IEC 62282-4-600

Edition 1.0 2022-08

INTERNATIONAL STANDARD

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colour inside

Fuel cell technologies –
Part 4-600: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Fuel cell/battery hybrid systems performance test methods for excavators

Technologies des piles à combustible –
Partie 4-600: Systèmes à piles à combustible pour la propulsion, autres que les véhicules routiers et groupes auxiliaires de puissance (GAP) – Méthodes d'essai des performances des systèmes hybrides à piles à combustible/batterie pour les pelles

IEC 62282-4-600:2022-08(en-fr)

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FUEL CELL TECHNOLOGIES –

Part 4-600: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Fuel cell/battery hybrid systems performance test methods for excavators

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

Draft	Report on voting
105/914/FDIS	105/925/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/standardsdev/publications.

A list of all parts of 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

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- withdrawn,
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FUEL CELL TECHNOLOGIES –

Part 4-600: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Fuel cell/battery hybrid systems performance test methods for excavators

1 Scope

This part of IEC 62282 covers the requirements for the performance test methods of fuel cell/battery hybrid systems intended to be used for electrically powered applications for excavators.

For this purpose, this document covers electrical performance and vibration tests for the fuel cell/battery hybrid system. This document also covers performance test methods which focus on vibration and other characteristics for balance of plant (BOP) installed in heavy-duty applications with fuel cell/battery hybrid system.

This document applies to both gaseous hydrogen-fuelled fuel cell power, liquid hydrogen-fuelled fuel cell power, direct methanol fuel cell power and battery hybrid power pack systems.

The following fuels are considered within the scope of this document:

– gaseous hydrogen, and

– methanol.

This document does not apply to reformer-equipped fuel cell power systems.

This document can be applied to fuel cell power systems used for either propulsion or for auxiliary power units (APU) purposes. In case of APU, the same hybrid power pack can be used on board or as a stationary APU. In case of the latter, this document can also be applied.

A block diagram of a fuel cell/battery hybrid system is shown in Figure 1. This document covers the configuration, mode of hybridization, operation mode for fuel cell and battery in power pack systems.

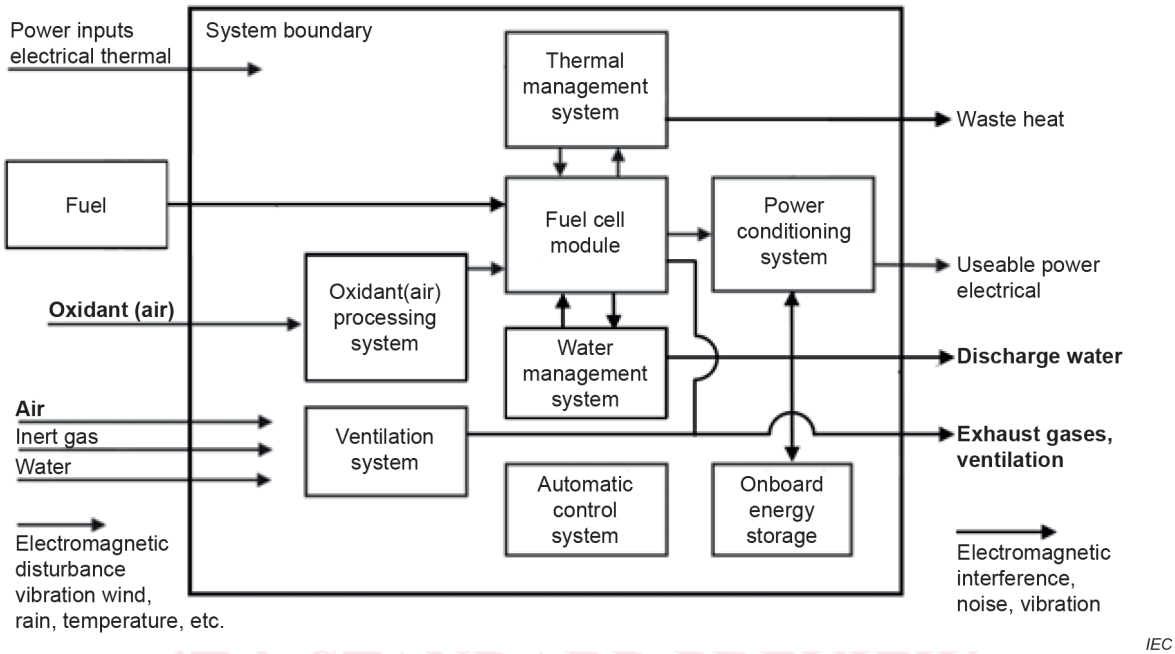

Figure 1 – Fuel cell/ battery hybrid systems block diagram

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, *International Electrotechnical Vocabulary (IEV) – Part 485: Fuel cell technologies*

IEC 60068-2-64:2008, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*
IEC 60068-2-64:2008/AMD1:2019

IEC 62282-4-101:2022, *Fuel cell technologies – Part 4-101: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Fuel cell power systems for electrically powered industrial trucks – Safety*

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

ISO 14687:2019, *Hydrogen fuel quality – Product specification*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given 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
fuel cell/battery hybrid system
fuel cell power system combined with a battery, for delivering useful electric power

Note 1 to entry: The fuel cell power system can deliver electric power, charge the battery, or both. The system can deliver and accept electric energy.

[SOURCE: IEC 60050-485:2020, 485-09-18]

3.1.2
fuel cell power system
generator system that uses one or more fuel cell modules (IEV 485-09-03) to generate electric power and heat

3.1.3
secondary battery
secondary cell
cell which is designed to be electrically recharged

Note 1 to entry: The recharge is accomplished by way of a reversible chemical reaction. Secondary batteries such as lithium-ion battery, metal-air battery, lead acid battery, nickel-metal hydride battery, etc, can be recharged by electric power from the fuel cell and/or from an outside power source.

[SOURCE: IEC 60050-482:2004, 482-01-03, modified – the term “secondary battery” has been added and a second sentence has been added to the note.]

3.1.4
power conditioning system
electric or electronic system able to convert generated power into the requested output conditions

3.1.5
load levelling system
electric or electronic device able to balance the power flow among the fuel cell stack, secondary batteries and load

Note 1 to entry: It is a method where during periods of high-power demand the secondary batteries can provide additional electrical power to the energy provided from the fuel cell stack to meet electrical demand. During periods of lower electrical power demand, the power from the fuel cell stack can be stored in the secondary batteries.

3.1.6
active hybrid system
hybrid system equipped with a DC/DC converter between the fuel cell and the battery, adjusting the voltage of each power source to the bus voltage and managing the power sharing between each power source

3.1.7
state of charge
SOC
available capacity in a battery pack or system expressed as a percentage of rated capacity

3.2 Abbreviated terms

BMS Battery management system
BOD Biochemical oxygen demand
BOP Balance of plant
FID Flame ionizer detector
EMS Energy management system
FMS Fuel cell management system
SOC State of charge
THC Total hydrocarbon

4 Symbols

The symbols and their meanings used in this part of IEC 62282 are given in Table 1 for electric/thermal performance with the appropriate units.

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

Symbol	Definition	Unit
E	**Energy**	
E_{mf}	Energy input of gaseous fuel per unit mass	kJ/kg
E_{Vf}	Energy input of the fuel per unit volume	kJ/m^3
E_{fin}	Fuel energy input	kJ
H	**Heating value**	
H_{f0}	Heating value of fuel on a molar basis under reference conditions	kJ/mol
H_{f0j}	Heating value of component j at reference temperature T_0	kJ/mol
H_{fl}	Heating value of liquid fuel	kJ/kg
M	**Molar mass**	
M_f	Molar mass of fuel	kg/mol
m	**Mass**	
m_f	Fuel mass measured over the test duration	kg
P, dP	**Power, power change rate**	
P_n	Average net electric power output	kW
P_d	Electric power output change range between P_{rated} and P_{min}	kW
P_{rated}	Rated electric power output	kW
P_{min}	Minimum electric power output	kW
dP_{down}	Decrease rate of electric power output	kW/s
dP_{up}	Increase rate of electric power output	kW/s
p	**Pressure**	
p_0	Reference pressure (101,325 kPa(abs))	kPa (abs)
p_f	Average fuel pressure	kPa (abs)
q_m	**Mass flow rate**	
q_{mf}	Average mass flow rate of fuel	kg/s

Symbol	Definition	Unit
$\boldsymbol{q_V}$	**Volumetric flow rate**	
q_{Vf}	Average volumetric flow rate of fuel under the test conditions	m^3/s
q_{Vf0}	Average volumetric flow rate of fuel under reference conditions	m^3/s
$\boldsymbol{T}$	**Temperature**	
T_0	Reference temperature (288,15 K)	K
T_f	Average fuel temperature	K
T_s	Standard temperature (273,15 K)	K
$\boldsymbol{t}$	**Time**	
Δt	Test duration	s
Δt_{st}	Start-up time	s
t_{st1}	Start-up initiation time	s
t_{st2}	Start-up completion time	s
Δt_{shut}	Shutdown time	s
t_{shut1}	Shutdown initiation time	s
t_{shut2}	Shutdown completion time	s
Δt_{lcdown}	Duration of the decrease in electric power output from t_{lc1} to t_{lc2}	s
Δt_{lcup}	Duration of the increase in electric power output from t_{lc3} to t_{lc4}	s
t_{rated}	Duration of the rated power output phase of an operation cycle from start-up, over ramp-up and rated power operation to shutdown	s
$\boldsymbol{V}$	**Volume**	
V_f	Fuel volume measured over the test duration	m^3
$\boldsymbol{V_m}$	**Molar volume**	
V_m	Reference molar volume of ideal gas (2,364 5 × 10^{-2} m^3/mol at reference temperature T_0 = 288,15 K or 2,241 4 × 10^{-2} m^3/mol at standard temperature T_s = 273,15 K, both at reference pressure p_0 = 101,325 kPa)	m^3/mol
$\boldsymbol{W}$	**Electric energy**	
W_{out}	Electric energy output	kW·h
W_{in}	Electric energy input	kW·h
$W_{instbat}$	Electric energy required over the duration from the start-up initiation time, t_{st1} to the battery recharge completion time, t_{st3bat}	kW·h
W_{inshut}	Electric energy input during shutdown time	kW·h
W_{outcyc}	Net electric energy output during an operating cycle from start-up, over ramp-up and rated operation to shutdown	kW·h
$\boldsymbol{x}$	**Molar ratio**	
x_j	Molar ratio of component j	
$\boldsymbol{\eta}$	**Efficiency**	
η_{el}	Electrical efficiency	%
η_{cyc}	Operation cycle electrical efficiency	%

5 Configuration of fuel cell and battery hybrid power system

5.1 General

5.1.1 Overview

There are two general types of configurations for the power mode operating electrically powered excavators contemplated by this document (------see Figure 2):

1) pure fuel cell mode: operates only a fuel cell power source without a battery hybrid power source;
2) fuel cell/battery hybrid mode: operates in cooperation with a main fuel cell and a secondary battery.

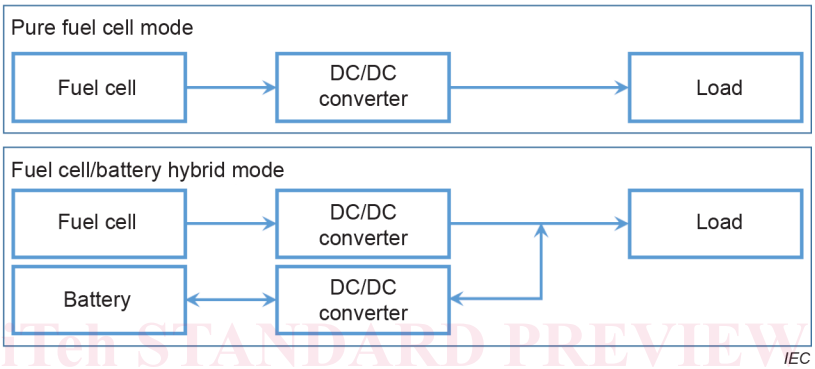

Figure 2 – Fuel cell/battery hybrid system configuration

5.1.2 Hybrid system

In an active hybrid system, a DC/DC converter shall be installed between the fuel cell and each battery. The converter adjusts the voltage of each power source to the bus voltage and manages the power sharing between each power source (see Figure 3).

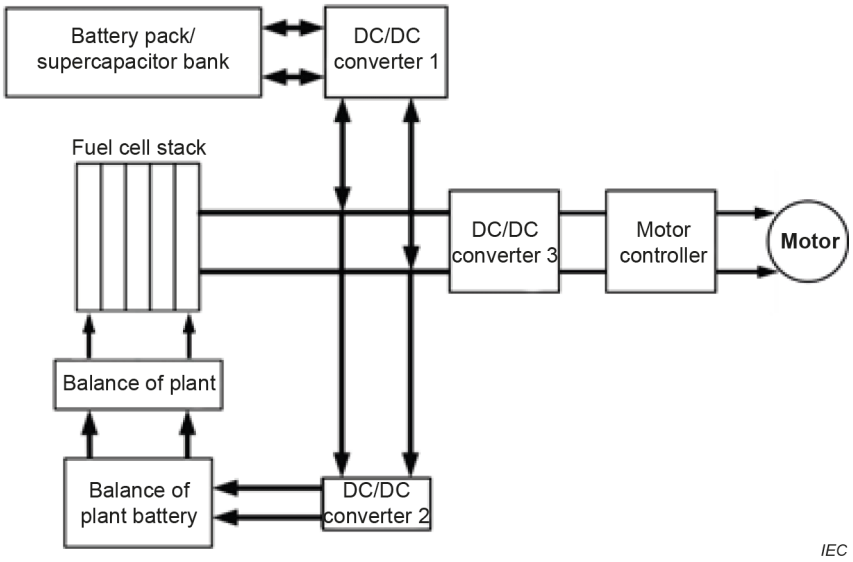

Figure 3 – Power hybridization of fuel cell and battery power system

6 Reference conditions

The reference conditions are specified as follows:

– reference temperature: T_0 = 288,15 K (15 °C);

– reference pressure: p_0 = 101,325 kPa (abs).

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 carefully 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:

a) objective;

b) test specifications;

c) test personnel qualifications;

d) quality management standards (e.g. ISO 9000 or other equivalent standards);

e) target uncertainty;

f) identification of measurement instruments (refer to Clause 9);

g) estimated range of test parameters;

h) data acquisition plan.

7.2 Measurement system analysis

A measurement system analysis shall be performed on the test item below to indicate the reliability of the test results. The following test results shall be analysed to determine the absolute and relative uncertainty. A test shall be planned so that the reliability of the results can be evaluated for the following:

– electrical efficiency

7.3 Data acquisition plan

In order to meet the target uncertainty, the proper duration and frequency of readings shall be defined and suitable data recording equipment shall be prepared before the performance test.

Automatic data acquisition using an appropriate digital system is preferable.

8 Test set-up

Figure 4 and Figure 5 are examples of the test set-up that are required to conduct fuel cell/battery hybrid systems with gaseous fuel and methanol described in this document.