

© Copyright SEK. Reproduction in any form without permission is prohibited.

## **Avledare –**

### **Del 4: Metalloxidavledare utan gnistgap för växelströmsnät**

*Surge arresters –*

*Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

Som svensk standard gäller europastandarden EN 60099-4:2014. Den svenska standarden innehåller den officiella engelska språkversionen av EN 60099-4:2014.

#### **Nationellt förord**

Europastandarden EN 60099-4:2014

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 60099-4, Third edition, 2014 - Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 60099-4, utgåva 2, 2004, SS-EN 60099-4/A1, utgåva 1, 2006 och SS-EN 60099-4/A2, utgåva 1, 2009, gäller ej fr o m 2017-08-04.

### *Standarder underlättar utvecklingen och höjer elsäkerheten*

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

### *SEK är Sveriges röst i standardiseringsarbetet inom elområdet*

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

### *Stora delar av arbetet sker internationellt*

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

### *Var med och påverka!*

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

### **SEK Svensk Elstandard**

Box 1284  
164 29 Kista  
Tel 08-444 14 00  
[www.elstandard.se](http://www.elstandard.se)

English Version

**Surge arresters - Part 4: Metal-oxide surge arresters without  
gaps for a.c. systems  
(IEC 60099-4:2014)**

Parafoudres - Partie 4: Parafoudres à oxyde métallique  
sans éclateur pour réseaux à courant alternatif  
(CEI 60099-4:2014)

Überspannungsableiter - Teil 4: Metalloxidableiter ohne  
Funkenstrecken für Wechselspannungsnetze  
(IEC 60099-4:2014)

This European Standard was approved by CENELEC on 2014-08-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

## Foreword

The text of document 37/416/FDIS, future edition 3 of IEC 60099-4, prepared by IEC/TC 37 "Surge arresters" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60099-4:2014.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-05-04
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-08-04

This document supersedes EN 60099-4:2004.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

## Endorsement notice

The text of the International Standard IEC 60099-4:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-2-17	NOTE	Harmonized as EN 60068-2-17.
IEC 60099-1	NOTE	Harmonized as EN 60099-1.
IEC 60099-5:2013	NOTE	Harmonized as EN 60099-5:2013 (not modified).
IEC 60721-3-2	NOTE	Harmonized as EN 60721-3-2.
IEC 62271-202:2006	NOTE	Harmonized as EN 62271-202:2007 (not modified).
ISO 3274	NOTE	Harmonized as EN ISO 3274.

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: [www.cenelec.eu](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60060-1	-	High-voltage test techniques - Part 1: General definitions and test requirements	EN 60060-1	-
IEC 60060-2	-	High-voltage test techniques - Part 2: Measuring systems	EN 60060-2	-
IEC 60068-2-11	1981	Environmental testing - Part 2: Tests - Test Ka: Salt mist	EN 60068-2-11	1999
IEC 60068-2-14	-	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	-
IEC 60071-1	-	Insulation co-ordination - Part 1: Definitions, principles and rules	EN 60071-1	-
IEC 60071-2	1996	Insulation co-ordination - Part 2: Application guide	EN 60071-2	1997
IEC 60270	-	High-voltage test techniques - Partial discharge measurements	EN 60270	-
IEC 60507	2013	Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems	EN 60507	2014
IEC 62217	-	Polymeric HV insulators for indoor and outdoor use - General definitions, test methods and acceptance criteria	EN 62217	-
IEC 62271-1	2007	High-voltage switchgear and controlgear - Part 1: Common specifications	EN 62271-1	2008
IEC 62271-200	2011	High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	EN 62271-200	2012
IEC 62271-203	2011	High-voltage switchgear and controlgear - Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	EN 62271-203	2012

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC/TS 60815-1	2008	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles	-	-
IEC/TS 60815-2	2008	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 2: Ceramic and glass insulators for a.c. systems	-	-
ISO 4287	-	Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters	EN ISO 4287	-
ISO 4892-1	-	Plastics - Methods of exposure to laboratory light sources - Part 1: General guidance	EN ISO 4892-1	-
ISO 4892-2	-	Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps	EN ISO 4892-2	-
ISO 4892-3	-	Plastics - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps	EN ISO 4892-3	-
CISPR/TR 18-2	-	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 2: Methods of measurement and procedure for determining limits	-	-

## CONTENTS

FOREWORD.....	11
INTRODUCTION.....	14
1 Scope .....	15
2 Normative references .....	15
3 Terms and definitions .....	16
4 Identification and classification .....	26
4.1 Arrester identification .....	26
4.2 Arrester classification .....	26
5 Standard ratings and service conditions .....	27
5.1 Standard rated voltages .....	27
5.2 Standard rated frequencies .....	27
5.3 Standard nominal discharge currents .....	27
5.4 Service conditions.....	27
5.4.1 Normal service conditions .....	27
5.4.2 Abnormal service conditions .....	27
6 Requirements .....	28
6.1 Insulation withstand .....	28
6.2 Reference voltage.....	28
6.3 Residual voltages .....	28
6.4 Internal partial discharges.....	29
6.5 Seal leak rate.....	29
6.6 Current distribution in a multi-column arrester .....	29
6.7 Thermal stability .....	29
6.8 Long term stability under continuous operating voltage .....	29
6.9 Heat dissipation behaviour of test sample .....	29
6.10 Repetitive charge transfer withstand .....	29
6.11 Operating duty .....	29
6.12 Power-frequency voltage versus time characteristics of an arrester .....	29
6.13 Short-circuit performance .....	30
6.14 Disconnecter .....	30
6.14.1 Disconnecter withstand.....	30
6.14.2 Disconnecter operation .....	30
6.15 Requirements on internal grading components.....	30
6.16 Mechanical loads .....	31
6.16.1 General .....	31
6.16.2 Bending moment.....	31
6.16.3 Resistance against environmental stresses .....	31
6.16.4 Insulating base and mounting bracket.....	31
6.16.5 Mean value of breaking load (MBL).....	31
6.16.6 Electromagnetic compatibility .....	31
6.17 End of life .....	31
6.18 Lightning impulse discharge capability .....	31
7 General testing procedure .....	32
7.1 Measuring equipment and accuracy .....	32
7.2 Reference voltage measurements .....	32

7.3	Test samples .....	32
7.3.1	General .....	32
7.3.2	Arrester section requirements .....	33
8	Type tests (design tests) .....	34
8.1	General.....	34
8.2	Insulation withstand tests .....	35
8.2.1	General .....	35
8.2.2	Tests on individual unit housings .....	36
8.2.3	Tests on complete arrester assemblies .....	36
8.2.4	Ambient air conditions during tests .....	36
8.2.5	Wet test procedure .....	36
8.2.6	Lightning impulse voltage test.....	37
8.2.7	Switching impulse voltage test.....	37
8.2.8	Power-frequency voltage test.....	37
8.3	Residual voltage tests .....	38
8.3.1	General .....	38
8.3.2	Steep current impulse residual voltage test.....	38
8.3.3	Lightning impulse residual voltage test .....	39
8.3.4	Switching impulse residual voltage test.....	39
8.4	Test to verify long term stability under continuous operating voltage .....	39
8.4.1	General .....	39
8.4.2	MO resistor elements stressed below $U_{ref}$ .....	40
8.4.3	Test procedure for MO resistor elements stressed at or above $U_{ref}$ .....	41
8.5	Test to verify the repetitive charge transfer rating, $Q_{rs}$ .....	44
8.5.1	General .....	44
8.5.2	Test procedure .....	45
8.5.3	Test evaluation .....	46
8.5.4	Rated values of repetitive charge transfer rating, $Q_{rs}$ .....	46
8.6	Heat dissipation behaviour of test sample .....	47
8.6.1	General .....	47
8.6.2	Arrester section requirements .....	47
8.6.3	Procedure to verify thermal equivalency between complete arrester and arrester section .....	47
8.7	Operating duty test .....	47
8.7.1	General .....	47
8.7.2	Test procedure .....	48
8.7.3	Rated thermal energy and charge values, $W_{th}$ and $Q_{th}$ .....	51
8.8	Power-frequency voltage-versus-time test.....	52
8.8.1	General .....	52
8.8.2	Test samples .....	53
8.8.3	Initial measurements .....	54
8.8.4	Test procedure .....	54
8.8.5	Test evaluation .....	55
8.9	Tests of arrester disconnector.....	55
8.9.1	General .....	55
8.9.2	Operating withstand test .....	55
8.9.3	Disconnector operation .....	56
8.9.4	Mechanical tests.....	57
8.9.5	Temperature cycling and seal pumping test .....	58



8.10	Short-circuit tests .....	58
8.10.1	General .....	58
8.10.2	Preparation of the test samples .....	59
8.10.3	Mounting of the test sample .....	63
8.10.4	High-current short-circuit tests .....	64
8.10.5	Low-current short-circuit test .....	67
8.10.6	Evaluation of test results .....	67
8.11	Test of the bending moment .....	67
8.11.1	General .....	67
8.11.2	Overview .....	67
8.11.3	Sample preparation .....	68
8.11.4	Test procedure .....	68
8.11.5	Test evaluation .....	68
8.11.6	Test on insulating base and mounting bracket .....	69
8.12	Environmental tests .....	69
8.12.1	General .....	69
8.12.2	Sample preparation .....	69
8.12.3	Test procedure .....	69
8.12.4	Test evaluation .....	70
8.13	Seal leak rate test .....	70
8.13.1	General .....	70
8.13.2	Sample preparation .....	70
8.13.3	Test procedure .....	70
8.13.4	Test evaluation .....	70
8.14	Radio interference voltage (RIV) test .....	70
8.15	Test to verify the dielectric withstand of internal components .....	72
8.15.1	General .....	72
8.15.2	Test procedure .....	72
8.15.3	Test evaluation .....	72
8.16	Test of internal grading components .....	72
8.16.1	Test to verify long term stability under continuous operating voltage .....	72
8.16.2	Thermal cyclic test .....	73
9	Routine tests and acceptance tests .....	74
9.1	Routine tests .....	74
9.2	Acceptance tests .....	75
9.2.1	Standard acceptance tests .....	75
9.2.2	Special thermal stability test .....	76
10	Test requirements on polymer-housed surge arresters .....	76
10.1	Scope .....	76
10.2	Normative references .....	76
10.3	Terms and definitions .....	76
10.4	Identification and classification .....	76
10.5	Standard ratings and service conditions .....	76
10.6	Requirements .....	76
10.7	General testing procedure .....	77
10.8	Type tests (design tests) .....	77
10.8.1	General .....	77
10.8.2	Insulation withstand tests .....	77

10.8.3	Residual voltage tests .....	77
10.8.4	Test to verify long term stability under continuous operating voltage .....	78
10.8.5	Test to verify the repetitive charge transfer rating, $Q_{rs}$ .....	78
10.8.6	Heat dissipation behaviour of test sample .....	78
10.8.7	Operating duty tests .....	78
10.8.8	Power frequency voltage-versus-time test .....	78
10.8.9	Tests of arrester disconnector .....	79
10.8.10	Short-circuit tests .....	79
10.8.11	Test of the bending moment .....	85
10.8.12	Environmental tests .....	92
10.8.13	Seal leak rate test .....	92
10.8.14	Radio interference voltage (RIV) test .....	92
10.8.15	Test to verify the dielectric withstand of internal components .....	92
10.8.16	Test of internal grading components .....	92
10.8.17	Weather ageing test .....	92
10.9	Routine tests .....	94
11	Test requirements on gas-insulated metal enclosed arresters (GIS-arresters) .....	94
11.1	Scope .....	94
11.2	Normative references .....	94
11.3	Terms and definitions .....	94
11.4	Identification and classification .....	94
11.5	Standard ratings and service conditions .....	95
11.6	Requirements .....	95
11.6.1	Withstand voltages .....	95
11.7	General testing procedures .....	98
11.8	Type tests (design tests) .....	98
11.8.1	General .....	98
11.8.2	Insulation withstand tests .....	98
11.8.3	Residual voltage tests .....	101
11.8.4	Test to verify long term stability under continuous operating voltage .....	101
11.8.5	Test to verify the repetitive charge transfer rating, $Q_{rs}$ .....	101
11.8.6	Heat dissipation behaviour of test sample .....	101
11.8.7	Operating duty tests .....	101
11.8.8	Power frequency voltage-versus-time test .....	101
11.8.9	Tests of arrester disconnector .....	101
11.8.10	Short-circuit tests .....	101
11.8.11	Test of the bending moment .....	101
11.8.12	Environmental tests .....	102
11.8.13	Seal leak rate test .....	102
11.8.14	Radio interference voltage (RIV) test .....	102
11.8.15	Test to verify the dielectric withstand of internal components .....	102
11.8.16	Test of internal grading components .....	102
11.9	Routine tests .....	102
11.10	Test after erection on site .....	102
12	Separable and dead-front arresters .....	102
12.1	Scope .....	102
12.2	Normative references .....	103
12.3	Terms and definitions .....	103

12.4	Identification and classification .....	103
12.5	Standard ratings and service conditions .....	103
12.6	Requirements .....	103
12.7	General testing procedure .....	104
12.8	Type tests (design tests) .....	104
12.8.1	General .....	104
12.8.2	Insulation withstand tests .....	104
12.8.3	Residual voltage tests .....	106
12.8.4	Test to verify long term stability under continuous operating voltage .....	106
12.8.5	Test to verify the repetitive charge transfer rating, $Q_{rs}$ .....	107
12.8.6	Heat dissipation behaviour of test sample .....	107
12.8.7	Operating duty tests .....	107
12.8.8	Power-frequency voltage versus time test .....	108
12.8.9	Tests of disconnector .....	108
12.8.10	Short-circuit test .....	108
12.8.11	Test of the bending moment .....	109
12.8.12	Environmental tests .....	109
12.8.13	Seal leak rate test .....	109
12.8.14	Radio interference voltage (RIV) test .....	109
12.8.15	Test to verify the dielectric withstand of internal components .....	110
12.8.16	Test of internal grading components .....	110
12.8.17	Internal partial discharge test .....	110
12.9	Routine tests and acceptance tests .....	110
13	Liquid-immersed arresters .....	110
13.1	Scope .....	110
13.2	Normative references .....	111
13.3	Terms and definitions .....	111
13.4	Identification and classification .....	111
13.5	Standard ratings and service conditions .....	111
13.6	Requirements .....	111
13.7	General testing procedure .....	112
13.8	Type tests (design tests) .....	112
13.8.1	General .....	112
13.8.2	Insulation withstand tests .....	112
13.8.3	Residual voltage tests .....	112
13.8.4	Test to verify long term stability under continuous operating voltage .....	113
13.8.5	Test to verify the repetitive charge transfer rating, $Q_{rs}$ .....	113
13.8.6	Heat dissipation behaviour of test sample .....	114
13.8.7	Operating duty tests .....	114
13.8.8	Power frequency voltage-versus-time test .....	114
13.8.9	Tests of arrester disconnector .....	114
13.8.10	Short-circuit tests .....	114
13.8.11	Test of the bending moment .....	116
13.8.12	Environmental tests .....	116
13.8.13	Seal leak rate test .....	117
13.8.14	Radio interference voltage (RIV) test .....	117
13.8.15	Test to verify the dielectric withstand of internal components .....	117
13.8.16	Test of internal grading components .....	117

13.9	Routine tests and acceptance tests.....	117
Annex A (normative)	Abnormal service conditions.....	118
Annex B (normative)	Test to verify thermal equivalency between complete arrester and arrester section .....	119
Annex C (normative)	Artificial pollution test with respect to the thermal stress on porcelain housed multi-unit metal-oxide surge arresters.....	121
C.1	Glossary .....	121
C.1.1	Measured quantities .....	121
C.1.2	Calculated quantities .....	121
C.2	General.....	122
C.3	Classification of site severity.....	125
C.4	Preliminary heating test: measurement of the thermal time constant $\tau$ and calculation of $\beta$ .....	125
C.5	Verification of the need to perform the pollution tests .....	126
C.6	General requirements for the pollution test.....	126
C.6.1	Test sample.....	126
C.6.2	Testing plant.....	127
C.6.3	Measuring devices and measuring procedures .....	127
C.6.4	Test preparation .....	129
C.7	Test procedures .....	129
C.7.1	Slurry method .....	129
C.7.2	Salt fog method .....	131
C.8	Evaluation of test results.....	132
C.8.1	Calculation of $K_{ie}$ .....	132
C.8.2	Calculation of the expected temperature rise $\Delta T_z$ in service .....	133
C.8.3	Preparation for the operating duty test.....	133
C.9	Example.....	133
C.9.1	Preliminary heating test .....	134
C.9.2	Verification of the need to perform the pollution test .....	134
C.9.3	Salt fog tests .....	134
C.9.4	Calculation performed after five test cycles.....	135
C.9.5	Calculation performed after 10 test cycles .....	136
Annex D (informative)	Typical information given with enquiries and tenders.....	137
D.1	Information given with enquiry .....	137
D.1.1	System data .....	137
D.1.2	Service conditions .....	137
D.1.3	Arrester duty.....	137
D.1.4	Characteristics of arrester .....	138
D.1.5	Additional equipment and fittings .....	138
D.1.6	Any special abnormal conditions.....	138
D.2	Information given with tender .....	138
Annex E (informative)	Ageing test procedure – Arrhenius law – Problems with higher temperatures .....	139
Annex F (informative)	Guide for the determination of the voltage distribution along metal-oxide surge arresters .....	141
F.1	General.....	141
F.2	Modelling of the surge arrester .....	141
F.3	Modelling of the boundary conditions .....	142
F.4	Calculation procedure .....	142

F.4.1	Capacitive representation of the MO resistor column .....	142
F.4.2	Capacitive and resistive representation of the MO resistor column .....	143
F.4.3	Determination of $U_{ct}$ .....	143
F.5	Example calculations .....	143
F.5.1	Modelling of the arrester and the boundary conditions .....	144
F.5.2	Resistive effects of the metal-oxide MO resistors .....	144
F.5.3	Results and conclusions from electric field calculations .....	144
Annex G (normative)	Mechanical considerations .....	149
G.1	Test of bending moment .....	149
G.2	Seismic test .....	150
G.3	Definition of mechanical loads .....	150
G.4	Definition of seal leak rate .....	151
G.5	Calculation of wind-bending-moment .....	152
G.6	Procedures of tests of bending moment for porcelain/cast resin and polymer-housed arresters .....	153
Annex H (normative)	Test procedure to determine the lightning impulse discharge capability .....	155
H.1	General .....	155
H.2	Selection of test samples .....	155
H.3	Test procedure .....	156
H.4	Test parameters for the lightning impulse discharge capability test .....	156
H.5	Measurements during the lightning impulse discharge capability test .....	156
H.6	Rated lightning impulse discharge capability .....	156
H.7	List of rated energy values .....	157
H.8	List of rated charge values .....	157
Annex I (normative)	Determination of the start temperature in tests including verification of thermal stability .....	158
Annex J (normative)	Determination of the average temperature of a multi-unit high-voltage arrester .....	159
Annex K (informative)	Example calculation of test parameters for the operating duty test (8.7) according to the requirements of 7.3 .....	161
Annex L (informative)	Comparison of the old energy classification system based on line discharge classes and the new classification system based on thermal energy ratings for operating duty tests and repetitive charge transfer ratings for repetitive single event energies .....	162
Bibliography	.....	168
Figure 1	– Illustration of power losses versus time during long term stability test .....	41
Figure 2	– Test procedure to verify the repetitive charge transfer rating, $Q_{rs}$ .....	45
Figure 3	– Test procedure to verify the thermal energy rating, $W_{th}$ , and the thermal charge transfer rating, $Q_{th}$ , respectively .....	49
Figure 4	– Test procedure to verify the power frequency versus time characteristic (TOV test) .....	53
Figure 5	– Examples of arrester units .....	62
Figure 6	– Examples of fuse wire locations for “Design A” arresters .....	62
Figure 7	– Examples of fuse wire locations for “Design B” arresters .....	63
Figure 8	– Short-circuit test setup for porcelain-housed arresters .....	63
Figure 9	– Short-circuit test setup for polymer-housed arresters .....	82

Figure 10 – Example of a test circuit for re-applying pre-failing circuit immediately before applying the short-circuit test current .....	84
Figure 11 – Thermomechanical test .....	88
Figure 12 – Example of the test arrangement for the thermomechanical test and direction of the cantilever load .....	89
Figure 13 – Water immersion .....	90
Figure 14 – Test set-up for insulation withstand test of unscreened separable arresters .....	105
Figure C.1 – Flow-chart showing the procedure for determining the preheating of a test sample .....	124
Figure F.1 – Typical three-phase arrester installation.....	145
Figure F.2 – Simplified multi-stage equivalent circuit of an arrester.....	146
Figure F.3 – Geometry of arrester model .....	147
Figure F.4 – Example of voltage-current characteristic of MO resistors at +20 °C in the leakage current region .....	148
Figure F.5 – Calculated voltage stress along the MO resistor column in case B .....	148
Figure G.1 – Bending moment – multi-unit surge arrester .....	149
Figure G.2 – Definition of mechanical loads .....	151
Figure G.3 – Surge arrester unit .....	152
Figure G.4 – Surge-arrester dimensions .....	153
Figure G.5 – Flow chart of bending moment test procedures.....	154
Figure J.1 – Determination of average temperature in case of arrester units of same rated voltages .....	160
Figure J.2 – Determination of average temperature in case of arrester units of different rated voltages .....	160
Figure L.1 – Specific energy in kJ per kV rating dependant on the ratio of switching impulse residual voltage ( $U_a$ ) to the r.m.s. value of the rated voltage $U_r$ of the arrester .....	163
Table 1 – Arrester classification .....	26
Table 2 – Preferred values of rated voltages .....	27
Table 3 – Arrester type tests .....	35
Table 4 – Requirements for high current impulses .....	50
Table 5 – Rated values of thermal charge transfer rating, $Q_{th}$ .....	52
Table 6 – Test requirements for porcelain housed arresters .....	61
Table 7 – Required currents for short-circuit tests .....	65
Table 8 – Test requirements for polymer-housed arresters.....	81
Table 9 – 10 kA and 20 kA three-phase GIS-arresters – Required withstand voltages .....	96
Table 10 – 2,5 kA and 5 kA three – phase – GIS arresters – Required withstand voltages .....	97
Table 11 – Insulation withstand test voltages for unscreened separable arresters .....	105
Table 12 – Insulation withstand test voltages for dead-front arresters or separable arresters in a screened/shielded housing .....	106
Table 13 – Partial discharge test values for separable and dead-front arresters .....	110
Table C.1 – Mean external charge for different pollution severities .....	125
Table C.2 – Characteristic of the sample used for the pollution test .....	127
Table C.3 – Requirements for the device used for the measurement of the charge .....	127

Table C.4 – Requirements for the device used for the measurement of the temperature .....	128
Table C.5 – Calculated values of $\Delta T_{Z \max}$ for the selected example .....	134
Table C.6 – Results of the salt fog test for the selected example .....	135
Table C.7 – Calculated values of $\Delta T_Z$ and of $T_{OD}$ after 5 cycles for the selected example .....	136
Table C.8 – Calculated values of $\Delta T_Z$ and of $T_{OD}$ after 10 cycles for the selected example .....	136
Table E.1 – Minimum demonstrated lifetime prediction.....	139
Table E.2 – Relationship between test durations at 115 °C and equivalent time at upper limit of ambient temperature.....	139
Table F.1 – Results from example calculations .....	145
Table L.1 – Peak currents for switching impulse residual voltage test .....	162
Table L.2 – Parameters for the line discharge test on 20 000 A and 10 000 A arresters .....	163
Table L.3 – Comparison of the classification system according to IEC 60099-4:2009 (Ed.2.2) and to IEC 60099-4:2014 (Ed.3.0) .....	165

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**SURGE ARRESTERS –****Part 4: Metal-oxide surge arresters  
without gaps for a.c. systems****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 60099-4 has been prepared by IEC technical committee 37: Surge arresters.

This third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.



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

- A new concept of arrester classification and energy withstand testing was introduced: the line discharge classification was replaced by a classification based on repetitive charge transfer rating ( $Q_{rs}$ ), as well as on thermal energy rating ( $W_{th}$ ) and thermal charge transfer rating ( $Q_{th}$ ), respectively. Requirements depend on the intended arrester application, being either a distribution class arrester (of  $I_n = 2,5$  kA; 5 kA or 10 kA) or a station class arrester (of  $I_n = 10$  kA or 20 kA). The new concept clearly differentiates between impulse and thermal energy handling capability, which is reflected in the requirements as well as in the related test procedures.
- Requirements and tests for UHV arresters (for highest system voltages  $U_s > 800$  kV) were introduced.
- Power-frequency voltage versus time tests – with and without prior duty – were introduced as type tests.
- Requirements and tests on disconnectors were added.
- "Test series B: 5 000 h" was removed from the weather ageing test, thus following the new approach of IEC 62217.
- Former Annexes C, D, E, H, I and J were removed. New Annexes for determining the start temperature for tests on thermal stability, for determining the axial temperature distribution along tall arresters, for providing an example of how to determine energy requirements for the operating duty test and for comparing the new classification system with the former line discharge class system were introduced.
- Definitions for new terms have been added.
- All former items "under consideration" were resolved or removed.

Clauses 10 to 13 contain particular requirements for polymer-housed surge arresters, gas-insulated metal enclosed arresters (GIS-arresters), separable and dead-front arresters, and liquid-immersed arresters, respectively. These are indicated in the form of replacements, additions or amendments to the original clauses or subclauses concerned.

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

FDIS	Report on voting
37/416/FDIS	37/421/RVD

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

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

A list of all parts in the IEC 60099 series, published under the general title *Surge arresters*, 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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**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.**

## INTRODUCTION

This part of IEC 60099 presents the minimum criteria for the requirements and testing of gapless metal-oxide surge arresters that are applied to a.c. power systems with  $U_s$  above 1 kV.

## **SURGE ARRESTERS –**

### **Part 4: Metal-oxide surge arresters without gaps for a.c. systems**

#### **1 Scope**

This part of IEC 60099 applies to non-linear metal-oxide resistor type surge arresters without spark gaps designed to limit voltage surges on a.c. power circuits with  $U_s$  above 1 kV.

#### **2 Normative references**

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

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

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60068-2-11:1981, *Environmental testing – Part 2-11: Tests – Test kA: Salt mist*

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

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

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

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

IEC 60507:2013, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*

IEC TS 60815-1:2008, *Selection and dimensioning of high voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2:2008, *Selection and dimensioning of high voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC 62217, *Polymeric insulators for indoor and outdoor use – General definitions, test methods and acceptance criteria*

IEC 62271-1:2007, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC 62271-200:2011, *High-voltage switchgear and controlgear – Part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

ISO 4287, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources - Part 1: General guidance*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

CISPR/TR 18-2, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits*