

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fuel cell technologies –
Part 3-200: Stationary fuel cell power systems – Performance test methods**

**Technologies des piles à combustible –
Partie 3-200: Systèmes à piles à combustible stationnaires – Méthodes d'essai
des performances**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2015 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.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

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: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

Plus de 60 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.



IEC 62282-3-200

Edition 2.0 2015-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fuel cell technologies –
Part 3-200: Stationary fuel cell power systems – Performance test methods**

**Technologies des piles à combustible –
Partie 3-200: Systèmes à piles à combustible stationnaires – Méthodes d'essai
des performances**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 27.070

ISBN 978-2-8322-2985-9

**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
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	9
3 Terms, definitions, operating process and symbols	11
3.1 Terms and definitions.....	11
3.2 Operating process.....	16
3.3 Symbols.....	17
4 Reference conditions	20
4.1 General.....	20
4.2 Temperature and pressure	21
4.3 Heating value base	21
5 Item of performance test.....	21
6 Test preparation	22
6.1 General.....	22
6.2 Uncertainty analysis.....	22
6.2.1 Uncertainty analysis items	22
6.2.2 Data acquisition plan	22
7 Measurement instruments and measurement methods.....	22
7.1 General.....	22
7.2 Measurement instruments	23
7.3 Measurement methods.....	23
7.3.1 Electric power measurements	23
7.3.2 Fuel input measurement	24
7.3.3 Recovered heat measurement	27
7.3.4 Purge gas flow measurement.....	27
7.3.5 Oxidant (air) input measurement.....	28
7.3.6 Other fluid flow measurement	29
7.3.7 Exhaust gas flow measurement	29
7.3.8 Discharge water measurement.....	30
7.3.9 Noise level measurement.....	31
7.3.10 Vibration level measurement.....	31
7.3.11 Total harmonic distortion measurement	31
7.3.12 Ambient condition measurement.....	31
8 Test plan	32
8.1 General.....	32
8.2 Ambient conditions.....	32
8.3 Maximum permissible variation in steady-state operating conditions	33
8.4 Test operating procedure	33
8.5 Duration of test and frequency of readings.....	33
9 Test methods and computation of test results	34
9.1 General.....	34
9.2 Efficiency test	34
9.2.1 General	34
9.2.2 Test method	34

9.2.3	Computation of inputs	34
9.2.4	Computation of output	44
9.2.5	Computation of waste heat rate	45
9.2.6	Computation of efficiencies	45
9.3	Electric power and thermal power response characteristics test	46
9.3.1	General	46
9.3.2	Criteria for the determination of attaining the steady-state set value	47
9.3.3	Electric power output response time test	48
9.3.4	90 % response time of rated net electric power output (optional)	49
9.3.5	Thermal power output response time test	50
9.4	Start-up and shutdown characteristics test	51
9.4.1	General	51
9.4.2	Test method for start-up characteristics test	51
9.4.3	Test method for shutdown characteristics test	51
9.4.4	Calculation of the start-up time	52
9.4.5	Calculation of the shutdown time	52
9.4.6	Calculation of the different forms of start-up energy	52
9.4.7	Calculation of the start-up energy	54
9.5	Purge gas consumption test	54
9.5.1	General	54
9.5.2	Test method	54
9.6	Water consumption test (optional)	55
9.6.1	General	55
9.6.2	Test method	55
9.7	Exhaust gas emission test	55
9.7.1	General	55
9.7.2	Test method	55
9.7.3	Data processing of emission concentration	56
9.7.4	Calculation of mean mass discharge rate	56
9.7.5	Calculation of mass concentration	56
9.8	Noise level test	56
9.8.1	General	56
9.8.2	Test method	56
9.8.3	Data processing	57
9.9	Vibration level test	57
9.10	Discharge water quality test	58
9.10.1	General	58
9.10.2	Test method	58
10	Test reports	59
10.1	General	59
10.2	Title page	59
10.3	Table of contents	59
10.4	Summary report	59
10.5	Detailed report	59
10.6	Full report	60
Annex A (normative)	Uncertainty analysis	61
A.1	General	61
A.2	Preparations	61
A.3	Basic assumptions	62

A.4	General approach	62
Annex B (normative)	Calculation of fuel heating value	64
Annex C (normative)	Reference gas	68
C.1	General.....	68
C.2	Reference gases for natural gas and propane gas	68
Annex D (informative)	Maximum acceptable instantaneous electric power output transient	71
	Bibliography.....	72
Figure 1	– Fuel cell power system diagram	9
Figure 2	– Operating process chart of fuel cell power system.....	17
Figure 3	– Symbol diagram	20
Figure 4	– Electric and thermal power response time	47
Figure 5	– Example of electric and thermal power response time to attain steady-state set value	48
Figure 6	– Example of electric power chart at start-up.....	51
Figure 7	– Electric power chart at shutdown.....	52
Table 1	– Symbols	18
Table 2	– Test classification and test item.....	21
Table 3	– Test item and system status	32
Table 4	– Maximum permissible variations in test operating conditions	33
Table 5	– Vibration correction factors.....	58
Table B.1	– Heating value for component of gaseous fuel.....	64
Table C.1	– Reference gas for natural gas	69
Table C.2	– Reference gas for propane gas	69

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUEL CELL TECHNOLOGIES –**Part 3-200: Stationary fuel cell power systems –
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.

International Standard IEC 62282-3-200 has been prepared by IEC technical committee 105: Fuel cell technologies.

This second edition cancels and replaces the first edition of IEC 62282-3-200, published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) a stabilization zone of $\pm 10\%$ for thermal output of 100 % response time is provided instead of the tests for thermal output of 90 % response time, while the tests for electric output of 90 % response time remain as an option;
- b) the calculations for the ramp rate in kW/s are deleted and only the calculations for the response time (s) remain;

- c) the procedures, criteria and figures of 9.3, Electric power and thermal power response characteristics test, are modified to ensure they produce accurate and consistent results;
- d) maximum acceptable instantaneous electric power output transient is moved to informative Annex D.

IEC has published a related but independent standard IEC 62282-3-201 on performance test methods of small stationary fuel cell power systems which is harmonized with this standard.

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

FDIS	Report on voting
105/547/FDIS	105/555/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 the 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 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 describes how to measure the performance of stationary fuel cell power systems for residential, commercial, agricultural and industrial applications.

This standard describes type tests and their test methods only. In this standard, no routine tests are required or identified, and no performance targets are set.

The following fuel cell types have been considered:

- alkaline fuel cells (AFC);
- phosphoric acid fuel cells (PAFC);
- polymer electrolyte fuel cells (PEFC);
- molten carbonate fuel cells (MCFC);
- solid oxide fuel cells (SOFC).

FUEL CELL TECHNOLOGIES –

Part 3-200: Stationary fuel cell power systems – Performance test methods

1 Scope

This part of IEC 62282 covers operational and environmental aspects of the stationary fuel cell power systems performance. The test methods apply as follows:

- power output under specified operating and transient conditions;
- electrical and heat recovery efficiency under specified operating conditions;
- environmental characteristics; for example, exhaust gas emissions, noise, etc. under specified operating and transient conditions.

This standard does not provide coverage for electromagnetic compatibility (EMC).

This standard does not apply to small stationary fuel cell power systems with electric power output of less than 10 kW which are dealt with IEC 62282-3-201.

Fuel cell power systems may have different subsystems depending upon types of fuel cell and applications, and they have different streams of material and energy into and out of them. However, a common system diagram and boundary has been defined for evaluation of the fuel cell power system (see Figure 1).

The following conditions are considered in order to determine the system boundary of the fuel cell power system:

- all energy recovery systems are included within the system boundary;
- all kinds of electric energy storage devices are considered outside the system boundary;
- calculation of the heating value of the input fuel (such as natural gas, propane gas and pure hydrogen gas, etc.) is based on the conditions of the fuel at the boundary of the fuel cell power system.