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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 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 the 2008 version of this Recommendation include:

- updating the references;
- informing when to add protection to untested ports;
- adding test requirements for external coaxial cable ports.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T K.45	2000-02-25	5
2.0	ITU-T K.45	2003-07-29	5
3.0	ITU-T K.45	2008-04-13	5
4.0	ITU-T K.45	2011-11-13	5

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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 (2011), *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.* <http://webstore.iec.ch/webstore/webstore.nsf/artnum/042407>

3 Definitions, abbreviations and conventions

3.1 Definitions and abbreviations defined elsewhere

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

3.2 Acronyms, abbreviations and conventions

This Recommendation uses the following additionnal acronyms, abbreviations and conventions:

ESD Electrostatic Discharge

ICT Information and Communication Technology

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

STP Special Test Protector

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

4 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
		Transverse/ differential	Yes	2.1.2a	3.1.2	4.1.2a	5.1.2a
		Port to earth	Yes	2.1.2b	n.a.	4.1.2b	5.1.2b
		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.

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 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	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.
Power induction and earth potential rise	Single	Transverse	No	2.2.1a	3.2.1	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	3.2.2	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	Acceptance criteria	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	5 of each polarity	None	A (Note)	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 which eliminate the need for primary protection, this test does not apply.
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	$U_{c(max)}$ = 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 µs	$U_{c(max)}$ = 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 µs	$U_{c(max)}$ = 4 kV R = 25 Ω	$U_{c(max)}$ = 4 kV R = 25 Ω	5 of each polarity	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 which eliminate the need for primary protection, refer to clause 10.1.1 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 µs	$U_{c(max)}$ = 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 µs	$U_{c(max)}$ = 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 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	Acceptance criteria	Comments
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	5 of each polarity	None	A	The multiple port test is simultaneously applied to 100% of the pairs in the same cable 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 which 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				
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	5 of each polarity	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 8 pairs. When the equipment contains high current-carrying components which eliminate the need for primary protection, do not remove these components and do not add primary protection.
2.1.4b	Multiple port, 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				

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	Acceptance criteria	Comments
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	5 of each polarity	None	A	This test only applies when the equipment contains high current-carrying components which 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 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				
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 R = 0 Ω	I = 5 kA/wire Limited to 30 kA total R = 0 Ω				
NOTE – The performance criterion A of [ITU-T K.44] is applied.								

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	Acceptance criteria	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 Frequency = 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 Frequency = 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. When the equipment contains high current-carrying components which 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	Acceptance criteria	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 Frequency = 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 Frequency = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 1500 V R = 200 Ω $t_{(max)}$ = 2 s $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (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 (Note 4)	When the equipment contains high current-carrying components which 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)	$U_{a.c.}$= 230 V Frequency = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω See acceptance criteria column.	$U_{a.c.}$ = 230 V Frequency = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1000 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 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.
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.6.3-3						

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

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 equal to = 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 4-2.

$$R = U_{a.c.(\max)}\sqrt{\frac{t}{1A^2s}} \tag{4-2}$$

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 4-1 and 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.

NOTE 4 – The performance criterion A of [ITU-T K.44] is applied.

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	Acceptance criteria	Comments
3.1.1	Lightning, inherent, differential	A.3-5 and A.6.2-1 1.2/50 – 8/20 combination wave	$U_{c(max)}$ = 1.0 kV R = 0 Ω	$U_{c(max)}$ = 1.5 kV R = 0 Ω	5 of each polarity	None	A (Note 3)	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 which 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 combination wave	$U_{c(max)}$ = 4 kV R = 0 Ω	$U_{c(max)}$ = 6 kV R = 0 Ω	5 of each polarity	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 which 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	5 of each polarity	None	A	This test only applies when the equipment contains high current-carrying components which 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	Acceptance criteria	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)	5 of each polarity	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)	5 of each polarity	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.
NOTE 3 – The performance criterion A of [ITU-T K.44] is applied.

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

NOTE 4 – 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	Acceptance criteria	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	5 of each polarity	None	A (Note 2)	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 which 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	5 of each polarity			
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	5 of each polarity			

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	Acceptance criteria	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	5 of each polarity	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 which 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 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	Acceptance criteria	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	5 of each polarity	None	A	This test only applies when the equipment contains high current-carrying components which 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	5 of each polarity			
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. NOTE 2 – The performance criterion A of [ITU-T K.44] is applied.								

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	Acceptance criteria	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 Frequency = 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 Frequency = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 600 V R = 600 Ω t = 0.2 s	5	None	A (Note 4)	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 which 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 Frequency = 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 Frequency = 16 ⅔, 50 or 60 Hz $U_{a.c.(max)}$ = 1500 V R = 200 Ω $t_{(max)}$ = 2 s $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (4-1) (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 which 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 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	Acceptance criteria	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 Frequency = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω See acceptance criteria column.	$U_{a.c.}$ = 230 V Frequency = 50 Hz t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1000 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 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 equal to = 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 4-2.

$$R = U_{a.c.(\max)}\sqrt{\frac{t}{1A^2s}} \tag{4-2}$$

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 A^2s 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.

NOTE 4 – The performance criterion A of [ITU-T K.44] is applied.

Table 5 – Test conditions for mains power ports

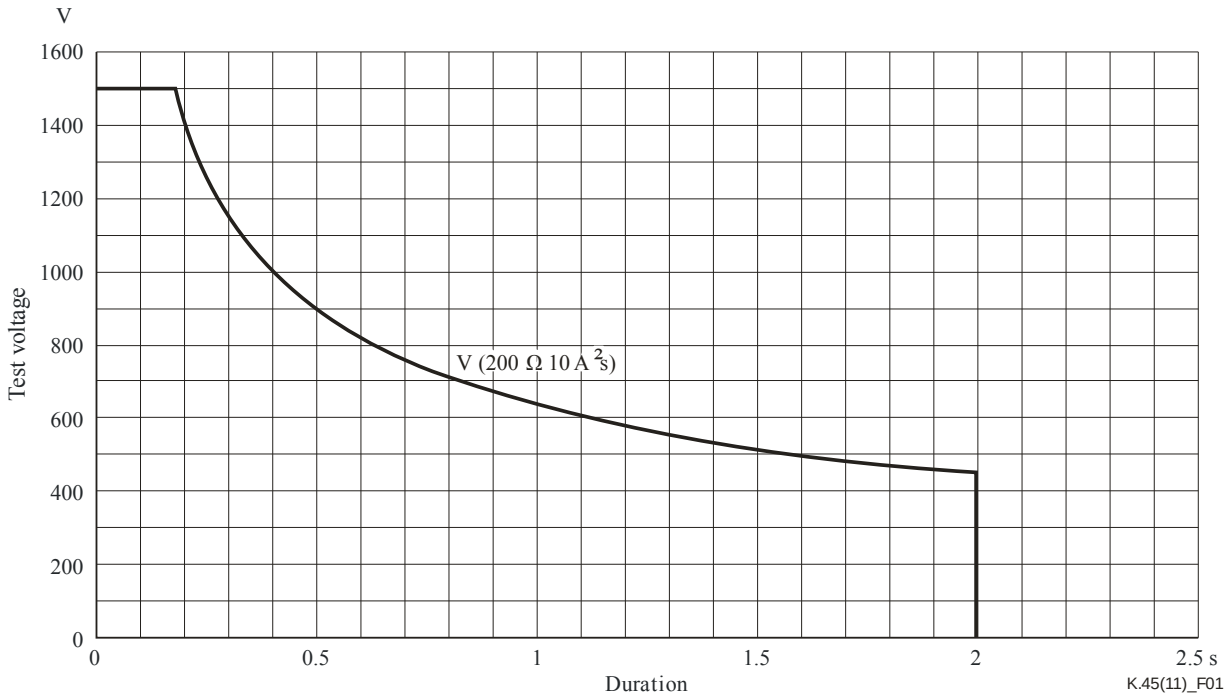
Test No.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	No. of tests	Primary protection	Acceptance criteria	Comments
5.1.1a	Lightning, inherent, transverse	A.3-5 and A.6.4-1 combination wave	$U_{c(max)}$ = 2.5 kV R = 0 Ω	$U_{c(max)}$ = 6.0 kV R = 0 Ω	5 of each polarity	None	A (Note 2)	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 combination wave	$U_{c(max)}$ = 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 combination wave	$U_{c(max)}$ = 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 combination wave	$U_{c(max)}$ = 6.0 kV R = 0 Ω	$U_{c(max)}$ = 10.0 kV R = 0 Ω	5 of each polarity	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 combination wave	$U_{c(max)}$ = 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 and A.6.4-3 combination wave	$U_{c(max)}$ = 6.0 kV R = 0 Ω	$U_{c(max)}$ = 10.0 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])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	No. of tests	Primary protection	Acceptance criteria	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 V Frequency = 50 or 60 Hz t = 1 s R = 200 Ω	$U_{a.c.}$ = 1500 V Frequency = 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, inherent, external port to port	A.3-6 and A.6.4-3 a.c.	$U_{a.c.}$ = 600 V Frequency = 50 or 60 Hz t = 1 s R = 200 Ω	$U_{a.c.}$ = 1500 V Frequency = 50 or 60 Hz t = 1 s R = 200 Ω				
NOTE 1 – The total lead length used to connect the agreed primary protector shall be 1 m. NOTE 2 – The performance criterion A of [ITU-T K.44] is applied.								

Table 6 – Test conditions for ESD 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	Level 4	5	n.a.	A
6.1.b	Contact discharge	IEC 61000-4-2 (2008)	Level 3	Level 4	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 A^2s with 200 Ω

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

[b-IEC 60364] IEC 60364-x (in force), *Low-voltage electrical installations*.

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