IEC 61881-2

Edition 1.0 2012-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock equipment – Capacitors for power electronics –
Part 2: Aluminium electrolytic capacitors with non-solid electrolyte

Applications ferroviaires – Matériel roulant – Condensateurs pour électronique de puissance –
Partie 2: Condensateurs électrolytiques à l'aluminium, à électrolyte non solide

IEC 61881-2:2012

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX U

ICS 45.060

ISBN 978-2-83220-259-3

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 2: Aluminium electrolytic capacitors with non-solid electrolyte

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International Standard IEC 61881-2 has been prepared by technical committee 9: Electrical equipment and systems for railways.

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

FDIS	Report on voting
9/1679/FDIS	9/1707/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- withdrawn,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 2: Aluminium electrolytic capacitors with non-solid electrolyte

1 Scope

This part of IEC 61881 applies to d.c. aluminium electrolytic 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. filtering, etc.

Capacitors not covered by this Standard:

– IEC 61881-1: Paper/plastic film capacitors;
– IEC 61881-3: Electric double-layer capacitors.

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 60062:2004, *Marking codes for resistors and capacitors*

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 60068-2-21:2006, *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 60384-1:2008, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 60384-4:2007, *Fixed capacitors for use in electronic equipment – Part 4: Sectional specification – Aluminium electrolytic capacitors with solid (MnO_2) and non-solid electrolyte*

IEC 60721-3-5:1997, *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 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*

3 Terms and definitions

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

3.1
capacitor element
indivisible electrolytic capacitor with non-solid electrolyte

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 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
aluminium electrolytic capacitor with non-solid electrolyte
capacitor consisting of oxide film formed on the surface of aluminium foil by anodic oxidation as dielectric and paper or fibber impregnated with liquid electrolyte in close contact with the dielectric as a part of the cathode

3.9
pressure relief structure
mechanism to release internal pressure of capacitor when exceeding the specified value

3.10
discharge device
device which can reduce the voltage between the terminals practically to zero, within a given time, after the capacitor has been disconnected from a network

3.11
rated d.c. voltage (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.

3.12
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

3.13
maximum peak current (I_P)
maximum peak current that can occur during continuous operation

3.14
rated ripple current (I_{ripple})
the r.m.s value of the maximum allowable alternating current of a specified frequency, at which the capacitor may be operated continuously at a specified temperature

3.15
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

Note 1 to entry: See surge voltage in IEC 60384-4:2007, 4.14.

3.16
operating temperature
temperature of the hottest point on the case of the capacitor when in steady-state conditions of temperature

SEE: 3.22

3.17
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

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

3.19
lower category temperature
lowest ambient temperature including internal heating in which a capacitor is designed to operate continuously

3.20
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

3.21
cooling-air temperature (T_{amb})
temperature of the cooling air measured at the inlet, under the steady-state condition of temperature

3.22
maximum operating temperature (T_{max})
highest temperature of the case at which the capacitor may be operated

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

3.23
steady-state conditions of temperature
thermal equilibrium attained by the capacitor at constant output and at constant coolant temperature

3.24
tangent of the loss angle of a capacitor
tan
power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage at a specified frequency

[SOURCE: IEC 60384-1:2008, 2.2.24]

$$\tan\delta = \frac{R_{esr}}{\frac{1}{\omega C}} = \frac{R_{esr}}{\frac{1}{2\pi f C}} = 2\pi f C \times R_{esr}$$

where R_{esr} is the equivalent series resistance;
ω is the angular frequency ($2\times\pi\times f$);
C is the capacitance.

3.25
equivalent series resistance of a capacitor (R_{esr})
effective resistance which, if connected in series with an ideal capacitor of capacitance value equal to that of the capacitor in question, would have a power loss equal to active power dissipated in that capacitor under specified operating conditions

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 60721-3-5:1997 class 5k2 which has a range from –25 °C to 40 °C. Where ambient temperature lies outside this range, it shall be 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 in 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 test requirements for capacitors.

5.1.2 Test conditions

Unless otherwise specified, the test conditions shall be as in IEC 60384-1:2008, 4.2.1.

NOTE IEC 60384-1:2008, 4.2.1 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, tangent of loss angle and leakage current, etc.) for the capacitor shall be as in IEC 60384-4:2007, 4.2.3 with the following exceptions.

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

Relative humidity shall be 25 % to 75 %.

5.1.4 Voltage treatment

The capacitor shall be subjected to voltage treatment as specified in IEC 60384-4:2007, 4.1. 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 of 5.1.3 for a suitable soak period for thermal equalization.

NOTE Leave time of capacitor to reach measuring condition may be generally 1 h to 4 h for capacitor cell and 4 h to 24 h for capacitor module and bank.

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 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	Tangent of loss angle	5.3	5.3	5.3	5.3
2	Leakage current	5.4	5.4	5.4	5.4
3	Insulation test between terminals and case	5.5.1[a] (if applicable and required)	5.5.2	5.5.1 [a] (if applicable)	5.5.2
4	Sealing test	5.6	—	—	—
5	Surge discharge test	5.7	5.7 (if applicable)	—	—
6	Change of temperature	5.8.1	5.8.1	—	—
7	Damp heat, steady state	5.8.2 (if applicable)	5.8.2[b] (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	Pressure relief test	5.11.1 (if applicable)	—	—	—
13	Passive flammability	5.12	—	—	—

[a] This test may be substituted by 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 capacitor 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 tests 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 certification detailing the results of the tests.