IEC 62282-2-100

Edition 1.0 2020-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Fuel cell technologies – Part 2-100: Fuel cell modules – Safety

Technologies des piles à combustible – Partie 2-100: Modules à piles à combustible – Sécurité

IEC 62282-2-100 :2020-05(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 27.070

ISBN 978-2-8322-8031-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FUEL CELL TECHNOLOGIES – Part 2-100: Fuel cell modules – Safety

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.
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International Standard IEC 62282-2-100 has been prepared by IEC technical committee 105: Fuel cell technologies.

This first edition cancels and replaces IEC 62282-2, published in 2012.

This edition includes the following significant technical changes with respect to IEC 62282-2:2012:

- references to IEC 60050-485[1] instead of IEC TS 62282-1;
- update of normative references;
- update of definitions, in particular **fuel cell module** for **normal operation**;
- leakage values under normal and abnormal operation have been addressed;
- a delayed ignition test has been included;
- protective measures to limit gas leakage have been included;

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1 Under preparation. Stage at the time of publication IEC BPUB 60050-485:2019.

- the requirements for insulation between live parts and **SELV** have been updated;
- the general safety strategy has been modified to reflect the needs for different application standards; the modifications are in line with similar modifications made to IEC 62282-3-100;
- the electrical components clause has been modified to reflect the needs for different application standards; the modifications are in line with similar modifications made to IEC 62282-3-100;
- protective earthing as part of the module or bonding as a measure within the installation has been introduced;
- a dielectric strength test has been completely updated by referring to IEC 62744-1 for voltages up to 1 000 V AC/1 500 V DC;
- a new “pressure drop method” leakage test method has been included;
- terms such as normal/abnormal e.g. in conjunction with operating conditions are used in a more consistent way;
- inclusion of definitions for **hazards** and **hazardous situations** based on the IEC 60079 series;
- the marking and instructions have been enlarged to provide the system integrator with the necessary information;
- a new Annex A addressing significant **hazards**, **hazardous situations** and events dealt with in this document, and linked to 4.1 (General safety strategy) has been added.

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

FDIS	Report on voting
105/782/FDIS	105/793/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.

NOTE In this document, the following print type is used:

– terms defined in Clause 3: **in bold type**.

The reader's attention is drawn to the fact that Annex C lists all of the “in-some-country” clauses on differing practices of a less permanent nature relating to the subject of this document.

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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FUEL CELL TECHNOLOGIES – Part 2-100: Fuel cell modules – Safety

1 Scope

This part of IEC 62282 provides safety related requirements for construction, operation under normal and abnormal conditions and the testing of **fuel cell modules**. It applies to **fuel cell modules** with the following electrolyte chemistry:

- alkaline;
- polymer electrolyte (including direct methanol **fuel cells**)[2];
- phosphoric acid;
- molten carbonate;
- solid oxide;
- aqueous solution of salts.

Fuel cell modules can be provided with or without an enclosure and can be operated at significant pressurization levels or close to ambient pressure.

This document deals with conditions that can yield **hazards** to persons and cause damage outside the **fuel cell modules**. Protection against damage inside the **fuel cell modules** is not addressed in this document, provided it does not lead to **hazards** outside the module.

These requirements can be superseded by other standards for equipment containing **fuel cell modules** as required for particular applications.

This document does not cover **fuel cell** road vehicle applications.

This document is not intended to limit or inhibit technological advancement. An appliance employing materials or having forms of construction differing from those detailed in the requirements of this document can be examined and tested according to the purpose of these requirements and, if found to be substantially equivalent, can be considered to comply with this document.

The **fuel cell modules** are components of final products. These products require evaluation according to appropriate end-product safety requirements.

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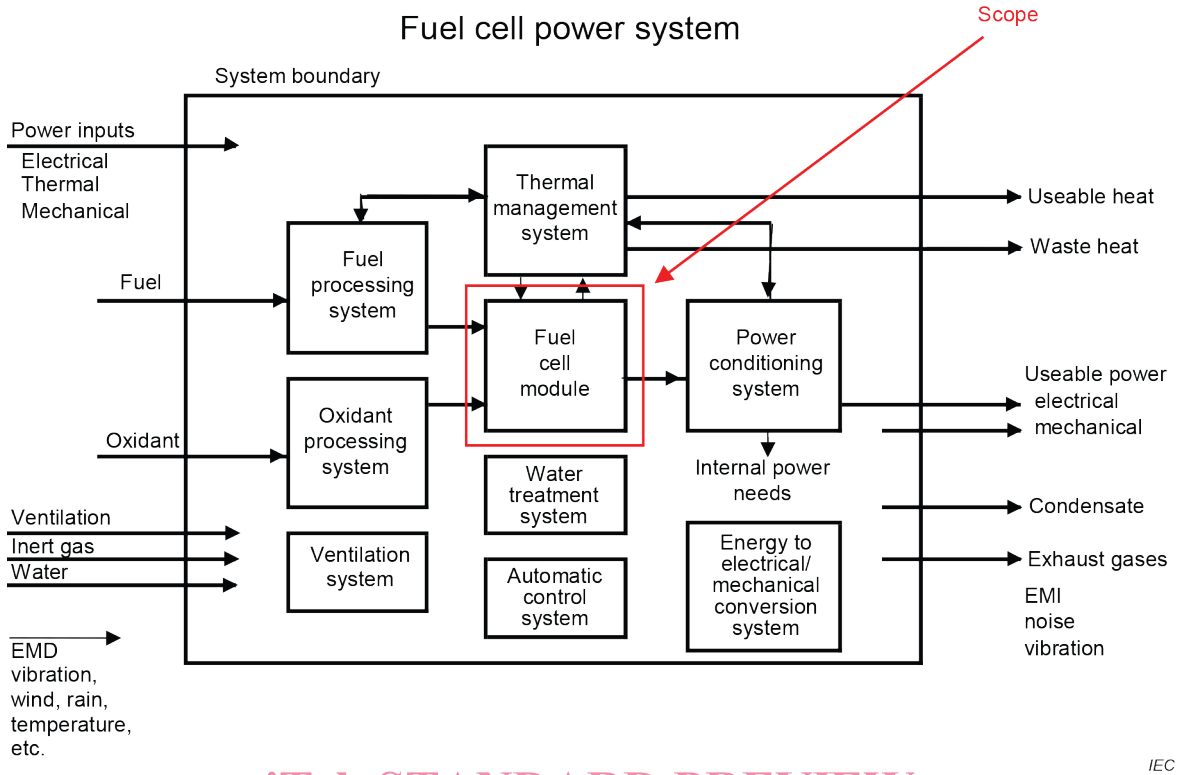
2 Also known as proton exchange membrane fuel cell.



Key

EMD electromagnetic disturbance

EMI electromagnetic interference

Figure 1 – Fuel cell power system components

This document covers only up to the DC output of the **fuel cell module**.

This document does not apply to peripheral devices as illustrated in Figure 1.

This document does not cover the storage and delivery of fuel and oxidant to the **fuel cell module**.

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 60079-10-1, *Explosive atmospheres − Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60352 (all parts), *Solderless connections*

IEC 60512-15 (all parts), *Connectors for electronic equipment – Tests and measurements – Part 15: Connector tests (mechanical)*

IEC 60512-16 (all parts), *Connectors for electronic equipment – Tests and measurements – Part 16: Mechanical tests on contacts and terminations*

IEC 60529*, Degrees of protection provided by enclosures (IP Code)*

IEC 60617, *Graphical symbols for diagrams* (available at http://std.iec.ch/iec60617)

IEC 60695 (all parts), *Fire hazard testing*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61204-7, *Low-voltage switch mode power supplies – Part 7: Safety requirements*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 62040-1, *Uninterruptible power systems (UPS) – Part 1: Safety requirements*

IEC 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62282-4-101, *Fuel cell technologies – Part 4-101: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Safety of electrically powered industrial trucks*

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

ISO 13849-1, *Safety of machinery – Safety related parts of control systems – Part 1: General principles for design*

ISO 23550, *Safety and control devices for gas and/or oil burners and appliances – General requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
fuel cell module
assembly incorporating one or more **fuel cell stacks** and, if applicable, additional components, which is intended to be integrated into a power system or a vehicle

Note 1 to entry: A **fuel cell module** comprises the following main components: one or more **fuel cell stack**(s), a piping system for conveying fuels, oxidants and exhausts, electric connections for the power delivered by the stack(s) and means for monitoring, control or both. Additionally, a **fuel cell module** can comprise: means for conveying additional fluids (e.g. cooling media, inert gas), means for detecting normal and abnormal operating conditions, enclosures or pressure vessels and module **ventilation** systems, and the required electronic components for module operation and power **conditioning**.

[SOURCE: IEC 60050-485:—, 485-09-03]

3.2
acceptance test
contractual test to prove to the customer that the item meets certain conditions of its specification

[SOURCE: IEC 60050-151:2001, 151-16-23, modified – The admitted term "hand-over test" has been deleted.]

3.3
maximum allowable differential working pressure
maximum differential pressure between the anode and cathode side, specified by the manufacturer, which the **fuel cell module** can withstand without any damage or permanent loss of functional properties

Note 1 to entry: The maximum allowable differential working pressure is expressed in Pa.

[SOURCE: IEC 60050-485:—, 485-17-02, modified – "fuel cell" has been replaced with "fuel cell module".]

3.4
allowable working pressure
maximum gauge pressure specified by the manufacturer which the **fuel cell module** can withstand without any damage or permanent loss of functional properties

Note 1 to entry: For **fuel cell modules** incorporating pressure relief devices, this is normally used to define the threshold of the set pressure.

3.5
ambient temperature
temperature of the medium surrounding a device, equipment or installation which may affect the performance of the device, equipment or installation

3.6
conditioning
<related to cells and stacks> preliminary step that is required to properly operate a **fuel cell module** (3.1) to achieve a desired performance following a protocol specified by the manufacturer

Note 1 to entry: The **conditioning** can include reversible processes, or irreversible processes, or both depending on the cell technology.

[SOURCE: IEC 60050-485:—, 485-11-08, modified – "fuel cell" has been replaced with "fuel cell module".]

3.7
fuel cell
electrochemical device that converts the chemical energy of a fuel and an oxidant to electric energy (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]

3.8
fuel cell stack
assembly of cells, separators, cooling plates, manifolds and a supporting structure that electrochemically converts, typically, hydrogen-rich gas and air reactants to DC power, heat and other reaction products

[SOURCE: IEC 60050-485:—, 485-06-01]

3.9
rated current
maximum continuous electric current as specified by the manufacturer, at which the **fuel cell module** has been designed to operate

[SOURCE: IEC 60050-485:—, 485-12-02, modified – “power system” has been replaced with “module” and the note has been deleted.]

3.10
crossover
cross leakage
leakage between the fuel side and the oxidant side of a **fuel cell**, in either direction, generally through the electrolyte

[SOURCE: IEC 60050-485:—, 485-06-25]

3.11
gas leakage
sum of all gases leaving the **fuel cell module** except the intended exhaust gases

Note 1 to entry: Gas leakage may occur from

– the **fuel cell stack**;
– associated pressure relief devices;
– other gas ducting and flow controlling components.

[SOURCE: IEC 60050-485:—, 485-06-24, modified – The Note 1 to entry has been added.]

3.12
hazard
potential source of harm

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

3.13
harm
injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

3.14
hazardous area
area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus

Note 1 to entry: IEC 60079-10 gives a classification of hazardous areas containing explosive gas atmospheres (see IEC 60050-426-03-03, IEC 60050-426-03-04 and IEC 60050-426-03-05).

[SOURCE: IEC 60050-426:2008, 426-03-01, modified – The Note 2 to entry has been deleted.]

3.15
heat deflection temperature
temperature at which a standard test bar deflects a specified distance under load

Note 1 to entry: It is used to determine short-term heat resistance.

3.16
lower flammability limit
LFL
minimum concentration of fuel in a fuel-air mixture where a combustion can be ignited by an ignition source

Note 1 to entry: A fuel-air mixture is flammable when combustion can be started by an ignition source. The main component is the proportions or composition of the fuel-air mixture. A mixture that has less than a critical amount of fuel, known as the **lower flammability limit** (LFL) or more than a critical amount of fuel, known as the rich or upper flammability limit (UFL), will not be flammable.

3.17
maximum operating pressure
maximum gauge pressure, specified by the manufacturer of a component or system, at which it is designed to operate continuously

Note 1 to entry: The **maximum operating pressure** is expressed in Pa.

Note 2 to entry: The **maximum operating pressure** includes all **normal operation**, both steady state and transient.

[SOURCE: IEC 60050-485:—, 485-17-04, modified – The Note 2 to entry has been added.]

3.18
ventilation
movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors)

[SOURCE: IEC 60050-426:2008, 426-03-14]

3.19
open-circuit voltage
OCV
no-load voltage
voltage across the **stack terminals** of a **fuel cell** with fuel and oxidant 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]

3.20
routine test
conformity test made on each individual item during or after manufacture

Note 1 to entry: Not to be confused with “Conformity test” [IEC 60050-151:2001, 151-16-15]: test for conformity evaluation or “Conformity evaluation” [IEC 60050-151:2001, 151-16-14]: systematic examination of the extent to which a product, process or service fulfils specified requirements.

[SOURCE: IEC 60050-151:2001, 151-16-17, modified – The note to entry has been added.]

3.21
safeguarding
control system actions, based on process parameters, taken to avoid conditions that might be **hazardous** to personnel or might result in damage to the **fuel cell** or its surroundings

[SOURCE: IEC 60050-485:—, 485-09-15]

3.22
safety extra low voltage
SELV
voltage under normal and single fault conditions that do not exceed the values given in the relevant application standard of 4.2.8

3.23
thermal equilibrium conditions
stable temperature conditions indicated by temperature changes of no more than 3 K (5 °F) or 1 % of the absolute operating temperature, whichever is higher between two readings 15 min apart

3.24
type test
conformity test made on one or more items representative of the production

Note 1 to entry: Not be confused with “Conformity test” [IEC 60050-151, 151-16-15]: test for conformity evaluation or “Conformity evaluation” [IEC 60050-151, 151-16-14]: systematic examination of the extent to which a product, process or service fulfils specified requirements.

[SOURCE: IEC 60050-151:2001, 151-16-16, modified – The note to entry has been added.]

3.25
normal operation
operation of the **fuel cell module** under the normal conditions as specified by the manufacturer such as the environment conditions, intended gas, electric grid, within its specified tolerances

3.26
auto-ignition temperature
lowest temperature (of a hot surface) at which under specified test conditions an ignition of a flammable gas or vapour in mixture with air or air-inert gas occurs

[SOURCE: ISO/IEC 80079-20-1:2017, 3.3, modified – "hot" has been added.]

3.27
hydrostatic relief valve
pressure relief valve actuated by hydrostatic inlet pressure that opens in proportion to the increase in pressure over the opening pressure

3.28
safety valve
pressure relief valve actuated by inlet static pressure and characterized by rapid opening or popping action

Note 1 to entry: ANSI/CSANGV2-2000 [21] has the following clause:

"The effectiveness of the pressure relief devices (PRDs) shall be demonstrated in accordance with section 18.9 (bonfire test)".

The bonfire tests are designed to demonstrate that the finished containers complete with the pressure relief devices specified in the design will prevent the rupture of the container when tested under some specified fire conditions.

Note 2 to entry: CGA 12.6-M94 [22] uses a big safety factor. The components are tested at four times the design pressure for 1 min.

This standard does not have a performance test for the PRD(s).

Note 3 to entry: The effectiveness of the PRD for the **fuel cell module** cannot be tested since it is not the end product. It is not known what pressures, in abnormal situations, the module could be subjected to. In fact, the abnormal situations are unknown at the module stage. The size and pressure of the fuel tank is unknown and so might be the gas train. Therefore, testing for performance at the module level would not be representative and using very high safety factors might be design-restrictive.

Note 4 to entry: The best idea might be to have the module manufacturer supply at least the following information to the end user:

a) type of PRD/PRV used;
b) setting (opening pressure) of the PRD/PRV;
c) flow capacity;
d) the end user should investigate the effectiveness of the module PRD/PRV in the end product.

3.29
stack terminal
bus bar
output terminal at which electric power is supplied from the **fuel cell stack**

[SOURCE: IEC 60050-485:—, 485-06-08]

4 Requirements

4.1 General safety strategy

The manufacturer shall perform in written form a risk analysis to ensure that

a) all reasonably foreseeable **hazards**, **hazardous** situations and events throughout the anticipated **fuel cell** power system's lifetime have been identified (see Annex A for a listing of typical **hazards**),
b) the risk for each of these **hazards** has been estimated from the combination of probability of occurrence of the **hazard** and of its foreseeable severity,
c) the two factors which determine each one of the estimated risks (probability and severity) have been eliminated or reduced to a level not exceeding the acceptable risk level, as far as is practically possible, through
    1) inherently safe design of the construction and its methods, or
    2) passive control of energy releases without endangering the surrounding environment (for example, burst disks, release valves, thermal cut-off devices) or by safety related control functions, and
    3) for residual risks which could not have been reduced by the measures according to 1) and 2), provision of labels, warnings or requirements of special training shall be given, considering that such measures need to be understood by the persons which are in the area of the **hazards**.