IEEE Standard for Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters)

Sponsor

Surge Protective Devices Committee
of the
Power Engineering Society

Approved 10 December 1996

IEEE Standards Board

Abstract: Surge-protective devices designed for application on the low-voltage ac supply mains (1000 V rms and less, frequency between 48 Hz and 62 Hz) are covered.
Keywords: low voltage, secondary arresters, surge-protective devices

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Introduction

[This introduction is not a part of IEEE Std C62.34-1996, IEEE Standard for Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters).]

Secondary arresters have been used since 1940 to protect the secondary winding of distribution transformers, kilowatt hour meters, and power equipment loads downstream from breakdown of insulation during lightning strikes. Performance criteria for secondary arresters are included in standards for performance of high-voltage arresters in IEEE Std C62.1-1989 and IEEE Std C62.11-1993.

With the proliferation of electronic equipment installed inside buildings, the emphasis has shifted away from protection of insulation on wiring devices to vulnerable electronic equipment.

The standards developers have attempted, as far as possible, to harmonize with relevant international standards.

The Accredited Standards Committee on Surge Arresters, C62, that reviewed and approved this standard, had the following members at the time of approval:

At the time this standard was completed, the Working Group on Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters) had the following membership:

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Contents

IEEE Standard for Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters)

1. Scope

This standard applies to surge-protective devices designed for application on the low-voltage ac supply mains (1000 V rms and less, frequency between 48 Hz and 62 Hz). Low-voltage surge-protective devices (secondary arresters) are intended to be connected at locations between, and including, the secondary terminals of the distribution transformer and the main service entrance panel. Surge-protective devices limit transient overvoltages by diverting surge current and subsequently automatically interrupting the passage of follow current.

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.

ANSI C84.1-1995, Voltage Ratings for Electric Power Systems and Equipment (60 Hertz).[1]

IEEE Std 4-1995, IEEE Standard Techniques for High-Voltage Testing (ANSI).[2]

C62.1-1989 (R1994) IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits (ANSI) .

IEEE Std C62.11-1993, IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (ANSI).

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

[1]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[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.

IEC 60529 (1989), Degrees of protection provided by enclosures (IP Code).[3]

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

UL 1449-1985, Transient Voltage Surge Suppressors (DoD).[4]

UL 94-1991, Tests for Flammability of Plastic Materials and Parts in Devices and Appliances (DoD).

UL 746C-1995, Polymeric Materials—Use in Electrical Equipment Evaluations (DoD).

3. Definitions

3.1 combination wave (1.2/50, 8/20): A wave delivered by a generator that applies a 1.2/50 voltage impulse across an open circuit and an 8/20 impulse current into a short circuit. The voltage, current, and waveforms that are delivered to the surge-protective device (SPD) are determined by the generator and the impedance of the SPD to which the surge is applied. The ratio of open-circuit voltage to peak short-circuit current is 2 Ω.

3.2 continuous operating current (I_c): The peak current flowing through the SPD when energized at the maximum continuous operating voltage.

3.3 design tests: Tests made 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.

3.4 duty cycle test: A test to determine if a device can repeatedly function, extinguish follow current, and avoid thermal runaway.

3.5 maximum-continuous operating voltage (MCOV) (U_c): The maximum rms value of power-frequency voltage that may be applied continuously between the terminals of the arrester without degradation or deleterious effects.

3.6 maximum discharge current (I_p): The maximum surge current that the SPD withstands without damage. The maximum discharge current is a peak impulse current, with a wave shape of 8/20.

3.7 measured limiting voltage: The maximum magnitude of voltage that is measured across the terminals of the SPD during the application of a series of impulses of specified wave shape and amplitude.

3.8 nominal discharge current (I_n): The discharge current that can be applied to an SPD a specified number of times without causing damage to it. The nominal discharge current is a peak surge current, with a wave shape of 8/20.

3.9 nominal system voltage: A nominal value assigned to designate a system of a given voltage class.

NOTE—See ANSI C84.1-1995.[5]

3.10 one-port SPD: A SPD with protective components connected in shunt with the circuit to be protected. A one-port SPD may have separate input and output terminals without a specified series impedance between these terminals.

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[3]IEC publications are available from IEC Sales Department, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[4]UL standards are available from Global Engineering, 1990 M Street NW, Suite 400, Washington, DC, 20036, USA.

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

3.11 preferred values: The parameters listed for various tests are preferred in the sense that their use promotes uniformity. However, specific applications may require values other than the listed preferred values.

3.12 routine tests: Tests made by the manufacturer on every device or on representative samples, or on parts or materials as required to verify that the product meets the design specifications.

3.13 secondary arrester: A surge-protective device that is intended to be connected to the low-voltage ac supply mains (1000 V rms and less, frequency between 48 Hz and 62 Hz) at locations between and including the secondary terminals of the distribution transformer and the main service entrance panel.

3.14 surge: A transient wave of voltage or current. The duration of a surge is not tightly specified, but it is usually less than a few milliseconds.

3.15 surge-protective device (SPD): A device that is intended to limit transient overvoltages and divert surge current. It contains at least one nonlinear component.

3.16 two-port SPD: An SPD with two sets of terminals—input and output. A specific series impedance is inserted between these terminals.

3.17 voltage protection level: A parameter that characterizes the performance of the SPD in limiting the voltage across its terminals. This value shall be equal to or greater than the highest value measured in measured limiting voltage tests.

4. Service conditions

4.1 Usual service conditions

4.1.1 Physical condition

The physical condition is ambient air temperature in the general vicinity of the arrester between –40 °C and +60 °C.

4.1.2 System conditions

The system condition are as follows:

a) Nominal power frequency of 48 Hz–62 Hz
b) System voltage within the ratings of the arrester under all usual system operating conditions

4.2 Unusual service conditions

Exposure to any of the service conditions in 4.2.1 and 4.2.2 may require special consideration in the design and application of arresters.

4.2.1 Physical conditions

a) Temperatures outside the range given in 4.1.1
b) Exposure to damaging fumes or vapors; excessive dirt; salt spray or other current-conducting deposits; steam; or explosive atmospheres, abnormal vibrations, or shocks
c) Unusual transportation or storage

4.2.2 System conditions

a) Nominal power frequency other than 48–62 Hz
b) System operating conditions where the rating of the device may be temporarily exceeded

5. Ratings

5.1 Identification

The following information shall be given by the manufacturer:

a) Manufacturer's name or trademark
b) Manufacturer's model number
c) Maximum continuous operating voltage
d) Nominal discharge current (per pole for multiple-pole devices)
e) Maximum discharge current (per pole for multiple-pole devices)
f) Voltage protection level
g) Continuous operating current or maximum steady-state power dissipation during operation at the maximum continuous operating voltage
h) Indication of disconnector operation (if any)
i) Position of normal use if significant
j) Assignment of terminals
k) Installation instructions
l) Nationally Recognized Testing Laboratory listings
m) Purpose: "protection of wiring devices only" or "protection of electronic equipment and wiring devices"
n) If a loss of neutral withstand rating is assigned, the relevant test voltage E (line-to-line) max shall be supplied
o) If a fault-current withstand rating is assigned, the relevant short-circuit test current shall be supplied

Marking of data under a) through c) shall be permanently attached to the arrester in order to permit the complete information to be obtained from the manufacturer.

Marking shall be indelible and easily legible. Letters shall be at least 2 mm in height.

5.2 Preferred values

The preferred values of nominal discharge current (I_n) on an 8/20 wave shape, open circuit voltage on the combination wave (V_{oc}), and maximum-discharge current (I_p) on an 8/20 wave shape are as listed in Table 1. Other values may be specified by the manufacturer or users.

Table 1—Preferred values

I_n (kA)	V_{oc} (kV)	I_p (kA)
1.5	3	5
3	6	10
5	10	20
10	20	40

6. Construction

This standard recognizes the existence of the following five kinds of secondary arresters:

a) Device with permanently attached wire leads, for mounting in a knock-out hole or with a bracket;
b) Device in a panel, to be connected to electrical service with suitable cable. Screw terminals are provided inside the arrester panel for electrical connections;
c) Device to install between the kW·h meter socket and the meter;
d) Device to install in a circuit breaker panel;
e) Device to install on secondary terminals of a distribution transformer.

Other kinds of secondary arresters are, of course, possible.

Secondary arresters with leads shall meet the following specifications:

1) Current-carrying capacity equal to or greater than copper with a diameter of 1.6 mm (AWG 14); the metallic conductor shall be made of noncorrosive material (e.g., copper or tin-plated copper, but not aluminum).
2) Arresters with permanently attached wire leads or wire leads attached to screw terminals shall have leads that are insulated to not less than 1.2 times the maximum voltage measured at the ends of the leads when the maximum surge discharge current is applied.
3) The insulation of each line conductor shall be black. The insulation of the arrester's grounding conductor shall be either white or green.

Secondary arresters may be suitable for either

a) Both indoor and outdoor operation, or
b) For indoor operation only.

Arresters for outdoor use shall be resistant to ultraviolet radiation and corrosion.

All secondary arrester housings shall be either nonflammable or self-extinguishing. Refer to UL 94-1991 and UL 746C-1995 for appropriate verification test methods.

7. Design tests

During design testing, any switches or circuit breakers in the device under test are to be set in the same position as during normal operation of the arrester. Fuses or circuit breakers inside the device under test shall neither be removed nor bypassed during these tests.

Tests in this standard may be done with a combination waveform or with separate surge generators for current and voltage tests. The specifications for the waveforms are:

Open-circuit voltage waveform:

— Front time: 1.2 µs ± 0.36 µs
— Time to half value: 50 µs ± 10 µs

Short-circuit current waveform:

— Front time: 8 µs (+1.0, –2.5) µs;
— Time to half value: 20 µs (+8, –4) µs

Both voltage and current values shall be as stated ±10%.

The ratio of peak open-circuit voltage to peak short-circuit current in the combined wave generator is 2 Ω ±0.25 Ω.

7.1 Determination of voltage protection level

These tests measure the response of the arrester to the surge.

The test shall be run on three new sample arresters.

7.1.1 Test procedure

The test shall be performed without simultaneously energizing the arrester from a power-frequency voltage.

No load is used for either a one-port or two-port device under test.

Apply one surge of each polarity with a magnitude of 0.1, 0.2, 0.5, and 1.0 times the nominal discharge current to each line terminal. Measure voltage as follows:

a) For a one-port arrester with wire leads, conductors with a length of 150 mm ± 10 mm (when straight) shall be used between the body of the arrester and the point where the voltage probes are connected to the loop that contains the surge current.
b) For arresters that do not have permanently attached wire leads, these tests are to be conducted with 150 mm ± 10 mm of 14 AWG insulated wire attached to each terminal. However, if the manufacturer specifies a wire gauge in the installation instructions, then the test is to be performed with 150 ± 10 mm of the smallest diameter wire that is recommended by the manufacturer.
c) For arresters that are contained inside a panel or enclosure, measurement of the voltage protection level shall be made at a distance of 150 ± 10 mm from the point where the conductors enter or exit from the panel or enclosure.
d) For arresters that are designed to be used in a kW· h meter socket or in a circuit breaker socket, the voltage protection level shall be measured at the socket.
    4) If a combination waveform generator is used, the peak current in the arrester shall be adjusted so that the specified currents will be applied.
    5) If separate surge generators are used for current and voltage tests, a current test shall be run per 7.1.1 and then a voltage test series shall be run with peak open-circuit voltages of 0.2, 0.4, 1.0, and 2.0 times the nominal discharge current peak magnitude. For example, if the nominal discharge current is 1.5 kA, then the peak open-circuit voltages shall be 300 V, 600 V, 1500 V, and 3000 V.

The conductors from the surge generator to the arrester, the arrester leads, and the conductors in the voltage probes shall be twisted together and secured in order to minimize the loop area that might receive error voltages from changing magnetic fields.

7.1.2 Interpretation of results

At the conclusion of these tests, the arrester shall be intact and functional.

The largest absolute value of the voltages measured during all of the tests is the voltage protective level. This parameter is printed on the manufacturer's specification sheet as the voltage protection level.

7.2 Maximum discharge current withstand test

The maximum discharge current withstand test shall be performed on three new sample arresters.

Voltage protection level at nominal discharge current shall be measured before and after the test.

7.2.1 Test procedure

This test shall be performed on arresters with the full-lead length per 7.1.1. Voltage shall be measured at the ends of the leads and recorded.

The test shall be performed without simultaneously energizing the arrester from a power-frequency voltage.

The peak current through the arrester shall be adjusted to the maximum discharge current per 5.2.

One surge of each polarity shall be applied to each line terminal with respect to the grounding conductor. For arresters that have two ports, the surges shall only be applied at the port intended for connection to the mains. It is not permissible to connect two or more line terminals in parallel for this test.

7.2.2 Evaluation

The design shall be considered adequate when for all three samples

a) No physical damage is evident.
b) The voltage protection level at nominal discharge current measured before and after the test has not changed more than ± 10%.

7.3 Accelerated ageing procedure for metal-oxide varistors

This procedure applies only to arresters that contain a metal-oxide varistor (MOV) without a series gap.

Metal-oxide varistors, when subjected to continuous voltage stress, may increase in watts loss with time. The accelerated ageing procedure is run to determine a voltage at which new varistors can be tested.

The accelerated ageing procedure may be performed on the varistor as part of the component approval. This procedure may be run by the varistor supplier and need not be repeated by the arrester manufacturer. No additional accelerated ageing tests are required for arresters using the same design, make, model, and rating MOV.

The detailed accelerated ageing procedure is given in Annex A, which is part of this standard.

7.4 Duty-cycle test

The duty-cycle test shall be performed on three sample arresters. They may, but need not be, the same samples used in the voltage protective level tests.

Voltage protection level at nominal discharge current shall be measured before and after the test.

7.4.1 Test procedure

During the duty-cycle test, the arrester shall be continuously energized with a power-frequency sinusoidal voltage with an rms value given by the maximum continuous operating voltage (MCOV) of the arrester.

For devices containing MOVs, the applied voltage shall be the corrected MCOV determined in the accelerated ageing procedure.

A series of 10 positive surges plus 10 negative surges shall be applied to each line terminal of the arrester, with respect to the grounding terminal. An interval of 50–60 s shall be allowed between consecutive surges on the same line terminal. The surges shall be 8/20 current waves of constant polarity and shall have a crest value equal to the nominal discharge current for the design being tested. Surges shall be timed to occur approximately 60 degrees before the crest of a power-frequency voltage having the same polarity as the impulse. The arrester shall be remain energized for 30 min after the 20 surges to verify thermal stability.

There are two satisfactory sources of power-frequency voltage for the duty cycle test—a motor generator set with an insulation voltage rating larger than the open circuit voltage of the surge generator, and the ac supply mains with a back filter.

a) If a motor-generator set is used, the available power-frequency fault current from this generator should be at least 4000 A rms.
b) If the ac supply mains with a back filter is used, the available power-frequency fault current through this back filter shall be at least 15 A. A fuse or circuit breaker shall be connected in the line conductor so that a short-circuit at the arrester port of the back filter will cause the fuse or circuit breaker to open within one cycle. If this fuse or circuit breaker opens during any of the duty-cycle tests, then the arrester has failed this test.

7.4.2 Test evaluation

The design shall be considered adequate when for all three samples

a) No physical damage is evident.
b) No circuit breaker or fuse opens during any of the tests. This includes the interrupters in the back-filter as well as any circuit breakers or fuses in the arrester itself.
c) The voltage protection level at nominal discharge current measured before and after the test has not changed more than ±10%.

7.5 Loss of neutral test

If the manufacturer claims a loss of neutral withstand capability for his arrester when it is connected at the distribution panel, then that capability shall be verified by the following procedure.

The arrester must withstand the overvoltage, disconnect itself from the circuit, or fail in an acceptable manner per 7.5.4.

NOTE—In the event of loss of neutral, arresters that are normally connected line-to-neutral can be subjected to line-to-line voltage until the system is shut off. The load condition, which can produce this voltage with loss of neutral, limits fault current to a low level. This test is for that condition; thus, the test voltage is E (line-to-line) max and the short-circuit current is limited to a low level. Refer to Annex B for further explanation of this condition.

7.5.1 Test specimens

The tests are to be performed on a total of six specimens—three each at two short-circuit current levels. The specimens for test are to be complete arresters chosen at random. For multiphase devices, the tests shall be run on a single phase.

7.5.2 Test circuit parameters

Power frequency: 48–62 Hz

Open-circuit voltage: System E (line-to-line) max

Short-circuit current:

a) 5 A ±10%

b) 25 A ±10%

7.5.3 Test procedure

Connect the arrester in a circuit with a short-circuit current of 5 A ±10%.

Monitor device temperature, or resistive component of current, or power dissipation, until the measured value is stable or declining (success) or continuously increasing (failure).

Maintain power frequency voltage for a minimum of 30 min. If success or failure is not clearly evident at the end of 30 min, maintain voltage until the evidence is clear or 7 h have elapsed.

Repeat the above sequence with a short-circuit current of 25 A ±10%.

7.5.4 Evaluation

The design shall be considered adequate when all six specimens meet the following criteria:

- Thermal recovery success is demonstrated or voltage is applied for 7 h without failure, and
- There is no explosion of the device, flame outside the device case or enclosure, exposure of live parts, or creation of any other hazardous condition.

7.6 Fault-current withstand test

If the manufacturer claims a fault-current withstand rating, then that rating shall be verified per the following procedure.

7.6.1 Test specimens

The tests are to be performed on six specimens—three each at two short-circuit current levels. The specimens for test are to be complete arresters chosen at random. For multiphase devices, the tests shall be run on a single phase.

7.6.2 Test circuit parameters

Power frequency:	48–62 Hz
Prefail source:	
Open-circuit voltage	3–4 × MCOV (see NOTE 1)
Short-circuit current	0.1–1 A (see NOTE 2)
Fault-current circuit:	
Open-circuit voltage	Not less than MCOV
Short-circuit current	a) 1–1.1 × claimed rating
	b) 0.4–0.5 × claimed rating

NOTES

1—If the specimens can be reliably prefailed with a voltage source lower than 3–4 × MCOV, then the lower voltage source is acceptable.

2—Prefailure current can be chosen by the manufacturer anywhere within this range to provide repeatable breakdown of the test specimens.

7.6.3 Test

The test consists of two parts—prefailure and application of short-circuit current.

7.6.3.1 Prefailure

Connect the arrester in a prefailure circuit with parameters per 7.6.2.

Energize the device at MCOV for 50–70 s, and then increase the voltage continuously at a rate of about 100 V/s until device failure is evident or 3–4 × MCOV is reached.

Failure may be indicated by collapse of the voltage across the test specimen or a sudden increase in current. When voltage across the specimen has collapsed to no more than the open-circuit voltage of the fault-current source, or 3–4 × MCOV has been held for 5 s, the prefailure voltage source shall be switched off.

7.6.3.2 fault-current withstand

Within 1 s after prefailure, connect the device to a circuit with an available rms fault current per 7.6.2. The device shall remain connected to the circuit for six cycles after the device begins to conduct the fault current. Within 1 s after disconnecting the device from the fault-current circuit, it shall be connected to a circuit energized at MCOV and remain for 2 min.

7.6.3.3 Evaluation

Repeat the above sequence with short-circuit current per 7.6.2 b).

7.6.3.4 Test evaluation

The design shall be considered adequate when for all six specimens there is no explosion of the device, flame outside the device case or enclosure, exposure of live parts, or creation of any other hazardous condition.

8. Routine tests

The tests listed in 8.1 through 8.3 shall be applied to 100% of production output except as otherwise specified.

8.1 Voltage protection level

This test may be applied to individual elements or to complete arresters.

The protective level shall be measured under the conditions determined in the design tests to produce the largest absolute value—the voltage protective level. The measured value shall not exceed the manufacturer's published maximum value.

8.2 Power-frequency voltage test

Energize the arrester at MCOV for not less than 2 s. Verify that current is in the normal range designated by the manufacturer.

8.3 Seal test

This test does not apply to liquid-immersed arresters or arresters that are virtually void free.

The arrester shall be tested to verify that the environmental seal meets the manufacturer's specifications. Acceptable methods are

a) Vacuum over water
b) Helium mass spectrometer
c) Pressure or vacuum decay
d) Halogen detection

Annex A

(normative)

Accelerated ageing procedure

A.1 Basis for accelerated ageing procedure

Based on Arrhenius life tests of metal-oxide varistors that increase in watts loss with time

a) 40 °C is a conservative weighted average use temperature.
b) The varistor ageing process is accelerated by temperature.
c) The temperature acceleration rate is reasonably estimated by an acceleration factor AF_T.

AF_T = 2. 5 ^ (ΔT/ 1O)

where

ΔT is the difference between test temperature and average use temperature.

Using the above formula, for 40 °C use, 1000 h test time, the equivalent service time is calculated for illustration.

AF_T = 2.5 ^[(115–40)/10] = 965

The 1000 h test at 115 °C is thus equivalent to

$$\text{Equivalent 40 °C time} = \frac{1000 \text{ (hours test)} \times 965 \text{ (acceleration)}}{24 \times 365 \text{ (hours per year)}} = 110 \text{ years}$$

The reason for not using watts loss readings at time zero is explained as follows.

On initial energization at temperature, various compositions of metal-oxide varistors may change rapidly and differently from their long-term character. Some compositions rapidly increase and some decrease to a more stable stage and thereafter display their long-term characteristic. It is the long-term characteristic that is of use for extrapolation to service life at continuous temperature. Based on this logic, the initial phenomena are ignored.

A.2 General

This is not a test and has no evaluation procedure. This is an accelerated ageing procedure from which an elevated voltage may be obtained. The elevated voltage is used in the duty-cycle test to simulate the performance of arresters as if they had been in service for an extended period of time.

The ageing procedure shall be applied to three typical sample varistors of the design, make, model, and rating being tested. The relevant MCOV for this procedure is the maximum voltage that the varistors must support in the arrester.

A.3 Determination of power ratios

Heat samples to 115 ±2 °C and energize at MCOV for 1000 h.

At 115 ± 2 °C, measure sample power dissipation (watts loss) at MCOV 2–5 h after the application of voltage and at 1000 h (–0 h + 100 h). The 100 h extended period is for the purpose of convenience only.

Determine for each sample the ratio of power dissipation at 1000 h to the initial power dissipation at 2–5 h. The maximum power ratio from the three samples shall be used to determine elevated MCOV for the duty cycle.

A.4 Determination of elevated MCOV

If the maximum power ratio is equal to or less than 1.0, the appropriate voltage elevating factor is 1.0.

If the maximum power ratio is greater than 1.10, use varistors aged at 115 ± 2 °C for 1000 h for the duty-cycle test.

If the maximum power ratio is 1.01 to 1.099, use the following procedure to determine the elevated voltage to be applied in the duty-cycle test:

a) At room temperature, take three new sample varistors of the design, make, model, and rating used in A.1 and measure watts loss at MCOV.
b) Multiply the (new sample) watts loss by the ratio determined in A.3.
c) For each sample, determine the corrected voltage required to obtain the increased watts loss thus determined.
d) The highest corrected voltage thus obtained is the elevated MCOV to be used in the duty-cycle test.

Annex B

(informative)

Loss of neutral condition

Refer to Figure B.1.

The neutral connection between the distribution transformer secondary and the entrance panel can be lost. If this occurs

a) There is a voltage divider between the load on leg B and the infinite impedance on leg A when leg A has no connected load.
b) Due to the above voltage divider, all 240 V is across leg A.
c) A realistic load is R_B = 10–40 Ω resulting in a fault current limited to 6–24 A at 240 V.

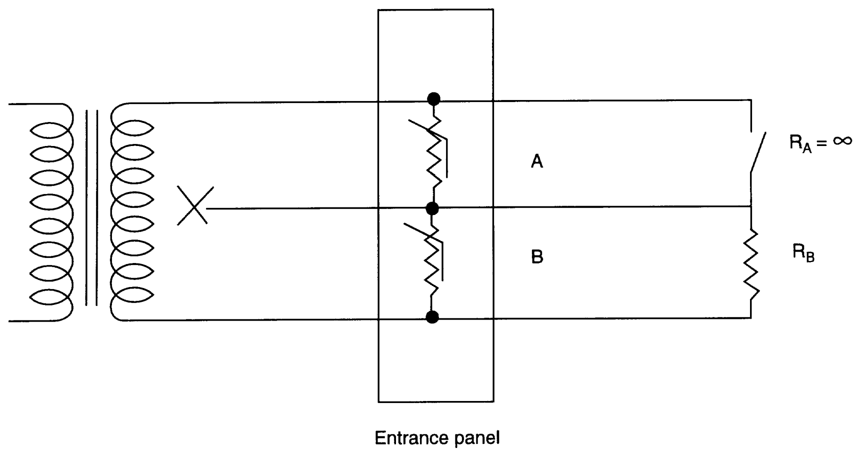

Figure B.1—Secondary circuit with loss of neutral

Annex C

(informative)

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