IEC 62282-3-201

Edition 3.0 2025-09

INTERNATIONAL STANDARD

Fuel cell technologies -
Part 3-201: Stationary fuel cell power systems - Performance test methods for small fuel cell power systems

ICS 27.070

ISBN 978-2-8327-0637-4

IEC 62282-3-201:2025-09(en)

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Fuel cell technologies - Part 3-201: Stationary fuel cell power systems - Performance test methods for small fuel cell power systems

FOREWORD

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IEC 62282-3-201 has been prepared by IEC technical committee 105: Fuel cell technologies. It is an International Standard.

This third edition cancels and replaces the second edition published in 2017 and Amendment 1:2022. This edition constitutes a technical revision.

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

a) revision of Introduction;
b) revision of terms and definitions;
c) revision of Table 1;
d) revision of Figure 1, Figure 2, Figure 3 and Figure 4;
e) revision of measurement instruments (10.2);

f) revision of minimum required measurement systematic uncertainty (10.4);
g) revision of test conditions (Clause 11);
h) revision of operating process (Clause 12);
i) revision of fuel consumption test (14.2);
j) revision of heat recovery test (14.4);
k) revision of Figure 13 and Figure 14;
l) revision of calculation of results (14.14.4);
m) revision of Annex A and Annex B.

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

Draft	Report on voting
105/1114/FDIS	105/1128/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

This part of IEC 62282 provides consistent and repeatable test methods for the electrical, thermal and environmental performance of small stationary fuel cell power systems.

This document limits its scope to small stationary fuel cell power systems (electrical power output below 10 kW, which is typical for residential, small commercial and off-grid applications) and provides test methods specifically designed for them in detail. It is based on the latest edition of IEC 62282-3-200, which generally describes performance test methods that are common to all types of fuel cells.

This document is intended for manufacturers of small stationary fuel cell power systems or those who evaluate the performance of their systems for certification purposes, or both.

Users of this document can selectively execute test items that are suitable for their purposes from those described in this document. This document is not intended to exclude any other methods.

1 Scope

This part of IEC 62282 provides test methods for the electrical, thermal, and environmental performance of small stationary fuel cell power systems that meet the following criteria:

- output: rated electric power output of less than 10 kW;
- output mode: grid-connected/independent operation or stand-alone operation with single-phase AC output or 3-phase AC output not exceeding 1 000 V, or DC output not exceeding 1 500 V;

  NOTE The limit of 1 000 V for alternating current comes from the definition for "low voltage" given in IEC 60050-601:1985, 601-01-26.
- operating pressure: maximum allowable working pressure of 0,1 MPa (gauge) for the fuel and oxidant passages;
- fuel: gaseous fuel (natural gas, liquefied petroleum gas, propane, butane, hydrogen, etc.) or liquid fuel (kerosene, methanol, etc.);
- oxidant: air.

This document describes type tests and their test methods only. No routine tests are required or identified, and no performance targets are set in this document.

This document provides test methods to be carried out under laboratory conditions.

This document covers fuel cell power systems whose primary purpose is the production of electric power and whose secondary purpose can be the utilization of heat. Accordingly, fuel cell power systems for which the use of heat is primary, and the use of electric power is secondary are outside the scope of this document.

All systems with integrated batteries are covered by this document. This includes systems where batteries are recharged internally or recharged from an external source.

This document does not cover additional auxiliary heat generators that produce thermal energy.

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.

CISPR 11, *Industrial, scientific, and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase*

IEC 61000-6-1:2016, *Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
background noise level
sound pressure level of ambient noise at the measurement point

Note 1 to entry: This measurement is taken as described in 15.2 with the fuel cell power system in the cold state.

3.2
battery
electrochemical energy storage device that provides energy input to auxiliary machines and equipment necessary to operate the fuel cell power system and/or provides electric energy output

Note 1 to entry: Back-up batteries for control software memory and similar applications are not included.

3.3
cold state
state of a fuel cell power system, which is entirely at ambient temperature with no power input or output, ready for start-up

Note 1 to entry: Power input to a control device for monitoring the fuel cell power system during cold state is not considered.

[SOURCE: IEC 60050-485:2020, 485-21-01, modified – "which is entirely" and "ready for start-up" added; Note 1 to entry added.]

3.4
degradation rate
reduction of the electrical efficiency of a stationary fuel cell power system per time of operation

Note 1 to entry: The degradation rate is expressed in efficiency per cent points per time (%/h).

3.5
discharge water
water that is discharged from the fuel cell power system including waste water and condensate

Note 1 to entry: Discharge water does not constitute part of a thermal recovery system.

3.6
electrical efficiency
ratio of the average net electric power output produced by a fuel cell power system to the average fuel power input supplied to the fuel cell power system

Note 1 to entry: Lower heating value (LHV) is assumed unless otherwise stated.

Note 2 to entry: Only the fuel energy is considered as input power to small fuel cell power systems.

[SOURCE: IEC 60050-485:2020, 485-10-02, modified – "electrical" instead of "electric" in the term;" average net electric power output" instead of "net electric power"; "average fuel power input" instead of "total enthalpy flow" and Note 2 to entry added.]

3.7
electric energy input
integrated value of electric power input at the electric input terminal

3.8
electric energy output
integrated value of electric power output at the electric output terminal

3.9
electric power input
electric power input at the electric input terminal of the fuel cell power system

3.10
electric power output
electric power output at the electric output terminal of the fuel cell power system

3.11
fuel cell power system
generator system that uses one or more fuel cell modules to generate electric power and heat

[SOURCE: IEC 60050-485:2020, 485-09-01]

3.12
fuel energy input
amount of chemical energy which is supplied to the fuel cell power system by the fuel

3.13
fuel input
amount of natural gas, hydrogen, methanol, liquid petroleum gas, propane, butane, or other material containing chemical energy entering the fuel cell power system while it is working at the specified operating conditions

3.14
fuel power input
fuel energy input per unit of time

3.15
heat recovery efficiency
ratio of the average recovered thermal power output of a fuel cell power system to the average fuel power input supplied to the fuel cell power system

Note 1 to entry: Lower heating value (LHV) is assumed unless otherwise stated.

Note 2 to entry: Only the fuel energy is considered as input power to small fuel cell power systems.

[SOURCE: IEC 60050-485:2020, 485-10-04, modified – "average recovered thermal power output" instead of "recovered heat flow"; "average total power input" instead of "total enthalpy flow"; Note 1 to entry deleted, new Note 1 to entry and Note 2 to entry added.]

3.16
heat recovery fluid
fluid circulating between the fuel cell power system and a heat sink for recovering the thermal energy output

3.17
inert purge gas
inert gas or dilution gas, not containing chemical energy, supplied to the fuel cell power system during specific conditions to make it ready for operation or shutdown

Note 1 to entry: Dilution gas containing chemical energy shall be considered as fuel.

3.18
integrated fuel input
volume or mass of fuel consumed by the fuel cell power system under specified operating conditions

3.19
interface point

measurement point at the boundary of a fuel cell power system at which material or energy, or both, either enters or leaves

Note 1 to entry: This boundary is intentionally selected to accurately measure the performance of the system, including all normal operation, both steady state and transient. If necessary, the boundary or the interface points of the fuel cell power system (Figure 2) to be assessed should be determined by agreement between the parties.

[SOURCE: IEC 60050-485:2020, 485-09-12, modified – Note 2 to entry deleted.]

3.20
mass concentration
concentration of mass of exhaust gas component per unit of volume

3.21
mass discharge rate
mass of discharged exhaust gas component per unit of time

3.22
minimum electric power output
minimum net power output, at which a fuel cell power system is able to operate continuously at a steady state

3.23
net electric power output
power generated by the fuel cell power system and available for external use

Note 1 to entry: The net electric power output can be negative during start-up, shutdown and storage state, which means actually an electric power input during these phases / state, to be provided externally and not generated by the fuel cell power system.

[SOURCE: IEC 60050-485:2020, 485-14-03, modified – "output" added to the term, Notes 1 and 2 to entry deleted, and new Note 1 to entry added.]

3.24
noise level
sound pressure level produced by the fuel cell power system

Note 1 to entry: The noise level is expressed as decibels (dB) and measured as described in 15.2.

3.25
operation cycle
complete sequence of successive operation phases of a fuel cell power system comprising start-up, ramp-up, rated operation and shutdown

3.26
operation cycle electrical efficiency
ratio of the net electric energy output of a fuel cell power system to the fuel energy fed to the same fuel cell power system during a complete operation cycle comprising start-up, ramp-up, rated operation and shutdown

3.27
overall energy efficiency
ratio of total usable power output (net electric power and recovered thermal power) to the average total power input supplied to the fuel cell power system

Note 1 to entry: For determining the total power input to small fuel cell power systems, power inputs other than fuel power input are neglected as insignificant

[SOURCE: IEC 60050-485:2020, 485-10-05, modified – alternative expression "or total thermal efficiency" deleted; "power output" instead of "energy flow"; "thermal power" instead of "heat flow"; "average total power input" instead of "total enthalpy flow"; Note 1 to entry changed.]

3.28
pre-generation state
state of a fuel cell power system at sufficient operating temperature and in such an operational mode, with zero electric power output, that the fuel cell power system is capable of being promptly switched to an operational state with a substantial electric active power output

[SOURCE: IEC 60050-485:2020, 485-21-04, modified – "active" added.]

3.29
ramp-up energy
electric and/or chemical (fuel) energy required for transitioning from positive net electric power output after start-up to rated net electric power output

3.30
ramp-up time
duration required for transitioning from positive net electric power output after start-up to rated net electric power output

3.31
rated electric power output
maximum continuous electric power output that a fuel cell power system is designed to achieve under normal operating conditions specified by the manufacturer

[SOURCE: IEC 60050-485:2020, 485-14-04, modified – "electric" and "output" added to the term, Note 1 to entry deleted.]

3.32
recovered heat
thermal energy that has been recovered for useful purpose

3.33
recovered thermal power
recovered heat per unit of time

Note 1 to entry: The recovered thermal power is measured by determining the temperatures and flow rates of the heat recovery fluid (water, steam, air or oil, etc.) entering and leaving the thermal energy recovery subsystem at the interface point of the fuel cell power system.

3.34
shutdown energy
sum of electric and/or chemical (fuel) energy required during the shutdown time

3.35
shutdown time
duration between the instant when a shutdown action is initiated at rated electric power output and the instant when the shutdown is completed, as specified by the manufacturer

Note 1 to entry: The shutdown operation is classified into types: normal shutdown and emergency shutdown.

[SOURCE: IEC 60050-485:2020, 485-20-04, modified – "a shutdown action is initiated at rated electric power output" instead of "the load is removed"; "Note 1 to entry" added.]

3.36
start-up energy
<fuel cell power systems without battery> sum of electric, thermal, mechanical and chemical (fuel) energy required by a fuel cell power system for transitioning from cold state or storage state to positive net electric power output

Note 1 to entry: The start-up process of fuel cell power systems without battery is shown in Figure 7.

[SOURCE: IEC 60050-485:2020, 485-18-05, modified – addition of domain, "for transitioning from cold state or storage state to positive net electric power output" instead of "during the start -up time" and Note 1 to entry added.]

3.37
start-up energy

<fuel cell power systems with battery> sum of electric, thermal, mechanical and chemical (fuel) energy required by a fuel cell power system for recharging the battery, which is discharged to supply rated electric power output during start-up time, to a known nominal state of charge

Note 1 to entry: The start-up process of fuel cell power systems with battery is shown in Figure 8.

[SOURCE: IEC 60050-485:2020, 485-18-05, modified – addition of domain "for recharging the battery, which is discharged to supply rated electric power output during start-up time, to a known nominal state of chargefor transitioning from cold state or storage state to positive net electric power output" instead of during the start -up time" and Note 1 to entry added.]