

---

**Tehnologije gorivnih celic - 4-600. del: Elektroenergetski sistemi z gorivnimi celicami za pogone, razen pogonov cestnih vozil in pomožnih elektroenergetskih enot (APU) - Preskusne metode delovanja gorivnih celic/baterijskih hibridnih sistemov za bagre (IEC 62282-4-600:2022)**

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)

Brennstoffzellen-Technologien - Teil 4-600: Brennstoffzellen-Energiesysteme für den Antrieb (mit Ausnahme von Straßenfahrzeugen und Hilfsantrieben) – Leistungskennwertepfverfahren für Brennstoffzellen/Batterie-Hybridssysteme für Bagger (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)

**Ta slovenski standard je istoveten z: EN IEC 62282-4-600:2022**

---

**ICS:**

27.070	Gorilne celice	Fuel cells
53.100	Stroji za zemeljska dela	Earth-moving machinery

**SIST EN IEC 62282-4-600:2022** en



EUROPEAN STANDARD

EN IEC 62282-4-600

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2022

ICS 27.070

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)

**STANDARD PREVIEW**

This European Standard was approved by CENELEC on 2022-09-16. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.



European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

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

**EN IEC 62282-4-600:2022 (E)****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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

**Endorsement notice**

The text of the International Standard IEC 62282-4-600:2022 was approved by CENELEC as a European Standard without any modification.

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	(standards.iteh.ai)/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	-	-





IEC 62282-4-600

Edition 1.0 2022-08

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**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**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 27.070

ISBN 978-2-8322-4199-8

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references .....	8
3 Terms, definitions and abbreviated terms .....	8
3.1 Terms and definitions.....	8
3.2 Abbreviated terms.....	10
4 Symbols .....	10
5 Configuration of fuel cell and battery hybrid power system.....	12
5.1 General.....	12
5.1.1 Overview .....	12
5.1.2 Hybrid system.....	12
6 Reference conditions .....	13
7 Test preparation .....	13
7.1 General.....	13
7.2 Measurement system analysis .....	13
7.3 Data acquisition plan .....	13
8 Test set-up .....	13
9 Instruments and measurement methods .....	15
9.1 General.....	15
9.2 Measurement instruments.....	15
9.3 Measurement points.....	16
9.4 Minimum required measurement systematic uncertainty.....	17
10 Test conditions .....	18
10.1 Laboratory conditions.....	18
10.2 Installation and operating conditions of the system .....	18
10.3 Power source conditions .....	18
10.4 Quality of test fuel.....	18
10.4.1 Hydrogen.....	18
10.4.2 Methanol solution .....	18
11 Operating process .....	18
12 Test plan .....	19
13 Type tests on electric performance .....	20
13.1 General.....	20
13.2 Fuel consumption test.....	20
13.2.1 Gaseous and liquid hydrogen fuel consumption test.....	20
13.2.2 Methanol fuel consumption test .....	23
13.3 Electric power output test.....	24
13.3.1 General .....	24
13.3.2 Test method .....	24
13.3.3 Calculation of average electric power output.....	24
13.3.4 Determination of state of charge of the battery .....	25
13.3.5 Computation of electrical efficiency .....	25
13.4 Type test on operational performance .....	25
13.4.1 Cold start maximum power output test .....	25
13.4.2 Power cycling electrical load test .....	26



13.4.3	Electric demand-following test .....	26
14	Power stability during operation .....	27
14.1	General .....	27
14.2	Delivered power .....	27
14.3	Regenerated power .....	27
15	Type tests on environmental performance .....	28
15.1	General .....	28
15.2	Noise test .....	28
15.2.1	General .....	28
15.2.2	Test conditions .....	28
15.3	Exhaust gas test .....	30
15.3.1	General .....	30
15.3.2	Components to be measured .....	30
15.3.3	Test method .....	30
15.3.4	Processing of data .....	31
15.4	Discharge water test .....	34
15.4.1	General .....	34
15.4.2	Test method .....	34
15.5	Vibration test .....	34
15.5.1	General .....	34
15.5.2	Vertical axis test .....	35
15.5.3	Longitudinal and lateral axes tests .....	35
15.5.4	Random vibration test .....	35
16	Test mode of fuel cell/battery hybrid system on an excavator .....	36
17	Test reports .....	36
17.1	General .....	36
17.2	Title page .....	36
17.3	Table of contents .....	36
17.4	Summary report .....	36
Annex A	(informative) Example of a test operation schedule .....	37
Annex B	(informative) Example of test mode for fuel cell/battery hybrid system .....	38
B.1	Test modes for excavator .....	38
B.1.1	General .....	38
B.1.2	Driving mode .....	38
B.1.3	Lifting mode .....	38
B.1.4	Excavating mode .....	38
B.1.5	Levelling mode .....	38
B.1.6	Breaking mode .....	38
B.2	Test condition .....	39
Annex C	(informative) Guidelines for the contents of detailed and full reports .....	40
C.1	General .....	40
C.2	Detailed report .....	40
C.3	Full report .....	40
Bibliography	.....	41
Figure 1	– Fuel cell/ battery hybrid systems block diagram .....	8
Figure 2	– Fuel cell/battery hybrid system configuration .....	12

Figure 3 – Power hybridization of fuel cell and battery power system .....	12
Figure 4 – Test set-up for fuel cell/battery hybrid system fed with hydrogen fuel which supplies only electricity .....	14
Figure 5 – Test set-up for fuel cell power system fed with methanol fuel which supplies only electricity .....	15
Figure 6 – Chronological series of changes in the operating state .....	19
Figure 7 – Energy flow for regenerated power and delivered power .....	27
Figure 8 – Noise measurement points for hybrid fuel cell power systems .....	29
Figure 9 – Random vibration ASD .....	35
Figure B.1 – Operation modes for excavator installed fuel cell/battery hybrid system .....	38
Table 1 – Symbols and their meanings for electric/thermal performance .....	10
Table 2 – Delivered power measurements .....	27
Table 3 – Regenerated power measurements .....	28
Table 4 – Compensation of readings against the effect of background noise .....	29
Table A.1 – Example of a test operation schedule .....	37
Table B.1 – Example of test mode for fuel cell/battery hybrid system with excavator .....	39

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

[SIST EN IEC 62282-4-600:2022](https://standards.iteh.ai/catalog/standards/sist/6e7e21f6-672e-4259-879a-a82fa3c28f48/sist-en-iec-62282-4-600-2022)

<https://standards.iteh.ai/catalog/standards/sist/6e7e21f6-672e-4259-879a-a82fa3c28f48/sist-en-iec-62282-4-600-2022>

## 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**

## 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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

**IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

ITEH STANDARD PREVIEW  
(standards.iteh.ai)

[SIST EN IEC 62282-4-600:2022](https://standards.iteh.ai/catalog/standards/sist/6e7e21f6-672e-4259-879a-a82fa3c28f48/sist-en-iec-62282-4-600-2022)

<https://standards.iteh.ai/catalog/standards/sist/6e7e21f6-672e-4259-879a-a82fa3c28f48/sist-en-iec-62282-4-600-2022>

## 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.