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

Recommendation ITU-T K.45

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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 AC power lines or railway systems, earth potential rise due to power faults, direct contact between telecommunication lines and power lines and electrostatic discharges.

Changes compared with Recommendation ITU-T K.45 (2017) include:

- external Ethernet port power contact test;
- renaming of some test titles for clarity.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.45	2000-02-25	5	11.1002/1000/4908
2.0	ITU-T K.45	2003-07-29	5	11.1002/1000/6497
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5.0	ITU-T K.45	2015-04-22	5	11.1002/1000/12407
6.0	ITU-T K.45	2016-06-29	5	11.1002/1000/12870
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Keywords

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.

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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.

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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 that 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

SPD Surge Protective Device

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

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
		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
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	[**]

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
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
		Ethernet port	No	2.4			
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 exemptions for short external cables are under study)

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 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 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 kV R = 25 Ω	$U_{c(max)}$ = 1.5 kV R = 25 Ω				
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 kV R = 25 Ω	$U_{c(max)}$ = 1.5 kV R = 25 Ω				
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 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 8.4 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 kV R = 25 Ω	$U_{c(max)}$ = 4 kV R = 25 Ω				
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 kV R = 25 Ω	$U_{c(max)}$ = 4 kV R = 25 Ω				

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

(Test exemptions for short external cables are under study)

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 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 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 kV R = 25 Ω	$U_{c(max)}$ = 1.5 kV R = 25 Ω				
2.1.4a	Multiple pair, lightning, port to earth	A.3-1 and A.6.1-4 10/700	$U_{c(max)}$ = 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 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
2.1.4b	Multiple port, lightning, port to external port	A.3-1 and A.6.1-5 10/700	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 6 kV R = 25 Ω				

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

(Test exemptions for short external cables are under study)

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
								required for each test – see clause 7.3 of [ITU-T K.44])
2.1.5a	Single pair, lightning current, port to earth	A.3-4 and A.6.1-2 8/20	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 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 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	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 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 kA/wire Limited to 6 kA total R = 0 Ω	I = 5 kA/wire Limited to 30 kA total R = 0 Ω				
2.1.7	Ethernet transverse	A.3-5 and A.6.7-5 1.2/50-8/20 combination wave generator (CWG) R1 = R2 =10 Ω and C1 = 1 µF, 6 kV	$U_{c(max)}$ = 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 exemptions for short external cables are under study)

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
2.1.8	Ethernet longitudinal/common mode to transverse/ differential mode conversion testsi	A.3-5 and A.6.7-4 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	
2.1.9	Screen/shield connection high current test	A.3-5 and 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	
2.1.10	Ethernet longitudinal/ common mode withstand test	A.3-5 and 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)	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., see Figure A.6.7-3 of [ITU-T K.44]. Monitor the impulse voltage to detect insulation 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 Ω and R_2 = 10 Ω	$U_{c(max)}$ = 2 500 V	$U_{c(max)}$ = 6 000 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 A^2s f = 16⅔ Hz, 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 = 16⅔ Hz, 50 Hz 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. 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						

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 A^2s f = 16⅔ Hz, 50 Hz 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 = 16⅔ Hz, 50 Hz 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 (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	If the equipment port has inherent primary protection, which eliminates the need for external 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)	$U_{a.c.}$= 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 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
2.3.1b	Mains power contact, inherent, port to earth	A.3-6 and A.6.1-2						
2.3.1c	Mains power contact, 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
								this test with the special test protector installed. (Note 3)
2.4	Ethernet mains power contact (Note 4)	A.3-6 and A.6.7-7	R = 10, 20, 40, 80, 160, 300, 600 and 1 000 Ω See acceptance criteria column.	*R* = 10, 20, 40, 80, 160, 300, 600 and 1 000 Ω See acceptance criteria column.	1	None		If the equipment port has inherent primary protection, which eliminates the need for external primary protection, refer to clause 10.1.4 of [ITU-T K.44].

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.

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

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 A^2s voltage–time curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 and boundary conditions in this table.

NOTE 3 – The AC mains voltage and frequency for Test 2.3.1 may be changed to the local mains supply voltage and frequency values. For AC 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.

NOTE 4 – Test 2.4 only applies for external Ethernet ports connected to the aerial Ethernet cable that is in parallel with an aerial AC mains cable.

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 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.
3.1.2	Lightning, coordination, 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 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 kA	I = 5 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 DC or AC 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 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	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 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)			
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	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Alternating ±5 surges (60 s between successive surges)			

Table 4a – Lightning test conditions for ports connected to external DC or AC 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
4.1.2a	Single pair, lightning, coordination, transverse	A.3-1 and A.6.3-1 (a and b) 10/700 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 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 µs	$U_{c(max)}$ = 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 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 4 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 DC or AC 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
4.1.5a	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.
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	Alternating ±5 surges (60 s between successive surges)			
4.1.6	Multiple pair, lightning current		n/a	n/a				
NOTE – 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 DC or AC 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 A^2s f = 16⅔ Hz, 50 Hz or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 0.2 s	$W_{sp(max)}$ = 0.2 A^2s f = 16⅔ Hz, 50 Hz 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. 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/coordination, transverse	A.3-6 and A.6.3-1 (a and b)	$W_{sp(max)}$ = 1 A^2s f = 16⅔ Hz, 50 Hz 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 = 16⅔ Hz, 50 Hz 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 (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 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/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 DC or AC 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 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 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						

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;

$R \leq 600$ Ω, 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–time combinations bounded (on and below) by the 10 A^2s voltage–time 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 AC mains voltage and frequency for Test4.3.1 may be changed to the local mains supply voltage and frequency values. For AC 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

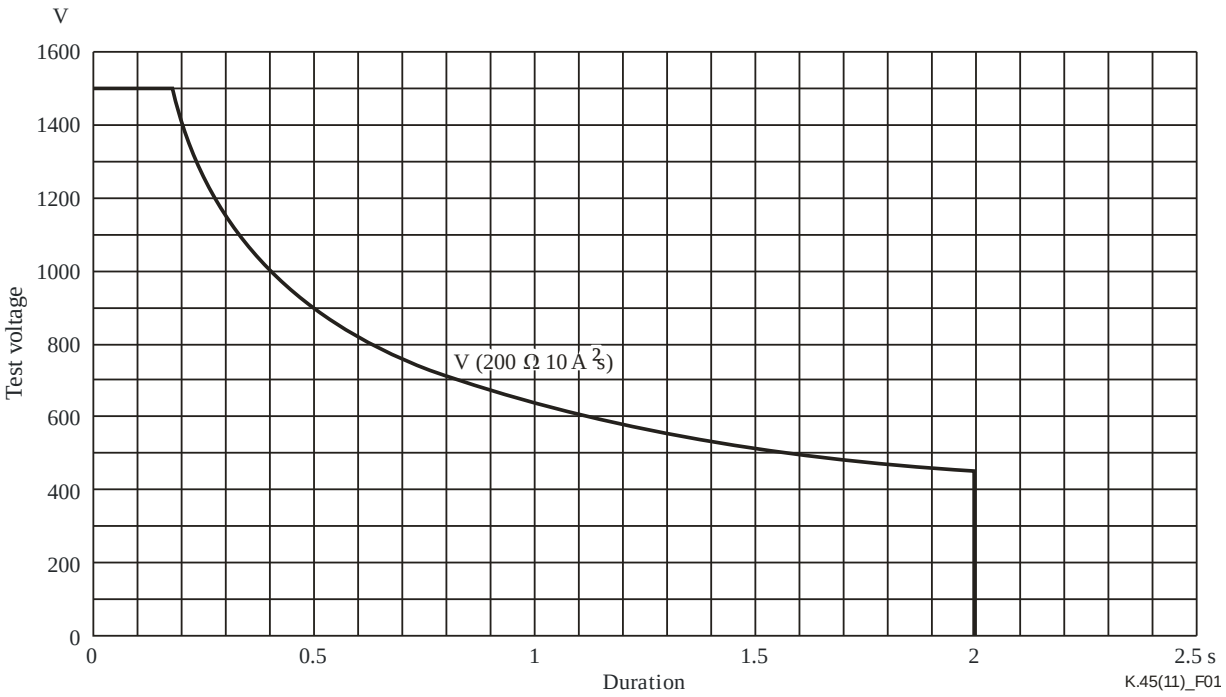
Test No.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	No. of tests	Primary protection (clause 8 of [ITU-T K.44])	Acceptance criteria (clause 9 of [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 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.
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				
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 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). 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 kV R = 0 Ω	$U_{c(max)}$ = 10.0 kV R = 0 Ω				
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 kV R = 0 Ω	$U_{c(max)}$ = 10.0 kV R = 0 Ω				
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.	$U_{(AC)}$ = 600 V f = 50 Hz or 60 Hz t = 1 s R = 200 Ω	$U_{(AC)}$ = 1 500 V f = 50 Hz 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.

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
5.2.2b	Neutral potential rise, inherent, external port to port	A.3-6 and A.6.4-3 a.c.						
NOTE – 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 – Tests 6.1.a and 6.1.b are applied 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 A^2s 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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