

TECHNICAL SPECIFICATION

**Reliability and availability evaluation of HVDC systems –
Part 1: HVDC systems with line commutated converters**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2013 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 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.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you 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It also gives information on projects, replaced and withdrawn publications.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 on-line 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 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

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.



TECHNICAL SPECIFICATION

**Reliability and availability evaluation of HVDC systems –
Part 1: HVDC systems with line commutated converters**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE



ICS 29.240.01

ISBN 978-2-8322-1182-3

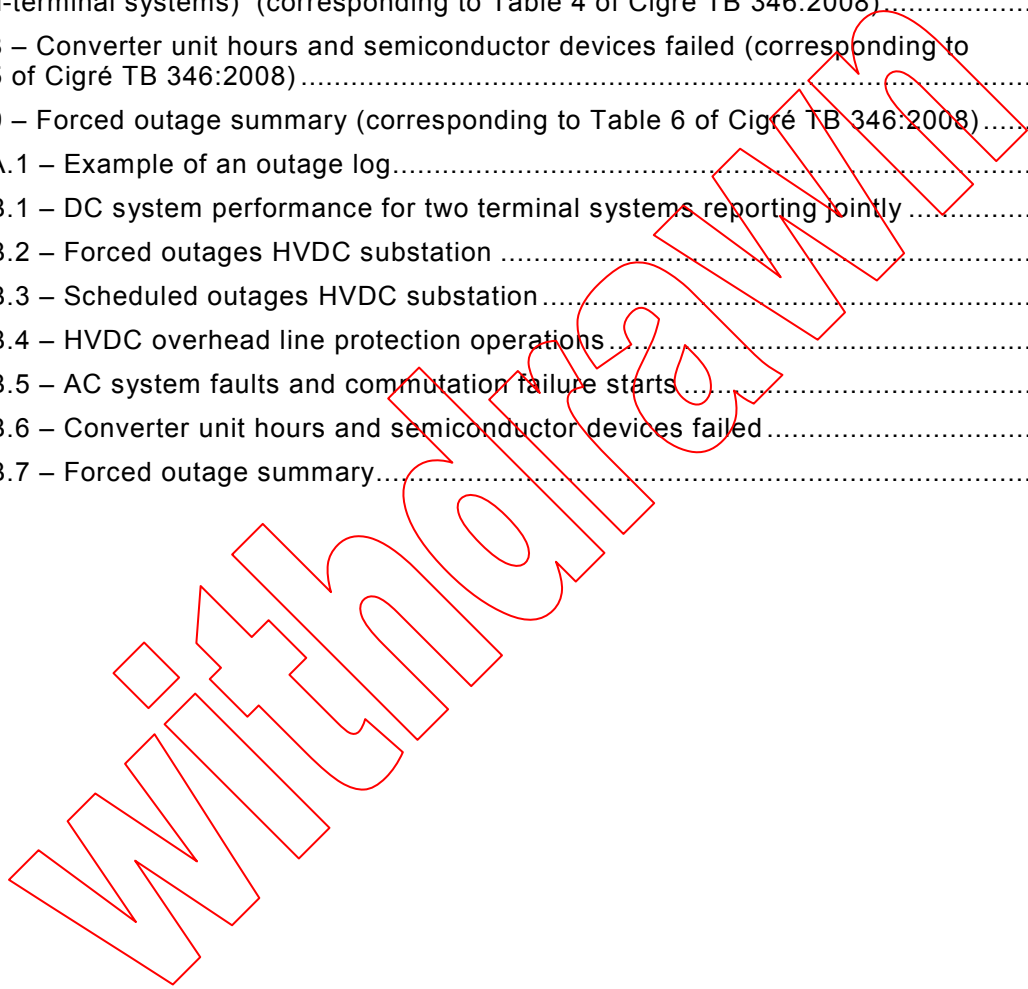
Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms, definitions and abbreviations	8
3.1 Outage terms.....	8
3.2 Capacity terms.....	8
3.3 Outage duration terms	9
3.4 Time categories	9
3.5 Availability and utilization terms.....	10
3.6 Commutation failure performance terms.....	11
3.7 Abbreviations and symbols	11
4 Classification of HVDC transmission system equipment.....	12
4.1 General.....	12
4.2 AC and auxiliary equipment (AC-E).....	12
4.2.1 General	12
4.2.2 AC filter and other reactive power equipment (AC-E.F).....	13
4.2.3 AC control and protection (AC-E.CP).....	13
4.2.4 Converter transformer (AC-E.TX).....	13
4.2.5 Synchronous compensator (AC-E.SC)	13
4.2.6 Auxiliary equipment and auxiliary power (AC-E.AX).....	13
4.2.7 Other AC switchyard equipment (AC-E.SW).....	13
4.3 Valves (V).....	14
4.3.1 General.....	14
4.3.2 Valve electrical (V.E).....	14
4.3.3 Valve cooling (V.VC).....	14
4.4 DC control and protection equipment (C-P).....	14
4.4.1 General.....	14
4.4.2 Local control and protection (C-P.L)	14
4.4.3 Master control and protection (C-P.M)	14
4.4.4 Telecommunications equipment (C-P.T)	14
4.5 Primary DC equipment (DC-E)	15
4.5.1 General	15
4.5.2 DC filters (DC-E.F)	15
4.5.3 DC smoothing reactors (DC-E.SR).....	15
4.5.4 DC switching equipment (DC-E.SW)	15
4.5.5 DC measuring equipment (DC-E.ME).....	15
4.5.6 DC earth electrode (DC-E.GE).....	15
4.5.7 DC earth electrode line (DC-E.EL).....	15
4.5.8 Other DC switchyard and valve hall equipment (DC-E.O).....	15
4.6 Other (O)	16
4.7 DC transmission line (TL).....	16
4.7.1 General	16
4.7.2 DC overhead transmission line (TL-OH).....	16
4.7.3 DC underground/submarine cable (TL-C).....	16
4.8 External (EXT).....	16
5 Classification and severity of fault events and restoration codes.....	16

5.1	Classification of fault events	16
5.2	Severity codes	17
5.3	Restoration codes	18
6	Instructions for compilation of report	18
6.1	General	18
6.2	General instructions	18
6.3	Instructions for Table 2 and Table 3	19
6.3.1	Section 1	19
6.3.2	Section 2	19
6.3.3	Sections 3, 4 and 5	19
6.3.4	Section 6	20
6.3.5	Section 7	20
6.4	Instructions for Table 4 and Table 5	23
6.4.1	Forced outages – Table 4	23
6.4.2	Scheduled outages – Table 5	23
6.5	Instructions for Table 6	25
6.6	Instructions for Table 7	26
6.7	Instructions for Table 8	26
6.8	Instructions for Table 9	27
7	Interpretation and evaluation of reports	28
7.1	Calculation of outage duration	28
7.2	External events	28
7.3	Protective operation	28
7.4	Performance of special controls	28
Annex A (informative)	Outage log form and examples	30
A.1	Example of an outage log	30
A.2	Examples of application of rule f) of 6.3 scheduled outage during a forced outage	32
A.2.1	Case 1: Scheduled outage does not increase ODF or extends outage duration	32
A.2.2	Case 2: Scheduled outage increases ODF	33
A.3	Examples of application of rule g) of 6.3 second outage during an outage	34
A.3.1	Case 1: Second outage does not increase ODF or extends outage duration	34
A.3.2	Case 2: Second outage extends duration	35
A.3.3	Case 3: Second outage with variable ODF	36
Annex B (informative)	Sample annual report	37
	Bibliography	43
	Figure A.1 – Scheduled outage does not increase ODF or extends outage duration	32
	Figure A.2 – Scheduled outage increases ODF	33
	Figure A.3 – Second outage does not increase ODF or extends outage duration	34
	Figure A.4 – Second outage extends duration	35
	Figure A.5 – Second outage with variable ODF	36
	Table 1 – Classification of fault events	17
	Table 2 – DC system performance for back-to-back systems and for two terminal systems reporting jointly (corresponding to Table 1 of Cigré TB 346:2008)	21

Table 3 – DC system performance for multi-terminal systems and for stations reporting separately as part of two-terminal systems (corresponding to Table 1 M/S of Cigré TB 346:2008)	22
Table 4 – Forced outages HVDC substation (corresponding to Table 2FS of Cigré TB 346:2008)	24
Table 5 – Scheduled outages HVDC substation (corresponding to Table 2 SS of Cigré TB 346:2008)	24
Table 6 – HVDC overhead line protection operations (corresponding to Table 3 of Cigré TB 346:2008).....	25
Table 7 – AC system faults and commutation failure starts (back-to-back, two terminal or multi-terminal systems) (corresponding to Table 4 of Cigré TB 346:2008).....	26
Table 8 – Converter unit hours and semiconductor devices failed (corresponding to Table 5 of Cigré TB 346:2008).....	27
Table 9 – Forced outage summary (corresponding to Table 6 of Cigré TB 346:2008).....	29
Table A.1 – Example of an outage log.....	30
Table B.1 – DC system performance for two terminal systems reporting jointly	37
Table B.2 – Forced outages HVDC substation	38
Table B.3 – Scheduled outages HVDC substation.....	39
Table B.4 – HVDC overhead line protection operations.....	40
Table B.5 – AC system faults and commutation failure starts.....	40
Table B.6 – Converter unit hours and semiconductor devices failed.....	41
Table B.7 – Forced outage summary.....	42



INTERNATIONAL ELECTROTECHNICAL COMMISSION

RELIABILITY AND AVAILABILITY EVALUATION OF HVDC SYSTEMS –**Part 1: HVDC systems with line commutated converters**

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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 62672-1, which is a technical specification, has been prepared by IEC technical committee 115: High voltage direct current (HVDC) transmission for DC voltages above 100 kV.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
115/68/DTS	115/75/RVC

Full information on the voting for the approval of this technical specification 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.

Annexes A and B are for information only.

A list of all parts in the IEC 62672 series, published under the general title *Reliability and availability evaluation of HVDC systems*, 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 web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

Withdrawn