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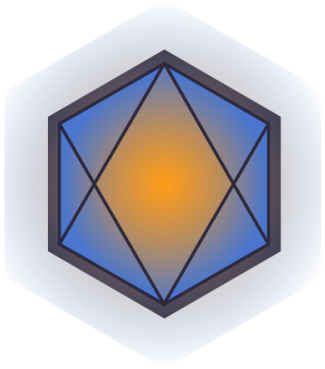

InComEss

Innovative polymer-based composite systems for high-efficient energy scavenging and storage

Deliverable

D9.9 Report on the standardization landscape and applicable standards

Deliverable Lead: UNE

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EXECUTIVE SUMMARY / ABSTRACT

The Spanish Association for Standardization, UNE, as a European Standardization Body, is a partner in the InComEss project to provide support regarding the standardization tasks included in it (WP 9, Exploitation, dissemination and communication). The main objective of these tasks is to facilitate the acceptance and utilization by the market of the developed solutions. In order to fulfil this commitment, this deliverable D9.9 'Report on the standardization landscape and applicable standards' has been prepared under the direction of UNE to provide the partners with information about the state of the art in standardization, including published standards and standards under development which can be interesting for the project objectives.

This deliverable contains the fields of interest related to InComEss project, specially linked to WP 1, and from this starting point, an identification of the relevant standardization technical committees (TCs) and organizations as well as of the published standards and standards under development that can be useful for the project activities with the final goal of ensuring compatibility and interoperability with what already exists in the market through standards. Furthermore, it can provide InComEss consortium basic information to help decide further steps in the standardization process and to identify standardization gaps that could be filled by the results of the project.

SCOPE

The purpose of deliverable D9.9 is to provide information on the standardization landscape and applicable standards relevant for the InComEss project. It pretends to provide starting information for the work packages ensuring compatibility and interoperability with already existing solutions by identifying existing standards and standards under development at European and International levels in the fields of piezoelectric and thermoelectric energy harvesting, power conditioning circuit, storage for energy harvesting, and wireless sensor network and IoT. This report also identifies the standardization technical committees (TCs) which could be of interest for the next stages of the project.

1 Introduction

1.1 Project presentation overview

InComEss project is a research and innovation action funded by European Commission under Programme H2020. Started on 1st of March 2020, the project will run for 42 months. It brings together 18 partners from 10 European countries (Spain, Germany, Portugal, Belgium, Finland, Greece, Estonia, Italy, United Kingdom and Netherlands). With regard to the typology of involved partners, the consortium includes technology and research centers, universities, SMEs, industrial companies and non-profit organizations. This composition represents a broad background and expertise which should promote the implementation of the developments and achievements of the project. The participation of a Standardization Body as UNE, representing CEN and CENELEC, provides the relevance, knowledge and experience in the standardization system and its internal procedures.

The main objective of InComEss is to develop efficient smart materials with energy harvesting and storage capabilities combining advanced polymer based-composite materials into a novel single/multi-source concept to harvest electrical energy from mechanical energy and/or waste heat ambient sources.

InComEss aims at developing next generation smart materials capable to harvest and store mechanical energy and waste heat, generate and store electric energy and supply electricity to power wireless sensor nodes (WSN) in building, automotive and aeronautic sectors towards the wider implementation of the Digital Single Market and IoT.

1.2 Short introduction about standardization

Standards are voluntary technical documents that set out requirements for a specific item, material, component, system or service, or describes in detail a particular method, procedure or best practice. Standards are developed and defined through a process of sharing knowledge and building consensus among technical experts nominated by interested parties and other stakeholders - including businesses, consumers and environmental groups, among others. These experts are organized in Technical Committees (TCs), which are subdivided in Subcommittees (SCs) or Working Groups (WGs). These TCs are included in the structure of the Standardization Organizations (National, European and International, with the respective mirror committees) and work following their internal regulations.

The standardization bodies operate at National (UNE, AFNOR, BSI, DIN, etc.), Regional (CEN, CENELEC, ETSI) or International (ISO, IEC, ITU) level. Sometimes there are different standardization bodies at the same level but covering different fields. This is the case of ISO (general issues), IEC (electrotechnical issues) and ITU (telecommunications) at International level, or CEN, CENELEC and ETSI at European level in the same way.

There are also different kinds of standardization documents. The most widespread is the standard, which has a different code depending on the organization under it is developed, e.g. EN for European Standards, ISO or IEC for International standards. Other types of documents are Technical Specifications (TS), Technical Reports (TR) and Workshop Agreements (CWA). Further Amendments to the standards are identified by adding A1, A2, etc. at the end of the standard code.

The formal definition of a standard is a “document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context”. These include requirements and/or recommendations in relation to products, systems, processes or services. European Standards (ENs) are documents that have been ratified by one of the three European Standardization Organizations (ESOs), CEN, CENELEC or ETSI, recognized as competent in the area of voluntary technical standardization as for the EU Regulation 1025/2012.

At European level, all the members of CEN and CENELEC shall adopt EN standards as national standards and have to withdraw any existing national standard which could conflict with them. A summary of the characteristics of the different standardization documents can be found in the following Table 1-1:

Table 1-1: Characteristics of different standardization documents

Type	International code	European code	National code	Main characteristics
Standard	ISO IEC	EN	UNE, NF, BS, DIN, etc. When adopting: UNE-EN, NF-EN, UNE-ISO, NF-ISO, etc.	- Elaboration: 3 years - 2 steps of member approval - European: compulsory national adoption - Revision: every 5 years
Technical Specification	ISO/TS IEC/TS	CEN/TS CLC/TS	When adopting: UNE-CEN/TS, NF-CEN/TS, UNE-ISO/TS, NF-ISO/TS, etc.	- Elaboration: 21 months - 1 step of member approval or internal approval in TC - European: optional national adoption - Revision: at 3 years (upgrading to EN or deletion)
Technical Report	ISO/TR IEC/TR	CEN/TR CLC/TR	When adopting: UNE-CEN/TR, NF-CEN/TR, UNE-ISO/TR, NF-ISO/TR, etc.	- Elaboration: free timeframe - Internal approval in TC - European: optional national adoption - No revision required
Workshop Agreement	IWA	CWA	Variable	- Elaboration: free timeframe (usually few months) - Internal approval in the Workshop - European: optional national adoption - Revision: at 3 years (upgrading to EN or deletion)

European and International Standardization Organizations have signed formal agreements in order to avoid duplication of efforts and promote global relevance of standards, which allows to adopt or develop in parallel each other's standards with the same content and code.

The technical collaboration between CEN and ISO was formalized through the Vienna Agreement (VA); CENELEC has also close cooperation with its international counterpart, IEC, through the Frankfurt Agreement (FA). The main objectives of these agreements are to provide a:

- framework for the optimal use of resources and expertise available for standardization work;
- mechanism for information exchange between international and European Standardization Organizations (ESOs) to increase the transparency of ongoing work at international and European levels.

More detail information on each agreement can be found in:

https://www.cencenelec.eu/intcoop/StandardizationOrg/Pages/default.aspx

As a result, new electrical standards projects are jointly planned between CENELEC and IEC, and where possible most are carried out at international level. This means that CENELEC will first offer a New Work Item (NWI) to its international counterpart. If accepted, CENELEC will cease working on the NWI. If IEC refuses, CENELEC will work on the standards content development, keeping IEC closely informed and giving IEC the opportunity to comment at the public enquiry stage. CENELEC and IEC vote in parallel (both organizations vote at the same time) during the standardization process. If the outcome of the parallel voting is positive, CENELEC will ratify the European standard and the IEC will publish the international standard. Close to 80% of CENELEC standards are identical to or based on IEC publications.

National standards could also be proposed as a base for new European or International standards.

The following Figure 1-1 shows the possible tracks of the standards:

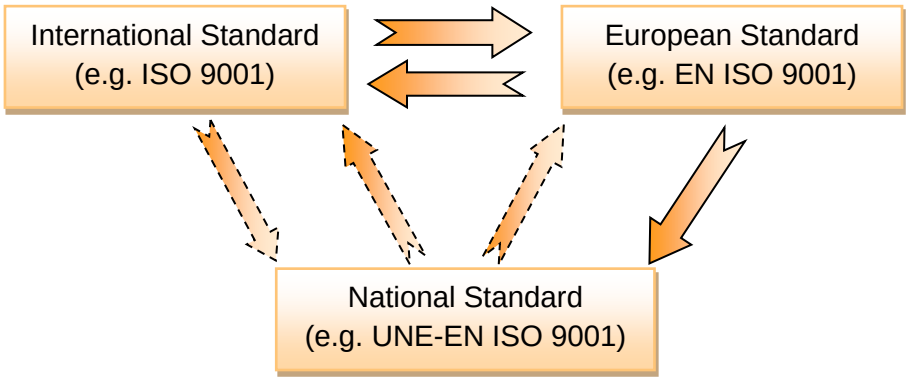

Figure 1-1: Possible tracks of standards adoption

Therefore, the code of any standard is the combination of the abovementioned issues, and could be explained as shown in Figure 1-2:

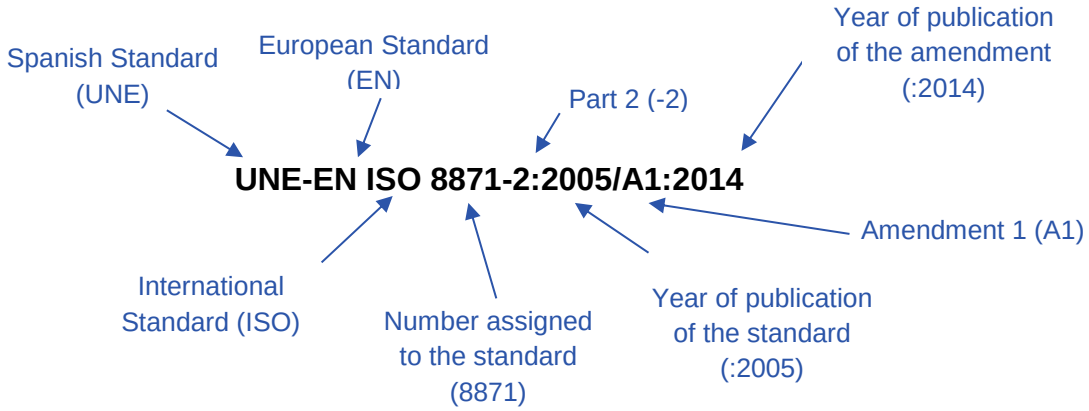

Figure 1-2: Example of identification of elements in the code of a standard

2 Standardization landscape related to InComEss

2.1 Methodology

This document presents the standardization activity found relevant for the InComEss project. Based on the general structure of the project and the technological parts that comprise the Energy Harvesting Systems (see Figure 2-1), a list of key concepts was identified as starting point for the identification of standardization areas and to make the search of the normative documents which could be of interest to all partners:

- Piezoelectric materials for Energy Harvesting
- Thermoelectric materials for Energy Harvesting
- Hybrid Thermo/Piezoelectric materials for Energy Harvesting
- Power Conditioning Circuit (transformer, DC/DC converter, AC/DC converter)
- Monolithic Supercapacitor for energy Storage
- Wireless Sensor Nodes (WSN) and IoT

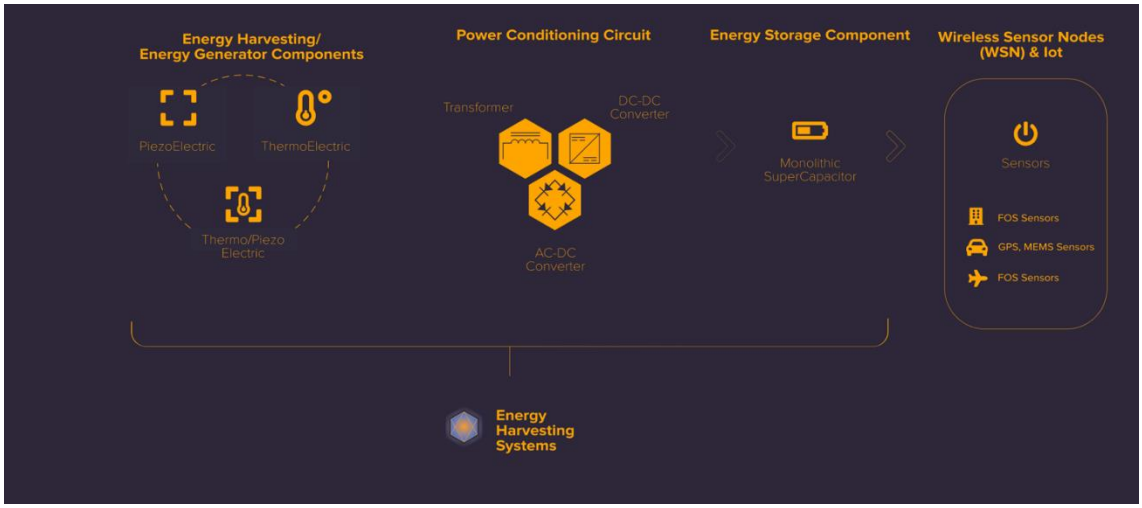

Figure 2-1: General structure of the project

Some other concepts such as plastics, fine ceramics, structural adhesives, printed electronics or nanotechnologies were also taken into consideration for further searches.

The document also describes the Technical Committees (TC) responsible for the elaboration of the identified standards which could be useful for the dissemination of the project and the development of subtask 9.3.2.

The standardization study covers European standardization developed by the European Standardization Bodies (CEN and CENELEC) and also the International standardization developed by the International Organizations for Standardization (ISO and IEC).

Apart from official standardization activities, other private standardization initiatives that could be relevant for the project are also included. Information about them has been provided by the partners. They are shown in subclause 2.2.7.

However, it should be noted that the standardization landscape may vary during the project lifetime and therefore a more detailed roadmap for future standardization activities of the project (what, how, where, etc) is not feasible at this initial stage and will be assessed in deliverable D9.10.

2.2 Relevant standards for InComEss

2.2.1 Piezoelectric Materials

Many aspects of piezoelectric energy harvesting rest on technology for which IEC/TC 49 and CENELEC/SR 49 prepare International and European standards respectively. Focusing on European level, **CLC/SR 49, *Piezoelectric and dielectric devices for frequency control and selection*** prepares European standards for piezoelectric and dielectric devices for frequency control and selection, such as resonators, filters, oscillators, sensors and their related products (excluding piezoelectric transducers).

Table 2-1: Selection of published standards on piezoelectric ceramics properties and oscillators

Reference	Title
EN 50324-1:2002	Piezoelectric properties of ceramic materials and components - Part 1: Terms and definitions
EN 50324-2:2002	Piezoelectric properties of ceramic materials and components - Part 2: Methods of measurement - Low power
EN 50324-3:2002	Piezoelectric properties of ceramic materials and components - Part 3: Methods of measurement - High power
EN 62884-1:2017	Measurement techniques of piezoelectric, dielectric and electrostatic oscillators - Part 1: Basic methods for the measurement
EN 62884-2:2017	Measurement techniques of piezoelectric, dielectric and electrostatic oscillators - Part 2: Phase jitter measurement method
EN IEC 62884-3:2018	Measurement techniques of piezoelectric, dielectric and electrostatic oscillators – Part 3: Frequency aging test methods
EN IEC 62884-4:2019	Measurement techniques of piezoelectric, dielectric and electrostatic oscillators - Part 4 : Short-term frequency stability test methods

No developing standards on these issues have been identified of interest for the project.

Regarding materials, the study has basically been focused on two fields: plastics and fine ceramics.

Since poly(vinylidene fluoride) (PVDF) is one of the polymers that will be used within the project, the following standard published by **ISO/TC 61, *Plastics*** shall be taken into account:

Table 2-2: Selection of published standards on plastics for piezoelectrics

Reference	Title
ISO 15014:2007	Plastics — Extruded sheets of poly(vinylidene fluoride) (PVDF) — Requirements and test methods (*ISO/TC 61/SC 11, Products*)

This International TC is responsible for the standardization of nomenclature, methods of test, and specifications applicable to materials and products in the field of plastics including processing (of products) by assembly in particular, but not limited to, polymeric adhesives, sealing, joining, welding (excluded: rubber, lacquers).

CEN/TC 249, *Plastics* is its European mirror committee.

Concerning **fine ceramics**, the technical committee **ISO/TC 206,** is responsible for the standardization in the field of fine ceramics materials and products in all forms: powders, monoliths, coatings and composites, intended for specific functional applications including mechanical, thermal, chemical, electrical, magnetic, optical and combinations thereof.

The term "fine ceramics" is defined as "a highly engineered, high performance, predominantly non-metallic, inorganic material having specific functional attributes."

Some standards on ceramics used for piezoelectric materials published by this TC are listed below:

Table 2-3: Selection of published standards on fine ceramics for the development of piezoelectric composite-based materials

Reference	Title
ISO 17859:2015	Fine ceramics (advanced ceramics, advanced technical ceramics) — Measurement method of piezoelectric strain at high electric field
ISO 19622:2018	Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for piezoelectric constant d33 of piezoelectric ceramics by direct quasi-static method
ISO 21819-1:2018	Fine ceramics (advanced ceramics, advanced technical ceramics) — Characteristic of piezoelectric properties under high-load conditions — Part 1: Resonant-antiresonant method under high-temperature conditions
ISO 21819-2:2018	Fine ceramics (advanced ceramics, advanced technical ceramics) — Characteristic of piezoelectric properties under high-load conditions — Part 2: Electrical transient response method under high vibration levels

At European level **CEN/TC 184** also deals with **Advanced technical ceramics** under the following scope:

Standardization in the field of advanced technical ceramics with specific tasks being classification, terminology, sampling and test methods. The methods of test are to include physical, chemical, thermal and textural properties for ceramic powder, monolithic ceramics, ceramic composites (including fibres) and ceramic coatings, plus test methods for applications.

Table 2-4: Selection of published standards on advanced technical ceramic composites for the development of piezoelectric materials

Reference	Title
EN 1007-1:2002	Advanced technical ceramics - Ceramic composites - Methods of test for reinforcement - Part 1: Determination of size content
EN 1007-3:2002	Advanced technical ceramics - Ceramic composites - Methods of test for reinforcement - Part 3: Determination of filament diameter and cross-section area
EN 1007-4:2004	Advanced technical ceramics - Ceramic composites - Methods of test for reinforcement - Part 4: Determination of tensile properties of filaments at ambient temperature
EN 1007-5:2010	Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements - Part 5: Determination of distribution of tensile strength and of tensile strain to failure of filaments within a multifilament tow at ambient temperature
EN 1007-6:2007	Advanced technical ceramic - Ceramic composites - Methods of test for reinforcements - Part 6: Determination of tensile properties of filaments at high temperature
EN 12789:2002	Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under air at atmospheric pressure - Determination of flexural strength
EN 13234:2006	Advanced technical ceramics - Mechanical properties of ceramic composites at ambient temperature - Evaluation of the resistance to crack propagation by notch sensitivity testing
EN 1389:2003	Advanced technical ceramics - Ceramic composites - Physical properties - Determination of density and apparent porosity
EN 658-1:1998	Advanced technical ceramics - Mechanical properties of ceramic composites at room temperature - Part 1: Determination of tensile properties

Reference	Title
EN 658-3:2002	Advanced technical ceramics - Mechanical properties of ceramic composites at room temperature - Part 3: Determination of flexural strength
EN 843-2:2006	Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 2: Determination of Young's modulus, shear modulus and Poisson's ratio
EN ISO 14544:2016	Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at high temperature - Determination of compression properties (ISO 14544:2013)
EN ISO 14574:2016	Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at high temperature - Determination of tensile properties (ISO 14574:2013)
EN ISO 17140:2016	Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at room temperature - Determination of fatigue properties at constant amplitude (ISO 17140:2014)

At the time of publication of this deliverable, no standards under development have been found in this field.

Related to the melt-spinning process, which is one of the techniques that will be used to manufacture the piezoelectric composite fibres within InComEss, some European standards have been found relevant for the characterization of the materials used and obtained in this process.

Table 2-5: Selection of published standards on piezoelectric materials characterization

Reference	Title	Technical Committee
EN ISO 1133-1:2011	Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method (ISO 1133-1:2011)	CEN/TC 249, Plastics
EN ISO 11357-1:2016	Plastics - Differential scanning calorimetry (DSC) - Part 1: General principles (ISO 11357-1:2016)	CEN/TC 249, Plastics
EN ISO 11357-2:2020	Plastics - Differential scanning calorimetry (DSC) - Part 2: Determination of glass transition temperature and step height (ISO 11357-2:2020)	CEN/TC 249, Plastics
EN ISO 11357-3:2018	Plastics - Differential scanning calorimetry (DSC) - Part 3: Determination of temperature and enthalpy of melting and crystallization (ISO 11357-3:2018)	CEN/TC 249, Plastics
EN ISO 11357-4:2014	Plastics - Differential scanning calorimetry (DSC) - Part 4: Determination of specific heat capacity (ISO 11357-4:2014)	CEN/TC 249, Plastics
EN ISO 11357-5:2014	Plastics - Differential scanning calorimetry (DSC) - Part 5: Determination of characteristic reaction-curve temperatures and times, enthalpy of reaction and degree of conversion (ISO 11357-5:2013)	CEN/TC 249, Plastics
EN ISO 11357-7:2015	Plastics - Differential scanning calorimetry (DSC) - Part 7: Determination of crystallization kinetics (ISO 11357-7:2015)	CEN/TC 249, Plastics
EN ISO 11358-1:2014	Plastics - Thermogravimetry (TG) of polymers - Part 1: General principles (ISO 11358-1:2014)	CEN/TC 249, Plastics
EN ISO 2060:1995	Textiles — Yarn from packages — Determination of linear density (mass per unit length) by the skein method (ISO 2060:1994)	CEN/TC 248, Textiles and textiles products

Reference	Title	Technical Committee
EN ISO 2062:2009	Textiles — Yarns from packages — Determination of single-end breaking force and elongation at break using constant rate of extension (CRE) tester (ISO 2062:2009)	CEN/TC 248, Textiles and textiles products

It shall be noted that some of these standards are currently under revision:

Table 2-2: Standards under development

Reference	Title
prEN ISO 11357-4	Plastics - Differential scanning calorimetry (DSC) - Part 4: Determination of specific heat capacity (ISO/DIS 11357-4:2020)
prEN ISO 11357-8	Plastics - Differential scanning calorimetry (DSC) - Part 8: Determination of thermal conductivity (ISO/DIS 11357-8:2019)
prEN ISO 11358-1 rev	Plastics - Thermogravimetry (TG) of polymers - Part 1: General principles

Concerning piezoelectric generators, the technical committee **IEC/TC 47, *Semiconductor devices*** has some publications related to energy harvesting based on piezoelectrics.

In general terms, this TC develops international standards for the design, manufacture, use and reuse of discrete semiconductor devices, integrated circuits, display devices, sensors, electronic component assemblies, interface requirements, and microelectromechanical devices, using environmentally sound practices.

Activities include wafer level reliability, package outlines, terms and definitions, quality issues, physical environmental testing, device specific test methods, device specifications and minimum content, pinouts, interface requirements, and applications.

Table 2-7: Selection of published standards on semiconductor devices based on piezoelectrics

Reference	Title
IEC 62830-1:2017	Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 1: Vibration based piezoelectric energy harvesting
IEC 62830-4:2019	Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 4: Test and evaluation methods for flexible piezoelectric energy harvesting devices
IEC 62969-3:2018	Semiconductor devices - Semiconductor interface for automotive vehicles - Part 3: Shock driven piezoelectric energy harvesting for automotive vehicle sensors (*Adopted at European level as EN IEC 62969-3:2018*)
IEC 63150-1:2019	Semiconductor devices - Measurement and evaluation methods of kinetic energy harvesting devices under practical vibration environment - Part 1: Arbitrary and random mechanical vibrations
IEC 62047-28:2017	Semiconductor devices - Micro-electromechanical devices - Part 28: Performance testing method of vibration-driven MEMS electret energy harvesting devices
IEC 62047-30:2017	Semiconductor devices - Micro-electromechanical devices - Part 30: Measurement methods of electro-mechanical conversion characteristics of MEMS piezoelectric thin film (*SC 47F, Micro-electromechanical systems*)

Table 2-8: Standards under development

Reference	Title
IEC 62047-37 ED1	Semiconductor devices - Micro-electromechanical devices - Part 37: Environmental test methods of MEMS piezoelectric thin films for sensor application (*SC 47F, Micro-electromechanical systems*)

2.2.2 Thermoelectric Materials

The thermoelectric materials developed in the project are focused on carbon-based material composites. Some standards on carbon nanotubes and graphene published by **ISO/TC 229, *Nanotechnologies*** and **IEC/TC 113, *Nanotechnology for electrotechnical products and systems*** have been identified:

Table 2-9: Selection of published standards on carbon nanotubes

Reference	Title
ISO/TS 10797:2012	Nanotechnologies — Characterization of single-wall carbon nanotubes using transmission electron microscope
ISO/TS 10798:2011	Nanotechnologies — Characterization of single-wall carbon nanotubes using scanning electron microscopy and energy dispersive X-ray spectrometry analysis
ISO/TS 10867:2019	Nanotechnologies — Characterization of single-wall carbon nanotubes using near infrared photoluminescence spectroscopy
ISO/TS 10868:2017	Nanotechnologies — Characterization of single-wall carbon nanotubes using ultraviolet-visible-near infrared (UV-Vis-NIR) absorption spectroscopy
ISO/TR 10929:2012	Nanotechnologies — Characterization of multiwall carbon nanotube (MWCNT) samples
ISO/TS 11251:2019	Nanotechnologies — Characterization of volatile components in single-wall carbon nanotube samples using evolved gas analysis/gas chromatograph-mass spectrometry
ISO/TS 11308:2020	Nanotechnologies — Characterization of carbon nanotube samples using thermogravimetric analysis
ISO/TS 11888:2017	Nanotechnologies — Characterization of multiwall carbon nanotubes — Mesoscopic shape factors
ISO/TS 13278:2017	Nanotechnologies — Determination of elemental impurities in samples of carbon nanotubes using inductively coupled plasma mass spectrometry
ISO/TS 19808:2020	Nanotechnologies — Carbon nanotube suspensions — Specification of characteristics and measurement methods
IEC TS 62607-2-1:2012	Nanomanufacturing - Key control characteristics - Part 2-1: Carbon nanotube materials - Film resistance
IEC TS 62607-2-4:2020	Nanomanufacturing - Key control characteristics - Part 2-4: Carbon nanotube materials - Test methods for determination of resistance of individual carbon nanotubes
IEC 62624:2009	Test methods for measurement of electrical properties of carbon nanotubes

Table 2-10: Selection of published standards on graphene

Reference	Title
ISO/TR 19733:2019	Nanotechnologies — Matrix of properties and measurement techniques for graphene and related two-dimensional (2D) materials

Reference	Title
IEC TS 62607-6-4:2016	Nanomanufacturing - Key control characteristics - Part 6-4: Graphene - Surface conductance measurement using resonant cavity

Table 2-3: Standards under development

Reference	Title
ISO/AWI TR 23463	Nanotechnologies — Characterization of carbon nanotube and carbon nanofiber aerosols in relation to inhalation toxicity tests
ISO/AWI TS 23690	Nanotechnologies — Multiwall carbon nanotubes — Determination of amorphous carbon content by thermogravimetric analysis
ISO/CD TS 21356-1	Nanotechnologies — Structural characterization of graphene — Part 1: Graphene from powders and dispersions
IEC/CD 62565-3-1	Nanomanufacturing — Material specifications — Part 3-1: Graphene — Blank detail specification
IEC/AWI 62607-6-3	Nanomanufacturing — Key control characteristics — Graphene – Part 6-3: Characterization of graphene domains and defects
IEC 62565-3-1 ED1	Nanomanufacturing - Material specifications - Part 3-1: Graphene - Blank detail specification

In the case of thermoelectric composite fibres, the following standards could be useful to characterize some electrical and mechanical properties of the compounds obtained by melt extrusion process used in InComEss:

Table 2-12: Selection of published standards on thermoelectric materials characterization

Reference	Title	Technical Committee
EN 62631-3-3:2016	Dielectric and resistive properties of solid insulating materials - Part 3-3: Determination of resistive properties (DC methods) - Insulation resistance	CLC/SR 112, Evaluation and qualification of electrical insulating materials and systems
EN ISO 3915:1999	Plastics - Measurement of resistivity of conductive plastics (ISO 3915:1981)	CEN/TC 249, Plastics
EN ISO 22007-1:2017	Plastics - Determination of thermal conductivity and thermal diffusivity - Part 1: General principles (ISO 22007-1:2017)	CEN/TC 249, Plastics
EN ISO 527-1:2019	Plastics - Determination of tensile properties - Part 1: General principles (ISO 527-1:2019)	CEN/TC 249, Plastics
EN ISO 527-2:2012	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics (ISO 527-2:2012)	CEN/TC 249, Plastics
EN ISO 180:2019	Plastics - Determination of Izod impact strength (ISO 180:2019)	CEN/TC 249, Plastics
EN ISO 1133-1:2011	Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method (ISO 1133-1:2011)	CEN/TC 249, Plastics

Regarding thermoelectric generators that also rely on the use of semiconductor devices, **IEC/TC 47** has the following publication:

Table 2-13: Selection of published standards on semiconductor devices based on thermoelectrics

Reference	Title
IEC 62830-2:2017	Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 2: Thermo power based thermoelectric energy harvesting

Table 2-14: Standards under development

Reference	Title
IEC 62830-5 ED1	Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 5: Test method for measuring generated power from flexible thermoelectric devices

2.2.3 Hybrid Thermo/Piezoelectric Materials

At the time of publication of this deliverable, no specific published or developing standards have been found in this field. InComEss project could contribute to the generation of standards since a Thermo/Piezoelectric Generator (TPEG) will be developed.

2.2.4 Power Conditioning Circuit

2.2.4.1 Power conversion

At European level, the standardization activity related to power conversion is carried out in **CLC/TC 22X, *Power electronics*,** which is the technical committee responsible for the preparation of standards dealing with equipment, their components for electronic power conversion and electronic power switching, including the means for their control, protection, monitoring and measurement, and their extension to the system aspect.

The international mirror committee **IEC/TC 22, *Power electronics systems and equipment*** has also published some standards:

Table 2-15: Selection of published standards on power electronics

Reference	Title
EN 50598-3:2015	Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Part 3: Quantitative eco design approach through life cycle assessment including product category rules and the content of environmental declarations
EN 60146-1-1:2010	Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements
EN 60146-1-3:1993	Semiconductor convertors - General requirements and line commutated convertors - Part 1-3: Transformers and reactors
EN 60146-2:2000	Semiconductor converters - Part 2: Self-commutated semiconductor converters including direct d.c. converters
EN 62477-1:2012	Safety requirements for power electronic converter systems and equipment - Part 1: General
EN IEC 62477-2:2018	Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC
IEC TR 60146-1-2:2019	Semiconductor converters - General requirements and line commutated converters - Part 1-2: Application guidelines

Table 2-16: Standards under development

Reference	Title
prEN IEC 62477-1	Safety requirements for power electronic converter systems and equipment - Part 1: General
IEC 63285-3 ED1	Power Converter Sub-System (PCSS) for use in Electrical Energy Storage Systems (EESS) - Part 3: Method of specifying the performance and test requirements (*SC 22H, Uninterruptible power systems (UPS)*)

2.2.4.2 Transformers

Concerning transformers there are two possible Technical Committees involved:

CLC/TC 38, *Instrument transformers*

prepares European Standards (using whenever possible IEC Standards) in the field of AC and/or DC current and/or voltage instrument transformers, including their subparts like (but not limited to) sensing devices, signal treatment, data conversion and analogic or digital interfacing.

Table 2-17: Selection of published standards on instrument transformers

Reference	Title
EN 60044-7:2000	Instrument transformers - Part 7: Electronic voltage Transformers
EN 60044-8:2002	Instrument transformers - Part 8: Electronic current transformers
EN 61869-1:2009	Instrument transformers - Part 1: General requirements
EN 61869-2:2012	Instrument transformers - Part 2: Additional requirements for current Transformers
EN 61869-3:2011	Instrument transformers - Part 3: Additional requirements for inductive voltage Transformers
EN 61869-4:2014	Instrument transformers - Part 4: Additional requirements for combined Transformers
EN 61869-5:2011	Instrument transformers - Part 5: Additional requirements for capacitor voltage Transformers
EN 61869-6:2016	Instrument transformers - Part 6: Additional general requirements for low-power instrument Transformer
EN IEC 61869-9:2019	Instrument transformers - Part 9: Digital interface for instrument Transformers
EN IEC 61869-10:2018	Instrument transformers - Part 10: Additional requirements for low-power passive current Transformers
EN IEC 61869-11:2018	Instrument transformers - Part 11: Additional requirements for low-power passive voltage Transformers
EN IEC 61869-14:2019	Instrument transformers - Part 14: Additional requirements for current transformers for DC applications
EN IEC 61869-15:2019	Instrument transformers - Part 15: Additional requirements for voltage transformers for DC applications

Table 2-18: Standards under development

Reference	Title
prEN 61869-1	Instrument transformers - Part 1: General requirements
prEN 61869-201	Instrument transformers - Part 201: General requirements for Instrument Transformers for low voltage applications
prEN 61869-220	Instrument transformers - Part 220: Safety requirements for Instrument Transformers for low voltage applications

IEC/TC 96, *Transformers, reactors, power supply units, and combinations thereof*

Standardization in the field of safety, EMC, EMF, energy efficiency and environmental aspects of transformers, reactors, power supply units, and combinations thereof. The standardization does not cover transformers, reactors and power supply units intended to be a part of distribution networks.

Table 2-19: Selection of published standards on transformers

Reference	Title
IEC 61558-1:2017	Safety of transformers, reactors, power supply units and combinations thereof - Part 1: General requirements and tests
IEC 61558-2-1:2007	Safety of power transformers, power supplies, reactors and similar products - Part 2-1: Particular requirements and tests for separating transformers and power supplies incorporating separating transformers for general applications
IEC 61558-2-2:2007	Safety of power transformers, power supplies, reactors and similar products - Part 2-2: Particular requirements and tests for control transformers and power supplies incorporating control transformers
IEC 61558-2-4:2009	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers
IEC 61558-2-6:2009	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers
IEC 61558-2-12:2011	Safety of transformers, reactors, power supply units and combination thereof - Part 2-12: Particular requirements and tests for constant voltage transformers and power supply units for constant voltage
IEC 61558-2-13:2009	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-13: Particular requirements and tests for auto transformers and power supply units incorporating auto transformers
IEC 61558-2-14:2012	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-14: Particular requirements and tests for variable transformers and power supply units incorporating variable transformers
IEC 61558-2-26:2013	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-26: Particular requirements and tests for transformers and power supply units all for saving energy and other purposes
IEC 62041:2017	Transformers, power supplies, reactors and similar products - EMC requirements

Table 2-20: Standards under development

Reference	Title
IEC 61558-2-1 ED3	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-1: Particular requirements and tests for separating transformers and power supplies incorporating separating transformers for general applications
IEC 61558-2-4 ED3	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers for general applications

Reference	Title
IEC 61558-2-6 ED3	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general applications
IEC 61558-2-16 ED2	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units for general applications

2.2.5 Energy Storage Supercapacitor

Storage for energy harvesting devices relies on standardization work by IEC/TC 21: *Secondary cells and batteries*, IEC/TC 35: *Primary cells and batteries*, IEC/TC 33*: Power capacitors and their applications*, and IEC/TC 40: *Capacitors and resistors for electronic equipment.*

Since InComEss tackles the development of supercapacitors for energy storage, the main reference committee is **IEC/TC 40, *Capacitors and resistors for electronic equipment*** which focuses its activity on the standardization of:

a) Capacitors, resistors, thermistors and varistors intended for use in electronic equipment.

b) Capacitors, resistors and inductors and complete electromagnetic interference (EMI) suppression filter units for EMI suppression.

c) Passive integrated circuits or networks containing resistors, capacitors, inductors or their combinations. For the dimensional standardization of the final package, requirements laid down by TC 47 shall be adopted whenever possible.

d) Packaging of electronic components for automatic handling, which is an activity undertaken on behalf of all relevant component technical committees.

e) Electric double layer capacitors for use in electric and electronic equipment.

Table 2-21: Selection of published standards on capacitors

Reference	Title
IEC 62391-1:2015	Fixed electric double-layer capacitors for use in electric and 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 62391-2-1:2006	Fixed electric double-layer capacitors for use in electronic equipment - Part 2-1: Blank detail specification - Electric double-layer capacitors for power application - Assessment level EZ

Table 2-22: Standards under development

Reference	Title
IEC 62391-1 ED3	Fixed electric double-layer capacitors for use in electric and electronic equipment - Part 1: Generic specification

Concerning the development of carbon-based electrodes used for supercapacitors, the following publications could be used as reference:

Table 2-23: Selection of published standards on carbon electrodes

Reference	Title	Technical Committee
IEC TR 62157:2001	Cylindrical machined carbon electrodes - Nominal dimensions	IEC/TC 27, Industrial

Reference	Title	Technical Committee
		electroheating and electromagnetic processing
IEC TS 62607-4-6:2018	Nanomanufacturing - Key control characteristics - Part 4-6: Nano-enabled electrical energy storage devices - Determination of carbon content for nano electrode materials, infrared absorption method	IEC/TC 113, Nanotechnologies

Table 2-24: Standards under development

Reference	Title
PWI 113-122	Nano-enabled electrical energy storage – Hybrid Supercapacitors for ISG application – Electrochemical characterisations of electrodes and modules

In addition, IEC/TC 47 on semiconductor devices is working on the development of the following standard:

Table 2-25: Standards under development

Reference	Title
IEC 62830-8 ED1	Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 8- Test and evaluation methods of flexible and stretchable supercapacitors for use in low power electronics

Standards on printed electronics that could serve as a reference for the manufacturing of supercapacitors are listed in subclause 2.2.7.2.

2.2.6 Wireless Sensor Networks (WSN) and IoT

At international level the technical subcommittee **ISO/IEC JTC 1/SC 41, *Internet of things and related technologies*** serves as the focus and proponent for the standardization programme on the Internet of Things and related technologies, including sensor networks and wearables technologies.

Table 2-26: Selection of published standards on sensor networks

Reference	Title
ISO/IEC 19637:2016	Information technology - Sensor network testing framework
ISO/IEC 20005:2013	Information technology - Sensor networks - Services and interfaces supporting collaborative information processing in intelligent sensor networks
ISO/IEC TR 22560:2017	Information technology - Sensor network - Guidelines for design in the aeronautics industry: Active air-flow control
ISO/IEC 29182-1:2013	Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 1: General overview and requirements
ISO/IEC 29182-2:2013	Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 2: Vocabulary and terminology
ISO/IEC 29182-3:2014	Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 3: Reference architecture views
ISO/IEC 29182-4:2013	Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 4: Entity models

Reference	Title
ISO/IEC 29182-5:2013	Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 5: Interface definitions
ISO/IEC 29182-6:2014	Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 6: Applications
ISO/IEC 29182-7:2015	Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 7: Interoperability guidelines
ISO/IEC 30128:2014	Information technology -- Sensor networks -- Generic Sensor Network Application Interface

Table 2-27: Selection of published standards on IoT

Reference	Title
ISO/IEC 21823-1:2019	Internet of Things (IoT) - Interoperability for IoT systems - Part 1: Framework

Table 2-28: Standards under development

Reference	Title
ISO/IEC 30149 ED1	Internet of Things (IoT) — Trustworthiness framework
ISO/IEC 30161 ED1	Internet of Things (IoT) - Requirements of IoT data exchange platform for various IoT services
ISO/IEC 30162 ED1	Internet of Things (IoT) - Compatibility requirements and model for devices within industrial IoT systems

2.2.7 Other areas of interest

Besides the key areas identified above, other topics of interest have been considered in which the standardization activity may be also relevant to the development of the InComEss project.

2.2.7.1 Materials

In addition to the specific standards published by **CEN/TC 249, *Plastics*** included in subclauses 2.2.1 and 2.2.2, other documents from this TC could also support the work carried out throughout the project:

Table 2-29: Selection of published standards on plastics

Reference	Title
EN ISO 1628-1:2009	Plastics - Determination of the viscosity of polymers in dilute solution using capillary viscometers - Part 1: General principles (ISO 1628-1:2009)
CEN/TS 16010:2013	Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates (*CEN/TC 249/WG 11, Plastics recycling*)
CEN/TS 16011:2013	Plastics - Recycled plastics - Sample preparation (*CEN/TC 249/WG 11, Plastics recycling*)
EN 15343:2007	Plastics - Recycled Plastics - Plastics recycling traceability and assessment of conformity and recycled content (*CEN/TC 249/WG 11, Plastics recycling*)
EN 15347:2007	Plastics - Recycled Plastics - Characterisation of plastics wastes (*CEN/TC 249/WG 11, Plastics recycling*)
CEN ISO/TR 21960:2020	Plastics - Environmental aspects - State of knowledge and methodologies (ISO/TR 21960:2020) (*CEN/TC 249/WG 24, Environmental aspects*)

Table 2-30: Standards under development

Reference	Title
FprEN 17104	Thermoplastics rigid protective wallcovering panels for internal use in buildings - Performance characteristics
prEN ISO 1628-1	Plastics - Determination of the viscosity of polymers in dilute solution using capillary viscometers - Part 1: General principles (ISO/DIS 1628-1:2020)
prEN ISO 16929	Plastics - Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot-scale test (ISO/DIS 16929:2020)
FprCEN/TS 16010	Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates (*CEN/TC 249/WG 11, Plastics recycling*)
prCEN/TS XXX	Plastics - Recycled plastics - Determination of solid contaminants content (*CEN/TC 249/WG 11, Plastics recycling*)
prEN ISO 527-4 rev	Plastics - Determination of tensile properties - Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites
prEN ISO 527-5 rev	Plastics - Determination of tensile properties - Part 5: Test conditions for unidirectional fibre-reinforced plastic composites
prEN ISO 6721-3	Plastics - Determination of dynamic mechanical properties - Part 3: Flexural vibration - Resonance-curve method (ISO/DIS 6721-3:2020)

On the other hand, since one of the use-cases included in InComEss to demonstrate the performance and efficiency of the smart materials combinations will address the aeronautical field, four useful European standards concerning structural adhesives and fibre reinforced plastics have been identified.

ASD-STAN is the technical body which promotes the harmonization of aerospace standards in Europe and pays attention to these areas where improved standardization can result in reduced costs to manufacturers.

Table 2-31: Selection of published standards on aerospace materials

Reference	Title
EN 2243-1:2005	Aerospace series – Non-metallic materials – Structural adhesive – Test method – Part 1: Single lap shear
EN 2243-2: 2005	Aerospace series – Non-metallic materials – Structural adhesive – Test method – Part 2: peel metal-metal
EN 2823:2017	Aerospace series - Fibre reinforced plastics - Determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics
EN 6032:2015	Aerospace series - Fibre reinforced plastics - Test method - Determination of the glass transition temperatures

2.2.7.2 Printed electronics

A further technology relevant to the energy harvesting and storage market is the technology of the printing of electronic components. In InComEss this technology will be applied to the supercapacitor manufacturing.

The Technical Committee **IEC/TC 119, *Printed Electronics*** is responsible for the standardization of terminology, materials, processes, equipments, products and health/safety/environment in the field of printed electronics.

Table 2-32: Selection of published standards on printed electronics

Reference	Title
IEC 62899-101:2019	Printed electronics - Part 101: Terminology – Vocabulary
IEC 62899-201:2016+AMD1:2018 CSV	Printed electronics - Part 201: Materials – Substrates
IEC 62899-202:2016	Printed electronics - Part 202: Materials - Conductive ink
IEC 62899-202-5:2018	Printed electronics - Part 202-5: Materials - Conductive ink - Mechanical bending test of a printed conductive layer on an insulating substrate
IEC 62899-303-1:2018	Printed electronics - Part 303-1: Equipment - Roll-to-roll printing - Mechanical dimensions
IEC 62899-401:2017	Printed electronics - Part 401: Printability – Overview
IEC 62899-501-1:2019	Printed electronics - Part 501-1: Quality assessment - Failure modes and mechanical testing - Flexible and/or bendable primary or secondary cells

Table 2-33: Standards under development

Reference	Title
IEC 62899-202-6 ED1	Printed electronics – Part 202-6: Materials – Conductive film – Measurement method for resistance changes under high temperature and humidity of a printed metal based conductive layer on a flexible substrate

2.2.7.3 *Nanotechnologies*

As key enabling technologies, the use and application of nanotechnologies will be present in the configuration of materials in InComEss. The main TCs that address this field have been identified.

At European level, **CEN/TC 352, *Nanotechnologies*** is engaged in standardization in the field of nanotechnologies that includes either or both of the following:

i) understanding and control of matter and processes at the nanoscale, typically, but not exclusively below 100 nanometres in one or more dimensions, where the onset of size dependent phenomena usually enables novel applications;

ii) utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules or bulk matter, to create improved materials, devices and systems that exploit these new properties.

Specific tasks include developing standards for: classification, terminology and nomenclature; metrology and instrumentation, including specifications for reference materials; test methodologies; modelling and simulation; science-based health, safety and environmental practices; and nanotechnology products and processes. Standards in each of these areas could be specific to a product, process or industry.

The technical mirror committee at international level is **ISO/TC 229**, with the same designation and scope.

More specifically related to the electrotechnical field, the technical committee **IEC/TC 113, *Nanotechnology for electrotechnical products and systems*** is in charge of the standardization of the technologies relevant to electrotechnical products and systems in the field of nanotechnology in close cooperation with other committees like ISO/TC 229.

In addition to the standards included in previous subclauses, a selection of horizontal published standards on nanotechnologies is shown below:

Table 2-34: Selection of published standards on nanotechnologies

Reference	Title
CEN ISO/TS 17200:2015	Nanotechnology - Nanoparticles in powder form - Characteristics and measurements (ISO/TS 17200:2013)
CEN ISO/TS 80004 (series)	Nanotechnologies – Vocabulary (ISO/TS 80004 series)
CEN/TS 16937:2016	Nanotechnologies - Guidance for the responsible development of nanotechnologies
CEN/TS 17010:2016	Nanotechnologies - Guidance on measurands for characterising nano-objects and materials that contain them
CEN/TS 17273:2018	Nanotechnologies - Guidance on detection and identification of nano-objects in complex matrices
CEN/TS 17275:2018	Nanotechnologies - Guidelines for the management and disposal of waste from the manufacturing and processing of manufactured nano-objects
CEN/TS 17276:2018	Nanotechnologies - Guidelines for Life Cycle Assessment - Application of EN ISO 14044:2006 to Manufactured Nanomaterials
ISO/TR 11360:2010	Nanotechnologies — Methodology for the classification and categorization of nanomaterials
ISO/TS 12805:2011	Nanotechnologies — Materials specifications — Guidance on specifying nano-objects
ISO/TR 13121:2011	Nanotechnologies — Nanomaterial risk evaluation
ISO/TR 16196:2016	Nanotechnologies — Compilation and description of sample preparation and dosing methods for engineered and manufactured nanomaterials
ISO/TR 16197:2014	Nanotechnologies — Compilation and description of toxicological screening methods for manufactured nanomaterials
ISO/TS 21362:2018	Nanotechnologies — Analysis of nano-objects using asymmetrical-flow and centrifugal field-flow fractionation

2.2.8 Other documents of interest

Outside of the work carried out by the officially recognized European and International Standardization Organizations, the following documents are also of interest to the InComEss partners due to the consideration of different aspects of the project:

- **ASTM D7136/D7136M-15:** Standard Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event.
- **ASTM D5229/D5229M-20:** Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials.
- **ASTM D5279-13:** Standard Test Method for Plastics: Dynamic Mechanical Properties: In Torsion.
- **ASTM D1238-13:** Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
- **ASTM D3835-16:** Standard Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer.
- **ASTM D4496-13:** Standard Test Method for DC Resistance or Conductance of Moderately Conductive Materials.
- **ASTM D257-14:** Standard Test Method for DC Resistance or Conductance of Insulating Materials.
- **ASTM D5930-17:** Standard Test Method for Thermal Conductivity of Plastics by Means of a Transient Line-Source Technique
- **RTCA-DO-160G:** Environmental Conditions and Test Procedures for Airbone Equipment.

3 Conclusions

After the analysis of the current standardization context at European and international levels, the following conclusions may be drawn:

There are several European and international technical committees, as well as published standards and under development related to InComEss project that may be useful for its development and also for its future dissemination. Although there is no specific standardization technical committee whose activity covers the InComEss project as a whole, some tasks to be addressed in the project may be related to standardization work. In particular, the study shows the absence of specific normative documents related to hybrid thermo/piezoelectric materials and, therefore, there is a good opportunity to fill this gap by raising a proposal based on the results of the project in this area to the standardization organizations. Concerning the power conditioning system, possibilities can also be explored to help set standards of some sort.

Depending on the assessment by InComEss partners of the impact of the identified standardization committees on their tasks and the level of contribution that their results can represent for these committees and for the development of deliverable D9.10 *Report on the contribution to standardization*, some actions could be performed:

- Monitoring of the standardization activity through updates reported by UNE;
- follow-up by joining one or more InComEss representatives to the standardization committees of interest. Standardization is an open activity and all interested parties may participate in a CEN/CENELEC/ISO/IEC technical committee through its National Mirror Committee and National Standardization Body;

NOTE: The participation in European or International TC shall be achieved according to the policy of the NSBs about the nomination of experts.

- dissemination of the InComEss project achievements by delivering information to the relevant TCs Secretaries or by attending relevant technical committee meetings.

Concerning the dissemination activities, although all the technical committees in this report have some relation to InComEss project, probably the most relevant are those related to the energy harvesting systems which are summarised in the following table:

Table 3-1: Main technical committees for dissemination activities

Subject	Technical Committee
Piezoelectric energy harvesting	CLC/SR 49, *Piezoelectric and dielectric devices for frequency control and selection* IEC/TC 49, *Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection*
	ISO/TC 61, *Plastics* CEN/TC 249, *Plastics*
	ISO/TC 206, *Fine ceramics* CEN/TC 184, *Advanced technical ceramics*
	IEC/TC 47, *Semiconductor devices*
Thermoelectric energy harvesting	ISO/TC 229, *Nanotechnologies* IEC/TC 113, *Nanotechnology for electrotechnical products and systems*
	ISO/TC 61, *Plastics* CEN/TC 249, *Plastics*
	IEC/TC 47, *Semiconductor devices*
Power conditioning system	CLC/TC 22X, *Power electronics*

Subject	Technical Committee
	IEC/TC 22, *Power electronic systems and equipment*
	CLC/TC 38, *Instrument transformers*
	IEC/TC 96, *Transformers, reactors, power supply units, and combinations thereof*
Supercapacitor	IEC/TC 40, *Capacitors and resistors for electronic equipment*
	IEC/TC 119, *Printed electronics*

The close relationship with these committees will facilitate the performance of dissemination actions and the preparation of a proposal for future standardization.

In the following stages of the project when the results are closer, next standardization subtask 9.3.2 will evaluate the interest and potential of these results to be part of future standards. This will be assessed by considering factors such as:

- the situation of the works of the relevant TCs at that moment,
- the possible contents of the project to be proposed and its relationship with the fields of activity of the TCs involved,
- the exploitation and IP protection plans of the project, balancing confidentiality requirements and benefits of inclusion in standards for future commercialization.

With the technical contribution of InComEss partners and the UNE assistance on standardization, a technical proposal should be elaborated from project results. UNE assistance within the consortium will ensure that this proposal fits the standardization procedures and requirements to be ready for inclusion in future development of new standards or into revised ones.

The evaluation, the standardization route, the technical proposal itself and the advance reached in the consensus building process will be reported in deliverable D9.10 *Report on the contribution to standardization*.

4 Annex I. Information on the scopes of published standards

This annex provides an overview of the scope of the published standards that have been identified in the present study.

EN 50324-1:2002, *Piezoelectric properties of ceramic materials and components - Part 1: Terms and definitions*

This standard includes a survey of marginal conditions as well as test methods for the determination of material relating to characteristics of piezoelectric ceramics and transducers which are mainly intended for use as sound generators and receivers in electro-acoustics and ultra-sound engineering. It also includes definitions and characteristics of piezoelectric ceramics and transducers

EN 50324-2:2002, *Piezoelectric properties of ceramic materials and components - Part 2: Methods of measurement - Low power*

The methods of measurement described in this European Standard are for use with piezoelectric components produced from the ceramic materials described in EN 50324 1 “Terms and definitions”. Methods of measurement for specific dielectric, piezoelectric and elastic coefficients are generally applicable to piezoelectric ceramics. The polycrystalline nature of ceramics, statistical fluctuations in composition and the influence of the manufacturing process, result in specified material coefficients being typical mean values. These values are provided for design information only. Piezoelectric transducers can have widely differing shapes and may be employed in a range of vibrational modes. Material parameters however, are measured on simple test-pieces (discs, rods etc. see EN 50324-1, Figure 2) using specific geometric and electrical boundary conditions. Consequently, the results of the tests provide basic material parameters only and must only be used as a guide to the actual properties of manufactured commercial components.

EN 50324-3:2002, *Piezoelectric properties of ceramic materials and components - Part 3: Methods of measurement - High power*

This European Standard relates to piezoelectric transducer ceramics for power application over a wide frequency range both as electromechanical or mechanoelectrical converters. This standard covers the large signal characterization of piezoelectric ceramics material only, and not the characterization of a complete assembled transducer. The selection of a material for a given power application is difficult and the advice given in clause 2 is mainly indicative.

EN 62884-1:2017, *Measurement techniques of piezoelectric, dielectric and electrostatic oscillators - Part 1: Basic methods for the measurement*

This standard specifies the measurement techniques for piezoelectric, dielectric and electrostatic oscillators, including Dielectric Resonator Oscillators (DROs) and oscillators using FBAR.

EN 62884-2:2017, *Measurement techniques of piezoelectric, dielectric and electrostatic oscillators - Part 2: Phase jitter measurement method*

EN 62884-2:2017 specifies the methods for the measurement and evaluation of the phase jitter measurement of piezoelectric, dielectric and electrostatic oscillators, including dielectric resonator oscillators (DROs) and oscillators using a thin-film bulk acoustic resonator (FBAR) and gives guidance for phase jitter that allows the accurate measurement of RMS jitter. In the measurement method, phase noise measurement equipment or a phase noise measurement system is used. NOTE Dielectric resonator oscillators (DROs) and oscillators using FBAR are under consideration.

EN IEC 62884-3:2018, *Measurement techniques of piezoelectric, dielectric and electrostatic oscillators – Part 3: Frequency aging test methods*

EN IEC 62884-3:2018 describes the methods for the measurement and evaluation of frequency aging tests of piezoelectric, dielectric and electrostatic oscillators, including Dielectric Resonator Oscillators (DRO) and oscillators using FBAR. The purpose of those tests is to provide statistical data supporting aging predictions. This document was developed from the works related to IEC 60679-1:2007 (third edition), the measurement techniques of which were restructured into different parts under a new project reference. This document describes the measurement method for frequency aging only.

EN IEC 62884-4:2019, *Measurement techniques of piezoelectric, dielectric and electrostatic oscillators - Part 4 : Short-term frequency stability test methods*

EN IEC 62884-4:2019 describes the methods for the measurement and evaluation of the short-term frequency stability tests of piezoelectric, dielectric and electrostatic oscillators. Its purpose is to unify the test and evaluation methods for short-term frequency stability.

ISO 15014:2007, *Plastics — Extruded sheets of poly(vinylidene fluoride) (PVDF) — Requirements and test methods*

ISO 15014:2007 specifies the requirements and test methods for solid flat extruded sheets of poly(vinylidene fluoride) homopolymers and poly(vinylidene fluoride) copolymers without fillers or reinforcing materials. The standard also applies to PVDF sheet in rolled form. It applies only to thicknesses from 1 mm to 15 mm.

ISO 17859:2015, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Measurement method of piezoelectric strain at high electric field*

This International Standard specifies the measurement method of piezoelectric strain at high electric field for high power piezoelectric devices. This International Standard is intended to be used to determine the piezoelectric strain coefficient of the materials by measuring strain vs. electric field:

— applied electric field: 0 to 2 MV/m;

— frequency of electric field: 0,1 to 1 Hz.

ISO 19622:2018, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for piezoelectric constant d33 of piezoelectric ceramics by direct quasi-static method*

This document specifies how to measure the piezoelectric constant d33 of piezoelectric ceramics using a direct quasi-static method (d33 meter method, Berlincourt method).

ISO 21819-1:2018, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Characteristic of piezoelectric properties under high-load conditions — Part 1: Resonant-antiresonant method under high-temperature conditions*

This document specifies a method of measuring piezoelectric properties of piezoelectric fine ceramics and other piezoelectric devices under high-temperature conditions, where the electromechanical coupling coefficient is determined based on measurements of resonance/antiresonance frequencies using impedance analysers.

ISO 21819-2:2018, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Characteristic of piezoelectric properties under high-load conditions — Part 2: Electrical transient response method under high vibration levels*

This document specifies a method of measuring piezoelectric properties of piezoelectric fine ceramics and other piezoelectric devices. It applies to electrical transient response methods for evaluating the piezoelectric properties of piezoelectric fine ceramics resonators under high vibration levels.

EN 1007-1:2002, *Advanced technical ceramics - Ceramic composites - Methods of test for reinforcement - Part 1: Determination of size content*

This part of EN 1007 specifies a method for the determination of the size content of ceramic fibres, including silicon carbide, silicon nitride, silicon carbon-nitride, alumino-silicate, alumina or silicon oxide fibres.

EN 1007-3:2002, *Advanced technical ceramics - Ceramic composites - Methods of test for reinforcement - Part 3: Determination of filament diameter and cross-section area*

This part of EN 1007 specifies three methods for the determination of the diameter and cross-section area of ceramic single filament, as used in fibre reinforcement of ceramic composites. Note: The cross-sectional area of filaments from different suppliers will vary significantly. The term "diameter" applies both to circular cross-section ("true diameter") and non-circular cross-sections ("apparent diameter").

EN 1007-4:2004, *Advanced technical ceramics - Ceramic composites - Methods of test for reinforcement - Part 4: Determination of tensile properties of filaments at ambient temperature*

This part of EN 1007 specifies the conditions for determination of tensile strength and elongation at fracture of single filaments of ceramic fibre such as tensile strength, Young modulus and stress-strain curve. The method applies to continuous ceramic filaments taken from tows, yarns, braids and knittings, which have strain to fracture less than or equal to 5 %. The method does not apply to check the homogeneity of strength properties of fibres, nor to assess the effects of volume under stress. Statistical aspects of filament failure are not included.

EN 1007-5:2010, *Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements - Part 5: Determination of distribution of tensile strength and of tensile strain to failure of filaments within a multifilament tow at ambient temperature*

This European Standard specifies the conditions, apparatus and procedure for determining the distribution of tensile strength and tensile strain to failure of ceramic filaments in multifilament tows at ambient temperature. This European Standard applies to tows of continuous ceramic filaments, which are assumed to act freely and independently under loading and behave linearly elastic up to failure.

EN 1007-6:2007, *Advanced technical ceramic - Ceramic composites - Methods of test for reinforcements - Part 6: Determination of tensile properties of filaments at high temperature*

This European Standard specifies the conditions for measurement of tensile properties of single filament of ceramic fibres at high temperatures in air or inert atmosphere (vacuum or controlled atmosphere). The method applies to continuous ceramic filaments taken from tows, yarns, staple fibre, braids and knitting, that have strain to fracture less or equal to 5 % and show linear elastic behaviour to fracture. The method does not apply to testing for homogeneity of strength properties of fibres, nor does it assess the effects of volume under stress. Statistical aspects of fibre failure are not included. Two methods are proposed depending on the temperature of the filament end: Hot end method: this method allows determination of tensile strength, of Young's modulus and of the stress strain curve. NOTE 1 Current experience with this technique is limited to 1 300 °C, because of the application temperature of ceramic glue. Cold end method. NOTE 2 This method is limited to 1 700 °C in air and 2 000 °C in inert atmosphere because of the limits of furnaces.

EN 12789:2002, *Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under air at atmospheric pressure - Determination of flexural strength*

This standard specifies the conditions for determination of the flexural strength of ceramic matrix composite materials with continuous fibre reinforcement under three-point or four-point bending for temperatures up to 1700°C in air at atmospheric pressure. This Prestandard applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional (x D, where $2 < x \leq 3$).

EN 13234:2006, *Advanced technical ceramics - Mechanical properties of ceramic composites at ambient temperature - Evaluation of the resistance to crack propagation by notch sensitivity testing*

This European Standard describes a method for the classification of ceramic matrix composite (CMC) materials with respect to their sensitivity to crack propagation using tensile tests on notched specimens with different notch depths. Two classes of ceramic matrix composite materials can be distinguished: materials whose strength is sensitive to the presence of notches and materials whose strength is not affected. For sensitive materials, this European Standard defines a method for determining equivalent fracture toughness. The parameter, Keq, is defined as the fracture toughness of a homogeneous material which presents the same sensitivity to crack propagation as the ceramic matrix composite material which is being considered. The definition of the Keq parameter offers the possibility to compare ceramic matrix composite materials with other materials with respect to sensitivity to crack propagation. For notch insensitive materials, the concept of Keq does not apply. This European Standard applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1 D), bidirectional (2 D), and tridirectional (x D, where $2 < x \leq 3$), loaded along one principal axis of reinforcement.

EN 1389:2003, *Advanced technical ceramics - Ceramic composites - Physical properties - Determination of density and apparent porosity*

This European Standard describes two methods for determination of the bulk density and apparent porosity of ceramic matrix composites with fibrous continuous reinforcement (1D, 2D, 3D). Two methods are described and are designated as Methods A and B, as follows: - Method A: Determination of bulk density only, by measurement of dimensions and mass; - Method B: Determination of bulk density and apparent porosity by liquid displacement.

EN 658-1:1998, *Advanced technical ceramics - Mechanical properties of ceramic composites at room temperature - Part 1: Determination of tensile properties*

This part of EN 658 specifies the conditions for determination of tensile properties of ceramic matrix composite materials with continuous fibre reinforcement at ambient temperature. This standard applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D) and tridirectional (x D, where $2 < x \leq 3$).

EN 658-3:2002, *Advanced technical ceramics - Mechanical properties of ceramic composites at room temperature - Part 3: Determination of flexural strength*

This part of EN 658 specifies the conditions for the determination of the flexural strength of ceramic matrix composite materials with continuous fibre reinforcement, under three-point or four-point bending at ambient temperature. This standard applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional xD with ($2 < x <= 3$), loaded along one principal axis of reinforcement.

EN 843-2:2006, *Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 2: Determination of Young's modulus, shear modulus and Poisson's ratio*

This part of EN 843 specifies methods for determining the elastic moduli, specifically Young's modulus, shear modulus and Poisson's ratio, of advanced monolithic technical ceramics at room temperature. This European Standard prescribes four alternative methods for determining some or all of these three parameters: A) The determination of Young's modulus by static flexure of a thin beam in three- or four-point flexure. B) The determination of Young's modulus by forced longitudinal resonance, or Young's modulus, shear modulus and Poisson's ratio by forced flexural and torsional resonance, of a thin beam. C) The determination of Young's modulus, shear modulus and Poisson's ratio from the time-of-flight of an ultrasonic pulse. D) The determination of Young's modulus from the fundamental natural frequency of a struck bar (impulse excitation method). All the test methods assume the use of homogeneous test pieces of linear elastic materials. NOTE 1 Not all ceramic materials are equally and linearly elastic in tension and compression, such as some porous materials and some piezoelectric materials. With the exception of Method C, the test assumes that the test piece has isotropic elastic properties. Method C may be used to determine the degree of anisotropy by testing in different orientations. NOTE 2 An ultrasonic method for dealing with anisotropic materials (ceramic matrix composites) can be found in ENV 14186 (see Bibliography). An alternative to Method D for isotropic materials using disc test pieces is given in Annex A. NOTE 3 At high porosity levels all of the methods except Method C can become inappropriate. The methods are only suitable for a maximum grain size (see EN 623-3), excluding deliberately added whiskers, of less than 10 % of the minimum dimension of the test piece. NOTE 4 The different methods given in this European Standard can produce slightly different results on the same material.

EN ISO 14544:2016, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at high temperature - Determination of compression properties (ISO 14544:2013)*

ISO 14544:2013 specifies the conditions for determination of compression properties of ceramic matrix composite materials with continuous fibre reinforcement for temperatures up to 2 000 °C. ISO 14544:2013 applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional (xD, with $2 < x \leq 3$), loaded along one principal axis of reinforcement.

EN ISO 14574:2016, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at high temperature - Determination of tensile properties (ISO 14574:2013)*

ISO 14574:2013 specifies the conditions for determination of tensile properties of ceramic matrix composite materials with continuous fibre reinforcement for temperatures up to 2 000 °C. ISO 14574:2013 applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bi-directional (2D), and tri-directional (xD, with $2 < x \leq 3$), loaded along one principal axis of reinforcement.

EN ISO 17140:2016, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at room temperature - Determination of fatigue properties at constant amplitude (ISO 17140:2014)*

ISO 17140:2014 specifies the conditions for the determination of properties at constant-amplitude of load or strain in uniaxial tension/tension or in uniaxial tension/compression cyclic fatigue of ceramic matrix composite materials (CMCs) with fibre reinforcement at room temperature. It applies to all ceramic matrix composites with fibre reinforcement, unidirectional (1D), bi-directional (2D), and tri-directional (xD, where $2 < x \leq 3$).

EN ISO 1133-1:2011, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method (ISO 1133-1:2011)*

This part of EN ISO 1133 specifies two procedures for the determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastic materials under specified conditions of temperature and load. Procedure A is a mass-measurement method. Procedure B is a displacement-measurement method. Normally, the test conditions for measurement of melt flow rate are specified in the material standard with a reference to this part of ISO 1133. The test conditions normally used for thermoplastics are listed in Annex A.

The MVR is particularly useful when comparing materials of different filler content and when comparing filled with unfilled thermoplastics. The MFR can be determined from MVR measurements, or vice versa, provided the melt density at the test temperature is known.

This part of ISO 1133 is also possibly applicable to thermoplastics for which the rheological behaviour is affected during the measurement by phenomena such as hydrolysis (chain scission), condensation and cross-linking, but only if the effect is limited in extent and only if the repeatability and reproducibility are within an acceptable range. For materials which show significantly affected rheological behaviour during testing, this part of ISO 1133 is not appropriate. In such cases, ISO 1133-2 applies.

NOTE The rates of shear in these methods are much smaller than those used under normal conditions of processing, and therefore it is possible that data obtained by these methods for various thermoplastics will not always correlate with their behaviour during processing. Both methods are used primarily in quality control.

EN ISO 11357-1:2016, *Plastics - Differential scanning calorimetry (DSC) - Part 1: General principles (ISO 11357-1:2016)*

EN ISO 11357-1:2016 specifies several differential scanning calorimetry (DSC) methods for the thermal analysis of polymers and polymer blends, such as thermoplastics (polymers, moulding compounds and other moulding materials, with or without fillers, fibres or reinforcements), thermosets (uncured or cured materials, with or without fillers, fibres or reinforcements), and elastomers (with or without fillers, fibres or reinforcements). This standard is intended for the observation and measurement of various properties of, and phenomena associated with, the above-mentioned materials, such as physical transitions (glass transition, phase transitions such as melting and crystallization, polymorphic transitions, etc.), chemical reactions (polymerization, crosslinking and curing of elastomers and thermosets, etc.), the stability to oxidation, and the heat capacity. EN ISO 11357-1:2016 specifies a number of general aspects of differential scanning calorimetry, such as the principle and the apparatus, sampling, calibration and general aspects of the procedure and test report common to all following parts. Details on performing specific methods are given in subsequent parts of EN ISO 11357.

EN ISO 11357-2:2020, *Plastics - Differential scanning calorimetry (DSC) - Part 2: Determination of glass transition temperature and step height (ISO 11357-2:2020)*

This document specifies methods for the determination of the glass transition temperature and the step height related to the glass transition of amorphous and partially crystalline plastics.

EN ISO 11357-3:2018, *Plastics - Differential scanning calorimetry (DSC) - Part 3: Determination of temperature and enthalpy of melting and crystallization (ISO 11357-3:2018)*

This document specifies a method for the determination of the temperatures and enthalpies of melting and crystallization of crystalline or partially crystalline plastics.

EN ISO 11357-4:2014, *Plastics - Differential scanning calorimetry (DSC) - Part 4: Determination of specific heat capacity (ISO 11357-4:2014)*

This document specifies methods for determining the specific heat capacity of plastics by differential scanning calorimetry.

EN ISO 11357-5:2014, *Plastics - Differential scanning calorimetry (DSC) - Part 5: Determination of characteristic reaction-curve temperatures and times, enthalpy of reaction and degree of conversion (ISO 11357-5:2013)*

This document specifies a method for the determination of reaction temperatures and times, enthalpies of reaction, and degrees of conversion using differential scanning calorimetry (DSC). The method applies to monomers, prepolymers, and polymers in the solid or liquid state. The material can contain fillers and/or initiators in the solid or liquid state.

EN ISO 11357-7:2015, *Plastics - Differential scanning calorimetry (DSC) - Part 7: Determination of crystallization kinetics (ISO 11357-7:2015)*

This document specifies two methods (isothermal and non-isothermal) for studying the crystallization kinetics of partially crystalline polymers using differential scanning calorimetry (DSC). It is only applicable to molten polymers. NOTE These methods are not suitable if the molecular structure of the polymer is modified during the test.

EN ISO 11358-1:2014, *Plastics - Thermogravimetry (TG) of polymers - Part 1: General principles (ISO 11358-1:2014)*

EN ISO 11358-1:2014 specifies general conditions for the analysis of polymers using thermogravimetric techniques. It is applicable to liquids or solids. Solid materials may be in the form of pellets, granules or powders. Fabricated shapes reduced to appropriate specimen size may also be analysed by this method.

EN ISO 2060:1995, *Textiles — Yarn from packages — Determination of linear density (mass per unit length) by the skein method (ISO 2060:1994)*

Specifies a method for the determination of the linear density of all types of yarn in package form. Includes seven optional procedures based on different methods of conditioning and preparation. This method is applicable to single yarns; folded yarns; cabled yarns. Not applicable to yarns which stretch more than 0,5 % when the tension, in centinewtons, per unit linear density of yarn, in tex, increases from 0,5 to 1,0. Not applicable to yarns having a linear density greater than 2 000 tex.

EN ISO 2062:2009, *Textiles — Yarns from packages — Determination of single-end breaking force and elongation at break using constant rate of extension (CRE) tester (ISO 2062:2009)*

ISO 2062:2009 specifies methods for the determination of the breaking force and elongation at break of textile yarns taken from packages. Four methods are given: A) manual; specimens are taken directly from conditioned packages; B) automatic; specimens are taken directly from conditioned packages; C) manual; relaxed test skeins are used after conditioning; D) manual; specimens are used after wetting. Method C is used in cases of dispute regarding elongation at break of the yarn. ISO 2062:2009 specifies methods using constant rate of specimen extension (CRE) tensile testers. Testing on the now obsolete constant rate of travel (CRT) and constant rate of loading (CRL) instruments is covered, for information, in Annex A, in recognition of the fact that these instruments are still in use and can be used by agreement. ISO 2062:2009 applies to all types of yarns, except glass, elastomeric, aramid, high molecular polyethylene (HMPE), ultra high molecular polyethylene

(UHMPE), ceramic and carbon yarns and polyolefin tape. ISO 2062:2009 is applicable to yarns from packages but can be applied to yarns extracted from fabrics, subject to agreement between the interested parties. ISO 2062:2009 is intended for the single-end (single-strand) testing of yarns.

IEC 62830-1:2017, *Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 1: Vibration based piezoelectric energy harvesting*

IEC 62830-1:2017 defines terms, definitions, symbols, configurations, and test methods that can be used to evaluate and determine the performance characteristics of vibration based piezoelectric energy harvesting devices for practical use. This document is applicable to energy harvesting devices for consumer, general industries, military and aerospace applications without any limitations on device technology and size.

IEC 62830-4:2019, *Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 4: Test and evaluation methods for flexible piezoelectric energy harvesting devices*

IEC 62830-4:2019 describes terms, definitions, symbols, configurations, and test methods that can be used to evaluate and determine the performance characteristics of flexible piezoelectric energy harvesting devices for practical use. This document is applicable to energy harvesting devices for consumers, general industries, wearable electronics, military, and biomedical applications without any limitations of device technology and size.

IEC 62969-3:2018, *Semiconductor devices - Semiconductor interface for automotive vehicles - Part 3: Shock driven piezoelectric energy harvesting for automotive vehicle sensors (Adopted at European level as EN IEC 62969-3:2018)*

This standard describes terms, definitions, symbols, configurations, and test methods that can be used to evaluate and determine the performance characteristics of mechanical shock driven piezoelectric energy harvesting devices for automotive vehicle sensor applications. This document is also applicable to energy harvesting devices for motorbikes, automobiles, buses, trucks and their respective engineering subsystems applications without any limitations of device technology and size.

IEC 63150-1:2019, *Semiconductor devices - Measurement and evaluation methods of kinetic energy harvesting devices under practical vibration environment - Part 1: Arbitrary and random mechanical vibrations*

IEC 63150-1:2019 specifies terms and definitions, and test methods for kinetic energy harvesting devices for one-dimensional mechanical vibrations to determine the characteristic parameters under a practical vibration environment. Such vibration energy harvesting devices often have their own non-linear mechanisms to efficiently capture vibration energy in a broadband frequency range. This document is applicable to vibration energy harvesting devices with different power generation principles (such as electromagnetic, piezoelectric, electrostatic, etc.) and with different non-linear behaviour to the external mechanical excitation.

IEC 62047-28:2017, *Semiconductor devices - Micro-electromechanical devices - Part 28: Performance testing method of vibration-driven MEMS electret energy harvesting devices*

This international standard specifies terms and definitions, and a performance testing method of vibration driven MEMS electret energy harvesting devices to determine the characteristic parameters for consumer, industry or any application. This document applies to vibration driven electret energy harvesting devices whose electrodes with a gap below 1 000 μm are covered by dielectric material with trapped charges and are fabricated by MEMS processes such as etching, photolithography or deposition.

IEC 62047-30:2017, *Semiconductor devices - Micro-electromechanical devices - Part 30: Measurement methods of electro-mechanical conversion characteristics of MEMS piezoelectric thin film*

IEC 62047-30:2017(E) specifies measuring methods of electro-mechanical conversion characteristics of piezoelectric thin film used for micro sensors and micro actuators, and its reporting schema to determine the characteristic parameters for consumer, industry or any other applications

of piezoelectric devices. This document applies to piezoelectric thin films fabricated by MEMS process.

ISO/TS 10797:2012, *Nanotechnologies — Characterization of single-wall carbon nanotubes using transmission electron microscope*

ISO/TS 10797:2012 establishes methods for characterizing the morphology of single-wall carbon nanotubes (SWCNTs) and identifying the elemental composition of other materials in SWCNT samples, using transmission electron microscopy and chemical analysis by energy dispersive X-ray spectrometry.

ISO/TS 10798:2011, *Nanotechnologies — Characterization of single-wall carbon nanotubes using scanning electron microscopy and energy dispersive X-ray spectrometry analysis*

ISO/TS 10798:2011 establishes methods to characterize the morphology, and to identify the elemental composition of catalysts and other inorganic impurities in raw and purified single-wall carbon nanotube (SWCNT) powders and films, using scanning electron microscopy and energy dispersive X-ray spectrometry analysis.

The methods described in ISO/TS 10798:2011 for SWCNTs can also be applied to the analysis of multiwall carbon nanotubes (MWCNTs).

ISO/TS 10867:2019, *Nanotechnologies — Characterization of single-wall carbon nanotubes using near infrared photoluminescence spectroscopy*

This document gives guidelines for the characterization of single-wall carbon nanotubes (SWCNTs) using near infrared (NIR) photoluminescence (PL) spectroscopy.

It provides a measurement method for the determination of the chiral indices of the semi-conducting SWCNTs in a sample and their relative integrated PL intensities.

The method can be expanded to estimate the relative mass concentrations of semi-conducting SWCNTs in a sample from their measured integrated PL intensities and knowledge of their PL cross-sections.

ISO/TS 10868:2017, *Nanotechnologies — Characterization of single-wall carbon nanotubes using ultraviolet-visible-near infrared (UV-Vis-NIR) absorption spectroscopy*

ISO/TS 10868:2017 provides guidelines for the characterization of compounds containing single-wall carbon nanotubes (SWCNTs) by using optical absorption spectroscopy.

The aim of this document is to describe a measurement method to characterize the diameter, the purity, and the ratio of metallic SWCNTs to the total SWCNT content in the sample.

The analysis of the nanotube diameter is applicable for the diameter range from 1 nm to 2 nm.

ISO/TR 10929:2012, *Nanotechnologies — Characterization of multiwall carbon nanotube (MWCNT) samples*

ISO/TR 10929:2012 identifies the basic properties of multiwall carbon nanotubes (MWCNTs) and the content of impurities, which characterize bulk samples of MWCNTs, and highlights the major measurement methods available to industry for the determination of these parameters.

ISO/TR 10929:2012 provides a sound basis for the research, development and commercialization of these materials.

ISO/TS 11251:2019, *Nanotechnologies — Characterization of volatile components in single-wall carbon nanotube samples using evolved gas analysis/gas chromatograph-mass spectrometry*

This document specifies a method for the characterization of evolved gas components in single-wall carbon nanotube (SWCNT) samples using evolved gas analysis/gas chromatograph mass spectrometry (EGA/GCMS).

NOTE Some difference could appear between qualitative and quantitative results of emitted gas and gas content in the sample due to the heating and the possible presence of catalysts.

ISO/TS 11308:2020, *Nanotechnologies — Characterization of carbon nanotube samples using thermogravimetric analysis*

This document gives guidelines for the characterization of carbon nanotube (CNT)-containing samples by thermogravimetric analysis (TGA), performed in either an inert or oxidizing environment. Guidance is provided on the purity assessment of the CNT samples through a quantitative measure of the types of carbon species present as well as the non-carbon impurities (e.g. metal catalyst particles) within the material.

In addition, this technique provides a qualitative assessment of the thermal stability and homogeneity of the CNT-containing sample. Additional characterization techniques are required to confirm the presence of specific types of CNT and to verify the composition of the metallic impurities present.

ISO/TS 11888:2017, *Nanotechnologies — Characterization of multiwall carbon nanotubes — Mesoscopic shape factors*

ISO/TS 11888:2017 describes methods for the characterization of mesoscopic shape factors of multiwall carbon nanotubes (MWCNTs). Techniques employed include scanning electron microscopy (SEM), transmission electron microscopy (TEM), viscometry, and light scattering analysis.

ISO/TS 11888:2017 also includes additional terms needed to define the characterization of static bending persistence length (SBPL). Measurement methods are given for the evaluation of SBPL, which generally varies from several tens of nanometres to several hundred micrometres.

Well-established concepts and mathematical expressions, analogous to polymer physics, are utilized for the definition of mesoscopic shape factors of MWCNTs.

ISO/TS 13278:2017, *Nanotechnologies — Determination of elemental impurities in samples of carbon nanotubes using inductively coupled plasma mass spectrometry*

ISO/TS 13278:2017 provides methods for the determination of residual elements other than carbon in samples of single-wall carbon nanotubes (SWCNTs) and multiwall carbon nanotubes (MWCNTs) using inductively coupled plasma mass spectrometry (ICP-MS).

The purpose of this document is to provide optimized digestion and preparation procedures for SWCNT and MWCNT samples in order to enable accurate and quantitative determinations of elemental impurities using ICP-MS.

ISO/TS 19808:2020, Nanotechnologies — Carbon nanotube suspensions — Specification of characteristics and measurement methods

This document specifies the characteristics to be measured of suspensions containing multi-walled carbon nanotubes (CNT suspensions). It includes the essential and additional characteristics of the CNT suspension, and the corresponding measurement methods.

Characteristics specific to health, environmental and safety issues are excluded from this document.

IEC TS 62607-2-1:2012, *Nanomanufacturing - Key control characteristics - Part 2-1: Carbon nanotube materials - Film resistance*

IEC/TS 62607-2-1:2012 which is a technical specification, provides a standardized method for categorizing a grade of commercial carbon nanotubes in terms of their electrical properties to enable a user to select a carbon nanotube material suitable for his application. The method is intended to assess whether the delivered materials from different production batches of the same production process are comparable regarding electrical properties of the final product which are related to electrical conductivity. The correlation between the measured parameters by the proposed method and a relevant product performance parameter has to be established for every application. This specification includes definitions of terminology used in this document, recommendations for sample preparation, outlines of the experimental procedures to measure sheet resistance of carbon nanotubes in thin films, methods of interpretation of results and discussion of data analysis, case studies and references.

IEC TS 62607-2-4:2020, *Nanomanufacturing - Key control characteristics - Part 2-4: Carbon nanotube materials - Test methods for determination of resistance of individual carbon nanotubes*

IEC TS 62607-2-4:2020 specifies the test method for determining the resistivity and the contact resistance of an individual CNT and the dependability of the measurement. This document includes outlines of the experimental procedures used to measure resistance of carbon nanotubes, methods of interpretation of results and discussion of data analysis, and case studies.

IEC 62624:2009, *Test methods for measurement of electrical properties of carbon nanotubes*

IEC 62624:2009 (IEEE 1650:2005) provides methods for the electrical characterization of carbon nanotubes (CNTs). The methods will be independent of processing routes used to fabricate the CNTs.

ISO/TR 19733:2019, *Nanotechnologies — Matrix of properties and measurement techniques for graphene and related two-dimensional (2D) materials*

This document provides a matrix which links key properties of graphene and related two-dimensional (2D) materials to commercially available measurement techniques. The matrix includes measurement techniques to characterize chemical, physical, electrical, optical, thermal and mechanical properties of graphene and related 2D materials.

IEC TS 62607-6-4:2016, *Nanomanufacturing - Key control characteristics - Part 6-4: Graphene - Surface conductance measurement using resonant cavity*

IEC TS 62607-6-4:2016 establishes a method for determining the surface conductance of two-dimensional (2D) single-layer or multi-layer atomically thin nano-carbon graphene structures. These are synthesized by chemical vapour deposition (CVD), epitaxial growth on silicon carbide (SiC), obtained from reduced graphene oxide (rGO) or mechanically exfoliated from graphite. The measurements are made in an air filled standard R100 rectangular waveguide configuration, at one of the resonant frequency modes, typically at 7 GHz. Surface conductance measurement by resonant cavity involves monitoring the resonant frequency shift and change in the quality factor before and after insertion of the specimen into the cavity in a quantitative correlation with the specimen surface area. This measurement does not explicitly depend on the thickness of the nano-carbon layer. The thickness of the specimen does not need to be known, but it is assumed that the lateral dimension is uniform over the specimen area.

EN 62631-3-3:2016, *Dielectric and resistive properties of solid insulating materials - Part 3-3: Determination of resistive properties (DC methods) - Insulation resistance*

This European standard covers methods of test for the determination of the insulation resistance of electrical insulating materials or insulating systems by applying DC voltage. This first edition cancels and replaces the first edition of IEC 60167, published in 1964, and constitutes a technical revision. This edition includes the following significant technical changes with respect to the first edition of IEC 60167: a) IEC 60167 has been completely revised, both editorially and technically, and incorporated into the new IEC 62631 series; b) test methods have been updated to current day state of the art.

EN ISO 3915:1999, Plastics - Measurement of resistivity of conductive plastics (ISO 3915:1981)

Specifies the requirements for the laboratory testing of the resistivity of specially prepared specimens of plastics made conductive by the incorporation of carbon black. The test is suitable for materials having a resistivity of less than 104 Ohm x m. A stable d.c. current is passed between electrodes at the ends of a test piece. A schematic diagram of the test circuit is given. The voltage drop between the two potential electrodes, set on the test piece while the current flows, is measured with an electrometer. The resistance of the portion of the test piece between the potential electrodes is independent of contact resistances.

EN ISO 22007-1:2017, *Plastics - Determination of thermal conductivity and thermal diffusivity - Part 1: General principles (ISO 22007-1:2017)*

EN ISO 22007-1:2017 describes the background to methods for the determination of the thermal conductivity and thermal diffusivity of polymeric materials. Different techniques are available for these measurements and some may be better suited than others for a particular type, state and form of material. EN ISO 22007-1:2017 provides a broad overview of these techniques. Standards specific to these techniques, as referenced in this document, are used to carry out the actual test method.

EN ISO 527-1:2019, *Plastics - Determination of tensile properties - Part 1: General principles (ISO 527-1:2019)*

This document specifies the general principles for determining the tensile properties of plastics and plastic composites under defined conditions. Several different types of test specimen are defined to suit different types of material which are detailed in subsequent parts of ISO 527. The methods are used to investigate the tensile behaviour of the test specimens and for determining the tensile strength, tensile modulus and other aspects of the tensile stress/strain relationship under the conditions defined. The methods are selectively suitable for use with the following materials: — rigid and semi-rigid moulding, extrusion and cast thermoplastic materials, including filled and reinforced compounds in addition to unfilled types; rigid and semi-rigid thermoplastics sheets and films; — rigid and semi-rigid thermosetting moulding materials, including filled and reinforced compounds; rigid and semi-rigid thermosetting sheets, including laminates; — fibre-reinforced thermosets and thermoplastic composites incorporating unidirectional or non-unidirectional reinforcements, such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcement, rovings and milled fibres; sheet made from pre-impregnated materials (prepregs); — thermotropic liquid crystal polymers. The methods are not normally suitable for use with rigid cellular materials, for which ISO 1926 is used, or for sandwich structures containing cellular materials.

EN ISO 527-2:2012, *Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics (ISO 527-2:2012)*

ISO 527-2:2012 specifies the test conditions for determining the tensile properties of moulding and extrusion plastics, based upon the general principles given in ISO 527-1.

EN ISO 180:2019, *Plastics - Determination of Izod impact strength (ISO 180:2019)*

This document specifies a method for determining the Izod impact strength of plastics under defined conditions. A number of different types of specimen and test configurations are defined. Different test parameters are specified according to the type of material, the type of test specimen and the type of notch. The method is used to investigate the behaviour of specified types of specimen under the impact conditions defined and for estimating the brittleness or toughness of specimens within the limitations inherent in the test conditions. The method is suitable for use with the following range of materials: — rigid thermoplastic moulding and extrusion materials, including filled and reinforced compounds in addition to unfilled types; rigid thermoplastics sheets; — rigid thermosetting moulding materials, including filled and reinforced compounds; rigid thermosetting sheets, including laminates; — fibre-reinforced thermosetting and thermoplastic composites incorporating unidirectional or non-unidirectional reinforcements such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings and milled fibres and sheet made from pre-impregnated materials (prepregs); — thermotropic liquid-crystal polymers. The method is not normally suitable for use with rigid cellular materials and sandwich structures containing cellular material. Notched specimens are also not normally used for long-fibre-reinforced composites or thermotropic liquid-crystal polymers. The method is suited to the use of specimens which can be either moulded to the chosen dimensions, machined from the central portion of a standard multipurpose test specimen (see ISO 20753) or machined from finished or semi-finished products such as mouldings, laminates and extruded or cast sheet. The method specifies preferred dimensions for the test specimen. Tests which are carried out on specimens of different dimensions or with different notches, or specimens which are prepared under different conditions, may produce results which are not comparable. Other factors, such as the energy capacity of the apparatus, its impact velocity and the conditioning of the specimens can also influence the results. Consequently, when comparative data are required, these factors are to be carefully controlled and recorded. The method is not intended to be used as a source of data for design calculations. Information on the typical behaviour of a material can be obtained, however, by testing at different temperatures, by

varying the notch radius and/or the thickness and by testing specimens prepared under different conditions.

IEC 62830-2:2017, *Semiconductor devices - Semiconductor devices for energy harvesting and generation - Part 2: Thermo power based thermoelectric energy harvesting*

IEC 62830-2:2017 describes procedures and definitions for measuring the thermo power of thin films used in micro-scale thermoelectric energy generators, micro heaters and micro coolers. This part of IEC 62830 specifies the methods of tests and the characteristic parameters of the thermoelectric properties of wire, bulk and thin films which have a thickness of less than 5 mm and energy harvesting devices that have thermoelectric thin films, in order to accurately evaluate their performance and practical uses. This part of IEC 62830 is applicable to energy harvesting devices for consumer, general industries, military and aerospace applications without any limitations of device technology and size.

EN 50598-3:2015, *Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Part 3: Quantitative eco design approach through life cycle assessment including product category rules and the content of environmental declarations*

This part of EN 50598 specifies the process and requirements to implement environmentally conscious product design principles, to evaluate ecodesign performance and to communicate potential environmental impacts for power electronics (e.g. complete drive modules, CDM), power drive systems and motor starters, all used for motor driven equipment in the power range of 0,12 kW up to 1 000 kW and low voltage (up to 1 000 V) applications over the whole life cycle. It defines the content for 2 different environmental declarations based on EN ISO 14021: - The basic version - which, in this context, will be referred to as an environmental declaration type II, with basic data and qualitative statements on ecodesign. - The full version - which, in this context, will be referred to as an environmental declaration type II+, based upon a life cycle assessment and including quantitatively evaluated potential environmental impacts. For that the general principles of EN ISO 14025 are taken into account and product category rules [PCR] for motor system components are included to ensure a harmonized approach. This part of EN 50598 is harmonized with the applicable generic and horizontal environmental standards and contains the additional details relevant in this context for the above-mentioned products.

EN 60146-1-1:2010, *Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements*

EN IEC 60146-1-1:2010 specifies the requirements for the performance of all semiconductor power converters and semiconductor power switches using controllable and/or non-controllable electronic valve devices. It is primarily intended to specify the basic requirements for converters in general and the requirements applicable to line commutated converters for conversion of a.c. power to d.c. power or vice versa. Parts of this standard are also applicable to other types of electronic power converter provided that they do not have their own product standards. This fourth edition constitutes a technical revision and introduces five main changes: - re-edition of the whole standard according to the current directives; - correction of definitions and addition of new terms, especially terms concerning EMC, harmonic distortion and insulation co-ordination; - the service condition tolerances have been revised according to the IEC 61000 series; - the insulation tests have been revised considering the insulation co-ordination; - addition of three annexes.

EN 60146-1-3:1993, *Semiconductor convertors - General requirements and line commutated convertors - Part 1-3: Transformers and reactors*

This standard specifies characteristics wherein convertor transformers differ from ordinary power transformers. In all other respects, the rules specified in HD 398.1 shall apply.

EN 60146-2:2000, *Semiconductor converters - Part 2: Self-commutated semiconductor converters including direct d.c. converters*

This standard applies to all types of semiconductor inverters of the self-commutated type and semiconductor convertors which contain at least one part of a self-commutated type, including direct a.c. convertors and d.c. convertors for all applications.

EN 62477-1:2012, *Safety requirements for power electronic converter systems and equipment - Part 1: General*

EN 62477-1:2012 applies to Power Electronic Converter Systems (PECS) and equipment, their components for electronic power conversion and electronic power switching, including the means for their control, protection, monitoring and measurement, such as with the main purpose of converting electric power, with rated system voltages not exceeding 1 000 V a.c. or 1 500 V d.c. This document may also be used as a reference standard for product committees producing product standards for: - adjustable speed electric power drive systems (PDS); - standalone uninterruptible power systems (UPS); - low voltage stabilized d.c. power supplies. For PECS for which no product standard exists, this standard provides minimum requirements for safety aspects. This part of IEC 62477 has the status of a group safety publication in accordance with IEC Guide 104 for power electronic converter systems and equipment for solar, wind, tidal, wave, fuel cell or similar energy sources. According to IEC Guide 104, one of the responsibilities of technical committees is, wherever applicable, to make use of basic safety publications and/or group safety publications in the preparation of their product standards. This International Standard: - establishes a common terminology for safety aspects relating to PECS and equipment; - establishes minimum requirements for the coordination of safety aspects of interrelated parts within a PECS; - establishes a common basis for minimum safety requirements for the PEC portion of products that contain PEC; - specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, during use and operation and, where specifically stated, during service and maintenance; - specifies minimum requirements to reduce risks with respect to pluggable and permanently connected equipment, whether it consists of a system of interconnected units or independent units, subject to installing, operating and maintaining the equipment in the manner prescribed by the manufacturer. This International Standard does not cover: - telecommunications apparatus other than power supplies to such apparatus; - functional safety aspects as covered by e.g. IEC 61508; - electrical equipment and systems for railways applications and electric vehicles.

EN IEC 62477-2:2018, *Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC*

EN IEC 62477-2:2018 applies to power electronic converter systems (PECS) and equipment, their components for electronic power conversion and electronic power switching, including the means for their control, protection, monitoring and measurement, such as with the main purpose of converting electric power, with rated system voltages from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC. This document can also be used as a reference standard for product committees producing product standards for:

- adjustable speed electric power drive systems (PDS),
- standalone uninterruptible power systems (UPS), and
- stabilized DC power supplies.

For PECS for which no product standard exists, this document provides minimum requirements for safety aspects. This document

- establishes a common terminology for safety aspects relating to PECS and equipment,
- establishes minimum requirements for the coordination of safety aspects of interrelated parts within a PECS,
- establishes a common basis for minimum safety requirements for the PEC portion of products that contain PEC,
- specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, during use and operation and, where specifically stated, during service and maintenance,
- specifies minimum requirements to reduce risks with respect to pluggable and permanently connected equipment, whether it consists of a system of interconnected units or independent units, subject to installing, operating and maintaining the equipment in the manner prescribed by the manufacturer,
- establishes an arc fault rating label requirement with testing instructions for PEC and PECS, and

- covers power electronic converters and systems in open type design, which are catalog (pre-defined commercially available) power electronic converters and systems or engineered solutions from same.

This document does not cover

- telecommunications apparatus other than power supplies to such apparatus,
- functional safety aspects as covered by, for example, IEC 61508 (all parts),
- electrical equipment and systems for railways applications and electric vehicles, and
- power electronic converters and systems in open type design, which are – in their major part – dimensioned, designed and constructed according to the user's individual requirements and specifications and follow power installation standards, for example IEC 61936-1.

IEC TR 60146-1-2:2019, *Semiconductor converters - General requirements and line commutated converters - Part 1-2: Application guidelines*

IEC TR 60146-1-2:2019 gives guidance on variations to the specifications given in IEC 60146-1-1:2009 to enable the specification to be extended in a controlled form for special cases. Background information is also given on technical points, which facilitates the use of IEC 60146-1-1:2009. This technical report primarily covers line commutated converters and is not in itself a specification, except as regards certain auxiliary components, in so far as existing standards may not provide the necessary data.

EN 60044-7:2000, *Instrument transformers - Part 7: Electronic voltage Transformers*

Applies to newly manufactured electronic voltage transformers with analogue output, for use with electrical measuring instruments and electrical protective devices at frequencies from 15 Hz to 100 Hz. The standard covers optical arrangements with electronic components. Three-phase voltage transformers are not included, but some of the requirements apply.

EN 60044-8:2002, *Instrument transformers - Part 8: Electronic current transformers*

This part of EN 60044 applies to newly manufactured electronic current transformers having an analogue voltage output or a digital output, for use with electrical measuring instruments and electrical protective devices at nominal frequencies from 15 Hz to 100 Hz.

EN 61869-1:2009, *Instrument transformers - Part 1: General requirements*

This European Standard is applicable to newly manufactured instrument transformers with analogue or digital output for use with electrical measuring instruments or electrical protective devices having rated frequencies from 15 Hz to 100 Hz. TC 38 decided to restructure the whole set of stand-alone Standards in the IEC 60044 series and transform it into a new set of standards composed of general requirements documents and specific requirements documents. This Standard is the first issue of this new series and can be regarded as a Product Family standard. It contains the general requirements for instrument transformers and shall be read in conjunction with the relevant specific requirements standard for the instrument transformer concerned.

EN 61869-2:2012, *Instrument transformers - Part 2: Additional requirements for current Transformers*

EN 61869-2:2012 is applicable to newly manufactured inductive current transformers for use with electrical measuring instruments and/or electrical protective devices having rated frequencies from 15 Hz to 100 Hz. This International Standard is to be used in conjunction with, and is based on, EN 61869-1:2007. Additionally it introduces technical innovations in the standardization and adaptation of the requirements for current transformers for transient performance.

EN 61869-3:2011, *Instrument transformers - Part 3: Additional requirements for inductive voltage Transformers*

EN 61869-3:2011 applies to new inductive voltage transformers for use with electrical measuring instruments and electrical protective devices at frequencies from 15 Hz to 100 Hz. This publication is to be read in conjunction with EN 61869-1:2007.

EN 61869-4:2014, *Instrument transformers - Part 4: Additional requirements for combined Transformers*

EN 61869-4:2014 applies to newly-manufactured combined transformers for use with electrical measuring instruments and electrical protective devices at frequencies from 15 Hz to 100 Hz. The requirements and tests of this standard, in addition to the requirements and tests of EN 61869-1, EN 61869-2 and EN 61869-3 cover current and inductive voltage transformers that are necessary for combined instrument transformers.

EN 61869-5:2011, *Instrument transformers - Part 5: Additional requirements for capacitor voltage Transformers*

EN 61869-5:2011 applies to new single-phase capacitor voltage transformers connected between line and ground for system voltages Um ≥ 72,5 kV at power frequencies from 15 Hz to 100 Hz. They are intended to supply a low voltage for measurement, control and protective functions. This publication is to be read in conjunction with EN 61869-1:2009.

EN 61869-6:2016, *Instrument transformers - Part 6: Additional general requirements for low-power instrument Transformer*

EN 61869-6:2016 is a product family standard and covers only additional general requirements for low-power instrument transformers (LPIT) used for a.c. applications having rated frequencies from 15 Hz to 100 Hz covering MV, HV and EHV or used for d.c. applications. This product standard is based on EN 61869-1:2009, in addition to the relevant product specific standard. This part of EN 61869 does not cover the specification for the digital output format of instrument transformers. It defines the errors in case of analogue or digital output. The other characteristics of the digital interface for instrument transformers are standardised in EN IEC 61869-9 as an application of the standards, the EN 61850 series, which details layered substation communication architecture. This part of EN 61869 considers additional requirements concerning bandwidth. This publication is to be read in conjunction with IEC 61869-1:2009.

EN IEC 61869-9:2019, *Instrument transformers - Part 9: Digital interface for instrument Transformers*

EN IEC 61869-9:2019 is a product family standard applicable to instrument transformers with digital output. The product standard is composed of EN 61869-1 and EN 61869-6, in addition to this standard and the relevant product specific standards in the EN 61869 series (Part 7, Part 8, Part 12, Part 13, Part 14, and Part 15). This standard defines requirements for digital communications of instrument transformer measurements. This European Standard contains specific requirements for electronic low power instrument transformers (LPIT) having a digital output.

EN IEC 61869-10:2018, *Instrument transformers - Part 10: Additional requirements for low-power passive current Transformers*

EN IEC 61869-10:2018 is a product standard and covers only additional requirements for low-power passive current transformers. The product standard for low-power passive current transformers comprises EN 61869-1, together with EN 61869-6 and this document with specific requirements. This document is applicable to newly manufactured low-power passive current transformers with analogue output for use with electrical measuring instruments or electrical protective devices having a rated frequency from 15 Hz to 100 Hz. This document covers low-power passive current transformers used for measurement or protection and multi-purpose low-power passive current transformers used for both measurement and protection.

EN IEC 61869-11:2018, *Instrument transformers - Part 11: Additional requirements for low-power passive voltage Transformers*

EN IEC 61869-11:2018 is a product standard and covers only additional requirements for low-power passive voltage transformers (passive LPVT). The product standard for low-power passive voltage transformers is composed of EN 61869-1, along with EN 61869-6 and this document with specific requirements. This document is applicable to newly manufactured low-power passive voltage transformers with analogue output having rated frequencies from 15 Hz to 100 Hz for use with electrical measuring instruments or electrical protective devices. This document covers low-power passive voltage transformers used for measurement or protection and low-power passive voltage

transformers used for both measurement and protection. Low-power passive voltage transformers have analogue output only (for digital output or for technology using any kind of active electronic components refer to future EN 61869-7). Such low-power passive voltage transformers can include the secondary signal cable (transmitting cable). The secondary voltage of the low-power passive voltage transformer is proportional to the primary voltage. Derivative output signals are not within the scope of this document.

EN IEC 61869-14:2019, *Instrument transformers - Part 14: Additional requirements for current transformers for DC applications*

EN IEC 61869-14:2019 provides all requirements specific to current transformers to be used in DC applications (DCCTs), whatever the technology used. The output signal can be analogue or digital. It is applicable to newly manufactured current transformers used for measuring, protection and/or control applications in DC power systems with a rated voltage above 1,5 kV. The general configuration of a single-pole low-power instrument transformer is described in Figure 601 of EN 61869-6:2016. The DCCTs intended for current measurement in the transistor branch of the VSC valve (referred to as CT4a and CT4b in Figure 1403 and Table 1402) are not covered by this document and will be considered in a future revision. EN IEC 61869-14:2019 applies to current transformers intended to be used in DC applications with at least one of the following functions: • measure DC current (with significant harmonics); • withstand DC voltage. Depending on the position on the DC system, different kinds of application exist, which are briefly described below, together with the approximate voltage or current wave shape.

EN IEC 61869-15:2019, *Instrument transformers - Part 15: Additional requirements for voltage transformers for DC applications*

EN IEC 61869-15:2019 provides all requirements specific to voltage transformers to be used in DC applications (DCVTs), whatever the technology used. The output signal can be analogue or digital. It is applicable to newly manufactured voltage transformers used for measuring, protection and/or control applications in DC power systems with a rated voltage above 1,5 kV. This document covers passive voltage dividers as well as active voltage transformers, used for measurement, control and protection. The general configuration of a single-pole low-power instrument transformer is described in Figure 601 of EN 61869-6:2016. EN IEC 61869-15:2019 applies to voltage transformers (VT) intended to be used in DC applications with the following functions: • measure DC voltage (with significant harmonics); • withstand DC voltage. Two main technologies of DC converters exist today: LCC and VSC • Line-commutated converters (LCC) are based on thyristor converters. They are characterized by a single direction of current flow, and a voltage polarity reversal possibility. Significant voltage and current harmonics exist up to frequencies of about 3 kHz to 4 kHz. • Voltage source converters (VSC) are based on transistor converters. They are characterized by a bi-directional current flow and a single voltage polarity. Voltage and current harmonics exist up to frequencies of about 20 kHz.

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof - Part 1: General requirements and tests*

IEC 61558-1:2017 deals with safety aspects of transformers, reactors, power supply units and combinations thereof such as electrical, thermal and mechanical safety. This document covers the following independent or associated stationary or portable types of dry-type transformers, power supply units, including switch mode power supply units, reactors and combinations thereof in the field of safety. The windings can be encapsulated or non-encapsulated. They are not forming a part of the distribution network.

IEC 61558-2-1:2007, *Safety of power transformers, power supplies, reactors and similar products - Part 2-1: Particular requirements and tests for separating transformers and power supplies incorporating separating transformers for general applications*

This part of IEC 61558 deals with safety aspects of separating transformers and power supplies incorporating separating transformers such as electrical, thermal and mechanical safety.

IEC 61558-2-2:2007, *Safety of power transformers, power supplies, reactors and similar products - Part 2-2: Particular requirements and tests for control transformers and power supplies incorporating control transformers*

This part of IEC 61558 deals with safety aspects of control transformers and power supplies incorporating control transformers such as electrical, thermal and mechanical safety.

IEC 61558-2-4:2009, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers*

IEC 61558-2-4:2009 deals with the safety of isolating transformers for general applications and power supply units incorporating isolating transformers for general applications. Transformers incorporating electronic circuits are also covered by this standard.

IEC 61558-2-6:2009, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 61558-2-6:2009 deals with the safety of safety isolating transformers for general applications and power supply units incorporating safety isolating transformers for general applications. Transformers incorporating electronic circuits are also covered by this standard.

IEC 61558-2-12:2011*, Safety of transformers, reactors, power supply units and combination thereof - Part 2-12: Particular requirements and tests for constant voltage transformers and power supply units for constant voltage*

IEC 61558-2-12:2011 deals with the safety of constant voltage transformers for general applications and power supply units for constant voltage for general applications. Constant voltage transformers incorporating electronic circuits are also covered by this standard.

IEC 61558-2-13:2009, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-13: Particular requirements and tests for auto transformers and power supply units incorporating auto transformers*

IEC 61558-2-13:2009 deals with the safety of auto transformers for general applications and power supply units incorporating auto transformers for general applications. Transformers incorporating electronic circuits are also covered by this standard.

IEC 61558-2-14:2012, *Safety of transformers, reactors, power supply units and combinations thereof - Part 2-14: Particular requirements and tests for variable transformers and power supply units incorporating variable transformers*

IEC 61558-2-14:2012 deals with safety of variable transformers for general applications and power supply units incorporating variable transformers for general applications. Transformers incorporating electronic circuits are also covered by this standard.

IEC 61558-2-26:2013, *Safety of transformers, reactors, power supply units and combinations thereof - Part 2-26: Particular requirements and tests for transformers and power supply units all for saving energy and other purposes*

IEC 61558-2-26:2013 deals with the safety of transformers, power supply units and switch mode power supply units all for saving energy and other purposes in electrical installations by adjusting the output voltage and/or other electrical characteristics on the output circuits without interruption affected by the transformers, power supply unit and switch mode power supply unit.

IEC 62041:2017, *Transformers, power supplies, reactors and similar products - EMC requirements*

IEC 62041:2017 is applicable to transformers, reactors and power supply units covered by the IEC 61558 series of standards. This document deals with the electromagnetic compatibility requirements for emission and immunity within the frequency range 0 Hz to 400 GHz. No tests need to be performed at frequencies where no requirements are specified

IEC 62391-1:2015, *Fixed electric double-layer capacitors for use in electric and electronic equipment - Part 1: Generic specification*

IEC 62391-1:2015 applies to fixed electric double-layer capacitors (referred to as capacitor(s)) mainly used in d.c. circuits of electric and electronic equipment. This part of IEC 62391 establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications of electronic components for quality assessment or any other purpose.

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*

Part 2 of IEC 62391 applies to electric double-layer capacitors for power application. Electric double-layer capacitors for power are intended for applications that require discharge currents in the range from mA to A. The characteristics of the capacitors include such performance as relatively high capacitance and low internal resistance, which is applicable to Class 3 of the measurement classification specified in IEC 62391-1. The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 62391-1 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification shall be of equal or higher performance level; lower performance levels are not permitted.

IEC 62391-2-1:2006*, Fixed electric double-layer capacitors for use in electronic equipment - Part 2-1: Blank detail specification - Electric double-layer capacitors for power application - Assessment level EZ*

A supplementary document to the sectional specification and contains requirements for style, layout and minimum content of detail specifications. Detail specifications not complying with these requirements may not be considered as being in accordance with IEC specifications nor shall they so be described. In the preparation of detail specifications, the content of 1.4 of the sectional specification shall be taken into account.

IEC TR 62157:2001, *Cylindrical machined carbon electrodes - Nominal dimensions*

Applies to cylindrical carbon electrodes, manufactured from upgraded coal, for use in electric direct-arc and submerged-arc furnaces, for melting silicium and carbide and for other purposes. Covers a) dimensions and tolerances on the length and diameter of carbon electrodes b) dimensions and thread details for carbon electrode heads and sockets.

IEC TS 62607-4-6:2018, *Nanomanufacturing - Key control characteristics - Part 4-6: Nano-enabled electrical energy storage devices - Determination of carbon content for nano electrode materials, infrared absorption method*

IEC TS 62607-4-6:2018 provides a method for determination of carbon content of nano electrode materials by infrared absorption spectroscopy method. The method is applicable to carbon contents of mass fraction between 0,001 % and 100 %.

This method will enable customers to a) decide whether or not a nano electrode material is usable, and b) select a nano electrode material with suitable carbon content for its application.

This document includes recommendations for sample preparation, outlines of the experimental procedures used to measure electrode nanomaterial properties, methods of interpretation of results and discussion of data analysis and case studies.

ISO/IEC 19637:2016, *Information technology - Sensor network testing framework*

ISO/IEC 19637:2016 specifies the testing framework for conformance test for heterogeneous sensor networks, the generic services between test manager (TMR) and test agent (TA) in the testing framework, and the guidance for creating testing platform and enabling the test of different sensor network protocols.

ISO/IEC 20005:2013, *Information technology - Sensor networks - Services and interfaces supporting collaborative information processing in intelligent sensor networks*

This international standard specifies services and interfaces supporting collaborative information processing (CIP) in intelligent sensor networks which includes CIP functionalities and CIP functional model, common services supporting CIP and common service interfaces to CIP.

ISO/IEC TR 22560:2017, *Information technology - Sensor network - Guidelines for design in the aeronautics industry: Active air-flow control*

This Technical Report describes the concepts, issues, objectives, and requirements for the design of an active air-flow control (AFC) system for commercial aircraft based on a dense deployment of wired and wireless sensor and actuator networks. It focuses on the architecture design, module definition, statement of objectives, scalability analysis, system-level simulation, as well as networking and implementation issues using standardized interfaces and service-oriented middleware architectures.

ISO/IEC 29182-1:2013, *Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 1: General overview and requirements*

ISO/IEC 29182-1:2013 provides a general overview of the characteristics of a sensor network and the organization of the entities that comprise such a network. It also describes the general requirements that are identified for sensor networks.

ISO/IEC 29182-2:2013, *Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 2: Vocabulary and terminology*

ISO/IEC 29182-2:2013 is intended to facilitate the development of International Standards in sensor networks. It presents terms and definitions for selected concepts relevant to the field of sensor networks. It establishes a general description of concepts in this field and identifies the relationships among those concepts. It may also be used as guidance for development of other parts of ISO/IEC 29182 and any other sensor network related standard.

ISO/IEC 29182-3:2014, *Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 3: Reference architecture views*

ISO/IEC 29182-3:2014 provides Sensor Network Reference Architecture (SNRA) views. The architecture views include business, operational, systems, and technical perspectives, and these views are presented in functional, logical, and/or physical views where applicable. ISO/IEC 29182-3:2014 focuses on high-level architecture views which can be further developed by system developers and implementers for specific applications and services.

ISO/IEC 29182-4:2013, *Information technology - Sensor networks: Sensor Network Reference Architecture (SNRA) - Part 4: Entity models*

The purpose of the ISO/IEC 29182 series is to provide guidance to facilitate the design and development of sensor networks, improve interoperability of sensor networks, and make sensor network components plug-and-play, so that it becomes fairly easy to add/remove sensor nodes to/from an existing sensor network. ISO/IEC 29182-4 presents models for the entities that enable sensor network applications and services according to the Sensor Network Reference Architecture (SNRA).

ISO/IEC 29182-5:2013, *Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 5: Interface definitions*

ISO/IEC 29182-5:2013 provides the definitions and requirements of sensor network (SN) interfaces of the entities in the Sensor Network Reference Architecture and covers the following aspects: interfaces between functional layers to provide service access for the modules in the upper layer to exchange messages with modules in the lower layer; interfaces between entities introduced in the Sensor Network Reference Architecture enabling sensor network services and applications.

ISO/IEC 29182-6:2014, *Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 6: Applications*

ISO/IEC 29182-6:2014, describes and provides a compilation of sensor network applications for which International Standardized Profiles (ISPs) are needed, guidelines for the structured description of sensor network applications, and examples for structured sensor network applications. It does not cover ISPs for which drafting rules are described in ISO/IEC TR 10000. Due to the generic character of ISO/IEC 29182, fully developed ISPs will not be included in this International Standard.

ISO/IEC 29182-7:2015, *Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 7: Interoperability guidelines*

ISO/IEC 29182-7:2015 provides a general overview and guidelines for achieving interoperability between sensor network services and related entities in a heterogeneous sensor network.

ISO/IEC 30128:2014, *Information technology -- Sensor networks -- Generic Sensor Network Application Interface*

This international standard specifies the interfaces between the application layers of service providers and sensor network gateways, which is Protocol A in interface 3, defined in ISO/IEC 29182-5. It covers the description of generic sensor network applications' operational requirements, the description of sensor network capabilities, and the mandatory and optional interfaces between the application layers of service providers and sensor network gateways.

ISO/IEC 21823-1:2019, *Internet of Things (IoT) - Interoperability for IoT systems - Part 1: Framework*

ISO/IEC 21823-1:2019(E) provides an overview of interoperability as it applies to IoT systems and a framework for interoperability for IoT systems. This document enables IoT systems to be built in such a way that the entities of the IoT system are able to exchange information and mutually use the information in an efficient way. This document enables peer-to-peer interoperability between separate IoT systems.

This document provides a common understanding of interoperability as it applies to IoT systems and the various entities within them.

EN ISO 1628-1:2009, *Plastics - Determination of the viscosity of polymers in dilute solution using capillary viscometers - Part 1: General principles (ISO 1628-1:2009)*

EN ISO 1628-1:2009 defines the general conditions for the determination of the reduced viscosity, intrinsic viscosity and K-value of organic polymers in dilute solution. It defines the standard parameters that are applied to viscosity measurement and can be used to develop standards for measuring the viscosities in solution of individual types of polymer. It can also be used to measure and report the viscosities of polymers in solution for which no separate standards exist.

CEN/TS 16010:2013, *Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates*

This Technical Specification specifies a system for sampling procedures for testing plastics waste and recyclates which take into account the specifics of the plastics waste and recyclates. It is intended to cover all stages of the plastic recycling process. The sampling procedures include the statistical specifics of the plastic waste and the behaviour of recyclates. The sampling method should produce a representative testing sample. Differences can arise due to: -the mixture of plastics; -the origin (e.g. green dot in Germany, or electronic/automotive industry); -the previous use of the plastic material; -the residual contents (e.g. of containers); -inert, residual or moisture content on or in the material. This Technical Specification is without prejudice to any existing legislation.

CEN/TS 16011:2013, *Plastics - Recycled plastics - Sample preparation*

This Technical Specification specifies the preparation of samples of recycled plastics prior to testing and takes account of the specifics of the material. Sample preparation should avoid any process that causes 'de-mixing' of the sample. Following preparation, the sample should remain representative. The behaviour of contaminants should be carefully analysed and observed to ensure this is homogeneous. This Technical Specification does not address any legal or product safety issues.

EN 15343:2007, *Plastics - Recycled Plastics - Plastics recycling traceability and assessment of conformity and recycled content*

This European Standard specifies the procedures needed for the traceability of recycled plastics. This gives the basis for the calculation procedure for the recycled content of a product. This standard is applicable without prejudice to any existing legislation. NOTE The procedures are needed to formulate or describe the traceability, while the traceability can be used as a basis for calculating the recycled content.

EN 15347:2007, *Plastics - Recycled Plastics - Characterisation of plastics wastes*

This European Standard provides a scheme for the characterisation of plastics wastes, laying out those properties for which the supplier of the waste shall make information available to the purchaser, and identifying test methods where applicable. The scheme provides for a division of information between "Required Data", where a statement is required, even if it is "unclassified", and additional "Optional Data" which the supplier may choose to provide if it adds value to the waste. This standard is applicable without prejudice to any existing legislation. NOTE This standard does not cover the characterisation of plastics recyclates.

CEN ISO/TR 21960:2020, *Plastics - Environmental aspects - State of knowledge and methodologies (ISO/TR 21960:2020)*

This document summarizes current scientific literature on the occurrence of macroplastics and microplastics, in the environment and biota. It gives an overview of testing methods, including sampling from various environmental matrix, sample preparation and analysis. Further, chemical and physical testing methods for the identification and quantification of plastics are described. This document gives recommendations for three steps necessary for the standardization of methods towards harmonized procedures for sampling, sample preparation and analysis. This document does not apply indoor and health related aspects. NOTE The collection of plastics or microplastics in the environment by citizen social monitoring projects is not in the scope of this document. Although such projects can help sensitize the society to environmental problems and can even reduce the entry and presence of plastics in the environment, this monitoring concept is not considered suitable for a robustly representative and scientific analysis of microplastics in the environment via standardization.

EN 2243-1:2005, *Aerospace series – Non-metallic materials – Structural adhesive – Test method – Part 1: Single lap shear*

The objective of this standard is to establish the test methods for defining the strength of suitable structural adhesives in metal to metal single lap shear, at ambient and other temperatures.

EN 2243-2: 2005, *Aerospace series – Non-metallic materials – Structural adhesive – Test method – Part 2: peel metal-metal*

This standard defines the general requirements for the determination of strength of structural adhesives by testing in peel metal to metal joints, at ambient or other temperatures. This method is not suitable for adhesives having an average peeling strength of less than 30 N per 25 mm.

EN 2823:2017, *Aerospace series - Fibre reinforced plastics - Determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics*

This European Standard specifies the method for determining the effect of exposure to a humid atmosphere on the physical and mechanical characteristics of fibre reinforced plastics. This standard applies to all laminates, whatever the nature of the reinforcement and organic matrix used, unless otherwise indicated in the material standard and/or technical specification.

EN 6032:2015, *Aerospace series - Fibre reinforced plastics - Test method - Determination of the glass transition temperatures*

This standard specifies a method to determine the apparent glass transition temperatures of non-metallic materials. This standard is applicable to unidirectional tape and woven fabric reinforced plastic or plastic materials like adhesive or neat resin for comparison of the influence on the glass transition temperature resulting from processing-parameters of non-metallic parts, for compatibility tests for checking co-curing effects of different prepreg types or with adhesive. This standard does not give any directions necessary to meet health and safety requirements. It is the responsibility of the user of this standard to consult and establish appropriate health and safety precautions.

IEC 62899-101:2019, *Printed electronics - Part 101: Terminology – Vocabulary*

IEC 62899-101:2019 defines terms used in the field of printed electronics, addressing topics including, but not limited to, materials, printing processes, and print characterization. It focuses on terms that are of particular importance to printed devices. Therefore, terms that are already defined in relation to conventional electronics materials, processes, devices, components or systems that

can be used in the field of printed electronics without alteration are not included in this document. Similarly, established terms and definitions in relation to printing technology that apply to the field of printed electronics are not included.

IEC 62899-201:2016+AMD1:2018 CSV, *Printed electronics - Part 201: Materials – Substrates*

IEC 62899-201:2016+A1:2018 defines the terms and specifies the evaluation method for substrates used in the printing process to form electronic components/devices. This international standard is also applied to the substrates which make surface treatment in order to improve their performance.

IEC 62899-202:2016, ***Printed electronics - Part 202: Materials - Conductive ink***

IEC 62899-202:2016 defines the terms and specifies the standard methods for characterisation and evaluation. This International Standard is applicable to conductive inks and conductive layer that are made from conductive inks.

IEC 62899-202-5:2018, ***Printed electronics - Part 202-5: Materials - Conductive ink - Mechanical bending test of a printed conductive layer on an insulating substrate***

IEC 62899-202-5:2018 specifies a mechanical bending test for evaluating the electrical properties of a printed conductive layer on an insulating substrate under repeated mechanical deformation.

IEC 62899-303-1:2018, *Printed electronics - Part 303-1: Equipment - Roll-to-roll printing - Mechanical dimensions*

IEC 62899-303-1:2018 defines standard mechanical dimensions (especially related to the web size) of equipment for printed electronics. This document covers web-based printing equipment, but it can be used for sheet-based products.

IEC 62899-401:2017, *Printed electronics - Part 401: Printability – Overview*

IEC 62899-401:2017 provides an introduction to the rest of the IEC 62899-4XX series and explains its modular structure. The IEC 62899-4XX series establishes requirements for the printability of printed electronics. These requirements are stated as measurement of quality, reproducibility, analysis and compliance test methods, as well as measuring methods for environmental conditions. The IEC 62899-4XX series specifies the measurements and the requirements of both the quality and the reproducibility of printed patterns as the result of the interaction of printing media, inks, substrate, and environmental conditions.

IEC 62899-501-1:2019, ***Printed electronics - Part 501-1: Quality assessment - Failure modes and mechanical testing - Flexible and/or bendable primary or secondary cells***

IEC 62899-501-1:2019 specifies failure modes and mechanical stress test methods for the determination of reliability characteristics of bendable or flexible printed primary cells and secondary cells and batteries.

CEN ISO/TS 17200:2015, *Nanotechnology - Nanoparticles in powder form - Characteristics and measurements (ISO/TS 17200:2013)*

ISO/TS 17200:2013 lists fundamental characteristics which are commonly determined for nanoparticles in powder form. ISO/TS 17200:2013 prescribes specific measurement methods for each of these characteristics.

CEN ISO/TS 80004 (series), *Nanotechnologies – Vocabulary (ISO/TS 80004 series)*

This series lists terms and definitions related to terms in the field of nanotechnologies. It is intended to facilitate communications between organizations and individuals in industry and those who interact with them.

CEN/TS 16937:2016, *Nanotechnologies - Guidance for the responsible development of nanotechnologies*

This Technical Specification provides a guidance for the responsible development of nanotechnologies taking into account: - Board Accountability; - Stakeholder Involvement; - Worker Health and Safety; - Benefits to and Risks for Public Health, Safety and the Environment; - Wider Social and Ethical Implications and Impacts; - Engagement with Business Partners; - Transparency and Disclosure. NOTE 1 This Technical Specification contributes to social responsibility as defined

in ISO 26000:2010. NOTE 2 Nanotechnology activities include industrial production, R&D, services, and marketing of products. This Technical Specification neither covers labelling and advertising aspects nor is it intended for certification purposes, nor does it imply any legally binding agreements. This Technical Specification intends to cover nanotechnology activities involving manufactured nanomaterials, and where relevant incidental nanomaterials.

CEN/TS 17010:2016, *Nanotechnologies - Guidance on measurands for characterising nano-objects and materials that contain them*

This Technical Specification provides guidelines for the identification of measurands to characterize nano-objects, and their agglomerates and aggregates and to assess specific properties relevant to the performance of materials that contain them. It provides guidance for relevant and reliable measurement.

CEN/TS 17273:2018, Nanotechnologies - Guidance on detection and identification of nano-objects in complex matrices

This document sets requirements for sampling and treatment of the complex matrices in order to obtain a liquid dispersion with sufficiently high concentration of the nano-objects of interest. This document provides guidelines for detection and identification of specific nano-objects in complex matrices, such as liquid environmental compartments, waste water and consumer products (e.g. food, cosmetics). This document requires for the identification a priori knowledge of the nature of the nano-objects like their chemical composition. The selected detection and identification methods are based on a combination of size classification and chemical composition analysis. Identification can also be supported, e.g. by additional morphology characterization. Currently only Field Flow Fractionation, Electron Microscopy and single particle Inductively Coupled Plasma – Mass Spectrometry fulfil this combination condition.

CEN/TS 17275:2018*, Nanotechnologies - Guidelines for the management and disposal of waste from the manufacturing and processing of manufactured nano-objects*

This document provides guidelines for all waste management activities from the manufacturing and processing of manufactured nano-objects. The guidelines apply to all actors in the waste management chain, namely MNO manufacturers, MNO modifiers, as well as waste disposal companies and carriers and consignees of WMP-MNOs. This document does not intend to provide guidelines on the management and disposal of nanocomposites, waste derived from consumer products containing nano-objects or waste containing only naturally occurring or incidental nano-objects. Also excluded from the scope are any waste from non-nanoscale materials resulting from the manufacturing and processing of MNOs.

CEN/TS 17276:2018, *Nanotechnologies - Guidelines for Life Cycle Assessment - Application of EN ISO 14044:2006 to Manufactured Nanomaterials*

This document provides guidelines for application of Life Cycle Assessments (LCA) of specific relevance to manufactured nanomaterials (MNMs), including their use in other products, according to EN ISO 14044:2006. It does not cover incidental nanomaterials.

ISO/TR 11360:2010, *Nanotechnologies — Methodology for the classification and categorization of nanomaterials*

ISO/TR 11360:2010 describes a classifying system, termed a “nano-tree”, upon whose basis wide ranges of nanomaterials can be categorized, including nano-objects, nanostructures and nanocomposites of various dimensionality of different physical, chemical, magnetic and biological properties.

ISO/TS 12805:2011, *Nanotechnologies — Materials specifications — Guidance on specifying nano-objects*

ISO/TS 12805:2011 provides guidance on the preparation of specifications for the characteristics of manufactured nano-objects and their measurement methods. This is intended to help ensure the delivery of products with consistent properties for subsequent processing and/or final product performance.

ISO/TS 12805:2011 includes guidance on specifying the physical and chemical characteristics of manufactured nano-objects, which might affect performance or subsequent processing.

ISO/TR 13121:2011, *Nanotechnologies — Nanomaterial risk evaluation*

ISO/TR 13121:2011 describes a process for identifying, evaluating, addressing, making decisions about, and communicating the potential risks of developing and using manufactured nanomaterials, in order to protect the health and safety of the public, consumers, workers and the environment.

ISO/TR 13121:2011 offers guidance on the information needed to make sound risk evaluations and risk management decisions, as well as how to manage in the face of incomplete or uncertain information by using reasonable assumptions and appropriate risk management practices. Further, ISO/TR 13121:2011 includes methods to update assumptions, decisions, and practices as new information becomes available, and on how to communicate information and decisions to stakeholders.

ISO/TR 13121:2011 suggests methods organizations can use to be transparent and accountable in how they manage nanomaterials. It describes a process of organizing, documenting, and communicating what information organizations have about nanomaterials.

ISO/TR 16196:2016, *Nanotechnologies — Compilation and description of sample preparation and dosing methods for engineered and manufactured nanomaterials*

ISO/TR 16196:2016 provides guidance regarding the preparation of nanomaterials for eco- and bio-toxicological testing. It provides guidance regarding factors pertaining to sample preparation and dose determination that might be useful in toxicological, including ecotoxicological, testing of engineered and manufactured nanoscale materials.

The descriptions of sample preparation method factors for both in vitro and in vivo toxicological testing of engineered and manufactured nanoscale materials include considerations about physico-chemical properties, media, methods for transformation and accumulation studies, health effects and dosimetry. The document is not intended to be a literature review nor a thorough assessment of the quality of the methods or data generated. The document is intended to complement other international efforts.

The focus of this document is on factors that might lead to results that are not relevant to safety evaluations. When featured, referenced methods are considered for their general interest and potential applicability. It is likely that most of the described methods are not generally applicable to all nanomaterials but they do demonstrate important factors and limitations that are common for a variety of nanomaterials.

ISO/TR 16197:2014, *Nanotechnologies — Compilation and description of toxicological screening methods for manufactured nanomaterials*

ISO/TR 16197:2014 provides a compilation and description of in vitro and in vivo methods that can be useful for the toxicological, including ecotoxicological screening of engineered and manufactured nanomaterials. Toxicological screening tests included in ISO/TR 16197:2014 can be used for such purposes as early decision-making in research and product development, rapid feedback on potential toxicological/safety concerns, or for the preliminary assessment of manufactured nanomaterials. ISO/TR 16197:2014 is divided between screening assays related to humans and screening assays related to the environment. A screening test is a relatively simple, inexpensive test that can be administered easily and provides an indication of potential adverse outcomes and effects on human health or the environment.

ISO/TS 21362:2018, *Nanotechnologies — Analysis of nano-objects using asymmetrical-flow and centrifugal field-flow fractionation*

This document identifies parameters and conditions, as part of an integrated measurement system, necessary to develop and validate methods for the application of asymmetrical-flow and centrifugal field-flow fractionation to the analysis of nano-objects and their aggregates and agglomerates dispersed in aqueous media. In addition to constituent fractionation, analysis can include size, size distribution, concentration and material identification using one or more suitable detectors. General

guidelines and procedures are provided for application, and minimal reporting requirements necessary to reproduce a method and to convey critical aspects are specified.

5 Annex 2. References, abbreviations and acronyms

For the elaboration of this report, the following sources have been consulted:

- CEN Website (www.cen.eu)
- CENELEC Website (www.cenelec.eu)
- CEN/CENELEC Projex Online database (projex.cen.eu) (restricted to authorized users)
- ISO Website (www.iso.org)
- ISO Project Portal (isotc.iso.org) (restricted to authorized users)
- IEC Website (www.iec.ch)

The main abbreviations and acronyms related to standardization are listed below:

Abbreviations and acronyms	
CEN	European Committee for Standardization
CENELEC (CLC)	European Committee for Electrotechnical Standardization
CWA	CEN or CENELEC Workshop Agreement
EN	European Standard
FA	Frankfurt Agreement
IEC	International Electrotechnical Commission; International Standard
ISO	International Organization for Standardization; International Standard
JTC	Joint Technical Committee
JWG	Joint Working Group
NMC	National Mirror Committee
NSB	National Standardization Body
SC	Subcommittee
TC	Technical Committee
TR	Technical Report
TS	Technical Specification
VA	Vienna Agreement
WG	Working Group
UNE	Spanish Association for Standardization