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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock equipment – Capacitors for power electronics –
Part 3: Electric double-layer capacitors

Applications ferroviaires – Matériel roulant – Condensateurs pour électronique de puissance –
Partie 3: Condensateurs électriques à double couche

IEC 61881-3:2012

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FOREWORD

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International Standard IEC 61881-3 has been prepared by subcommittee 9: Electrical equipment and systems for railways.

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

FDIS	Report on voting
9/1680/FDIS	9/1708/RVD

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

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

A list of all parts of IEC 61881 series, under the general title *Railway applications – Rolling stock equipment – Capacitors for power electronics*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

RAILWAY APPLICATIONS – ROLLING STOCK EQUIPMENT – CAPACITORS FOR POWER ELECTRONICS –

Part 3: Electric double-layer capacitors

1 Scope

This part of IEC 61881 applies to d.c. electric double-layer capacitors (cell, module and bank) for power electronics intended to be used on rolling stock.

This standard specifies quality requirements and tests, safety requirements, and describes installation and operation information.

NOTE Example of the application for capacitors specified in this Standard; d.c. energy storage, etc.

Capacitors not covered by this Standard:

– IEC 61881-1: Paper/plastic film capacitors;

– IEC 61881-2: Aluminium electrolytic capacitors with non-solid electrolyte.

Guidance for installation and operation is given in Clause 9.

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.

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*
and Amendment 1:1992

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-17:1994, *Environmental testing – Part 2-17: Tests. Test Q: Sealing*

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60571:1998, *Electronic equipment used on rail vehicles*
and Amendment 1:2006

IEC 60721-3-5, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 5: Ground vehicle installations*

IEC 61373:2010, *Railway applications – Rolling stock equipment – Shock and vibration tests*

IEC 62236-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

IEC 62391-1:2006, *Fixed electric double-layer capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 62391-2:2006, *Fixed electric double-layer capacitors for use in electronic equipment – Part 2: Sectional specification – Electric double-layer capacitors for power application*

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

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

IEC 62576:2009, *Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics*

3 Terms and definitions

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

3.1
capacitor element
indivisible part of a capacitor consisting of two electrodes (typically made of carbon) separated by an electrolyte impregnated separator

Note 1 to entry: In the literature this type of capacitor element is often called EDLC (Electric double layer capacitor) element. An electric double-layer capacitor element utilizes the ability to accumulate electric charge in an electric double layer which is formed at the boundary surface between an electrode material (electronic conductor) and an electrolyte. This capacitor is essentially designed for operation with direct current voltage.

3.2
capacitor cell
one or more capacitor elements, packaged in the same enclosure with terminals brought out

SEE: Annex A

3.3
capacitor module
assembly of two or more capacitor cells, electrically connected to each other with or without additional electronics

SEE: Annex A

3.4
capacitor bank
assembly of two or more capacitor modules

SEE: Annex A

3.5
capacitor
general term used when it is not necessary to state whether a reference is made to capacitor cell, module or bank

[SOURCE: IEC 61881-1:2010, 3, modified]

3.6
capacitor equipment
assembly of capacitor banks and their accessories intended for connection to a network

SEE: Annex A

3.7
capacitor for power electronics
capacitor intended to be used in power electronic equipment and capable of operating continuously under sinusoidal and non-sinusoidal current and voltage

Note 1 to entry: Capacitor in this standard is d.c. capacitor.

3.8
pressure relief structure
mechanism to release internal pressure of capacitor cell when exceeding specified value

3.9
discharge device
device capable of reducing the voltage between the terminals practically to zero, within a given time, after the capacitor has been disconnected from a network

3.10
rated voltage (d.c.) (U_R)
maximum d.c. voltage which may be applied continuously to a capacitor at any temperature between the lower category temperature and the upper category temperature

[SOURCE: IEC 60384-1:2008, 2.2.16, modified]

Note 1 to entry: In typical traction application, the maximum voltage is the sum of the d.c. voltage and peak a.c. voltage or peak pulse voltage applied to the capacitor.

3.11
insulation voltage (U_i)
r.m.s. value of the sine wave voltage designed for the insulation between terminals of capacitors to case or earth. If not specified, r.m.s. value of the insulating voltage is equivalent to the rated voltage divided by √2

3.12
maximum peak current (I_P)
maximum peak current that can occur during continuous operation

3.13
rated current (I_R)
r.m.s. value of the maximum allowable current at which the capacitor may be operated continuously at a specified temperature

Note 1 to entry: The cooling conditions of the module should be defined by the manufacturer.

3.14
maximum surge current (I_S)
peak non-repetitive current induced by switching or any other disturbance of the system which is allowed for a limited number of times

3.15
operating temperature
temperature of the hottest point on the case of the capacitor when in steady-state conditions of temperature

SEE: 3.22

3.16
ambient temperature
temperature of the air surrounding the non-heat dissipating capacitor or temperature of the air in free air conditions at such a distance from the heat dissipating capacitor that the effect of the dissipation is negligible

3.17
upper category temperature
highest ambient temperature including internal heating in which a capacitor is designed to operate continuously

Note 1 to entry: Depending on the application the upper category temperature can be different. For traction energy storage application the continuous operation is based on the rated current, for other applications like board net stabilising it is based on the rated voltage.

3.18
lower category temperature
lowest ambient temperature including internal heating in which a capacitor is designed to operate continuously

Note 1 to entry: Depending on the application the lower category temperature can be different. For traction energy storage application the continuous operation is based on the rated current, for other applications like board net stabilising it is based on the rated voltage.

3.19
case temperature rise (ΔT_{case})
difference between the temperature of the hottest point of the case and the temperature of the cooling air under the steady-state conditions of temperature

3.20
cooling air temperature (T_{amb})
temperature of the cooling air measured at the inlet, under the steady-state conditions of temperature

3.21
maximum operating temperature (T_{max})
highest temperature of the case at which the capacitor may be operated

Note 1 to entry: The operating temperature is different from upper category temperature.

3.22
steady-state conditions of temperature
thermal equilibrium attained by the capacitor at constant output and at constant coolant temperature

3.23
internal resistance (R_S)
d.c resistance causing losses in a capacitor due to termination jointing, electrolyte, electrodes, etc.

4 Service conditions

NOTE See IEC 60077-1.

4.1 Normal service conditions

4.1.1 General

This standard gives requirements for capacitors intended for use in the following conditions:

4.1.2 Altitude

Not exceeding 1 400 m. See IEC 62498-1.

NOTE The effect of altitude on cooling air characteristics and insulation clearance should be taken into consideration, if the altitude exceeds 1 400 m.

4.1.3 Temperature

The climatic ambient temperatures are derived from IEC 60721-3-5 class 5k2 which has a range from –25 °C to 40 °C. Where ambient temperature lies outside this range, it shall be as agreed between the purchaser and the manufacturer.

NOTE Classes of temperature are listed in IEC 62498-1:2010, Table 2.

4.2 Unusual service conditions

This standard does not apply to capacitors, whose service conditions are such as to be in general incompatible with its requirements, unless otherwise agreed between the manufacturer and the purchaser.

Unusual service conditions require additional measurements, which ensure that the conditions of this standard are complied with even under these unusual service conditions.

If such unusual service conditions exist then they shall be notified to the manufacturer of the capacitor.

Unusual service conditions can include:

– unusual mechanical shocks and vibrations;
– corrosive and abrasive particles in the cooling air;
– dust in the cooling air, particularly if conductive;
– explosive dust or gas;
– oil or water vapour or corrosive substances;
– nuclear radiation;
– unusual storage or transport temperature;
– unusual humidity (tropical or subtropical region);
– excessive and rapid changes of temperature (more than 5 K/h) or of humidity (more than 5 %/h);
– service areas higher than 1 400 m above sea level;
– superimposed electromagnetic fields;
– excessive over voltages, as far as they exceed the limits given in Clause 6 and 9.4;
– airtight (poor change of air) installations.

5 Quality requirements and tests

5.1 Test requirements

5.1.1 General

This subclause gives the tests and requirements for capacitors.

5.1.2 Test conditions

Unless otherwise specified, the test conditions for capacitors shall be as in IEC 60068-1:1988, 5.3.

NOTE IEC 60068-1:1988, 5.3 specifies the following standard atmospheric conditions for measurements and tests.

Temperature: 15 °C to 35 °C

Relative humidity: 25 % to 75 %

Air pressure: 86 kPa to 106 kPa

5.1.3 Measurement conditions

The measurement conditions (i.e. capacitance, internal resistance, leakage current, etc.) for the capacitor shall be as in IEC 60068-1:1988, 5.3 with following exception.

The temperature shall be 25 °C ± 2 °C.

5.1.4 Voltage treatment

The capacitor shall be charged up to U_R and be held for 30 min by means of a d.c. source. Then the capacitor shall be discharged through a suitable discharge device.

5.1.5 Thermal treatment

The capacitor shall be placed in the environment at the temperature defined in 5.1.3 for a suitable soak period for thermal equalization.

5.2 Classification of tests

5.2.1 General

The tests are classified as type tests, routine tests, and acceptance tests.

The type tests and the routine tests consist of the tests shown in Table 1.

Table 1 – Classification of tests

No.	Tests Item	Type tests		Routine tests	
		Cell	Module or bank	Cell	Module or bank
1A	Capacitance	5.3	5.3	5.3	5.3
1B	Internal resistance	5.3	5.3	5.3	5.3
2A	Leakage current	5.4.1	—	—	—
2B	Self-discharge	5.4.2 [a]	5.4.2	—	—
3	Insulation test between terminals and case	5.5.1.1 [a] (if applicable and required)	5.5.2.1	5.5.1.2 [a] (if applicable)	5.5.2.2
4	Sealing test	5.6	—	—	—
5	Surge discharge test	5.7	5.7	—	—
6	Change of temperature	5.8.1	5.8.1	—	—
7	Damp heat, steady state	5.8.2 (if applicable)	5.8.2 (module only)	—	—
8	Mechanical tests of terminals	5.9.1 [a]	5.9.1 (if applicable)	—	—
9	External inspection	5.9.2	5.9.2	5.9.2	5.9.2
10	Vibration and shocks	5.9.3	5.9.3	—	—
11	Endurance test	5.10	—	—	—
12	Endurance cycling test	5.11	5.11 [b]	—	—
13	Pressure relief test	5.12	—	—	—

No.	Tests Item	Type tests		Routine tests	
		Cell	Module or bank	Cell	Module or bank
14	Passive flammability	5.13	—	—	—
15	EMC test	—	5.14	—	—

[a] This test may be substituted by capacitor module or bank test, when agreed between the manufacturer and the purchaser.

[b] This test may be substituted by capacitor cell test, when agreed between the manufacturer and the purchaser.

5.2.2 Type tests

Type tests are intended to prove the soundness and safety of the design of the capacitor and its suitability for operation under the conditions detailed in this standard.

The type tests shall be carried out by the manufacturer, and the purchaser shall, on request, be supplied with a certificate, detailing the results of such tests.

These tests shall be made upon capacitors which are designed identical to that of the capacitors defined in the contract.

In agreement between the manufacturer and the purchaser, a capacitor of a similar design can be used, when the same or more severe test conditions can be applied.

It is not essential that all type tests be carried out on the same capacitor sample. The choice is left to the manufacturer.

5.2.3 Routine tests

The test sequence for quality requirements shall be as follows.

Routine tests shall be carried out by the manufacturer on every capacitor before delivery. Upon request, the manufacturer shall deliver the capacitor with a certification detailing the results of the tests.

5.2.4 Acceptance tests

All or a part of the type tests and the routine tests may be carried out by the manufacturer, on agreement with the purchaser.

The number of samples that may be subjected to such repeat tests, the acceptance criteria, as well as permission to deliver any of these capacitors shall be subject to the agreement between the manufacturer and the purchaser, and shall be stated in the contract.

5.3 Capacitance and internal resistance

5.3.1 Measurement procedure for capacitance and internal resistance

The capacitance and internal resistance of the capacitor shall be measured in accordance with IEC 62576:2009, 4.1.1 through 4.1.4 with following exceptions.

a) Unless otherwise specified, the capacitor preconditioning shall be carried out according to 5.1.4 and 5.1.5.

b) Unless otherwise specified, measurement temperature shall be 25 °C ± 2 °C (see 5.1.3).

c) Measuring for the voltage drop characteristics: down to 0,3 U_R.

The voltage–time characteristics between capacitor terminals during capacitance and internal resistance measurement, is shown in Figure 1.