

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Thyristor valves for high voltage direct current (HVDC) power transmission –
Part 1: Electrical testing**

**Valves à thyristors pour le transport d'énergie en courant continu à haute
tension (CCHT) –
Partie 1: Essais électriques**



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 60700-1

Edition 2.0 2015-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Thyristor valves for high voltage direct current (HVDC) power transmission –
Part 1: Electrical testing**

**Valves à thyristors pour le transport d'énergie en courant continu à haute
tension (CCHT) –
Partie 1: Essais électriques**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.200

ISBN 978-2-8322--2805-0

**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.....	7
3 Terms and definitions.....	7
3.1 Insulation co-ordination terms.....	8
3.2 Valve construction terms.....	9
3.3 Terms related to type tests.....	10
3.4 Terms related to production tests.....	10
4 General requirements.....	10
4.1 Guidelines for the performance of type tests.....	10
4.1.1 Evidence in lieu.....	10
4.1.2 Test object.....	10
4.1.3 Sequence of tests.....	10
4.1.4 Test procedures.....	11
4.1.5 Ambient temperature for testing.....	11
4.1.6 Frequency for testing.....	11
4.1.7 Test reports.....	11
4.2 Atmospheric correction.....	11
4.3 Treatment of redundancy.....	11
4.3.1 Dielectric tests.....	11
4.3.2 Operational tests.....	11
4.4 Criteria for successful type testing.....	12
4.4.1 General.....	12
4.4.2 Criteria applicable to thyristor levels.....	12
4.4.3 Criteria applicable to the valve as a whole.....	13
5 List of type tests.....	13
6 Dielectric tests on valve support.....	14
6.1 Purpose of tests.....	14
6.2 Test object.....	14
6.3 Test requirements.....	15
6.3.1 General.....	15
6.3.2 Valve support d.c. voltage test.....	15
6.3.3 Valve support a.c. voltage test.....	15
6.3.4 Valve support switching impulse test.....	16
6.3.5 Valve support lightning impulse test.....	16
7 Dielectric tests for multiple valve units (MVU).....	16
7.1 Purpose of tests.....	16
7.2 Test object.....	16
7.3 Test requirements.....	17
7.3.1 MVU d.c. voltage test to earth.....	17
7.3.2 MVU a.c. voltage test.....	18
7.3.3 MVU switching impulse test.....	18
7.3.4 MVU lightning impulse test.....	19
8 Dielectric tests between valve terminals.....	20
8.1 Purpose of tests.....	20
8.2 Test object.....	20

8.3	Test requirements	20
8.3.1	Valve d.c. voltage test	20
8.3.2	Valve a.c. voltage test	21
8.3.3	Valve impulse tests (general)	22
8.3.4	Valve switching impulse test.....	23
8.3.5	Valve lightning impulse test.....	23
8.3.6	Valve steep front impulse test	23
8.4	Valve non-periodic firing test	24
8.4.1	Purpose of test	24
8.4.2	Test object.....	24
8.4.3	Test requirements	24
9	Periodic firing and extinction tests	25
9.1	Purpose of tests	25
9.2	Test object	26
9.3	Test requirements	26
9.3.1	General	26
9.3.2	Maximum continuous operating duty tests	27
9.3.3	Maximum temporary operating duty test ($\alpha = 90^\circ$).....	28
9.3.4	Minimum a.c. voltage tests	29
9.3.5	Temporary undervoltage test.....	30
9.3.6	Intermittent direct current tests.....	31
10	Tests with transient forward voltage during the recovery period	31
10.1	Purpose of tests	31
10.2	Test object	31
10.3	Test requirements	31
11	Valve fault current tests	33
11.1	Purpose of tests	33
11.2	Test object	33
11.3	Test requirements	33
11.3.1	General	33
11.3.2	One-loop fault current test with re-applied forward voltage.....	34
11.3.3	Multiple-loop fault current test without re-applied forward voltage	35
12	Tests for valve insensitivity to electromagnetic disturbance	35
12.1	Purpose of tests	35
12.2	Test object	36
12.3	Test requirements	36
12.3.1	General	36
12.3.2	Approach one	36
12.3.3	Approach two.....	36
12.3.4	Acceptance criteria	37
13	Testing of special features and fault tolerance.....	37
13.1	Purpose of tests	37
13.1.1	General	37
13.1.2	Circuits to facilitate the proper control, protection and monitoring of the valve.....	37
13.1.3	Features included in the valve to provide fault tolerance	37
13.2	Test object	37
13.3	Test requirements	38
14	Production tests	38

14.1	General.....	38
14.2	Purpose of tests	38
14.3	Test object.....	38
14.4	Test requirements	38
14.5	Routine test – minimum requirements.....	38
14.5.1	Visual inspection.....	38
14.5.2	Connection check	39
14.5.3	Voltage-grading circuit check	39
14.5.4	Voltage withstand check.....	39
14.5.5	Partial discharge tests.....	39
14.5.6	Check of auxiliaries.....	39
14.5.7	Firing check.....	39
14.5.8	Pressure test	39
15	Method for loss determination	39
16	Presentation of type test results	39
Annex A (normative) Test safety factors		40
A.1	General.....	40
A.2	Test safety factors for dielectric tests	40
A.2.1	Impulse tests	40
A.2.2	AC and d.c. temporary and long-term voltage tests.....	43
A.3	Test safety factors for operational tests	43
Annex B (normative) Partial discharge measurements		44
B.1	Measurement of partial discharge.....	44
B.2	Partial discharge during a.c. tests.....	44
B.3	Partial discharge during d.c. tests.....	44
B.4	Composite a.c. plus d.c. voltage stress.....	45
Figure 1 – Steep front impulse test voltage.....		8
Table 1 – Thyristor level faults permitted during type tests.....		13
Table 2 – List of type tests		14

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**THYRISTOR VALVES FOR HIGH VOLTAGE DIRECT
CURRENT (HVDC) POWER TRANSMISSION –****Part 1: Electrical testing**

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 60700-1 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition published in 1998, its Amendment 1:2003 and its Amendment 2: 2008. This edition constitutes a technical revision.

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

- a) Definitions of terms "redundant thyristor levels", "thyristor level", "valve section" have been changed for clarification.
- b) The notes were added to test requirements of dielectric d.c. voltage tests for valve support, MVU, valve, specifying that before repeating the test with opposite polarity, the tested

object may be short-circuited and earthed for several hours. The same procedure may be followed at the end of the d.c. voltage test.

- c) Table 1 on thyristor level faults permitted during type tests was supplemented.
- d) The alternative MVU dielectric test method was added.
- e) It was specified that production tests may include routine tests as well as sample tests.
- f) It was added into test requirements for periodic firing and extinction tests that a scaling factor for tests shall be applied when testing with valve sections.

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

CDV	Report on voting
22F/341/CDV	22F/351A/RVC

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 in the IEC 60700 series, published under the general title *Thyristor valves for high voltage direct current (HVDC) power transmission*, 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.

THYRISTOR VALVES FOR HIGH VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION –

Part 1: Electrical testing

1 Scope

This part of IEC 60700 applies to thyristor valves with metal oxide surge arresters directly connected between the valve terminals, for use in a line commutated converter for high voltage d.c. power transmission or as part of a back-to-back link. It is restricted to electrical type and production tests.

The tests specified in this standard are based on air insulated valves. For other types of valves, the test requirements and acceptance criteria can be agreed.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060, *High-voltage test techniques*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60099 (all parts), *Surge arresters*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 61803:1999, *Determination of power losses in high-voltage direct current (HVDC) converter stations*

IEC 61803:1999/AMD 1:2010¹

ISO/IEC Guide 25, *General requirements for the technical competence of testing laboratories*²

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

¹ There exists a consolidated edition 1.1 (2011) that comprises IEC 61803:1999 and its Amendment 1:2010.

² Withdrawn.