IEC 62282-4-102

Edition 2.0 2022-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fuel cell technologies –
Part 4-102: Fuel cell power systems for electrically powered industrial trucks – Performance test methods

Technologies des piles à combustible –
Partie 4-102: Systèmes à piles à combustible pour chariots de manutention électriques – Méthodes d'essai des performances

IEC 62282-4-102:2022-12(en-fr)

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FUEL CELL TECHNOLOGIES –

Part 4-102: Fuel cell power systems for electrically powered industrial trucks – Performance test methods

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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IEC 62282-4-102 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 2017. This edition constitutes a technical revision.

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

a) alignment of the Scope with the second edition of IEC 62282-4-101:2022;
b) deletion of terms and definitions (previous entries 3.5, 3.10, and 3.15);
c) addition of new terms in Clause 3: "delivered power" (3.13) and "regenerated power" (3.14);
d) revision of symbols and their meanings in alignment with those of IEC 62282-3-201;
e) replacement of "reference conditions" with "standard conditions" as seen in Clause 5;
f) revision of the test method for the accessory load voltage spike test (13.3.2);

g) addition of clarifications in Clause 14 (Power stability under operation);

h) addition of a checklist for performance criteria dealt with in this document (Annex C).

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

Draft	Report on voting
105/947/FDIS	105/954/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,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This part of IEC 62282-4 provides consistent and repeatable test methods for the electric, thermal and environmental performance of fuel cell power systems for electrically powered industrial trucks.

The IEC 62282-4 series deals with categories such as safety, performance, and interchangeability of fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APUs). This document (IEC 62282-4-102) focuses on performance test methods for fuel cell power systems used to drive industrial electric trucks, which are being manufactured and used increasingly worldwide. This is because such applications are urgently needed in the world.

This part of IEC 62282-4 describes type tests and their test methods only. No routine tests are required or identified, and no performance targets are set in this document.

Fuel cell systems used in electrically powered industrial trucks, such as forklift trucks, use both batteries and fuel cells, and so operate in several different modes. Similarly, forklift trucks operate in different modes. The purpose of this document is to evaluate the fuel cell system in the various combinations of fuel cell modes and forklift truck modes. This document breaks down these different modes and provides a framework for designing and evaluating a fuel cell system for use specifically in a forklift truck.

This part of IEC 62282-4 is intended to be used by either manufacturers of fuel cell power systems used for electrically powered industrial trucks or those who evaluate the performance of the systems used in them for certification purposes or both.

Users of this document can select and perform the tests they need from those described. This document is not intended to exclude any other tests.

FUEL CELL TECHNOLOGIES –

Part 4-102: Fuel cell power systems for electrically powered industrial trucks – Performance test methods

1 Scope

This part of IEC 62282 specifies the performance test methods of fuel cell power systems for propulsion and auxiliary power units (APU). This document covers fuel cell power systems for propulsion other than those for road vehicles.

This document covers the performance test methods of fuel cell power systems intended to be used for electrically powered industrial trucks as defined in ISO 5053-1, except for:

– rough-terrain trucks;
– non-stacking low-lift straddle carrier;
– stacking high-lift straddle carrier;
– rough-terrain variable-reach truck;
– slewing rough-terrain variable-reach truck;
– variable-reach container handler;
– pedestrian propelled trucks.

This document applies to gaseous hydrogen-fuelled fuel cell power systems and direct methanol fuel cell power systems for electrically powered industrial trucks. The following fuels are considered within the scope of this document:

– gaseous hydrogen, and
– methanol.

This document covers the fuel cell power system as defined in 3.7 and Figure 1.

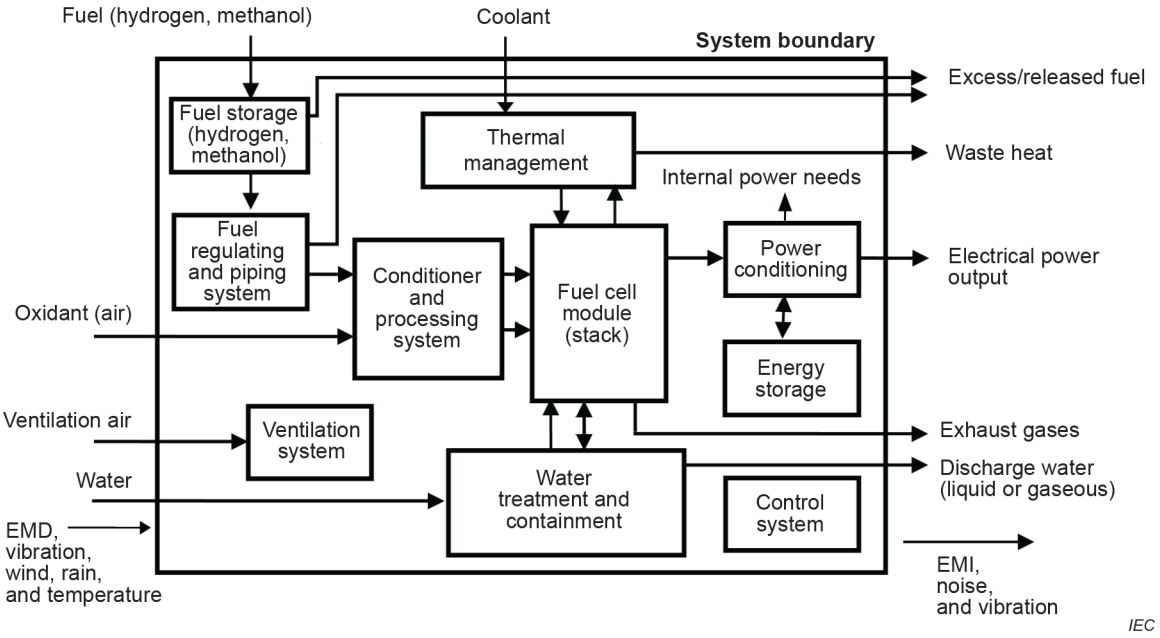
This document applies to DC type fuel cell power systems, with a rated output voltage not exceeding DC 150 V for indoor and outdoor use.

This document covers fuel cell power systems whose fuel source container is permanently attached to either the industrial truck or the fuel cell power system.

All systems with integrated energy storage systems are covered by this document. This includes systems such as batteries for internal recharges or recharged from an external source.

The following are not included in the scope of this document:

– detachable type fuel source containers;
– hybrid trucks that include an internal combustion engine;
– reformer-equipped fuel cell power systems;
– fuel cell power systems intended for operation in potentially explosive atmospheres;
– fuel storage systems using liquid hydrogen.



Key

EMD electromagnetic disturbance

EMI electromagnetic interference

NOTE A fuel cell power system can contain all or some of the above components.

Figure 1 – Fuel cell power systems for electrically powered industrial trucks

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 62282-6-300:2012, *Fuel cell technologies – Part 6-300: Micro fuel cell power systems – Fuel cartridge interchangeability*

ISO 6798-1, *Reciprocating internal combustion engines – Measurement of sound power level using sound pressure – Part 1: Engineering method*

ISO 6798-2, *Reciprocating internal combustion engines – Measurement of sound power level using sound pressure – Part 2: Survey method*

ISO 14687, *Hydrogen fuel quality – Product specification*

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
noise level
sound pressure level produced by the fuel cell power system measured at a specified distance in all operation modes

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

3.2
background noise level
sound pressure level of ambient noise at the measurement point

3.3
battery
electrochemical energy storage device that either provides energy input to support parasitic loads or provides electric energy output or both

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

3.4
cold state
state of a fuel cell power system at ambient temperature with no power input or output

[SOURCE: IEC 60050-485:2020, 485-21-01]

3.5
discharge water
water 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
fuel cell system electric efficiency
ratio of the average electric power output of a fuel cell power system for a given duration to the average fuel power fed to the same fuel cell power system for the same duration

3.7
fuel cell power system
generator system that uses one or more fuel cell modules to generate electric power and heat

Note 1 to entry: The fuel cell power system for use with industrial trucks will be in one of the forms as outlined in IEC 62282-4-101:2022, 3.9 and 3.10.

[SOURCE: IEC 60050-485:2020, 485-09-01, modified – Note 1 to entry has been added.]

3.8
fuel input
amount of hydrogen or methanol supplied to the fuel cell power system

3.9
fuel consumption
volume or mass of fuel consumed by the fuel cell power system under specified operating conditions

3.10
minimum electric power output
minimum power output, at which a fuel cell power system is able to operate continuously at a steady state

3.11
rated power
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 – Note 1 to entry has been deleted.]

3.12
test duration
time interval in which data points required for the computation of test results are recorded

3.13
delivered power
current and voltage delivery requirements of the industrial truck at various intervals as necessary in order to maintain acceptable truck performance

3.14
regenerated power
electro-dynamic power in which the energy produced by the motors is fed into the contact line or into energy storage on-board devices

Note 1 to entry: Examples of storage devices: batteries, flywheels.

[SOURCE: IEC 60050-811:2017, 811-06-25, modified – The term "regenerative braking" has been replaced with "regenerated power" and in the definition "braking" has been replaced with "power".]

4 Symbols

The symbols and their meanings used in this document are given in Table 1 for electric and thermal performance and in Table 2 for environmental performance, with the appropriate units.

Table 1 – Symbols and their meanings for electric and thermal performance

Symbol	Definition	Unit
$\boldsymbol{M, m}$	**Molar mass, mass**	
M_f	Molar mass of fuel	kg/mol
m_f	Fuel mass measured over the test duration	kg
$\boldsymbol{p}$	**Pressure**	
p_s	Standard pressure (101,325 kPa (abs))	kPa (abs)
p_f	Average fuel pressure	kPa (abs)
$\boldsymbol{P}$	**Power**	
P_n	Average net electric power output	kW
P_{fin}	Average fuel power input	kJ/s
$\boldsymbol{E}$	**Input energy**	
E_{mf}	Input energy of fuel per mass	kJ/kg
E_{vf}	Input energy of fuel per volume	kJ/l
E_{fin}	Total fuel input energy	kJ
$\boldsymbol{q_m}$	**Mass flow rate**	
q_{mf}	Average mass flow rate of fuel under the test conditions	kg/s

Symbol	Definition	Unit
q_V	**Volumetric flow rate**	
q_{Vf}	Average volumetric flow rate of fuel under the test conditions	l/min
q_{Vfs}	Average volumetric flow rate of fuel under standard conditions	l/min
H	**Heating value**	
H_{fs}	Heating value of fuel on a molar basis under standard conditions	kJ/mol
H_{fl}	Heating value of liquid mass	kJ/kg
t	**Time**	
Δt	Test duration	s, min
T	**Temperature**	
T_s	Standard temperature (273,15 K)	K
T_f	Average fuel temperature	K
V, V_m	**Volume, molar volume**	
V_f	Total fuel volume measured over the test duration	l
V_{ms}	Standard molar volume of ideal gas (22,414 l/mol) (at standard temperature T_0 = 273,15 K and pressure p_0 = 101,325 kPa)	l/mol
W	**Electric energy**	
W_{out}	Electric energy output	kW · h
η	**Efficiency**	
η_{el}	Electric efficiency	%
η_{th}	Heat recovery efficiency	%
η_{total}	Overall energy efficiency	%

Table 2 – Symbols and their meanings for environmental performance

Symbol	Definition	Unit
φ	**Volume fraction**	
$\varphi_{B,meas}$	measured volume fraction of the component B	vol % or ml/m^3
$\varphi_{B,corr}$	corrected volume fraction of the component B	vol % or ml/m^3
$\varphi_{at}(O_2)$	measured O_2 (oxygen) volume fraction in atmosphere at air inlet in dry state	vol %
$\varphi_{ex}(O_2)$	measured O_2 volume fraction in dry exhaust gas	vol %
$\varphi_{ex,corr}(CO)$	corrected CO volume fraction in dry exhaust gas	ml/m^3
$\varphi_{ex,corr}(THC)$	corrected total hydrocarbon (THC) volume fraction in dry exhaust gas (carbon equivalent)	ml/m^3
γ	**Mass concentration**	
$\gamma_{ex}(CO)$	CO mass concentration in dry exhaust gas	mg/m^3
$\gamma_{ex}(THC)$	THC mass concentration in dry exhaust gas	mg/m^3
ε	**Emission**	
$\varepsilon(CO)$	mass of CO emission per energy of input fuel	mg/kW · h
$\varepsilon(THC)$	mass of THC emission per energy of fuel input	mg/kW · h
α	**Atom ratio**	

Symbol	Definition	Unit
α(THC)	hydrogen to carbon atom ratio of the THC in the exhaust gas	
ω	**Mass fraction**	
ω_B	mass fraction of methanol	

5 Standard conditions

The standard conditions are specified as follows:

– standard temperature: T_s = 273,15 K (0 °C);

– standard pressure: p_s = 101,325 kPa (abs).

6 Heating value base

Except if otherwise specified, the given heating value of fuel shall be the low heating value (LHV) or similar.

NOTE The heating values of hydrogen and methanol (LHV and HHV) are given in Annex A.

In cases where the LHV is applied for the calculation of energy efficiency, it is not necessary to add the LHV, as shown below:

η_{el}, η_{th}, or η_{total} = XX %

If the higher heating value (HHV) is applied, the HHV shall be added to the value of energy efficiency as follows:

η_{el}, η_{th}, *or* η_{total} = XX % (HHV)

7 Test preparation

7.1 General

Clause 7 describes typical items that shall be considered prior to the implementation of a test. For each test, an effort shall be made to minimize uncertainty by selecting high-precision instruments and planning the tests with attention to detail. Detailed test plans shall be prepared by the parties to the test using this document as their basis. A written test plan shall be prepared.

The following items shall be considered for the test plan:

1) objective;
2) test specifications;
3) test personnel qualifications;
4) quality management standards (ISO 9000, ISO 9001 and ISO 9004, collectively known as the ISO 9000 family, or other equivalent standards);
5) target uncertainty;
6) identification of measurement instruments (refer to Clause 9);
7) estimated range of test parameters;
8) data acquisition plan.