BS EN IEC 62282-7-2:2021

BSI Standards Publication

Fuel cell technologies

Part 7-2: Test methods — Single cell and stack performance tests for solid oxide fuel cells

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National foreword

This British Standard is the UK implementation of EN IEC 62282-7-2:2021. It is identical to IEC 62282-7-2:2021. It supersedes PD IEC/TS 62282-7-2:2014, which will be withdrawn on 19 January 2022.

The UK participation in its preparation was entrusted to Technical Committee GEL/105, Fuel cell technologies.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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EUROPÄISCHE NORM

EN IEC 62282-7-2

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English Version

Fuel cell technologies - Part 7-2: Test methods - Single cell and stack performance tests for solid oxide fuel cells (SOFCs) (IEC 62282-7-2:2021)

Technologies des piles à combustible - Partie 7-2: Méthodes d'essai - Essais de performance de cellule élémentaire et de pile pour les piles à combustible à oxyde solide (SOFC) (IEC 62282-7-2:2021)

Brennstoffzellentechnologien - Teil 7-2: Prüfverfahren - Prüfungen zum Nachweis des Einzelzellen- und Stackleistungsverhaltens von Festoxid-Brennstoffzellen (SOFC) (IEC 62282-7-2:2021)

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European foreword

The text of document 105/847/FDIS, future edition 1 of IEC 62282-7-2, prepared by IEC/TC 105 "Fuel cell technologies" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62282-7-2:2021.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-03-25
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2024-06-25

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In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60352 (series)	NOTE	Harmonized as EN 60352 (series)
IEC 60359	NOTE	Harmonized as EN 60359
IEC 60512-1-1	NOTE	Harmonized as EN 60512-1-1
IEC 60512-8-1	NOTE	Harmonized as EN 60512-8-1
IEC 60512-8-2	NOTE	Harmonized as EN 60512-8-2
IEC 62282-2-100	NOTE	Harmonized as EN IEC 62282-2-100
IEC 62282-8-101	NOTE	Harmonized as EN IEC 62282-8-101

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60050-485	-	International Electrotechnical Vocabulary (IEV) - Part 485: Fuel cell technologies	-	-
IEC 60584-1	-	Thermocouples - Part 1: EMF specifications and tolerances	EN 60584-1	-
IEC 60584-3	-	Thermocouples - Part 3: Extension and compensating cables - Tolerances and identification system	EN IEC 60584-3	-
IEC 61515	-	Mineral insulated metal-sheathed thermocouple cables and thermocouples	EN 61515	-
ISO 5168	-	Measurement of fluid flow - Procedures for the evaluation of uncertainties	-	-
ISO 6141	-	Gas analysis - Contents of certificates for calibration gas mixtures	EN ISO 6141	-
ISO 6142-1	-	Gas analysis - Preparation of calibration gas mixtures - Part 1: Gravimetric method for Class I mixtures	EN ISO 6142-1	-
ISO 6143	-	Gas analysis - Comparison methods for determining and checking the composition of calibration gas mixtures	EN ISO 6143	-
ISO 6145-7	-	Gas analysis - Preparation of calibration gas mixtures using dynamic methods - Part 7: Thermal mass-flow controllers	EN ISO 6145-7	-
ISO 6974	series	Natural gas - Determination of composition with defined uncertainty by gas chromatography	EN ISO 6974	series
ISO 7066-2	-	Assessment of uncertainty in the calibration and use of flow measurement devices - Part 2: Non-linear calibration relationships	-	-
ISO 8573-1	-	Compressed air - Part 1: Contaminants and purity classes	-	-

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Publication	Year	Title	EN/HD	Year
ISO 8756	-	Air quality; handling of temperature, pressure and humidity data	-	-
ISO 12185	-	Crude petroleum and petroleum products - Determination of density - Oscillating U-tube method	EN ISO 12185	-

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FUEL CELL TECHNOLOGIES –

Part 7-2: Test methods – Single cell and stack performance tests for solid oxide fuel cells (SOFCs)

FOREWORD

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IEC 62282-7-2 has been prepared by IEC technical committee 105: Fuel cell technologies. It is an International Standard.

This first edition cancels and replaces IEC TS 62282-7-2 published in 2014.

This edition includes the following significant technical changes with respect to IEC TS 62282-7-2:2014:

a) users can substitute selected test methods of this document with equivalent test methods of IEC 62282-8-101 for solid oxide cell (SOC) operation for energy storage purposes, operated in reverse or reversible mode;
b) terms and definitions are aligned with the corresponding terms and definitions in IEC 62282-8-101;
c) symbols are aligned with the corresponding symbols in IEC 62282-8-101.

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
105/847/FDIS	105/851/RVD

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

The language used for the development of this International Standard is English.

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

A list of all parts in the IEC 62282 series, published under the general title *Fuel cell technologies*, can be found on the IEC website.

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

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

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INTRODUCTION

This part of IEC 62282 specifies test methods for a single cell and stack (denoted as "cell/stack" hereafter) that is required in power generation systems using solid oxide fuel cells (SOFCs).

SOFCs have a broad range of geometry and size. As such, in general, peripherals like current collectors and gas manifolds are unique to each cell or stack and are often incorporated into a cell or stack to form one integrated unit. In addition, they tend to have a significant effect on the power generation characteristics of the cell or stack. This document therefore introduces as its subject "cell/stack assembly units", which are defined as those units containing not only a cell or stack but also peripherals.

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FUEL CELL TECHNOLOGIES –

Part 7-2: Test methods – Single cell and stack performance tests for solid oxide fuel cells (SOFCs)

1 Scope

This part of IEC 62282 applies to SOFC cell/stack assembly units, testing systems, instruments and measuring methods, and specifies test methods to test the performance of SOFC cells and stacks.

This document is not applicable to small button cells that are designed for SOFC material testing and provide no practical means of fuel utilization measurement.

This document is used based on the recommendation of the entity that provides the cell performance specification or for acquiring data on a cell or stack in order to estimate the performance of a system based on it. Users of this document can selectively execute test items suitable for their purposes from those described in this document.

Users can substitute selected test methods of this document with equivalent test methods of IEC 62282-8-101 for solid oxide cell (SOC) operation for energy storage purposes, operated in reverse or reversible mode.

2 Normative references

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

IEC 60050-485, *International Electrotechnical Vocabulary (IEV) – Part 485: Fuel cell technologies* (available at http://www.electropedia.org)

IEC 60584-1, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 60584-3, *Thermocouples – Part 3: Extension and compensating cables – Tolerances and identification system*

IEC 61515, *Mineral insulated metal-sheathed thermocouple cables and thermocouples*

ISO 5168, *Measurement of fluid flow – Procedures for the evaluation of uncertainties*

ISO 6141, *Gas analysis – Contents of certificates for calibration gas mixtures*

ISO 6142-1, *Gas analysis – Preparation of calibration gas mixtures – Gravimetric method for Class I mixtures*

ISO 6143, *Gas analysis – Comparison methods for determining and checking the composition of calibration gas mixtures*

ISO 6145-7, *Gas analysis – Preparation of calibration gas mixtures using dynamic methods – Part 7: Thermal mass-flow controllers*

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ISO 6974 (all parts), *Natural gas – Determination of composition with defined uncertainty by gas chromatography*

ISO 7066-2, *Assessment of uncertainty in the calibration and use of flow measurement devices – Part 2: Non-linear calibration relationships*

ISO 8573-1, *Compressed air – Part 1: Contaminants and purity classes*

ISO 8756, *Air quality – Handling of temperature, pressure and humidity data*

ISO 12185, *Crude petroleum and petroleum products – Determination of density – Oscillating U-tube method*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-485 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 http://www.iso.org/obp

3.1.1
cell/stack assembly unit
unit including a single cell or stack, as well as gas supply parts, current collector parts, and any other peripherals as required for power generation tests

3.1.2
active electrode area
geometric electrode area upon which an electrochemical reaction occurs

Note 1 to entry: Usually this is the smaller of the anode and cathode areas.

3.1.3
current density
current divided by the active electrode area

3.1.4
average repeating unit voltage
cell/stack assembly unit voltage divided by the number of the cells in a series connection in the unit

3.1.5
standard temperature and pressure
STP
temperature of 0 °C and an absolute pressure of 101,325 kPa, respectively

3.1.6
anode gas
gas that is supplied to the inlet of the anode of a single cell/stack assembly unit

Note 1 to entry: Such a gas belongs to one of the following categories:

a) pure hydrogen or mixture that contains hydrogen as a principal component with water vapour or nitrogen

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b) reformed gas of raw fuel of SOFC such as methane or kerosene premixed with water vapour or air as oxidant;

c) simulated gas of reformate that contains hydrogen, water vapour, carbon monoxide, carbon dioxide, methane, nitrogen, etc., as main components;

d) methane, alcohols and other raw fuels directly supplied in pure form or mixed with water vapour and/or air.

3.1.7
cathode gas
gas that is supplied to the inlet of the cathode of a single cell/stack assembly unit

Note 1 to entry: Oxygen and nitrogen are its main components.

3.1.8
current collector
conductive material in a fuel cell that collects electrons from the anode side or conducts electrons to the cathode side

3.1.9
stable state
condition of a cell/stack assembly unit at which the unit is stable enough for any controlling parameter and the output voltage or output current of the unit to remain within its tolerance range of variation

3.1.10
theoretical current
current when the supplied anode gas or cathode gas is completely consumed in electrochemical reactions divided by the number of cells in a series connection

3.1.11
effective fuel utilization
ratio of the actual output current of the cell/stack assembly unit to the theoretical current

Note 1 to entry: The effective utilization is the utilization of reactants in the electrochemical reaction due to the actual current. This may be less than the actual or total utilization if there are gas inlet and cross leaks.

Note 2 to entry: Causes of less-than-optimal currents include losses due to electronic conduction within the cell/stack assembly, gas leaks and anode gas pass-through.

Note 3 to entry: A calculation method of effective fuel utilization is given in Annex B.

3.1.12
effective oxygen utilization
ratio of the actual output current of the cell/stack assembly unit to the theoretical current

Note 1 to entry: The effective utilization is the utilization of reactants in the electrochemical reaction due to the actual current. This may be less than the actual or total utilization if there are gas inlet and cross leaks.

Note 2 to entry: A calculation method of effective oxygen utilization is given in Annex C.

3.1.13
maximum effective fuel utilization
highest effective fuel utilization that the unit can operate at, without causing unacceptable degradation

Note 1 to entry: The acceptable degradation rate is usually obtained from the developer.

3.1.14
minimum cell/stack assembly unit voltage
lowest cell/stack assembly unit voltage specified by the manufacturer

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3.1.15
open circuit voltage
OCV
voltage across the terminals of a fuel cell with cathode and anode gases present and in the absence of external current flow

Note 1 to entry: Also known as "no-load voltage".

3.1.16
power density
ratio of the power to the active electrode area of a cell/stack assembly unit

Note 1 to entry: Power density is calculated from the voltage multiplied by the current density ($P_d = V \times J$, where J is current density).

3.1.17
total impedance
frequency-dependent losses due to ohmic, activation, diffusion, concentration effects, stray (parasitic) capacitance and inductances

3.1.18
total resistance
real part of the low-frequency limit of total impedance

3.1.19
stoichiometric ratio
ratio between the number of moles of reactant gas flowing per unit time to that needed by the electrochemical reaction

Note 1 to entry: The terms, "stoichiometric ratio" and "reactant gas utilization," are related. The reciprocal of the fraction of the gas utilized is the stoichiometric ratio.

3.2 Symbols

Table 1 lists the symbols and units that are used in this document.

Table 1 – Symbols

Symbol	Definition	Unit
a	Error limit specified from specification of instrument	[a]
I	Current	A
J	Current density	A/cm^2
n	Number of transferred electrons	
N	Number of cells in a series connection	
p_a	Absolute pressure of anode gas	kPa
p_c	Absolute pressure of cathode gas	kPa
P	Output power	W
P_d	Output power density	W/cm^2
q_a	Flow rate of anode gas	l/min (STP)
q_c	Flow rate of cathode gas	l/min (STP)
q_j	Flow rate of fuel component j in anode gas	l/min (STP)
t	Time	s, min, h
T_{op}	Cell/stack assembly unit operating temperature	°C
u_I	Combined standard uncertainty for instruments	[a]
$u_{I,i}$	Standard uncertainty for instrument i	[a]

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Symbol	Definition	Unit
U_f	Effective fuel utilization	%
U_{O2}	Effective oxygen utilization	%
U_I	Extended instrument uncertainty	[a]
V	Voltage	V
x_i	Molar fraction of component i or Mole percent of component i	mol/mol or mol % [b]
c_i	Concentration of component i	mol/m^3
ξ_j	Hydrocarbon conversion rate for hydrocarbon component j	%

[a] Denotes where the unit varies depending on the specification.

[b] Mole percent expressed as one hundred times mole fraction.

4 General safety conditions

An operating fuel cell uses oxidizing and combustible gases. Typically, these gases are stored in high-pressure containers. The fuel cell itself may be operated at pressures greater than atmospheric pressure. Those who carry out cell/stack assembly unit testing shall be trained and experienced in the operation of test systems and specifically in safety procedures involving electrical equipment and reactive, compressed gases.

The test personnel are responsible for obtaining and following all applicable safety codes and generally accepted engineering practices related to their test system, facility, fuels (with particular attention to compressed gases), and exhaust products.

Materials which are compatible with the use and storage of the reactant gases shall be used during testing. Local safety codes and standards for working with hydrogen, hydrocarbons and carbon monoxide should be followed.

In summary, safely operating a test station requires appropriate technical training and experience as well as safety facilities and equipment, all of which are outside the scope of this document.

5 Cell/stack assembly unit

A cell/stack assembly unit includes a cell or stack, gas supply, current leads, and such other peripherals as required for power generation tests. It shall be provided with single or multiple measuring points for temperature and voltage, and one set of current lead points, all to be specified by the manufacturer.

As shown in Annex A, the boundary of a cell/stack assembly unit goes through the anode gas supply port, cathode gas supply port, temperature measuring point, current lead points, voltage measuring points and mechanical load application points.

Some cell/stack assembly units may have no exhaust port for the anode gas or cathode gas because of the configuration of the cells. In such cases, the gas flow field pattern and its material shall be determined by the method recommended by the manufacturer. The load application method shall be also based on the recommendation of the manufacturer. The maximum operating temperature from the manufacturer shall not be exceeded.

If the components of a cell/stack assembly unit other than a cell/stack are not specified by the manufacturer, the following shall be described in the test report, as a minimum:

a) materials and geometry of the peripheral components to be used for testing;

b) flow patterns and directions of anode and cathode gases;

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