.3, IEC 62128-3:2013, 7.6. For voltages equal to or higher than U_{TI} , 5 ms | Yes | Yes |
| 4.3 | Combination of thyristors and contactor | Yes | Bidirectional | Specified by the manufacturer or the purchaser | Yes | Yes |
| NOTE IEC 62128-1 defines two functionalities for VLDs, VLD-O and VLD-F. In this document a discrimination is not necessary. | | | | | | |
| ^a For transient low currents associated with low energy dissipation no welding shut may occur. | | | | | | |

5 Characteristics and requirements of the VLDs

5.1 Marking

VLDs shall be identified by the following minimum information which shall appear on the rating plate (nameplate):

- manufacturer's name or trademark and manufacture type designation;

- class of VLD according to IEC 62848-2 (optional);
- rated current I_r in A;
- short time withstand current I_w in kA;
- nominal triggering voltage U_{TN} ;
- year of manufacture;
- serial number.

The terminals of unidirectional devices shall be marked with the symbols + and -.

In case of small VLDs not having space for a rating plate with all information, the devices shall be marked with the manufacturer's name or trademark, the type designation and the nominal triggering voltage. The remaining information shall be given in a data-sheet.

5.2 Service requirements

5.2.1 Normal outdoor service conditions

VLDs which conform to this document shall be suitable for operation under the following normal service conditions:

- ambient temperature within the range of -40 °C to +40 °C;
- solar radiation lower than 1 120 W/m² as given in IEC 62498-2;
- altitude not exceeding 1 400 m (from Annex B in IEC 61992-1:2006);
- any pollution not exceeding PD 4 as given in IEC 62497-1.

The equipment shall be suitable for installation in the vicinity of a rail track on foundations designed so as to damp the main effects of the passage of the trains. Nevertheless, a limited vibration or limited shocks may affect the equipment, which shall be capable of operating satisfactorily when subjected to the following conventional accelerations separately applied:

- g_v : vertical acceleration: 5 m/s²;
- g_h : horizontal acceleration: 5 m/s².

5.2.2 Normal indoor service conditions

VLDs which conform to this document shall be suitable for operation under the following normal service conditions:

- ambient temperature within the range of -5 °C to +40 °C (from Annex B in IEC 61992-1:2006);
- altitude not exceeding 1 400 m (from Annex B in IEC 61992-1:2006);
- any pollution not exceeding PD3 as given in IEC 62497-1.

5.2.3 Abnormal service conditions

The following are examples of abnormal service conditions which require special consideration in the manufacture or application of VLD and should be brought to the attention of the supplier:

- temperature in excess of +40 °C or below -5 °C for indoor installations or below -40 °C for outdoor installations;
- application at altitudes higher than 1 400 m; in this case the temperature-rise tests and dielectric tests (for VLDs inside a cabinet), carried out at laboratories at lower levels, shall take into account a correction in the temperature-rises and dielectric test values to be agreed between the involved parties;

- all excessive environmental conditions that may degrade insulating surface or mounting hardware: fumes, vapours dirt, salt spray or other conducting materials; moisture, humidity, dropping water or steam;
- explosive mixtures of dust, gases or fumes;
- special mechanical requirements (earthquakes, vibrations, high ice loads, high cantilever stresses);
- unusual transportation or storage;
- heat sources near the VLD.

5.3 General characteristics

The following characteristics shall be defined to identify each VLD:

- the class of VLD;
- if relevant, the auxiliary power supply voltage, with its tolerances.

The manufacturer shall specify whether the device is recoverable or non-recoverable at defined currents and durations.

5.4 Minimum requirements

5.4.1 Response time

A VLD shall become conductive in a time not greater than the specified response time depending on the applied voltage. The response time of the VLD shall be stated as function of the applied voltage.

For VLDs of Classes 2, 3 and 4 the triggering may be delayed intentionally in order that unwanted triggering will not take place due to switching transients and similar phenomena.

5.4.2 Additional requirements for VLDs of Class 1

If gas discharge tubes are used in VLDs, they shall comply with IEC 61643-311.

5.4.3 Additional requirements for VLDs of Classes 3 and 4

The VLD shall not open if the current through it exceeds its breaking capacity.

The VLD shall open at an adjustable time after it has closed unless the breaking capacity is exceeded. The range of variation of this time setting shall be specified.

If the VLD re-opens automatically and then re-triggers, after a set number of operations in a given time interval either:

- it shall be prevented from re-opening and a warning or an alarm shall be signalled; or
- only a warning or an alarm shall be signalled.

The VLD shall provide the possibility to be manually operated at site.

If the VLD requires a power supply for operation, the VLD shall be provided with a failsafe function such that it turns into the conductive state in case of failure of the power supply.

5.5 Electrical characteristics and thermal rating

In addition to the general characteristics indicated in 5.3, the manufacturer shall state the following electrical characteristics of each type of VLD if applicable. In case of adjustable parameters, the setting ranges shall be stated:

- for VLDs of Classes 3 and 4, the nominal voltages of the electric traction systems in which the VLDs are to be installed;
- the nominal triggering voltage U_{Tn} ;
- the non-triggering voltage U_W ;
- the maximum response time as function of the voltage;
- the instantaneous triggering voltage U_{Ti} ;
- the maximum leakage current I_L at U_W , when the VLD is in its non-conducting state;
- the short-time withstand current I_W and the duration of the current flow;
- the rated current I_r ;
- the maximum residual voltage at the short-time withstand current;
- the maximum residual voltage at the rated current;
- the conditions in which the VLD is recoverable;
- the lightning current impulse, or sequence of lightning impulses, which the VLD can withstand in the specified test conditions;
- for VLDs of Classes 3 and 4, the breaking capacity, determined in accordance with 6.8;
- for VLDs of Classes 3 and 4, the making capacity, in accordance with 6.4.3.

5.6 Protection of VLDs against lightning

If requested by the purchaser the VLD shall withstand the effects of the specified lightning surges. The requirements can be different according to the class of VLD. If necessary a surge arrester, according to IEC 62848-1, may be integrated into the VLD.

5.7 Command and control (Classes 3 and 4 only)

5.7.1 Local control

On the cabinet, the following characteristics and measuring indications should be foreseen to provide a monitoring and control locally:

- a) the instantaneous DC voltage across the terminals of the VLD;
- b) the instantaneous DC current flowing through the device;
- c) the operating state of the VLD (open or closed);
- d) a push or touch button to manually command the closing and the opening of the device;
- e) a push or touch button to start a manual self-test (if possible);
- f) access to recorded data as given in 5.7.3, the activations, warnings, alarms, etc., in the past and stored in a register file (if applicable).

NOTE 1 Conventionally the voltage in item a) is the voltage on the rails relative to earth. This means that if the rail potential is positive the figure displayed is positive.

NOTE 2 The manual self-test procedure in item e) will trigger the thyristor and will also close the contactor for a limited time (typically 1 s).

5.7.2 Remote signalling

If remote signalling is requested at least the following signals shall be offered:

- a) contactor open;
- b) contactor closed;
- c) warnings, alarms.

Further information may be agreed between purchaser and manufacturer such as current or voltage.

5.7.3 Operation and alarm recordings

Recordings are optional. A list of the recordings that can be stored is indicated as an example in the following:

- a) operation recordings:
 - 1) the status of the VLD;
 - 2) the total number of operations (1 operation = 1 x close + 1 x open);
- b) alarm recordings with time stamp:
 - 1) interruption of the auxiliary power supply of the device;
 - 2) device in closed position state during a long period of time, eventually parameterised in 2 or more levels;
 - 3) internal operation faults: an internal self-diagnostic function controls the correct functioning of closing and opening the device; in case of an internal fault, an alarm is created;
 - 4) the exceeding of a given frequency of operations, eventually parameterised in 2 or more levels.

6 Type tests

6.1 General

The characteristics of the VLD shall be verified by type tests.

Type tests shall be carried out as indicated in Table 2. All tests are mandatory unless stated otherwise.

Once made, these type tests need not be repeated unless the design is changed so as to modify the VLD performance. In such a case only the relevant tests need be repeated.

For all the tests the ambient temperature shall be recorded.

An alternating current test is foreseen, if requested, because even if the VLD is not specified to conduct AC, the wave-form of the current in the VLD can flow in both directions due to ripple currents from the substations, tripping of the feeders during short-circuits or earth faults in the DC power system, transient effects due to switching of the current by the trains, regenerative braking currents of the trains or AC currents injected by AC power systems.