

IEEE Standard Test Specifications for Surge-Protective Devices for Low-Voltage AC Power Circuits

Sponsor

**Surge Protective Devices Committee
of the
IEEE Power Engineering Society**

Approved 29 February 2000

IEEE-SA Standards Board

Abstract: This standard establishes methods for testing and measuring the performance characteristics for surge-protective devices used in low-voltage ac power circuits. Definitions are stated that apply specifically to surge-protective devices. The testing requirements are categorized into two groups, in which a minimum set of basic tests (BTs) are prescribed for all surge-protective devices within the scope of its documents, supplemented by additional tests (ATs) that might be needed to establish particular application requirements.

Keywords: discharge voltage, electromagnetic interference (EMI), flashover, impulse, lightning, surge-protective devices

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2000 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 7 June 2000. Printed in the United States of America.

Print: ISBN 0-7381-1990-3 SH94837
PDF: ISBN 0-7381-1991-1 SS94837

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

IEEE is the sole entity that may authorize the use of certification marks, trademarks, or other designations to indicate compliance with the materials set forth herein.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not a part of IEEE Std C62.62-2000, IEEE Standard Test Specifications for Surge-Protective Devices for Low-Voltage AC Power Circuits).

The purpose of this standard is to provide users, independent laboratories, and manufacturers with a test specification applicable to surge-protective devices intended for limiting transient overvoltages that can appear on ac power circuits of 1000 V (rms) or less. The standard contains test specifications that allow the user to compare different surge-protective devices. It is one of several successor documents to IEEE Std C62.41-1991, which characterized the surge voltage environment to which low-voltage ac power circuits are exposed.

The interest in low-voltage ac surge-protective devices has grown with the trend to use highly sophisticated electrical and electronic equipment that is exposed and susceptible to surges from the environment. This standard provides an overview of test methods for protective devices.

Suggestions for improvements to this Standard will be welcomed. They should be sent to the Secretary, IEEE-SA Standards Board, Institute of Electrical and Electronics Engineers, 3 Park Avenue, New York, NY 10016-5997.

Participants

The Working Group 3.6.6 on Low-Voltage AC Power Circuit Surge Protectors had the following membership who contributed to the writing of this document:

Matthew S. Wakeham, *Chair*

Doug Dorr, *Secretary*

Warren Boxleitner
Francis J. Fiederlein
Laurence H. Fish
M. Michael Flack
H. Edward Foelker
Ernie Gallo

Gary L. Goedde
David W. Hutchins
P. A. Jedlicka
Wilhelm H. Kapp
Benny Lee
Ed H. Marrow, Jr.
Francois D. Martzloff

Richard Odenberg
William T. Rhoades
Hans Steinhoff
Mike F. Stringfellow
Bernard I. Wolff
Donald M. Worden

The following members of the balloting committee voted on this standard:

James J. Burke
Chrys Chrysanthou
Robert Davidson, Jr.
Cliff C. Erven
Laurence H. Fish
H. Edward Foelker
Ernie Gallo
Peter A. Goodwin
Andrew Robert Hileman
David W. Hutchins
David W. Jackson

Wilhelm H. Kapp
Joseph L. Koepfinger
Gerald E. Lee
William A. Maguire
Francois D. Martzloff
Richard Odenberg
Joseph C. Osterhout
Michael Parente
John B. Posey
Hazairin Samaulah
Ronald B. Standler

Hans Steinhoff
Keith B. Stump
Lewis Douglas Sweeney
Dennis P. Symanski
Edgar R. Taylor, Jr.
Arnold Vitols
Arthur C. Westrom
Steve G. Whisenant
James Wilson
Jonathan J. Woodworth
Donald M. Worden

The final conditions for approval of this standard were met on 29 February 2000. This standard was conditionally approved by the IEEE-SA Standards Board on 30 January 2000, with the following membership:

Richard J. Holleman, *Chair*
Donald N. Heirman, *Vice Chair*
Judith Gorman, *Secretary*

Satish K. Aggarwal
Dennis Bodson
Mark D. Bowman
James T. Carlo
Gary R. Engmann
Harold E. Epstein
Jay Forster*
Ruben D. Garzon

James H. Gurney
Lowell G. Johnson
Robert J. Kennelly
E. G. "Al" Kiener
Joseph L. Koepfinger*
L. Bruce McClung
Daleep C. Mohla
Robert F. Munzner

Louis-François Pau
Ronald C. Petersen
Gerald H. Peterson
John B. Posey
Gary S. Robinson
Akio Tojo
Hans E. Weinrich
Donald W. Zipse

*Member Emeritus

Also included is the following nonvoting IEEE-SA Standards Board liaison:

Robert E. Hebner

Catherine Berger
IEEE Standards Project Editor

National Electrical Code and NEC are both registered trademarks of the National Fire Protection Association, Inc.
National Electrical Safety Code and NESC are both registered trademarks of the Institute of Electrical and Electronics Engineers, Inc.

Contents

1.	Overview.....	1
1.1	Scope.....	1
1.2	Purpose.....	1
2.	References.....	1
3.	Definitions.....	2
4.	Service conditions.....	7
4.1	Normal service conditions	7
4.2	Nonstandard service conditions	7
5.	Safety and electromagnetic interference (EMI).....	8
6.	General test considerations	9
6.1	Safety	9
6.2	Surge-protective device test specimens	9
6.3	Connection	9
6.4	Mounting.....	9
6.5	Standard test conditions	9
6.6	Categorization of tests.....	10
6.7	Failure modes.....	10
7.	Performance characteristics and test descriptions.....	10
7.1	Surge response voltage test (BT)	10
7.2	Maximum continuous operating voltage (MCOV) (BT)	11
7.3	Maximum single withstand surge current test (BT)	11
7.4	Minimum surge life with line voltage applied (BT)	11
7.5	Voltage regulation (BT).....	12
7.6	Load current capability (AT)	12
7.7	Protection status indication (AT).....	13
7.8	Standby power dissipation test (AT).....	13
7.9	Insulation resistance (AT).....	13
7.10	Dielectric withstand voltage (AT)	13
7.11	Failure safety mode.....	14
7.12	Response to front of wave.....	14
8.	Construction.....	15
8.1	Enclosure.....	15
8.2	Overcurrent protection	15
	Annex A (normative) Regulatory requirements	16
	Annex B (informative) Figures and definitions.....	17
	Annex C (informative) Bibliography.....	22

IEEE Standard Test Specifications for Surge-Protective Devices for Low-Voltage AC Power Circuits

1. Overview

1.1 Scope

This standard applies to surge-protective devices intended to be installed on the load side of the main service disconnect packaged to be connected to 50 Hz or 60 Hz ac power circuits rated at 1000 V (rms) or less. Performance characteristics and standard methods for testing and rating are established for these devices, which may be composed of any combination of components. The tests in this standard are aimed at providing comparisons among the variety of surge-protective devices available.

Many of the tests described in this standard may stress a surge-protective device. Care should be taken to ensure that stressed devices are not compared with unstressed devices unless that is the desired intent. The suppression characteristics of some surge-protective devices change with successive surging as well as with changes in the environment. These changes may be permanent in nature. Selection and careful organization of appropriate tests can reduce the quantity of test samples needed.

The voltage and energy levels employed in the majority of the tests described in this standard are hazardous and appropriate cautions must be exercised in their performance.

1.2 Purpose

The purpose of this standard is to provide users, independent laboratories, and manufacturers with test methods and test specifications applicable to low-voltage surge-protective devices, intended for limiting transient overvoltages that can appear on ac power circuits of 1000 V (rms) or less.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

Accredited Standards Committee C2-1997, National Electrical Safety Code[®] (NESC[®]).¹

¹The NESC is available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

ANSI C84.1-1995, American National Standard for Voltage Ratings for Electric Power Systems and Equipment (60 Hz).²

IEEE Std C62.1-1989 (Reaff 1994), IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits.³

IEEE Std C62.2-1989 (Reaff 1994), IEEE Guide for Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems.

IEEE Std C62.11-1999, IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV).

IEEE Std C62.31-1987 (Reaff 1998), IEEE Standard Test Specifications for Gas Tube Surge-Protective Devices.

IEEE Std C62.33-1982 (Reaff 1994), IEEE Standard Test Specifications for Varistor Surge-Protective Devices.

IEEE Std C62.35-1987 (Reaff 1993), IEEE Standard Test Specifications for Avalanche Junction Semiconductor Surge-Protective Devices.

IEEE Std C62.41-1991 (Reaff 1995), IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

IEEE Std C62.42-1992 (Reaff 1999), IEEE Guide for the Application of Gas Tube and Air Gap Arrester Low-Voltage (Equal to or Less than 100 Vrms or 1200 Vdc) Surge-Protective Devices.

IEEE Std C62.45-1992 (Reaff 1998), IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.

IEEE Std 4-1995, IEEE Standard Techniques for High-Voltage Testing.

NFPA 70-1999, The National Electrical Code[®] (NEC[®]).⁴

UL 1449-1996, Standard for Transient Voltage Surge Suppressors, Second Edition.⁵

3. Definitions

The following definitions apply specifically to surge-protective devices and do not necessarily cover other applications.

3.1 certification tests: Tests run on a regular, periodic basis to verify that selected key performance characteristics of a product, or representative samples thereof, have remained within performance specifications.

²ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

³IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁴NFPA publications are published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA (<http://www.nfpa.org/>).

⁵UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>).

3.2 clamping voltage: The peak voltage across the surge-protective device measured under conditions of a specified surge current and specified current waveform.

3.3 combination surge: *See: combination wave.*

3.4 combination wave: A surge delivered by an instrument that has the inherent capability of applying a 1.2/50-voltage wave across an open-circuit, and delivering an 8/20-current wave into a short circuit. The instantaneous impedance to which the combination wave is applied determines the exact wave that is delivered. The peak magnitudes of the voltage or current wave shall be specified. *Syn: combination surge.*

3.5 crest (peak) value: The maximum absolute value that a wave, surge, or impulse attains.

3.6 design tests: Tests made by the manufacturer on each design to establish the performance characteristics and to demonstrate compliance with the appropriate standards of the industry. Once made, they need not be repeated unless the design is changed (so as to modify performance).

3.7 dielectric withstand voltages: The maximum voltage that may be applied between line or phase terminals and the neutral or ground terminals (or the device enclosure) without causing electrical failure or breakdown of the device insulation.

3.8 discharge current: The surge current that flows through the surge-protective device when conduction occurs.

3.9 discharge current withstand rating: The specified magnitude and wave shape of a discharge current that can be applied to a surge-protective device a specified number of times without causing damage or degradation beyond specified limits.

3.10 discharge voltage: The voltage that appears across other terminals of a surge-protective device during passage of discharge current.

3.11 discharge voltage-current characteristic: The variation of the crest values of discharge voltage with respect to discharge current.

3.12 disruptive discharge: (A) The sudden and large increase in current through an insulating medium, due to the complete failure of the medium under the electrostatic stress. (B) An increase that causes explosive mechanical or electrical failure in one of the failure modes.

3.13 fault current: The current from the connected power system that flows in a short circuit.

3.14 flashover: A disruptive discharge around or over the surface of a solid or liquid insulator.

3.15 follow (power) current: The current from the connected power source that flows through a surge-protective device during and following the passage of discharge current.

3.16 grounded system: An electric system in which at least one conductor or point (usually the neutral conductor of neutral point of transformer or generator windings) is intentionally grounded, either solidly or through a grounding device.

3.17 impulse: A surge of unidirectional polarity.

3.18 impulse sparkover voltage: The highest value of voltage attained by an impulse of a designated wave shape and polarity applied across the terminals of a gap-type surge-protective device prior to the flow of discharge current.