IEC 62282-4-102

Edition 1.0 2017-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fuel cell technologies –
Part 4-102: Fuel cell power systems for industrial electric 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 62282-4-102:2017-04(en-fr)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 27.070

ISBN 978-2-8322-4125-7

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FUEL CELL TECHNOLOGIES –

Part 4-102: Fuel cell power systems for industrial electric 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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International Standard IEC 62282-4-102 has been prepared by IEC technical committee 105: Fuel cell technologies.

The text of this standard is based on the following documents:

FDIS	Report on voting
105/635/FDIS	105/642/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62282 series, under the general title *Fuel cell technologies*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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 industrial electric 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). Among the categories mentioned above, this document (IEC 62282-4-102) focuses on fuel cell power systems for industrial electric trucks because such an application is urgently demanded 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 standard.

Fuel cells used in industrial electric trucks, such as forklift trucks, are hybrids 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 will break down these different modes and provide a framework for designing and evaluating a fuel cell system for use specifically in a forklift truck.

This part of IEC 62282-4 is to be used by manufacturers of fuel cell power systems used for industrial electric trucks and/or those who evaluate the performance of their systems for certification purposes.

Users of this document selectively execute test items that are suitable for their purposes from those described in this document. This document is not intended to exclude any other methods.

FUEL CELL TECHNOLOGIES –

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

1 Scope

This document covers performance test methods of fuel cell power systems intended to be used for electrically powered industrial trucks.

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 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 standard:

– gaseous hydrogen, and
– methanol.

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

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.

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

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, for example, batteries for internal recharges or recharged from an external source.

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

ISO 9000, *Quality management series of standards*

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 terminological databases for use in standardisation 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
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: Expressed as 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 provides energy input to support parasitic loads and/or provides electrical energy output

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]

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

3.6
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.]

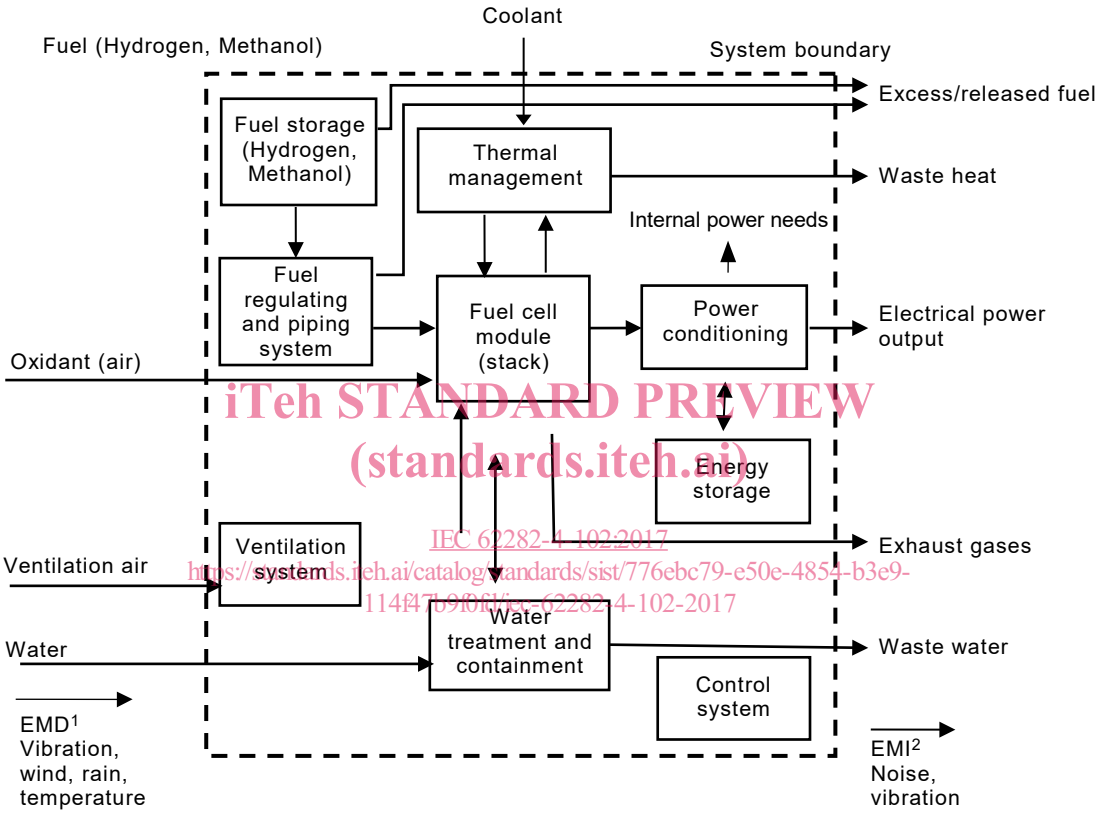
3.7
fuel cell system electrical efficiency
ratio of the average electric power output of a fuel cell power system at a given duration to the average fuel power fed to the same fuel cell power system at the same duration

3.8
fuel cell power system
generator system that uses one or more fuel cell module(s) 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.]



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

3.9
fuel input
amount of hydrogen or methanol supplied to the fuel cell power system

3.10
fuel power consumption
amount of energy per time unit contained in the fuel consumed by the fuel cell power system

3.11
fuel consumption
volume or mass of fuel consumed by the fuel cell power system under specified operating conditions

3.12
minimum electric power output
minimum power output, at which a fuel cell power system is able to operate continuously at a steady state

3.13
rated power
maximum continuous electric output power that a fuel cell power system (3.8) 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]

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.]

3.16
test duration
time interval in which data points required for the computation of test results are recorded

4 Symbols

The symbols and their meanings used in this part of IEC 62282-4 are given in Table 1 for electric/thermal performance and in Table 2 for environmental performance, with the appropriate units.

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

Symbol	Definition	Unit
M, m	**Molar mass, mass**	
M_{mf}	Molar mass of fuel	g/mol
p	**Pressure**	
p_0	Reference pressure (101,325 kPa (abs))	kPa (abs)
p_f	Average fuel pressure	kPa (abs)
P, dP	**Power, power change rate**	
P_n	Average net electric power output	kW
P_{inf}	Average fuel power input	kJ/s
E	**Input energy**	
E_{fm}	Input energy of fuel (mass and volume)	kJ/kg
E_{inf}	Total fuel input energy	kJ
q_m	**Mass flow rate**	
q_{mf}	Average mass flow rate of fuel	kg/s
q_V	**Volumetric flow rate**	
q_{Vf}	Average volumetric flow rate of fuel under the test conditions	l/min
q_{Vf0}	Average volumetric flow rate of fuel under reference conditions	l/min
H	**Heating value**	
H_{f0}	Heating value of fuel on a molar basis under reference conditions	kJ/mol
t	**Time**	
Δ_t	Test duration	s
T	**Temperature**	
T_0	Reference temperature (273,15 K)	K
T_f	Average fuel temperature	K
ΔT	Temperature difference between heat recovery fluid output and input	K
V	**Volume, molar volume**	
V_{m0}	Reference molar volume of ideal gas (22,414 l/mol) (at reference temperature T_0 = 273,15 K and pressure p_0 = 101,325 kPa)	m^3/mol
W	**Electric energy**	
W_{out}	Electric energy output	kW·h
η	**Efficiency**	
η_e	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**	
$\varphi_{B,meas}$	the measured volume fraction of each component	vol % or ml/m^3
$\varphi_{B,corr}$	the corrected volume fraction of each component	vol % or ml/m^3
$\varphi_{at(O_2)}$	the measured O_2 (oxygen) volume fraction in atmosphere at air inlet in dry state	vol %
$\Phi_{ex(O_2)}$	measured O_2 volume fraction in dry exhaust gas	vol %
$\varphi_{ex(CO)corr}$	the corrected CO volume fraction in dry exhaust gas	ml/m^3
$\varphi_{ex(THC)corr}$	the corrected THC volume fraction in dry exhaust gas	ml/m^3 C equivalent
Γ	**Mass concentration**	
$\gamma_{ex(CO)}$	the CO mass concentration in dry exhaust gas	mg/m^3
$\gamma_{ex(THC)}$	the THC mass concentration in dry exhaust gas	mg/m^3
ε	**Emission**	
ε_{CO}	the mass of CO emission per unit energy of input fuel	mg/kW·h
ε_{THC}	the mass of THC per unit energy of fuel input	mg/kW·h
α	**Atom ratio**	
α_{THC}	the hydrogen to carbon atom ratio of the THC in the exhaust gas.	
H	**Heating value**	

5 Reference conditions

The reference conditions are specified as follows:

– reference temperature: T_0 = 273,15 K (0 °C);
– reference pressure: p_0 = 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 1 The heating values of hydrogen and methanol (LHV and HHV) are given in Annex A.

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

$$\eta_e,\ \eta_{th},\ \text{or}\ \eta_{total} = XX\ \%$$

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

$$\eta_e,\ \eta_{th},\ or\ \eta_{total} = XX\ \%\ (HHV)$$