IEC 62282-7-2

Edition 2.0 2025-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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 62282-7-2:2025-03(en-fr)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

IEC 62282-7-2

Edition 2.0 2025-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 27.070 ISBN 978-2-8327-0241-3

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

FUEL CELL TECHNOLOGIES –

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

FOREWORD

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

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

This second edition cancels and replaces the first edition published in 2021. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Table 1 has been revised to specify the units missing for some terms;
b) bibliographical entries (ISO/TR 15916, SOCTESQA test modules and ISO/IEC Guide 98-6:2021) have been added to provide further information.

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

Draft	Report on voting
105/1093/FDIS	105/1099/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/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, or
- revised.

INTRODUCTION

Solid oxide fuel cells (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.

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 https://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 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, petroleum products and related products – Determination of density – Laboratory density meter with an oscillating U-tube sensor*

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 terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://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 used in power generation tests

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

Note 1 to entry: Usually the active electrode area 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
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;

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 or air, or both.

e) condensable gas operating in gas phase such as anhydrous ammonia (NH_3) as raw input fuel or in cracked form.

3.1.6
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.

3.1.7
current collector
conductive material in a cell/stack assembly unit that collects electrons from the anode side or conducts electrons to the cathode side

3.1.8
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

3.1.9
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

3.1.10
effective fuel utilization
ratio of the actual output current of the cell/stack assembly unit to the theoretical current that is calculated for the supplied fuel

Note 1 to entry: The effective utilization is the utilization of reactants in the electrochemical reaction at the anode due to the actual current. This can 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.

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

3.1.11
effective oxygen utilization
ratio of the actual output current of the cell/stack assembly unit to the theoretical current that is calculated for the supplied oxygen

Note 1 to entry: The effective utilization is the utilization of reactants in the electrochemical reaction at the cathode due to the actual current. This can 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.

3.1.12
maximum effective fuel utilization
highest effective fuel utilization that the cell/stack assembly unit can operate at, without causing unacceptable degradation

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

3.1.13
minimum cell/stack assembly unit voltage
lowest cell/stack assembly unit voltage specified by the manufacturer

3.1.14
open circuit voltage
OCV
voltage across the terminals of a cell/stack assembly unit with cathode and anode gases present and in the absence of external current flow

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

3.1.15
total impedance
frequency-dependent losses due to ohmic, activation, diffusion, concentration effects, stray (parasitic) capacitance and inductances

3.1.16
total resistance
real part of the low-frequency limit of total impedance

3.1.17
stoichiometric ratio
ratio between the number of moles of reactant gas flowing per unit time to that used 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	Term	Unit
a	Error limit specified from specification of instrument	[a]
I	Current	A
J	Current density	A/cm^2
A	Active electrode area	cm^2
Z	Total impedance	$\Omega\ cm^2$
n	Number of transferred electrons	
N	Number of cells in a series connection in the cell/stack assembly unit	
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 [b])
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 or K
u_C	Combined standard uncertainty for instruments	[a]
$u_{I,i}$	Standard uncertainty for instrument i	[a]
U_f	Effective fuel utilization	%
U_{O2}	Effective oxygen utilization	%
U_I	Instrument expanded uncertainty	[a]
V	Voltage	V
x_i	Molar fraction of component i or mole percent of component i	mol/mol or mol % [c]
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] Abbreviation for standard temperature and pressure

[c] 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. In some cases, the fuel can be a toxic condensable gas (such as ammonia). The fuel cell itself can be operated at pressures greater than atmospheric pressure. Leaks or outlet flows from cell/stack assembly unit can contain toxic elements (e.g. when using ammonia as a fuel). 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, and toxic compounds if applicable (e.g. when using ammonia as a fuel).

Materials which are compatible with the use and storage of the reactant gases shall be used during testing.

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. 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 assembly unit goes through the anode gas supply port, cathode gas supply port, temperature, pressure measuring point, current lead points, voltage measuring points and mechanical load application points.

Some cell/stack assembly units can 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 recommended by 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;
c) locations of temperature measurement, mechanical load application, voltage measurement and current leads;
d) magnitude of the mechanical load;
e) configuration of assembly unit and its assembling method.

6 Testing system

6.1 Subsystems in testing system

6.1.1 General

As shown in Figure 1, a testing system consists of an anode gas control subsystem, cathode gas control subsystem, cell/stack assembly unit temperature control subsystem, output power control subsystem, measurement and data acquisition subsystem and safety subsystem. It can also include a mechanical load control subsystem, anode gas and cathode gas pressure control subsystem or a test system control subsystem that controls the whole testing system, or both, if necessary.