



DPC: 16 / 30349069 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: 16 September 2016

Origin: European

**Latest date for receipt of comments: 10 November 2016**

Project No. 2016/02829

Responsible committee: PEL/33 Power capacitors

Interested committees:

Title: Draft BS EN 61071 Capacitors for power electronics

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 10 November 2016**

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](mailto: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 European discussions in which the UK took an active part. Your comments on this draft are welcome and will assist in the preparation of the consequent British Standard. Comment is particularly welcome on national legislative or similar deviations that may be necessary.

Even if this draft standard is not approved by the UK, if it receives the necessary support in Europe, the UK will be obliged to publish the official English Language text unchanged as a British Standard and to withdraw any conflicting standard.

## UK Vote

Please indicate whether you consider the UK should submit a negative (with reasons) or positive vote on this draft.

## Submission of Comments

- The guidance given below is intended to ensure that all comments receive efficient and appropriate attention by the responsible BSI committee. **Annotated drafts are not acceptable and will be rejected.**
- All comments must be submitted, preferably electronically, to the Responsible Committee Secretary at the address given on the front cover. Comments should be compatible with version 6.0 or version 97 of Microsoft Word for Windows, if possible; otherwise comments in ASCII text format are acceptable. **Any comments not submitted electronically should still adhere to these format requirements.**
- All comments submitted should be presented as given in the example below. Further information on submitting comments and how to obtain a blank electronic version of a comment form are available from the BSI website at: <http://drafts.bsigroup.com/>

## Template for comments and secretariat observations

|                  |                               |
|------------------|-------------------------------|
| Date: xx/xx/20xx | Document: <b>ISO/DIS xxxx</b> |
|------------------|-------------------------------|

| 1  | 2                                          | (3)                           | 4               | 5                                                                                                                                  | (6)                                                                      | (7)                                                |
|----|--------------------------------------------|-------------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------|
| MB | Clause No./ Subclause No./Annex (e.g. 3.1) | Paragraph/ Figure/ Table/Note | Type of comment | Comment (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.                                       |                                                    |

**33/592/CDV****COMMITTEE DRAFT FOR VOTE (CDV)  
PROJET DE COMITÉ POUR VOTE (CDV)**

|                                                                                                                                                                                                                                                                                                                   |                                                               |                                                                                                                                                  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Project number<br>Numéro de projet                                                                                                                                                                                                                                                                                |                                                               | IEC 61071/Ed2                                                                                                                                    |  |
| IEC/TC or SC: <b>TC 33</b><br>CEI/CE ou SC:                                                                                                                                                                                                                                                                       |                                                               | Secretariat / Secrétariat<br><b>Italy</b>                                                                                                        |  |
| <input checked="" type="checkbox"/> Submitted for parallel voting in CENELEC<br><br>Soumis au vote parallèle au CENELEC                                                                                                                                                                                           | Date of circulation<br>Date de diffusion<br><b>2016-09-16</b> | Closing date for voting (Voting mandatory for P-members)<br>Date de clôture du vote (Vote obligatoire pour les membres (P))<br><b>2016-12-09</b> |  |
| Also of interest to the following committees<br>Intéresse également les comités suivants                                                                                                                                                                                                                          |                                                               | Supersedes document<br>Remplace le document<br><b>33/591/RR</b>                                                                                  |  |
| Proposed horizontal standard<br>Norme horizontale suggérée<br><input type="checkbox"/> Other TC/SCs are requested to indicate their interest, if any, in this CDV to the TC/SC secretary<br>Les autres CE/SC sont requis d'indiquer leur intérêt, si nécessaire, dans ce CDV à l'intention du secrétaire du CE/SC |                                                               |                                                                                                                                                  |  |
| Functions concerned<br>Fonctions concernées<br><input checked="" type="checkbox"/> Safety<br>Sécurité<br><input checked="" type="checkbox"/> EMC<br>CEM<br><input checked="" type="checkbox"/> Environment<br>Environnement<br><input checked="" type="checkbox"/> Quality assurance<br>Assurance qualité         |                                                               |                                                                                                                                                  |  |

CE DOCUMENT EST TOUJOURS À L'ÉTUDE ET SUSCEPTIBLE DE MODIFICATION. IL NE PEUT SERVIR DE RÉFÉRENCE.

LES RÉCIPIENDAIRES DU PRÉSENT DOCUMENT SONT INVITÉS À PRÉSENTER, AVEC LEURS OBSERVATIONS, LA NOTIFICATION DES DROITS DE PROPRIÉTÉ DONT ILS AURAIENT ÉVENTUELLEMENT CONNAISSANCE ET À FOURNIR UNE DOCUMENTATION EXPLICATIVE.

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.

Title : IEC 61071/Ed2: Capacitors for power electronics

**Introductory note**

At the last plenary meeting held in London on 6<sup>th</sup> May, 2014, TC 33 decided to update IEC 61071 (see 33/568/RM) and MT 18 was charged for this project.

**Copyright © 2016 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 .....                                                                                      |  | 4  |
| 3  |                                                                                                     |  |    |
| 4  | 1 Scope .....                                                                                       |  | 6  |
| 5  | 2 Normative references .....                                                                        |  | 7  |
| 6  | 3 Terms and definitions .....                                                                       |  | 7  |
| 7  | 4 Service conditions.....                                                                           |  | 12 |
| 8  | 4.1 Normal service conditions.....                                                                  |  | 12 |
| 9  | 4.2 Unusual service conditions .....                                                                |  | 13 |
| 10 | 5 Quality requirements and tests.....                                                               |  | 13 |
| 11 | 5.1 Test requirements.....                                                                          |  | 13 |
| 12 | 5.2 Classification of tests.....                                                                    |  | 14 |
| 13 | 5.3 Capacitance and $\tan \delta$ measurements (routine test).....                                  |  | 15 |
| 14 | 5.4 Measurement of the tangent of the loss angle ( $\tan \delta$ ) of a capacitor (type test) ..... |  | 15 |
| 15 | 5.5 Voltage test between terminals .....                                                            |  | 16 |
| 16 | 5.6 AC voltage test between terminals and case .....                                                |  | 16 |
| 17 | 5.7 Test of internal discharge device .....                                                         |  | 17 |
| 18 | 5.8 Sealing test .....                                                                              |  | 17 |
| 19 | 5.9 Surge discharge test.....                                                                       |  | 17 |
| 20 | 5.10 Thermal stability test.....                                                                    |  | 18 |
| 21 | 5.11 Self-healing test.....                                                                         |  | 19 |
| 22 | 5.12 Resonance frequency measurement .....                                                          |  | 20 |
| 23 | 5.13 Environmental testing .....                                                                    |  | 20 |
| 24 | 5.14 Mechanical testing .....                                                                       |  | 20 |
| 25 | 5.15 Endurance test .....                                                                           |  | 21 |
| 26 | 5.16 Destruction test .....                                                                         |  | 23 |
| 27 | 5.17 Disconnecting test on internal fuses.....                                                      |  | 27 |
| 28 | 6 Overloads .....                                                                                   |  | 29 |
| 29 | 6.1 Maximum permissible voltages .....                                                              |  | 29 |
| 30 | 7 Safety requirements.....                                                                          |  | 30 |
| 31 | 7.1 Discharge device .....                                                                          |  | 30 |
| 32 | 7.2 Case connections .....                                                                          |  | 30 |
| 33 | 7.3 Protection of the environment .....                                                             |  | 30 |
| 34 | 7.4 Other safety requirements .....                                                                 |  | 30 |
| 35 | 8 Markings.....                                                                                     |  | 30 |
| 36 | 8.1 Marking of the units .....                                                                      |  | 30 |
| 37 | 9 Guide to installation and operation.....                                                          |  | 31 |
| 38 | 9.1 General .....                                                                                   |  | 31 |
| 39 | 9.2 Choice of rated voltage.....                                                                    |  | 32 |
| 40 | 9.3 Operating temperature.....                                                                      |  | 32 |
| 41 | 9.4 Special service conditions.....                                                                 |  | 33 |
| 42 | 9.5 Overvoltages .....                                                                              |  | 33 |
| 43 | 9.6 Overcurrents.....                                                                               |  | 33 |
| 44 | 9.7 Switching and protective devices .....                                                          |  | 34 |
| 45 | 9.8 Choice of creepage distance and clearance.....                                                  |  | 34 |
| 46 | 9.9 Connections .....                                                                               |  | 34 |
| 47 | 9.10 Parallel connections of capacitors.....                                                        |  | 34 |

|    |                                                                                                |    |
|----|------------------------------------------------------------------------------------------------|----|
| 48 | 9.11 Series connections of capacitors .....                                                    | 35 |
| 49 | 9.12 Magnetic losses and eddy currents .....                                                   | 35 |
| 50 | 9.13 Guide for internal fuse and disconnector protection in capacitors .....                   | 35 |
| 51 | 9.14 Guide for unprotected capacitors .....                                                    | 35 |
| 52 |                                                                                                |    |
| 53 | Annex A (informative) Waveforms .....                                                          | 36 |
| 54 | Annex B (normative) Operational limits of capacitors with sinusoidal voltages as a function of |    |
| 55 | frequency and at maximum temperature ( $\theta_{\max}$ ) .....                                 | 38 |
| 56 | Annex C (normative) Resonance frequency measuring methods – Examples .....                     | 40 |
| 57 |                                                                                                |    |
| 58 | Bibliography .....                                                                             | 42 |
| 59 |                                                                                                |    |
| 60 | Figure 1 – Destruction test arrangement .....                                                  | 25 |
| 61 | Figure 2 – N source d.c., type 1 .....                                                         | 26 |
| 62 | Figure 3 – N source d.c., type 2 .....                                                         | 27 |
| 63 | Figure A.1 – Example of waveforms and their circuits .....                                     | 37 |
| 64 | Figure B.1 – Supply conditions .....                                                           | 38 |
| 65 | Figure C.1 – Measuring circuit .....                                                           | 40 |
| 66 | Figure C.2 – Relation between the voltage across the capacitor and the supply frequency ...    | 40 |
| 67 | Figure C.3 – Discharge current wave shape .....                                                | 41 |
| 68 |                                                                                                |    |
| 69 | Table 1 – Test voltage between terminals .....                                                 | 16 |
| 70 | Table 2 – Testing the robustness of terminals .....                                            | 20 |
| 71 | Table 3 – Endurance test .....                                                                 | 22 |
| 72 | Table 4 – Destruction test as a function of type of safety system .....                        | 23 |
| 73 | Table 5 – Maximum permissible voltages .....                                                   | 29 |
| 74 |                                                                                                |    |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## CAPACITORS FOR POWER ELECTRONICS

## 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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 61071 Ed.2.0 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This second edition cancels and replaces the first edition published in 2007. It constitutes a technical revision. This second edition includes the following significant technical changes with respect to the last edition of IEC 61071:

- Introduction of new terms and definitions
- clarifications for surge discharge test
- indications for measuring procedure during thermal stability test
- clarifications for self-healing test
- clarifications for endurance test
- clarifications for destruction test
- update of normative references
- general editorial review

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

|             |                  |
|-------------|------------------|
| FDIS        | Report on voting |
| 33/XXX/FDIS | 33/XXX/RVD       |

128  
129 Full information on the voting for the approval of this standard can be found in the report on voting  
130 indicated in the above table.

131 This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

132 The committee has decided that the contents of this document will remain unchanged until the stability  
133 date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific  
134 document. At this date, the document will be

- 135 • reconfirmed,  
136 • withdrawn,  
137 • replaced by a revised edition, or  
138 • amended.

139 The National Committees are requested to note that for this document the stability date is 2020

140 THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE  
141 PUBLICATION STAGE.

142

143

## CAPACITORS FOR POWER ELECTRONICS

### 1 Scope

This International Standard applies to capacitors for power electronics applications.

The operating frequency of the systems in which these capacitors are used is usually up to 15kHz, while the pulse frequencies may be up to 5 to 10 times the operating frequency.

The standard distinguishes between a.c. and d.c. capacitors which are considered as components when mounted in enclosures.

This standard covers an extremely wide range of capacitor technologies for numerous applications, e.g. overvoltage protection, d.c. and a.c. filtering, switching circuits, d.c. energy storage, auxiliary inverters, etc.

The following are excluded from this standard:

- capacitors for induction heat-generating plants operating at frequencies between 40 Hz and 24 000 Hz (see IEC 60110-1 and IEC 60110-2);
- capacitors for motor applications and the like (see IEC 60252-1 and IEC 60252 -2);
- capacitors to be used in circuits for blocking one or more harmonics in power supply networks;
- small a.c. capacitors as used for fluorescent and discharge lamps (see IEC 61048 and IEC 61049);
- capacitors for suppression of radio interference (see IEC 60384-14);
- shunt capacitors for a.c. power systems having a rated voltage above 1 000 V (see IEC 60871-1 and IEC 60871-2);
- shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V (see IEC 60831-1 and IEC 60831-2);
- shunt power capacitor of the non-self-healing type for a.c. systems having a rated voltage up to and including 1 000 V (see IEC 60931-1 and IEC 60931-2);
- electronic capacitors not used in power circuits;
- series capacitors for power systems (see IEC 60143);
- coupling capacitors and capacitors dividers (see IEC 60358);
- capacitors for microwave ovens (see IEC 61270-1);
- capacitors for railway applications (see IEC 61881).

Examples of applications are given in Clause 9.1.

## 178 2 Normative references

179 The following referenced documents are indispensable for the application of this document. For dated  
180 references, only the edition cited applies. For undated references, the latest edition of the referenced  
181 document (including any amendments) applies.

182 IEC 60068-2-6, *Environmental testing – Part 2: Tests. Test Fc: Vibration (sinusoidal)*

183 IEC 60068-2-14, *Environmental testing – Part 2: Tests. Test N: Change of temperature*

184 IEC 60068-2-20, *Environmental testing – Part 2: Tests. Test T: Soldering*

185 IEC 60068-2-21, *Environmental testing – Part 2: Tests. Test U: Robustness of terminations and integral*  
186 *mounting devices*

187 IEC 60068-2-78, *Environmental testing – Part 2: Tests. Test Cab: Damp heat, steady state*

188 IEC 60071-1, *Insulation coordination – Part 1: Definitions, principle and rules*

189 IEC 60071-2, *Insulation coordination – Part 2: Application guide*

190 IEC 60269-1, *Low-voltage fuses – Part 1: General requirements*

191 IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles,*  
192 *requirements and tests*

193 IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hotwire based test methods, Glow-wire*  
194 *flammability test method for end-products*

195 IEC 60695-2-12, *Fire hazard testing – Part 2-12: Glowing/hotwire based test methods, Glow-wire*  
196 *flammability test method for materials*

197 IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*

198

## 199 3 Terms and definitions

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

### 201 3.1

#### 202 **capacitor element (or element)**

203 a device consisting essentially of two electrodes separated by a dielectric

204 [IEV 436-01-03]

### 205 3.2

#### 206 **capacitor unit (or unit)**

207 assembly of one or more capacitor elements in the same container with terminals brought out [IEV 436-  
208 01-04]

### 209 3.3

#### 210 **capacitor bank**

211 number of capacitor units connected so as to act together

212 [IEV 436-01-06]

- 213 **3.4**  
 214 **capacitor**  
 215 general term used when it is not necessary to state whether reference is made to an element, a unit or  
 216 a capacitor bank
- 217 **3.5**  
 218 **capacitor equipment**  
 219 assembly of capacitor units and their accessories intended for connection in power electronic equipment
- 220 **3.6**  
 221 **capacitor for power electronics**  
 222 power capacitor intended to be used in power electronic equipment and capable of operating  
 223 continuously under sinusoidal and non-sinusoidal current and voltage
- 224 **3.7**  
 225 **metal-foil capacitor (non-self-healing)**  
 226 capacitor in which the electrodes usually consist of metal foils separated by a dielectric  
 227 NOTE In the event of a breakdown of the dielectric, the capacitor does not restore itself.
- 228 **3.8**  
 229 **self-healing metallized dielectric capacitor**  
 230 capacitor, of which at least one electrode consists of a metallic deposit on the dielectric  
 231 NOTE In the event of local breakdown of the dielectric, the electric properties of the capacitor are rapidly and essentially self-  
 232 restored.
- 233 **3.9**  
 234 **a.c. capacitor**  
 235 capacitor essentially designed for operation with alternating voltage  
 236 NOTE AC capacitors may be used with d.c. voltage up to the rated voltage only when authorized by the capacitor  
 237 manufacturer.
- 238 **3.10**  
 239 **d.c. capacitor**  
 240 capacitor essentially designed for operation with direct voltage  
 241 NOTE DC capacitors may be used with a specified a.c. voltage only where authorized by the capacitor manufacturer.
- 242 **3.11**  
 243 **model capacitor**  
 244 unit which simulates a complete unit or element in an electrical test, without reducing the severity of the  
 245 electrical, thermal or mechanical conditions  
 246 NOTE 1 The model unit may be of a different size from the complete unit.  
 247 NOTE 2 The combined sum of stresses should always be considered, for instance the sum of temperature and mechanical  
 248 conditions as well as electrical stresses.
- 249 **3.12**  
 250 **internal (element) fuse**  
 251 fuse connected inside a capacitor unit, in series with an element or a group of elements  
 252 [IEV 436-03-16]
- 253 **3.13**  
 254 **safety devices**  
 255 **3.13.1**  
 256 **overpressure disconnecter**  
 257 disconnecting device inside a capacitor, designed to interrupt the current path in case of abnormal  
 258 increase of internal overpressure

- 259 **3.13.2**  
 260 **overpressure detector**  
 261 device designed to detect abnormal increase of the internal pressure, usually used to operate an  
 262 electrical switch and indirectly interrupt the current path
- 263 **3.13.3**  
 264 **segmented metallization design**  
 265 pattern design of the metal layer over the dielectric shaped in a way to allow a small part of it to be  
 266 isolated in case of local short circuit or breakdown, in order to restore the full functionality of the unit  
 267 with a negligible loss of capacitance
- 268 **3.13.4**  
 269 **special unsegmented metallization design**  
 270 design of the metal layer over the dielectric shaped in a way that safe self-healing features operating at  
 271 a voltage up to  $U_s$  guarantee the full functionality of the unit with a negligible loss of capacitance.
- 272 **3.14 Safety protection**  
 273 **Protected capacitor**  
 274 capacitor that can be submitted to the destruction test as described at 5.16  
 275 Note: protected capacitors alone are not sufficient to prevent all possible dangers in case of malfunction
- 276 **Unprotected capacitor**  
 277 capacitor that don't meet the destruction test as described at 5.16
- 278 **3.15**  
 279 **discharge device of a capacitor**  
 280 a device which may be incorporated in a capacitor, capable of reducing the voltage between the  
 281 terminals practically to zero, within a given time, after the capacitor has been disconnected from a  
 282 network  
 283 [IEV 436-03-15 modified]
- 284 **3.16**  
 285 **rated a.c. voltage**  
 286  $U_N$   
 287 maximum operating peak recurrent voltage of either polarity of a reversing type waveform for which the  
 288 capacitor has been designed  
 289 NOTE 1 The waveform can have many shapes. Examples are given in Annex A.  
 290 NOTE 2 The mean value of the waveform may be positive or negative.  
 291 NOTE 3 It is important to note that the rated a.c. voltage is not an r.m.s. value.  
 292
- 293 **3.17**  
 294 **rated d.c. voltage**  
 295  $U_{NDC}$   
 296 maximum operating peak voltage of either polarity but of a non-reversing type waveform, for which the  
 297 capacitor has been designed, for continuous operation  
 298 NOTE 1 Damping capacitors, for gate turn-off thyristor (GTO) can be regarded as d.c. capacitors with a ripple voltage equal to  
 299 the rated d.c. voltage  $U_{NDC} = U_r$ .  
 300 In the case of reversal voltage ( $U_{rev}$ ), the use should be agreed between user and manufacturer.  
 301 NOTE 2 If the reversal voltage is small (less than 10 %), the voltage waveform can be considered to be non- reversing. For test  
 302 purposes,  $U_{NDC}$  and  $U_r$  should be increased by  $U_{rev}$ , the reversal voltage.  
 303

- 304 **3.18**  
305 **ripple voltage**  
306  $U_r$   
307 peak-to-peak alternating component of the unidirectional voltage
- 308 **3.19**  
309 **non-recurrent surge voltage**  
310  $U_s$   
311 peak voltage induced by a switching or any other disturbance of the system which is allowed for a  
312 limited number of times and for durations shorter than the basic period
- 313 **3.20**  
314 **insulation voltage**  
315  $U_i$   
316 r.m.s. value of the sine wave voltage designed for the insulation between terminals of capacitors to case  
317 or earth
- 318 **3.21**  
319 **maximum peak current**  
320  $\hat{I}$   
321 maximum repetitive peak current that can occur during continuous operation
- 322 **3.22**  
323 **maximum current**  
324  $I_{\max}$   
325 maximum r.m.s. current for continuous operation
- 326 **3.23**  
327 **maximum surge current**  
328  $\hat{I}_s$   
329 peak non-repetitive current induced by switching or any other disturbance of the system which is  
330 allowed for a limited number of times, for durations shorter than the basic period
- 331 **3.24**  
332 **pulse frequency**  
333  $f_p$   
334 repetition rate of periodic current pulses
- 335 **3.25**  
336 **current pulse width**  
337  $\tau$   
338 time of current flow during charging or discharging from one voltage value to another, of the capacitor  
339 NOTE Pulse current waveform examples are shown in Annex A.
- 340 **3.26**  
341 **resonance frequency**  
342  $f_r$   
343 lowest frequency at which the impedance of the capacitor becomes minimum
- 344 **3.27**  
345 **duty cycle**
- 346 **3.26.1**  
347 **continuous duty**  
348 operation time such that a capacitor is at thermal equilibrium for most of the time

- 349 **3.26.2**  
 350 **intermittent duty**  
 351 discontinuous working or operation with variable loads which should be described in terms of ON/OFF  
 352 or HIGH/LOW periods with their durations
- 353 **3.28**  
 354 **thermal equilibrium**  
 355 a capacitor is in a state of thermal equilibrium when the temperature measured anywhere on its case or  
 356 internally is less than 3° K above or below that temperature which would be reached after waiting an  
 357 infinitely long time under fixed conditions of ambient temperature, cooling, and internal power loss  
 358
- 359 **3.29**  
 360 **thermal time constant**  
 361 a measure of the time required for a capacitor to reach thermal equilibrium after a change in ambient  
 362 temperature, cooling, or internal power loss  
 363
- 364 **3.30**  
 365 **lowest operating temperature**  
 366  $\theta_{\min}$   
 367 lowest temperature of the dielectric at which the capacitor may be energized
- 368 **3.31**  
 369 **container temperature rise**  
 370  $\Delta\theta_{\text{case}}$   
 371 difference between the temperature of the hottest point of the container and the temperature of the  
 372 cooling air
- 373 **3.32**  
 374 **cooling-air temperature**  
 375  $\theta_{\text{amb}}$   
 376 temperature of the cooling air measured at the hottest position of the capacitor, under steady-state  
 377 conditions, midway between two units
- 378 NOTE If only one unit is involved, it is the temperature measured at a point approximately 0,1 m away from the capacitor  
 379 container and at two-thirds of the height from its base.
- 380 **3.32.1**  
 381 **outlet fluid temperature for forced-cooled capacitors**  
 382 temperature of the cooling fluid as it leaves the capacitor, measured at the hottest point
- 383 **3.32.2**  
 384 **inlet fluid temperature for forced-cooled capacitors**  
 385 temperature of the cooling fluid measured in the middle of the inlet fluid channel at a point not  
 386 influenced by the heat dissipation of the capacitor
- 387 **3.33**  
 388 **maximum operating temperature**  
 389  $\theta_{\max}$   
 390 highest temperature of the case at which the capacitor may be operated under steady state condition
- 391 **3.34**  
 392 **hotspot temperature**  
 393 the highest temperature present inside the capacitor dielectric
- 394 **3.35**  
 395 **steady-state conditions**  
 396 thermal equilibrium attained by the capacitor at constant output and at constant cooling conditions

397 **3.36**  
 398 **capacitor losses**  
 399 active power dissipated in the capacitor

400 [IEV 436-04-10]

401 NOTE Unless otherwise stated, the capacitor losses are understood to include losses in fuses and discharge resistors forming  
 402 an integral part of the capacitor. At high frequency, the capacitor losses are predominantly due to losses in connections,  
 403 contacts and electrodes.

404 **3.37**  
 405 **tangent of the loss angle of a capacitor**

406  **$\tan \delta$**   
 407 ratio between the equivalent series resistance and the capacitive reactance of a capacitor at a specified  
 408 sinusoidal alternating voltage, frequency and temperature

409 [IEV 436-04-11]

410 
$$\tan \delta = R_{\text{esr}} \omega C = \tan \delta + R_s \omega C$$

411 
$$\tan \delta = \text{dielectric loss factor}$$

412 **3.38**  
 413 **equivalent series resistance of a capacitor**

414  **$R_{\text{esr}}$**   
 415 effective resistance which, if connected in series with an ideal capacitor of capacitance value equal to  
 416 that of the capacitor in question, would have a power loss equal to active power dissipated in that  
 417 capacitor under specified operating conditions

418 **3.39**  
 419 **series resistance**

420  **$R_s$**   
 421 effective ohmic resistance of the conductors of a capacitor under specified operating conditions

422 **3.40**  
 423 **maximum power loss**

424  **$P_{\text{max}}$**   
 425 maximum power loss at which the capacitor may be operated at the maximum case temperature

426 **3.41**  
 427 **maximum frequency for maximum power loss and maximum current**

428  **$f_2$**   
 429 frequency at which the maximum current ( $I_{\text{max}}$ ) produces the maximum power loss ( $P_{\text{max}}$ ) in the  
 430 capacitor

431 NOTE For explanation of  $f_2$ , see Annexe B.

## 432 **4 Service conditions**

### 433 **4.1 Normal service conditions**

434 This standard gives requirements for capacitors intended for use in the following conditions.

#### 435 **4.1.1 Altitude**

436 Altitude shall not exceed 1 000 m unless the effects on cooling and external insulation are taken into  
 437 account.

438 NOTE The effect of altitude on convection cooling and external insulation should be taken into consideration, if the altitude  
 439 exceeds 1 000 m.