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TECHNICAL SPECIFICATION

Fuel cell technologies –
Part 7-1: Single cell test methods for polymer electrolyte fuel cell (PEFC)

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FOREWORD

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62282-7-1, which is a technical specification, has been prepared by IEC technical committee 105: Fuel cell technologies.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
105/241/DTS	105/253A/RVC

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

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This Technical Specification describes standard single-cell test methods for polymer electrolyte fuel cells (PEFCs); it provides consistent and repeatable methods to test the performance of single cells. This Technical Specification is to be used by component manufacturers or stack manufacturers who assemble components in order to evaluate the performance of cell components, including membrane-electrode assemblies (MEAs) and flow plates. This Technical Specification is also available for fuel suppliers to determine the maximum allowable impurities in fuels.

Users of this Technical Specification may selectively execute test items suitable for their purposes from those described in this technical specification. This document is not intended to exclude any other methods.

FUEL CELL TECHNOLOGIES –

Part 7-1: Single cell test methods for polymer electrolyte fuel cell (PEFC)

1 Scope

This part of IEC 62282 covers cell assemblies, test apparatus, measuring instruments and measuring methods, performance test methods, and test reports for PEFC single cells.

This Technical Specification is used for evaluating:

a) the performance of membrane electrode assemblies (MEAs) for PEFCs,
b) materials or structures of other components of PEFCs, or
c) the influence of impurities in fuel and/or in air on the fuel cell performance.

2 Normative references

The following referenced documents are indispensable for the application 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/TS 62282-1:2010, *Fuel cell technologies – Part 1: Terminology*

ISO/TS 14687-2:2008, *Hydrogen fuel – Product specification – Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1
anode
the electrode at which fuel oxidation takes place by the removal of electrons from the fuel to the external electric load, concurrent with the release of protons (H^+) to the polymer electrolyte

3.2
catalyst
substance that accelerates (increases the rate of) a reaction without being consumed itself

The catalyst lowers the activation energy of the reaction, allowing for an increase in the reaction rate. This is also referred to as an electrocatalyst, as defined in IEC/TS 62282-1.

3.3
catalyst-coated membrane
CCM
term used to describe a membrane (in a PEFC) whose surfaces are coated with a layer of catalyst to form the reaction zone of the electrode

3.4

cathode

the electrode at which oxidant reduction takes place, facilitated by the donation of electrons from the external circuit and protons (H^+) from the polymer electrolyte, followed by the release of reduced oxidant products (water)

3.5

clamping plate (or pressure plate)

frame used to compress the cell components together to maintain electrical conductivity and sealing

3.6

current collector

conductive material, which can consist of metals, graphite or composite materials, that collects electrons from an anode or disburses electrons to a cathode

3.7

electrode

catalytic layer that facilitates either an oxidation or reduction reaction, and has both electronic and ionic conduction.

3.8

flow plate

conductive plate made of metals, a material such as graphite, or a conductive polymer that may be a carbon-filled composite, which is incorporated with flow channels for fuel or oxidant gas feed and has electrical contact with an electrode

3.9

fuel

hydrogen or hydrogen-containing gas that reacts at the anode

3.10

fuel cell

electrochemical device that converts the chemical energy of a fuel and an oxidant to electrical energy (DC power), heat and reaction products

The fuel and oxidant are typically stored outside of the fuel cell and transferred into the fuel cell as the reactants are consumed.

3.11

gas diffusion electrode

GDE

component on the anode or cathode side comprising all electronic conductive elements of the electrode, i.e. gas diffusion layer and catalyst layer

3.12

gas diffusion layer

GDL

porous conductive component placed between an electrode and a flow plate, to serve as electric contact and allow access of reactants to the electrode and the removal of reaction products

3.13

gasket

sealing component which prevents the reaction gas from leaking out of a cell

3.14
limiting current density
the current density where the cell voltage sharply decreases to near zero

3.15
maximum current density
the highest current density specified by the manufacturer allowed for a short time

3.16
membrane electrode assembly
MEA
component of a fuel cell (3.10) consisting of an electrolyte membrane with gas diffusion electrodes (3.11) on either side

3.17
minimum cell voltage
the lowest cell voltage specified by the manufacturer

3.18
open circuit voltage
OCV
the cell voltage at zero current density with the cell under operating conditions

3.19
oxidant
oxygen or oxygen-containing gas (e.g., air) that reacts at the cathode

3.20
polymer electrolyte
polymer resin membrane having proton exchange capability in which current is carried by the movement of such ions from an anode to a cathode

3.21
polymer electrolyte fuel cell
PEFC
fuel cell that employs a polymer electrolyte membrane as an electrolyte, which is also called a proton exchange membrane fuel cell (PEMFC)

3.22
power
measure calculated from the voltage multiplied by the current at a steady state ($P = V \times I$)

3.23
power density
measure calculated by dividing the power by the geometric, electrode area

3.24
rated current density
maximum current density specified by the manufacturer of the MEA or single cell for continuous operation

3.25
rated power density
maximum power density specified by the manufacturer of the MEA or single cell for continuous operation

3.26
rated voltage
minimum cell voltage specified by the manufacturer of the MEA or single cell for continuous operation

3.27
single cell
cell typically consisting of an anode flow plate, MEA, cathode flow plate and sealing gaskets (see Annex B for additional information)

3.28
single cell test
test of the fuel cell performance based on a single cell

3.29
stoichiometry
molar ratio of the fuel (or oxidant) gases supplied to the cell to that required by the chemical reaction, as calculated from the current

4 General safety considerations

An operating fuel cell uses oxidizing and reducing gases. Typically, these gases are stored in high-pressure containers. The fuel cell itself may or may not be operated at pressures greater than atmospheric pressure.

Those who carry out single cell testing shall be trained and experienced in the operation of single cell test systems and specifically in safety procedures involving electrical equipment and reactive, compressed gases. Safely operating a single cell test station requires appropriate technical training and experience as well as safe facilities and equipment, all of which are outside the scope of this technical specification.

5 Cell components

5.1 General

A single cell of a PEFC shall be composed of all or some of the following components:

a) an MEA,
b) gaskets,
c) an anode-side flow plate and a cathode-side flow plate,
d) an anode-side current collector and a cathode-side current collector,
e) an anode-side clamping plate and a cathode-side clamping plate,
f) electrically insulating sheets,
g) clamping or axial load hardware which may include bolts, washers, springs, etc.,
h) temperature-control devices,
i) other miscellaneous parts.

5.2 Sizing the membrane electrode assembly (MEA)

The electrode area shall be as large as needed to measure desired parameters. A suggested electrode size should be approximately 25 cm^2, though larger cells having larger electrodes may give more relevant data for practical applications. The active electrode area shall be reported and shall be the smaller of the two electrode active areas. The approximate uncertainty in the area measurement shall be reported also.

5.3 Gas diffusion layer (GDL)

A gas diffusion layer shall be made of highly gas-diffusible, electrically conductive and corrosion-resistant materials.

5.4 Gasket

The gasket material shall be compatible with fuel cell reactants, components and reaction products, and cell operating temperature. It shall prevent gas leakage.

5.5 Flow plate

Flow plates shall be made of materials that have negligible gas permeability, but high electric conductivity. Resin-impregnated, high-density, synthetic graphite, polymer/carbon composites, or corrosion-resistant metal, such as titanium or stainless steel, is recommended. If metal is used, the plate surface may be coated/plated (e.g., with gold) in order to reduce contact resistance. The flow plate should be corrosion-resistant and should provide a suitable seal.

A serpentine flow channel is suggested. Further information about a suggest design is given in Annex A. The flow field configuration shall be documented in the test report.

The flow plates for testing shall allow the accurate measurement of cell operating temperature. For example, flow plates may have a small hole on an edgewise face in order to accommodate a temperature sensor. In this case, the hole shall reach the centre of the flow plate.

NOTE If the objective of testing is to evaluate the design of a particular flow channel, it is not necessary to use the suggested flow plate design.

5.6 Current collector

Current collectors shall be made of materials that have high electric conductivity, such as metal. Metal collectors may be plated with contact-resistance-reducing materials, such as gold or silver; however care must be taken in choosing the coating material. It must be compatible with the cell components and reactants and products.

They should be thick enough to minimize voltage drop over their surface area. They should provide an output terminal for wire connection.

If metal flow plates act as current collectors, independent current collectors are not required.

5.7 Clamping plate (or pressure plates)

Clamping plates (or pressure plates) shall be flat and smooth-surfaced, with their mechanical properties strong enough to withstand the bending force being applied when clamped with bolts.

If the clamping plates are conductive, they shall be insulated from the current collectors in order to prevent short-circuiting.

5.8 Clamping hardware

Clamping hardware shall have high mechanical strength in order to withstand the stresses generated during installation and operation. Washers and springs may be used to maintain constant, uniform pressure on the single cell. A torque wrench or other measuring device shall be used to set exact pressure on the cell.

It is recommended to electrically insulate the clamping hardware.

5.9 Temperature-control device

The single cell shall be provided with a temperature-control device (for heating/cooling) in order to maintain it at a constant temperature and with a uniform temperature profile along the flow plate and across the cell. The temperature-control device may be programmable to follow a fixed temperature profile. The temperature-control device shall have means to prevent over-temperature.

There are multiple ways of achieving this requirement.

One simple way is to convectively cool and electrically heat the clamping (pressure) plates. The heating can be achieved by attaching a skin resistance heater to the external surface of the plate. An alternate method is to insert a cartridge heater into a hole in the plate.

In either case, care is required to maintain isolation for electrical safety.

6 Cell assembly

6.1 Assembly procedure

Cell assembly procedures have large impact on the repeatability of fuel cell data. Specific procedures shall be documented for the following assembly operations:

a) membrane alignment, including identification of anode and cathode sides,
b) diffusion media (i.e., GDL) alignment, including identification of anode and cathode parts, as well as the sides to be placed facing the membrane and flowfield,
c) gasket/seal placement,
d) alignment fixtures or jigs to be used, if any,
e) compression procedures and specifications, such as diffusion media compression values, bolt tightening order, compression springs, and final torque specifications.

NOTE Pressure may be checked by pressure-sensitive paper/film.

Typical alignment of cell component is shown in Annex B.

After assembling, the isolation between the clamping plates and current collectors shall be checked.

6.2 Cell orientation and gas connections

A cell shall be operated in an orientation which facilitates product water removal. The cell orientation shall be documented.

Many flow patterns can be used; the flow pattern shall be documented. Examples are given in Annex A.

6.3 Leak check

The differential pressure on the membrane is the most critical. The maximum differential pressure specified by the manufacturer should not be exceeded.

The cell must have minimal external and internal leakage. Examples leak-check procedures are given in Annex C. In principle, the leak-check procedure consists of injecting an inert or test gas into both the anode and cathode sides. By using a suitable pressure difference, the nature and direction of the leak can be ascertained. The maximum pressures, the nature of the test gas and leakage rates shall be documented. If a leak is detected, other tests, such as bubble test, may be performed to further delineate type and nature of leak.