AS 60099.4:2022

Australian STANDARD®

STANDARDS Australia

Surge arresters

Part 4: Metal-oxide surge arresters without gaps for a.c. systems (IEC 60099-4:2014 (ED. 3.0) MOD)

AVA Documents
Document Sharing Hub

AS 60099.4:2022

This Australian Standard ® was prepared by EL-007, Power Switchgear. It was approved on behalf of the Council of Standards Australia on 29 November 2022.

This Standard was published on 16 December 2022.

The following are represented on Committee EL-007:

Australian Industry Group
Energy Networks Australia
Engineers Australia
Institute of Electrical Inspectors
University of New South Wales

This Standard was issued in draft form for comment as DR AS 60099.4:2022.

Keeping Standards up-to-date

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:
www.standards.org.au

ISBN 978 1 76139 000 5

Documents
Document Sharing Hub

Full document details: AS 60099.4-2022

Surge arresters

Part 4: Metal-oxide surge arresters without gaps for a.c. systems (IEC 60099-4:2014 (ED. 3.0) MOD)

Originated as AS 1307.2—1987.
Revised and redesignated as AS 60099.4:2022.

© IEC Geneva Switzerland 2022 — All rights reserved
© Standards Australia Limited 2022

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of either the IEC or the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth). If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please see the contact details on the back cover or the contact us page of the website for further information.

Documents
Document Sharing Hub

Full document details: AS 60099.4-2022

Preface

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee EL-007, Power Switchgear, to supersede AS 1307.2—1996, *Surge arresters, Part 2: Metal-oxide surge arresters without gaps for a.c. systems.*

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this document as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this document is to present the minimum criteria for the requirements and testing of nonlinear 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.

This document is an adoption with national modifications, and has been reproduced from, IEC 60099-4:2014, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*.

The modifications are additional requirements and recommendations and are set out in Appendices ZZ to ZI, which have been added at the end of the source text.

Appendix ZZ lists the variations to IEC 60099-4:2014 for the application of this document in Australia.

Appendix ZA specifies spark production class for gapless distribution arresters.

Appendix ZB specifies tests for the verification of spark production class.

Appendix ZC specifies a multi-pulse lightning impulse current operating duty test for distribution arresters.

Appendix ZD reproduces a paper which provides information about fire ignition by electrically produced incandescent particles.

Appendix ZE reproduces a paper which provides information about fire ignition by copper particles of controlled size.

Appendix ZF reproduces a paper which provides information about spark detection under short-circuit testing conditions.

Appendix ZG specifies additional requirements for the identification and classification of distribution arresters.

Appendix ZH provides additional information that is to be given with enquiries and tenders.

Appendix ZI provides a test to determine the safety of arrester configurations using overvoltage conditions.

As this document has been reproduced from an International Standard, the following applies:

(a) In the source text “this part of IEC 60099” should read “this document”.

(b) A full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

National Foreword

The appendices to this document specify additional requirements for Australian conditions, as well as providing additional information, testing and evaluation that may be required by a purchaser or user of distribution class surge arresters and, in special applications, station class surge arresters. The information and testing relate, in particular, to spark production and multi-pulse lightning surge testing, and were included in AS 1307.2:1996, which has been superseded by this document.

Users of this document should note the potential hazard presented by an arrester accessory provided to help an arrester achieve a spark production classification. Such an accessory may contain an explosive charge to power the operation of the device and which, when operating, is capable of posing a hazard to adjacent personnel or equipment. This document specifies requirements for appropriate warnings to be shown on these devices.

Appendices are indicated as normative or informative. A normative appendix provides mandatory requirements that need to be followed in order to claim conformance to this Australian Standard. An informative appendix provides relevant background information but does not contain mandatory requirements.

Of particular note, Appendix ZA covers the spark behaviour of surge arresters as the result of short-circuit failure. Appendix ZB describes how to measure spark emissions and is reproduced from Appendix L of AS 1307.2—1996. Additional information about the emission of sparks and incandescent particles and how they relate to the ignition of grass or leaf litter in bushfire prone areas, as well as test assessment methods are detailed in Appendices ZD, ZE and ZF. This information is reproduced and adapted from AS 1033.1, *High voltage fuses (for rated voltages exceeding 1000 V), Part 1: Expulsion type*, which contains the original work on sparkless fuses and related requirements. Appendix ZI deals with the behaviour of surge arrester configuration during overvoltage conditions.

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

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 Disconnector 30
6.14.1 Disconnector withstand 30
6.14.2 Disconnector 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

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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, Qrs 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

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

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

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

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

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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 τ and calculation of β 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 ΔT_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

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

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

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

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 ΔT_Z and of T_{OD} after 5 cycles for the selected example 136
Table C.8 – Calculated values of ΔT_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 ^{o}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

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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.

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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.

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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.

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

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*

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

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*

3 Terms and definitions

For the purposes of this document, the following definitions apply.

3.1
acceptance tests
tests made on arresters or representative samples after agreement between manufacturer and user

3.2
arrester – dead-front type
dead-front arrester
arrester assembled in a screened/shielded housing providing system insulation and conductive ground shield, intended to be installed in an enclosure for the protection of underground and pad-mounted distribution equipment and circuits

Note 1 to entry: The use of dead-front arresters is common in the USA. Most dead-front arresters are load-break arresters.

Note 2 to entry: The arresters are assembled in an insulated housing with varying levels of shielding and screening as determined by safety or contact requirements for the installation. The differences between the descriptions from one manufacturer to another in regard to shielding, screening and degrees of such can be very subtle, but the focus is on safety and conductivity of the exterior housing to either permit, or not, workers to handle the arresters energized and with or without live line tools.

3.3
arrester disconnector
device for disconnecting an arrester from the system in the event of arrester failure, to prevent a persistent fault on the system and to give visible indication of the failed arrester

Note 1 to entry: Clearing of the fault current through the arrester during disconnection generally is not a function of the device.

3.4
arrester – liquid-immersed type
liquid-immersed arrester
arrester designed to be immersed in an insulating liquid

3.5
arrester – separable type
separable arrester
arrester assembled in an insulated or screened/shielded housing providing system insulation, intended to be installed in an enclosure for the protection of distribution equipment and systems

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

Note 1 to entry: The use of separable arresters is common in Europe. Electrical connection may be made by sliding contact or by bolted devices; however, all separable arresters are dead-break arresters.

Note 2 to entry: The arresters are assembled in an insulated housing with varying levels of shielding and screening as determined by safety or contact requirements for the installation. The differences between the descriptions from one manufacturer to another in regard to shielding, screening and degrees of such can be very subtle, but the focus is on safety and conductivity of the exterior housing to either permit, or not, workers to handle the arresters energized and with or without live line tools.

3.6
bending moment
force perpendicular to the longitudinal axis of an arrester multiplied by the vertical distance between the mounting base (lower level of the flange) of the arrester and the point of application of the force

3.7
breaking load
force perpendicular to the longitudinal axis of a porcelain-housed or cast resin arrester leading to mechanical failure of the arrester housing

3.8
cast resin housed arrester
arrester using a housing made from only one organic based material (e.g. cycloaliphatic epoxy) that fractures similarly to a porcelain housing under mechanical overstress

3.9
continuous current of an arrester
current flowing through the arrester when energized at the continuous operating voltage

Note 1 to entry: The continuous current, which consists of a resistive and a capacitive component, may vary with temperature, stray capacitance and external pollution effects. The continuous current of a test sample may, therefore, not be the same as the continuous current of a complete arrester.

Note 2 to entry: The continuous current is, for comparison purposes, expressed either by its r.m.s. or peak value.

3.10
continuous operating voltage of an arrester
U_c
designated permissible r.m.s. value of power-frequency voltage that may be applied continuously between the arrester terminals in accordance with 8.7

3.11
damage limit (mechanical)
lowest value of a force perpendicular to the longitudinal axis of a polymer-housed arrester leading to mechanical failure of the arrester housing

3.12
dead-break arrester
arrester which can be connected and disconnected from the circuit only when the circuit is de-energized

3.13
designation of an impulse shape
combination of two numbers, the first representing the virtual front time (T_1) and the second the virtual time to half-value on the tail (T_2)

Note 1 to entry: It is written as T_1/T_2, both in microseconds, the sign "/" having no mathematical meaning.

3.14
discharge current of an arrester
impulse current which flows through the arrester

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

3.15
disruptive discharge
phenomenon associated with the failure of insulation under electric stress, which includes a collapse of voltage and the passage of current

Note 1 to entry: The term applies to electrical breakdowns in solid, liquid and gaseous dielectric, and combinations of these.

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of electric strength. In a liquid or gaseous dielectric the loss may be only temporary.

3.16
distribution class arrester
arrester intended for use on distribution systems, typically of $U_s \leq 52$ kV, to protect components primarily from the effects of lightning

Note 1 to entry: Distribution class arresters may have nominal discharge currents, I_n, of 2,5 kA; 5 kA or 10 kA.

Note 2 to entry: Distribution arresters are classified as “Distribution DH”, “Distribution DM” and “Distribution DL” (see Table 1).

3.17
electrical unit
portion of an arrester in which each end of the unit is terminated with an electrode which is exposed to the external environment

Note 1 to entry: An electrical unit may have more than one mechanical unit (see Figure 5).

3.18
fail-open current rating for liquid-immersed arrester
fault current level above which the arrester is claimed to evolve into an open circuit upon failure

3.19
fail-short current rating for liquid-immersed arrester
fault current level below which the arrester is claimed to evolve into a short-circuit upon failure

3.20
fault indicator
device intended to provide an indication that the arrester is faulty and which does not disconnect the arrester from the system

3.21
flashover
disruptive discharge over a solid surface

3.22
front of an impulse
part of an impulse which occurs prior to the peak

3.23
gas-insulated metal enclosed surge arrester
GIS-arrester
gas-insulated metal-enclosed metal-oxide surge arrester without any integrated series or parallel spark gaps, filled with gas other than air

Note 1 to entry: The gas pressure is normally higher than 1 bar = 10^5Pa.

Note 2 to entry: A surge arrester used in gas-insulated switchgear.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

3.24
grading ring of an arrester
metal part, usually circular in shape, mounted to modify electrostatically the voltage distribution along the arrester

3.25
high current impulse of an arrester
peak value of discharge current having a 4/10 impulse shape which is used to test the stability of the arrester on direct lightning strokes

3.26
housing
external insulating part of an arrester, which provides the necessary creepage distance and protects the internal parts from the environment

Note 1 to entry: A housing may consist of several parts providing mechanical strength and protection against the environment.

Note 2 to entry: Where the definition of a housing would differ from this for special types of arresters (e.g. for GIS, deadfront/separable and liquid immersed arresters), alternative definitions are given in clauses specific to those arresters (e.g. Clauses 11, 12 and 13).

3.27
impulse
unidirectional wave of voltage or current which, without appreciable oscillations, rises rapidly to a maximum value and falls, usually less rapidly, to zero with small, if any, excursions of opposite polarity, with defining parameters being polarity, peak value, front time and time to half-value on the tail

3.28
insulating base
a short insulator (or set of insulators) on which the arrester is mounted to provide a means of connecting a current monitoring device between the base of the arrester and earth

3.29
internal grading system of an arrester
grading impedances, in particular grading capacitors connected in parallel to one single or to a group of non-linear MO resistors, to control the voltage distribution along the MO resistor stack

3.30
internal parts
MO resistor with supporting structure and internal grading system, if equipped

3.31
lightning current impulse
8/20 current impulse with limits on the adjustment of equipment such that the measured values are from 7 μs to 9 μs for the virtual front time and from 18 μs to 22 μs for the time to half-value on the tail

Note 1 to entry: The time to half-value on the tail is not critical and may have any tolerance during the residual voltage type tests (see 8.3).

3.32
lightning impulse discharge
an approximately sine half-wave current impulse having a time duration within 200 μs to 230 μs during which the instantaneous value of the impulse current is greater than 5 % of its peak value

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

3.33
lightning impulse protection level
LIPL or U_{pl}
the maximum residual voltage of the arrester for the nominal discharge current

3.34
load-break arrester
arrester which can be connected and disconnected when the circuit is energized

3.35
long-duration current impulse
rectangular current impulse which rises rapidly to maximum value, remains substantially constant for a specified period and then falls rapidly to zero, with defining parameters being polarity, peak value, virtual duration of the peak and virtual total duration.

3.36
mean breaking load
MBL
the average breaking load for porcelain or cast resin-housed arresters determined from tests

3.37
mechanical unit
portion of an arrester in which the MO resistors within the unit are mechanically restrained from moving in an axial direction

Note 1 to entry: An arrester may contain more than one mechanical units within an electrical unit (see Figure 5).

Note 2 to entry: A mechanical unit may have more than one electrical unit (see Figure 5).

3.38
metal-oxide surge arrester without gaps
arrester having non-linear MO resistors connected in series and/or in parallel without any integrated series or parallel spark gaps, incorporated in a housing with terminals for electrical and mechanical connection

Note 1 to entry: Wherever the term “arrester” or “surge arrester” is used in this document, the term refers to a metal-oxide surge arrester without gaps.

3.39
mounting bracket
means by which a distribution class arrester is physically attached to a pole or other structure

Note 1 to entry: For polymer housed distribution class arresters, the mounting bracket is typically of an insulating material and is typically attached to the bottom (ground) end of the arrester; for porcelain-housed distribution class arresters, the bracket is typically metal (often steel) and is connected by a “belly band” around the porcelain housing at some distance from the ground end of the arrester.

3.40
nominal discharge current of an arrester
I_n
peak value of lightning current impulse, which is used to classify an arrester

3.41
non-gapped line arrester
NGLA
arrester without internal or external series gaps intended for installation in overhead lines in parallel to the line insulators in order to prevent flashovers

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

3.42
non-linear metal-oxide resistor
MO resistor
part of the surge arrester which, by its non-linear voltage versus current characteristics, acts as a low resistance to overvoltages, thus limiting the voltage across the arrester terminals, and as a high resistance at normal power-frequency voltage

3.43
peak (crest) value of an impulse
maximum value of a voltage or current impulse

Note 1 to entry: Superimposed oscillations may be disregarded.

3.44
peak (crest) value of opposite polarity of an impulse
maximum amplitude of opposite polarity reached by a voltage or current impulse when it oscillates about zero before attaining a permanent zero value

3.45
polymer-housed surge arrester
arrester using polymeric and composite materials for housing

Note 1 to entry: Designs with an enclosed gas volume are possible. Sealing may be accomplished by use of the polymeric material itself or by a separate sealing system.

3.46
porcelain-housed surge arrester
arrester using porcelain as housing material, with fittings and sealing systems

3.47
power-frequency voltage versus time characteristic of an arrester
the maximum time durations for which corresponding power-frequency voltages may be applied to arresters without causing damage or thermal instability, under specified conditions in accordance with 6.12

3.48
pressure-relief device of an arrester
means for relieving internal pressure in an arrester and preventing violent shattering of the housing following prolonged passage of fault current or internal flashover of the arrester

3.49
prospective current of a circuit
current that would flow at a given location in a circuit if it were short-circuited at that location by a link of negligible impedance

3.50
protective characteristics of an arrester
a combination of lightning impulse protection level (LIPL), switching impulse protection level (SIPL) and steep current impulse protection level (STIPL)

3.51
puncture (breakdown)
disruptive discharge through a solid

3.52
rated frequency of an arrester
frequency of the power system on which the arrester is designed to be used

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

3.53
rated short-circuit current
I_s
highest tested power-frequency current that may develop in a failed arrester as a short-circuit current without causing violent shattering of the housing or any open flames for more than two minutes under the specified test conditions

3.54
rated voltage of an arrester
U_r
maximum permissible 10 s power frequency r.m.s. overvoltage that can be applied between the arrester, as verified in the TOV test and the operating duty test

Note 1 to entry: The rated voltage is used as a reference parameter for the specification of operating characteristics.

3.55
reference current of an arrester
peak value (the higher peak value of the two polarities if the current is asymmetrical) of the resistive component of a power-frequency current used to determine the reference voltage of the arrester

Note 1 to entry: The reference current should be high enough to make the effects of stray capacitances at the measured reference voltage of the arrester units (with designed grading system) negligible and is to be specified by the manufacturer. The reference current will be typically in the range of 0,05 mA to 1,0 mA per square centimetre of disc area for single column arresters.

3.56
reference voltage of an arrester
U_{ref}
peak value of power-frequency voltage divided by √2, which is obtained when the reference current flows through the arrester

Note 1 to entry: The reference voltage of a multi-unit arrester is the sum of the reference voltages of the individual units.

Note 2 to entry: Measurement of the reference voltage is necessary for the selection of a correct test sample in the operating duty test (see 8.7).

3.57
repetitive charge transfer rating
Q_{rs}
maximum specified charge transfer capability of an arrester, in the form of a single event or group of surges that may be transferred through an arrester without causing mechanical failure or unacceptable electrical degradation to the MO resistors

Note 1 to entry: The charge is calculated as the absolute value of current integrated over time. For the purpose of this standard this is the charge that is accumulated in a single event or group of surges lasting for not more than 2 s and which may be followed by a subsequent event at a time interval not shorter than 60 s.

3.58
residual voltage of an arrester
U_{res}
peak value of voltage that appears between the terminals of an arrester during the passage of discharge current

Note 1 to entry: The term "discharge voltage" is used in some countries.

3.59
routine tests
tests made on each arrester, or on parts and materials, as required, to ensure that the product meets the design specifications

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

3.60
seal (gas/water tightness)
ability of an arrester to avoid ingress of matter affecting the electrical and/or mechanical behaviour

3.61
section of an arrester (prorated section)
complete, suitably assembled part of an arrester necessary to represent the behaviour of a complete arrester with respect to a particular test

Note 1 to entry: A section of an arrester is not necessarily a unit of an arrester. For certain tests, a MO resistor alone constitutes a section.

3.62
shed
insulating part projecting from the housing, intended to increase the creepage distance

3.63
specified long-term load
SLL
force perpendicular to the longitudinal axis of an arrester, allowed to be continuously applied during service without causing any mechanical damage to the arrester

3.64
specified short-term load
SSL
greatest force perpendicular to the longitudinal axis of an arrester, allowed to be applied during service for short periods and for relatively rare events (for example, short-circuit current loads and extreme wind gusts) without causing any mechanical damage to the arrester

Note 1 to entry: SSL does not relate to mechanical strength requirements for seismic loads. See G.2.

3.65
station class arrester
arresters intended for use in stations to protect the equipment from transient overvoltages, typically but not only intended for use on systems of $U_s \geq 72{,}5$ kV

Note 1 to entry: Station class arresters may have nominal discharge currents, I_n, of 10 kA or 20 kA.

Note 2 to entry: Station class arresters are classified as “Station SH”, “Station SM” and “Station SL” (see Table 1).

Note 3 to entry: Station class arresters may also be used in distribution systems of $U_s \leq 52$ kV.

3.66
steep current impulse
current impulse with a virtual front time of 1 μs with limits in the adjustment of equipment such that the measured values are from 0,9 μs to 1,1 μs and the virtual time to half-value on the tail is not longer than 20 μs

Note 1 to entry: The time to half-value on the tail is not critical and may have any tolerance during the residual voltage type tests (see 8.3).

3.67
steep current impulse protection level
STIPL
the maximum residual voltage of the arrester for a steep current impulse of magnitude equal to the magnitude of the nominal discharge current

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

3.68
switching current impulse of an arrester
peak value of discharge current having a virtual front time greater than 30 μs but less than 100 μs and a virtual time to half-value on the tail of roughly twice the virtual front time

3.69
switching impulse protection level
SIPL or U_{ps}
the maximum residual voltage of the arrester for the switching impulse discharge current specified for its class

3.70
tail of an impulse
part of an impulse which occurs after the peak

3.71
terminal line force
force perpendicular to the longitudinal axis of the arrester measured at the centre line of the arrester

3.72
thermal charge transfer rating
Q_{th}
maximum specified charge that may be transferred through an arrester or arrester section within 3 minutes in a thermal recovery test without causing a thermal runaway

Note 1 to entry: This rating is verified by the operating duty type test.

3.73
thermal energy rating
W_{th}
maximum specified energy, given in kJ/kV of U_r, that may be injected into an arrester or arrester section within 3 minutes in a thermal recovery test without causing a thermal runaway

Note 1 to entry: This rating is verified by the operating duty type test.

3.74
thermal runaway of an arrester
situation when the sustained power loss of an arrester exceeds the thermal dissipation capability of the housing and connections, leading to a cumulative increase in the temperature of the MO resistor elements culminating in failure

3.75
thermal stability of an arrester
state of an arrester if, after an operating duty causing temperature rise, the temperature of the MO resistors decreases with time when the arrester is energized at specified continuous operating voltage and at specified ambient conditions

3.76
torsional loading
each horizontal force at the top of a vertical mounted arrester housing which is not applied to the longitudinal axis of the arrester

3.77
type tests
design tests
tests which are made upon the completion of the development of a new arrester design to establish representative performance and to demonstrate compliance with the relevant standard

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

Note 1 to entry: Once made, these tests need not be repeated unless the design is changed so as to modify its performance. In such a case, only the relevant tests need be repeated.

3.78
unipolar sine half-wave current impulse
a unipolar current impulse consisting of one half-cycle of an approximately sinusoidal current

3.79
unit of an arrester
arrester unit
completely housed part of an arrester which may be connected in series and/or in parallel with other units to construct an arrester of higher voltage and/or current rating

3.80
virtual duration of the peak of a rectangular impulse
time during which the amplitude of the impulse is greater than 90 % of its peak value

3.81
virtual front time of a current impulse
T_1
time in microseconds equal to 1,25 multiplied by the time in microseconds for the current to increase from 10 % to 90 % of its peak value

Note 1 to entry: If oscillations are present on the front, the reference points at 10 % and 90 % should be taken on the mean curve drawn through the oscillations.

3.82
virtual origin of an impulse
point on a graph of voltage versus time or current versus time determined by the intersection between the time axis at zero voltage or zero current and the straight line drawn through two reference points on the front of the impulse

Note 1 to entry: For current impulses the reference points shall be 10 % and 90 % of the peak value.

Note 2 to entry: This definition applies only when scales of both ordinate and abscissa are linear.

Note 3 to entry: If oscillations are present on the front, the reference points at 10 % and 90 % should be taken on the mean curve drawn through the oscillations.

3.83
virtual steepness of the front of an impulse
quotient of the peak value and the virtual front time of an impulse

3.84
virtual time to half-value on the tail of an impulse
T_2
time interval between the virtual origin and the instant when the voltage or current has decreased to half its peak value, expressed in microseconds

3.85
virtual total duration of a rectangular impulse
time during which the amplitude of the impulse is greater than 10 % of its peak value

Note 1 to entry: If small oscillations are present on the front, a mean curve should be drawn in order to determine the time at which the 10 % value is reached.

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

4 Identification and classification

4.1 Arrester identification

Metal-oxide surge arresters shall be identified by the following minimum information which shall appear on a nameplate permanently attached to the arrester:

designation of arrester (see Table 1)

continuous operating voltage;

rated voltage;

rated frequency, if other than one of the standard frequencies (see 5.2);

nominal discharge current;

rated short-circuit current in kiloamperes (kA). For arresters for which no short-circuit rating is claimed, the value "0" shall be indicated;

the manufacturer's name or trade mark, type and identification of the complete arrester;

identification of the assembling position of the unit (for multi-unit arresters only);

the year of manufacture;

serial number (at least for arresters with rated voltage above 60 kV).

If sufficient space is available the nameplate should also contain

repetitive charge transfer rating, Qrs;

contamination withstand level of the enclosure (see IEC TS 60815-1).

4.2 Arrester classification

Station and distribution class arresters are classified as indicated in Table 1, and they shall meet at least the test requirements and performance characteristics specified in Table 3.

Depending on application, NGLA may take on the classification of any one of the arresters indicated in Table1.

Table 1 – Arrester classification

Arrester class	Station			Distribution		
Designation	**SH**	**SM**	**SL**	**DH**	**DM**	**DL**
Nominal discharge current[a]	20 kA	10 kA	10 kA	10 kA	5 kA	2,5 kA
Switching impulse discharge current[a]	2 kA	1 kA	0,5 kA	--	--	--
Q_{rs} (C)	≥ 2,4	≥ 1,6	≥ 1,0	≥ 0,4	≥ 0,2	≥ 0,1
W_{th} (kJ/kV)	≥10	≥ 7	≥ 4	--	--	--
Q_{th} (C)	--	--	--	≥ 1,1	≥ 0,7	≥ 0,45

[a] Other currents may be specified upon agreement between manufacturer and user.

NOTE The letters "H", "M" and "L" in the designation stand for "high", "medium" and "low" duty, respectively.

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

5 Standard ratings and service conditions

5.1 Standard rated voltages

Standard values of rated voltages for arresters (in kilovolts r.m.s.) are specified in Table 2 in equal voltage steps within specified voltage ranges.

Table 2 – Preferred values of rated voltages

Range of rated voltage kV r.m.s.	Steps of rated voltage kV r.m.s.
3 to 30	1
30 to 54	3
54 to 96	6
96 to 288	12
288 to 396	18
396 to 900	24
Other values of rated voltages may be accepted.	

5.2 Standard rated frequencies

The standard rated frequencies are 50 Hz and 60 Hz.

5.3 Standard nominal discharge currents

The standard nominal 8/20 discharge currents are: 20 kA, 10 kA, 5 kA, and 2,5 kA.

5.4 Service conditions

5.4.1 Normal service conditions

Surge arresters which conform to this standard shall be suitable for normal operation under the following normal service conditions:

a) ambient air temperature within the range of –40 °C to +40 °C;

b) solar radiation;

NOTE The effects of maximum solar radiation (1,1 kW/m^2) have been taken into account by preheating the test specimen in the type tests. Other heat sources that may affect the application of the arrester are not considered under normal service condition.,

c) altitude not exceeding 1 000 m;

d) frequency of the a.c. power supply not less than 48 Hz and not exceeding 62 Hz;

e) power-frequency voltage applied continuously between the terminals of the arrester not exceeding its continuous operating voltage;

f) wind speeds ≤ 34 m/s;

g) vertical erection, not suspended.

5.4.2 Abnormal service conditions

Surge arresters subject to other than normal application or service conditions may require special consideration in design, manufacture or application. The use of this standard in case of abnormal service conditions is subject to agreement between the manufacturer and the user. A list of possible abnormal service conditions is given in Annex A.

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

6 Requirements

6.1 Insulation withstand

The arrester shall be designed such that the housings are able to adequately withstand voltages during conduction of lightning and switching impulse currents and during anticipated maximum power frequency overvoltages. The external insulation withstand capability of the housings shall be demonstrated by tests according to 8.2, while the internal insulation withstand capability shall be demonstrated by tests according to 8.15.

6.2 Reference voltage

The reference voltage of each arrester shall be measured by the manufacturer at the reference current selected by the manufacturer (see 7.2). The minimum reference voltage of the arrester at the reference current used for routine tests shall be specified and published in the manufacturer's data.

6.3 Residual voltages

The purpose of the measurement of residual voltages is to obtain the maximum residual voltages for a given design for all specified currents and wave shapes. These are derived from the type test data and from the maximum residual voltage at a lightning current impulse used for routine tests as specified and published by the manufacturer.

The maximum residual voltage of a given arrester design for any current and wave shape is calculated from the residual voltage of sections tested during type tests multiplied by a specific scale factor. This scale factor is equal to the ratio of the declared maximum residual voltage, as checked during the routine tests, to the measured residual voltage of the sections at the same current and wave shape.

For some arresters with a rated voltage of less than 36 kV (as per NOTE 1 of 9.1, item b)), the reference voltage may be used for this calculation instead of the residual voltage.

Manufacturers' literature shall contain, for each arrester listed, the following residual voltage information:

Maximum lightning impulse residual voltage for impulse currents of at least 0,5; 1 and 2 times the nominal discharge current of the arrester (see 8.3.3)

Maximum switching impulse residual voltage for impulse currents given in Table 1 (see 8.3.4)

Maximum steep current impulse residual voltage, excluding inductive voltage contribution, for an impulse current having peak value equal to the nominal discharge current of the arrester (see 8.3.2)

Maximum steep current impulse residual voltage, including inductive voltage contribution for an impulse current having peak value equal to the nominal discharge current of the arrester. This residual voltage shall be equal to

Maximum steep current impulse residual voltage (see 8.3.2), excluding inductive voltage contribution + Magnitude of inductive voltage drop

where, for AIS arresters,

Magnitude of inductive voltage drop = 2,5; 5; 10 or 20 kV/m of arrester length for arresters with nominal discharge current of 2,5; 5; 10 or 20 kA, respectively

or, for GIS and separable and dead-front arresters,

Magnitude of inductive voltage drop = 0,75; 1,5; 3 or 6 kV/m of arrester length for arresters with nominal discharge current of 2,5; 5; 10 or 20 kA, respectively

NOTE 1 The contribution of inductive voltage drop is significant only for steep current impulses. It effectively increases the protection level of the arrester above the MO resistor-only steep current impulse

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

residual voltage determined from 8.3.2. The maximum steep current impulse residual voltage including inductive voltage contribution is provided for users who wish to perform insulation coordination studies.

NOTE 2 Typical maximum residual voltages for different types of arrester are given in Annex F of IEC 60099-5: 2013.

6.4 Internal partial discharges

Under normal and dry operating conditions, internal partial discharges shall be below a level that might cause damage to internal parts. This shall be demonstrated by routine test according to item c) of 9.1.

6.5 Seal leak rate

For arresters having an enclosed gas volume and a separate sealing system, seal leak rates shall be specified as defined in 8.13 and item d) of 9.1.

6.6 Current distribution in a multi-column arrester

The manufacturer shall specify the highest allowed difference between currents in columns of a multi-column arrester, see item e) of 9.1.

6.7 Thermal stability

When agreed between manufacturer and user, a special thermal stability test may be performed according to 9.2.2.

6.8 Long term stability under continuous operating voltage

MO resistors shall be subjected to an accelerated ageing test to provide assurance that they will exhibit stable conditions over the anticipated lifetime of the arrester (see 8.4)

6.9 Heat dissipation behaviour of test sample

Pro-rated sections used for tests involving thermal recovery shall have thermal properties that do not result in over-estimation of arrester performance. Tests shall be performed to validate the heat dissipation behaviour of the pro-rated sections (see 8.6)

6.10 Repetitive charge transfer withstand

Arresters shall withstand repetitive charge transfers as checked during type tests (see 8.5).

The repetitive charge transfer withstand is demonstrated on individual MO resistors in the test to verify the repetitive charge transfer rating (see 8.5.2).

NOTE There may be special applications where single event charge transfers cause energy dissipations higher than the rated thermal energy rating.

6.11 Operating duty

Arresters shall be able to absorb energy from switching events or transfer charge from lightning events and subsequently thermally recover under applied temporary overvoltage and following continuous operating voltage conditions. This capability is demonstrated by the operating duty test (see 8.7).

6.12 Power-frequency voltage versus time characteristics of an arrester

The manufacturer shall supply data on the allowable time duration of power-frequency voltage and the corresponding voltage value which may be applied to the arrester after the arrester has been preheated to the start temperature as per 8.7.2.3 without damage or thermal runaway. The data shall be given without prior energy or charge duty and – in case of U_r >

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

10 kA – with prior duty corresponding to the thermal energy rating W_{th} or the thermal charge transfer rating Q_{th}.

This information shall be presented as power-frequency voltage versus time curves (TOV curves) with the energy or charge duty prior to this power-frequency voltage application stated on the above-mentioned curve.

The TOV characteristic is demonstrated on thermally prorated sections in the test to verify the power frequency voltage versus time characteristic (TOV test) (see 8.8).

6.13 Short-circuit performance

The manufacturer shall declare a short-circuit current rating for each family of arresters. Only for applications with expected short-circuit currents below 1 kA the rated value “zero” may be claimed. In this case “0” shall be indicated on the name plate. In any case, the arrester shall be subjected to a short-circuit test according to 8.10 to show that it will not fail in a manner that causes violent shattering of the housing and that self-extinguishing of open flames (if any) occurs within a defined period of time.

6.14 Disconnector

6.14.1 Disconnector withstand

When an arrester is fitted or associated with a disconnector, this device shall withstand, without operating, each of the following tests:

For distribution class arresters:

- test to verify the repetitive charge transfer rating, Q_{rs} (see 8.5.2);
- operating duty test with rated values of thermal charge rating, Q_{th} (see 8.7.2);
- mechanical tests on agreement between manufacturer and user (see NOTES 1 and 2 of 8.9.4.1)
- temperature cycling and seal pumping test (see 8.9.5)

For non-gapped line arresters (NGLA):

- test to verify the repetitive charge transfer rating, Q_{rs} with lightning impulse discharges according to Annex H or long duration currents (see 8.5.2);
- operating duty test with rated values of thermal energy rating, W_{th} (see 8.7.2);
- bending moment test (see 8.9.4.2);
- tensile load test (see 8.9.4.3);
- torsional load test (see 8.9.4.4);
- temperature cycling and seal pumping test (see 8.9.5)

6.14.2 Disconnector operation

The time delay for the operation of the disconnector is determined for three values of current according to 8.9.3. There shall be clear evidence of effective and permanent disconnection by the device.

6.15 Requirements on internal grading components

Internal grading components, if used in the arrester, shall be able to withstand the combination of stresses arising in service, and the impedance of the grading components shall also show sufficient stability during the service life. This shall be demonstrated by operating duty test (see 8.7) and the TOV test (see 8.8) being performed with internal grading components included in the test sections.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

Furthermore, the components shall withstand the accelerated ageing and cyclic tests as specified in 8.16.

6.16 Mechanical loads

6.16.1 General

The manufacturer shall specify the maximum permissible terminal loads relevant for installation and service, such as cantilever, torque and tensile loads.

6.16.2 Bending moment

The arrester shall be able to withstand the manufacturer's declared values for bending loads (see 8.11).

When determining the mechanical load applied to a surge arrester, the user should consider, for example, wind, ice and electromagnetic forces likely to affect the installation.

Surge arresters enclosed within their package should withstand the transportation loads specified by the user in accordance with IEC 60721-3-2, but not less than Class 2M1.

NOTE Unlike porcelain-housed arresters, polymer-housed arresters may show mechanical deflections in service.

6.16.3 Resistance against environmental stresses

The arrester shall be able to withstand environmental stresses as defined in 8.12.

6.16.4 Insulating base and mounting bracket

When an insulating base and/or a mounting bracket is provided with the arrester, the base and/or bracket shall be subjected to mechanical tests separately from the arrester (see 8.11.6).

6.16.5 Mean value of breaking load (MBL)

For porcelain and cast-resin housed arresters the MBL shall be ≥ 1,2 times the specified short-term load (SSL). This shall be demonstrated in the bending moment test of 8.11.

6.16.6 Electromagnetic compatibility

Arresters are not sensitive to electromagnetic disturbances and therefore no immunity test is necessary.

In normal dry operating conditions, surge arresters shall not emit significant disturbances. For arresters intended for use on systems of U_s ≥ 72,5 kV, this shall be demonstrated by a radio interference voltage test (RIV) according to 8.14.

6.17 End of life

On request from users, each manufacturer shall give enough information so that all the arrester components may be scrapped and/or recycled in accordance with international and national regulations.

6.18 Lightning impulse discharge capability

For NGLA arresters to be installed in overhead lines with system voltages exceeding 52 kV, the lightning impulse discharge capability shall be demonstrated by the tests and procedures of Annex H.

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

7 General testing procedure

7.1 Measuring equipment and accuracy

The measuring equipment shall meet the requirements of IEC 60060-2. The values obtained shall be accepted as accurate for the purpose of compliance with the relevant test clauses.

Unless stated elsewhere, all tests with power-frequency voltages shall be made with an alternating voltage having a frequency between the limits of 48 Hz and 62 Hz and an approximately sinusoidal wave shape.

7.2 Reference voltage measurements

The reference voltage of an arrester is measured at the reference current on sections and units when required. The measurement shall be performed at an ambient temperature of 20 °C ± 15 K, and this temperature shall be recorded.

As an acceptable approximation, the peak value of the resistive component of current may be taken to correspond to the momentary value of the current at the instant of voltage peak.

7.3 Test samples

7.3.1 General

Unless otherwise specified, all tests shall be made on the same arresters, arrester sections or arrester units. They shall be new, clean, completely assembled (for example, with grading rings if applicable) and arranged to simulate as closely as possible the conditions in service.

For tests involving verification of thermal stability the sections shall contain the highest number of parallel columns of MO resistors that is assembled within one arrester housing for the actual design.

When tests are made on sections it is necessary that the sections represent the behaviour of all possible arresters within the manufacturer's tolerances with respect to a specific test.

NOTE Due to the usually very complex internal design of GIS arresters, it may not be practical to carry out the test on test samples with many MO resistor columns in parallel. On the other hand, to achieve thermal equivalence with single-column sections is more realistic in GIS arresters than in AIS arresters because of their better cooling characteristic. Therefore, for GIS arresters single-column sections are accepted if thermal equivalence as per Annex B can be proven.

In general, the samples shall cover the highest residual voltage and the lowest reference voltage of the type of MO resistors used in the arrester. If thermal charge transfer rating is specified in the operating duty test and for the TOV test (see 8.7 and 8.8) the samples shall have the highest lightning impulse protection level U_{pl} per unit length of the design. If thermal energy rating is specified in the operating duty test the test samples shall have a reference voltage value at the lower end of the variation range declared by the manufacturer. In case of multi-column arresters, the highest value of uneven current distribution shall be considered. In order to comply with these demands the following shall be fulfilled:

a) The ratio between the rated voltage of the complete arrester to the rated voltage of the section is defined as n. The volume of the MO resistor elements used as test samples shall not be greater than the minimum volume of all MO resistor elements used in the complete arrester divided by n.

b) The reference voltage of the test section shall be equal to $k\ U_r/n$ where k is the ratio between the minimum reference voltage of the arrester and its rated voltage. If $U_{ref} \geq k\ U_r/n$ for an available test sample, the factor n shall be reduced correspondingly. (If $U_{ref} < k\ U_r/n$ the arrester may absorb too much energy. Such a section can be used only after agreement from the manufacturer.)

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

c) For multi-column arresters the distribution of the current between the columns shall be measured at the impulse current for current distribution test (see item e) of 9.1). The highest current value shall not be higher than an upper limit specified by the manufacturer. Furthermore, for tests that are required to be performed on test sections with multiple columns the discharge energy shall be increased by a factor βg/βa where βg is the guaranteed current sharing factor and βa is the actual current sharing factor for the test section. If the test is performed on single columns the energy shall be increased by a factor βg.

d) The samples in the test to verify the repetitive charge transfer rating shall be of the longest length of the type of MO resistors used in the design, and shall have a 10-kA residual voltage stress of not less than 0,97 × ($U_{10\ kA}$ per mm of MO resistor length)$_{max}$, where ($U_{10\ kA}$ per mm of MO resistor length)$_{max}$ is the highest 10-kA residual voltage stress specified by the manufacturer for any length of the type of MO resistors used in the arrester. If only samples of lower 10-kA residual voltage stress are available, the required transferred charge shall be increased for the test by the factor

($U_{10\ kA}$ per mm of MO resistor length$_{)max}$ / ($U_{10\ kA}$ per mm of MO resistor length)$_{actual}$

e) The continuous operating voltage applied in tests involving thermal recovery shall fulfil the following requirement: The ratio of the continuous operating voltage to the rated voltage of the section shall be not less than the maximum ratio claimed for the arrester type.

7.3.2 Arrester section requirements

7.3.2.1 Thermally prorated section

The arrester section for thermal recovery tests shall thermally represent the arrester being modelled. Thermal equivalence shall be verified according to the procedure specified in Annex B.

The rated voltage of the prorated section shall be at least 3 kV.

In order to achieve thermal equivalence it may be necessary to introduce components that are usually not part of the design. It has to be assured that these measures do not affect the dielectric strength of the sample during energy or charge injection.

A thermally prorated section may also be a real arrester or arrester unit of the design.

In case of designs with two or more MO columns in parallel the thermally prorated section shall contain the same number of parallel columns as the actual arrester.

Upon agreement between manufacturer and user the thermally prorated section of a multi-column design arrester may contain only one single column if thermal equivalence is achieved.

For GIS arresters of multi-column design the thermally prorated section may contain only one single column if thermal equivalence is achieved.

No further requirements apply, especially on the design of the prorated section. Therefore, the thermally prorated section need not be a sliced portion of the arrester and need not contain only the same material as in the arrester. It may have a design different to that of the modelled arrester, as long as thermal equivalence and sufficient dielectric strength for the energy and charge injection, respectively, are assured.

7.3.2.2 Dielectrically prorated section

The arrester section for internal dielectric strength tests shall represent a sliced portion of the arrester being modelled, including the MO resistors, the housing and the supporting structure.

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

The rated voltage shall be at least 3 kV.

The section shall meet the following requirements: it shall be an exact copy of the real arrester with regard to diameters, materials etc. The mechanically supporting structure shall be included. Elements that are only located at distributed positions in the arrester being modelled, such as distance holders and spacers, shall be present in the model. The active part shall have the same surrounding medium as in the real arrester.

A dielectrically prorated section may also be a real arrester or arrester unit of the design.

An exact drawing of the dielectric model shall be published in the test report.

7.3.2.3 Section for residual voltage tests

The arrester section for the residual voltage tests shall be a complete arrester unit, a stack of series connected MO resistors or an individual MO resistor in still air. For multi-column arresters the section may be made of the actual number of MO resistors or resistor columns in parallel or of only one MO resistor or resistor column, respectively.

7.3.2.4 Section for the test to verify the repetitive charge transfer rating, Q_{rs}

The arrester section for the test to verify the repetitive charge transfer rating, Q_{rs}, shall be an individual MO resistor either in still air or in the actual surrounding medium of the design. The choice is at the discretion of the manufacturer.

8 Type tests (design tests)

8.1 General

Type tests defined in this clause apply to porcelain-housed arresters. The tests also apply to other types of arrester (polymer-housed, GIS, dead-front and separable, and liquid-immersed) unless otherwise noted in 10.8 for polymer-housed arresters, 11.8 for GIS arresters, 12.8 for dead-front and separable arresters, or 13.8 for liquid-immersed arresters.

Type tests shall be made as indicated in Table 3.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

Table 3 – Arrester type tests

Arrester class	Station	Station	Distribution
Nominal discharge current	20 kA 10 kA	20 kA 10 kA	10 kA 5 kA 2,5 kA
Typical U_s (kV), rms value	> 245	≤ 245	≤ 52
1 Insulation withstand tests on the arrester housing			
a) Lightning impulse	8.2.6	8.2.6	8.2.6
b) Switching impulse	8.2.7	Not required	Not required
c) Power-frequency	Not required	8.2.8	8.2.8
2 Residual voltage test			
a) Steep current	8.3.2	8.3.2	8.3.2
b) Lightning impulse	8.3.3	8.3.3	8.3.3
c) Switching impulse	8.3.4	8.3.4	Not required
3 Test to verify long term stability under continuous operating voltage	8.4	8.4	8.4
4 Repetitive charge transfer withstand	8.5	8.5	8.5
5 Heat dissipation behaviour verification of test sample	8.6	8.6	8.6
6 Operating duty test	8.7	8.7	8.7
7 Power-frequency voltage versus time	8.8	8.8	8.8
8 Arrester disconnector/fault indicator (when fitted)	8.9	8.9	8.9
9 Short-circuit tests	8.10	8.10	8.10
10 Bending moment	8.11	8.11	8.11
11 Environmental tests	8.12	8.12	8.12
12 Seal leak rate	8.13	8.13	8.13
13 Radio interference voltage (RIV)	8.14	8.14	Not required
14 Test to verify the dielectric withstand of the internal components of an arrester	8.15	8.15	8.15
15 Test of internal grading components	8.16	8.16	8.16
16 Polluted housing test	Annex C	Annex C	Annex C
Numbers in rows 1-16 refer to clauses and subclauses in this standard. NOTE Type tests for other types of arresters (polymer-housed, GIS, dead-front and separable, and liquid-immersed) are specified in 10.8, 11.8, 12.8 and 13.8.			

The required numbers of samples and their conditions are specified in the individual clauses. Arresters that differ only in methods of mounting or arrangement of the supporting structure, and which are otherwise based on the same components and similar construction resulting in the same performance characteristics including their heat dissipation conditions and internal atmosphere, are considered to be of the same design.

8.2 Insulation withstand tests

8.2.1 General

The voltage withstand tests demonstrate the voltage withstand capability of the external insulation of the arrester housing. For other designs the test has to be agreed upon between the manufacturer and the user.

Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

The tests shall be performed in the conditions and with the test voltages specified below. The outside surface of insulating parts shall be carefully cleaned and the internal parts removed or rendered inoperative to permit these tests.

If any of the conditions relating dry arc distance to test voltage, as described in 8.2.6, 8.2.7 or 8.2.8, is fulfilled then the relevant test specified in 8.2.6, 8.2.7 or 8.2.8 need not be performed, since, under these conditions, the insulation withstand voltage of the arrester will inherently meet the minimum requirement.

8.2.2 Tests on individual unit housings

For arresters intended for use on systems of $U_s \leq 245$ kV, lightning impulse voltage tests according to 8.2.6 and power-frequency voltage tests according to 8.2.8 shall be performed on individual unit housings.

The applicable tests shall be run on the longest arrester housing. If this does not represent the highest specific voltage stress per unit length, additional tests shall be performed on the unit housing having the highest specific voltage stress. For the test, the MO resistors shall be removed from the housing or replaced by insulators.

8.2.3 Tests on complete arrester assemblies

For arresters intended for use on systems of $U_s > 245$ kV, lightning impulse voltage tests according to 8.2.6 and switching impulse voltage tests according to 8.2.7 shall be performed on complete arrester assemblies.

The switching impulse tests for arresters intended for outdoor use shall be performed under wet conditions with the arrester placed on a pedestal. Details of the pedestal used shall be stated in the test report. The switching impulse tests for arresters intended for indoor use shall be performed under dry conditions

The housing shall be equipped with the complete external grading system. The MO resistors shall be replaced by resistors, capacitors or higher resistance MO resistors to obtain, approximately, the same voltage grading of the arrester during high current discharges as would be given by the actual MO resistors used in the arrester. When using MO resistors, the resistors shall have a protection characteristic that will result in at least 1 A peak during the insulation withstand test.

NOTE The use of higher resistance MO resistors is an alternative for lightning and switching impulse voltage tests but not for the power-frequency voltage test because of the inability of the arrester to survive for 1 min at the applied power frequency voltage for current flow of 1 A.

8.2.4 Ambient air conditions during tests

The voltage to be applied during a withstand test is determined by multiplying the specified withstand voltage by the correction factor taking into account density and humidity (see IEC 60060-1).

Humidity correction shall not be applied for wet tests.

8.2.5 Wet test procedure

The external insulation of outdoor arresters shall be subjected to wet withstand tests under the test procedure given in IEC 60060-1.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

8.2.6 Lightning impulse voltage test

The arrester shall be subjected to a standard lightning impulse voltage dry test according to IEC 60060-1. The test voltage shall be at least 1,3 times the maximum residual voltage of the arrester at nominal discharge current.

NOTE The 1,3 factor is obtained from $1{,}15 * e^{1\,000/8\,150}$, which reflects a 15 % coordination factor to take into account discharge currents higher than nominal and the statistical nature of the withstand voltage of the insulation, and a 13 % margin to account for variation in air pressure from sea level up to normal service altitudes not exceeding 1 000 m.

Fifteen consecutive impulses at the test voltage value shall be applied for each polarity. The arrester shall be considered to have passed the test if no internal disruptive discharges occur and if the number of the external disruptive discharges does not exceed two in each series of 15 impulses. The test voltage shall be equal to the lightning impulse protection level of the arrester multiplied by 1,3.

If the dry arcing distance or the sum of the partial dry arcing distances in m is larger than the test voltage in kV divided by 500 kV/m, this test is not required.

8.2.7 Switching impulse voltage test

Station class arresters according to Table 1 intended for use on systems of $U_s > 245$ kV shall be subjected to a standard switching impulse voltage test according to IEC 60060-1. Arresters for outdoor use shall be tested in wet conditions, arresters for indoor use in dry conditions. The test voltage shall be at least the maximum switching impulse residual voltage of the arresters multiplied by $1{,}1 \times e^{m \times 1\,000/8\,150}$ where

- for arresters intended for use on systems of $U_s \leq 800$ kV, $m = 1$
- for arresters intended for use on systems of $U_s > 800$ kV, m is taken from IEC 60071-2:1996, Figure 9, phase-to-earth insulation, where the value on the abscissa shall be 1,1 times the switching impulse protection level of the arrester

  NOTE 1 The factor $1{,}1 \times e^{m \times 1\,000/8\,150}$ reflects a 10 % coordination factor to take into account discharge currents higher than normal and the statistical nature of the withstand voltage of the insulation, and a 13 % margin to account for variation in air pressure from sea level up to normal service altitudes not exceeding 1 000 m

When the insulation requirements of arresters intended for use on systems of $U_s > 800$ kV calculated from the above are still higher than selected for the protected equipment the same insulation levels should apply also for the arresters.

Fifteen consecutive impulses at the test voltage value shall be applied for each polarity. The arrester shall be considered to have passed the test if no internal disruptive discharges occur and if the number of the external disruptive discharges does not exceed two in each series of 15 impulses.

If the dry arcing distance or the sum of the partial dry arcing distances is larger than given by the equation $d = 2{,}2 \times [e^{(U/1\,069)} - 1]$, where d is the distance in m and U is the test voltage in kV, this test is not required.

NOTE 2 The equation is derived from formula G.3 of IEC 60071-2:1996, where U_{50} is given as $k \times 1\,080 \times \ln(0{,}46 \times d + 1)$, k is the gap factor and d is the distance. For the purpose of this standard, the gap factor k is assumed to be equal to 1,1, and two standard deviations of 0,05 each are taken into account to achieve the withstand voltage.

8.2.8 Power-frequency voltage test

The housings of arresters intended for outdoor use shall be tested in wet conditions, and housings of arresters intended for indoor use shall be tested in dry conditions.

Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

Housings of distribution class arresters according to Table 1 shall withstand a power-frequency voltage with a peak value equal to the lightning impulse protection level multiplied by 0,88 for a duration of 1 min.

NOTE 1 The factor of 0,88 takes into account a safety margin of 1,15 for lightning impulse currents higher than nominal discharge current, an altitude correction factor of 1,13 for 1 000 m installation altitude, a factor 0,8 as a typical ratio between switching and lightning impulse protection level and a test conversion factor of 0,6 × √2 for conversion from switching impulse voltage to peak value of power-frequency voltage according to Table 2 of IEC 60071-2:1996.

Housings of station class arresters according to Table 1 intended for application on systems of $U_s \leq 245$ kV shall withstand a power-frequency voltage with a peak value equal to the switching impulse protection level multiplied by 1,06 for a duration of 1 min.

NOTE 2 The factor of 1,06 takes into account a safety margin of 1,1 for higher switching impulse currents, an altitude correction factor of 1,13 for 1 000 m installation altitude, and a test conversion factor of 0,6 × √2 according to Table 2 of IEC 60071-2:1996.

If the dry arcing distance or the sum of the partial dry arcing distances is larger than given by the equation $d = [1{,}82 \times (e^{(U/859)} - 1)]^{0{,}833}$, where d is the distance in m and U is the peak value of the power-frequency test voltage in kV, this test is not required.

NOTE 3 The equation is derived from formula G.1 of IEC 60071-2:1996, where the peak value of U_{50} is given as $750 \times \sqrt{2} \times \ln(1 + 0{,}55 \times d^{1{,}2})$, d being the distance. Following the recommendations given in IEC 60071-2, for the purpose of this standard the gap factor k is assumed to be equal to 1, the withstand voltage is assumed to be 90 % of U_{50}, and a 10 % reduction in U_{50} is assumed for wet conditions compared to dry.

8.3 Residual voltage tests

8.3.1 General

The purpose of the residual voltage type test is to obtain the data necessary to derive the maximum residual voltage as explained in 6.3. It includes the calculation of the ratio between voltages at specified impulse currents and the voltage level checked in routine tests. The latter voltage can be either the reference voltage or the residual voltage at a suitable lightning current impulse in the range 0,01 to 2 times the nominal discharge current depending on the manufacturer's choice of routine test procedure.

The maximum residual voltage at a lightning current impulse used for routine tests shall be specified and published in the manufacturer's data. Maximum residual voltages of the design for all specified currents and wave-shapes are obtained by multiplying the measured residual voltages of the test sections by the ratio of the declared maximum residual voltage at the routine test current to the measured residual voltage for the section at the same current.

For arresters with rated voltages below 36 kV (see item b) of 9.1), the manufacturer may choose to check only the reference voltage by routine test. The maximum reference voltage shall then be specified. The measured residual voltages of the test sections are multiplied by the ratio of this maximum arrester reference voltage to the measured reference voltage of the test sections to obtain maximum residual voltages for all specified currents and wave shapes.

All residual voltage tests shall be made on the same three samples of complete arresters or arrester sections. The time between discharges shall be sufficient to permit the samples to return to approximately ambient temperature. For multi-column arresters the test may be performed on sections made of only one column; the residual voltages are then measured for currents obtained from the total currents in the complete arrester divided by the number of columns.

8.3.2 Steep current impulse residual voltage test

One steep current impulse with a peak value equal to the nominal discharge current of the arrester ±5 % shall be applied to each of the three samples. The peak value and the impulse shape of the voltage appearing across the three samples shall be recorded and, if necessary,

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

corrected for inductive effects of the voltage measuring circuit as well as the geometry of the test sample and the test circuit.

The following procedure shall be used to determine if an inductive correction is required:

- A steep current impulse as described above shall be applied to a non-ferrous metal block having the same dimensions as the MO resistor samples being tested. The peak value and the shape of the voltage appearing across the metal block shall be recorded.
- If the peak voltage on the metal block is less than 2 % of the peak voltage of the MO resistor samples, no inductive correction to the MO resistor measurements is required.
- If the peak voltage on the metal block is between 2 % and 20 % of the peak voltage on the MO resistor sample, then the impulse shape of the metal block voltage shall be subtracted from the impulse shape of each of the MO resistor voltages and the peak values of the resulting impulse shapes shall be recorded as the corrected MO resistor voltages.
- If the peak voltage on the metal block is greater than 20 % of the peak voltage on the MO resistor samples, then the test circuit and the voltage measuring circuit shall be improved and the test shall be repeated.

NOTE 1 A possible way to achieve identical current wave shapes during all measurements is to perform them with both the test sample and the metal block in series in the test circuit. Only their positions relative to each other need to be interchanged for measuring the voltage drop on the metal block or on the test sample.

The highest of the three measured residual voltages, corrected if necessary as indicated above, and multiplied by the scale factor (see 7.3) is defined as the steep current protection level of the arrester excluding the inductive voltage contribution of the arrester.

In addition, the maximum steep current residual voltage including inductive voltage contribution has to be calculated as specified in 6.3.

NOTE 2 Connecting leads to connect the arrester to the power system will introduce additional inductive voltage drop for steep current impulse currents.

8.3.3 Lightning impulse residual voltage test

One lightning current impulse shall be applied to each of the three samples for each of the following three peak values of approximately 0,5, 1 and 2 times the nominal discharge current of the arrester. Virtual front time shall be within 7 μs to 9 μs while the half-value time (which is not critical) may have any tolerance. The residual voltages are determined in accordance with 6.3. The maximum values of the determined residual voltages shall be drawn in a residual voltage versus discharge current curve. The residual voltage read on such a curve corresponding to the nominal discharge current is defined as the lightning impulse protection level of the arrester.

If a complete arrester routine test cannot be carried out at one of the above currents, then additional type tests shall be carried out at a current in the range of 0,01 to 0,25 times nominal discharge current for comparison to the complete arrester.

8.3.4 Switching impulse residual voltage test

One switching current impulse shall be applied to each of the three samples with peak values according to Table 1 with a tolerance of ±5 %. The residual voltages are determined in accordance with 6.3. The highest of these three voltages is defined as the switching impulse residual voltage of the arrester.

8.4 Test to verify long term stability under continuous operating voltage

8.4.1 General

Typically, under normal operation, a surge arrester is stressed at a voltage below its reference voltage, U_{ref}. The test to verify long term stability for such cases is given in 8.4.2.

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

However, for certain arrester designs the normal operating voltage may be at or even above U_{ref}, in which case it may not be possible to perform a test in the same manner, and an alternative test for this case is given in 8.4.3.

8.4.2 MO resistor elements stressed below U_{ref}

8.4.2.1 Procedure

This test shall be performed on three new samples of MO resistors with a reference voltage fulfilling the requirements of 7.3. The power-frequency voltage shall fulfil the requirements stated for the operating duty test (see 8.7.1).

All material (solid or liquid) in direct contact with the MO resistors in the arrester shall be present during the ageing test with the same design as used in the complete arrester.

During the test, the MO resistors shall be placed in a temperature-controlled oven in the same surrounding medium as used in the arrester. The volume of the oven chamber shall be at least twice the volume of the MO resistor and the density of the medium in the chamber shall not be less than the density of the medium in the arrester.

NOTE 1 The medium surrounding the MO resistor within the arrester may be subject to a modification during the normal life of the arrester due to internal partial discharges. Possible change of the medium surrounding the MO resistor in the field can significantly increase the power losses.

A suitable test procedure taking into account such modifications is under consideration. During this time an alternative procedure consists in performing the test in N_2 or SF_6 (for GIS-arresters) with a low oxygen concentration (less than 0,1 % in volume). This ensures that even in the total absence of oxygen, the arrester will not age.

If the manufacturer can prove that the test carried out in the open air is equivalent to that carried out in the actual medium, the ageing procedure can be carried out in the open air.

The MO resistors shall be heated to 115 °C ± 4 K and the MO resistor power losses P_{start} shall be measured at the corrected maximum continuous operating voltage of U_{ct} (see below) 3 h ± 15 min after the voltage application. The samples shall be maintained at this voltage for 1 000 h, during which the oven temperature shall be controlled to keep the surface temperature of the MO resistor at 115 °C ± 4 K.

The MO resistor power losses shall be measured at U_{ct} at intervals of not more than 100 h after the first measurement, and a final measurement, P_{end}, shall be made after $1\,000^{+100}_{0}$ h of ageing. The lowest power losses attained during the test period shall be designated as P_{min} (see Figure 1).

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

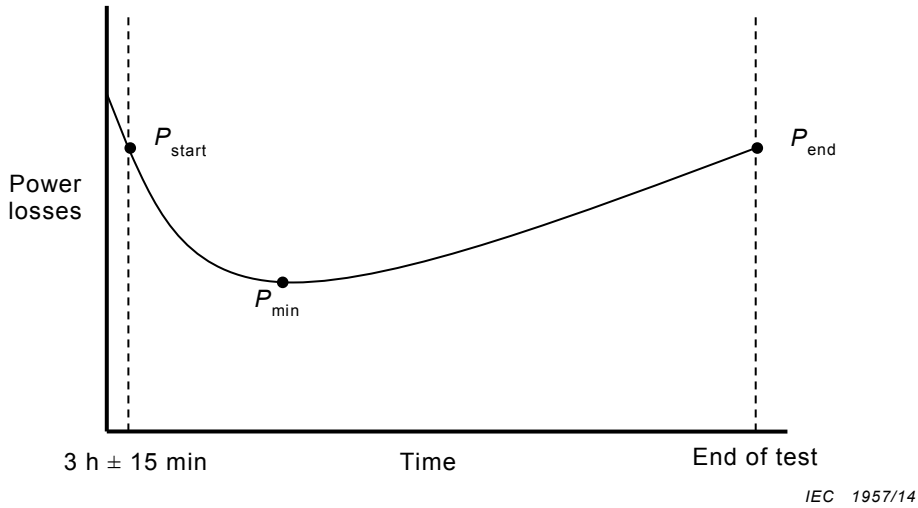

Figure 1 – Illustration of power losses versus time during long term stability test

Accidental intermediate de-energizing of the test samples, not exceeding a total duration of 24 h during the test period is permissible. The interruption will not be counted in the duration of the test. The final measurement should be performed after not less than 100 h of continuous energizing. Within the temperature range allowed, all measurements shall be made at the same temperature ±1 K.

The relevant voltage for this procedure is the corrected maximum continuous operating voltage (U_{ct}), which the MO resistors support in the arrester including voltage unbalance effects. This voltage shall be determined by voltage distribution measurements or computations.

NOTE 2 Information on procedures for voltage distribution calculations is given in Annex F.

For arresters with a length H of less than 1 m, except for arresters with conductive, grounded enclosures such as GIS-arresters, liquid-immersed, dead-front or screened/shielded separable arresters, the voltage may be determined from the following formula:

$$U_{ct} = U_c\,(1 + 0{,}15\,H)$$

where

H is the total length of the arrester (m).

8.4.2.2 Evaluation

The test shall be considered passed if, for all three MO resistors, the following criteria are met:

any increase of power losses from P_{min} is not greater than 1,3 times P_{min} during the remaining test period

all measurements of power losses throughout the ageing period, including the final measurement, P_{end}, is not greater than 1,1 times P_{start}.

8.4.3 Test procedure for MO resistor elements stressed at or above U_{ref}

8.4.3.1 General

If U_{ct} is close to or above the reference voltage, it may not be possible to perform an accelerated ageing test at U_{ct}, due to the extreme voltage dependence for the power losses and stability of available voltage source. If $U_{ct} \geq 0{,}95 \times U_{ref}$ and if it is not possible to perform

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

an accelerated ageing test according to 8.4.2.1, this alternative test procedure shall apply and replaces 8.4.2.1 and 8.4.2.2

The steps required for the procedure are as follows:

1) Calculate power losses, P_{ct}, for the highest stressed MO resistor in the arrester (at T_a = 40 °C and $U = U_c$).
2) Determine the steady-state temperature, T_{st}, for the highest stressed part of the arrester by using one of the three alternative procedures of 8.4.3.2.
3) At a voltage U_{ct}, determine the ratio, k_x, of power loss at 115 °C to power loss at T_{st} for the type of MO resistors used.
4) Perform an accelerated ageing test at constant power losses of $k_x \times P_{ct}$.
5) Interrupt the test for a short time and take measurements of power losses at 100 h intervals.
6) If $T_{st} > 60$ °C, increase test temperature or test time.
7) Evaluate the power losses of step 5) according to 8.4.3.4

8.4.3.2 Determination of test parameters

Calculate the power losses, P_{ct}, at the maximum ambient temperature of 40 °C with the arrester energized at U_c, for the highest voltage stressed MO resistor according to Annex F including the effect of the resistive current.

NOTE 1 For dead-front and liquid-immersed arresters, 65 °C and 95 °C, respectively, apply as maximum ambient temperatures.

Select one of the three following test procedures to determine the steady-state temperature, T_{st}, of the most stressed part of the arrester at maximum ambient temperature.

NOTE 2 The test procedures are considered to be conservative in increasing order from 1 to 3.

1) At an ambient temperature of 25 °C ± 10 K, energize the complete arrester at the claimed U_c until steady-state temperature conditions have been attained. The temperature shall be measured on MO resistors at five points as evenly spaced as possible over the most highly stressed 20 % portion of the length of each column of the arrester. If this 20 % portion contains less than five MO resistors, the number of measuring points may be limited to one point on each MO resistor. The average temperature rise above ambient of the MO resistor elements shall be added to the maximum ambient temperature to obtain the temperature T_{st}.
2) At the maximum ambient temperature, energize a thermally pro-rated section representative for the arrester type at a voltage level, which results in the same power losses per MO resistor as determined above. Keep the power losses constant by adjusting the voltage if necessary. Measure the temperature of the MO resistors in steady-state condition and calculate the average steady-state temperature, which is set equal to $T_{st.}$
3) At an ambient temperature of 25 °C ± 10 K, energize a thermally pro-rated section representative for the arrester type at a voltage level which results in the same power losses per MO resistor as determined above. Keep the power losses constant by adjusting the voltage if necessary. Measure the temperature of the MO resistors in steady-state condition and calculate the average steady-state temperature rise, ΔT_{st}, above ambient. Determine the temperature $T_{st,}$ by adding ΔT_{st} to the maximum ambient temperature.

The thermally prorated section shall be in accordance with 7.3.2.1.

At a voltage U_{ct}, determine the ratio, k_x, of power losses at 115 °C to power losses at T_{st} for the type of MO resistors used. For this test the voltage source shall fulfil the requirements according to 8.7.1.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

8.4.3.3 Procedure

The test shall be performed on three typical samples of MO resistors with a reference voltage fulfilling the requirements of 7.3. Three MO resistor samples shall be subjected to constant power losses equal to $k_x \times P_{ct}$ (tolerance $^{+30}_{0}$ %) for 1 000 h. During the test, the temperature shall be controlled to keep the surface temperature of the MO resistor at the required test temperature $T_t \pm 4$ K. The applied test voltage at the start of the test shall be not less than $0{,}95 \times U_{ct}$.

If the temperature, T_{st}, is equal to or below 60 °C, T_t shall be 115 °C. If T_{st} is above 60 °C, either the test temperature or the testing time shall be increased as follows.

Increase of the test temperature

$$T_t = 115 + (T_{st} - T_{a,max} - \Delta T_n)$$

where

T_t is the test temperature in °C;

T_{st} is the steady-state temperature of the MO resistors in °C;

$T_{a,max}$ is the maximum ambient temperature in °C;

ΔT_n = 20 K.

NOTE 1 For liquid-immersed arresters ΔT_n = 25 K, which results from the requirement that the operating duty test starting temperature for these arresters (120 °C) is 25 K above the maximum ambient temperature (95 °C), while for other arresters the difference between the operating duty test starting temperature and the maximum ambient temperature is 20 K.

Increase of the testing time

$$t = t_0 \times 2{,}5^{\Delta T/10}$$

where

t is the testing time in h;

t_0 = 1 000 h;

ΔT is the temperature above 60 °C.

NOTE 2 For dead-front and liquid-immersed arresters, t_0 is 2 000 h and 7 000 h, respectively, and ΔT is the temperature above 85 °C and 120 °C, respectively.

One to two hours after the voltage application, the voltage is adjusted to a voltage in the range $0{,}95 \times U_{ct}$ to U_{ct} and the power losses, P_{start}, are measured. This measurement is repeated once in approximately every 100 h after the first measurement, and at the final testing time $^{+100}_{0}$ h of ageing the final power losses, P_{end}, are measured.

All material (solid or liquid) in direct contact with the MO resistors in the arrester shall be present during the ageing test with the same design as used in the complete arrester.

During the test, the MO resistors shall be placed in a temperature-controlled oven in the same surrounding medium as used in the arrester. The volume of the oven chamber shall be at least twice the volume of the MO resistor and the density of the medium in the chamber shall not be less than the density of the medium in the arrester.

NOTE 3 The medium surrounding the MO resistor within the arrester may be subject to a modification during the normal life of the arrester due to internal partial discharges. Possible change of the medium surrounding the MO resistor in the field can significantly increase the power losses.

A suitable test procedure taking into account such modifications is under consideration. During this time an alternative procedure consists in performing the test in N_2 or SF_6 (for GIS-arresters) with a low oxygen

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

concentration (less than 0,1 % in volume). This ensures that even in the total absence of oxygen, the arrester will not age.

If the manufacturer can prove that the test carried out in the open air is equivalent to that carried out in the actual medium, the ageing procedure can be carried out in the open air.

Accidental intermediate de-energizing of the test samples, not exceeding a total duration of 24 h during the test period is permissible. The interruption will not be counted in the duration of the test. The final measurement should be performed after not less than 100 h of continuous energizing. Within the temperature range allowed, all measurements shall be made at the same temperature ±1 K.

8.4.3.4 Evaluation

The test shall be considered passed if, for all three MO resistors, the following criteria are met:

any increase of power losses from P_{min} is not greater than 1,3 times P_{min} during the remaining test period

all measurements of power losses throughout the ageing period, including the final measurement, P_{end}, is not greater than 1,1 times P_{start}.

8.5 Test to verify the repetitive charge transfer rating, Q_{rs}

8.5.1 General

The purpose of this test is to verify the repetitive charge transfer rating, Q_{rs}, of an arrester.

Repetitive charge transfer capability is specified as an impulse current stress that can be withstood by the MO resistors of an arrester twenty times without mechanical or unacceptable electrical damage. One impulse current stress is considered to represent a charge transfer event that may occur under real system conditions.

The repetitive charge transfer rating is related to a certain very low failure probability and is thus not a deterministic but a statistical value. The test is performed on individual MO resistors at a charge value in the range 1,1 to 1,2 times the rated value selected from the list in 8.5.4. By this approach it is assumed that the performance of the individual MO resistors can also be assigned to a full arrester built from these MO resistors, based on the test requirements and the chosen statistical approach.

Charge has been chosen as a test basis for the purpose of better comparison between different makes of MO resistors.

For this test long-duration impulse currents or unipolar sine half-wave current impulses of similar time durations shall be applied. Only for MO resistors that are intended for use in distribution class arresters and in NGLA, lightning impulse currents 8/20 μs or lightning impulse discharges as per 3.32 may be used. The choice is at the discretion of the manufacturer.

An arrester shall be assigned a Q_{rs} value from the list given in 8.5.4.

A first test sequence shall be performed on 10 samples of MO resistors selected according to 7.3.1 d). If not more than one MO resistor fails, the entire test is passed. If two MO resistors fail, a second sequence identical to the first shall be performed on an additional 10 samples. The entire test shall then be passed if there is no failure of an MO resistor during this second sequence. If more than two MO resistors fail in the first test sequence or any MO resistor fails in the second test sequence, the entire test is failed.

Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022

8.5.2 Test procedure

Figure 2 gives an overview of the test procedure.

Initial tests • Residual voltage test at nominal discharge current • Reference voltage test at specified reference current
Application of 1,1 times Q_{rs} • 1st sequence:, 20 impulses per sample (10 samples) • if not more than one sample failure during 1st sequence: test passed • if not more than two sample failures during 1st sequence: conduct 2nd sequence with 10 samples, 20 impulses per sample • if more than two sample failures in 1st sequence or any sample failure in 2nd sequence: test failed
Test evaluation: check for • no mechanical damage at visual inspection • change of reference voltage within ±5% • change of residual voltage at nominal discharge current within ±5% • withstand capability to one 8/20 current impulse of at least 0,5 kA/cm^2 peak current density or 2 times I_n, whichever is lower

Figure 2 – Test procedure to verify the repetitive charge transfer rating, Q_{rs}

Ten test samples shall be tested in the first sequence. Depending on the results, it may be necessary to test an additional ten samples in a second sequence.

The samples shall fulfil the requirements in 7.3.

The following procedure shall be followed:

Each sample shall be subjected to a residual voltage test at nominal discharge current and a reference voltage test at specified reference current before and after the test. For MO resistors in multi-column arresters the nominal discharge current applied in the test is the highest nominal discharge current used for the type of MO resistors in any design.

Each sample shall be subjected to twenty current impulses administered in ten groups of two impulses, with time between impulses within a group of 50 s to 60 s and time between groups sufficient for cooling to ambient temperature.

The wave shape and duration of the current impulses shall be as follows:

a) for arresters not intended for application on overhead transmission or distribution lines (i.e. intended for use in stations): long-duration (rectangular) impulses of 2 ms to 4 ms virtual total duration or unipolar sine half-wave impulses of 2 ms to 4 ms total duration;

b) for NGLA: lightning impulse discharges according to Annex H;

c) for distribution class arresters: 8/20 lightning impulses.

The charge content of each impulse shall be as follows:

a) for single-column arresters: at least equal to the claimed repetitive charge transfer rating (selected from the list given in 8.5.4) multiplied by 1,1;

b) for multi-column arresters: at least equal to the claimed repetitive charge transfer rating (selected from the list given in 8.5.4) multiplied by 1,1, then divided by the number of columns, and then multiplied by the current sharing factor β_g (see item c) of 7.3).

NOTE 1 The requirement of testing at least 1,1 times the rated charge values is considered to give sufficient confidence that the performance of the individual MO resistors can also be assigned to complete arresters built from this type of MO resistors.

AVA Documents
Document Sharing Hub
© Standards Australia Limited 2022
Full document details: AS 60099.4-2022

NOTE 2 If MO resistors tested with charge values for single-column arresters are used in a multi-column arrester and no new test is performed the repetitive charge transfer rating for the complete multi-column arrester is the next lower or equal value (in the list shown in 8.5.4) to the repetitive charge transfer rating of the MO resistors times the number of columns and divided by the current sharing factor.

8.5.3 Test evaluation

The full test shall be considered passed if either

- not more than one sampled failed during the first sequence, or
- not more than two samples failed during two sequences.

Otherwise, the test is considered as failed and a lower charge level, Q_{rs}, from the list shown in 8.5.4 shall be selected, and the test shall be repeated for this lower charge level following the procedure given in 8.5.2.

NOTE 1 If only one failure occurs during the first sequence and this happens, in the worst case, at the very first impulse application, 180 impulses without failure will have been applied at the end, giving a failure probability of max. 1/181 = 0,005 6 or 0,56 % for the complete test. If two failures occur during the first sequence and this happens, again as a worst case, at the very first applications on two of the samples, 360 impulses without failure will have been applied at the end of both sequences, giving again a failure probability of max. 2/362 = 0,005 6 or 0,56 % for the complete test.

Each individual sample shall be considered to have withstood the complete series of impulses if all the following criteria are met:

- there is no indication of mechanical damage (puncture, flashover or cracking);
- any change of the reference voltage before and after the test, measured at the same temperature ± 3 K, is within ±5 %;
- any change of the residual voltage at nominal discharge current before and after the test is within ±5 %;
- a final application of a current impulse 8/20 μs of an amplitude resulting in a current density of at least 0,5 kA/cm^2 or in 2 times I_n, whichever is lower, is passed without mechanical damage.

NOTE 2 Burning or arcing damage **to** the metallization is not considered a mechanical damage if all other pass criteria are met.

8.5.4 Rated values of repetitive charge transfer rating, Q_{rs}

The repetitive charge transfer rating values shall be taken from the following list:

- from 0,1 C to 1,2 C in steps of 0,1 C
- from 1,2 C to 4,4 C in steps of 0,4 C
- from 4,4 C up to 10,0 C in steps of 0,8 C
- from 10 C to 20 C in steps of 2 C
- from 20 C upward in steps of 4 C

NOTE The following factors to calculate corresponding impulse current amplitudes from the charge values are given for guidance:

- Long-duration current, 2 ms: $\hat{\imath}$ / A ≈ 500 × Q_{rs} / C
- Long-duration current, 4 ms: $\hat{\imath}$ / A ≈ 250 × Q_{rs} / C
- Unipolar sine half-wave, 2 ms: $\hat{\imath}$ / A ≈ 786 × Q_{rs} / C
- Unipolar sine half-wave, 4 ms: $\hat{\imath}$ / A ≈ 393 × Q_{rs} / C
- Lightning current impulse 8/20: $\hat{\imath}$ / kA ≈ 62 × Q_{rs} / C
- Lightning impulse discharge according to 3.32: $\hat{\imath}$ / kA ≈ 8 × Q_{rs} / C

The resulting current amplitudes are informative and are approximate values, calculated under the assumption of an ideally rectangular impulse current shape in case of the long-duration current impulses, of an ideal lightning current impulse 8/20 μs and of an ideally sinusoidal half-wave current of 200 μs base time in case of the long-duration

AVA Documents
Document Sharing Hub

© Standards Australia Limited 2022

Full document details: AS 60099.4-2022