IEC 61881-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock equipment – Capacitors for power electronics –
Part 1: Paper/plastic film capacitors

Applications ferroviaires – Matériel roulant – Condensateurs pour électronique de puissance –
Partie 1: Condensateurs papier et film plastique

IEC 61881-1:2010

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

Part 1: Paper/plastic film capacitors

FOREWORD

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International Standard IEC 61881-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

IEC 61881-1 cancels and replaces IEC 61881 (1999).

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

FDIS	Report on voting
9/1405/FDIS	9/1454/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.

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- withdrawn,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 1: Paper/plastic film capacitors

1 Scope

This part of IEC 61881 applies to capacitors for power electronics intended to be used on rolling stock.

The rated voltage of capacitors covered by this part is limited to 10 000 V.

The operating frequency of the systems in which these capacitors are used is usually up to 15 kHz, while the pulse frequencies may be up to 5 to 10 times the operating frequency.

It distinguishes between AC and DC capacitors.

They are considered as components mounted in enclosures.

NOTE This standard covers an extremely wide range of capacitor technologies for numerous applications: overvoltage protection, DC and AC filtering, switching circuits, DC energy storage, auxiliary inverters, etc.

Examples are given in Clause 9.

The following are excluded from this standard:

– capacitors for induction heat-generating plants operating at frequencies between 40 Hz and 24 000 Hz (see IEC 60110-1 and 60110-2);
– capacitors for motor applications and the like (see IEC 60252-1 and IEC 60252-2);
– capacitors to be used in circuits for blocking one or more harmonics in power supply networks;
– small AC capacitors as used for fluorescent and discharge lamps (see IEC 61048 and IEC 61049);
– capacitors for suppression of radio interference (see IEC 60384-14);
– shunt capacitors for AC power systems having a rated voltage above 1 000 V (see IEC 60871-1 and IEC 60871-2);
– shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1 000 V (see IEC 60831-1 and IEC 60831-2);
– shunt power capacitor of the non self-healing type for AC systems having a rated voltage up to and including 1 000 V (see IEC 60931-1 and IEC 60931-2);
– series capacitors for power systems (see IEC 60143-1, IEC 60143-2 and IEC 60143-3);
– coupling capacitors and capacitors dividers (see IEC 60358);
– capacitors for applications requiring energy storage/high current discharge such as photocopiers and lasers;
– capacitors for microwave ovens;
– capacitors for power electronics (see IEC 61071).

2 Normative references

The following referenced documents are indispensable for the application 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 60068-2-14, *Environmental testing – Part 2-14: Tests. Test N: Change of temperature*

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 60269-1, *Low-voltage fuses – Part 1: General requirements*

IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

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

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

IEC 62491, *Industrial systems, installations and equipment and industrial products – Labelling of cables and cores*

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

3 Terms and definitions

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

3.1
capacitor element (or element)
indivisible part of a capacitor consisting of two electrodes separated by a dielectric

3.2
capacitor unit (or unit)
assembly of one or more capacitor elements in the same case with terminals brought out

3.3
capacitor bank
assembly of two or more capacitor units, electrically connected to each other

3.4
capacitor
general term used when it is not necessary to state whether reference is made to an element, a unit or a capacitor bank

3.5
capacitor equipment
assembly of capacitor units and their accessories intended for connection to a network

3.6
capacitor for power electronics
power capacitor intended to be used in power electronic equipment and capable of operating continuously under sinusoidal and non sinusoidal current and voltage

3.7
metal-foil capacitor (non self-healing)
capacitor in which the electrodes usually consist of metal foils separated by a dielectric, in the event of a breakdown of the dielectric; the capacitor does not restore itself

3.8
self-healing metallized dielectric capacitor
capacitor, the electrodes of which are metallized (usually by evaporation); in the event of dielectric breakdown, the capacitor restores itself

3.9
AC capacitor
capacitor essentially designed for operation with alternating voltage

NOTE AC capacitors may be used with DC voltage up to the rated voltage only when authorized by the capacitor manufacturer.

3.10
DC capacitor
capacitor essentially designed for operation with direct voltage

NOTE DC capacitors may be used with a specified AC voltage only where authorized by the capacitor manufacturer.

3.11
model capacitor
smaller unit which simulates a complete unit or element in an electrical test, without reducing the severity of the electrical, thermal or mechanical conditions

NOTE The combined sum of stresses should always be considered, for instance the sum of temperature, mechanical conditions and electrical stresses.

3.12
internal (element) fuse
device incorporated in the capacitor which disconnects an element or a group of elements in the event of breakdown

3.13
safety devices

3.13.1
overpressure disconnector
disconnecting device inside a capacitor, designed to interrupt the current path in case of capacitor failure

3.13.2
overpressure detector
device designed to detect abnormal increase of the internal pressure by an electrical switch/signal and indirectly interrupt the current path

3.13.3
segmented metallization design
design of the metal layer over the dielectric shaped in a way to allow a small part of it to be isolated in case of local short circuit or breakdown, in order to restore the full functionality of the unit with a negligible loss of capacitance

3.13.4
special unsegmented metallization design
design of the metal layer over the dielectric shaped in a way that safe self-healing features operating at a voltage up to U_s guarantee the full functionality of the unit with a negligible loss of capacitance

3.14
discharge device of a capacitor
a device which may be incorporated in a capacitor, capable of reducing the voltage between the terminals practically to zero, within a given time, after the capacitor has been disconnected from a network

3.15
rated AC voltage (U_N)
maximum operating peak recurrent voltage of either polarity of a reversing type waveform for which the capacitor has been designed

NOTE 1 The waveform can have many shapes. Examples are given in Annex A.

NOTE 2 The mean value of the waveform may be positive or negative.

NOTE 3 It is important to note that the rated AC voltage is not an r.m.s. value.

NOTE 4 Definitions used in this standard can be different from those of IEC 60077-1.

3.16
rated DC voltage (U_{NDC})
maximum operating peak voltage of either polarity but of a non-reversing type waveform, for which the capacitor has been designed, for continuous operation

Damping capacitors, for gate turn-off thyristor (GTO) can be regarded as DC capacitors with a ripple voltage equal to the rated DC voltage $U_{NDC} = U_r$.

In the case of reversal voltage, the use should be agreed between user and manufacturer.

NOTE If the reversal voltage is small (less than 10 %), the voltage waveform can be considered to be not reversing. For test purposes, U_{NDC} and U_r should be increased by U, the reversal voltage.

3.17
ripple voltage (U_r)
peak-to-peak alternating component of the unidirectional voltage

3.18
non-recurrent surge voltage (U_s)
peak voltage induced by a switching or any other disturbance of the system which is allowed for a limited number of times and for durations shorter than the basic period

3.19
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, the r.m.s. value of the insulating voltage is equivalent to the rated voltage divided by $\sqrt{2}$.

3.20
maximum peak current ($\hat{I}$)
maximum peak current that can occur during continuous operation

3.21
maximum current (I_{max})
maximum r.m.s. current for continuous operation

3.22
maximum surge current ($\hat{I}_s$)
peak non-repetitive current induced by switching or any other disturbance of the system which is allowed for a limited number of times, for durations shorter than the basic period

3.23
pulse frequency (f_p)
repetition rate of periodic current pulses

3.24
current pulse width (τ)
time of current flow during charging or discharging from one voltage value to another, of the capacitor

NOTE Pulse current waveform examples are shown in Annex A.

3.25
resonance frequency (f_r)
lowest frequency at which the impedance of the capacitor becomes minimum

3.26
duty cycle

3.26.1
continuous duty
operation time such that a capacitor is at thermal equilibrium for most of the time

3.26.2
intermittent duty

discontinuous working or operation with variable loads which should be described in terms of ON/OFF or HIGH/LOW periods with their durations

3.27
operating temperature
temperature of the hottest point on the case of the capacitor when in thermal equilibrium

3.28
lowest operating temperature (θ_{min})
lowest temperature at which the capacitor may be energized

3.29
case temperature rise ($\Delta\theta_{case}$)
difference between the temperature of the hottest point of the case and the temperature of the cooling air

3.30
cooling-air temperature (θ_{amb})
temperature of the cooling air measured at the hottest position of the capacitor, under steady-state conditions, midway between two units

If only one unit is involved, it is the temperature measured at a point approximately 0,1 m away from the capacitor case and at two-thirds of the height from its base.

3.30.1
outlet fluid temperature for forced-cooled capacitors
temperature of the cooling fluid as it leaves the capacitor, measured at the hottest point

3.30.2
inlet fluid temperature for forced-cooled capacitors
temperature of the cooling fluid measured in the middle of the inlet fluid channel at a point not influenced by the heat dissipation of the capacitor

3.31
maximum operating temperature (θ_{max})
highest temperature of the case at which the capacitor may be operated

3.32
steady-state conditions
thermal equilibrium attained by the capacitor at constant output and at constant cooling-air temperature

3.33
capacitor losses
active power consumed by a capacitor

NOTE Unless otherwise stated, the capacitor losses are understood to include losses in fuses and discharge resistors forming an integral part of the capacitor.

At high frequency, the capacitor losses are predominantly due to losses in connections, contacts and electrodes.

3.34
tangent of the loss angle of a capacitor tan δ
ratio between the equivalent series resistance and the capacitive reactance of a capacitor at a specified sinusoidal alternating voltage, frequency and temperature

$$\tan \delta = R_{esr}\ \omega C = \tan_d + R_s\ \omega C$$

$\tan_d$ = dielectric loss factor

3.35
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

3.36
series resistance R_s
effective ohmic resistance of the conductors of a capacitor under specified operating conditions

3.37
maximum power loss (P_{max})
maximum power loss with which the capacitor may be loaded at the maximum case temperature

3.38
maximum frequency for maximum power loss and maximum current (f_2)
frequency at which the maximum current (I_{max}) produces the maximum power loss (P_{max}) in the capacitor. For explanation of (f_2) see Annex B.

4 Service conditions

NOTE See IEC 60077-1.

4.1 Normal service conditions

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

4.1.1 Altitude

Not exceeding 1 400 m (IEC 62491 class A1).

NOTE The effect of altitude on convection cooling and external insulation should be taken into consideration, if the altitude exceeds 1400 m. In this case the derating or a proper design shall be agreed between manufacturer and user

4.1.2 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 agreed between the user and the manufacturer.

The upper limit of case temperature θ_{max} at which the capacitor may be operated, shall be chosen among the values 55 °C, 70 °C and 85 °C.

4.1.3 Operating temperature with forced ventilation

If capacitors are intended for forced cooling with a fluid medium, the operating temperature conditions specified in 4.1.2 shall be observed.

The following Table 1 of preferred temperatures of cooling fluid shall be applied.

Table 1 – Maximum temperature of cooling medium for unlimited time

Inlet temperature °C	Outlet temperature °C
35	40
45	50
55	60

The lowest inlet temperature for the cooling fluid may be –25 °C.

There are two methods of specifying the upper temperature limit of the cooling medium using either the inlet temperature or the outlet temperature.

Unless otherwise agreed, the choice of method shall be left to the capacitor manufacturer.

For the inlet method, the flow of cooling medium shall be specified.

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 user.