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**Resistibility of telecommunication equipment
installed in the access and trunk networks to
overvoltages and overcurrents**

Recommendation ITU-T K.45

ITU-T

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Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents

Summary

Recommendation ITU-T K.45 specifies resistibility requirements and test procedures for telecommunication equipment installed between telecommunication centres and between a telecommunication centre and the customer's premises.

Overvoltages or overcurrents covered by this Recommendation include surges due to lightning on or near the line plant, short-term induction from adjacent a.c. power lines or railway systems, earth potential rise due to power faults, direct contact between telecommunication lines and power lines, and electrostatic discharges.

Major changes compared with Recommendation ITU-T K.45 (2013) include:

- adding test requirements for unshielded twisted pair Ethernet ((UTP_E));
- adding test requirements for shielded twisted pair Ethernet (STP_E);
- adding test requirements for power over Ethernet (PoE);
- adding STP_E shield testing.

History

| Edition | Recommendation | Approval | Study Group | Unique ID* |
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1.2/50-8/20, 10/700, access equipment, common mode, differential, external port, internal port, longitudinal, overcurrent, overvoltage, power contact, power induction, resistibility, surges, telecommunication equipment, transverse, trunk.

* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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Recommendation ITU-T K.45

Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents

1 Scope

This Recommendation specifies resistibility requirements and test procedures for telecommunication equipment installed between telecommunication centres and between a telecommunication centre and the customer's premises. Equipment which is attached to or installed within the customer's premises is outside the scope of this Recommendation. [ITU-T K.44], covering basic test methods and test circuits, is an integral part of this Recommendation. It should be read in conjunction with [ITU-T K.11] and [ITU-T K.39] (technical and general economic aspects of protection).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T K.11] Recommendation ITU-T K.11 (2009), *Principles of protection against overvoltages and overcurrents*.
- [ITU-T K.39] Recommendation ITU-T K.39 (1996), *Risk assessment of damages to telecommunication sites due to lightning discharges*.
- [ITU-T K.44] Recommendation ITU-T K.44 (2017), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*.
- [IEC 61000-4-2] IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*.

3 Definitions

3.1 Terms defined elsewhere

Definitions used in this Recommendation are defined in [ITU-T K.44].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the abbreviations and acronyms defined in [ITU-T K.44] as well as the following:

- CWG Combination Wave Generator
- ESD Electrostatic Discharge
- PoE Power over Ethernet
- STP Special Test Protector

STP_E Shielded Twisted Pair Ethernet
UTP_E Unshielded Twisted Pair Ethernet

5 Conventions

This Recommendation uses the conventions defined in [ITU-T K.44] as well as the following:

- IT Designation specified in [b-IEC 60364] for a power distribution system in which there is no point connected with earth (isolation), except perhaps via a high impedance, on the power-supply equipment (generator or transformer) and a direct connection of a point on the electrical device being supplied with earth.
- TT Designation specified in [b-IEC 60364] for a power distribution system in which there is a direct connection of a point on the power-supply equipment (generator or transformer) with earth and a direct connection of a point on the electrical device being supplied with earth.

6 Tests

A summary of the applicable tests is given in Table 1. The numbers given in the "port type" columns, e.g., 2.2.1.a, refer to the "Test No." of Tables 2 to 5. The words "under study" mean that ITU-T is still studying this test. The test conditions applicable to the four ports (symmetric, coaxial, dedicated power feed and mains power) are given in Tables 2 to 5. The test conditions for electrostatic discharge (ESD) are given in Table 6. For information on the headings and terms used in the tables, refer to clause 10 of [ITU-T K.44].

Refer to clause 5.2 of [ITU-T K.44] on selecting the enhanced resistibility requirement.

NOTE 1 – The port to external port test for the basic test level does not apply when the equipment is designed to be always used with a connection to earth.

NOTE 2 – The external port test applies to ports used to connect externally attached equipment to equipment installed within the same building. The mains power contact test does not apply in this situation.

NOTE 3 – The power induction test does not apply to ports used to connect to antennas installed under the scope of [b-ITU-T K.71].

Table 1 – Applicable tests

| Test type | No. of pairs simultaneously tested | Test connection | Primary protection | Port type | | | |
|-------------------|--|--------------------------------------|--------------------|----------------|--------------|---------------------------|------------------|
| | | | | Symmetric port | Coaxial port | Dedicated power feed port | Mains power port |
| Lightning voltage | Single | Transverse/differential | No | 2.1.1a | 3.1.1 | 4.1.1a | 5.1.1a |
| | | Port to earth | No | 2.1.1b | n/a | 4.1.1b | 5.1.1b |
| | | Port to external port | No | 2.1.1c | n/a | 4.1.1c | 5.1.1c |
| | | Coordination/Transverse/differential | Yes | 2.1.2a | 3.1.2 | 4.1.2a | 5.1.2a |
| | | Coordination/Port to earth | Yes | 2.1.2b | n/a | 4.1.2b | 5.1.2b |
| | | Coordination/Port to external port | Yes | 2.1.2c | n/a | 4.1.2c | 5.1.2c |
| | Multiple | Port to earth | No | 2.1.3a | n/a | n/a | n/a |
| | | Port to external port | No | 2.1.3b | n/a | n/a | n/a |
| | | Port to earth | Yes | 2.1.4a | n/a | n/a | n/a |
| | | Port to external port | Yes | 2.1.4b | n/a | n/a | n/a |
| | Unshielded twisted pair Ethernet (UTP _E) | Port to Earth | No | 2.1.8 | n/a | n/a | n/a |
| | | Transverse | No | 2.1.7 | n/a | n/a | n/a |
| | | Voltage impulse test | No | 2.1.10 | n/a | n/a | n/a |
| | | Power over Ethernet (PoE) | No | 2.1.11 | n/a | n/a | n/a |
| | Shielded twisted pair Ethernet (STP _E) | Port to Earth | No | 2.1.8 | | n/a | n/a |
| | | Shield to earth | No | 2.1.9 | | n/a | n/a |
| Lightning current | Single | Port to earth | No | 2.1.5a | n/a | 4.1.5a | n/a |
| | | Port to external port | No | 2.1.5b | n/a | 4.1.5b | n/a |
| | | Differential | n/a | n/a | 3.1.3 | n/a | n/a |
| | | Shield to earth | n/a | n/a | 3.1.4 | n/a | n/a |
| | | Shield to external port | n/a | n/a | 3.1.5 | n/a | n/a |
| | Multiple | Port to earth | No | 2.1.6a | n/a | n/a | n/a |
| | | Port to external port | No | 2.1.6b | n/a | n/a | n/a |

Table 1 – Applicable tests

| Test type | No. of pairs simultaneously tested | Test connection | Primary protection | Port type | | | |
|--|------------------------------------|-----------------------|--------------------|----------------|--------------|---------------------------|---------------------|
| | | | | Symmetric port | Coaxial port | Dedicated power feed port | Mains power port |
| Power induction and earth potential rise | Single | Transverse | No | 2.2.1a | Under Study | 4.2.1a | n/a |
| | | Port to earth | No | 2.2.1b | n/a | 4.2.1b | 5.2.1 (under study) |
| | | Port to external port | No | 2.2.1c | n/a | 4.2.1c | 5.2.1 (under study) |
| | | Transverse | Yes | 2.2.2a | Under study | 4.2.2a | n/a |
| | | Port to earth | Yes | 2.2.2b | n/a | 4.2.2b | n/a |
| | | Port to external port | Yes | 2.2.2c | n/a | 4.2.2c | [**] |
| Neutral potential rise | Single | Port to earth | No | n/a | n/a | n/a | 5.2.2a |
| | | Port to external port | No | n/a | n/a | n/a | 5.2.2b |
| Mains power contact | Single | Transverse | No | 2.3.1a | n/a | 4.3.1a | n/a |
| | | Port to earth | No | 2.3.1b | n/a | 4.3.1b | n/a |
| | | Port to external port | No | 2.3.1c | n/a | 4.3.1c | n/a |
| NOTE – There are no internal ports in access network equipment (due to its small physical size). | | | | | | | |

Table 2a – Lightning test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---|--|---|---|---|---|--|--|
| 2.1.1a | Single pair, lightning, inherent, transverse | A.3-1 and A.6.1-1 (a and b) 10/700 | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | None | A | This test does not apply when the equipment is designed to always be used with primary protection. When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44].) |
| 2.1.1b | Single pair, lightning, inherent, port to earth | A.3-1 and A.6.1-2 10/700 | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | | | | |
| 2.1.1c | Single pair, lightning, inherent, port to external port | A.3-1 and A.6.1-3 10/700 | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | | | | |
| 2.1.2a | Single pair, lightning, coordination, transverse | A.3-1 and A.6.1-1 (a and b) 10/700 | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | Special test protector (STP); see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port | A When the test is performed with $U_c = U_{c(max)}$, the special test protector must operate. Of course, it may also operate with a voltage of $U_c < U_{cmax}$ | When the equipment contains high current-carrying components that eliminate the need for primary protection, refer to clause 10.1.1 of [ITU-T K.44]. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44].) |
| 2.1.2b | Single pair, lightning, coordination, port to earth | A.3-1 and A.6.1-2 10/700 | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | | | | |
| 2.1.2c | Single pair, lightning, coordination, port to external port | A.3-1 and A.6.1-3 10/700 | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | | | | |

Table 2a – Lightning test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---|---|--|--|---|---|---|---|
| 2.1.3a | Multiple pair, lightning, inherent, port to earth | A.3-1 and A.6.1-4 10/700 | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | None | A | The multiple port test is simultaneously applied to 100% of the pairs in the same cable limited to a maximum of eight pairs. This test does not apply when the equipment is designed to be always used with primary protection. When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44]) |
| 2.1.3b | Multiple pair, lightning, inherent, port to external port | A.3-1 and A.6.1-5 10/700 | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$ | | | | |
| 2.1.4a | Multiple pair, lightning, port to earth | A.3-1 and A.6.1-4 10/700 | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | Agreed primary protector. When performing the external port to external port test, also add an STP/primary protector to the untested port | A | The multiple port test is simultaneously applied to 100% of the pairs in the same cable limited to a maximum of eight pairs. When the equipment contains high current-carrying components that eliminate the need for primary protection, do not remove these components and do not add primary protection. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44]) |
| 2.1.4b | Multiple port, lightning, port to external port | A.3-1 and A.6.1-5 10/700 | $U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$ | $U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$ | | | | |

Table 2a – Lightning test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|--|---|--|---|---|---|--|---|
| 2.1.5a | Single pair, lightning current, port to earth | A.3-4 and A.6.1-2 8/20 | $I = 1 \text{ kA/wire}$ $R = 0 \Omega$ | $I = 5 \text{ kA/wire}$ $R = 0 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | None | A | This test only applies when the equipment contains high current-carrying components that eliminate the need for primary protection. Do not remove these components. The multiple port test is simultaneously applied to 100% of the pairs in the same cable limited to a maximum of eight pairs. |
| 2.1.5b | Single pair, lightning current, port to external port | A.3-4 and A.6.1-3 8/20 | $I = 1 \text{ kA/wire}$ $R = 0 \Omega$ | $I = 5 \text{ kA/wire}$ $R = 0 \Omega$ | | | | |
| 2.1.6a | Multiple pair, lightning current, port to earth | A.3-4 and A.6.1-4 8/20 | $I = 1 \text{ kA/wire}$ Limited to 6 kA total $R = 0 \Omega$ | $I = 5 \text{ kA/wire}$ Limited to 30 kA total $R = 0 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | None | A | |
| 2.1.6b | Multiple pair, lightning current, port to external port | A.3-4 and A.6.1-5 8/20 | $I = 1 \text{ kA/wire}$ Limited to 6 kA total $R = 0 \Omega$ | $I = 5 \text{ kA/wire}$ Limited to 30 kA total $R = 0 \Omega$ | | | | |
| 2.1.7 | Ethernet transverse | A.3-5 and A.6.7-5 1.2/50-8/20 combination wave generator (CWG) $R_1 = 10 \Omega$ and $R_2 = 10 \Omega$ | $U_{c(\text{max})} = 2\,500 \text{ V}$ | $U_{c(\text{max})} = 6\,000 \text{ V}$ | Alternating ± 5 surges (60 s between successive surges) | None | A | |
| 2.1.8 | STP _E /UTP _E Ethernet simultaneous port to earth | A.3-5 and A.6.7-4 1.2/50-8/20 CWG $R = 10 \Omega$ | $U_{c(\text{max})} = 2\,500 \text{ V}$ | $U_{c(\text{max})} = 6\,000 \text{ V}$ | Alternating ± 5 surges (60 s between successive surges) | None | A | |

Table 2a – Lightning test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|--|---|---|--|--|---|--|---|--|
| 2.1.9 | STP _E Ethernet simultaneous port to earth test | A.3-5 and A.6.7-6 1.2/50-8/20 CWG $R = 5 \Omega$ | $U_{c(max)} = 2\,500\text{ V}$ | $U_{c(max)} = 6\,000\text{ V}$ | Alternating ± 5 surges (60 s between successive surges) | None | A | |
| 2.1.10 | UTP _E Ethernet port rated impulse voltage test | A.3-5 and A.6.7-3a 1.2/50-8/20 CWG $R = 5 \Omega$ | $U_{c(max)} = 2\,500\text{ V}$ surge | $U_{c(max)} = 6\,000\text{ V}$ surge | Alternating ± 5 surges (60 s between successive surges) | None (Note) | A | There shall be no insulation breakdown during the test and the post-test resistance shall be at least 2 M Ω when measured at 500 V d.c. Monitor the impulse voltage to detect breakdown or voltage protector operation. |
| 2.1.11 | PoE Mode A and Mode B transverse testing | A.3-5 and A.6.7-2 1.2/50-8/20 CWG $R_1 = 10 \Omega$ and $R_2 = 10 \Omega$ | $U_{c(max)} = 2\,500\text{ V}$ | $U_{c(max)} = 6\,000\text{ V}$ | Alternating ± 5 surges (60 s between surges) | None | A | |
| NOTE – When the cabling is fitted with SPDs, the equipment user and manufacturer may use different test conditions upon mutual agreement; this topic is currently under study. | | | | | | | | |

Table 2b – Power induction and earth potential rise test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---|---|--|---|--------------|---|--|---|
| 2.2.1a | Power induction, inherent, transverse | A.3-6 and A.6.1-1 (a and b) | $W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz, 50 or 60 Hz}$ $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$ | $W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz, 50 Hz or 60 Hz}$ $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$ | 5 | None | A | <p>This test does not apply when the equipment is designed to be always used with primary protection.</p> <p>When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply.</p> |
| 2.2.1b | Power induction and earth potential rise, inherent, port to earth | A.3-6 and A.6.1-2 | | | | | | |
| 2.2.1c | Power induction and earth potential rise, inherent, port to external port | A.3-6 and A.6.1-3 | | | | | | |

Table 2b – Power induction and earth potential rise test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---|---|---|---|--------------|--|--|--|
| 2.2.2a | Power induction, inherent/ coordination, transverse | A.3-6 and A.6.1-1 (a and b) | $W_{sp(max)} = 1 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz, } 50 \text{ Hz or } 60 \text{ Hz}$ $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 1.0 \text{ s}$ (Note 1) | $W_{sp(max)} = 10 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz, } 50 \text{ Hz or } 60 \text{ Hz}$ $U_{a.c.(max)} = 1 \text{ 500 V}$ $R = 200 \Omega$ $t_{(max)} = 2 \text{ s}$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2} \quad (4-1)$ (Note 2) | 5 | Special test protector (STP); see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port. | A | When the equipment contains high current-carrying components that eliminate the need for primary protection, refer to clause 10.1.3 of [ITU-T K.44]. |
| 2.2.2b | Power induction and earth potential rise, inherent/ coordination, port to earth | A.3-6 and A.6.1-2 | | | | | | |
| 2.2.2c | Power induction inherent/ coordination, port to external port | A.3-6 and A.6.1-3 | | | | | | |
| 2.3.1a | Mains power contact, inherent, transverse | A.3-6 and A.6.1-1 (a and b) | | | 1 | None | | |
| 2.3.1b | Mains power contact, inherent, port to earth | A.3-6 and A.6.1-2 | | | | | | |

Table 2b – Power induction and earth potential rise test conditions for ports connected to external symmetric pair cables

| Test No. | Test description | Test circuit (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|---|--|---|---|---|--------------|---|--|---|
| 2.3.1c | Mains power contact, inherent, port to external port | A.3-6 and A.6.1-3 | $U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10, 20, 40, 80, 160, 300, 600$ and $1\,000 \, \Omega$ See acceptance criteria column. | $U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10, 20, 40, 80, 160, 300, 600$ and $1\,000 \, \Omega$ See acceptance criteria column. | | | For basic level: criterion B. For enhanced level: criterion A for test resistors 160, 300, 600, and 1 000 Ω ; criterion B for the other resistor values. | In some situations, the test may be performed with a reduced number of current limit resistors. Refer to item 12 of clause 7.3 of [ITU-T K.44] and clause I.1.4 of [ITU-T K.44] for guidance on selecting the necessary size of resistors. When the equipment is designed to be always used with primary protection, and the operator agrees, perform this test with the special test protector installed. (Note 3) |
| <p>NOTE 1 – The test conditions for Test 2.2.2 (basic test level) may be adapted to the local conditions by variation of the test parameters within the following limits, so that $I^2t = 1 \text{ A}^2\text{s}$ is fulfilled:</p> <p>$U_{a.c.(\text{max})} = 300 \text{ V} \dots 600 \text{ V}$, selected to meet local conditions; $t \leq 1.0 \text{ s}$, selected to meet local conditions; $R \leq 600 \, \Omega$, is to be calculated according to Equation 4-2.</p> $R = U_{a.c.(\text{max})} \sqrt{t} \quad (4-2)$ <p>NOTE 2 – For Test 2.2.2 (enhanced test level), the equipment shall comply with the specified criterion for all voltage–time combinations bounded (on and below) by the 10 A²s voltage–time curve in Figure 1. The curve in Figure 1 is defined by Equation 4-1 and boundary conditions in this table.</p> <p>NOTE 3 – The a.c. mains voltage and frequency for Test 2.3.1 may be changed to the local mains supply voltage and frequency values. For a.c. test voltage values other than 230 V, the test resistor values should be adjusted to provide the same prospective short-circuit current values that occur in the 230 V test condition.</p> | | | | | | | | |

Table 3a – Lightning test conditions for ports connected to external coaxial cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---------------------------------------|--|---|---|---|---|--|--|
| 3.1.1 | Lightning, inherent, differential | A.3-5 and A.6.2-1 1.2/50 – 8/20 CWG | $U_{c(max)} = 1.0 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 1.5 \text{ kV}$ $R = 0 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | None | A | This test does not apply when the equipment is designed to be always used with primary protection. When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply. |
| 3.1.2 | Lightning, coordination, differential | A.3.5 and A.6.2-1 1.2/50 – 8/20 CWG | $U_{c(max)} = 4 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 6 \text{ kV}$ $R = 0 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | Special test protector (STP); see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port. | A When the test is performed with $U_c = U_{c(max)}$, the special test protector must operate. Of course, it may also operate with a voltage of $U_c < U_{c(max)}$. | When the equipment contains high current-carrying components that eliminate the need for primary protection, refer to clause 10.2 of [ITU-T K.44]. |
| 3.1.3 | Lightning, current, differential | A.3.4 and A.6.2-1 8/20 | $I = 1 \text{ kA}$ | $I = 5 \text{ kA}$ | Five of each polarity | None | A | This test only applies when the equipment contains high current-carrying components that eliminate the need for primary protection. Do not remove these components. |

Table 3a – Lightning test conditions for ports connected to external coaxial cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|--|--|---|---|---|--|--|---|
| 3.1.4 | Lightning shield test, port to earth | A.3.4 and A.6.2-2 8/20 | $I = 4$ kA (Note 1) $I = 2$ kA (Note 2) | $I = 20$ kA (Note 1) $I = 5$ kA (Note 2) | Alternating ± 5 surges (60 s between successive surges) | Special test protector (STP); see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port. | A | Only applies to earthed equipment and equipment without isolation capacitors in the coaxial cable path. |
| 3.1.5 | Lightning shield test, port to external port | A.3.4 and A.6.2-3 8/20 | $I = 4$ kA (Note 1) $I = 2$ kA (Note 2) | $I = 20$ kA (Note 1) $I = 5$ kA (Note 2) | Alternating ± 5 surges (60 s between successive surges) | Special test protector (STP); see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port. | A | Only applies to earthed equipment and equipment without isolation capacitors in the coaxial cable path. |

NOTE 1 – Equipment designed to be connected to antennas/equipment exposed to direct lightning currents, e.g., connected to antennas/equipment mounted on a tower.

NOTE 2 – Applicable equipment not covered by Note 1.

Table 3b – Power induction and earth potential rise test conditions for ports connected to external coaxial cables

NOTE – The test conditions for earth potential rise are under study.

Table 4a – Lightning test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---|--|---|---|---|--|--|--|
| 4.1.1a | Single pair, lightning, inherent, transverse | A.3-1 and A.6.3-1 (a and b) 10/700 μ s | $U_{c(max)} = 1.5$ kV $R = 25$ Ω | $U_{c(max)} = 1.5$ kV $R = 25$ Ω | Alternating ± 5 surges (60 s between successive surges) | None | A | This test does not apply when the equipment is designed to be always used with primary protection. When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply. |
| 4.1.1b | Single pair, lightning, inherent, port to earth | A.3-1 and A.6.3-2 10/700 μ s | $U_{c(max)} = 1.5$ kV $R = 25$ Ω | $U_{c(max)} = 1.5$ kV $R = 25$ Ω | Alternating ± 5 surges (60 s between successive surges) | | | |
| 4.1.1c | Single pair, lightning, inherent, port to external port | A.3-1 and A.6.3-3 10/700 μ s | $U_{c(max)} = 1.5$ kV $R = 25$ Ω | $U_{c(max)} = 1.5$ kV $R = 25$ Ω | Alternating ± 5 surges (60 s between successive surges) | | | |
| 4.1.2a | Single pair, lightning, coordination, transverse | A.3-1 and A.6.3-1 (a and b) 10/700 μ s | $U_{c(max)} = 4$ kV $R = 25$ Ω | $U_{c(max)} = 4$ kV $R = 25$ Ω | Alternating ± 5 surges (60 s between successive surges) | Special test protector (STP); see clause 8 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port | A When the test is performed with $U_c = U_{c(max)}$, the special test protector must operate. Of course, it may also operate with a voltage of $U_c < U_{cmax}$. | When the equipment contains high current-carrying components that eliminate the need for primary protection, do not remove these components and do not add primary protection. During the test this protection must operate at $U_c = U_{c(max)}$. If the primary protector is a clamping type device, use the test circuit and test levels specified in test 4.1.5. |
| 4.1.2b | Single pair, lightning, coordination, port to earth | A.3-1 and A.6.3-2 10/700 μ s | $U_{c(max)} = 4$ kV $R = 25$ Ω | $U_{c(max)} = 4$ kV $R = 25$ Ω | | | | |
| 4.1.2c | Single pair, lightning, coordination, port to external port | A.3-1 and A.6.3-3 10/700 μ s | $U_{c(max)} = 4$ kV $R = 25$ Ω | $U_{c(max)} = 4$ kV $R = 25$ Ω | | | | |
| 4.1.3 | Multiple pair, lightning, inherent, | | n/a | n/a | | | | |

Table 4a – Lightning test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|--|---|--|---|---|--|---|--|---|
| | port to earth and port to external port | | | | | | | |
| 4.1.4 | Multiple pair, lightning, port to earth and port to external port | | n/a | n/a | | | | |
| 4.1.5a | Single pair, lightning current, port to earth | A.3-4 and A.6.3-2 8/20 μs | $I = 1 \text{ kA/wire}$ $R = 0 \Omega$ | $I = 5 \text{ kA/wire}$ $R = 0 \Omega$ | Alternating ±5 surges (60 s between successive surges) | None | A | This test only applies when the equipment contains high current-carrying components that eliminate the need for primary protection. |
| 4.1.5b | Single pair, lightning current, port to external port | A.3-4 and A.6.3-3 8/20 μs | $I = 1 \text{ kA/wire}$ $R = 0 \Omega$ | $I = 5 \text{ kA/wire}$ $R = 0 \Omega$ | Alternating ±5 surges (60 s between successive surges) | | | |
| 4.1.6 | Multiple pair, lightning current | | n/a | n/a | | | | |
| NOTE 1 – As there is little knowledge of the agreed primary protector, it is not possible to give guidance. In the interim, test conditions for symmetric pair ports have been provided. | | | | | | | | |

Table 4b – Power induction and earth potential rise test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

| Test No. | Test description | Test circuit (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|--|---|--|--|--------------|--|--|---|
| 4.2.1a | Power induction, inherent, transverse | A.3-6 and A.6.3-1 (a and b) | $W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}$, 50 Hz or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$ | $W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}$, 50 Hz or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$ | 5 | None | A | <p>This test does not apply when the equipment is designed to be always used with primary protection.</p> <p>When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply.</p> |
| 4.2.1b | Power induction and earth potential rise, inherent, port to earth | A.3-6 and A.6.3-2 | | | | | | |
| 4.2.1c | Power induction and earth potential rise, inherent, port to external port | A.3-6 and A.6.3-3 | | | | | | |
| 4.2.2a | Power induction, inherent/coordination, transverse | A.3-6 and A.6.3-1 (a and b) | $W_{sp(max)} = 1 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}$, 50 Hz or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 1.0 \text{ s}$ (Notes 1) | $W_{sp(max)} = 10 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}$, 50 Hz or 60 Hz $U_{a.c.(max)} = 1\,500 \text{ V}$ $R = 200 \Omega$ $t_{(max)} = 2 \text{ s}$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (4-1) (Notes 2) | 5 | Special test protector (STP); see clause 8 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port. | A | <p>When the equipment contains high current-carrying components that eliminate the need for primary protection, do not remove these components and do not add primary protection.</p> |
| 4.2.2b | Power induction and earth potential rise, inherent/coordination, port to earth | A.3-6 and A.6.3-2 | | | | | | |
| 4.2.2c | Power induction and earth potential rise, inherent/coordination, port to external port | A.3-6 and A.6.3-3 | | | | | | |

Table 4b – Power induction and earth potential rise test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

| Test No. | Test description | Test circuit (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|--|---|--|--|--------------|---|---|--|
| 4.3.1a | Mains power contact, inherent, transverse | A.3-6 and A.6.3-1 (a and b) | $U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10, 20, 40, 80, 160, 300, 600 \text{ and } 1\,000 \, \Omega$ See acceptance criteria column. | $U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10, 20, 40, 80, 160, 300, 600 \text{ and } 1\,000 \, \Omega$ See acceptance criteria column. | 1 | None | For basic level: criterion B. For enhanced level: criterion A for test resistors 160, 300 and 600 Ω ; criterion B for the other resistor. | In some situations, the test may be performed with a reduced number of current limit resistors. Refer to item 11 of clause 7.3 of [ITU-T K.44] and to clause I.1.4 of [ITU-T K.44] for guidance on selecting the necessary size of resistors. When the equipment is designed to be always used with primary protection, and the operator agrees, perform this test with the special test protector installed. |
| 4.3.1b | Mains power contact, inherent, port to earth | A.3-6 and A.6.3-2 | | | | | | |
| 4.3.1c | Mains power contact, inherent, port to external port | A.3-6 and A.6.3-3 | | | | | | |

Table 4b – Power induction and earth potential rise test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

NOTE 1 – The test conditions for Test 4.2.2 (basic test level) may be adapted to the local conditions by variation of the test parameters within the following limits, so that $I^2t = 1 \text{ A}^2\text{s}$ is fulfilled:

$U_{\text{a.c.}(\text{max})} = 300 \text{ V} \dots 600 \text{ V}$, selected to meet local conditions;

$t \leq 1.0 \text{ s}$, selected to meet local conditions;

$R \leq 600 \Omega$, is to be calculated according to Equation 4-2.

$$R = U_{\text{a.c.}(\text{max})} \sqrt{t} \quad (4-2)$$

NOTE 2 – For Test 4.2.2 (enhanced test level) the equipment shall comply with the specified criterion for all voltage–time combinations bounded (on and below) by the $10 \text{ A}^2\text{s}$ voltage–time curve in Figure 1. The curve in Figure 1 is defined by Equation 4-1 and the boundary conditions in this table.

NOTE 3 – The a.c. mains voltage and frequency for Test 2.3.1 may be changed to the local mains supply voltage and frequency values. For a.c. test voltage values other than 230 V , the test resistor values should be adjusted to provide the same prospective short-circuit current values that occur in the 230 V test condition.

Table 5 – Test conditions for mains power ports

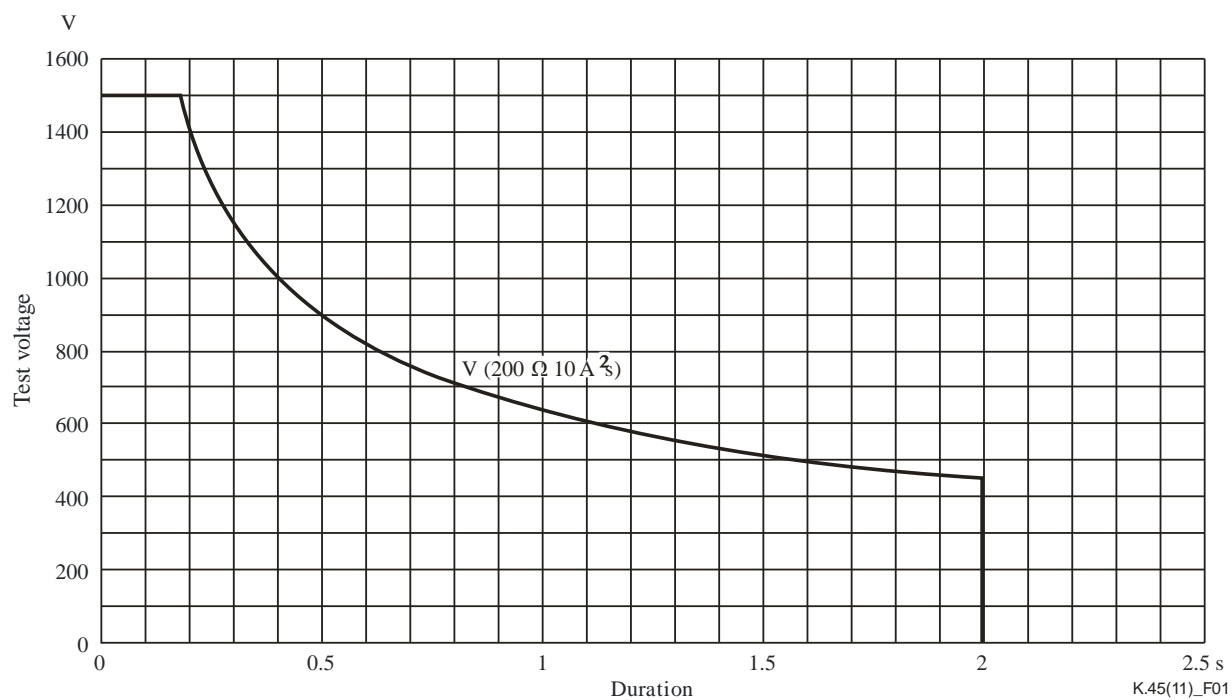
| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|----------|---|--|---|---|---|--|--|--|
| 5.1.1a | Lightning, inherent, transverse | A.3-5 and A.6.4-1 1.2/50-8/20 CWG | $U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | None | A | This test does not apply when the equipment is designed to be always used with primary protection. |
| 5.1.1b | Lightning, inherent, port to earth | A.3-5 and A.6.4-2 1.2/50-8/20 CWG | $U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$ | | | | |
| 5.1.1c | Lightning, inherent, port to external port | A.3-5 and A.6.4-3 1.2/50-8/20 CWG | $U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$ | | | | |
| 5.1.2a | Lightning, inherent/coordination, transverse | A.3-5 and A.6.4-1 1.2/50-8/20 CWG | $U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$ | Alternating ± 5 surges (60 s between successive surges) | Agreed primary protector (mains). When performing the external port to external port test, also add an STP/primary protector to the untested port. | A | |
| 5.1.2b | Lightning, inherent/coordination, port to earth | A.3-5 and A.6.4-2 1.2/50-8/20 CWG | $U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$ | | | | |
| 5.1.2c | Lightning, inherent/coordination, port to external port | A.3-5 for and A.6.4-3 1.2/50-8/20 CWG | $U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$ | $U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$ | | | | |

Table 5 – Test conditions for mains power ports

| Test No. | Test description | Test circuit and waveform (see figures in Annex A of [ITU-T K.44]) | Basic test levels (also see clause 7 of [ITU-T K.44]) | Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) | No. of tests | Primary protection (clause 8 of [ITU-T K.44]) | Acceptance criteria (clause 9 of [ITU-T K.44]) | Comments |
|---|---|--|--|---|--------------|---|--|---|
| 5.2.1 | Earth potential rise | | Under study | Under study | | | | |
| 5.2.2a | Neutral potential rise, inherent, port to earth | A.3-6 and A.6.4-2 a.c. | $U_{a.c.} = 600 \text{ V}$ $f = 50 \text{ Hz or } 60 \text{ Hz}$ $t = 1 \text{ s}$ $R = 200 \Omega$ | $U_{a.c.} = 1\,500 \text{ V}$ $f = 50 \text{ Hz or } 60 \text{ Hz}$ $t = 1 \text{ s}$ $R = 200 \Omega$ | 5 | None | A | This test applies only when the equipment is to be installed with TT or IT mains system and the operator requests it. |
| 5.2.2b | Neutral potential rise, inherent, external port to port | A.3-6 and A.6.4-3 a.c. | $U_{a.c.} = 600 \text{ V}$ $f = 50 \text{ Hz or } 60 \text{ Hz}$ $t = 1 \text{ s}$ $R = 200 \Omega$ | $U_{a.c.} = 1\,500 \text{ V}$ $f = 50 \text{ Hz or } 60 \text{ Hz}$ $t = 1 \text{ s}$ $R = 200 \Omega$ | | | | |
| NOTE 1 – The total lead length used to connect the agreed primary protector shall be 1 m. | | | | | | | | |

Table 6 – Test conditions for electrostatic discharge applied to the enclosure

| Test No. | Test description | Test circuit | Basic test level | Enhanced test level | Number of tests | Primary protection | Acceptance criteria |
|--|-------------------|----------------------|------------------|---------------------|-----------------|--------------------|---------------------|
| 6.1.a | Air discharge | IEC 61000-4-2 (2008) | Level 3 (8 kV) | Level 4 (15 kV) | 5 | n/a | A |
| 6.1.b | Contact discharge | IEC 61000-4-2 (2008) | Level 3 (6 kV) | Level 4 (8 kV) | 5 | n/a | A |
| NOTE 1 – The test applies to the equipment enclosure. | | | | | | | |
| NOTE 2 – The performance criterion A of [ITU-T K.44] is applied. | | | | | | | |



Test voltage versus duration for a specific energy and source resistance.

Figure 1 – Test voltage versus duration to give 10 A²s with 200 Ω

Bibliography

- [b-ITU-T K.71] Recommendation ITU-T K.71 (2011), *Protection of customer antenna installations*.
- [b-IEC 60364] IEC 60364 (all parts), *Low-voltage electrical installations*.

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