Recognized as an
American National Standard (ANSI)

IEEE Std C62.64-1997

IEEE Standard Specifications for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits

Sponsor

Surge Protective Devices Committee
of the
IEEE Power Engineering Society

Approved 21 January 1997

IEEE Standards Board

Approved 28 May 1997

American National Standards Institute

Abstract: This standard applies to surge protectors for application on multiconductor and coaxial, balanced or unbalanced, data, communications, and signaling circuits with voltages less than or equal to 1000 V rms, or 1200 V dc. These surge protectors are intended to limit voltage surges, current surges, or both.
Keywords: communications circuits, data circuits, electrical protection, signaling circuits, surge protectors

---

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

ISBN 1-55937-875-1

Introduction

(This introduction is not part of IEEE Std C62.64-1997, IEEE Standard Specifications for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits.)

This first issue of IEEE Std C62.64-1997 has been developed by the Low-Voltage Data, Communications, and Signaling Circuit Working Group of the Low-Voltage Surge Protective Devices Subcommittee. It provides preferred values of the parameters that are used to specify the performance of these surge protectors. The tests that are used to characterize the parameters are in IEEE Std C62.36-1994, so the two standards are companion documents.

This standard is directed toward service providers who wish to provide electrical protection against surges on low-voltage circuits. The standardized preferred values promote consistency by helping users in selecting appropriate parameter values, and by aiding suppliers in focusing their resources on parameters of interest. Yet, this standard is flexible enough that applications needing values that differ from the preferred levels can use whatever is required.

This standard covers a wide range of possible protectors. They may limit voltages, currents, or both. Not all specification values apply to each protector. The user of the standard selects, from among the many possible specifications, the tests and parameter values needed by the application. For instance, a protector for an application that requires only voltage limiting would not specify values from the current-limiting specifications (see Clause 6), and would select only the parameters from the voltage-limiting specifications (see Clause 5) that are required by the application. In that way, a voltage-limiting surge protector may include, for example, a specification value for return loss (see 7.2), but not for longitudinal balance (see 7.3).

The preferred values of this standard also provide standardized values of important parameters for use with international standardization efforts.

The Accredited Standards Committee on Surge Arresters, C62, had the following members at the time of ballot:

Joseph L. Koepfinger, *Chair* **John A. Gauthier,** *Secretary*

Organization Represented	*Name of Representative*
Alliance for Telecommunication Industry Solutions	Chrysanthos Chrysanthou
Association of American Railroads	Wayne Etter
Bonneville Power Administration	Gerald E. Lee
Canadian Standards Association	D. M. Smith
Electric Light and Power	James W. Wilson R. A. Jones William A. Maguire Gary N. Miller *(Alt.)*
Institute of Electrical and Electronics Engineers	Joseph L. Koepfinger J. J. Burke G. L. Gaibrois Wilhelm H. Kapp C. Hansell *(Alt.)* Edgar R. Taylor, Jr. *(Alt.)*
National Electrical Manufacturers Association	Dennis W. Lenk Larry Bock Hans Steinhoff Jonathan J. Woodworth
National Institute for Science and Technology	Francois D. Martzloff
Rural Electrification Administration	E. Cameron
Underwriters Laboratories	P. Nortarian
Members-at-Large	Joseph C. Osterhout Steven G. Whisenant

At the time this standard was completed, the Low-Voltage Data, Communications, and Signaling Circuit Working Group had the following membership:

Michael Parente, *Chair* **Chrysanthos Chrysanthou,** *Secretary*

J. Stanley Bonnesen
Nisar Chaudhry
Ernie J. Gallo
Wilhelm H. Kapp
David Kerr
Benny Lee
E. H. Marrow, Jr.
Albert R. Martin
Brian D. Price
William J. Shannon
Donald B. Turner
Dee Unterweger

The following persons were on the balloting committee:

Warren Boxleitner
Chrysanthos Chrysanthou
Peter A. Goodwin
David W. Hutchins
David W. Jackson
Wilhelm H. Kapp
Jeff J. Kester
Joseph L. Koepfinger
Gerald E. Lee
William A. Maguire
Albert R. Martin
Francois D. Martzloff
Michael Maytum
Richard Odenberg
Joseph C. Osterhout
Michael Parente
William J. Shannon
Hans Steinhoff
L. Douglas Sweeney
Edgar R. Taylor, Jr.
Donald B. Turner
Arnold Vitols
James W. Wilson Jr.
Donald M. Worden

Contents

IEEE Standard Specifications for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits

1. Overview

This standard is divided into seven clauses. Clause 1 provides the scope of this standard. Clause 2 lists references to publications that are needed to apply this standard. Clause 3 provides general specifications that may be needed for a surge protector regardless of its voltage- or current-limiting function. Clause 4 provides mechanical and environmental specifications that may be needed regardless of a protector's voltage- or current-limiting function. Clause 5, for protectors that limit surge voltages, is partitioned into two subclauses. The first provides specifications that avoid disturbing the circuit when no voltage surges are present; the second covers the voltage-limiting performance of the protector when a surge is present. Clause 6, for protectors that limit surge currents, is partitioned into two subclauses. The first provides specifications that avoid disturbing the circuit when no current surges are present; the second covers the current-limiting performance of the protector when a surge is present. Clause 7 provides specifications that may apply to either type of protector, and are intended to avoid disturbing the circuit when no surges are present.

1.1 Scope

This standard applies to surge protectors for application on multiconductor and coaxial, balanced or unbalanced, data, communications, and signaling circuits with voltages less than or equal to 1000 V rms, or 1200 V dc. These surge protectors are intended to limit voltage surges, current surges, or both.

This standard provides performance criteria and tables of preferred values for performance based on characterization tests performed in accordance with IEEE Std C62.36-1994[1]. The surge protectors covered are multiple-component series or parallel combinations of linear or nonlinear elements, packaged for the purpose of limiting voltage, current, or both. Figure 1 of IEEE Std C62.36-1994, reproduced here for convenience, illustrates as functional block diagrams the surge protectors covered by this standard.

This standard is not intended to cover packaged single gas tube, air gap, varistor, or avalanche junction surge-protective devices, which are included in IEEE Std C62.31-1987, IEEE Std C62.32-1981, IEEE Std C62.33-1982, and IEEE Std C62.35-1987, respectively. Safety aspects of performance specifications are not covered; such aspects are covered in the National Electrical Code® (NEC®) (NFPA 70-1996). Specifically excluded from this standard are protectors for low-voltage power circuit applications.

[1]Information on references can be found in Clause 2.

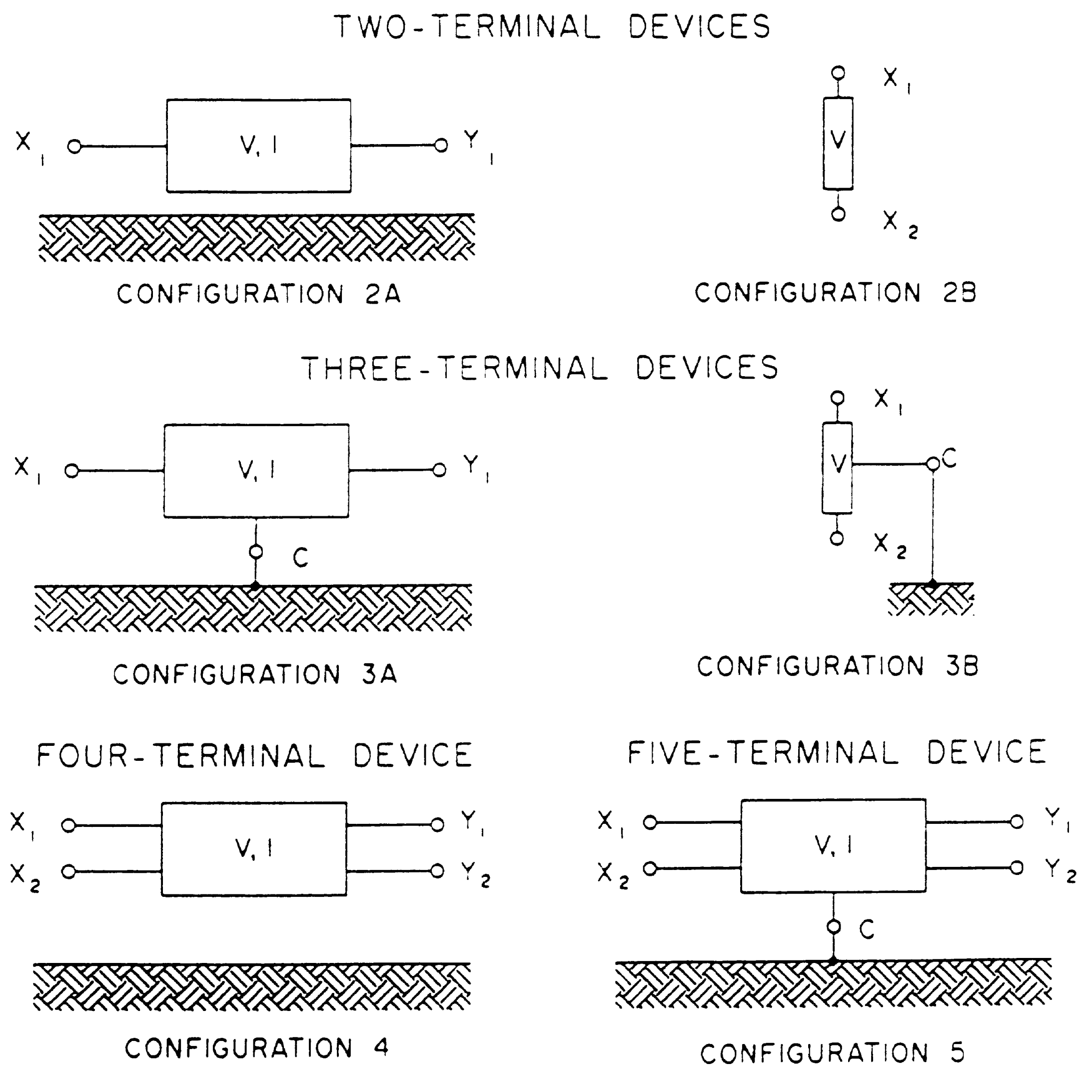

Figure 1—Basic configurations

The surge protectors covered by this standard are to be tested by means of the connections or terminations that are used when the surge protector is installed in the field. For surge protectors that are intended to be used with a base or connector, that base or connector shall be part of the tests.

The tables of preferred performance values of this standard provide a means of comparison among various surge protectors. They also provide a common engineering language beneficial to the user and manufacturer of surge protectors used in low-voltage data, communications, and signaling circuits.

This standard uses terminology for surge protective devices as defined in IEEE Std 100-1996.

1.2 Specification types

Tables of specifications in this standard often refer to *specification types.* In such tables, each specification type is given an alphanumeric designation that refers only to the parameter of that table. All of the parameter values on the same row as the designator apply to that specification type. A given surge protector may have a different specification type designation in other tables. For instance, a surge protector may have specification type designation 1 for the insulation resistance specification, but specification type designation B for the impulse-limiting voltage specification, and specification type designation 3 for impulse reset.

1.3 Preferred values

The values for the parameters listed in the tables for the various specification types are preferred in the sense that their use promotes uniformity. However, specific applications may require values other than the preferred values of the tables.

2. References

This standard shall be used in conjunction with the following publications:

IEEE Std 100-1996, IEEE Standard Dictionary of Electrical and Electronics Terms.[2]

IEEE Std 455-1985 (Reaff 1992), IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band (ANSI).

IEEE Std C62.31-1987 (Reaff 1993), IEEE Standard Test Specifications for Gas-Tube Surge-Protective Devices (ANSI).

IEEE Std C62.32-1981 (Reaff 1993), IEEE Standard Test Specifications for Low-Voltage Air Gap Surge-Protective Devices (Excluding Valve and Expulsion Type Devices) (ANSI).

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

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

IEEE Std C62.36-1994, IEEE Standard Test Methods for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits.

ITU Recommendation K.17, Tests on Power-Fed Repeaters, Geneva, 1988.[3]

NFPA 70-1996, National Electrical Code® (NEC®) (ANSI).[4]

3. General specifications

3.1 Marking and documentation

The following information shall be provided by the manufacturer, by means of markings, product information data sheets, technical practice bulletins, or other suitable documentation:

a) Manufacturer’s name or trademark, and model identifier;
b) Intended application;

[2]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.
[3]ITU-T publications are available from the International Telecommunication Union, Place des Nations, CH-1211, Geneva 20, Switzerland.
[4]The NEC® is available from the NFPA, Publications Sales, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA. It is also available from the IEEE.

c) Operating temperature-humidity exposure category (controlled or uncontrolled);
d) Any applicable safety agency approvals;
e) Complete list of specification types, in accordance with the characteristics in this specification, to the extent that the specifications are applicable;
f) Installation instructions;
g) If the surge protector has replaceable components, then the replacement instructions shall be included in the documentation or marking information;
h) If the surge protector is dependent on polarity, or if it could be incorrectly installed, then the terminal identification shall be included in the marking information;
i) If the surge protector has mechanical, optical, or other means to indicate the need to be replaced or reset, an explanation of the meaning of the indicator shall be included in the documentation or marking;
j) If the surge protector contains radioactive material, it shall be marked in accordance with applicable regulations.

3.2 Marking

Each surge protector shall be marked in such a manner as to identify the manufacturer and model. Any marking on the surge protector of the information specified in 3.1 shall be indelible and legible.

3.3 Mechanical design

The surge protector shall not have sharp edges, corners, etc., that could injure personnel during installation or maintenance. If preloaded springs are employed in the construction, they shall be adequately contained such that they do not cause injury during installation or removal of the surge protector.

The surge protector shall have sufficient mechanical strength such that it does not explode, thereby creating hazardous projectiles, when subjected to surges within the scope of this standard.

3.4 Lead pull-out

External leads shall be capable of withstanding a 20 lb (89 N) pull for 1 min.

3.5 Mounting arrangements

The surge protector shall be capable of being mounted securely in its intended position. Any visual indicators shall be readily accessible and viewable.

4. Mechanical and environmental specifications

4.1 Operating temperature and humidity

Two categories of operating temperature and humidity for the application of surge protectors are covered in this standard. Each category has an associated range of temperature and relative humidity.

— Controlled temperature and humidity
Temperature: 2 °C to 50 °C
Relative humidity: 10% to 80%

— Uncontrolled temperature and humidity
  Temperature: –40 °C to 65 °C
  Relative humidity: 5% to 96%, except that above 50 °C the relative humidity may be reduced to 20%

4.2 Test temperature

Where only one extreme temperature is specified for a characteristic, or if the specified range is narrower than the full range of 4.1, the extreme temperature or narrow range represents the generally accepted worst-case test condition for a generic protector technology within the application. If it is known beforehand that a particular device technology causes a surge protector to be insensitive to temperature when testing a particular characteristic, a room temperature within the range 20–25 °C may be used instead for that test.

If a temperature for a particular test is not specified, the specification value may be measured at any temperature within the range of temperatures for the application (see 4.1). Tests related to lightning-caused surges need not be done at temperatures below –20 °C.

4.3 Temperature and humidity exposure

This characteristic specifies the ability of a surge protector to perform its function after being exposed to temperature and humidity conditions of storage, and while being exposed to the extreme temperatures of its application (see 4.1).

4.3.1 Specification

The duration of exposure to humidity shall be selected from Table 1.

Table 1—Temperature and humidity exposure

Specification type	Duration of exposure (days)
A	10
B	21
C	56

4.3.2 Test method

The surge protector shall be subjected to a sequence of three exposures to humidity and temperature.

During the first exposure, the surge protector is maintained at 40 °C ± 2 °C at a relative humidity between 90% and 96%. The duration of this exposure shall be selected from Table 1. At the end of the exposure, the surge protector shall be subjected to a temperature of 20–25 °C for not less than 1 h and not more than 2 h. Immediately after this recovery period, the test criteria shall be satisfied.

During the second exposure, the surge protector shall be subjected to the minimum temperature of its exposure category of 4.1 (2 °C or –40 °C). The duration of this exposure shall be 24 h. At the end of the exposure, but while the surge protector is maintained at the minimum temperature, the test criteria shall be satisfied.

During the third exposure, the surge protector shall be subjected to the maximum temperature of its exposure category of 4.1 (50 °C or 65 °C). The duration of this exposure shall be 24 h. At the end of the exposure, but while the surge protector is maintained at the maximum temperature, the test criteria shall be satisfied.

During the three exposures, the air flow in the test chamber shall be controlled to provide a free-convection heat-transfer environment with the protector shielded from direct flow of forced air. The surge protector is not subjected to bias voltage or current during the three exposures.

Surge protectors that are subjected to the environmental cycling tests of 5.2.6 or 5.2.7 need not be subjected to the first exposure (40 °C; 90–96% relative humidity) portion of this test sequence. They shall be exposed to the low and high temperature portions of the test sequence.

4.3.3 Test criteria

For surge protectors that limit voltage, the impulse-limiting voltage shall be less than or equal to the specified value, and the insulation resistance shall be greater than or equal to the specified value. For surge protectors that limit current, the transition current and dc series resistance shall be less than or equal to the specified value.

4.4 Vibration during shipping

This characteristic verifies that a surge protector can withstand the vibration experienced in shipping and handling.

4.4.1 Specification

After being subjected to the vibration conditions in Table 2, the surge protector shall be capable of performing its voltage-limiting and current-limiting functions.

Table 2—Frequency sweep criteria for simulation of transportation vibration

Vibration frequency (Hz)	Acceleration (g)	Sweep rate (oct/min)
5–100	0.5	0.1
100–500	1.5	0.25

4.4.2 Test method

Unpowered surge protectors shall be subjected to the swept-frequency vibration conditions of Table 2. The full range of frequencies is swept once at the indicated rate. The vibration and subsequent electrical tests shall be performed at ambient temperature of 20–25 °C. The test criteria are measured after vibration is stopped and the surge protector is at rest.

4.4.3 Test criteria

For surge protectors that limit voltage, the impulse-limiting voltage and dc series resistance shall be less than or equal to the specified value, and the insulation resistance shall be greater than or equal to the specified value. For surge protectors that limit current, the transition current and dc series resistance shall be less than or equal to the specified value.

4.5 Drop test

This characteristic verifies that a surge protector can withstand the mechanical shock that results if it is dropped during installation.

4.5.1 Specification

The surge protector shall not crack or become damaged after being subjected to the drop. In addition, the surge protector shall be capable of performing its voltage-limiting and current-limiting functions.

4.5.2 Test method

Surge protectors that are intended for the uncontrolled temperature and humidity category (see 4.1) shall be conditioned at –40 °C. Surge protectors intended for the controlled temperature and humidity category shall be conditioned at 2 °C. Conditioning shall be for a duration of at least 1 h. Installation drop tests shall be done by dropping the surge protector with its shipping package material removed.

Within 15 s after the conditioning, the surge protector shall be dropped once onto a concrete surface from a height of 1.5 m. The area subjected to the drop shall be that considered most likely to crack or be damaged. If necessary, the protector shall be reassembled after the drop before testing. Any module intended to be replaceable that is damaged during the drop may be replaced.

4.5.3 Criteria

The surge protector shall not crack or become damaged, except as allowed for replaceable modules. For surge protectors that limit voltage, the impulse-limiting voltage and dc series resistance shall be less than or equal to the specified value, and the insulation resistance shall be greater than or equal to the specified value. For surge protectors that limit current, the transition current and dc series resistance shall be less than or equal to the specified value.

5. Voltage-limiting specifications

The performance specifications of Clause 5 apply to the voltage-limiting function of a surge protector.

5.1 Nonsurge performance specifications

The nonsurge voltage-limiting performance specifications of 5.1.1 through 5.1.3 are intended to ensure that, in its quiescent state, the surge protector does not disturb operation of the protected circuit.

5.1.1 Rated voltage

This characteristic specifies the maximum value of voltage (dc or peak of a sinusoid) that may be continuously applied to the voltage-limiting terminals of a surge protector without degrading the transmission characteristics of the circuit to which it is connected and without causing insulation resistance of the protector to be less than a specified amount.

5.1.1.1 Specification

Unless otherwise specified, the value of rated voltage shall be selected from among the preferred values of Table 3.

5.1.1.2 Test method

The rated voltage shall be verified in accordance with 7.1 of IEEE Std C62.36-1994. The rated voltage test shall be performed at 20–25 °C, as well as at the minimum and maximum temperatures of the intended temperature-humidity category (see 4.1). If the rated voltage is a dc rating, the measurement shall be done in both polarities.

Table 3—Preferred values of rated voltage

Specification type	Minimum (V)
1	5
2	8
3	10
4	12
5	15
6	25
7	40
8	50
9	60
10	70
11	100
12	120
13	150
14	200
15	215
16	245
17	265
18	300
19	400
20	500

5.1.1.3 Test criteria

The insulation resistance of the surge protector, when measured at the rated voltage, shall be greater than the value specified in 5.1.2.

5.1.2 Insulation resistance

This characteristic specifies the minimum insulation resistance of a surge protector.

5.1.2.1 Specification

The minimum values of insulation resistance shall be selected from those in Table 4.

5.1.2.2 Test method

Insulation resistance shall be measured in accordance with 7.4 of IEEE Std C62.36-1994. The measurement shall be made in both polarities. Insulation resistance shall be measured at the minimum and maximum temperatures of the intended temperature-humidity category (see 4.1). The measurement of insulation resistance shall be made at the rated voltage. However, additional measurements may be made at voltages lower

Table 4—Minimum insulation resistance

Specification type	Insulation resistance (MΩ)
1	1.25
2	10
3	50
4	100

than the rated voltage if the application requires. If additional lower voltages are used, values of 10 V, 50 V, or 100 V are suggested.

5.1.2.3 Test criterion

The minimum measured insulation resistance, in either polarity, and at all test voltages and temperatures, shall satisfy the value for a given specification type from Table 4.

5.1.3 Capacitance

This characteristic specifies the maximum capacitance of a surge protector between conductors and from conductor(s) to common.

5.1.3.1 Specification

The maximum value of capacitance shall be selected from those in Table 5.

Table 5—Maximum capacitance

Specification type	Capacitance (pF)
1	5
2	10
3	30
4	200
5	500

5.1.3.2 Test method

The capacitance shall be measured in accordance with 7.5 of IEEE Std C62.36-1994. The measurement shall be made with a test signal of 1 V rms and at 1 MHz. No dc bias shall be applied. Measurements shall be done at 20–25 °C, as well as at the minimum and maximum temperatures of the intended temperature-humidity category (see 4.1).

5.1.3.3 Test criterion

The maximum capacitance shall satisfy the value for a given specification type from Table 5.

5.2 Active performance specifications

The active voltage-limiting performance specifications in 5.2.1 through 5.2.7 are intended to ensure the ability of a surge protector to perform its voltage protection function.

5.2.1 Impulse-limiting voltage

This characteristic specifies the maximum voltage at which a surge protector limits a voltage impulse.

5.2.1.1 Specification

The impulse-limiting voltage of a surge protector shall not exceed the values selected from Table 6 when tested at all three of the following specified rates of rise:

a) Any one rate-of-rise between 100 V/s and 100 kV/s
b) 100 V/µs
c) 1000 V/µs

For each rate of rise, a different level of impulse-limiting voltage may be selected from Table 6. The impulse-limiting voltage of a surge protector shall consist of three different values written in the sequence XXX/YYY/ZZZ. Each entry in the sequence corresponds to the limiting voltage selected for each rate-of-rise. For example, the sequence 160/265/NA indicates that a particular surge protector having a rated voltage of 100 V will limit below 160 V at 100 V/s to 100 kV/s; 265 V at 100 V/µs; and that a limit at 1000 V/µs is not applicable for that surge protector. Note that the value in Table 6 (1.6 × rated voltage) refers to any of the rated voltages of Table 3.

Table 6—Maximum impulse-limiting voltage (100 V/s to 100 kV/s, 100 V/µs, 1000 V/µs)

Specification type	Impulse-limiting voltage (V)
A	1.6 × rated voltage
B	265
C	400
D	500
E	600
F	700
G	800
H	900
I	1000
J	1200

5.2.1.2 Test method

The surge protector shall be tested in accordance with 8.2 of IEEE Std C62.36-1994. The test shall be performed at the three rates of rise: 100 V/s to 100 kV/s; 100 V/µs; and 1000 V/µs. For each rate-of-rise, apply sufficient impulse voltage to cause the device to enter its conducting mode. The current conducted by the protector shall not exceed its impulse life capability. For the 100 V/µs and 1000 V/µs rates-of-rise, the short-circuit current of the generator shall have a peak value between 10 A and 100 A and a 10/1000 µs waveform. The load resistors (R_L, R_{L1}, R_{L2}) and source resistors (R_S, R_{S1}, R_{S2}) shall be infinite ohms (open circuit); the dc power supplies (e, e_1, e_2) shall be zero volts (0 V). For the rate-of-rise in 5.2.1.1 a), the ambient temperature shall be –40 °C and 65 °C; for the rates-of-rise in 5.2.1.1 b) and c), the ambient temperature shall be –20 °C and 65 °C.

5.2.1.3 Test criterion

The impulse-limiting voltage of the surge protector shall be less than or equal to the specified value at each rate-of-rise.

5.2.2 Impulse reset

This characteristic verifies that a surge protector, when connected in a simulated application circuit, reverts to its quiescent state within a specified duration after having limited an impulse. Because this standard covers low-voltage data, communication, and signaling circuits, which have low volt-ampere capabilities, this impulse reset specification applies to surge protectors for applications under 150 VA.

5.2.2.1 Specification

The simulated application (voltage and current levels), reset time, and impulse specification shall be selected from those in Table 7. A simulated application shall be selected such that the source voltage is below the rated voltage of the surge protector.

Table 7—Impulse reset

Specification type	Source voltage (V)	Source current (mA)	Impulse waveform (µs)	Max reset time (ms)
1	52.5	260	25 A[b], 10/1000	30
1	135	200[a]	25 A[b], 10/1000	30
2	52.5	260	25 A[b], 10/1000	150
2	135	200[a]	25A[b], 10/1000	150
3	140	825	25 A[b], 10/1000	30
4	52	200	100 A[c]	150
4	80	242[a]	100 A[c]	150
4	135	104[a]	100 A[c]	150
5	150	200[a]	500 A, 10/1000	150

[a] The protector may be paralleled by a series combination of a 135–150 Ω resistor and a 0.08–0.1 µF capacitor.

[b] Alternatively, a peak current having the same magnitude as the impulse life test current may be used.

[c] The waveform of the short-circuit current shall be 10/1000 µs, or the generator of ITU Recommendation K.17 shall be used. If the K.17 generator is used, it shall have an open-circuit voltage of 4000 V, 10/700 µs, with R_3 equal to 25 Ω.

5.2.2.2 Test method

Impulse reset shall be measured in accordance with 8.5 of IEEE Std C62.36-1994. The source voltage, source current, and impulse waveform shall be selected for each specification type from Table 7. Specification types having more than one reset source listed shall be tested with each applicable source. The test shall be performed at 50 °C for the controlled temperature and humidity category, and at 65 °C for the uncontrolled temperature and humidity category (see 4.1). The load resistors R_L, R_{L1}, and R_{L2}, shall be infinite ohms (open circuit). The reset time shall be measured as the duration between the onset of conduction of the impulse and the restoration to the quiescent state. The test shall be repeated in the opposite polarity. Note that a reset time of zero seconds indicates a high probability that the surge protector is open-circuit, and the test is invalid.

5.2.2.3 Test criterion

For each reset source listed for a selected specification type, the reset time of the surge protector shall be less than or equal to the specified maximum in Table 7.

5.2.3 AC life

This characteristic verifies that a surge protector can conduct alternating currents of specified parameters for a given number of repetitions without experiencing a failure mode relevant to the application.

5.2.3.1 Specification

Preferred values for ac life test currents and their durations are listed in Table 8.

Table 8—AC life test currents

Test current[a] (A rms)	Test duration (s)	Life operations
0.5	30	1
1.0	1	60
5.0	1	5
10	1	5
120	0.1	1[b]

[a] Currents are for one pair of terminals (e.g., X_1 to common).
[b] Protector may fail, but shall fail in a short-circuit, low limiting-voltage, or low insulation resistance failure mode.

5.2.3.2 Test method

The ac life test shall be performed in accordance with 8.7 of IEEE Std C62.36-1994. The ac life test shall be conducted at the maximum and minimum operating temperatures of the application (2 °C to 50 °C for controlled temperature and humidity, or –40 °C to 65 °C for uncontrolled temperature and humidity). Separate samples shall be tested for each test current.

The sources shall have a frequency of 50 Hz or 60 Hz. The load resistors shall be infinite ohms (open circuit). Insulation resistance and impulse-limiting voltage are to be measured after each ac life-test surge.

5.2.3.3 Test criteria

The surge protector has met the ac life requirements if after conducting each of the specified number of operations it meets the criteria of the insulation resistance and impulse-limiting voltage tests. After the specified number of operations it shall satisfy the impulse reset test.

A protector shall be considered to have reached end-of-life if any of the following conditions apply:

a) The insulation resistance, when measured at rated voltage, is less than the appropriate value selected from Table 4. The test shall be performed as in 5.1.2.

b) The impulse-limiting voltage exceeds the maximum value specified for the device at 100 V/µs. The test shall be performed as in 5.2.1.

c) The device fails to revert to the quiescent state within the specified duration during the impulse reset test. The test shall be performed as in 5.2.2.

5.2.4 Impulse life

This characteristic verifies that a surge protector can conduct impulse currents of specified parameters for a given number of repetitions without experiencing a failure mode relevant to the application.

5.2.4.1 Specification

Preferred values for impulse life test currents are listed in Table 9.

Table 9—Impulse life test currents

Peak short-circuit current[a] (peak amperes)	Current waveform (µs)	Life operations
± 10	10/1000	1500
± 100	10/1000	100
± 100	10/1000	300
± 300	10/1000	50
± 500	10/1000	400
± 1000	10/250	10
± 2000	10/250	5

[a]Currents are for one pair of terminals (e.g., X_1 to common).

5.2.4.2 Test method

The impulse life test shall be performed in accordance with 8.8 of IEEE Std C62.36-1994. The impulse life test shall be conducted at the following maximum and minimum operating temperatures, depending on the application as follows:

2 °C to 50 °C for controlled temperature and humidity
–20 °C to 65 °C for uncontrolled temperature and humidity

Protectors shall be tested with both positive and negative waveforms. Half of the test sample shall be tested with one polarity of impulse, and the other half with the other polarity. Separate samples shall be tested for each test current.

The load resistors shall be infinite ohms (open circuit). Insulation resistance and impulse-limiting voltage are to be measured after each impulse life-test surge.

5.2.4.3 Test criteria

The surge protector has met the impulse life requirements if after conducting each of the specified number of operations it meets the criteria of the insulation resistance and impulse-limiting voltage tests. After the specified number of operations it shall satisfy the impulse reset test.

A protector shall be considered to have reached end-of-life if any of the following conditions apply:

a) The insulation resistance, when measured at rated voltage, is less than the appropriate value selected from Table 4. The test shall be performed as in 5.1.2.
b) The impulse-limiting voltage exceeds the maximum value specified for the device at 100 V/μs. The test shall be performed as in 5.2.1.
c) The device fails to revert to the quiescent state within the specified duration during the impulse reset test. The test shall be performed as in 5.2.2.

5.2.5 Maximum single-impulse discharge

This characteristic verifies that a surge protector can conduct a specified current impulse without failing in an unacceptable mode. This test applies only to surge protectors connected to outside cables that do not have a metallic screen (i.e., to unshielded cable).

5.2.5.1 Specification

Unless otherwise specified, apply an impulse current having a waveform and a peak amplitude selected from among the preferred values in Table 17.

5.2.5.2 Test method

Maximum single-impulse discharge shall be tested in accordance with 8.9 of IEEE Std C62.36-1994. The load resistance, R_L, shall be an open circuit. The impulse current shall be applied simultaneously to the terminals that connect to outside cables.

5.2.5.3 Test criterion

After application of the current impulse, it shall be verified that the impulse-limiting voltage of the surge protector does not exceed the impulse-limiting voltage requirement at 100 V/μs in 5.2.1.

5.2.6 Environmental cycling with impulse surges

This characteristic specifies the ability of the voltage-limiting function of a surge protector to conduct repeated impulse surges of specified parameters while undergoing temperature cycling at high humidity. This characteristic applies only to surge protectors intended for the uncontrolled temperature and humidity of 4.1.

5.2.6.1 Specification

During and after environmental cycling, the voltage-limiting surge protector shall continue to function when subjected to impulse surges from a test generator.

5.2.6.2 Test method

The surge protector shall be tested in accordance with 8.12 of IEEE Std C62.36-1994. The noncondensing environmental cycle shall be as in Figure 17 of IEEE Std C62.36-1994. The period of exposure shall be

30 days. The open-circuit voltage of the surge generator shall have a rate-of-rise between 100 V/µs and 1000 V/µs. The short-circuit current of the surge generator shall have a peak value of 10 A, 25 A, or 100 A, and a 10/1000 µs waveform. For configurations 4 and 5, impulse current is applied simultaneously to all terminals that connect to outside cables. The dc voltage applied to the surge protector during environmental cycling shall be the rated voltage or lower.

5.2.6.3 Test criteria

During environmental cycling, and within 1 h after cycling, the surge protector shall satisfy the specifications for insulation resistance (see 5.1.2) and impulse-limiting voltage (see 5.2.1). The specification value for insulation resistance during the cycle may differ from that used after cycling.

5.2.7 Environmental cycling with ac surges

This characteristic specifies the ability of the voltage-limiting function of a surge protector to conduct repeated ac surges of specified parameters while undergoing temperature cycling at high humidity. This characteristic applies only to surge protectors intended for the uncontrolled temperature and humidity of 4.1.

5.2.7.1 Specification

During and after environmental cycling, the voltage-limiting surge protector shall continue to function when subjected to ac surges from a test generator.

5.2.7.2 Test method

The surge protector shall be tested in accordance with 8.13 of IEEE Std C62.36-1994. The noncondensing environmental cycle shall be as in Figure 17 of IEEE Std C62.36-1994. The period of exposure shall be 30 days. The short-circuit current of the generator shall be 1 A rms; the duration of each ac surge shall be 1 s. For configurations 4 and 5, ac surge current is applied simultaneously to all terminals that connect to outside cables. The dc voltage applied to the surge protector during environmental cycling shall be the rated voltage or lower.

5.2.7.3 Test criteria

During environmental cycling, and within 1 h after cycling, the surge protector shall satisfy the specifications for insulation resistance (see 5.1.2) and impulse-limiting voltage (see 5.2.1). The specification value for insulation resistance during the cycle may differ from that used after cycling.

6. Current-limiting specifications

The performance specifications of Clause 6 apply to the current-limiting function of a surge protector.

6.1 Nonsurge performance specifications

The nonsurge current-limiting performance specifications in 6.1.1 through 6.1.3 are intended to ensure that, in its quiescent state, the surge protector does not disturb operation of the protected circuit.

6.1.1 Rated current

This characteristic specifies the level of current that a surge protector continuously conducts at a specified temperature, without degrading the normal circuit functions.

6.1.1.1 Specification

The rms value of rated current for a surge protector shall be selected from Table 10.

Table 10—Performance characteristics of current-protective surge protectors (20 °C)

Specification type	Rated current (A rms)	Transition current (A rms)	Response time (s)	Minimum resistance (Ω)	Maximum resistance (Ω)
1	0.11	0.2	90	13	30
2	0.145	0.25	90	7	15
2a	0.15	0.25	210	0	21
3	0.11	0.35	35	12	18
4	0.135	0.5	210	8	12
5	0.15	0.54	210	0.8	4
5a	0.35	0.54	210	3	4
6	0.09	1.0 0.18	0.8 60	11	20
7	0.12	1.0 0.24	3 60	4	8
8	0.145	1.0 0.29	4 60	3	6
9	0.15	1.0 0.3	10 60	6	12
10	0.12	1.5	1	4	8
11	0.145	1.5	2	3	6
12	0.15	1.5	4.5	6	12
13	0.18	5 0.36	0.65 60	0.8	2
14	1.2	1.9	210	0	0.25
15	0.9	15	0.1	0.07	0.12
16	2.3	15	2.5	0.02	0.04
17	7	15	150	0.005	0.02

6.1.1.2 Test method

The surge protector shall be tested in accordance with 7.2 of IEEE Std C62.36-1994. The rated current shall be 50 Hz or 60 Hz, or a dc level corresponding to the rms value of the ac source. The voltage of the source shall be the blocking voltage of the current-limiting device selected from Table 13.

Unless otherwise specified, the test shall be performed at the high ambient temperature of the application (see 4.1): 50 °C for controlled temperature and humidity; 65 °C for uncontrolled temperature and humidity. All current-limiting devices in the surge protector shall be powered simultaneously during the test. The rated current shall be conducted for at least 1 h.

The values in Table 10 apply at 20–25 °C. If the surge protector is to be used at other temperatures, the current versus temperature curves for the current-limiting devices of Table 10 should be consulted to ensure that the chosen device conducts the rated current over the whole range of temperatures for which the surge protector is specified.

6.1.1.3 Test criterion

At the conclusion of the test, the surge protector shall not experience a failure mode relevant to the application.

6.1.2 DC series resistance

This characteristic specifies the acceptable value of resistance between the terminals of a surge protector, at a specified temperature.

6.1.2.1 Specification

The dc series resistance of a surge protector shall be selected from the minimum and maximum resistance columns of Table 10.

6.1.2.2 Test method

The surge protector shall be tested in accordance with 7.3 of IEEE Std C62.36-1994. The test temperature shall be 20–25 °C. The test current shall equal the rated current selected for the corresponding device of Table 10.

6.1.2.3 Test criterion

The dc series resistance shall be within the values specified in the minimum and maximum resistance columns of Table 10.

NOTE—In some cases the resistance of the series element in the surge protector may shift after the first application of transition current. Surge protectors having a series element exhibiting this behavior have a “post-trip” resistance rating, which is typically higher than those in Table 10. For tests such as ac life (see 6.2.5) that require the measurement of resistance after the application of transition current, this post-trip resistance should be used as the test criterion.

6.1.3 Inductance

This characteristic specifies the maximum inductance between the input and output terminals of a current-limiting surge protector.

6.1.3.1 Specification

The maximum value of inductance shall be selected from those in Table 11.

Table 11—Maximum inductance

Specification type	Inductance (μH)
1	0.5
2	1.0

6.1.3.2 Test method

The inductance shall be measured in accordance with 7.6 of IEEE Std C62.36-1994. The measurement shall be made with a test signal of 1 MHz at a current of 10 mA rms. No dc bias shall be applied. The measurement shall be made at a temperature of 20–25 °C.

For protector types 4 and 5 of Figure 1, the inductance shall be measured between terminals X_1 and X_2 with terminals Y_1 and Y_2 connected together. The inductance between terminals X_1 and X_2 shall be halved to give the average input-to-output inductance of terminal X_1 to Y_1 and X_2 to Y_2.

6.1.3.3 Test criterion

The maximum inductance shall satisfy the value for a given specification type from Table 11.

6.2 Active performance specifications

The active current-limiting performance specifications in 6.2.1 through 6.2.7 are intended to ensure the ability of a surge protector to perform its current protection function.

6.2.1 Transition current

This characteristic specifies the level of current required to cause a current-protective device in a surge protector to change state within a specified duration and ambient temperature.

6.2.1.1 Specification

The transition current for a current-protective device in a surge protector shall be selected from Table 10. The corresponding value in the “response time” column of Table 10 shall be the maximum duration permitted for a change of state to occur.

6.2.1.2 Test method

The surge protector shall be tested in accordance with 8.3 of IEEE Std C62.36-1994. Unless otherwise specified, the test shall be done at the low ambient temperature of the application (see 4.1): 2 °C for controlled temperature and humidity; –40 °C for uncontrolled temperature and humidity. The current source shall be 50 Hz or 60 Hz, or a dc level corresponding to the rms value of the ac source. The load current during the stabilization period shall be zero amperes (0 A).

The values in Table 10 apply at 20–25 °C. If the surge protector is to be used at other temperatures, the transition current versus temperature curves for the current-limiting devices of Table 10 should be consulted to ensure that the transition current of the device is satisfactory over the range of temperatures for which the surge protector is specified.

6.2.1.3 Test criterion

The current-limiting device shall change state within the specified response time. Change of state has occurred when the current in the device falls below 10% of the initially applied transition current.

6.2.2 Current reset

This characteristic verifies that resettable, series-connected, current-protective devices in a surge protector revert to their quiescent state within a specified duration after having limited an abnormal current. This specification applies only to surge protectors that contain resettable, series-connected, current-protective devices.

6.2.2.1 Specification

The current-protective device shall return to its quiescent state within a specified time duration. Unless otherwise specified, the reset duration should be selected from the preferred values in Table 12.

Table 12—Current reset durations

Specification type	Reset duration (s)
1	15
2	30
3	60
4	90
5	120

6.2.2.2 Test method

Current reset shall be measured in accordance with 8.6 of IEEE Std C62.36-1994. The load current shall be the rated current. The test shall be performed at a temperature between 20 °C and 25 °C, as well as at the minimum and maximum temperatures of the application selected from 4.1. The source current shall be 50 Hz or 60 Hz, or a dc level corresponding to the rms value of the ac source.

For those current-protective devices that require temporary interruption of the source current to return to their quiescent state, the source current shall be interrupted for the reset duration specified in Table 12. When the rated current (see 6.1.1) is reapplied, it should be conducted for at least twice the specified response time of 6.2.1 to ensure that the device has returned to, and remains in, its quiescent state.

6.2.2.3 Test criterion

After the reset duration of Table 12, the load current shall be at least 98.5% of the rated current.

6.2.3 Trip endurance

This characteristic specifies that a surge protector containing a self-resetting, current-limiting device shall continue to function after applying the blocking voltage to the protector for a specified period of time.

6.2.3.1 Specification

The blocking voltage for a current-protective device in a surge protector shall be selected from Table 13, with dc voltage equal to the peak of the corresponding ac rms voltage. The trip endurance time shall be selected from Table 14.

Table 13—Blocking voltage

Specification type	Voltage (V rms)	Voltage (V dc)
1	15	21.2
2	30	42.4
3	60	85
4	120	170
5	250	354
6	600	850

Table 14—Trip endurance time

Specification type	Time
1	15 min
2	30 min
3	1 h
4	24 h

6.2.3.2 Test method

The surge protector shall be tested in accordance with 8.10 of IEEE Std C62.36-1994. The ambient temperature shall be 20–25 °C. The source resistance shall be adjusted to a value that allows an initial current greater than or equal to the transition current to be conducted by the protector. The source shall continue to be applied to the protector for the selected trip endurance time from Table 14. The frequency of the source shall be 50 Hz or 60 Hz, or a dc level corresponding to the rms value of the ac source.

6.2.3.3 Test criteria

After the specified trip endurance time, the surge protector shall satisfy the transition current test (see 6.2.1) and the current reset test (see 6.2.2).

6.2.4 Blocking-cycle life

This characteristic specifies that a surge protector containing a self-resetting, current-limiting device shall continue to function after repeated trip cycles of specified current and duration, applied at the blocking voltage.

6.2.4.1 Specification

The blocking voltage for a current-protective device in a surge protector shall be selected from Table 13. The number of trip cycles, the trip cycle current, and the trip cycle duration for the blocking-cycle life test shall be selected from Table 15.

Table 15—Blocking-cycle life

Specification type	Current (A rms)	Duration (s)	Applications
1	1	1	60
2	3	5	10
3	10	6	100
4	40	6	100
5	100	6	100

6.2.4.2 Test method

The surge protector shall be tested in accordance with 8.11 of IEEE Std C62.36-1994. The ambient temperature shall be 20–25 °C. The open-circuit voltage of the source shall be the blocking voltage selected from Table 13. The source resistance shall be adjusted to a value that allows conduction of the current chosen from Table 15 when the protector is temporarily replaced by a short circuit. The frequency of the source shall be 0 Hz, 50 Hz, or 60 Hz. After removal of power after a trip cycle, the power shall not be reapplied for at least 2 min.

6.2.4.3 Test criteria

After the specified number of cycles, the surge protector shall satisfy the transition current test (see 6.2.1) and the current reset test (see 6.2.2).

6.2.5 AC life

This characteristic verifies that no failure mode relevant to the application occurs if the current-protective device(s) of a surge protector repetitively conducts alternating currents that are below the transition current of the current-limiting device(s).

6.2.5.1 Specification

Unless otherwise specified, apply 60 current surges (50 Hz or 60 Hz) of 1 s duration each, and having a magnitude selected from the preferred values in Table 16.

Table 16—AC life test current magnitude

Specification type	Test current (A rms)
1	0.1
2	0.5
3	1.0

6.2.5.2 Test method

The ac life test shall be performed in accordance with 8.7 of IEEE Std C62.36-1994. The ac source shall be connected to the terminals of the surge protector such that the ac surge current is conducted by the current-protective device(s).

The peak value of the ac source voltage should not exceed the blocking voltage of the current-protective device(s), which may differ from the rated voltage of the surge protector (see 5.1.1). The ac life tests shall be performed at a temperature in the range 20–25 °C, as well as at the minimum and maximum temperatures of the application selected from 4.1.

6.2.5.3 Test criteria

After conducting the specified current surge for 60 operations, the following performance specifications shall be satisfied:

a) DC series resistance (see 6.1.2)
b) Rated current (see 6.1.1)
c) Transition current (see 6.2.1)
d) Current reset (see 6.2.2) (only for resettable current-protective surge protectors)

6.2.6 Impulse life

This characteristic verifies that a current-protective surge protector can conduct an impulse current of specified parameters for a given number of repetitions without experiencing a failure mode relevant to the application.

6.2.6.1 Specification

Unless otherwise specified, apply 30 surges of 25 A peak current, each having a waveform of 10/1000 µs. The current shall be measured with the protector replaced by a short circuit.

6.2.6.2 Test method

The impulse life test shall be performed in accordance with 8.8 of IEEE Std C62.36-1994. The impulse surge generator should be connected to the terminals of the surge protector such that the impulse current is conducted by the current-protective device(s).

The impulse life tests shall be performed at a temperature in the range 20–25 °C, as well as at the minimum and maximum temperatures of the application selected from 4.1.

6.2.6.3 Test criteria

After conducting the specified current surge for 30 operations, the following performance specifications shall be satisfied:

a) DC series resistance (see 6.1.2)
b) Rated current (see 6.1.1)
c) Transition current (see 6.2.1)
d) Current reset (see 6.2.2) (only for resettable current-protective surge protectors)

6.2.7 Maximum single-impulse discharge

This characteristic verifies that a current-protective surge protector can conduct a specified impulse current without experiencing a failure mode relevant to the application. This test applies only to surge protectors connected to outside cables that do not have a metallic screen (i.e., to unshielded cable).

6.2.7.1 Specification

Unless otherwise specified, apply an impulse current having a waveform and a peak amplitude selected from among the preferred values in Table 17.

6.2.7.2 Test method

The maximum single impulse discharge test shall be performed in accordance with 8.9 of IEEE Std C62.36-1994. The peak value of the impulse-voltage source should not exceed the blocking voltage of the current-protective device(s), which may differ from the rated voltage of the surge protector (see 5.1.1). The test shall be done at a temperature in the range 20–25 °C.

6.2.7.3 Test criteria

After application of the current impulse, it shall be verified that the transition current of the surge protector does not exceed the specified value (see 6.2.1). The current-limiting device(s) are permitted to fail in a high-resistance mode such that transmission through the surge protector is interrupted.

Table 17—Maximum single impulse current

Specification type	Impulse current (peak amperes)	Impulse waveform (μs)
1	10	10/1000
2	50	10/1000
3	100	10/1000
4	300	10/1000
5	500	10/1000
6	96	10/350
7	120	10/350
8	144	10/350
9	2000	10/250
10	5000	20/100
11	2500	8/20
12	5000	8/20
13	10 000	8/20
14	20 000	8/20

7. Transmission specifications

The transmission specifications of this clause apply to surge protectors that limit voltages, currents, or both. They are applicable only for certain applications, and compliance shall be indicated in the documentation accompanying the surge protector as in item e) of 3.1.

7.1 Insertion loss

This characteristic specifies the acceptable loss of power transmitted to the load when a surge protector is inserted into a system. Insertion loss is expressed as a ratio, in decibels, of the voltage across the load after a surge protector is inserted (V_2), to the voltage across the load before the surge protector is inserted (V_0). The following formula applies:

$$\text{insertion loss} = 20\log\frac{V_2}{V_0}$$

7.1.1 Specification

The maximum (negative) value of insertion loss depends on the application. Unless otherwise specified, a surge protector shall not cause an insertion loss that is more negative than the selected value from Table 18 over the rated frequency range of the application.

Table 18—Values of insertion loss

Specification type	Insertion loss (dB)
A	–0.1
B	–0.3
C	–1.0
D	–3.0

7.1.2 Test method

Insertion loss shall be measured in accordance with 7.7 or 7.11 of IEEE Std C62.36-1994. The frequency and characteristic impedance at which the measurement is made shall be specified. The measurement shall be made for all applicable configurations at 20–25 °C, as well as at the minimum and maximum temperatures of the intended temperature-humidity category (see 4.1).

7.1.3 Test criterion

The measured values of insertion loss shall not be more negative than the value selected from Table 18.

7.2 Return loss

This characteristic specifies the maximum return loss that a surge protector can cause at a specified frequency or range of frequencies when inserted into a system. Return loss occurs if the characteristic impedance of the inserted surge protector does not equal the characteristic impedance of the system. This mismatch of impedances causes the reflection of power back to the source. The following formula applies for return loss:

$$\text{Return loss in dB} = 20\text{Log}\left|\rho\right|$$

where

ρ is the reflection coefficient of the surge protector in the system.

7.2.1 Specification

The maximum allowable return loss caused by a surge protector applies over the frequency range of the application. In the absence of specific requirements, the maximum allowable value shall be selected from Table 19.

Table 19—Values of return loss

Specification type	Return loss (dB)
A	–18
B	–24
C	–30

7.2.2 Test method

Return loss shall be measured in accordance with 7.9 of IEEE Std C62.36-1994. The frequency of the measurement shall be swept through the specified frequency range. The characteristic impedance at which the measurement is made shall be specified. The measurement shall be made for all applicable configurations at 20–25 °C, as well as at the minimum and maximum temperatures of the intended temperature-humidity category (see 4.1).

7.2.3 Test criteria

The absolute value of return loss of a surge protector shall be greater than or equal to the absolute value of return loss selected from Table 19.

7.3 Longitudinal balance

This characteristic specifies the minimum acceptable level of longitudinal balance of a surge protector used on balanced circuits. The specification covers the frequency range of 0–4 kHz, and is intended to address the level of longitudinal-to-metallic voltage conversion caused by induction from power lines.

7.3.1 Specification

Over the frequency range of 0–4 kHz, the surge protector shall have an acceptable level of longitudinal balance.

7.3.2 Test method

The surge protector shall be tested in accordance with 7.10 of IEEE Std C62.36-1994.

The impedances to be used in the test circuit are shown in Table 20. (The values in Table 20 are from IEEE Std 455-1985.) The frequency of the test shall be no higher than 4 kHz. Unless otherwise specified, the test may be done at frequencies of 200 Hz, 500 Hz, 1000 Hz, and 3000 Hz.

Table 20—Impedance values for longitudinal balance test

f (kHz)	Z1, Z2, Z3, and Z4 (Ω)	Z5 (Ω)
< 4	300	350

7.3.3 Test criterion

The surge protector shall have a longitudinal balance that satisfies the requirements of Figure 2.

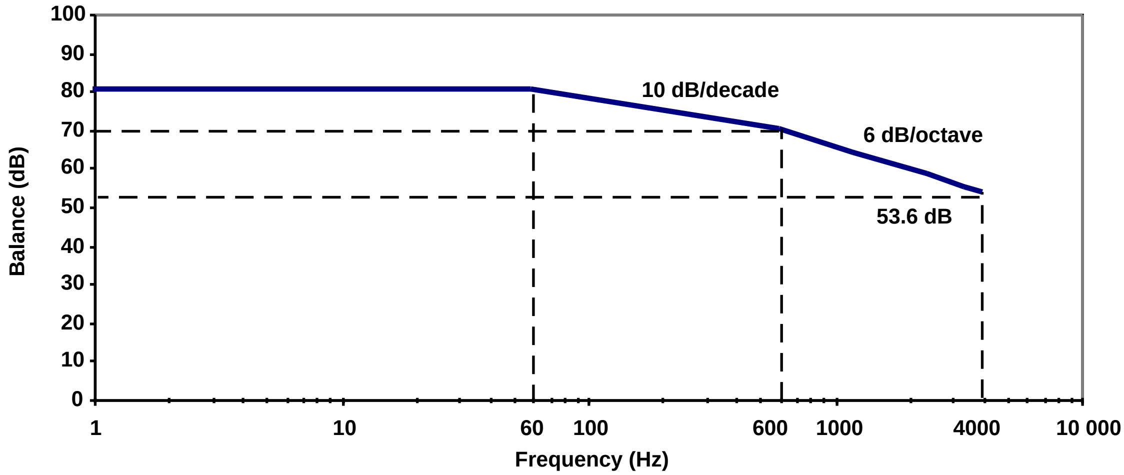

Figure 2—Minimum longitudinal-to-metallic balance

7.4 Bit error rate (BER)

This characteristic specifies the maximum number of errors during a specified time period caused by insertion of a surge protector into a digital transmission circuit.

7.4.1 Specification

The worst-case increment in bit errors caused by insertion of the protector shall be 10^{-7}.

7.4.2 Test method

The surge protector shall be tested in accordance with 7.13 of IEEE Std C62.36-1994.

Apply the maximum appropriate baud rate of pseudo-random bit pattern for the digital transmission circuit of the application. Measure the BER with and without the surge protector in the test circuit for the duration selected from Table 21. The send and receive impedances of the BER testers shall be equal to the characteristic impedance of the application.

Table 21—Duration of BER test

Rate of pseudo-random bit pattern (R)	Duration
R < 64 kb/s	1 h
64 kb/s ≤ R< 1554 kb/s	30 min
R ≥ 1554 kb/s	10 min

7.4.3 Test criterion

The surge protector shall not increase the BER by more than 10^{-7} during the test.