



## BSI Standards Publication

### Fuel cell technologies

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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

## National foreword

This British Standard is the UK implementation of EN 62282-4-600:2022. It is identical to IEC 62282-4-600:2022.

The UK participation in its preparation was entrusted to Technical Committee GEL/105, Fuel cell technologies.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2022

ISBN 978 0 539 06491 9

ICS 27.070

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2022.

### Amendments/corrigenda issued since publication

| Date | Text affected |
|------|---------------|
|------|---------------|

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English Version

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  
(IEC 62282-4-600:2022)

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)

Brennstoffzellen-Technologien - Teil 4-600:  
Brennstoffzellen-Energiesysteme für den Antrieb (mit  
Ausnahme von Straßenfahrzeugen und Hilfsantrieben) -  
Leistungskennwerteprüfverfahren für  
Brennstoffzellen/Batterie-Hybridsysteme für Bagger  
(IEC 62282-4-600:2022)

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Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

## **European foreword**

The text of document 105/914/FDIS, future edition 1 of IEC 62282-4-600, prepared by IEC/TC 105 "Fuel cell technologies" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62282-4-600:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2023-06-16
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2025-09-16

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In the official version, for Bibliography, the following notes have to be added for the standards indicated:

|                     |                                                          |
|---------------------|----------------------------------------------------------|
| IEC 60068-2-6       | NOTE Harmonized as EN 60068-2-6                          |
| IEC 60945           | NOTE Harmonized as EN 60945                              |
| IEC 61000-4-11:2020 | NOTE Harmonized as EN IEC 61000-4-11:2020 (not modified) |
| IEC 61672-1         | NOTE Harmonized as EN 61672-1                            |
| IEC 62282-3-200     | NOTE Harmonized as EN 62282-3-200                        |
| IEC 62282-3-201     | NOTE Harmonized as EN 62282-3-201                        |
| IEC 62282-4-102     | NOTE Harmonized as EN 62282-4-102                        |
| CISPR 11:2015       | NOTE Harmonized as EN 55011:2016 (modified)              |
| ISO 6974 (series)   | NOTE Harmonized as EN ISO 6974 (series)                  |
| ISO 6975            | NOTE Harmonized as EN ISO 6975                           |
| ISO 9000            | NOTE Harmonized as EN ISO 9000                           |
| ISO 10523           | NOTE Harmonized as EN ISO 10523                          |

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: [www.cenelec.eu](http://www.cenelec.eu).

| <u>Publication</u> | <u>Year</u> | <u>Title</u>                                                                                                     | <u>EN/HD</u>       | <u>Year</u> |
|--------------------|-------------|------------------------------------------------------------------------------------------------------------------|--------------------|-------------|
| 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                     | EN 60068-2-64      | 2008        |
| AMD 1              | 2019        |                                                                                                                  | /A1                | 2019        |
| IEC 62282-4-101    | 2022        | Fuel cell technologies - Part 4-101: Fuel cell power systems for electrically powered industrial trucks - Safety | EN IEC 62282-4-101 | 2022        |
| IEC 62282-6-300    | 2012        | Fuel cell technologies - Part 6-300: Micro fuel cell power systems - Fuel cartridge interchangeability           | EN 62282-6-300     | 2013        |
| ISO 14687          | 2019        | Hydrogen fuel quality - Product specification                                                                    | -                  | -           |

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## 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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IEC 62282-4-600 has been prepared by IEC technical committee 105: Fuel cell technologies.  
It is an International Standard.

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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://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](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 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.

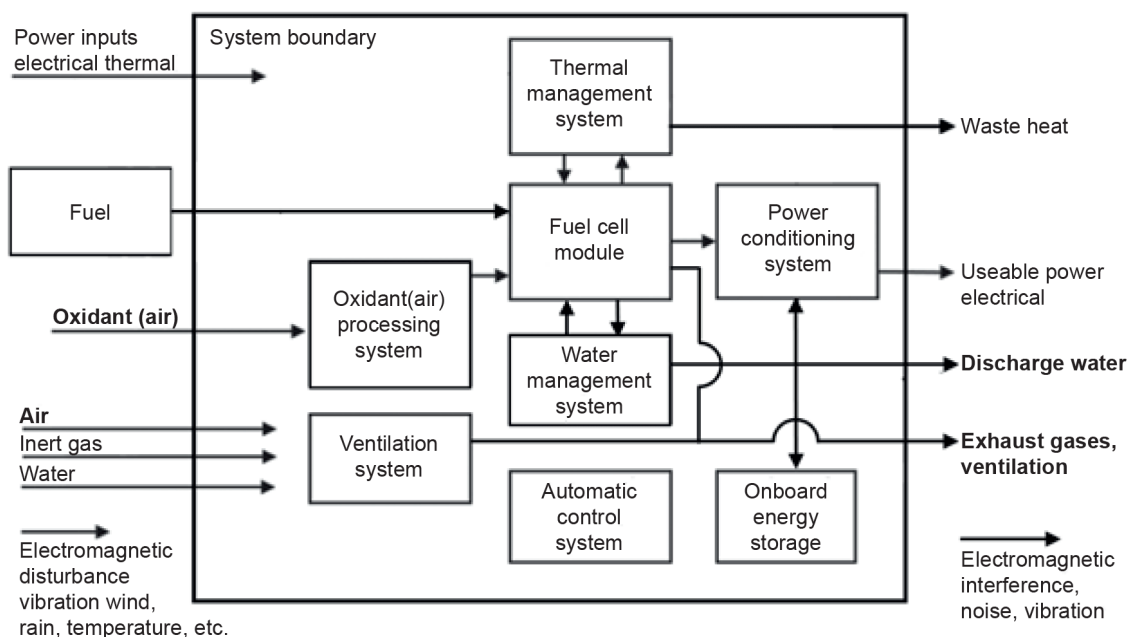
The following fuels are considered within the scope of this document:

- 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.



IEC

**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              |
|-----------------------------|----------------------------------------------------------------------|-------------------|
| <b><i>E</i></b>             | <b>Energy</b>                                                        |                   |
| $E_{mf}$                    | Energy input of gaseous fuel per unit mass                           | kJ/kg             |
| $E_{vf}$                    | Energy input of the fuel per unit volume                             | kJ/m <sup>3</sup> |
| $E_{fin}$                   | Fuel energy input                                                    | kJ                |
| <b><i>H</i></b>             | <b>Heating value</b>                                                 |                   |
| $H_{f0}$                    | Heating value of fuel on a molar basis under reference conditions    | kJ/mol            |
| $H_{f0j}$                   | Heating value of component <i>j</i> at reference temperature $T_0$   | kJ/mol            |
| $H_{fl}$                    | Heating value of liquid fuel                                         | kJ/kg             |
| <b><i>M</i></b>             | <b>Molar mass</b>                                                    |                   |
| $M_f$                       | Molar mass of fuel                                                   | kg/mol            |
| <b><i>m</i></b>             | <b>Mass</b>                                                          |                   |
| $m_f$                       | Fuel mass measured over the test duration                            | kg                |
| <b><i>P, dP</i></b>         | <b>Power, power change rate</b>                                      |                   |
| $P_n$                       | 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              |
| <b><i>p</i></b>             | <b>Pressure</b>                                                      |                   |
| $p_0$                       | Reference pressure (101,325 kPa(abs))                                | kPa<br>(abs)      |
| $p_f$                       | Average fuel pressure                                                | kPa<br>(abs)      |
| <b><i>q<sub>m</sub></i></b> | <b>Mass flow rate</b>                                                |                   |
| $q_{mf}$                    | Average mass flow rate of fuel                                       | kg/s              |