IEC 62282-8-101

Edition 1.0 2020-02

INTERNATIONAL STANDARD

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Fuel cell technologies –
Part 8-101: Energy storage systems using fuel cell modules in reverse mode – Test procedures for the performance of solid oxide single cells and stacks, including reversible operation

Technologies des piles à combustible –
Partie 8-101: Système de stockage de l'énergie utilisant des modules à piles à combustible en mode inversé – Procédures d'essai pour la performance des cellules élémentaires et des piles à oxyde solide, comprenant le fonctionnement réversible

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUEL CELL TECHNOLOGIES –

Part 8-101: Energy storage systems using fuel cell modules in reverse mode – Test procedures for the performance of solid oxide single cells and stacks, including reversible operation

FOREWORD

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International Standard IEC 62282-8-101 has been prepared by IEC technical committee 105: Fuel cell technologies.

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

FDIS	Report on voting
105/765/FDIS	105/779/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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- withdrawn,
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- amended.

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INTRODUCTION

This document describes test methods for a single cell or stack (denoted as "cell/stack" hereafter) that are intended for application to energy storage systems using solid oxide fuel cells (SOFC) in combination with solid oxide electrolysis cells (SOEC), or directly using reversible solid oxide cells (Re-SOC, see Note in Clause 1). The test methods aim to provide guidelines for the characterization of real-time performance and durability of the cell/stack.

SOFC, SOEC and Re-SOC have a broad range of geometries (e.g. planar, tubular and their variations) 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 a stack but also peripherals.

This document is generally applicable to all types or geometries of SOFC, SOEC and Re-SOC, unless where explicitly mentioned.

IEC 62282-8 (all parts) aims to develop performance test methods for power storage and buffering systems based on electrochemical modules (combining electrolysis and fuel cells, in particular reversible fuel cells), taking into consideration both options of re-electrification and substance (and heat) production for sustainable integration of renewable energy sources.

Under the general title "Energy storage systems using fuel cell modules in reverse mode", the IEC 62282-8 series will consist of the following parts:

- IEC 62282-8-101: *Test procedures for the performance of solid oxide single cells and stacks, including reversible operation*
- IEC 62282-8-102: *Test procedures for the performance of single cells and stacks with proton exchange membranes, including reversible operation*
- IEC 62282-8-103[1]: *Alkaline single cell and stack performance including reversible operation*
- IEC 62282-8-201: *Test procedures for the performance of power-to-power systems*
- IEC 62282-8-202[2]: *Power-to-power systems – Safety*
- IEC 62282-8-300 series[3]: *Power-to-substance systems*

As a priority dictated by the emerging needs for industry and opportunities for technological development, IEC 62282-8-101, IEC 62282-8-102 and IEC 62282-8-201 have been initiated jointly and as a priority. These documents are presented as a package to highlight the need for an integrated approach as regards the system application (i.e. a solution for energy storage) and its fundamental constituent components (i.e. fuel cells operated in reverse or reversible mode).

IEC 62282-8-103, IEC 62282-8-202 and IEC 62282-8-300 (all parts) are suggested but are left for initiation at a later stage.

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1 Under consideration.

2 Under consideration.

3 Under consideration.

FUEL CELL TECHNOLOGIES –

Part 8-101: Energy storage systems using fuel cell modules in reverse mode – Test procedures for the performance of solid oxide single cells and stacks, including reversible operation

1 Scope

This part of IEC 62282 addresses solid oxide cell (SOC) and stack assembly unit(s). It provides for testing systems, instruments and measuring methods to test the performance of SOC cell/stack assembly units for energy storage purposes. It assesses performance in fuel cell mode, in electrolysis mode and/or in reversible operation.

This document is not applicable to small button cells that are designed for SOC material testing and provide no practical means of reactant utilization measurement, or to single-chamber SOC. This document is not intended to be applied to fuel cell/stack assembly units for power generation purposes only, since this is covered in IEC TS 62282-7-2. Therefore, test methods are not included in this document that are applicable to fuel cell mode only and that are already described in IEC TS 62282-7-2.

This document is intended for data exchanges in commercial transactions between cell/stack manufacturers and system developers 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 may selectively execute test items suitable for their purposes from those described in this document. Users can also substitute selected test methods of this document with equivalent test methods of IEC TS 62282-7-2 for SOC operation in fuel cell mode only.

NOTE 1 In the context of this document, the term "reversible" does not refer to the thermodynamic meaning of an ideal process. It is common practice in the fuel cell community to call the operation mode of a solid oxide cell that alternates between fuel cell mode and electrolysis mode "reversible".

NOTE 2 This document considers only steam electrolysis. Other reactants in electrolysis mode can be used, provided appropriate measures are taken for handling the specific reactants and products, and the guidelines as regards the measurement, control and post-test analysis of results are adapted accordingly.

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 – Part 485: Fuel cell technologies* (available at www.electropedia.org)

IEC 61515:2016, *Mineral insulated metal-sheathed thermocouple cables and thermocouples*

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

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

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 – Part 1: 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 volumetric methods – Part 7: Thermal mass-flow controllers*

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

3 Terms, definitions, abbreviated terms 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
active electrode area
effective electrode area
geometric area of the electrode where the electrochemical reaction takes place

Note 1 to entry: Usually this corresponds to the smaller of the two areas of negative electrode or positive electrode.

Note 2 to entry: Area perpendicular to the ionic current flow, usually expressed in m^2 or cm^2.

[SOURCE: IEC TS 62282-7-2:2014, 3.1.2, modified – Definition and Note 1 to entry reworded and Note 2 to entry added.]

3.1.2
area-specific resistance
ASR
R_{ASR}
internal resistivity of any component of a cell or a stack, including the change of potential due to the electrochemical reaction

Note 1 to entry: It is normalized by the active electrode area and is expressed in $\Omega\ m^2$ or $\Omega\ cm^2$.

Note 2 to entry: This note applies to the French language only.

3.1.3
average repeating unit voltage
average RU voltage
cell/stack assembly unit voltage divided by the number of the cells in a series connection in the unit

Note 1 to entry: Average voltage is expressed in V.

[SOURCE: IEC TS 62282-7-2:2014, 3.1.4 modified – In the term, word "cell" replaced by "repeating unit", and Note 1 to entry added.]

3.1.4
interconnector
interconnect
conductive and gas-tight component connecting single cells in a stack

Note 1 to entry: Gas tightness is relevant for planar-type geometries of SOC.

Note 2 to entry: This item is only applicable to planar-type geometries of SOCs, as opposed to tubular geometries (see IEC 60050-485:—, 485-06-04).

[SOURCE: IEC 60050-485:—, 485-06-05, modified – Words "fuel cell stack" replaced by "stack", and Notes 1 and 2 to entry added.]

3.1.5
catalyst
substance that accelerates (increases the rate of) a reaction without being consumed itself

Note 1 to entry: The catalyst lowers the activation energy of the reaction, allowing for an increase in the reaction rate.

[SOURCE: IEC 60050-485:—, 485-01-01, modified – Definition reworded, and Note 2 to entry removed.]

3.1.6
single cell
cell
basic unit of a solid oxide cell

3.1.7
axial load
compression force
compressive load applied to the single cell or the end plates of a planar SOC stack to ensure electric contact and/or gas tightness

Note 1 to entry: The compression force is in practice expressed in N.

[SOURCE: IEC 60050-485:—, 485-06-14, modified – Words "end plates of a fuel cell" replaced by "single cell or the end plates of a planar SOC", "electric" added, and Note to entry replaced.]

3.1.8
conditioning
preliminary step of treatment that is required to properly operate a SOC and is usually realized by following a protocol specified by the manufacturer

Note 1 to entry: The conditioning may include reversible and/or irreversible processes depending on the cell technology.

[SOURCE: IEC 60050-485:—, 485-11-08, modified – Words "of treatment" added, "fuel cell" replaced by "SOC", and "to achieve a desired performance" replaced by "and is usually realized by".]

3.1.9
contact layer
layer applied between the interconnect and the cell to minimize the contact resistance

3.1.10
current collector
electronically conductive material in a cell/stack assembly unit that collects/conducts electrons from/to the electrodes

[SOURCE: IEC 60050-485:—, 485-06-07, modified – Word "electronically" added, "fuel cell" replaced with "cell/stack assembly unit", and "anode/cathode" replaced with "electrodes".]

3.1.11
current density
current per unit active area

Note 1 to entry: The current density is expressed in A/m^2 or A/cm^2.

[SOURCE: IEC 60050-485:—, 485-12-01, modified – Word "electric" deleted before "current".]

3.1.12
derived quantities
quantities that can be derived or calculated from test input parameters, and/or test output parameters (e.g. current density, reactant utilization, electric efficiency)

Note 1 to entry: In comparison to test output parameters, derived quantities are not directly measurable.

3.1.13
dwell time
time between changes in the setting of operating conditions

3.1.14
electrode gas
gas present at the positive or negative electrode

Note 1 to entry: Electrode gases can be reactants, products or inert gas.

3.1.15
reactant utilization
effective reactant utilization
ratio of converted substance flow through a given electrode of the cell/stack assembly unit to the input substance flow of the same electrode

Note 1 to entry: The three types of reactant utilization are:

– fuel utilization (negative electrode in SOFC mode);

– oxygen utilization (positive electrode in SOFC mode);

– steam conversion (negative electrode in SOEC mode).

Note 2 to entry: In SOFC mode, the effective reactant utilization can also be calculated as the ratio of actual output current of the cell/stack assembly unit to the theoretical Faradaic current.

Note 3 to entry: Under the assumption that the electrolyte has neither leak nor electronic conductivity, the reactant utilization is equivalent to the effective reactant utilization and can be calculated according to IEC TS 62282-7-2:2014, Annex B and Annex C.