

1613™

IEEE Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations

IEEE Power Engineering Society

Sponsored by the
Substations Committee



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IEEE Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations

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Substations Committee
of the
IEEE Power Engineering Society

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IEEE-SA Standards Board

Abstract: Service conditions, electrical ratings, thermal ratings, and environmental testing requirements are defined for communications networking devices to be installed in electric power substations. This standard establishes a common reproducible basis for designing and evaluating communications networking devices for use in this harsh environment.

Keywords: autodialers, bridges, communications networking device, derating, dielectric test, environmental requirements, ESD test, Ethernet hubs, fast transient test, firewalls, humidity, impulse test, insulation test, modems, power apparatus, RF test, routers, SWC test, switches, temperature range, temperature rise, voltage rating

The Institute of Electrical and Electronics Engineers, Inc.
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Introduction

(This introduction is not part of IEEE Std 1613-2003, IEEE Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations.)

This standard has been compiled from the relevant clauses of IEEE Std C37.90TM-1989 [B6]^a, IEEE Std C37.90.1TM-2002 [B7], IEEE Std C37.90.2TM-1995 [B8], and IEEE Std C37.90.3TM-2001 [B9]. In addition, it establishes more stringent requirements than exist in these IEEE or relevant IEC standards in the following areas:

- Clause 4 requires the operation of the device with no fans or forced ventilation. It also requires startup after soaking at the temperature extremes (not required in IEEE Std C37.90-1989 [B6] or in IEC 60255-6:1988 [B1]).
- Clause 7, Clause 8, and Clause 9 define the communications required during tests and two performance classes. Class 1 allows communications errors or interruption during the defined transient, but requires automatic recovery. Class 2 requires communication without errors or interruption. (Neither are presently defined in IEEE or IEC).
- Clause 8 requires testing at a field strength level of 35 V/m, as defined in IEEE Std C37.90.2-1995 [B8] and reflecting North American experience. This is more severe than IEC 60255-22-3:2000 [B2] that requires only 10 V/m maximum. The test method is the one defined by IEC 60255-22-3:2000.
- Clause 9 requires testing at voltage levels corresponding to a relative humidity less than 35%, identical to IEEE Std C37.90.3-2001 [B9] (not required by IEC 61000-4-2:2001 [B3]).

The protection of metallic communications circuits into electric power substations is not covered in this standard, but is the specific topic of IEEE Std 487TM-2000 [B10]. The following excerpt is Clause 1 from IEEE Std 487-2000:

“1. Overview

“Wire-line telecommunication facilities serving electric supply locations often require special high voltage protection against the effects of fault-produced ground potential rise or induced voltages, or both. Some of the telecommunication services are used for control and protective relaying purposes and may be called upon to perform critical operations at times of power system faults. This presents a major challenge in the design and protection of the telecommunication system because power system faults can result in the introduction of interfering voltages and currents into the telecommunication circuit at the very time when the circuit is most urgently required to perform its function. Even when critical services are not involved, special high-voltage protection may be required for both personnel safety and plant protection at times of power system faults. Effective protection of any wire-line telecommunication circuit requires coordinated protection on all circuits provided over the same telecommunication cable.”

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^aThe numbers in brackets correspond to the numbers in the bibliography in Annex B.

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Contents

1.	Overview.....	1
1.1	Scope.....	1
1.2	Purpose.....	1
2.	References.....	2
3.	Definitions and word usage	2
3.1	Definitions	2
3.2	Word usage	2
4.	Service conditions.....	3
4.1	Usual service conditions	3
4.2	Other conditions.....	4
5.	Electrical ratings of control power inputs.....	4
5.1	DC rated control power inputs.....	5
5.2	Allowable ac component in dc control voltage supply	5
5.3	AC rated control power inputs.....	5
6.	Insulation tests	5
6.1	General requirements.....	6
6.2	Dielectric power frequency test.....	6
6.3	Impulse voltage test	7
7.	SWC tests.....	9
7.1	Scope.....	9
7.2	Purpose.....	9
7.3	Test waveforms.....	9
7.4	Test generator characteristics.....	11
7.5	Verification of test generator characteristics	12
7.6	Equipment to be tested.....	13
7.7	Test points.....	13
7.8	Application of test wave	13
7.9	Conditions of tests	14
7.10	Coupling to test generator.....	15
7.11	Test procedures	18
7.12	Device performance classes.....	20
7.13	Conditions to be met (acceptance criteria)	20
7.14	Test records.....	21
8.	Radio frequency (RF) susceptibility tests.....	21
8.1	Electromagnetic environment.....	22
8.2	Test conditions.....	22
8.3	Test levels	23

8.4	In-Service conditions	23
8.5	Test environment	23
8.6	Test equipment.....	24
8.7	Test procedure.....	25
8.8	Device performance classes.....	26
8.9	Conditions to be met (acceptance criteria)	26
8.10	Test records.....	27
9.	Electrostatic discharge (ESD) tests.....	27
9.1	ESD disturbance tests	28
9.2	Device performance classes.....	34
9.3	Conditions to be met (acceptance criteria)	34
10.	Vibration and shock.....	35
Annex A	(normative) Verification of test generator characteristics.....	36
Annex B	(informative) Bibliography.....	40

IEEE Standard for Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations

1. Overview

Communications networking devices are being installed in electric power substations. Examples include radios, encryption devices, port switches, autodialers, modems, Ethernet hubs and switches, routers, gateways, and firewalls. This standard establishes a common reproducible basis for designing and evaluating communications networking devices for this harsh environment. It does not include communications facilities and equipment integral to protective relaying applications.

1.1 Scope

This document specifies standard service conditions, standard ratings, environmental performance requirements, and testing requirements for communications networking devices installed in electric power substations. It does not cover such equipment designed for operation in other environments, such as office locations. It does not cover such equipment used in protective relaying applications, for which IEEE Std C37.90™-1989 [B6]¹, IEEE Std C37.90.1™-2002 [B7], IEEE Std C37.90.2™-1995 [B8], and IEEE Std C37.90.3™-2001 [B9] apply.

1.2 Purpose

The purpose of this standard is to define the environmental conditions present in electric power substations and to establish a common reproducible basis for designing and evaluating communications networking devices to be installed in those substations. It is a freestanding document, with only one normative reference to another standard.

¹The numbers in brackets correspond to the numbers of the bibliography in Annex B.

2. References

This standard shall be used in conjunction with the following publication. When the following publication is superseded by an approved revision, the revision shall apply.

IEEE Std C37.100™-1992 (Reaff 2001), IEEE Definitions for Power Switchgear.^{2, 3}

3. Definitions and word usage

For this standard, the following terms and definitions apply. IEEE 100™, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B4], should be referenced for terms not defined in this clause.

3.1 Definitions

3.1.1 autodialer: A device that can open a telephone line and initiate a call by transmitting a stored telephone number. This functionality could be built into a modem or it may be a stand-alone device.

3.1.2 communications networking device: An intelligent electronic device (IED) that is an element of a communications network. Examples of such IEDs include modems, Ethernet hubs and switches, routers, bridges, autodialers, firewalls, and port switches.

3.1.3 firewall: A device or combination of hardware and software used to enforce communication security by blocking unauthorized access to a local area network (LAN).

3.1.4 port switch: A serial communication device that allows a user to connect to one of several communication ports through a single interface.

3.1.5 shielded enclosure: Screen or solid metal housing designed expressly for the purpose of isolating the internal equipment from the external electromagnetic environment.

3.2 Word usage

3.2.1 Shall

The word *shall*, equivalent to “is required to,” is used to indicate mandatory requirements, strictly to be followed in order to conform to the standard and from which no deviation is permitted.

3.2.2 Recommended

The word *recommended* is used to indicate flexibility of choice with a strong preference alternative.

3.2.3 Must

The use of the word *must* is deprecated and shall not be used when stating mandatory requirements. The word *must* is used only to describe unavoidable situations.

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3.2.4 Should

The word *should*, equivalent to “is recommended that,” is used to indicate the following:

- Among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others.
- That a certain course of action is preferred but not required.
- That (in the negative form) a certain course of action is deprecated but not prohibited.

3.2.5 May

The word *may*, equivalent to “is permitted,” is used to indicate a course of action permissible within the limits of this standard.

3.2.6 Can

The word *can*, equivalent to “is able to,” is used to indicate possibility and capability, whether material or physical.

4. Service conditions

(This clause is adapted from the IEEE Std C37.90-1989 [B6] revision that was in progress when IEEE Std 1613-2003 was approved.)

Service conditions include operational and nonoperational temperature and relative humidity. Conditions outside the scope of this standard are listed in 4.2.

4.1 Usual service conditions

Communications networking devices conforming to this standard shall be suitable for operation under the conditions outlined in 4.1.1 through 4.1.3.

4.1.1 Operational temperature range

Operational temperature is the temperature of still air (i.e., no fans or forced-air movement) measured 30 cm from the surface of the unit (i.e., communications networking device) enclosure while in operation. For a specified temperature range (e.g., -20°C to $+55^{\circ}\text{C}$), a unit shall be able to start up and continue its operation at the specified minimum temperature (i.e., -20°C) within 5 min after having been de-energized for a sufficient time so that its internal components have cooled to that temperature without condensation. A unit shall also be able to start up and continue its operation within 5 min at the specified maximum temperature (i.e., $+55^{\circ}\text{C}$) after having been de-energized for a sufficient time so that its internal components have heated to that temperature.

The manufacturer shall declare one of the following ranges of ambient temperature for which the unit is to be rated:

- a) -40°C to $+70^{\circ}\text{C}$
- b) -30°C to $+65^{\circ}\text{C}$
- c) -20°C to $+55^{\circ}\text{C}$ (the default range if no other range is specified)
- d) Range defined by the manufacturer

4.1.2 Nonoperational temperature range

Nonoperational temperature is the air temperature for conditions of transport, storage, and installation, so that the unit will not experience damage due to indefinite exposure to such temperatures.

The manufacturer shall declare one of the following ranges of ambient temperature for which the unit is to be rated:

- a) $-50\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$
- b) $-40\text{ }^{\circ}\text{C}$ to $+75\text{ }^{\circ}\text{C}$
- c) $-30\text{ }^{\circ}\text{C}$ to $+65\text{ }^{\circ}\text{C}$
- d) Range defined by the manufacturer

If a nonoperational temperature range is not specified, the default nonoperational temperature range shall be the same as the operational temperature range.

4.1.3 Relative humidity

Communications networking devices shall be capable of withstanding an average relative humidity up to 55% outside of the device or communication networking system's enclosure or cover for a temperature within the defined operational and nonoperational ranges, with excursions up to 95% without internal condensation for a maximum of 96 h.

4.2 Other conditions

Other conditions not covered by this standard may require special construction, treatment, or operational considerations. These conditions shall be brought to the attention of the people responsible for the application, manufacture, and operation of communications networking devices. Among such conditions are exposure to the following:

- a) Damaging smoke, fumes, or vapors
- b) Moisture or dripping water
- c) Dust (abrasive, magnetic, conductive, obstructive, etc.)
- d) Explosive mixtures of dust and gases
- e) Steam
- f) Salt air
- g) Shock and vibration (see Clause 10)
- h) Seismic disturbances
- i) Transportation or storage conditions
- j) Extreme temperature or sudden change in temperature
- k) Extreme variations of supply voltage
- l) Excessive electrical wave distortion
- m) Excessive electrical noise
- n) Electromagnetic radiation other than the radiation specified in Clause 8
- o) Nuclear radiation

5. Electrical ratings of control power inputs

(This clause has been adapted from IEEE Std C37.90-1989 [B6].)

This clause defines the ratings of dc and ac control power inputs and allowable ripple on dc supplies.

5.1 DC rated control power inputs

DC power supplies and auxiliary circuits with dc voltage rating shall be able to continuously withstand the maximum design voltage shown in Table 1. They shall be capable of operating successfully over a range from 80% of rated voltage to the maximum design voltage. Power supplies with a wide dc voltage range (i.e., 12 V to 250 V) are encouraged.

Table 1—Maximum design voltage for dc control power

Rated voltage (V)	Maximum design voltage (V)
12	14
24	28
48	56
110	123
125	140
220	246
250	280

5.2 Allowable ac component in dc control voltage supply

Communications networking devices shall operate properly with an alternating component (i.e., ripple) of 5% peak or less in the dc control voltage supply, provided the minimum instantaneous voltage is not less than 80% of rated voltage. The ripple content of dc supply expressed as percentage is defined as

$$\frac{(\text{peak value} - \text{dc component})}{(\text{dc component})} \times 100 \quad (1)$$

NOTE—Equation (1) refers to low-frequency ripple as might typically be introduced on the dc control power bus by a battery charger. Higher frequency effects, such as might be introduced by a dc-dc converter within the device or equipment itself, are not sufficiently defined at this time to be included in this standard.

5.3 AC rated control power inputs

AC power supplies and auxiliary circuits with ac voltage ratings shall be capable of operating successfully over a minimum range of 85% to 110% of rated voltage and frequency. The ac voltage rating shall be 120 V 60 Hz, 240 V 50 Hz, or 120–240 V 50–60 Hz.

6. Insulation tests

(This clause is adapted from IEEE Std C37.90-1989 [B6].)

Insulation tests include dielectric power frequency tests and impulse tests. These tests and their application to the device under test are identical to the tests and applications specified in IEEE Std C37.90-1989 [B6].

6.1 General requirements

Atmospheric conditions for insulation tests shall be within the following ranges:

- Ambient air temperature: 15 °C to 35 °C
- Relative humidity: 45% to 75%
- Air pressure: 86 kPa to 106 kPa⁴

6.2 Dielectric power frequency test

The dielectric power frequency test consists of applying a specified voltage to the insulation systems of the device under test to prove that the insulation is in accordance with the rated insulation voltage stated by the manufacturer.

6.2.1 Test voltage and waveform

The test voltages and wave form shall be as shown in Table 2.

Table 2—Dielectric test voltage

Product rated voltage	Test voltage root mean square (rms)
50 and below ^a	500
51 to 250	2000

^aGenerally utilized for communications or low-level input/output.

The test source shall be substantially sinusoidal with a frequency between 45 Hz and 65 Hz.

The source voltage shall be verified with an accuracy better than 5%.

The test voltage source shall be such that, when applying the specified value to the device under test, the voltage drop observed is less than 10%.

These dielectric tests may be conducted using a dc source. For dc testing, the test voltages shall be 1.4 times the values given for ac tests.

6.2.2 Test requirements

Dielectric power frequency tests are considered to be both type tests and production tests to be performed by the manufacturer.

Dielectric tests, in accordance with this standard, may be performed once by the user on new devices to determine whether specifications are fulfilled. New devices, for this test, are defined as devices that

- Have not been in service,
- Are not more than one year old from the date of shipment, and
- Have been suitably stored to prevent deterioration.

⁴860 mbar to 1060 mbar.

Additional dielectric tests may be made using 75% of the test voltage determined in accordance with Table 2 at the point of installation to determine the practicality of placing or continuing the equipment in service.

6.2.3 Points to be tested

Dielectric tests shall be performed

- a) Between each independent circuit and the ground circuit. The terminals of each independent circuit may be connected together. For devices with an insulating enclosure, the ground circuit shall be represented by a metal foil covering the entire enclosure except the terminals around which a suitable gap shall be left to avoid flashover to the terminals. Insulation tests requiring this metal foil shall be performed as design tests only.
- b) Between independent circuit groups, with the terminals of each independent circuit in the group being connected together. Independent circuit groups are to be defined by the manufacturer.
- c) Between the terminals of open contacts—only as a design test. Dielectric tests are not required across contacts with surge-suppression components, nor across solid-state output circuits. If a dielectric test is not performed, the surge withstand capability (SWC) test (see Clause 7) is to be substituted for the dielectric test.

6.2.4 Test method

During the testing, no input or auxiliary energizing quantity shall be applied to the device.

Test voltage shall be applied directly to the device terminals.

The open-circuit voltage of the testing equipment is initially set to not more than 50% of the specified voltage. It is then applied to the device under test. From this initial value, the test voltage shall be raised to the specified value, in such a manner that no appreciable transients occur, and then maintained for 1 min. It shall then be reduced smoothly to zero as rapidly as possible.

As an alternate, to be used at the point of manufacture only, it is permissible to test any device for 1 s at a value 20% higher than the standard 1 min test voltage.

6.2.5 Criteria for acceptance

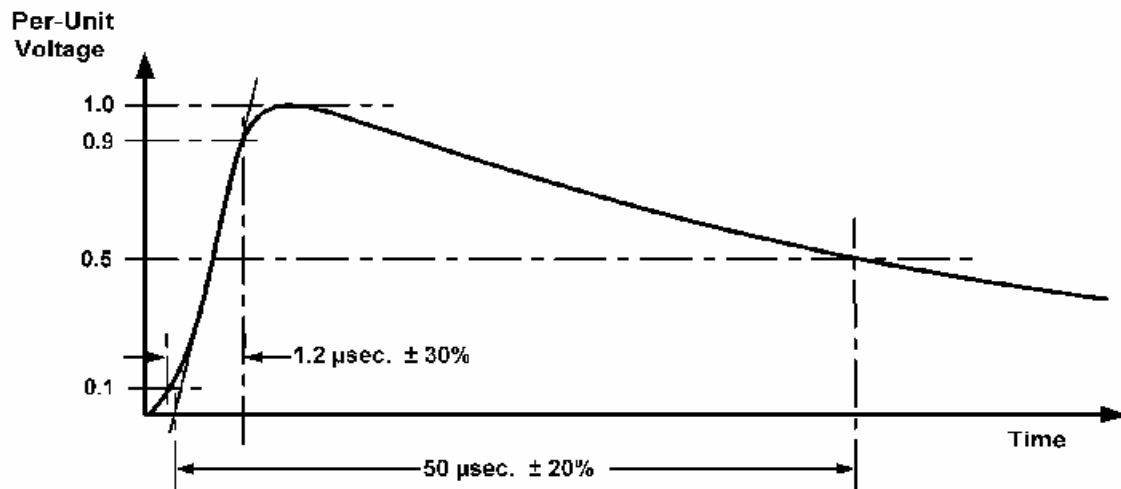
During the dielectric test, no breakdown or flashover shall occur and no components shall be damaged. After the test, the device shall still comply with all relevant performance requirements.

6.3 Impulse voltage test

The impulse voltage test consists of applying a specified impulse voltage to the insulation to prove the ability of the device to withstand, without damage, overvoltages of very high values and very short duration.

6.3.1 Impulse test voltage and waveform

The impulse test wave form shall be in accordance with Figure 1 and its explanatory notes.



NOTES

- a) *Waveform polarity:* Positive and negative
- b) *Rise time:* $1.2 \mu\text{s} \pm 30\%$
- c) *Magnitude:* $5 \text{ kV} +0/-10\%$
- d) *Time to half value:* $50 \mu\text{s} \pm 20\%$
- e) *Source impedance:* $500 \Omega \pm 10\%$
- f) *Output energy:* $0.5 \text{ J} \pm 10\%$

Figure 1—Impulse voltage waveform

6.3.2 Impulse test requirements

Impulse voltage tests are considered design tests.

Impulse tests, in accordance with this standard, may be repeated once by the user only on new devices, to determine whether specifications are fulfilled. New devices, for this test, are defined as devices that have not been in service, that are not more than one year old from the date of shipment, and that have been suitably stored to prevent deterioration.

Additional impulse tests may be made using 75% of the test voltage given (see 6.3.1) at the point of installation to determine the practicality of placing or continuing the equipment in service.

6.3.3 Points to be impulse tested

Impulse voltage tests shall be applied

- a) Between each independent circuit and the ground circuit. The terminals of each independent circuit may be connected together. For devices with an insulating enclosure, the ground circuit shall be represented by a metal foil covering the entire enclosure except the terminals around which a suitable gap shall be left to avoid flashover to the terminals.
- b) Between independent circuit groups, with the terminals of each independent circuit in the group being connected together. Independent circuit groups are to be defined by the manufacturer.