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

Recommendation ITU-T K.21

ITU-T





## Recommendation ITU-T K.21

### 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 (ESDs). 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.

#### History

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#### Keywords

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

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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 that is attached to or installed within a customer's 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. This Recommendation 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.12] Recommendation ITU-T K.12 (2010), *Characteristics of gas discharge tubes for the protection of telecommunications installations*.
- [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 (2019), *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
dpf	dedicated power feed
ESD	Electrostatic Discharge
MSPD	Multiservice Surge Protective Device
n/a	not applicable
PE	Protective Earth
PoE	Power over Ethernet
STP	Special Test Protector
STP <sub>E</sub>	Ethernet Shielded Twisted Pair
USB	Universal Serial Bus
UTP <sub>E</sub>	Ethernet 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.

The test items with the description of "coordination" require to use "special test protector" corresponding to primary protection. To select them, refer to clause 8 of [ITU-T K.44], and Annex C of [ITU-T K.12]. Their characteristics shall be recorded in the test report.

For the equipment contain "high current-carrying components" (voltage limiter that diverts the surge current in most cases, and not removed when the equipment is used) that eliminate the need for primary protection, the test method is specified in the "comments" column in Tables 2 to 5. In this case, the test items with the description of "inherent" are not applied, and the test items with the description of "Lightning current" are applied. For the definition and information regarding "high current-carrying components", refer to clauses 3, 4, and 10 of [ITU-T K.44].

For the details of applying the tests, a practical guide is given in [b-ITU-T K.Imp44].

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 within 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., 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

**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	
	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	
	Ethernet unshielded twisted pair (UTP <sub>E</sub> )	Port to earth	No	2.1.8	n/a	n/a	n/a	
		Transverse/differential	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	
	Ethernet shielded twisted pair (STP <sub>E</sub> )	Shield to earth	No	2.1.9		n/a	n/a	
		Port to earth	No	2.1.8		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
		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
Transverse/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/differential	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/differential	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	

**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
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/ differential	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			

n/a not applicable.

**Table 1b – Lightning test conditions for ports connected to internal cables**

No. of pairs simultaneously tested	Test connection	Primary protection	Unshielded cable	Shielded cable	PoE feed	DC powered equipment	DC power source
Single	Shielded cable to earth	No		7.2			
	USB shielded cable to earth	No		7.3			
	Screen/ shield connection high current test	No		7.4			
	Ethernet transverse/ differential	No	7.7	7.7			
	Twisted pair port transverse/ differential	No	7.10	7.10			
	DC powered equipment port	No				7.8	
	DC power source port	No					7.9
Multiple	Unshielded cable with symmetric pairs	No	7.1				
	PoE Mode A and Mode B transverse/ differential testing	No			7.5		
	Ethernet longitudinal/common mode withstand test	No	7.6				

**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/differential	A.3-1 and A.6.1-1 (a and b) 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	Alternating $\pm 5$ surges (60 s between successive surges)	None	A	<p>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. (Note 1)</p> <p>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.</p> <p>When the equipment contains high current-carrying components that eliminate the need for primary protection, this test does not apply.</p> <p>(Lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44].)</p>
2.1.1b	Single pair, lightning, inherent, port to earth	A.3-1 and A.6.1-2 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				
2.1.1c	Single pair, lightning, inherent, port to external port	A.3-1 and A.6.1-3 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				

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

Test No.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	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, coordination, transverse/differential	A.3-1 and A.6.1-1 (a and b) 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$	Alternating $\pm 5$ 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 STP must operate. 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, coordination, port to earth	A.3-1 and A.6.1-2 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				
2.1.2c	Single pair, lightning, coordination, port to external port	A.3-1 and A.6.1-3 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				
2.1.3a	Multiple pair, lightning, inherent, port to earth	A.3-1 and A.6.1-4 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	Alternating $\pm 5$ 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 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.
2.1.3b	Multiple pair, lightning, inherent, port to external port	A.3-1 and A.6.1-5 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$				

**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	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$	Alternating $\pm 5$ 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 eight pairs. When the equipment contains high current-carrying components that eliminate the need for primary protection, do not remove these components and do not add primary protection. (Lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44].)
2.1.4b	Multiple pair, lightning, port to external port	A.3-1 and A.6.1-5 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				

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

Test No.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.1.5a	Single pair, lightning current, port to earth	A.3-4 and A.6.1-2 8/20	$I = 1 \text{ kA/wire}$ $R = 0 \Omega$	$I = 5 \text{ kA/wire}$ $R = 0 \Omega$	Alternating $\pm 5$ 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 eight pairs.
2.1.5b	Single pair, lightning current, port to external port	A.3-4 and A.6.1-3 8/20	$I = 1 \text{ kA/wire}$ $R = 0 \Omega$	$I = 5 \text{ kA/wire}$ $R = 0 \Omega$				
2.1.6a	Multiple pair, lightning current, port to earth	A.3-4 and A.6.1-4 8/20	$I = 1 \text{ kA/wire}$ Limited to 6 kA total $R = 0 \Omega$	$I = 5 \text{ kA/wire}$ Limited to 30 kA total $R = 0 \Omega$				
2.1.6b	Multiple pair, lightning current, port to external port	A.3-4 and A.6.1-5 8/20	$I = 1 \text{ kA/wire}$ Limited to 6 kA total (Note 2) $R = 0 \Omega$	$I = 5 \text{ kA/wire}$ Limited to 30 kA total (Note 2) $R = 0 \Omega$				
2.1.7	Ethernet transverse/differential	A.3-5 and A.6.7-5 1.2/50-8/20 combination wave generator (CWG) $R_1 = 10 \Omega$ and $R_2 = 10 \Omega$	$U_{c(\max)} = 2\,500 \text{ V}$	$U_{c(\max)} = 6\,000 \text{ V}$	Alternating $\pm 5$ 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
2.1.8	Ethernet longitudinal/common mode to transverse/differential mode conversion tests	A.3-5 and A.6.7-4 1.2/50-8/20 CWG $R = 10 \Omega$	$U_{c(max)} = 2\,500 \text{ V}$	$U_{c(max)} = 6\,000 \text{ V}$	Alternating $\pm 5$ 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 $R = 5 \Omega$	$U_{c(max)} = 2\,500 \text{ V}$	$U_{c(max)} = 6\,000 \text{ V}$	Alternating $\pm 5$ surges (60 s between successive surges)	None (Note 3)	A	
2.1.10	UTP <sub>E</sub> port rated impulse voltage test	A.3-5 and A.6.7-3a 1.2/50-8/20 CWG $R = 5 \Omega$	$U_{c(max)} = 2\,500 \text{ V}$ surge	$U_{c(max)} = 6\,000 \text{ V}$ surge	Alternating $\pm 5$ surges (60 s between successive surges)	None (Note 3)	A	There shall be no insulation breakdown during the test and the post-test resistance shall be at least 2 M $\Omega$ when measured at 500 V d.c.; see Figure A.6.7-3. Monitor the impulse voltage to detect insulation breakdown or voltage protector operation.
2.1.11	PoE Mode A and Mode B transverse/differential test	A.3-5 and A.6.7-2 1.2/50-8/20 CWG $R_1 = 10 \Omega$ and $R_2 = 10 \Omega$	$U_{c(max)} = 2\,500 \text{ V}$	$U_{c(max)} = 6\,000 \text{ V}$	Alternating $\pm 5$ surges (60 s between successive surges)	None	A	

NOTE 1 – This exception can be applied only to equipment where the user has specified a primary protector and has agreed to always use it; it cannot be applied to products where the user or the use are unknown, e.g., to products sold in the general market.

NOTE 2 – Peak current is set by the weaker of the ports under test and the external port coupled to earth.



**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
NOTE 3 – 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>I</i> : current; <i>R</i> : 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/differential	A.3-6 and A.6.1-1 (a and b)	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}, 50 \text{ Hz}$ or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}, 50 \text{ Hz}$ or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$	5	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees. (Note 1)  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/coordination, transverse/differential	A.3-6 and A.6.1-1 (a and b)	$W_{sp(max)} = 1 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}, 50 \text{ Hz}$ or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 1.0 \text{ s}$ (Note 2)		5		A	
2.2.2b	Power induction and earth potential	A.3-6 and A.6.1-2						

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

Test No.	Test description	Test circuit (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
	rise, inherent/coordination, port to earth							
2.2.2c	Power induction and earth potential rise, inherent/coordination, port to external earth	A.3-6 and A.6.1-3		$W_{sp(max)} = 10 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz, } 50 \text{ Hz or } 60 \text{ Hz}$ $U_{a.c.(max)} = 1\,500 \text{ V}$ $R = 200 \, \Omega$ $t_{(max)} = 2 \text{ s}$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2} \quad (6-1)$ <p>(Note 3)</p>		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.		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].
2.3.1a	Mains power contact, inherent, transverse/differential	A.3-6 and A.6.1-1 (a and b)			1	None		
2.3.1b	Mains power contact, inherent, port to earth	A.3-6 and A.6.1-2						

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

Test No.	Test description	Test circuit (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection (see clause 8 of [ITU-T K.44])	Acceptance criteria (see clause 9 of [ITU-T K.44])	Comments
2.3.1c	Mains power contact, inherent, port to external port	A.3-6 and A.6.1-3	$U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10 \text{ } \Omega, 20 \text{ } \Omega, 40 \text{ } \Omega, 80 \text{ } \Omega, 160 \text{ } \Omega, 300 \text{ } \Omega, 600 \text{ } \Omega$ and $1\ 000 \text{ } \Omega$ See acceptance criteria column.	$U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10 \text{ } \Omega, 20 \text{ } \Omega, 40 \text{ } \Omega, 80 \text{ } \Omega, 160 \text{ } \Omega, 300 \text{ } \Omega, 600 \text{ } \Omega$ and $1\ 000 \text{ } \Omega$ See acceptance criteria column.			For basic level: criterion B. For enhanced level: criterion A for test resistors $160 \text{ } \Omega, 300 \text{ } \Omega, 600 \text{ } \Omega,$ and $1\ 000 \text{ } \Omega$ ; 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 STP installed. (Note 1, Note 4) 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].
2.4	Ethernet port DC insulation resistance	A.6.7-3	$U_{DC} = \pm 500 \text{ V DC}$	$U_{DC} = \pm 500 \text{ V DC}$	2	None	Insulation resistance $> 2 \text{ M}\Omega$	Test in both polarities, Ensures no port to earth conduction up to $350 \text{ V AC}$

**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
<p>NOTE 1 – This exception can be applied only to equipment where the user has specified a primary protector and has agreed to always use it; it cannot be applied to products where the user or the use are unknown, e.g., to products sold in the general market.</p> <p>NOTE 2 – 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 <math>I^2t = 1 \text{ A}^2\text{s}</math> is fulfilled:</p> <p><math>U_{\text{a.c.}(\text{max})} = 300 \text{ V} \dots 600 \text{ V}</math>, selected to meet local conditions;</p> <p><math>t \leq 1.0 \text{ s}</math>, selected to meet local conditions;</p> <p><math>R \leq 600 \Omega</math>, is to be calculated according to Equation 6-2:</p> $R = U_{\text{a.c.}(\text{max})} \sqrt{t} \tag{6-2}$ <p>NOTE 3 – 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 <math>10 \text{ A}^2\text{s}</math> voltage–duration curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 and the boundary conditions in this table.</p> <p>NOTE 4 – The a.c. mains voltage and frequency for Test 2.3.1 may be changed to the local mains supply voltage and frequency values. For a.c. test voltage values other than 230 V, the test resistor values should be adjusted to provide the same prospective short-circuit current values that occur in the 230 V test condition.</p> <p><math>t</math>: duration; <math>U_{\text{a.c.}}</math>: alternating current voltage; <math>U_{\text{a.c.}(\text{max})}</math>: maximum alternating current voltage; <math>W_{\text{sp}(\text{max})}</math> maximum specific energy; <math>f</math>: frequency</p>								

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

Test No.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	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, transverse/differential	A.3-5 and A.6.2-1 1.2/50 – 8/20 CWG	$U_{c(max)} = 1.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 1.5 \text{ kV}$ $R = 0 \Omega$	Alternating $\pm 5$ 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].)
3.1.2	Lightning, coordination, transverse/differential	A.3.5 and A.6.2-1 1.2/50 – 8/20 CWG	$U_{c(max)} = 4 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 0 \Omega$	Alternating $\pm 5$ 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 STP must operate. 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, transverse/differential	A.3.4 and A.6.2-1 8/20	$I = 1 \text{ kA}$	$I = 5 \text{ kA}$	Alternating $\pm 5$ 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 $\pm 5$ surges (60 s between successive surges)	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 $\pm 5$ surges (60 s between successive surges)	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 or equipment exposed to direct lightning currents, e.g., connected to antennas or 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/differential	A.3-1 and A.6.3-1 (a and b) 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	Alternating $\pm 5$ 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. (Note 1) 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	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				
4.1.1c	Single pair, lightning, inherent, port to external port	A.3-1 and A.6.3-3 10/700	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				

**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, coordination, transverse/differential	A.3-1 and A.6.3-1 (a and b) 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$	Alternating $\pm 5$ 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 (Note 2) When the test is performed with $U_c = U_{c(max)}$ , the STP must operate. 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, coordination, port to earth	A.3-1 and A.6.3-2 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				
4.1.2c	Single pair, lightning, coordination, port to external port	A.3-1 and A.6.3-3 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$				
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	$I = 1 \text{ kA/wire}$ $R = 0 \Omega$	$I = 5 \text{ kA/wire}$ $R = 0 \Omega$	Alternating $\pm 5$ 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	$I = 1 \text{ kA/wire}$ $R = 0 \Omega$	$I = 5 \text{ kA/wire}$ $R = 0 \Omega$				
4.1.6	Multiple pair, lightning current		n/a	n/a				
<p>NOTE 1 – This exception can be applied only to equipment where the user has specified a primary protector and has agreed to always use it; it cannot be applied to products where the user or the use are unknown, e.g., to products sold in the general market.</p> <p>NOTE 2 – 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.</p>								

**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/differential	A.3-6 and A.6.3-1 (a and b)	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}, 50 \text{ Hz}$ or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz},$ 50 Hz or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$	5	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees. (Note 1)  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/differential	A.3-6 and A.6.3-1 (a and b)	$W_{sp(max)} = 1 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz}, 50 \text{ Hz}$ or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 1.0 \text{ s}$ (Note 2)	$W_{sp(max)} = 10 \text{ A}^2\text{s}$ $f = 16\frac{2}{3} \text{ Hz},$ 50 Hz or 60 Hz $U_{a.c.(max)} = 1 \text{ 500 V}$ $R = 200 \Omega$ $t_{(max)} = 2 \text{ s}$  $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2} \text{ (6-1)}$ (Note 3)	5	Special test protector (STP); see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port.	A	When the equipment contains high current-carrying components that eliminate the need for primary protection, 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						

**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/coordination, port to external port	A.3-6 and A.6.3-3						
4.3.1a	Mains power contact, inherent, transverse/differential	A.3-6 and A.6.3-1 (a and b)	$U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10 \text{ } \Omega, 20 \text{ } \Omega, 40 \text{ } \Omega, 80 \text{ } \Omega, 160 \text{ } \Omega, 300 \text{ } \Omega, 600 \text{ } \Omega$ and $1\ 000 \text{ } \Omega$ See acceptance criteria column. (Note 4)	$U_{a.c.} = 230 \text{ V}$ $f = 50 \text{ Hz}$ $t = 15 \text{ min}$ for each test resistor $R = 10 \text{ } \Omega, 20 \text{ } \Omega, 40 \text{ } \Omega, 80 \text{ } \Omega, 160 \text{ } \Omega, 300 \text{ } \Omega, 600 \text{ } \Omega$ and $1\ 000 \text{ } \Omega$ See acceptance criteria column. (Note 4)	1	None	For basic level: criterion B. For enhanced level: criterion A for test resistors $160 \text{ } \Omega, 300 \text{ } \Omega, 600 \text{ } \Omega$ and $1\ 000 \text{ } \Omega$ ; 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 STP installed. (Note 1)
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 – This exception can be applied only to equipment where the user has specified a primary protector and has agreed to always use it; it cannot be applied to products where the user or the use are unknown, e.g., to products sold in the general market. NOTE 2 – The test conditions for Test 4.2.2 (basic test level) may be adapted to the local conditions, by variation of the test parameters within the following limits, so that $I^2t = 1 \text{ A}^2\text{s}$ is fulfilled:								

**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
<p><math>U_{a.c.(max)} = 300 \text{ V} \dots 600 \text{ V}</math>, selected to meet local conditions;</p> <p><math>t \leq 1.0 \text{ s}</math>, selected to meet local conditions;</p> <p><math>R \leq 600 \Omega</math>, is to be calculated according to Equation 6-2:</p> $R = U_{a.c.(max)} \sqrt{t} \tag{6-2}$ <p>NOTE 3 – 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<sup>2</sup>s voltage–duration curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 and the boundary conditions in this table.</p> <p>NOTE 4 – 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.</p>								

**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/differential	A.3-5 and A.6.4-1 1.2/50-8/20 CWG	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	Alternating $\pm 5$ 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. (Note 2) (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	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$				
5.1.1c	Lightning, inherent, port to external port	A.3-5 and A.6.4-3 1.2/50-8/20 CWG	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$				
5.1.2a	Lightning, inherent/coordination, transverse/differential	A.3-5 and A.6.4-1 1.2/50-8/20 CWG	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$	Alternating $\pm 5$ surges (60 s) between successive surges)	Agreed primary protector (mains) (Note 3). 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/coordination, port to earth	A.3-5 and A.6.4-2 1.2/50-8/20 CWG	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$				
5.1.2c	Lightning, inherent/coordination, port to external port	A.3-5 and A.6.4-3 1.2/50-8/20 CWG	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$				

**Table 5 – Test conditions for mains power ports**

Test No.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44]) (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
5.2.1	Earth potential rise	A.3-5 and A.6.4-1 1.2/50-8/20 CWG	Under study	Under study	5	None	A	
5.2.2a	Neutral potential rise, inherent, port to earth	A.3-5 and A.6.4-2 a.c.	$U_{(AC)} = 600 \text{ V}$ $f = 50 \text{ Hz}$ or $60 \text{ Hz}$ $t = 1 \text{ s}$ $R = 200 \Omega$	$U_{(AC)} = 1\,500 \text{ V}$ $f = 50 \text{ Hz}$ or $60 \text{ Hz}$ $t = 1 \text{ s}$ $R = 200 \Omega$	5	None	A	This test applies only when the equipment is to be installed with a TT or IT mains system and the operator requests it.
5.2.2b	Neutral potential rise, inherent, port to external port	A.3-5 for and A.6.4-3 a.c.						
<p>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.</p> <p>NOTE 2 – This exception can be applied only to equipment where the user has specified a primary protector and has agreed to always use it; it cannot be applied to products where the user or the use are unknown, e.g., to products sold in the general market.</p> <p>NOTE 3 – The total lead length used to connect the agreed primary protector shall be 1 m.</p>								

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

Test No.	Test description	Test circuit	Basic test level (Note)	Enhanced test level (Note)	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 (8 kV)	Level 4 (15 kV)	5	n/a	A
6.1b	Contact discharge	[IEC 61000-4-2]	Level 3 (6 kV)	Level 4 (8 kV)	5	n/a	A
NOTE – The test applies to the equipment enclosure.							

**Table 7 – Lightning test conditions for ports connected to internal cables**  
(Test exemptions for short cables are under study)

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	A.3-5 and A.6.5-1 1.2/50-8/20 CWG $R = 10 \Omega$ (The value of $R$ is independent of the number of conductors)	$U_{c(max)} = 1 \text{ kV}$	$U_{c(max)} = 1.5 \text{ kV}$	Alternating $\pm 5$ 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 except for unshielded Ethernet ports. (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)
7.2	Shielded cable to earth	A.3-5 and A.6.5-2 1.2/50-8/20 CWG $R = 0 \Omega$ The value of $R$ is independent of the number of conductors	$U_{c(max)} = 1 \text{ kV}$	$U_{c(max)} = 1.5 \text{ kV}$	Alternating $\pm 5$ 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	A.3-5 and A.6.5-2 1.2/50-8/20 CWG $R = 0 \Omega$	$U_{c(max)} = 100 \text{ V}$	$U_{c(max)} = 150 \text{ V}$	Alternating $\pm 5$ surges (60 s between successive surges)	None	A	Test is performed with the supplied cable (not the 20 m cable specified in Figure A.6.5-2 of [ITU-T K.44]). (Lower voltage level testing also required – see clause 7.3 of [ITU-T K.44].)

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

(See clause 6, NOTE 5, for exemptions)

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])	Intermediate test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clause 7 of [ITU-T K.44])	Number of tests	Primary protection (clause 8 of [ITU-T K.44])	Acceptance criteria (clause 9 of [ITU-T K.44])	Comments
7.4	Screen/shield connection high current test	A.3-5 and A.6.7-6 1.2/50-8/20 CWG R = 5 Ω	$U_{c(max)} = 2.5 \text{ kV}$	$U_{c(max)} = 4.0 \text{ kV}$	$U_{c(max)} = 6.0 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	
7.5	PoE Mode A and Mode B transverse/differential test	A.3-5 and A.6.7-2 1.2/50-8/20 CWG R1 = 10 Ω and R2 = 10 Ω	$U_{c(max)} = 2.5 \text{ kV}$	$U_{c(max)} = 4.0 \text{ kV}$	$U_{c(max)} = 6.0 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	
7.6	Ethernet longitudinal /common mode withstand test	A.3-5 and A.6.7-3a 1.2/50-8/20 CWG R = 5 Ω	$U_{c(max)} = 2.5 \text{ kV}$	$U_{c(max)} = 4.0 \text{ kV}$	$U_{c(max)} = 6.0 \text{ kV}$	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. (see Figure A.6.7-3). Monitor the impulse voltage to detect insulation breakdown or voltage protector operation.
7.7	Ethernet transverse/differential	A.3-5 and A.6.7-5 1.2/50-8/20 CWG	$U_{c(max)} = 2.5 \text{ kV}$	$U_{c(max)} = 4.0 \text{ kV}$	$U_{c(max)} = 6.0 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	

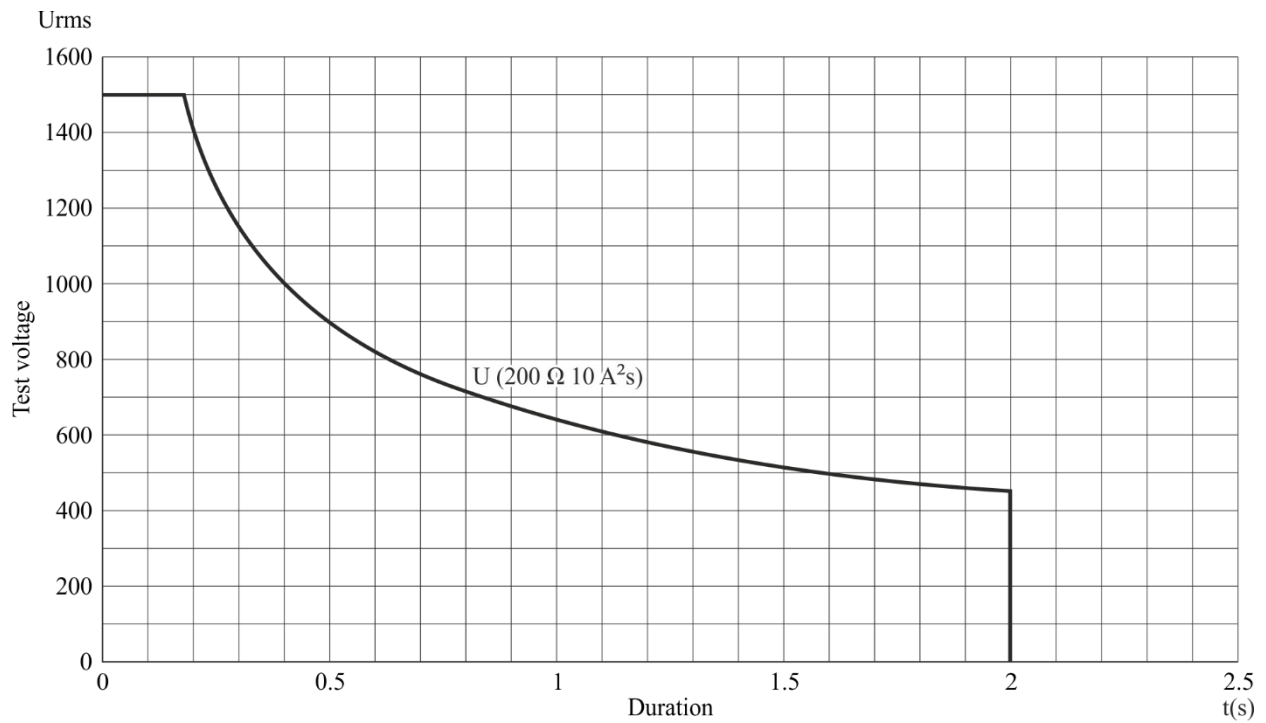


**Table 7 – Lightning test conditions for ports connected to internal cables**  
(Test exemptions for short cables are under study)

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
7.8	DC powered equipment port	A.3-5 (1.2/50-8/20 CWG) and A.6.6-1a Coupling element: 10 Ω + 9 μF in series	$U_{c(max)} = 1 \text{ kV}$	$U_{c(max)} = 1.5 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	See [ITU-T K.44] clauses 7.1.1 and 10.5.3
7.9	DC power source port	A.3-5 (1.2/50-8/20 CWG) and A.6.6-1b Coupling element: 10 Ω + 9 μF in series	$U_{c(max)} = 1 \text{ kV}$	$U_{c(max)} = 1.5 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	See [ITU-T K.44] clauses 7.1.1 and 10.5.4
7.10	Twisted pair port transverse/differential	A.3-5 and A.6.7-5 1.2/50-8/20 CWG	$U_{c(max)} = 1 \text{ kV}$	$U_{c(max)} = 1.5 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	

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.



Test voltage versus duration for a specific energy and source resistance

K.21(11)\_F01

**Figure 1 – Test voltage versus duration to give 10 A<sup>2</sup>s with 200 Ω**

## Annex A

### Special resistibility requirements

(This annex forms an integral part of this Recommendation.)

#### A.1 Introduction

There are circumstances where even the enhanced resistibility requirements are not sufficient for customer premises due to environmental conditions, national regulations, economic and technical considerations, installation standards or reliability of service requirements. Network operators may then request the special resistibility requirement.

The special resistibility requirement applies when all of the following conditions coexist:

- IT or TT power system;
- earthing and bonding is not installed in compliance with [ITU-T K.66];
- primary protection is not installed in compliance with [ITU-T K.66] when required by a risk assessment;
- there is difficulty in installing multiservice surge protective devices (MSPDs).

In this case, the network operator may need to request special resistibility requirements. Some guidance and possible test levels are provided in clause A.2.

Informative clause A.2 contains both test descriptions and requirements for special resistibility requirements. It is proposed that the test requirements, described in [ITU-T K.44] clause 7, Test conditions, be amended as indicated.

#### A.2 Special resistibility requirements

Clause A.1 specifies when these special resistibility requirements are necessary.

Table A.2-1 provides special requirements that are used to ensure safety and resistibility when bonding cannot be achieved.

These special requirements are in addition to the enhanced ITU-T K.21 tests and apply to equipment with both earthed SPDs and without earthed SPDs.

To ensure the safety of the customer, without appropriate earthing and bonding, the equipment shall contain port to port isolation as given in Table A.2-1. To ensure safety with earthed SPDs, appropriate earthing and bonding is required.

**Table A.2-1a – Special lightning test conditions for ports connected to external symmetric pair cables**

Test No.	Test description	Test circuit and waveform (see [ITU-T K.44] Annex A figures)	Special test levels (also see [ITU-T K.44] clauses 5 and 7)	Number of tests	Primary protection	Acceptance criteria	Comments
2.1.2a	Single port, lightning, coordination, transverse/differential	A.3-1 and A.6.1-1 (a and b) 10/700	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \text{ } \Omega$ $R_1 = 100 \text{ } \Omega$	5 of each polarity	Special test protector; see [ITU-T K.44] clause 8.4.	A When the test is performed with $U_c = U_{c(max)}$ , the special test protector must operate. 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 [ITU-T K.44] clause 10.1.1. Ethernet port tests are under study.
2.1.2b	Single port, lightning, coordination, port to earth	A.3-1 and A.6.1-2 10/700	$U_{c(max)} = 13 \text{ kV}$ $R = 25 \text{ } \Omega$ $R_1 = 100 \text{ } \Omega$				
2.1.2c	Single port, lightning, coordination, port to external port	A.3-1 and A.6.1-3 10/700	$U_{c(max)} = 13 \text{ kV}$ $R = 25 \text{ } \Omega$ $R_1 = 100 \text{ } \Omega$				

**Table A.2-1b – Special lightning test conditions for mains power ports**

Test No.	Test description	Test circuit and waveform (see [ITU-T K.44] Annex A figures)	Special test levels (also see [ITU-T K.44] clauses 5 and 7)	Number of tests	Primary protection	Acceptance criteria	Comments
5.1.1a	Lightning, inherent, transverse/differential	A.3-5 and A.6.4-1 combination wave generator	$U_{c(max)} = 10 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	None When performing the external port to symmetric pair port test, also add an STP/primary protector to the untested port. $R_1 = 100 \Omega$ for the untested port.	A	
5.1.1b	Lightning, inherent, port to earth	A.3-5 and A.6.4-2 combination wave generator	$U_{c(max)} = 10 \text{ kV}$ $R = 0 \Omega$				
5.1.1c	Lightning, inherent, port to external port	A.3-5 and A.6.4-3 combination wave generator	$U_{c(max)} = 10 \text{ kV}$ $R = 0 \Omega$				

**Table A.2-1c – Special lightning test conditions for ports connected to internal cables**

Test No.	Test description	Test circuit and waveform (see figures in Annex A)	Special test levels (also see clauses 5 and 7)	Number of tests	Primary protection	Acceptance criteria	Comments
7.1	Unshielded cable	Internal POTS line transverse/differential Figures A.3-5 and A.6.1-1 (a and b) Combination wave generator $R = 2 \Omega$  Figures A.3-1 and A.6.1-1 (a and b) 10/700 $R = 25 \Omega$ , 300 V GDT generator coupling, no STP	$U_{c(max)} = 4 \text{ kV (10 A}^2\text{s)}$  OR  $U_{c(max)} = 8 \text{ kV (10 A}^2\text{s)}$	5 of each polarity	None	A	Only applies to POTS ports.

**Table A.2-1c – Special lightning test conditions for ports connected to internal cables**

Test No.	Test description	Test circuit and waveform (see figures in Annex A)	Special test levels (also see clauses 5 and 7)	Number of tests	Primary protection	Acceptance criteria	Comments
		Internal POTS line to earth Figures A.3-5 and A.6.5-1. Combination wave generator R = 10 Ω  Figures A.3-1 and 6.5-1 10/700 R = 25 Ω	$U_{c(max)} = 10 \text{ k V}$  AND $U_{c(max)} = 13 \text{ k V}$				
7.2	Shielded cable port (includes coaxial cable ports)	Figures A.3-5 (Combination wave generator) and A.6.5-2 R = 0 Ω	$U_{c(max)} = 10 \text{ kV}$	Alternating ±5 surges (60 s between successive surges)	None	A	(Lower voltage level testing also required – see [ITU-T K.44] clause 7.3)
NOTE – For equipment without an earth connection, wrap the equipment in foil and connect the foil to the generator return.							

## 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*.
- [b-ITU-T K.Imp44] Implementers' Guide K.Imp44 (2012), *Guide on the use of the overvoltage resistibility Recommendations*.  
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