PD IEC TS 63337:2024

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Basic qualification of DC-link film capacitors for automotive use — General requirements, test conditions and tests

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Basic qualification of DC-link film capacitors for automotive use – General requirements, test conditions and tests

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BASIC QUALIFICATION OF DC-LINK FILM CAPACITORS FOR AUTOMOTIVE USE – GENERAL REQUIREMENTS, TEST CONDITIONS AND TESTS

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IEC TS 63337 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
40/3093/DTS	40/3117/RVDTS

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

The language used for the development of this Technical Specification is English.

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This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn, or
- revised.

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INTRODUCTION

This Technical Specification is based on a publication of the "ZVEI/ECPE Film Capacitors Core Group" working group with representatives from vehicle, device and capacitor manufacturers. It is adopted to the electrical specifications valid for electrically propelled vehicles – voltage class B systems, as given in ISO 21498-1.

Because AEC-Q200 is not applicable for the capacitors considered here, this document defines a set of tests to ensure the basic suitability of the capacitor for application as a DC-link capacitor in HV applications or in the intermediate circuit of the 48 V on-board electrical system.

This Technical Specification makes no claim to completeness. Automotive manufacturers and device manufacturers are free to request additional state-of-the-art tests at any time. It is also important to understand that a basic qualification as described in this document cannot replace a comprehensive technology qualification being performed in advance of product development.

As the individual manufacturers can make changes, only the company standards of the respective manufacturers created on the basis of this Technical Specification apply.

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BASIC QUALIFICATION OF DC-LINK FILM CAPACITORS FOR AUTOMOTIVE USE – GENERAL REQUIREMENTS, TEST CONDITIONS AND TESTS

1 Scope

This document provides requirements, test conditions and tests to validate characteristics including the service life of customized DC-link film capacitors for use in motor vehicle components.

Standard DC-link capacitors qualified according to other IEC standards or AEC-Q200 are excluded from the scope of this document.

The requirements, test conditions and tests listed in this document apply to customized film capacitors developed for use in motor vehicle power electronics for the application as a DC-link capacitor in HV applications or in the intermediate circuit of the 48 V on-board electrical system.

These qualification requirements can be expanded or adapted for the application of technologically innovative designs, if necessary. The content and scope of supplements is therefore to be specified and documented in coordination between the responsible parties prior to sourcing.

Power electronics in the motor vehicle need to be tested in accordance with the environmental qualification standards of the vehicle manufacturers.

The tests in this document do not replace the tests specified in the Component Requirement Specifications for complete vehicle components or additional or deviating further requirements, test conditions and tests described therein.

This document contains no tests to validate the thermal interface between capacitors, power electronics and the cooling system on the component level.

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 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

IEC 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

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

IEC 60384-1:2021, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

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IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60695-2-12, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 61071:2017, *Capacitors for power electronics*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 21498-1:2021, *Electrically propelled road vehicles – Electrical specifications and tests for voltage class B systems and components – Part 1: Voltage sub-classes and characteristics*

3 Terms, definitions, symbols and abbreviated terms

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1 General terms and definitions

3.1.1
component
complete device, control unit or mechatronic (with housing)

3.1.2
component element
single part of a component

Note 1 to entry: In this document, “component element” designates a capacitor as described in the Scope.

3.1.3
system
functionally linked components, e.g. power train consisting of electric machine, power electronics, control

3.1.4
device under test
component element to be tested, system or the component to be tested

3.1.5
vehicle pre-conditioning
vehicle climate control prior to departure using energy from the mains supply

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3.2 Terms and definitions related to operating voltages and temperatures

3.2.1
working voltage
U_{op}
DC voltage that can occur in an electric system under normal operating conditions according to the customer's specifications, disregarding transients and ripple

Note 1 to entry: The working voltage shall be less than the rated DC voltage.

[SOURCE: ISO 21498-1:2021, 3.16 modified – "AC voltage (rms) or" has been deleted and Note 1 to entry has been added.]

3.2.2
overvoltage
U_{max}
maximum permissible voltage which can be applied to a capacitor for a specified duration at the specified temperature

Note 1 to entry: The maximum permissible voltage specified for a capacitor includes transients, ripple or other disturbances, which can appear within the system under abnormal operating conditions. The duration, number and accumulated duration of overvoltage events need to be agreed between manufacturer and user.

Note 2 to entry: This definition additional to that of the rated DC voltage 3.2.3 is necessary to reflect the customer specifications valid for electrically propelled vehicles (mission profiles), which include normal operation at battery voltage and abnormal operation (overvoltage events), see Annex C for details.

3.2.3
rated DC voltage
U_{RDC}
U_{NDC}
<capacitor> maximum operating voltage of either polarity but of a non-reversing type waveform, for which the capacitor has been designed for continuous operation disregarding transients

Note 1 to entry: The rated DC voltage of the capacitor is aligned with the maximum battery voltage, for which the system is designed. It does not include overvoltage events, like transients. See Annex C for details.

Note 2 to entry: The rated voltage in this specification is different from the general "rated voltage" which is defined in IEC 60384-1 in order to align it to the specification of operating conditions in motor vehicle power electronics.

Note 3 to entry: In IEC 61071 the symbol U_{NDC} is used, but since the letter "N" normally stands for "nominal" it is replaced in this document by "R".

[SOURCE: IEC 61071:2017, 3.18 modified – "maximum operating peak voltage" has been replaced by "maximum operating voltage", "disregarding transients" has been added at the end of the definition, Note 1, Note 2 and Note 3 to entry have been added.]

3.2.4
maximum operating temperature
T_{max}
<capacitor> highest temperature at which the capacitor can be operated under steady state conditions for a specified duration

Note 1 to entry: T_{max} is the temperature of the case measured at the hottest point of the case if no self-heating occurs, or the hotspot temperature inside the case under ripple current load condition. The terminations are part of the external surface of the case.

Note 2 to entry: The temperature time profiles shall be agreed between manufacturer and user.

[SOURCE: IEC 61071:2017, 3.34, modified – "highest temperature of the case" has been replaced by "highest temperature", "for a specified duration" has been added, as well as Note 1 and Note 2 to entry.]

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3.2.5
hotspot temperature
the highest temperature present inside the capacitor dielectric

Note 1 to entry: The hot spot temperature cannot be directly measured in operation. Normally the position of a hot spot and the temperature increase by ripple current load is determined by use of simulation tools and verified by measuring the temperature increase at a sample specially prepared with thermal sensors.

[SOURCE: IEC 61071:2017, 3.35, modified – Note 1 to entry has been added.]

3.3 Symbols and abbreviated terms

For the purposes of this document and the subordinate specifications, the following symbols and abbreviated terms apply.

C	capacitance
C_0	initial capacitance on the new part
C_N	nominal capacitance
ΔC	measured change in capacitance after exposure
ΔT	rise or change in temperature in general
ESL	equivalent series inductance
ESR	equivalent series resistance
f	frequency
HV	high voltage
I	current
R_{iso}	insulation resistance
RH	relative humidity
T_{RT}	room temperature
T_{amb}	ambient temperature of a capacitor
T_{max}	maximum operating temperature (3.2.4)
T_{min}	minimum ambient temperature (lower category temperature, typically -40°C)
T_{op}	operating temperature
$\tan\delta$	loss factor
U_{op}	operating voltage
U_{RDC}	rated DC voltage <capacitor> (3.2.3)
U_{max}	overvoltage limit, test voltage for high temperature overvoltage test
U_t	test voltage
(dU/dt_{pulse})	set value for charge/discharge test
(dU/dt_{short})	set value for the short-circuit test
U_{TC}	isolation voltage of the terminals (T – Terminal) to the case (C – Case)

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4 General requirements

4.1 Deviations from this document

Any deviations from this Technical Specification are listed on the cover sheet of the company standards (in justified exceptional cases, deviations may be represented in the body of the standard in italics). If, in individual cases, modifications to individual test sections are required, such modifications shall be agreed upon separately between the departments responsible of the manufacturer and the user.

4.2 Service life and qualification tests

A vehicle with an electric power train is typically described with the design service life parameters given in Table 1.

Table 1 – Example for a design service life

Service life	15 years
Mileage	300 000 km
Operating hours, driving	8 000 h
Operating hours, charging/ pre-conditioning	30 000 h (22 000 h charging + 8 000 h vehicle pre-conditioning)

The tests described in Clause 5 to Clause 7 are intended to validate the characteristics and service life of capacitors for use in the vehicle.

The basis of the specified tests are the currently-known failure mechanisms and the motor vehicle-specific application profiles of power electronics.

The validation includes:

a) Electrical characterisation (frequency-dependent)
   - E-01 Capacitance;
   - E-02 Insulation resistance;
   - E-03 ESR;
   - E-04 ESL;
   - E-05 Insulation strength to surrounding area (e.g. housing).

b) Mechanical characterisation
   - M-01 Geometry;
   - M-02 Visual inspection.

c) Environmental tests / exposure tests
   - B -01 Thermal shock;
   - B-02 Damp heat, steady state;
   - B-03 High temperature;
   - B-04 Vibration;
   - B-05 Charge/discharge test;
   - B-06 Short-circuit test.

The characterisation measurements are intended to determine the basic functional characteristics and mechanical data of component elements. They shall be performed before, during and after the test.

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