IEC 62282-8-102

Edition 1.0 2019-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Fuel cell technologies –
Part 8-102: Energy storage systems using fuel cell modules in reverse mode – Test procedures for the performance of single cells and stacks with proton exchange membranes, including reversible operation

Technologies des piles a combustible –
Partie 8-102: Systèmes 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 membrane échangeuse de protons, comprenant le fonctionnement réversible

IEC 62282-8-102:2019-12(en-fr)

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FUEL CELL TECHNOLOGIES –

Part 8-102: Energy storage systems using fuel cell modules in reverse mode – Test procedures for the performance of single cells and stacks with proton exchange membranes, including reversible operation

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International Standard IEC 62282-8-102 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
105/763/FDIS	105/776/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

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- withdrawn,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

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INTRODUCTION

This part of IEC 62282 describes test methods for a single cell and stack (denoted as "cell/stack" hereafter) that are intended for use in energy storage systems that use proton exchange membrane fuel cells (PEMFC) in combination with proton exchange membrane water electrolysers (PEMWE), or directly using proton exchange membrane cells (Re-PEM).

This document is intended to be used 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 can selectively execute test items suitable for their purposes from those described in this document.

PEMFCs, PEMWEs and Re-PEMs 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 unit", which are defined as those units containing not only a cell or a stack, but also peripherals.

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 consists 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 (all parts)[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 parts 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 reversing 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 8-102: Energy storage systems using fuel cell modules in reverse mode – Test procedures for the performance of single cells and stacks with proton exchange membranes, including reversible operation

1 Scope

This part of IEC 62282 deals with PEM cell/stack assembly units, testing systems, instruments and measuring methods, and test methods to test the performance of PEM cells and stacks in fuel cell mode, electrolysis and/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:— [4], *International Electrotechnical Vocabulary – Part 485: Fuel cell technologies*

IEC TS 62282-7-1:2017, *Fuel cell technologies – Part 7-1: Test methods – Single cell performance tests for polymer electrolyte fuel cells (PEMFC)*

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
active electrode area
geometric area of the electrode perpendicular to the direction of the current flow

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

[SOURCE: IEC 60050-485:—, 485-02-08, modified – "electrode" added to the term, the term "effective area" has been deleted, and the notes to entry have been replaced with a new note to entry.]

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4 Under preparation. Stage at the time of preparation: IEC FDIS 60050-485:2019.

3.1.2
area-specific resistance
ASR
internal resistivity with respect to the active electrode area, including the change of potential due to the electrochemical reaction

Note 1 to entry: This note applies to the French language only.

3.1.3
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.

3.1.4
catalyst-coated membrane
CCM
<in a PEMFC (3.1.24)> polymer membrane whose surfaces are coated with a catalyst layer (3.1.5) to form the reaction zone of the electrode (3.1.8)

Note 1 to entry: See also membrane electrode assembly (MEA) (3.1.17).

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

[SOURCE: IEC 60050-485:—, 485-04-03]

3.1.5
catalyst layer
surface porous region adjacent to either side of the membrane containing the catalyst (3.1.3), typically with ionic and electronic conductivity

Note 1 to entry: The catalyst layer comprises the spatial region where the electrochemical reactions can take place.

3.1.6
current collector
conductive material in a fuel cell (3.1.13) that collects electrons from the negative electrode (3.1.20) side or conducts electrons to the positive electrode (3.1.25) side

3.1.7
current density
current per unit active area (IEV 485-02-08)

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

3.1.8
electrode
electronic conductor (or semi-conductor) through which an electric current enters or leaves the electrochemical cell as the result of an electrochemical reaction

Note 1 to entry: An electrode is either a positive electrode (3.1.25) or a negative electrode (3.1.20).

3.1.9
electrolyte
liquid or solid substance containing mobile ions that render it ionically conductive

Note 1 to entry: The electrolyte is the main distinctive feature of the different fuel cell technologies (e.g. a liquid, polymer, molten salt, solid oxide) and determines the usable operating temperature range.

3.1.10
end plate
component located on either end of the cell stack in the direction of current flow, serving to transmit the required compression to the stacked cells

Note 1 to entry: The end plate can comprise ports, ducts, and manifolds for the supply of fluids (reactants, coolant) to the cell stack.

[SOURCE: IEC 60050-485:—, 485-06-06, modified – The admitted terms have been deleted, "fuel cell stack" has been replaced by "cell stack in the direction of current flow" in the definition, and the second sentence of Note 1 to entry has been deleted.]

3.1.11
flow plate
electronically conductive plate which incorporates channels for fuel (3.1.12) or oxidant (3.1.22) gas flow in fuel cell mode, while for water and gas flow in electrolysis mode and which comprises an electric contact with an electrode (3.1.8)

Note 1 to entry: The conductive plate material can be metal, a material such as graphite, or a conductive polymer that can be a carbon-filled composite.

3.1.12
fuel
hydrogen or hydrogen-containing gas that reacts at the negative electrode (3.1.20) in a fuel cell (3.1.13)

3.1.13
fuel cell
electrochemical device that converts the chemical energy of a fuel (3.1.12) and an oxidant (3.1.22) to electric energy (direct current (DC) power), heat and reaction products

Note 1 to entry: The fuel and oxidant are typically stored outside the fuel cell and transferred into the fuel cell as they are consumed.

[SOURCE: IEC 60050-485:—, 485-08-01]

3.1.14
gas diffusion electrode
GDE
type of electrode specifically designed for gaseous reactants or products or both

Note 1 to entry: A gas diffusion electrode usually comprises one or more porous layers, like the gas diffusion layer (3.1.15) and the catalyst layer (3.1.5).

Note 2 to entry: Gas diffusion electrodes can be negative gas diffusion electrodes and positive gas diffusion electrodes.

Note 3 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-485:—, 485-02-02, modified – The abbreviated term "GDE" has been added, and "anodes" and "cathodes" have been replaced by "negative … electrodes" and "positive … electrodes" in Note 2 to entry.]

3.1.15
gas diffusion layer
GDL
porous substrate placed between the catalyst layer (3.1.5) and the flow plate (3.1.11) to serve as electric contact and allow the access of reactants to the catalyst layer and the removal of reaction products

Note 1 to entry: The gas diffusion layer is a component of a gas diffusion electrode (3.1.14).

Note 2 to entry: The gas diffusion layer is also called a porous transport layer (PTL).

Note 3 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-485:—, 485-04-05, modified – "Bipolar plate" has been replaced by "flow plate" in the definition, and Note 2 to entry has been added.]

3.1.16
internal resistance
ohmic resistance inside a fuel cell (3.1.13), measured between current collectors (3.1.6), caused by the electronic and ionic resistances of the different components (electrodes, electrolyte, flow plates and current collectors)

Note 1 to entry: The term ohmic refers to the fact that the relation between voltage drop and current is linear and obeys Ohm's law.

[SOURCE: IEC 60050-485:—, 485-15-04]

3.1.17
membrane electrode assembly
MEA
component of a PEMFC (3.1.24) consisting of an electrolyte membrane, electrode and gas diffusion layer (3.1.15) on either side or a component of a PEMWE (3.1.26) consisting of an electrolyte membrane with catalyst layers (3.1.5) on either side.

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC TS 62282-7-1:2017, 3.19, modified – "or a component of a PEMWE…on either side" has been added.]

3.1.18
minimum cell voltage
lowest permitted fuel cell voltage specified by the manufacturer

3.1.19
maximum cell voltage
highest electrolyser voltage specified by the manufacturer

3.1.20
negative electrode
electrode (3.1.8) at which hydrogen gas is consumed or produced

Note 1 to entry: It is also called hydrogen electrode. In fuel cell mode it is called the anode, where the hydrogen is oxidized. In electrolysis mode, it is called the cathode, where water is reduced producing hydrogen.

Note 2 to entry: In fuel cell mode, the negative electrode gas is usually hydrogen or a mixture which contains hydrogen as a principal component mixed with water vapour and/or inert gas.

3.1.21
open circuit voltage
OCV
voltage across the terminals of a fuel cell (3.1.13) with fuel (3.1.12) and an oxidant (3.1.22) present and in the absence of external current flow

Note 1 to entry: The open circuit voltage is expressed in V.

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

[SOURCE: IEC 60050-485:—, 485-13-02, modified – The term "no-load" voltage has been deleted.]

3.1.22
oxidant
oxygen or oxygen-containing gas (e.g. air) that reacts at the positive electrode (3.1.25) in fuel cell mode

3.1.23
polymer electrolyte
polymer material containing mobile ions that render it ironically conductive

[SOURCE: IEC 60050-485:—, 485-03-01, modified – In the definition, "liquid or solid substance" has been replaced by "polymer material".]

3.1.24
proton exchange membrane fuel cell
PEMFC
fuel cell (3.1.13) that employs a polymer with (proton) ionic exchange capability as the electrolyte (3.1.9)

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-485:—, 485-08-08, modified – The admitted term "solid polymer fuel cell" has been deleted, and the term "polymer electrolyte fuel cell" has been deleted.]

3.1.25
positive electrode
electrode (3.1.8) at which oxygen is consumed or produced

Note 1 to entry: It may also be called oxygen electrode. In fuel cell mode it is called cathode where oxygen is reduced producing water. In the electrolysis mode, it is called anode where oxygen and protons are formed from water.

3.1.26
proton exchange membrane water electrolyser
PEMWE
electrolyser that employs a polymer with (proton) ionic exchange capability as the electrolyte (3.1.9)

Note 1 to entry: This note applies to the French language only.

3.1.27
power density
ratio of the electric power to the active electrode area (3.1.1) of the cell/stack assembly unit electrodes

3.1.28
rated current density
maximum current density specified by the manufacturer, at which the cell/stack (3.1.32) assembly has been designed to operate continuously

3.1.29
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 (hydrogen) utilization (negative electrode in PEMFC mode);
- oxygen utilization (positive electrode in PEMFC mode);
- water conversion (positive electrode in PEMWE mode).

Note 2 to entry: In PEMFC 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.

3.1.30
reversible proton exchange membrane cell
RPEMC
Re-PEM
cell composed of three functional elements: negative electrode (3.1.20), proton exchange membrane electrolyte and positive electrode (3.1.25)

Note 1 to entry: Re-PEM can be used in fuel cell mode (PEMFC) or in electrolysis mode (PEMWE).

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

Note 3 to entry: This note applies to the French language only.

3.1.31
stable state
condition of a cell/stack assembly unit stable enough for any controlling parameter and the output/input voltage or output/input current of the unit to remain within its tolerance range of variation

3.1.32
stack
assembly of cells, separators, cooling plates, end plates, manifolds and a supporting structure that is used as a fuel cell (PEMFC) and/or a water electrolyser (PEMWE)

3.1.33
test input parameter
TIP
parameters whose values can be set in order to define the test conditions of the test system including the operating conditions of the test object

Note 1 to entry: TIPs have to be controllable and measurable. Values of TIPs are known before conducting the test. TIPs can be either static or variable. Static TIPs shall remain constant and variable TIPs are varied during the test.

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

3.1.34
test output parameter
TOP
parameters that indicate the response of the test system/test object as a result of variation of one or more TIPs

Note 1 to entry: Values of TOPs are unknown before conducting the test and will be measured during the test. TOPs need to be measurable.

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

3.1.35
dwell time
time between changes in the setting of operating conditions

3.2 Symbols

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