



DPC: 24 / 30496141 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 12 July 2024
Origin: International**Latest date for receipt of comments: 31 July 2024**

Project No. 2023/02824

Responsible committee: W/- Miscellaneous Standards

Interested committees:

Title: BS EN IEC 60358-1 Coupling capacitors and capacitor dividers

Part 1: General rules

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 31 July 2024

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Committee Secretary: **Committee Service Centre (BSI)**
Direct tel: **020 8996 7009**
E-mail: csc@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



33/711/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:
IEC 60358-1 ED2

DATE OF CIRCULATION:
2024-07-05

CLOSING DATE FOR COMMENTS:
2024-08-30

SUPERSEDES DOCUMENTS:
33/698/CD, 33/704A/CC

IEC TC 33 : POWER CAPACITORS AND THEIR APPLICATIONS	
SECRETARIAT: Italy	SECRETARY: Mr Stefano Zunino
OF INTEREST TO THE FOLLOWING COMMITTEES:	HORIZONTAL FUNCTION(S):
ASPECTS CONCERNED:	

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

Coupling capacitors and capacitor dividers - Part 1: General rules

NOTE FROM TC/SC OFFICERS:

Copyright © 2024 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.

CONTENTS

1		
2	FOREWORD.....	6
3	INTRODUCTION.....	8
4	1 Scope.....	10
5	2 Normative references	10
6	3 Terms and definitions	11
7	3.1 General terms and definitions	12
8	3.2 Coupling capacitor and capacitor divider terms and definitions	15
9	4 Normal and special environmental conditions	16
10	4.1 General.....	16
11	4.2 Normal service conditions	16
12	4.2.1 Ambient air temperature	16
13	4.2.2 Altitude.....	17
14	4.2.3 Vibrations or earthquakes.....	17
15	4.2.4 Other service conditions for indoor equipment	17
16	4.2.5 Other service conditions for outdoor equipment	17
17	4.3 Special service conditions	18
18	4.3.1 General	18
19	4.3.2 Altitude.....	18
20	4.3.3 Ambient temperature	19
21	4.3.4 Earthquakes	19
22	4.4 System earthing	19
23	5 Ratings.....	19
24	5.1 Standard values of rated frequency	19
25	5.2 Standard values of rated voltages	19
26	5.2.1 Rated voltage U_r for AC.....	19
27	5.2.2 Rated voltage U_r for DC	20
28	5.3 Standard values of rated voltage factor	20
29	5.3.1 Standard values of rated voltage factor for AC voltages.....	20
30	5.3.2 Standard values of rated voltage factor for DC voltages	21
31	6 Design requirements	21
32	6.1 Insulation requirements	21
33	6.2 Other insulation requirements.....	23
34	6.2.1 Low voltage terminal not exposed to weather	23
35	6.2.2 Low voltage terminal exposed to weather	24
36	6.2.3 Partial discharges.....	24
37	6.2.4 Chopped lightning impulse test.....	24
38	6.2.5 Capacitance at power frequency.....	24
39	6.2.6 Losses of the capacitor at power frequency	25
40	6.2.7 External insulation requirements.....	25
41	6.3 Electromagnetic emission requirements – Radio interference voltage (RIV).....	26
42	6.4 Mechanical requirements.....	26
43	6.5 Tightness of equipment	27
44	6.5.1 General	27
45	6.5.2 Liquid tightness	27
46	6.5.3 Gas tightness	27

47	6.6	Voltage grading for DC capacitors	28
48	6.7	Requirements for temperature rise	29
49	6.8	Capacitor element ageing requirements	29
50	6.8.1	General	29
51	6.8.2	Capacitor element design criteria	29
52	6.9	Marking of the equipment	30
53	6.9.1	General	30
54	6.9.2	Markings of the rating plate	30
55	7	Tests	31
56	7.1	General	31
57	7.2	Classification of tests	31
58	7.2.1	General	31
59	7.2.2	Routine tests	33
60	7.2.3	Type tests	33
61	7.2.4	Special tests	34
62	7.2.5	Design tests	34
63	7.3	Routine tests	36
64	7.3.1	General	36
65	7.3.2	Tightness of equipment	37
66	7.3.3	Capacitance and $\tan\delta$ measurement at power-frequency	37
67	7.3.4	Power-frequency or DC withstand test	38
68	7.3.5	Partial discharge measurement	39
69	7.3.6	AC-withstand test on low-voltage terminal of the equipment	40
70	7.3.7	Resistance measurement for DC equipment	40
71	7.3.8	Verification of markings	40
72	7.3.9	Gas dew point measurement	40
73	7.4	Type tests	41
74	7.4.1	General	41
75	7.4.2	Impulse tests	41
76	7.4.3	Wet test for outdoor equipment	42
77	7.4.4	Radio interference voltage test	44
78	7.4.5	Polarity reversal test for DC equipment	44
79	7.4.6	Temperature rise test	45
80	7.4.7	Enclosure tightness test at ambient temperature	47
81	7.4.8	Mechanical tests	47
82	7.5	Special tests	48
83	7.5.1	Determination of the temperature coefficient of capacitance T_c	48
84	7.5.2	Enclosure tightness test at low and high temperatures	49
85	7.5.3	Internal arc test	50
86	7.5.4	Multiple chopped impulse test on primary terminals	50
87	7.5.5	Measurement of the impedance depending on frequency	50
88	7.5.6	Thermal stability test	50
89	7.5.7	Corrosion test	51
90	7.6	Design tests	51
91	7.6.1	Ageing test	51
92	8	Rules for transport, storage, erection, operation and maintenance	52
93	8.1	General	52
94	8.2	Conditions during transport, storage and installation	52

95	8.3	Installation	53
96	8.3.1	General	53
97	8.3.2	Unpacking and lifting	53
98	8.3.3	Assembly.....	53
99	8.3.4	Mounting	53
100	8.3.5	Connections	53
101	8.3.6	Final installation inspection and tests	53
102	8.4	Maintenance.....	54
103	8.4.1	General	54
104	8.4.2	Responsibilities for the manufacturer.....	54
105	9	Safety.....	54
106	10	Influence of products on the natural environment	54
107	Annex A (informative)	Typical diagram of an equipment.....	56
108	Annex B (informative)	Partial discharge test circuit and instrumentation.....	57
109	Annex C (normative)	Radio interference voltage – Measurement circuit.....	59
110	Annex D (informative)	Superimposed impulse voltage test.....	61
111	Annex E (informative)	Test circuit for superimposed impulse voltage tests.....	63
112	Annex F (informative)	High-frequency characteristic measurements	65
113	F.1	Bridge method for measurement of the high-frequency capacitance and	
114		equivalent series resistance	65
115	Annex G (informative)	Composite AC/DC voltages.....	66
116	G.1	Composite AC/DC voltage descriptions	66
117	G.2	Example 1 – without 3PWM.....	67
118	G.3	Example 2 – with 3PWM.....	68
119	G.4	Conclusion	69
120	Annex H (informative)	Voltage definitions	70
121	Bibliography.....		71
122			
123	Figure 1 – Factor m for the switching impulse withstand test.....		18
124	Figure 2 – Reduced scale model capacitor element geometry		30
125	Figure 3 – Flow charts test sequence to be applied when performing the routine test.....		35
126	Figure 4 – Flow charts test sequence to be applied when performing the type test.....		36
127	Figure 5 – Test sequence for polarity reversal tests		45
128	Figure 6 – Flow chart for temperature rise test.....		46
129			
130	Figure A.1 – Example of a diagram for a coupling capacitor (with and without low		
131	voltage terminal).....		56
132	Figure A.2 – Example of a diagram for a capacitor divider (with and without low voltage		
133	terminal)		56
134	Figure B.1 – Test circuit.....		57
135	Figure B.2 – Alternative circuit.....		57
136	Figure B.3 – Example of balanced test circuit		58
137	Figure B.4 – Example of calibration circuit		58
138	Figure C.1 – Measuring circuit		60
139	Figure D.1 – Schematic representation of superimposed impulse voltage tests.....		61

140	Figure E.1 – Test circuit for superimposed impulse tests using blocking capacitor	63
141	Figure E.2 – Test circuit for superimposed impulse tests using sphere gap	64
142	Figure F.1 – Wiring diagram of the measuring circuit for the high-frequency	
143	capacitance and equivalent series resistance of a coupling capacitor	65
144	Figure G.1 – Example of an unsymmetrically VSC converter	66
145	Figure G.2 – Maximum peak voltage without 3PWM.....	67
146	Figure G.3 – Both individual AC voltage curves with 3PWM	69
147	Figure G.4 – Superimposed voltage curve with 3PWM, based on Figure G.3	69
148	Figure H.1 – Voltage overview and definitions.....	70
149		
150	Table 1 – Rated ambient temperature categories	16
151	Table 2 – Standard values of rated voltage factors	20
152	Table 3 – Standard insulation levels for AC voltages.....	22
153	Table 4 – Partial discharge test voltages and permissible levels	24
154	Table 5 – Creepage distance for AC	25
155	Table 6 – Static withstand test loads for insulators.....	26
156	Table 7 – Permissible temporary leakage rates for gas systems	28
157	Table 8 – Marking of the rating plate	30
158	Table 9 – Test voltages for units, stacks and complete equipment	39
159	Table 10 – Modalities of application of the test loads to the line primary terminals	48
160	Table 11 – Voltage definitions for DC application	70
161		
162		

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COUPLING CAPACITORS AND CAPACITOR DIVIDERS –

Part 1: General rules

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 60358-1 has been prepared by IEC Technical Committee 33: Power capacitors and their applications.
- This standard cancel and replaces the first edition of IEC 60358-1:2012, and constitutes a technical revision.
- This second edition of IEC 60358-1 includes the following significant technical changes with respect to the first edition:
- new terms and definitions are presented in clause 3.
 - new definitions in clause 4, clause 5
 - gas-insulated capacitors and capacitor dividers are integrated in clause 6.
 - new tests in routine, type, special and design test sections are introduced, see clause 7
 - new clause 8, clause 9 and clause 10
 - new Annex D, Annex E, Annex F, Annex G and Annex H

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

FDIS	Report on voting
33/xxx/FDIS	33/xxx/RVD

216
217 Full information on the voting for the approval of this standard can be found in the report on
218 voting indicated in the above table.

219 The language used for the development of this International Standard is English

220 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
221 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available
222 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described
223 in greater detail at www.iec.ch/publications.

224 The updated list of standards issued by IEC TC 33 is available at the website: <https://www.iec.ch>

225 IEC 60358-1, Coupling capacitors and capacitor dividers – Part 1: General rules

226 IEC 60358-2, Coupling capacitors and capacitor dividers – Part 2: AC or DC single-phase
227 coupling capacitor connected between line and ground for power line carrier-
228 frequency (PLC) application

229 IEC 60358-3, Coupling capacitors and capacitor dividers – Part 3: AC or DC single-phase
230 coupling capacitor for harmonic-filters applications

231 IEC 60358-4, Coupling capacitors and capacitor dividers – Part 4: DC or AC single-phase
232 capacitor dividers

233 The committee has decided that the contents of this publication will remain unchanged until the
234 stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to
235 the specific publication. At this date, the publication will be

- 236 • reconfirmed,
237 • withdrawn,
238 • replaced by a revised edition, or
239 • amended.

240

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

241

242

INTRODUCTION

243 This document is the first revision of the standard IEC 60358-1, defining general rules for
244 coupling capacitors and capacitor dividers.

245 The main modifications of this revision are listed below:

- 246 • terms and definitions:
 - 247 – new terms and definitions are presented in clause 3;
- 248 • normal and special environmental conditions:
 - 249 – new definitions in clause 4 are introduced;
- 250 • ratings:
 - 251 – addition of HV insulation levels above 800 kV;
 - 252 – new definition on rated voltage U_r for AC and DC applications;
 - 253 – clause 5, new definitions for DC application are integrated;
 - 254 – new standard values of rated voltages are defined;
- 255 • design and construction:
 - 256 – clarification of the altitude correction for external insulation and dielectric tests;
 - 257 – external insulation requirements for DC application;
 - 258 – gas-insulated capacitors and capacitor dividers are integrated in clause 6;
 - 259 – new test with its requirements on capacitor element ageing is defined;
- 260 • type tests:
 - 261 – temperature rise test: more accurate definition of the test duration;
 - 262 – lightning impulse test: new test procedure (15 impulses) for $U_m \geq 300$ kV;
 - 263 – mechanical test: moved from special test to type test;
 - 264 – new enclosure tightness test for gas-insulated capacitors and dividers;
- 265 • routine tests:
 - 266 – tightness tests for gas-insulated equipment;
 - 267 – gas dew point measurements;
 - 268 – new flowchart of routine tests presented in Figure 3;
- 269 • special tests:
 - 270 – determination of temperature coefficient of the capacitor element;
 - 271 – new enclosure tightness test on low and hot temperature;
 - 272 – information about internal ark tests;
 - 273 – information about multiple chopped impulse tests;
 - 274 – new test on impedance measurements depending on frequency;
 - 275 – new test on thermal stability;
 - 276 – new test on corrosion;
 - 277 – new flowchart of type tests presented in Figure 4;
- 278 • design tests (new clause):
 - 279 – ageing tests of capacitor elements;
- 280 • commissioning tests (new clause):
 - 281 – new installation inspection;
 - 282 – gas dew point test moved from special test to commissioning tests;

- 283 • rules for transport, storage, erection, operation and maintenance:
 - 284 – new mandatory rules for user and manufacturer;
 - 285 – new conditions for transportation and storage;
- 286 • new annexes:
 - 287 – Annex D (informative): provide information about superimposed impulse voltages;
 - 288 – Annex E (informative): provide information on test setups for superimposed impulse
 - 289 voltage tests;
 - 290 – Annex F (informative): is introduced on high-frequency characteristic measurements;
 - 291 – Annex G (informative): provide information about composite AC/DC voltages;
 - 292 – Annex H (informative): present a summary of all voltages used in DC application;
 - 293

COUPLING CAPACITORS AND CAPACITOR DIVIDERS –

Part 1: General rules

1 Scope

This part of IEC 60358 applies to:

- Capacitors and capacitor dividers, with rated voltage > 1 000 V, connected line to ground with the low voltage terminal either permanently earthed or connected to devices, for applications listed hereunder and other similar uses.

This standard serves as basic standard for the coupling capacitors and capacitor dividers. The different parts of this standard will present the supplementary specifications and tests, for example IEC 60358-2, IEC 60358-3 or IEC 60358-4.

NOTE Diagrams of coupling capacitor and capacitor divider to which this standard applies are given in Figures A.1 and A.2.

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 60038, *IEC standard voltages*

IEC 60050-321:1986, *International Electrotechnical Vocabulary – Chapter 321: Instrument transformers*

IEC 60050-436:1990, *International Electrotechnical Vocabulary – Chapter 436: Power capacitors*

IEC 60050-601:1985, *International Electrotechnical Vocabulary – Chapter 601: Generation, transmission and distribution of electricity – General*

IEC 60050-604:1987, *International Electrotechnical Vocabulary – Chapter 604: Generation, transmission and distribution of electricity – Operation*

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

IEC 60068-2-17, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

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

IEC 60071-2, *Insulation co-ordination – Part 2: Application guidelines*

IEC 60071-11, *Insulation co-ordination – Part 11: Definitions, principles and rules for HVDC system*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

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

IEC 60296, *Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF₆) and complementary gases to be used in its mixtures for use in electrical equipment*

- 336 IEC 60480, *Specifications for the re-use of sulphur hexafluoride (SF₆) and its mixtures in*
337 *electrical equipment*
- 338 IEC 60721 (all parts), *Classification of environmental conditions*
- 339 IEC guide 109-2003, *Environmental aspects – Inclusion in electrotechnical product standards*
- 340 IEC TS 60815-1:2008, *Selection and dimensioning of high-voltage insulators intended for use*
341 *in polluted conditions – Part 1: Definitions, information and general principles*
- 342 IEC TS 60815-2:2008, *Selection and dimensioning of high-voltage insulators intended for use*
343 *in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*
- 344 IEC TS 60815-3:2008, *Selection and dimensioning of high-voltage insulators intended for use*
345 *in polluted conditions – Part 3: Polymer insulators for a.c. systems*
- 346 IEC 60867, *Insulating liquids – Specifications for unused liquids based on synthetic aromatic*
347 *hydrocarbons*
- 348 IEC 61099, *Insulating liquids – Specifications for unused synthetic organic esters for electrical*
349 *purposes*
- 350 IEC 61462, *Composite hollow insulators – Pressurized and unpressurized insulators for use in*
351 *electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods and*
352 *acceptance criteria and design recommendations*
- 353 IEC 62217:2012, *Polymeric HV insulators for indoor and outdoor use – General definitions, test*
354 *methods and acceptance criteria*
- 355 IEC 62271-4:2022, *High-voltage switchgear and controlgear – Part 4: Handling procedures for*
356 *gases for insulation and/or switching*
- 357 IEC 62770, *Fluids for electrotechnical applications – Unused natural esters for transformers*
358 *and similar electrical equipment*
- 359 IEC 63012, *Insulating liquids – Unused modified or blended esters for electrotechnical*
360 *applications*
- 361 ISO 4628-3, *Paints and varnishes – Evaluation of degradation of coatings – Designation of*
362 *quantity and size of defects, and of intensity of uniform changes in appearance – Part 3:*
363 *Assessment of degree of rusting*
- 364 ISO 22479, *Corrosion of metals and alloys – Sulfur dioxide test in a humid atmosphere (fixed*
365 *gas method)*
- 366 CISPR/TR 18-2, *Radio interference characteristics of overhead power lines and high-voltage*
367 *equipment – Part 2: Methods of measurement and procedure for determining limits*

368 **3 Terms and definitions**

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

370 ISO and IEC maintain terminology databases for use in standardization at the following
371 addresses:

- 372 • IEC Electropedia: available at <https://www.electropedia.org/>;
- 373 • ISO Online browsing platform: available at <https://www.iso.org/obp>.

374 NOTE Some of these terms and definitions are identical with or are similar to those of IEC 60050-321:1986,
375 IEC 60050-436:1990, IEC 60050-601:1985 and IEC 60050-604:1987. These are indicated by the relevant reference
376 in brackets.

377 **3.1 General terms and definitions**

378 **3.1.1**

379 **rated frequency of equipment**

380 f_r

381 frequency for which the coupling capacitor has been designed

382 **3.1.2**

383 **rated voltage**

384 U_r

385 AC: based on the maximum voltage U_m including superimposed harmonic and sub-harmonic
386 voltages between phase to ground

387 DC: the highest value of line to ground voltage, including harmonics and commutation
388 overshoots, for which the equipment is designed and may be used in respect of its insulation

389 **3.1.3**

390 **highest voltage for equipment**

391 U_m

392 AC: the highest r.m.s. value of phase-to-phase voltage for which the equipment is designed and
393 may be used in respect of its insulation

394 [SOURCE: IEC 60050-614:2016, 614-03-01, modified – Symbol added, "(rms value)" deleted,
395 "service" replaced with "operating" and "greatest" replaced with "highest"]

396 **3.1.4**

397 **Creepage distance voltage**

398 U_{cd}

399 voltage which is needed to calculate the creepage distance based on IEC/TS 60815-4

400 **3.1.5**

401 **DC system voltage**

402 U_{DC}

403 highest mean or average operating voltage to earth, excluding harmonics and commutation
404 overshoots

405 [SOURCE: IEC 60071-5]

406 **3.1.6**

407 **Maximum DC-system voltage**

408 U_{DCmax}

409 maximum DC-system voltage is almost a pure DC voltage with a magnitude dependent on
410 voltage control and measuring tolerance excluding harmonics and commutation overshoots

411 **3.1.7**

412 **Rated lightning impulse withstand voltage**

413 U_{LIWV}

highest peak value of the lightning impulse voltage which does not cause breakdown of
insulation under specified conditions

[SOURCE: IEC60050-442:2002, 442-09-18 – modified]

414 **3.1.8**

415 **Rated switching impulse withstand voltage**

416 U_{SIWV}

highest peak value of the switching impulse voltage which does not cause breakdown of
insulation under specified conditions

[SOURCE: IEC60050-442:2002, 442-09-18 – modified]

3.1.9**Maximum voltage across a capacitor** U_C

maximum composite AC/DC voltage across a capacitor placed between the converter transformer and the VSC converter.

3.1.10**rated insulation level**

combination of voltage values which characterises the insulation of the equipment with regard to its capability to withstand dielectric stresses

3.1.11**isolated neutral system**

system where the neutral point is not intentionally connected to earth, except for high impedance connections for protection or measurement purposes

[SOURCE: IEC 60050-601:1985, 601-02-24]

3.1.12**solidly earthed (neutral) system**

system whose neutral point(s) is (are) earthed directly

[SOURCE: IEC 60050-601:1985, 601-02-25]

3.1.13**impedance earthed (neutral) system**

system whose neutral point(s) is (are) earthed through impedances to limit earth fault currents

[SOURCE: IEC 60050-601:1985, 601-02-26]

3.1.14**resonant earthed (neutral) system**

system in which one or more neutral points are connected to earth through reactances which approximately compensate the capacitive component of a single-phase-to-earth fault current

[SOURCE: IEC 60050-601:1985, 601-02-27]

NOTE 1 to entry: With resonant earthing of a system, the residual current in the fault is limited to such an extent that an arcing fault in air is self-extinguishing.

3.1.15**earth fault factor**

at a given location of a three-phase system, and for a given system configuration, the ratio of the highest r.m.s. phase-to-earth power frequency voltage on a healthy phase during a fault to earth affecting one or more phases at any point on the system to the r.m.s. value of phase-to-earth power frequency voltage which would be obtained at the given location in the absence of any such fault

[SOURCE: IEC 60050-604:1987, 604-03-06]

3.1.16**earthed neutral system**

system in which the neutral is connected to earth either solidly or through a resistance or reactance of sufficiently low value to reduce transient oscillations and to give a current sufficient for selective earth fault protection

- a) A three-phase system with effectively earthed neutral at a given location is a system characterized by an earth fault factor at this point which does not exceed 1,4

NOTE 1 to entry: This condition is obtained approximately when, for all system configurations, the ratio of zero-sequence reactance to the positive-sequence reactance is less than 3 and the ratio of zero-sequence resistance to positive-sequence reactance is less than one.

- b) A three-phase system with non-effectively earthed neutral at a given location is a system characterized by an earth fault factor at this point that may exceed 1,4

3.1.17

unified specific creepage distance USCD

creepage distance of an insulator divided by the r.m.s value of the highest operating voltage across the insulator

NOTE 1 to entry: This definition differs from that of specific creepage distance where the line-line value of the highest voltage for the equipment is used (for AC systems usually $U_m/\sqrt{3}$). For line-to-earth insulation, this definition will result in a value that $\sqrt{3}$ times that given by the definition of specific creepage distance in IEC/TR 60815-1:2008.

NOTE 2 to entry: For U_m see IEC 60050-604:1987, 604-03-01.

NOTE 3 to entry: It is generally expressed in mm/kV and usually expressed as a minimum.

3.1.18

exposed installation

installation in which the apparatus is subject to overvoltages of atmospheric origin.

NOTE Such installations are usually connected to overhead transmission lines either directly or through a short length of cable.

3.1.19

non-exposed installation

installation in which the apparatus is not subject to overvoltages of atmospheric origin

NOTE 1 to entry: Such installations are usually connected to underground cable networks.

3.1.20

rated voltage factor

F_V

multiplying factor to be applied to the rated voltage U_r to determine the maximum voltage at which equipment must comply with relevant thermal requirements for a specified time

3.1.21

rated temperature category of the equipment

range of temperature of the ambient air or of the cooling medium for which the equipment has been designed

3.1.22

line terminal

terminal intended for connection to a line conductor of a network

[SOURCE: IEC 60050-436:1990, 436-03-01]

3.1.23

mechanical stress

stresses on different parts of the equipment as a function of four main forces:

- forces on the terminals due to the line connections,
- forces due to the wind on the cross-section of the equipment with and without line trap mounted on the top of a coupling/filter capacitor,
- seismic forces and
- electrodynamic forces due to short circuit current

3.1.24

voltage-connected equipment

equipment which has only one connection to the high voltage line

NOTE 1 to entry: Under normal conditions the top connection carries only the current of the equipment.

3.1.25

current-connected equipment

equipment which has two connections to the high voltage line

NOTE 1 to entry: The terminals and the top connection are designed to carry the line current under normal conditions.

3.1.26**line trap-connected coupling/filter capacitor**

coupling/filter capacitor which supports a line trap on its top

NOTE 1 to entry: In this case, the two connections to the line trap carry the HV line current and one connection from the line trap to the capacitor carries the current of the capacitor

NOTE 2 to entry: The pedestal-mounting line traps in two phases generate additional forces during a short circuit in more than one phase.

3.2 Coupling capacitor and capacitor divider terms and definitions**3.2.1****equipment**

general term used for this standard, either for complete capacitor, capacitor divider, RC-divider

3.2.2**coupling capacitor**

capacitor used for the transmission of signals in a power system

[SOURCE: IEC 60050-436:1990, 436-02-11]

3.2.3**capacitor divider**

a capacitor stack forming a capacitor divider by providing a voltage tap

[SOURCE: IEC 60050-436:1990, 436-02-11, modified]

3.2.4**(capacitor) element**

device consisting essentially of two electrodes separated by a dielectric

3.2.5**(capacitor) unit**

assembly of one or more capacitor elements in the same container with terminals brought out

[SOURCE: IEC 60050-436:1990, 436-01-04]

3.2.6**(capacitor) stack**

assembly of capacitor units connected in series

[SOURCE: IEC 60050-436:1990, 436-01-05]

3.2.7**capacitor**

general term used when it is not necessary to state whether reference is made to a capacitor unit or to a capacitor stack

3.2.8**rated capacitance of a capacitor or capacitor divider**

C_r

capacitance value for which the capacitor has been designed

NOTE 1 to entry: This definition applies:

- for a capacitor unit, to the capacitance between the terminals of the unit;
- for a capacitor stack, to the capacitance between line and low voltage terminals or between line and earth terminals of the stack

3.2.9**low voltage terminal of a coupling capacitor**

terminal (N_{HF}) intended for connection to earth either directly or via a drain coil of negligible value of impedance, at rated frequency, for power line carrier (PLC) application.

[SOURCE: IEC 60050-436:1990, 436-03-04, modified]

3.2.10**capacitance tolerance**

permissible difference between the actual capacitance and the rated capacitance under specified conditions

[SOURCE: IEC 60050-436:1990, 436-04-01]

3.2.11**equivalent series resistance of a capacitor**

virtual resistance which, if connected in series with an ideal capacitor of capacitance value equal to that of the capacitor in question, would have a power loss equal to the active power dissipated in that capacitor under specified operating conditions at a given high frequency

3.2.12**capacitor losses**

active power dissipated in the capacitor

[SOURCE: IEC 60050-436:1990, 436-04-10]

3.2.13**tangent of the loss angle ($\tan \delta$) of a capacitor**

ratio between the active power P_a and the reactive power P_r :

$$\tan \delta = P_a / P_r$$

3.2.14**temperature coefficient of capacitance**

T_C

fractional change of the capacitance for a given change in temperature:

$$T_C = \frac{\Delta C}{C_{20^\circ\text{C}} \cdot \Delta T} \quad \text{in } \frac{1}{\text{K}} \text{ or } \frac{1}{^\circ\text{C}}$$

ΔC represents the observed change in capacitance over the temperature interval ΔT

$C_{20^\circ\text{C}}$ represents the capacitance measured at 20 °C

NOTE to entry: The term $\Delta C / \Delta T$ according to this definition is usable only if the capacitance is an approximate linear function of the temperature in the range under consideration. If not, the temperature dependency of the capacitance can be shown in a graph or a table.

3.2.15**dielectric of a capacitor**

insulating material between the electrodes

NOTE to entry: The major insulation generally consists of paper, plastic film, or a mixed of paper and plastic film subsequently treated and impregnated with oil or gas at atmospheric pressure or higher.

4 Normal and special environmental conditions**4.1 General**

Detailed information concerning classification of environmental conditions is given in the IEC 60721 series.

4.2 Normal service conditions**4.2.1 Ambient air temperature**

The equipment is classified into three categories as given in Table 1.

Table 1 – Rated ambient temperature categories

Category	Minimum temperature °C	Maximum temperature °C
----------	---------------------------	---------------------------



–5/40	–5	40
–25/40	–25	40
–40/40	–40	40

The lower limit for storage temperature shall be selected from the following values:

–5 °C, –25 °C or –40 °C.

The upper limit for storage temperature shall be selected from the following values:

+40 °C, +55 °C or +70 °C.

4.2.2 Altitude

The altitude does not exceed 1 000 m.

4.2.3 Vibrations or earthquakes

Vibrations due to causes external to the equipment or earthquakes are negligible.

4.2.4 Other service conditions for indoor equipment

Other considered service conditions for indoor capacitors or capacitor dividers are the following:

- a) the influence of solar radiation may be neglected;
- b) the ambient air is not significantly polluted by dust, smoke, corrosive gases, vapours or salt;
- c) the conditions of humidity are as follows:
 - the average value of the relative humidity, measured during a period of 24 h, does not exceed 95 %;
 - the average value of the water vapour pressure for a period of 24 h, does not exceed 2,2 kPa;
 - the average value of the relative humidity, for a period of one month, does not exceed 90 %;
 - the average value of the water vapour pressure, for a period of one month, does not exceed 1,8 kPa.

For these conditions, condensation may occasionally occur.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 To withstand the effects of high humidity and condensation, such as breakdown of insulation or corrosion of metallic parts, equipment designed for such conditions can be used.

NOTE 3 Condensation can be prevented by special design of the housing, by suitable ventilation and heating or by the use of dehumidifying equipment.

4.2.5 Other service conditions for outdoor equipment

Other considered service conditions are the following:

- a) average value of the ambient air temperature, measured over a period of 24 h, does not exceed 35 °C;
- b) solar radiation up to a level of 1 000 W/m² (on a clear day at noon) should be considered;
- c) the ambient air may be polluted by dust, smoke, corrosive gases, vapours or salt. The pollution does not exceed the pollution levels given in Table 5;
- d) the wind pressure does not exceed 700 Pa (corresponding to 34 m/s wind speed);
- e) account should be taken of the presence of condensation or precipitation.

4.3 Special service conditions

4.3.1 General

When equipment may be used under conditions different from the normal service conditions given in clause 4.2, the user's requirements should refer to standardized steps as follows.

4.3.2 Altitude

The coordination withstand voltages are considered valid up to an altitude of 1 000 m. To consider the reduced withstand capability of the air at an installation site with an altitude above 1 000 m, the required type test insulation withstand level of external insulation at standard reference atmospheric conditions shall be determined by multiplying the withstand voltage required on site by an altitude correction factor K_a . The correction factor shall not be applied for routine tests, because a routine test validates the quality of the internal insulation only.

For AC applications, the altitude correction factor shall be determined in accordance with IEC 60071-2:2018, subclause 6.2.2, using Formula H.13 from IEC 60071-2:2018, Annex H, as follows:

$$K_a = e^{m \frac{(H-1000)}{8150}}$$

where

H is the altitude above sea level (in metres);

m is as follows:

$m = 1,0$ for co-ordination lightning impulse withstand voltages;

$m = 1,0$ for power-frequency withstand voltages in case of wet tests;

m is in accordance with Figure 1 for co-ordination switching impulse withstand voltages.

To determine the value of m for the switching pulse, shown in Figure 1, the switching pulse value, applicable for standard operating conditions, must be used.

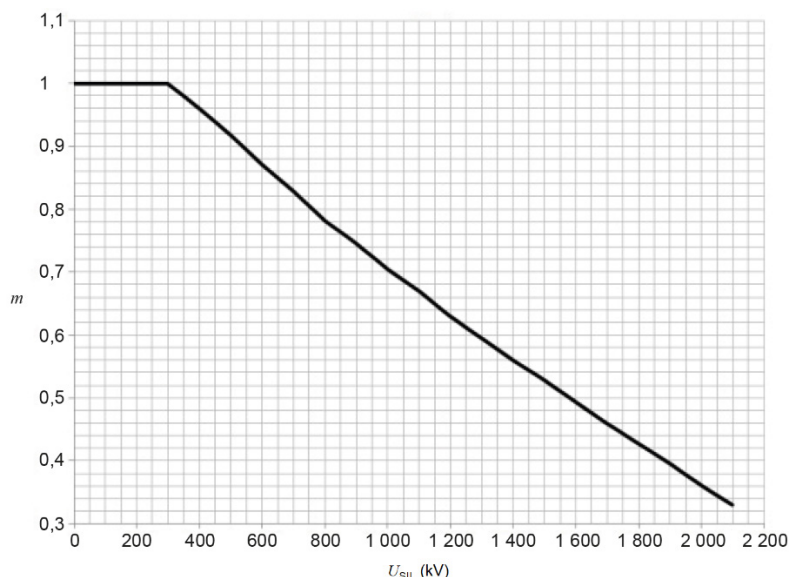


Figure 1 – Factor m for the switching impulse withstand test

For DC applications, the exponent m for the DC withstand voltage test wet is not defined yet. The value of exponent m shall be agreed between manufacture and purchaser.

To verify the withstand voltages corrected for altitude, the arcing distance of the capacitor or capacitor divider needs to be increased. If increasing the arcing distance is based on a verified arcing distance of a similar product, it can be considered valid without further testing.

673 If the withstand voltages corrected for altitude cannot be validated by an increased arcing
674 distance of a similar product, external insulation shall be tested in accordance with IEC 60071-
675 2:2018, subclause 7.3.7.

676 NOTE It is considered that the altitude does not affect the internal insulation.

677 4.3.3 Ambient temperature

678 For installation in a place where the ambient temperature can be significantly outside the normal
679 service condition range stated in subclause 4.2.1, the preferred ranges of minimum and
680 maximum temperature to be specified should be:

681 a) –50 °C and +40 °C for very cold climates;

682 b) –5 °C and +50 °C for very hot climates.

683 In extreme cases, the purchasers shall inform the manufacturer of another temperature range.

684 In certain regions with frequent occurrence of warm humid winds, sudden changes of
685 temperature may occur resulting in condensation even indoors.

686 Under certain conditions of solar radiation, appropriate measures e.g. roofing, forced
687 ventilation, etc. may be necessary, in order not to exceed the specified temperature rises.

688 4.3.4 Earthquakes

689 For installations where earthquakes are likely to occur, the relevant severity level in accordance
690 with IEC 62271 shall be specified by the user.

691 The compliance with such special requirements, if applicable, must be demonstrated, either by
692 calculation or by testing as defined by relevant standards.

693 4.4 System earthing

694 The considered system earthings are:

695 a) isolated neutral system (see 3.1.14);

696 b) resonant earthed (neutral) system (see 3.1.17);

697 c) earthed neutral system (see 3.1.19):

698 1) solidly earthed (neutral) system (see 3.1.15)

699 2) impedance earthed (neutral) system (see 3.1.16)

700 5 Ratings

701 5.1 Standard values of rated frequency

702 The standard values of the rated frequency for AC applications are:

703 50 Hz – 60 Hz

704 5.2 Standard values of rated voltages

705 5.2.1 Rated voltage U_r for AC

706 The standard values of rated voltage of an equipment connected between one line of a three-
707 phase system and earth or between a system neutral point and earth shall be $1/\sqrt{3}$ times the
708 values of rated system voltage. Standard IEC 60038 provides a list of rated voltage values.
709 Harmonics and sub-harmonics superimposed to U_m must be considered according to following
710 formula:

711
$$U_r = \frac{U_m}{\sqrt{3}} + \sqrt{\sum_{h \neq 1} U_h^2}$$

712 $\sqrt{\sum U_h^2}$: r.m.s. voltage of AC voltage components

713 U_h represents a single harmonic voltage phase-to-earth with its frequency according to the
714 harmonic order h based on the rated frequency.

715 NOTE The upper limit of harmonic order depends on the application. The upper limit can be provided by the system
716 manufacturer and stated in the technical specification.

717 5.2.2 Rated voltage U_r for DC

718 The value of rated voltage of an equipment connected between one line and earth is the value
719 of the maximum DC-system voltage U_{DCmax} .

720 For DC application with significant AC voltage, these must be included in the rated voltage
721 according to following formula:

$$722 \quad U_r = U_{DCmax} + \sqrt{2} \cdot U_{hmax} + \sqrt{2} \cdot \sqrt{\sum_{h, h \neq hmax} U_h^2}$$

723 $\sqrt{\sum U_h^2}$: r.m.s. voltage of AC voltage components

724 U_h represents a single harmonic voltage with its frequency according to the harmonic order h
725 based on the corresponding AC network frequency.

726 $hmax$ is the harmonic order for the maximum harmonic voltage component on the equipment.
727 The value of $hmax$ can also be 1, i.e., the fundamental frequency. For reference consider
728 Annex H.

729
730 NOTE 1 Depending on application, the value of U_r can be different, lower values are possible. Annex G provides
731 further information and examples on how the value of U_r can be determined.

732 NOTE 2 The upper limit of harmonic order depends on the application. The upper limit can be provided by the system
733 manufacturer and stated in the technical specification.

734

735 5.3 Standard values of rated voltage factor

736 5.3.1 Standard values of rated voltage factor for AC voltages

737 The voltage factor is determined by the maximum operating voltage which, in turn, is dependent
738 on the system earthing conditions.

739 The standard voltage factors appropriate to the different earthing conditions are given in Table 2
740 below, together with the permissible duration of maximum operating voltage (i.e. rated time).

741 **Table 2 – Standard values of rated voltage factors**

Rated voltage factor F_V	Rated time	Method of connecting the primary terminal and system earthing conditions
1,2	Continuous	Between phase and earth in an effectively earthed neutral system (3.1.16 a))
1,5	30 s	
1,2	Continuous	Between phase and earth in a non-effectively earthed neutral system (3.1.16 b)) with automatic earth-fault tripping.
1,9	30 s	
1,2	Continuous	Between phase and earth in an isolated neutral system (3.1.11) without automatic earth-fault tripping or in a resonant earthed system (3.1.14) without automatic earth-fault tripping.
1,9	8 h	

NOTE 1 Reduced rated times are permissible by agreement between manufacturer and user.

NOTE 2 The thermal requirements of an equipment is based on the rated voltage whereas the rated insulation level is based on the highest voltage for equipment U_m (IEC 60071-1).

742 The maximum operating voltage of an equipment must be lower or equal to the highest voltage
743 of equipment $U_m/\sqrt{3}$ or the rated voltage U_r multiplied with the rated voltage factor 1,2 for
744 continuous service, whichever is the lowest.