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SERIES K: PROTECTION AGAINST INTERFERENCE

Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents

Recommendation ITU-T K.21

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Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents

Summary

Recommendation ITU-T K.21 specifies resistibility requirements and test procedures for telecommunication equipment that is attached to or installed within a 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 alternating current (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. The sources for overvoltages in internal lines are mainly inductive coupling caused by lightning currents being conducted in nearby lightning strikes or lightning currents being conducted by nearby conductors.

Major changes compared with the 2008 edition of this Recommendation include:

- updated references;
- added information on which universal serial bus (USB) ports should be tested;
- added information on when to add protection to untested ports;
- added test requirements for external coaxial cable ports;
- added test requirements for multiple conductor internal unshielded cable ports.

Major changes compared with the 2011 edition of this Recommendation include:

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

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.21	1988-11-25		11.1002/1000/1390
2.0	ITU-T K.21	1996-10-18	5	11.1002/1000/3881
3.0	ITU-T K.21	2000-10-06	5	11.1002/1000/5153
4.0	ITU-T K.21	2003-07-29	5	11.1002/1000/6493
5.0	ITU-T K.21	2008-04-13	5	11.1002/1000/9401
6.0	ITU-T K.21	2011-11-13	5	11.1002/1000/11421
7.0	ITU-T K.21	2015-04-22	5	11.1002/1000/12404
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Keywords

1.2/50-8/20, 10/700, customer premises equipment, Ethernet, external port, internal port, overvoltage, overcurrent, power over Ethernet (PoE), power contact, power induction, resistibility, surges, telecommunication equipment, transverse, universal serial bus (USB).

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* 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.

FOREWORD

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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.21

Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents

1 Scope

This Recommendation specifies resistibility requirements and test procedures for telecommunication equipment which is attached to or installed within a customers' premises. The requirements of this Recommendation assume that earthing and bonding is in accordance with [ITU-T K.66].

The types of equipment covered by this Recommendation include all types of telecommunication equipment, e.g., modems, telephones, routers, implementations of digital subscriber lines and personal computers.

NOTE – Associated equipment containing ports with a low surge impedance to earth connected by short cables, e.g., printers using universal serial bus (USB) cables, may be susceptible to damage due to circulating earth currents. Refer to [ITU-T K.66] and [b-ITU-T K.85] for methods of protection.

This Recommendation applies to both external and internal ports. [ITU-T K.44], covering basic test methods and test circuits, is an integral part of this Recommendation and should be read in conjunction with [ITU-T K.11] and [ITU-T K.39].

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 (2016), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*.

[ITU-T K.66] Recommendation ITU-T K.66 (2011), *Protection of customer premises from overvoltages*.

[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

This Recommendation uses terms defined in [ITU-T K.44].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

a.c. alternating current

CWG Combination Wave Generator

d.c. direct current

ESD Electrostatic Discharge

n.a. not applicable

PE Protective Earth

PoE Power over Ethernet

STP Special Test Protector

STP_E Shielded Twisted Pair Ethernet

USB Universal Serial Bus

UTP_E Unshielded Twisted Pair Ethernet

4.1 Symbols

This Recommendation uses the following symbols:

f frequency

I current

R resistance

t duration

$U_{a.c.}$ alternating current voltage

$U_{a.c.(max)}$ maximum alternating current voltage

U_c charging voltage

$U_{c(max)}$ maximum charging voltage

U_{rms} root mean square voltage

$W_{sp(max)}$ maximum specific energy

5 Conventions

Conventions and symbols used in this Recommendation are defined in [ITU-T K.44].

6 Tests

A summary of the tests applicable to equipment installed in a customer's premises is given in Table 1. The numbers given in the "Port type" columns, e.g., 2.2.1a, 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. The test conditions for internal cable ports are given in Table 7. 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 always be 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. Where the equipment external to the building is installed in the "inherently protected" area shown in Figure 3 of [b-ITU-T K.71], the internal port test can be applied.

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].

NOTE 4 – The internal port tests in Table 7 apply to ports connected by short cables, e.g., universal serial bus (USB) and printer cables. Table 7 does not apply to ports connected infrequently, e.g., for maintenance ports.

Table 1a – Applicable tests for external ports

Test type	No. of pairs simultaneously tested	Test connections	Primary protection	Port type			
				Symmetric port	Co-axial 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 (UTP_E) Ethernet	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 (STP_E) Ethernet	Shield to earth	No	2.1.9, 2.1.12	2.1.9, 2.1.12	n.a.	n.a.
		Port to earth	No	2.1.8	2.1.8	n.a.	n.a.

Table 1a – Applicable tests for external ports

Test type	No. of pairs simultaneously tested	Test connections	Primary protection	Port type			
				Symmetric port	Co-axial port	Dedicated power feed port	Mains power port
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.
	Multiple	Port to earth	No	2.1.6a, 2.1.10	n.a.	n.a.	n.a.
		Port to external port	No	2.1.6b	n.a.	n.a.	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.
Insulation	Multiple	Port to earth	n.a.	2.1.10, 7.6	n.a.	n.a.	n.a.
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
		Coordination Transverse	Yes	2.2.2a	Under study	4.2.2a	n.a.
		Coordination Port to earth	Yes	2.2.2b	n.a.	4.2.2b	n.a.
		Coordination Port to external port	Yes	2.2.2c	n.a.	4.2.2c	n.a.
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.
n.a.: not applicable.							

Table 1b – Applicable tests for ports connected to internal cabling

Test type	Primary protection	Unshielded cable	Shielded cable	PoE	Floating d.c. power interface	Earthed d.c. power interface
Lightning	No	7.1, 7.6, 7.7	7.2, 7.3, 7.4, 7.7	7.5	7.8	7.9

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see 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 µs	$U_{c(max)}$ = 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	Test 2.1.1 does not apply when the equipment is designed to always be used with primary protection and the operator agrees. If this test is not performed, the appropriate test from Table 7 applies. If the inherent protection of the port under test contains surge protective devices (SPDs) that are connected to PE, a $U_{c(max)}$ of 1.5 kV shall be used instead of 6 kV. If the equipment has an insulated case, the 6 kV test is applied with the equipment wrapped in conductive foil and the foil is connected to the generator return. 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 µs	$U_{c(max)}$ = 1.5 kV R = 25 Ω	$U_{c(max)}$ = 6 kV See comments R = 25 Ω				
2.1.1c	Single pair, lightning, inherent, port to external port	A.3-1 and A.6.1-3 10/700 µs	$U_{c(max)}$ = 1.5 kV R = 25 Ω	$U_{c(max)}$ = 6 kV See comments R = 25 Ω				

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.1.2a	Single pair, lightning, co-ordination, transverse	A.3-1 and A.6.1-1 (a and b) 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω	Alternating ±5 surges (60 s between successive surges)	Special test protector; 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 10.1.1 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, co-ordination, port to earth	A.3-1 and A.6.1-2 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				
2.1.2c	Single pair, lightning, co-ordination, port to external port	A.3-1 and A.6.1-3 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω $U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				
2.1.3a	Multiple pair, lightning, inherent, port to earth	A.3-1 and A.6.1-4 10/700 µs	$U_{c(max)}$ = 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	The multiple pairs test is simultaneously applied to 100% of the pairs in the same street cable, but limited to a maximum of 8 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.
2.1.3b	Multiple pair, lightning, inherent, port to external port	A.3-1 and A.6.1-5 10/700 µs	$U_{c(max)}$ = 1.5 kV R = 25 Ω	$U_{c(max)}$ = 1.5 kV R = 25 Ω				

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.1.4a	Multiple pair, lightning, port to earth	A.3-1 and A.6.1-4 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω	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 pairs test is simultaneously applied to 100% of the pairs in the same street cable, but limited to a maximum of 8 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 pair, lightning, port to external port	A.3-1 and A.6.1-5 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				
2.1.5a	Single pair, lightning current, port to earth	A.3-4 and A.6.1-2 8/20 µs	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω	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 pairs test is simultaneously applied to 100% of the pairs in the same street cable, but limited to a maximum of 8 pairs.
2.1.5b	Single pair, lightning current, port to external port	A.3-4 and A.6.1-3 8/20 µs	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω				
2.1.6a	Multiple pair, lightning current, port to earth	A.3-4 and A.6.1-4 8/20 µs	I = 1 kA/wire Limited to 6 kA total R = 0 Ω	I = 5 kA/wire Limited to 30 kA total R = 0 Ω	Alternating ±5 surges (60 s between	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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.1.6b	Multiple pair, lightning current, port to external port	A.3-4 and A.6.1-5 8/20 µs	I = 1 kA/wire Limited to 6 kA total (Note 1) R = 0 Ω	I = 5 kA/wire Limited to 30 kA total (Note 1) R = 0 Ω	successive surges)			
2.1.7	Ethernet transverse	Figures A.3-5 Figure A.6.7-5 [1.2/50-8/20 combination wave generator (CWG)] R = 10 Ω (and 10 Ω shunt that is shown as optional in diagram)	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	
2.1.8	STP_E/UTP_E Ethernet simultaneous port to earth	Figures A.3-5 Figure A.6.7-4 (1.2/50-8/20 CWG) R = 10	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	
2.1.9	STP_E Ethernet simultaneous port to earth test (see Note 2)	Figures A.3-5 Figure A.6.7-6 (1.2/50-8/20 CWG) R = 10 Ω	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.1.10	UTP_E Ethernet port rated impulse voltage test	Figures A.3-5 Figure A.6.7-3a (1.2/50-8/20 CWG) R = 5 Ω	$U_{c(max)}$ = 2 500 V surge	$U_{c(max)}$ = 6 000 V surge	Alternating ±5 surges (60 s between successive surges)	None (Note 2)	A	There shall be no insulation breakdown during the test and the post test resistance shall be at least 2 MΩ 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 test	Figures A.3-5 Figure A.6.7-2 (1.2/50-8/20 CWG) R = 10 Ω (and 10 Ω shunt that is shown as optional in diagram)	$U_{c(max)}$ 2 500 V	$U_{c(max)}$ 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	
2.1.12	STP_E Ethernet shield bond test	Figures A.3-5 Figure A.6.7-6 (1.2/50-8/20 CWG) R = 5 Ω	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	

NOTE 1 – Peak current is set by the weaker of the ports under test and the external port coupled to earth.

NOTE 2 – 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.

I: current; R: resistance; $U_{c(max)}$: maximum charging voltage

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see 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 A^2s f = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 0.2 s	$W_{sp(max)}$ = 0.2 A^2s f = 16 ⅔,50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 0.2 s	5	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees. When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply.
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						
2.2.2a	Power induction inherent/ co-ordination, transverse	A.3-6 and A.6.1-1 (a and b)	$W_{sp(max)}$ = 1 A^2s f = 16 ⅔,50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 1.0 s (Note 1)	$W_{sp(max)}$ = 10 A^2s f = 16 ⅔,50 or 60 Hz $U_{a.c.(max)}$ = 1 500 V R = 200 Ω $t_{(max)}$ = 2 s $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (6-1) (Note 2)	5	Special test protector; 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/ co-ordination, port to earth	A.3-6 and A.6.1-2						
2.2.2c	Power induction and earth potential rise, inherent/ co-ordination, port to external earth	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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.3.1a (Note 3)	Mains power contact, transverse	A.3-6 and A.6.1-1 (a and b)	$U_{a.c.}$ = 230 V f = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1 000 Ω See acceptance criteria column.	$U_{a.c.}$ = 230 V f = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1 000 Ω See acceptance criteria column.	1	None	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 11, clause 7.2 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.
2.3.1b (Note 3)	Mains power contact, port to earth	A.3-6 and A.6.1-2						
2.3.1c (Note 3)	Mains power contact, port to external port	A.3-6 and A.6.1-3						

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 $I^2t = 1\ A^2s$ is fulfilled:

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

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

$R \leq 600\ \Omega$, is to be calculated according to Equation 6-2:

$$R = U_{a.c.(max)} \sqrt{t} \qquad (6\text{-}2)$$

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
NOTE 2 – For Test 2.2.2 (enhanced test level), the equipment shall comply with the specified criterion for all voltage/duration combinations bounded (on and below) by the 10 A^2s voltage/duration curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 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. *t*: duration; $U_{a.c.}$: alternating current voltage; $U_{a.c.(max)}$: maximum alternating current voltage; $W_{sp(max)}$ maximum specific energy; *f*: frequency								

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see 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 kV R = 0 Ω	$U_{c(max)}$ = 1.5 kV R = 0 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. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
3.1.2	Lightning, co-ordination, differential	A.3.5 and A.6.2-1 1.2/50 – 8/20 CWG	$U_{c(max)}$ = 4 kV R = 0 Ω	$U_{c(max)}$ = 6 kV R = 0 Ω	Alternating ±5 surges (60 ss between successive surges)	Special test protector; 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]. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
3.1.3	Lightning, current, differential	A.3.4 and A.6.2-1 8/20	I = 1 kA	I = 5 kA	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.

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see 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; 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.

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
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; 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])	Number of tests	Primary protection (see clause 9 of [ITU-T K.44])	Acceptance criteria (see 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 µs	$U_{c(max)}$ = 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	Test 4.1.1 does not apply when the equipment is designed to be always used with primary protection and the operator agrees. If this test is not performed, the appropriate test from Table 7 applies. If the inherent protection of the port under test contains SPDs that are connected to earth, a $U_{c(max)}$ of 1.5 kV shall be used instead of 6 kV. If the equipment has an insulated case, the 6 kV test is applied with the equipment wrapped in conductive foil and the foil is connected to the generator return. 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].)
4.1.1b	Single pair, lightning, inherent, port to earth	A.3-1 and A.6.3-2 10/700 µs	$U_{c(max)}$ = 1.5 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				
4.1.1c	Single pair, lightning, inherent, port to external port	A.3-1 and A.6.3-3 10/700 µs	$U_{c(max)}$ = 1.5 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				

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])	Number of tests	Primary protection (see clause 9 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
4.1.2a	Single pair, lightning, co-ordination, transverse	A.3-1 and A.6.3-1 (a and b) 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω	Alternating ±5 surges (60 s between successive surges)	Special test protector; 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 (Note 1) 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, 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. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
4.1.2b	Single pair, lightning, co-ordination, port to earth	A.3-1 and A.6.3-2 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				
4.1.2c	Single pair, lightning, co-ordination, port to external port	A.3-1 and A.6.3-3 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				
4.1.3	Multiple pair, lightning, inherent, port to earth and port to external port		n.a.	n.a.				
4.1.4	Multiple pair, lightning, port to earth and port to external port		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])	Number of tests	Primary protection (see clause 9 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
4.1.5a	Single pair, lightning current, port to earth	A.3-4 and A.6.3-2 8/20 µs	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω	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.
4.1.5b	Single pair, lightning current, port to external port	A.3-4 and A.6.3-3 8/20 µs	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω				
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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see 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 A^2s f = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 0.2 s	$W_{sp(max)}$ = 0.2 A^2s f = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 0.2 s	5	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees. When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply.
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/ co-ordination, transverse	A.3-6 and A.6.3-1 (a and b)	$W_{sp(max)}$ = 1 A^2s f = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 1.0 s (Note 1)	$W_{sp(max)}$ = 10 A^2s f = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 1 500 V R = 200 Ω $t_{(max)}$ = 2 s $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (6-1) (Note 2)	5	Special test protector; 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, do not remove these components and do not add primary protection.
4.2.2b	Power induction and earth potential rise, inherent/ co-ordination, port to earth	A.3-6 and A.6.3-2						

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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
4.2.2c	Power induction and earth potential rise, inherent/ co-ordination, port to external port	A.3-6 and A.6.3-3						
4.3.1a	Mains power contact, transverse	A.3-6 and A.6.3-1 (a and b)	$U_{a.c.}$ = 230 V f = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1 000 Ω See acceptance criteria column. (Note 3)	$U_{a.c.}$ = 230 V f = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1 000 Ω See acceptance criteria column. (Note 3)	1	None	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 11, clauses 7.2 and 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, port to earth	A.3-6 and A.6.3-2						
4.3.1c	Mains power contact, 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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
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 A^2s is fulfilled: $U_{a.c.(max)}$ = 300 V... 600 V, selected to meet local conditions; $t \leq 1.0$ s, selected to meet local conditions; $R \leq 600\ \Omega$, is to be calculated according to Equation 6-2: $$R = U_{a.c.(max)} \sqrt{t} \quad (6\text{-}2)$$ NOTE 2 – For Test 4.2.2 (enhanced test level), the equipment shall comply with the specified criterion for all voltage/duration combinations bounded (on and below) by the 10 A^2s voltage/duration curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 and the boundary conditions in this table. NOTE 3 – The a.c. mains voltage and frequency for Test 4.3.1 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]) Note 1	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) Note 1	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see 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 kV R = 0 Ω	$U_{c(max)}$ = 6.0 kV R = 0 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 and the operator agrees. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
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 kV R = 0 Ω	$U_{c(max)}$ = 6.0 kV R = 0 Ω				
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 kV R = 0 Ω	$U_{c(max)}$ = 6.0 kV R = 0 Ω				

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]) Note 1	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44]) Note 1	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
5.1.2a	Lightning, inherent/ co-ordination, transverse	A.3-5 and A.6.4-1 1.2/50-8/20 CWG	$U_{c(max)}$ = 6.0 kV R = 0 Ω	$U_{c(max)}$ = 10.0 kV R = 0 Ω	Alternating ±5 surges (60 s between successive surges)	Agreed primary protector (mains) (Note 2). When performing the external port to external port test, also add an STP/primary protector to the untested port.	A	(Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
5.1.2b	Lightning, inherent/ co-ordination, port to earth	A.3-5 and A.6.4-2 1.2/50-8/20 CWG	$U_{c(max)}$ = 6.0 kV R = 0 Ω	$U_{c(max)}$ = 10.0 kV R = 0 Ω				
5.1.2c	Lightning, inherent/ co-ordination, port to external port	A.3-5 for and A.6.4-3 1.2/50-8/20 CWG	$U_{c(max)}$ = 6.0 kV R = 0 Ω	$U_{c(max)}$ = 10.0 kV R = 0 Ω				
5.2.1	Earth potential rise		Under study	Under study	5	None	A	
5.2.2a	Neutral potential rise, port to earth	A.3-6 and A.6.4-2 a.c.	$U_{a.c.}$ = 600 V f = 50 or 60 Hz t = 1 s R = 200 Ω	$U_{a.c.}$ = 1 500 V f = 50 or 60 Hz t = 1 s R = 200 Ω	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, port to external port	A.3-6 and A.6.4-3 a.c.						
NOTE 1 – The tests in this table apply to both mains-powered equipment and the combination of portable power supplies and equipment for portable supply-powered equipment. NOTE 2 – The total lead length used to connect the agreed primary protector shall be 1 m.								

Table 6 – Test conditions for ESD applied to the enclosure

Test no.	Test description	Test circuit	Basic test level (Note 1)	Enhanced test level (Note 1)	Number of tests	Primary protection	Acceptance criteria (see clause 9 of [ITU-T K.44])
6.1a	Air discharge	[IEC 61000-4-2]	Level 3	Level 4	5	n.a.	A
6.1b	Contact discharge	[IEC 61000-4-2]	Level 3	Level 4	5	n.a.	A
NOTE 1 – The test applies to the equipment enclosure.							

Table 7 – Lightning test conditions for ports connected to internal cables

Test no.	Test description (Note 1)	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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
7.1	Unshielded cable with symmetric pairs	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.5-1 R = 10 Ω (The value of R is independent of the number of conductors)	$U_{c(max)}$ = 1 000 V	$U_{c(max)}$ = 1 500 V	Alternating ±5 surges (60 s between successive surges)	None	A	The test is applied simultaneously to all symmetric cable pairs connected to the equipment port under test. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
7.2	Shielded cable to earth	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.5-2 R = 0 Ω	$U_{c(max)}$ = 1 000 V	$U_{c(max)}$ = 1 500 V	Alternating ±5 surges (60 s between successive surges)	None	A	(Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
7.3	USB shielded cable to earth	Figures A.3-5 (1.2/50-8/20 CWG) and	$U_{c(max)}$ = 100 V	$U_{c(max)}$ = 150 V	Alternating ±5 surges (60 s	None	A	Test is performed with the supplied cable (not the 20 m

Table 7 – Lightning test conditions for ports connected to internal cables

Test no.	Test description (Note 1)	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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
		A.6.5-2 R = 0 Ω			between successive surges)			cable specified in Figure A.6.5-2). (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
7.4	STP_E Ethernet simultaneous port to earth	Figures A.3-5 Figure A.6.7-6 (1.2/50-8/20 CWG) R = 5 Ω	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	
7.5	PoE Mode A and Mode B transverse testing	Figures A.3-5 Figure A.6.7-2 (1.2/50-8/20 CWG) R = 10Ω (and 10 Ω shunt that is shown as optional in diagram)	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	
7.6	UTP_E Ethernet port rated impulse voltage	Figures A.3-5 Figure A.6.7-3a (1.2/50-8/20 CWG) R = 5 Ω	$U_{c(max)}$ = 2 500 V surge	$U_{c(max)}$ = 6 000 V surge	Alternating ±5 surges (60 s between successive surges)	None (Note 2)	A	There shall be no insulation breakdown during the test and the post test resistance shall be at least 2 MΩ when measured at 500 V d.c. Monitor the impulse voltage to detect breakdown or voltage protector operation.

Table 7 – Lightning test conditions for ports connected to internal cables

Test no.	Test description (Note 1)	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])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
7.7	UTP_E/STP_E Ethernet transverse	Figures A.3-5 Figure A.6.7-5 [1.2/50-8/20 combination wave generator (CWG)] R = 10 Ω (and 10 Ω shunt that is shown as optional in diagram)	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 V	Alternating ±5 surges (60 s between successive surges)	None	A	
7.8	Floating d.c. power interface	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.6-2 R = 0 Ω Coupling element: 10 Ω + 9 µF in series	$U_{c(max)}$ = 1 000 V	$U_{c(max)}$ = 1 500 V	Alternating ±5 surges (60 s between successive surges)	None	A	For d.c. power supplies with both sides floating. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
7.9	Earthed d.c. power interface	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.6-1a R = 0 Ω dpf1 coupling element: 10 Ω + 9 µF in series dpf2 connected to generator return	$U_{c(max)}$ = 1 000 V	$U_{c(max)}$ = 1 500 V	Alternating ±5 surges (60 s between successive surges)	None	A	For d.c. power supplies with one side earthed. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)

NOTE 1 – For equipment without an earth connection, wrap the equipment in foil and connect the foil to the generator return.

NOTE 2 – 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.

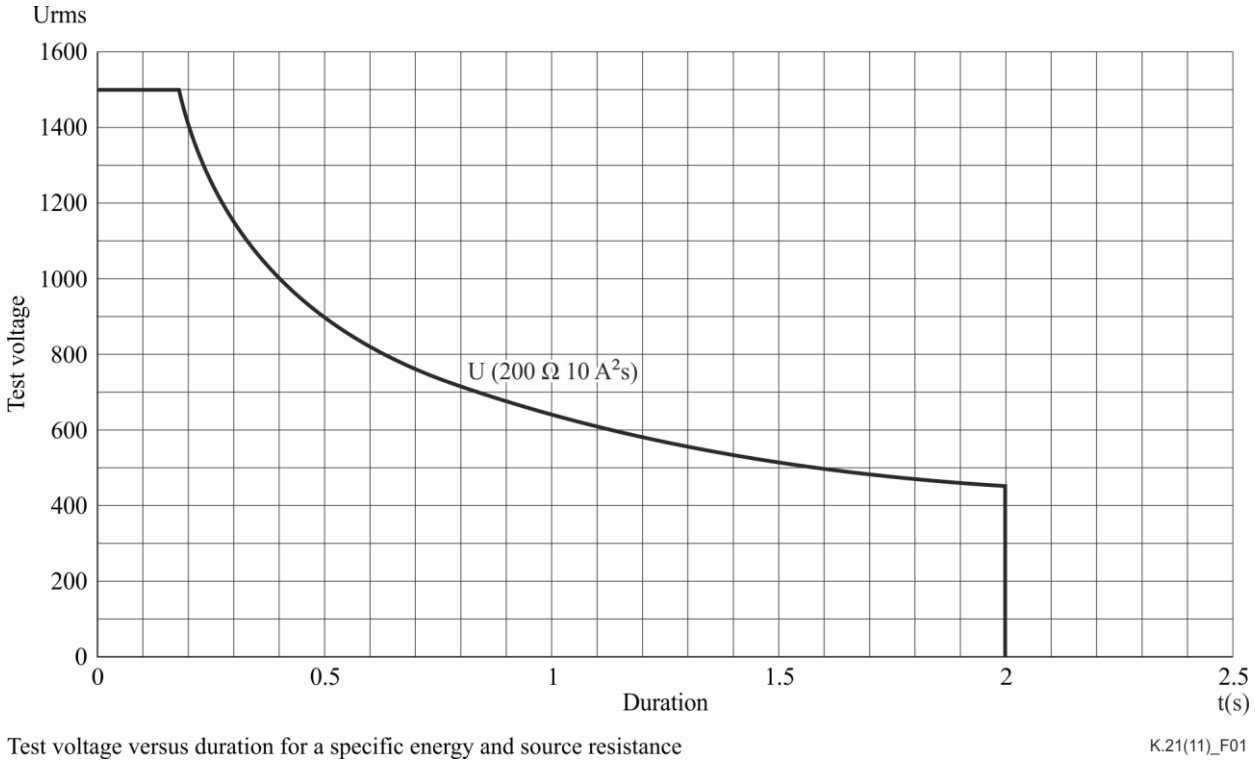

Figure 1 – Test voltage versus duration to give 10 A^2s with 200 Ω

Bibliography

[b-ITU-T K.71] Recommendation ITU-T K.71 (2011), *Protection of customer antenna installations*.

[b-ITU-T K.85] Recommendation ITU-T K.85 (2011), *Requirements for the mitigation of lightning effects on home networks installed in customer premises*.

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