



# TECHNICAL SPECIFICATION

---

**Nanomanufacturing – Material specifications –  
Part 5-2: Nano-enabled electrodes of electrochemical capacitors – Blank detail  
specification**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 07.120

ISBN 978-2-8322-0060-5

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	7
3 Terms and definitions .....	8
3.1 General terms .....	8
3.2 Terms related to capacitors.....	9
3.3 General product description and procurement information.....	10
3.4 Chemical key control characteristics .....	11
3.5 Physical key control characteristics.....	11
3.6 Structural key control characteristics.....	12
3.7 Electrochemical key control characteristics .....	13
3.8 Measurement methods relevant for this document .....	14
4 General introduction regarding measurement methods .....	15
5 Specification format of nano-enabled electrode of electrochemical capacitor .....	16
5.1 General procurement information .....	16
5.2 Chemical key control characteristics .....	17
5.3 Physical key control characteristics.....	17
5.4 Structural key control characteristics.....	18
5.5 Electrochemical key control characteristics .....	18
6 Overview of test methods .....	19
Annex A (normative) KCC measurement procedures – supporting information .....	22
A.1 Water content: Karl Fischer method .....	22
A.1.1 General .....	22
A.1.2 Documented measurement procedure.....	22
A.2 Ash content: Incineration .....	22
A.2.1 General .....	22
A.2.2 Documented measurement procedure.....	22
A.3 Ash content: Thermal gravimetric analysis (TGA).....	22
A.3.1 General .....	22
A.3.2 Documented measurement procedure.....	22
A.4 Magnetic impurities: ICP-MS.....	23
A.4.1 General .....	23
A.4.2 Documented measurement procedure.....	23
A.4.3 Adaptations required .....	23
A.5 Magnetic impurities: ICP-OES.....	23
A.5.1 General .....	23
A.5.2 Documented measurement procedure.....	23
A.6 Magnetic impurities: ASS .....	23
A.6.1 General .....	23
A.6.2 Documented measurement procedure.....	23
A.7 Bending strength: Lacquer cylinder bending tester .....	24
A.7.1 General .....	24
A.7.2 Documented measurement procedure.....	24
A.8 Peel strength .....	24
A.8.1 General .....	24
A.8.2 Documented measurement procedure.....	24

A.9	Rebound rate .....	24
A.9.1	General .....	24
A.9.2	Documented measurement procedure.....	24
A.10	Electrolyte adsorption capacity .....	24
A.10.1	General .....	24
A.10.2	Documented measurement procedure.....	25
A.11	Contact angle .....	25
A.11.1	General .....	25
A.11.2	Documented measurement procedure.....	25
A.12	Resistivity .....	25
A.12.1	General .....	25
A.12.2	Documented measurement procedure.....	25
A.12.3	Adaptations required .....	25
A.13	Thickness .....	25
A.14	Surface and rolling density.....	25
A.14.1	General .....	25
A.14.2	Documented measurement procedure.....	26
A.14.3	Adaptations required .....	26
A.15	Specific surface area and pore volume .....	26
A.15.1	General .....	26
A.15.2	Documented measurement procedure.....	26
A.16	Surface roughness.....	26
A.17	Specific capacitance: CCC, CCD .....	26
A.17.1	General .....	26
A.17.2	Documented measurement procedure.....	27
A.18	Voltage maintenance rate .....	27
A.18.1	General .....	27
A.18.2	Documented measurement procedure.....	27
A.19	Leakage current: CCC, CCD, CVD .....	27
A.19.1	General .....	27
A.19.2	Documented measurement procedure.....	27
A.20	Endurance in cycling.....	27
A.20.1	General .....	27
A.20.2	Documented measurement procedure.....	28
A.21	Temperature endurance.....	28
A.21.1	General .....	28
A.21.2	Documented measurement procedure.....	28
A.22	DC resistance: CCC, CCD .....	28
A.22.1	General .....	28
A.22.2	Documented measurement procedure.....	28
Bibliography.....		29
Table 1	– Format for general product description and procurement information.....	16
Table 2	– Format for chemical key control characteristics .....	17
Table 3	– Format for physical key control characteristics .....	17
Table 4	– Format for structural key control characteristics .....	18
Table 5	– Format for electrochemical key control characteristics.....	18
Table 6	– Overview of measurement methods.....	20

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### NANOMANUFACTURING – MATERIAL SPECIFICATIONS –

#### Part 5-2: Nano-enabled electrodes of electrochemical capacitors – Blank detail specification

#### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TS 62565-5-2 has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems. It is a Technical Specification.

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

Draft	Report on voting
113/628/DTS	113/643/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.

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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

A list of all parts in the IEC 62565 series, published under the general title *Nanomanufacturing – Material specifications*, can be found on the IEC website.

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](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

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

## INTRODUCTION

This Technical Specification specifies how to report the various characteristics of electrodes for industrial use in electrotechnical products, and how to incorporate these into a bilateral detail specification between vendor and user.

Electrochemical capacitors are widely used in the fields of electric vehicles, high speed trains, aircraft, photovoltaic, wind power and electronics, due to their ultra-fast charge/discharge capability, long cycle life, wide working temperature range, high security reliability and low maintenance cost [1]<sup>1</sup>. In the manufacture process of electrochemical capacitor, the electrode is a bridge between raw material and device. Therefore, the performance of the electrode is very critical in the whole electrochemical capacitor industry chain because the properties of electrodes not only reflect the performance of upstream raw material but also determine the performance of electrochemical capacitor [2][3][4][5][6][7][8][9].

For the purposes of development and commercialization of raw nanomaterials for electrodes and the electrochemical capacitor and assembly produced therefrom, the product characteristics and characterization methods need to be specified in a standardized way. This blank detail specification will benefit different stakeholders as follows: for material suppliers, it provides necessary feedback from the manufacturers to guide the design and production of raw materials; for the end-product manufacturers, it provides a toolbox for evaluating product quality so as to manage and improve process control, yield of products; for commercialization and trade, it provides a guidance on referred test methods for electrode classification; in addition, it will strengthen the links between material manufacture and down-stream user.

In this blank detail specification, the key chemical, physical, structural and electrochemical characteristics that will significantly influence the performance of electrochemical capacitors and their measurement methods are listed. These characteristics and characterization methods are not limited only to nano-enabled electrodes but also can be reference for other electrodes which are constructed by coating electrode materials on a current collector.

---

<sup>1</sup> Numbers in square brackets refer to the Bibliography.

## NANOMANUFACTURING – MATERIAL SPECIFICATIONS –

### Part 5-2: Nano-enabled electrodes of electrochemical capacitors – Blank detail specification

#### 1 Scope

This part of IEC 62565, which is a Technical Specification, establishes a blank detail specification that lists the relevant key control characteristics (KCC) including chemical, physical, structural, and electrochemical characteristics of nano-enabled electrode for electrochemical capacitors. Electrodes of both electric double layer capacitors and pseudo capacitors with nano/ nanostructured materials such as nanoporous activated carbon, graphene, carbon nanotube, carbon black, carbon aerogel, carbon nanomaterial coating collector, etc., are included. For other electrodes, this document can be used for reference.

In addition, this document enables the customer to specify requirements in a standardized manner and to verify through standardized methods that the nano-enabled electrode of the electrochemical capacitors meets the required properties.

Numeric values to be specified for the characteristics in this document are intentionally left blank and are determined by agreement between customer and electrochemical capacitor supplier. Properties and characteristics deemed by the customer or supplier as not relevant to a specific application are classified as "not applicable" or "not specified".

#### 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 TS 62607-4-2, *Nanomanufacturing – Key control characteristics – Part 4-2: Nano-enabled electrical energy storage – Physical characterization of cathode nanomaterials, density measurement*

IEC TS 62607-4-3, *Nanomanufacturing – Key control characteristics – Part 4-3: Nano-enabled electrical energy storage – Contact and coating resistivity measurements for nanomaterials*

IEC TS 62607-4-8, *Nanomanufacturing – Key control characteristics – Part 4-8: Nano-enabled electrical energy storage – Determination of water content in electrode nanomaterials, Karl Fischer method*

IEC TS 62607-6-20, *Nanomanufacturing – Key control characteristics – Part 6-20: Graphene-based material – Metallic impurity content: ICP-MS<sup>2</sup>*

ISO 9277, *Determination of the specific surface area of solids by gas adsorption – BET method*

ISO 15901-2, *Pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption – Part 2: Analysis of nanopores by gas adsorption*

---

<sup>2</sup> Under preparation. Stage at the time of publication: IEC DTS 62607-6-20:2021.

[This is a preview - click here to buy the full publication](#)

ISO 25178 (all parts), *Geometrical product specifications (GPS) – Surface texture: Areal*