

TECHNICAL REPORT

Fuel cell technologies – **Part 7-3: Test methods – Status of accelerated tests for fuel cell stacks and components and perspectives for standardization**

Document Preview

[IEC TR 62282-7-3:2025](https://standards.iteh.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025)

<https://standards.iteh.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025>





THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2025 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 Varembe
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 It also gives information on projects, replaced and withdrawn publications.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, graphical symbols and the glossary. 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 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

International
Standards
Document Preview
standards.iteh.ai

[IEC TR 62282-7-3:2025](https://standards.iteh.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025)

<https://standards.iteh.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025>

TECHNICAL REPORT

Fuel cell technologies – iTeh Standards
Part 7-3: Test methods – Status of accelerated tests for fuel cell stacks and
components and perspectives for standardization (http://standards.itih.ai)

Document Preview

[IEC TR 62282-7-3:2025](https://standards.itih.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025)

<https://standards.itih.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.070

ISBN 978-2-8327-0277-2

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

CONTENTS

FOREWORD..... 3

INTRODUCTION..... 5

1 Scope..... 7

2 Normative references 7

3 Terms, definitions, abbreviated terms and symbols..... 7

 3.1 Terms and definitions..... 7

 3.2 Abbreviated terms and symbols 8

 3.2.1 Abbreviated terms 8

 3.2.2 Symbols 9

4 Outlook of a possible standard/specification on accelerated tests..... 9

5 Project review and suggested liaisons 10

6 Intrinsic degradation mechanisms and their effects..... 11

7 Quantification methods for determining (accelerated) degradation..... 16

 7.1 General..... 16

 7.2 In-operando diagnostic methods 16

 7.3 Mathematical transfer function formulation method 17

 7.4 Post-test methods..... 17

8 Approaches to accelerated testing..... 19

 8.1 Internal reference test and accelerated test validation 19

 8.2 Single-component accelerated tests..... 19

 8.3 Stack environment and system influence: combining degradation mechanisms within an accelerated test 20

 8.4 Product duty cycle 21

 8.5 Combining accelerated tests to an accelerated test programme 21

9 Accelerated testing environment..... 22

10 Conclusions..... 23

Bibliography..... 25

Table 1 – PEFC degradation phenomena, governing parameters and diagnostics..... 12

Table 2 – SOC Degradation phenomena, governing parameters and diagnostics 14

Table 3 – Examples of diagnostic methods for the measurement of key degradation properties 18

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUEL CELL TECHNOLOGIES –

Part 7-3: Test methods – Status of accelerated tests for fuel cell stacks and components and perspectives for standardization

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TR 62282-7-3 has been prepared by IEC technical committee 105: Fuel cell technologies. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
105/1091/DTR	105/1103/RVDTR

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 Technical Report 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, or
- revised.

iTeh Standards
(<https://standards.itih.ai>)
Document Preview

[IEC TR 62282-7-3:2025](#)

<https://standards.itih.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025>

INTRODUCTION

The scope of accelerated testing is to reduce the time for qualification of the degradation or the long-term performance of a specific cell, cell component, stack, stack module or stack component compared to testing at nominal operating conditions. To generate an accelerated test, operating conditions stress a test item or one of its components, usually through the exaggeration of one of the testing parameters (the so-called stress factor). The results of this test are expected to provide a comparative assessment of the robustness (or degradation) of the test item and possibly – through an established transfer function – an estimation of the projected lifetime of the test item under nominal (non-stressed) conditions.

An accelerated test thus cannot be a self-standing experiment, since it cannot be applied universally to all cell technologies, architectures or material combinations. Degradation phenomena are different and occur heterogeneously for different fuel cell (stack) technologies and in different operating modes. Also, different fabrication process of cells and components can lead to different responses under stressed conditions (although the responses at nominal conditions could be similar). In any case, for each accelerated test, a benchmark test item (operated at nominal conditions and adequately characterized) is necessary in order to have a meaningful reference against which the accelerated test can provide the required understanding of long-term durability of that same item. Nevertheless, actual long-term testing under normal operating conditions could be the only method to obtain an accurate degradation rate.

Tests on components (ex-situ tests) would only be relevant for comparison of such components, since the relevance for performance within a system can only be provided in the integrated assembly. For systems and end products, a generally applicable accelerated test for a given application (without the need for benchmarking) is certainly useful and is possible in the same way as there exist standardized drive cycles for vehicles/propulsion systems. However, it is still considered a major challenge to define an operating cycle that represents the actual application including events that contribute to degradation like start-stop cycles, air-air-starts, freeze starts, pressure and humidity cycles, temperature cycles etc. Nevertheless, standardized types of tests could be defined, generic for all types of fuel cells, with specific test conditions and cycles adapted to each application case and to each mission profile to be represented.

It is important to understand whether existing standards for testing performance of cells or stacks (e.g. IEC 62282-7-1 and IEC 62282-7-2, or IEC 62282-8-101 and IEC 62282-8-102) are sufficient for the definition of the testing approach, and only need a specific (quantified) definition of the required test parameters for them to be suitable for the accelerated estimation of durability or lifetime degradation. For example, an increase in operating temperature can be an accelerating test in solid oxide fuel cells (SOFCs). However, the measurements of electrochemical performance of cells/stacks at higher temperatures can be carried out according to the normal standard method (i.e. IEC 62282-7-2 or IEC 62282-8-101). The accelerated test is expected to enable an inference, from measurement of performance degradation at high temperature in this example, of the long-term durability of the tested cell/stack at nominal conditions (i.e. nominal temperature), and – crucially – in a shorter period of testing time than at nominal conditions. However, the increase of operation temperature (for example) can change not only cationic diffusion at the electrode/electrolyte interfaces but also the performance of electrodes/ionic diffusion. In this case, the one stress factor of increasing temperature can affect multiple performance degradation mechanisms of the SOFC, possibly with different time scales. Therefore, it will be difficult to univocally correlate an accelerating factor between degradation/lifetime in the test conditions and degradation/lifetime in nominal conditions. Defining a window of acceptance where the effects of one accelerating stress factor can be called representative of a single degradation mechanism can be a viable approach, even if other intrinsic mechanisms are affected to a lesser degree. To do this would likely require support from dedicated modelling activities, as well as by gathering the experience from manufacturers and comparing results with real long term durability tests.

In other cases, new, dedicated test procedures can be formulated to accelerate specific degradation mechanisms (e.g. controlled oxidation of solid oxide cell (SOC) electrodes to estimate redox stability).

In order to validate the reliability and representativeness of accelerated test procedures, post-test characterisation on samples having undergone tests are indispensable, also to compare the morphological/chemical state of test items after accelerated testing with samples from "real-time" ageing. Though this would fall outside the scope of TC 105, there is a description of such techniques and their applicability in Clause 4.

In this document, only intrinsic degradation mechanisms are considered, inherent to the operation of the cell/stack, and excluding degradation caused by externalities (impurities, shocks, etc.). Nevertheless, it is noted that an approach on contamination is still missing in the standards portfolio, both on fuel and air sides.

Finally, operating fuel cells in electrolysis mode will be considered, either for systems that can operate in reverse mode, or because it has been found that electrolysis mode can be a means to accelerate degradation mechanisms that occur in fuel cell mode.

This document has been compiled based on input from several National Committees and experts, convened in Ad Hoc Group 11 of IEC TC 105, and from two European projects funded by the Fuel Cells and Hydrogen Joint Undertaking (ID-FAST and AD ASTRA). The current Report represents a consensus on the status of accelerated tests for fuel cell stacks and components and outlines the perspectives for standardization of accelerated test procedures.

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC TR 62282-7-3:2025](https://standards.iteh.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025)

<https://standards.iteh.ai/catalog/standards/iec/45c57ec6-9c1e-48b9-9fcb-4a69b961b2a6/iec-tr-62282-7-3-2025>

FUEL CELL TECHNOLOGIES –

Part 7-3: Test methods – Status of accelerated tests for fuel cell stacks and components and perspectives for standardization

1 Scope

The objective of this document is to answer several questions that have been circulating in the area of fuel cell development for many years: "What do we know about influencing fuel cell degradation, can we control it and accelerate it in a predictable way, is there a need for accelerated test procedures and can these be formulated adequately enough to be captured in international standards?"

This document is a generic assessment of the feasibility of standardizing accelerated test procedures (both proton exchange membrane (PEM) and oxide ion-conducting solid oxide cell (SOC) technologies) for fuel cell stacks that have been engineered for a specific system application. This document comprises a review of literature and projects, a discussion of the main physical phenomena of interest in accelerated testing campaigns (focusing on the cell and stack levels, not looking at the system as a black box), a compendium of measurement techniques that are applicable, and it suggests a macroscopic approach to the formulation of a representative accelerated testing campaign.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, abbreviated terms and symbols

3.1 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>

3.1.1

accelerated lifetime test

ALT

process of testing a product by subjecting it to aggravated operating conditions (stress, strain, temperatures, voltage, vibration rate, pressure etc.), thus in excess of nominal service parameters, in an effort to uncover faults and modes of failure in a short period of time to define explicitly its full lifetime

Note 1 to entry: This is thus a test for fast-forwarding time, and it is a destructive test in principle. Usually, it is conducted applying the more relevant failure stresses (this means that they are previously identified), aggravating normal conditions of use.

For example, if a manufacturer/supplier wishes to guarantee a product for e.g. 10 years, by ALT it can verify what is the risk to be accounted for, without waiting 10 years or more. This type of test is particularly relevant for components or systems that are to be introduced to the market.

3.1.2 accelerated stress test AST

process of applying high levels of stress for a short period of time to a device under test (DUT) assuming it will exhibit the same degradation mechanisms as it would in a longer period of time at lower stress levels

Note 1 to entry: This is thus a test for assessing degradation generated by stress. Although it is non-destructive in principle, the device could also be damaged, but certainly less than during ALT. It is not finalised to the determination of the lifetime, but at the determination/study of potential long-term failure mechanisms and possible mitigation strategies. It is a test more suitable for research and development (R&D), because it is useful e.g. for verifying what the effect is of specific operating conditions on the test object or the system, with a view to developing better materials and components.

3.2 Abbreviated terms and symbols

3.2.1 Abbreviated terms

ACL	anode catalyst layer	LSCF	lanthanum strontium cobalt ferrite
ALT	accelerated lifetime test	MEA	membrane-electrode assembly
ASR	area-specific resistance	MPL	microporous layer
AST	accelerated stress test	NEDO	New Energy Development Organization
BET	Brunner-Emmett-Teller	OCV	open-circuit voltage
BoP	balance-of-plant	OEM	original equipment manufacturer
BPP	bipolar plate	PEFC	polymer electrolyte fuel cell
CCM	catalyst-coated membrane	PEM	proton exchange membrane
CL	catalyst layer	R&D	research and development
CV	cyclic voltammetry	RDE	rotating disc electrode
DUT	device under test	RH	relative humidity
ECSA	electrochemically active surface area	SEM	scanning electron microscopy
EIS	electrochemical impedance spectroscopy	SOC	solid oxide cell
EDX	energy dispersive X-ray analysis	SOFC	solid oxide fuel cell
EPMA	electron probe microanalysis	STP	standard temperature and pressure
FCTT	United States Fuel Cell Technical Team	TEM	transmission electron microscopy
FCCJ	fuel Cell Commercialization Conference of Japan	TPB	triple-phase boundary
FIB-SEM	focused ion beam SEM	XPS	X-ray photoelectron spectroscopy
GDL	gas diffusion layer	XRD	X-ray diffraction
HRTEM	high-resolution transmission electron microscopy	XRF	X-ray fluorescence
ICP	inductively coupled plasma		

3.2.2 Symbols

ASR	area specific resistance	$\Omega \cdot \text{m}^2$, $\Omega \cdot \text{cm}^2$
J	current density	A/m^2 , A/cm^2
$\Delta J/\Delta t$	rate of current density variation	$\text{A}/\text{m}^2\text{s}$
q_v	rate of variation of the gas volumetric flow rate	m^3/s^2
T	temperature	$^{\circ}\text{C}$, K
x	undefined parameter	-
$\Delta x/\Delta t$	rate of change of x	s^{-1}
$\Delta \alpha_r$	relative degradation rate	-

NOTE 1 To express the rate of change of a certain parameter x , a dot above the parameter symbol can be used. For instance, \dot{T} can be used to express the temperature ramp with a unit of K/s , \dot{q}_v used to express the speed of variation of the gas flow rate with a unit of $(\text{m}^3/\text{s})/\text{s}$. Alternatively, $(\Delta x/\Delta t)$ can be used. For instance, the temperature ramp can be expressed by $(\Delta T/\Delta t)$ and the speed of current density variation can be expressed by $(\Delta J/\Delta t)$.

NOTE 2 The quantity $\Delta \alpha$ chosen for calculating the degradation rate can be the cell or stack voltage, current, power density or ASR, each with their own unit.

4 Outlook of a possible standard/specification on accelerated tests

From a supplier's point of view, a standard to define test methods for estimating the lifetime of the product (ALT) is of highest importance, also in view of engendering the required confidence to formulate product guarantees, which in turn are crucial for investors and project developers to market innovative solutions. After having defined the correct end application, accelerated tests are expected to predict lifetime and the influence of correlated events (freeze start, air-air-start, starvation, cell potential reversal, cycling, etc.). A standard for these tests would define the test and measurement methods, the testing protocols (e.g. kinds and ranges of stress to be applied, etc.) and provide a clear indication of the degradation mechanisms that the application of such procedures would accelerate. The definition of certain test parameters can be given (e.g. air and H₂ quality) to be able to compare different solutions by a common test procedure.

In the case of ALTs, it is important to quantify the degree of acceleration that the tests would lead to. In the case of ASTs, used for R&D, the aim of these tests would be to provide a benchmark for comparison between different products/components/materials as to the response to a specific degradation mechanism or event. In order to predict the influence of single events on lifetime, further systematic tests can reveal, by knowing type and number/frequency of the defined events and the nominal operational profile of the tested system, the resulting lifetime in "real-world" conditions (not in accelerated tests).

Possibly, indications can be given as to the number of test repetitions required for reliability, so that the standard could be used also for "certification" by accredited bodies.

In the rest of this document, reference will be made to accelerated tests generically, without specifying ALT or AST, since each accelerated testing procedure can be declined as addressing a specific degradation mechanism (AST) or estimated lifetime (ALT) depending on the parameter and protocol definitions. This differentiation will be the task of a subsequent work on a Technical Specification or International Standard.