# IEC 62282-4-102

Edition 2.0 2022-12
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside

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



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



**THIS PUBLICATION IS COPYRIGHT PROTECTED**
**Copyright © 2022 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

**About the IEC**
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - webstore.iec.ch/advsearchform**
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - webstore.iec.ch/justpublished**
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - webstore.iec.ch/csc**
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

**IEC Products & Services Portal - products.iec.ch**
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - www.electropedia.org**
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 62282-4-102

Edition 2.0 2022-12
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.070

ISBN 978-2-8322-6314-3

**Warning! Make sure that you obtained this publication from an authorized distributor.**

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD ..... 5
INTRODUCTION ..... 7
1 Scope ..... 8
2 Normative references ..... 9
3 Terms and definitions ..... 10
4 Symbols ..... 13
5 ~~Reference~~ Standard conditions ..... 15
6 Heating value base ..... 15
7 Test preparation ..... 16
7.1 General ..... 16
7.2 Data acquisition plan ..... 16
8 Test set-up ..... 16
9 Instruments and measurement methods ..... 18
9.1 General ..... 18
9.2 Measurement instruments ..... 18
9.3 Measurement points ..... 19
9.4 Minimum required measurement systematic uncertainty ..... 20
10 Test conditions ..... 20
10.1 Laboratory conditions ..... 20
10.2 Installation and operating conditions of the system ..... 20
10.3 Indication of battery condition ..... 21
10.4 Determination of state of charge of the battery ..... 21
10.5 Quality of test fuel ..... 21
10.5.1 Hydrogen ..... 21
10.5.2 Methanol solution ..... 21
11 Fuel consumption test ..... 21
11.1 Hydrogen fuel consumption test ..... 21
11.1.1 General ..... 21
11.1.2 Test method ..... 21
11.1.3 Calculation of results ..... 22
11.2 Methanol fuel consumption test ..... 24
11.2.1 General ..... 24
11.2.2 Test method ..... 24
11.2.3 Calculation of average methanol fuel power input ..... 25
12 Electric~~al~~ power output test ..... 25
12.1 General ..... 25
12.2 Test method ..... 26
12.3 Calculation of average electric~~al~~ power output ..... 26
12.4 Computation of electric~~al~~ efficiency ..... 26
13 Type tests on operational performance ..... 26
13.1 ~~Cold start~~ Maximum power output test ..... 26
13.1.1 General ..... 26
13.1.2 Test method ..... 27
13.1.3 Processing of data ..... 27
13.2 Power cycling electric~~al~~ load test ..... 27

13.2.1 General ..... 27
13.2.2 Test method ..... 27
13.2.3 Processing of data ..... 27
13.3 Accessory load voltage spike test ..... 27
13.3.1 General ..... 27
13.3.2 Test method ..... 27
13.3.3 Processing of data ..... 28
14 Power stability under operation ..... 28
14.1 General ..... 28
14.2 Delivered power ..... 28
14.3 ~~Power absorbed~~ Regenerated power ..... 29
15 Type tests on environmental performance ..... 30
15.1 General ..... 30
15.2 Noise test ..... 30
15.2.1 General ..... 30
15.2.2 Test conditions ..... 30
15.2.3 Test method ..... 31
15.2.4 Processing of data ..... 32
15.3 Exhaust gas test ..... 32
15.3.1 General ..... 32
15.3.2 Components to be measured ..... 32
15.3.3 Test method ..... 32
15.3.4 Processing of data ..... 33
15.4 Discharge water test ..... 35
15.4.1 General ..... 35
15.4.2 Test method ..... 35
16 Test reports ..... 36
16.1 General ..... 36
16.2 Title page ..... 36
16.3 Table of contents ..... 36
16.4 Summary report ..... 36
16.5 Checklist for performance parameters ..... 36
Annex A (informative) Heating values for hydrogen and methanol at ~~reference~~ standard conditions ..... 37
Annex B (informative) Guidelines for the contents of detailed and full reports ..... 38
B.1 General ..... 38
B.2 Detailed report ..... 38
B.3 Full report ..... 38
Annex C (informative) Checklist for performance criteria dealt with in this document ..... 39
Bibliography ..... 42

~~Figure 1 – Fuel cell power systems for industrial electric trucks .....~~
Figure 1 – Fuel cell power systems for electrically powered industrial trucks ..... 9
Figure 2 – Example of a test set-up for hydrogen fuel ..... 17
Figure 3 – Example of a test set-up for methanol fuel ..... 18
Figure 4 – Energy flow for regenerated power and delivered power ..... 28
Figure 5 – Noise measurement points for fuel cell power systems ..... 31

Table 1 – Symbols and their meanings for electric and thermal performance ..... 14
Table 2 – Symbols and their meanings for environmental performance ..... 15
Table 3 – Delivered power measurements ..... 29
Table 4 – ~~Power absorbed~~ Regenerated power measurements ..... 30
Table 5 – ~~Compensation of readings against~~ Correction values corresponding to the effect of background noise ..... 31
Table A.1 – Heating values for hydrogen and methanol at ~~reference~~ standard conditions ..... 37

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

# FUEL CELL TECHNOLOGIES –

## Part 4-102: Fuel cell power systems for ~~industrial electric trucks~~ 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.
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.

**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 62282-4-102:2017. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

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.

**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.**

# 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 ~~industrial electric trucks~~ 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 ~~for~~ used to drive industrial electric trucks, which are being manufactured and used increasingly worldwide. This is because such applications are urgently ~~demanded~~ 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 ~~industrial electric trucks~~ electrically powered industrial trucks, such as forklift trucks, ~~are hybrids~~ 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 ~~industrial electric trucks and/~~ 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 ~~selectively execute test items that are suitable for their purposes from those described in this document~~ can select and perform the tests they need from those described. This document is not intended to exclude any other ~~methods~~ tests.

# FUEL CELL TECHNOLOGIES –

## Part 4-102: Fuel cell power systems for ~~industrial electric trucks~~ 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.

~~The scope of this document is limited to electrically powered industrial trucks. Hybrid trucks that include an internal combustion engine are not included in the scope. The scope of this standard will be applicable to material-handling equipment, e.g. forklifts.~~

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

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. ~~A fuel source container of the detachable type is not permitted.~~

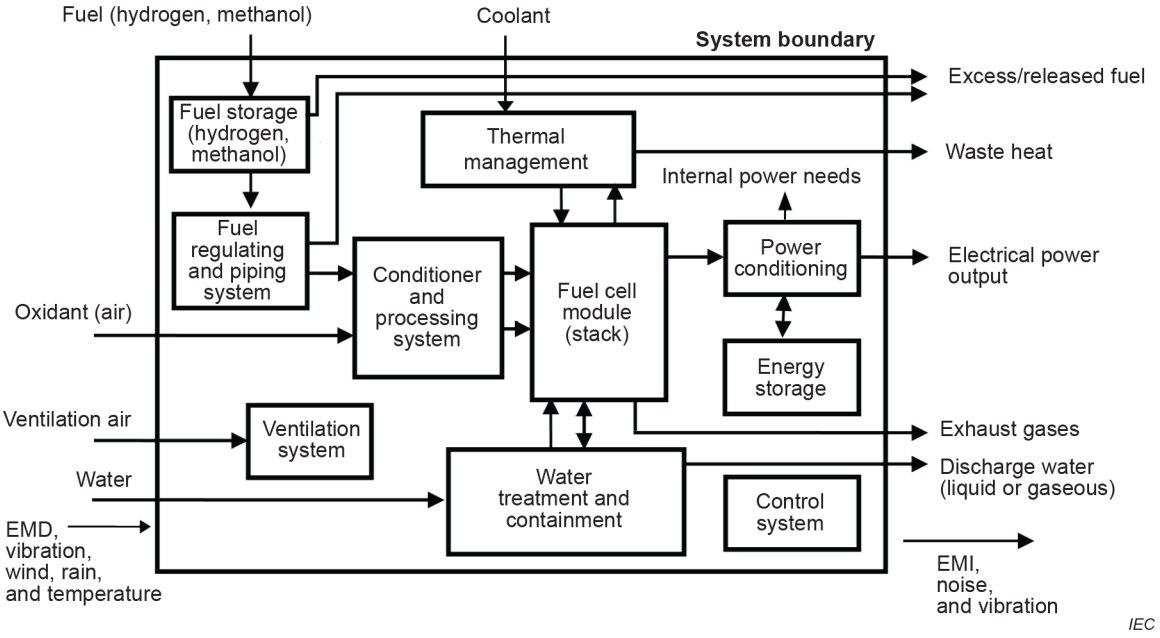
~~Fuel cell power systems intended for operation in potentially explosive atmospheres are excluded from the scope of this document.~~

~~This document does not cover the fuel storage systems using liquid hydrogen.~~

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 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*~~

~~IEC 62282-3-201, *Fuel cell technologies – Part 3-201: Small stationary fuel cell power systems – Performance test methods for small fuel cell power systems*~~

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

~~ISO 9000, *Quality management series of standards*~~

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*

~~ISO 14687-2, *Hydrogen fuel – Product specification – Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*~~

## 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

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

**3.3**
**battery**
electrochemical energy storage device that either provides energy input to support parasitic loads ~~and/~~or provides electric~~al~~ 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/TS 62282-1:2013, 3.110.1~~ IEC 60050-485:2020, 485-21-01]

~~**3.5**~~
~~**discharge rate**~~
~~mass of discharged exhaust gas component per unit of time~~

**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.

~~[SOURCE: IEC/TS 62282-1:2013, 2.2, modified – Note 1 to entry added.]~~

**3.6**
**fuel cell system electrica~~l~~ efficiency**
ratio of the average electric power output of a fuel cell power system ~~at~~ for a given duration to the average fuel power fed to the same fuel cell power system ~~at~~ 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

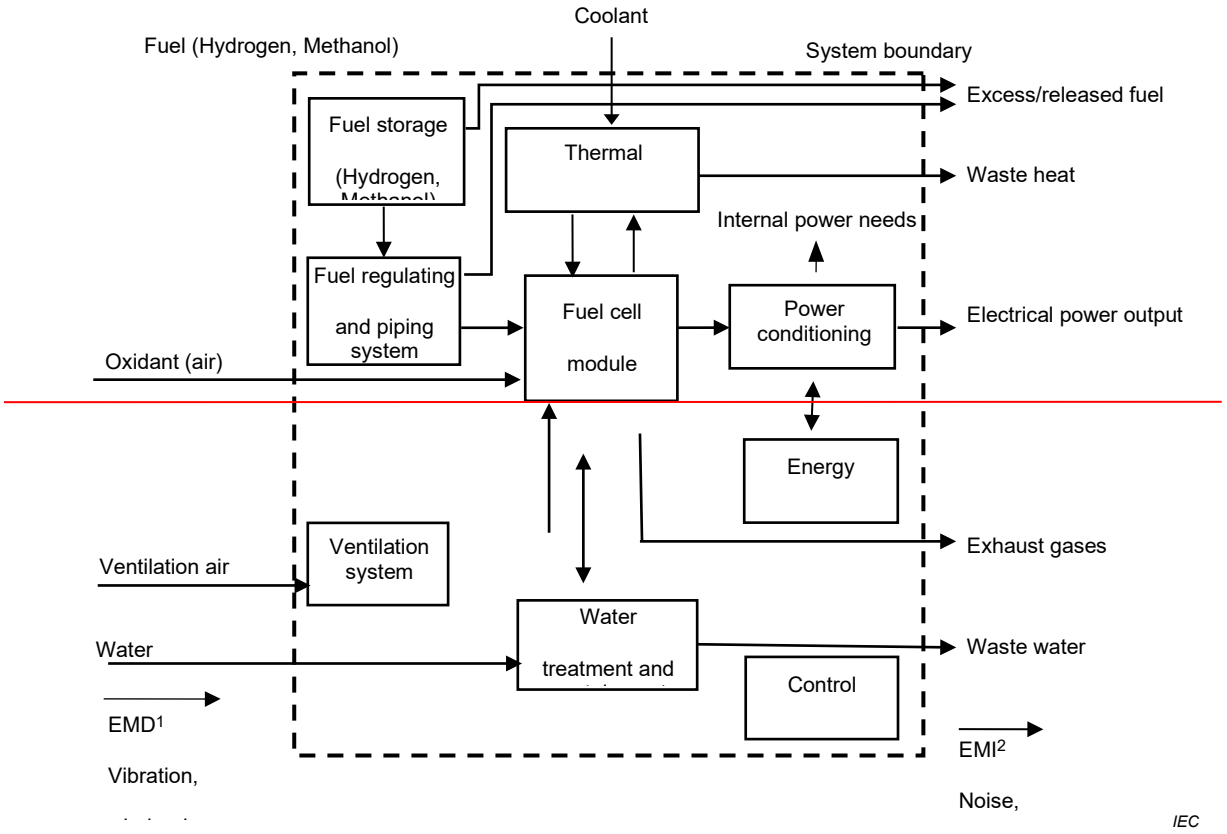
~~Note 1 to entry: See Figure 1 for a block diagram of a fuel cell power system.~~

~~Note 2 to entry: A fuel cell power system may contain all or some of the components shown in Figure 1. The fuel cell power system for use with industrial trucks will be in one of the forms as outlined in 3.9 and 3.10 of IEC 62282-4-101.~~

~~[SOURCE: IEC/TS 62282-1:2013, 3.49, modified – New Note 1 to entry has been added, and existing Note 1 to entry has become Note 2 to entry with the addition of the second sentence.]~~

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.]




~~Key~~

~~Fuel cell power system including subsystems. The interface is defined as a conceptual or functional one instead of hardware such as a power package.~~

~~Subsystems; fuel cell module, fuel processor, etc. These subsystem configurations depend on the kind of fuel, type of fuel cell or system.~~

~~The interface points in the boundary to be measured for calculation data.~~

~~1 EMD electromagnetic disturbance~~

~~2 EMI electromagnetic interference~~

**~~Figure 1 – Fuel cell power systems for industrial electric trucks~~**

**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~~**
**~~fuel power consumption~~**
~~amount of energy per time unit contained in the fuel consumed by the fuel cell power system~~

**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 ~~power~~ that a fuel cell power system is designed to achieve under normal operating conditions specified by the manufacturer

[SOURCE: ~~IEC/TS 62282-1:2013, 3.85.4, modified – Note 1 to entry deleted~~ IEC 60050-485:2020, 485-14-04, modified – Note 1 to entry has been deleted.]

~~**3.14**~~
~~**auxiliary load**~~
~~power consumed by auxiliary machines and equipment such as balance of plant (BOP) necessary to operate a fuel cell power system~~

~~**3.15**~~
~~**storage state**~~
~~condition of a fuel cell power system that is non-operational and possibly requiring, under conditions specified by the manufacturer, the input of thermal or electric energy in order to prevent deterioration of the components and/or energize the control systems and other components, and is ready for start-up~~

~~[SOURCE: IEC/TS 62282-1:2013, 3.110.6, modified – Reference to an inert atmosphere has been deleted, "and/or energize control systems and other components, and is ready for start-up" has been added.]~~

**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.