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English version

High temperature accelerated ageing of advanced ceramic specimens for solar receivers and other applications under concentrated solar radiation

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European foreword

This CEN Workshop Agreement (CWA 17726:2021) has been developed in accordance with the CEN-CENELEC Guide 29 “CEN/CENELEC Workshop Agreements – A rapid prototyping to standardization” and with the relevant provisions of CEN/CENELEC Internal Regulations – Part 2. It was approved by a Workshop of representatives of interested parties on 2020-12-15, the constitution of which was supported by CEN following the public call for participation made on 2020-01-31. However, this CEN Workshop Agreement does not necessarily include all relevant stakeholders.

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Introduction

Concentrated solar power (CSP) is an important building block in installing a secure, competitive and sustainable energy system.

Advanced materials solutions for NEXT generation high efficiency concentrated solar power (CSP) TOWER systems (NEXTOWER) project is a four-year research and development project, funded by the European Commission, which aims at demonstrating high-performance durable materials for the next generation of concentrated solar power (CSP) air-based tower systems, making them commercially competitive in the energy market beyond 2020.

NEXTOWER comprises two main parts: steel and ceramic. The main objective related to ceramic is to develop new mechanically tough and highly thermally conductive ceramic receivers, working under extreme thermal cycling without failure at a maximum operating temperature of up to 1 400 °C and delivering up to 25 years of continued operation.

A general objective in NEXTOWER is the exploitation and standardization, addressing the integration of NEXTOWER in the standardization system.

Some of the results obtained in NEXTOWER regarding the use of advanced ceramics are:

1. Innovative ceramic for high-temperature open volumetric receivers based on all-SiC honeycomb manufactured by a mix of extrusion and slip casting through re-crystallization SiC more resistant to oxidation; better ceramics for high-temperature receivers, with superior thermal properties and reliability. Ceramic receivers optimized for oxidation, in terms of porosity and strength.
2. Innovative ceramic for high-temperature open volumetric receivers based on more flexible siliconized silicon carbide (Si-SiC) multiparts made by additive manufacturing (3D printing), especially designed for higher toughness, higher thermal conductivity and thermal shock resistance through a more open structure, with an optimized joining technique, improving lifetime and avoiding interfacial cracking.
3. Coating and surface treatments to improve thermomechanical properties and emissivity.
4. Proposal to amend ISO 18755 “Fine ceramics (advanced ceramics, advanced technical ceramics) – Determination of thermal diffusivity of monolithic ceramics by laser flash method”.
5. This CWA defines a methodology for testing the performance of the material ceramic materials and will be one of the standardization results. Both the standards community and NEXTOWER partners will benefit from it.

1 Scope

This document defines the requirements, operation and analysis for high temperature accelerated ageing of ceramic specimens for solar receivers and other applications under concentrated solar radiation, reaching a solar concentration up to 1 MW/m² peak and temperatures up to 1 400 °C.

This document also describes the structural and resistance post analysis of the irradiated samples.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 843-1, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature — Part 1: Determination of flexural strength*

EN 843-2, *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 843-5, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature — Part 5: Statistical analysis*

EN 843-6, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature — Part 6: Guidance for fractographic investigation*

EN ISO 9488, *Solar energy — Vocabulary*

EN ISO 22975-3:2014, *Solar energy — Collector components and materials — Part 3: Absorber surface durability*

ISO 9050, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 20509:2003, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Determination of oxidation resistance of non-oxide monolithic ceramics*

IEC/TS 62862-1-1, *Solar thermal electric plants — Part 1-1: Terminology*

ASTM E 903, *Standard test method for solar absorptance, reflectance, and transmittance of materials using integrating spheres*

ASTM E 1441-19, *Standard Guide for Computed Tomography (CT)*

ASTM C 1499-09, *Standard test method for monotonic equibiaxial flexural strength of advanced ceramics at ambient temperature*

ASTM G 173-03, *Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface*

ASTM C 1322, *Standard practice for fractography and characterization of fracture origins in advanced ceramics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 62862-1-1 and EN ISO 9488 and the following apply.

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

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

3.1

thermal cycling

temperature which is simply and cyclically repeated between a specific high value and a specific low value