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**Resistibility of telecommunication equipment
installed in a telecommunication centre to
overvoltages and overcurrents**

Recommendation ITU-T K.20

ITU-T



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Resistibility of telecommunication equipment installed in a telecommunication centre to overvoltages and overcurrents

Summary

Recommendation ITU-T K.20 specifies resistibility requirements and test procedures for telecommunication equipment that is attached to or installed within a telecommunication centre.

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. The sources for overvoltages in internal lines, between equipment/racks, are mainly inductive coupling caused by lightning currents being conducted in nearby lightning strokes or lightning currents being conducted in nearby conductors.

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

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

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

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

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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2.0	ITU-T K.20	1988-11-25		11.1002/1000/1387
3.0	ITU-T K.20	1991-03-18	V	11.1002/1000/1388
4.0	ITU-T K.20	1993-03-12	V	11.1002/1000/1389
5.0	ITU-T K.20	1996-10-18	5	11.1002/1000/3880
6.0	ITU-T K.20	2000-02-25	5	11.1002/1000/4904
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1.2/50-8/20, 10/700, Ethernet, external ports, internal port, overvoltage, overcurrent, power over Ethernet (PoE), power contact, power induction, resistibility, subscriber line integrated circuit, SLIC, surges, telecommunication equipment, telecommunication centres, transverse, universal serial bus, USB.

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

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The 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.

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Recommendation ITU-T K.20

Resistibility of telecommunication equipment installed in a telecommunication centre to overvoltages and overcurrents

1 Scope

This Recommendation specifies resistibility requirements and test procedures for equipment installed in a telecommunication centre where the earthing, bonding and cabling between equipment/racks is in accordance with [ITU-T K.27]. This Recommendation applies to both external and internal ports. [ITU-T K.44] is an integral part of this Recommendation and should be read in conjunction with [ITU-T K.11], [ITU-T K.39] and [ITU-T K.46].

This Recommendation applies to all telecommunication equipment, whether network operator or customer owned, including telephony, routers and modems, etc. It does not apply to personal computers and printers, etc.

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), <i>Principles of protection against overvoltages and overcurrents</i> . |
| [ITU-T K.27] | Recommendation ITU-T K.27 (2015), <i>Bonding configurations and earthing inside a telecommunication building</i> . |
| [ITU-T K.39] | Recommendation ITU-T K.39 (1996), <i>Risk assessment of damages to telecommunication sites due to lightning discharges</i> . |
| [ITU-T K.44] | Recommendation ITU-T K.44 (2016), <i>Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation</i> . |
| [ITU-T K.46] | Recommendation ITU-T K.46 (2012), <i>Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges</i> . |
| [IEC 61000-4-2] | IEC 61000-4-2 (2008), <i>Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test</i> . |

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 IT power distribution system [ITU-T K.44].

3.1.2 TT power distribution system [ITU-T K.44].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CWG Combination Wave Generator

ESD Electrostatic Discharge

PoE Power over Ethernet

SLIC Subscriber Line Integrated Circuit

STP Shielded Twisted Pair

USB Universal Serial Bus

UTP Unshielded Twisted Pair

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

5 Conventions

None.

6 Tests

A summary of the tests applicable to equipment installed in a telecommunication centre is given in Table 1. The numbers given in the "Port type" columns, e.g., 2.2.1a, refer to the "Test no." of Tables 2 to 5. The words "under study" mean that ITU-T is still studying this test. The test conditions applicable to the four ports: symmetric, coaxial, dedicated power feed and mains power are given in Tables 2 to 5. The test conditions for electrostatic discharge (ESD) are given in Table 6. The test conditions for internal cable ports are given in Table 7. For information on the headings and terms used in the tables, refer to clause 10 of [ITU-T K.44].

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

NOTE 1 – For small telecommunication centres, the resistance of the earth electrode may be significantly high. When the "enhanced" requirement is specified, and the centre has 250 symmetric pairs or fewer, apply the port to the external port test from [b-ITU-T K.45], but retain the inherent test voltages from this Recommendation.

NOTE 2 – The external port test applies to ports used to connect externally-attached equipment to equipment installed within the same building. The mains power contact test does not apply in this situation. Where the equipment external to the building is installed in the "inherently protected" area shown in Figure 3 of [b-ITU-T K.71] the internal port test can be applied.

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

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

Table 1a – Applicable tests for external ports

Test type	No. of pairs simultaneously tested	Test 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	n.a.	n.a.	4.1.1c	5.1.1c	
		Coordination /Transverse/differential	Yes	2.1.2a	3.1.2	4.1.2a	5.1.2a	
		Coordination /Port to earth	Yes	2.1.2b	n.a.	4.1.2b	5.1.2b	
		Coordination /Port to external port	Yes	2.1.2c	n.a.	4.1.2c	5.1.2c	
	Multiple	Port to earth	No	2.1.3a	n.a.	n.a.	n.a.	
		Port to external port	No	2.1.3b	n.a.	n.a.	n.a.	
		Port to earth	Yes	2.1.4a	n.a.	n.a.	n.a.	
		Port to external port	Yes	2.1.4b	n.a.	n.a.	n.a.	
	Unshielded twisted pair (UTP) Ethernet	Port to earth	No	n.a.	n.a.	n.a.	n.a.	
		Transverse	No	2.1.7	n.a.	n.a.	n.a.	
		Voltage impulse test	No	2.1.9	2.1.9	n.a.	n.a.	
		Power over Ethernet (PoE)	No	2.1.10	2.1.10	n.a.	n.a.	
	Shielded twisted pair (STP) Ethernet	Port to earth	No	2.1.8	2.1.8	n.a.	n.a.	
		Shield test	No	2.1.11	2.1.11	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	n.a.	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.	
Multiple		Port to earth	No	2.1.6a	n.a.	n.a.	n.a.	
		Port to external port	No	n.a.	n.a.	n.a.	n.a.	
Insulation	Multiple	Port to earth	n.a.	2.1.9, 7.6	n.a.	n.a.	n.a.	

Table 1a – Applicable tests for external ports

Test type	No. of pairs simultaneously tested	Test connection	Primary protection	Port type			
				Symmetric port	Coaxial port	Dedicated power feed port	Mains power port
Power induction and earth potential rise	Single	Transverse	No	2.2.1a	Under study	4.2.1a	n.a
		Port to earth	No	2.2.1b	n.a.	4.2.1b	5.2.1 under study
		Port to external port	No	2.2.1c	n.a.	4.2.1c	n.a.
		Coordination Transverse	Yes	2.2.2a	Under study	4.2.2a	n.a.
		Coordination Port to earth	Yes	2.2.2b	n.a.	4.2.2b	n.a.
		Coordination Port to external port	Yes	2.2.2c	n.a.	4.2.2c	n.a.
Neutral potential rise	Single	Port to earth	No	n.a.	n.a.	n.a.	5.2.2a
		Port to external port	No	n.a.	n.a.	n.a.	5.2.2b
Mains power contact	Single	Transverse	No	2.3.1a	n.a.	4.3.1a	n.a.
		Port to earth	No	2.3.1b	n.a.	4.3.1b	n.a.
		Port to external port	No	2.3.1c	n.a.	4.3.1c	n.a.

Table 1b – Applicable tests for internal ports

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

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
2.1.1a	Single pair, lightning, inherent, transverse	A.3-1 and A.6.1-1 (a and b) 10/700 μ s	$U_{c(max)} = 1.0$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	alternating ± 5 surges (60 seconds between successive surges)	None	A	This test does not apply when the equipment is designed to always be used with primary protection and the operator agrees. If this test does not apply, perform the appropriate test from Table 7. When the equipment contains high current-carrying components which eliminate the need for primary protection, this test does not apply. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44])
2.1.1b	Single pair, lightning, inherent, port to earth	A.3-1 and A.6.1-2 10/700 μ s	$U_{c(max)} = 1.0$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ 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 μ s	n.a.	n.a.				
2.1.2a	Single pair, lightning, coordination, transverse	A.3-1 and A.6.1-1 (a and b) 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 4$ kV $R = 25 \Omega$	alternating ± 5 surges (60 seconds between successive surges)	Special test protector; see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port.	A When the test is performed with $U_c = U_{c(max)}$, the special test protector must operate. Of course it may also operate with a voltage of $U_c < U_{c(max)}$.	When the equipment contains high current-carrying components which 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 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 4$ 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 μ s	n.a.	n.a.				
2.1.3a	Multiple pair, lightning,	A.3-1 and A.6.1-4 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	alternating ± 5 surges	None	A	The multiple pair test is simultaneously applied to 100% of

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
	inherent, port to earth				(60 seconds between successive surges)			the pairs in the same street cable, but limited to a maximum of eight pairs.
2.1.3b	Multiple pair, lightning, inherent, port to external port	A.3-1 and A.6.1-5 10/700 μ s	n.a.	n.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. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44])
2.1.4a	Multiple pair, lightning, port to earth	A.3-1 and A.6.1-4 10/700 μ s	$U_{c(max)} = 4 \text{ kV}$ $R = 25 \Omega$	$U_{c(max)} = 6 \text{ kV}$ $R = 25 \Omega$	alternating ± 5 surges (60 seconds between successive surges)	Agreed primary protector.	A	The multiple pair test is simultaneously applied to 100% of the pairs in the same street cable but limited to a maximum of eight pairs.
2.1.4b	Multiple pair, lightning, port to external port	A.3-1 and A.6.1-5 10/700 μ s	n.a.	n.a.		When performing the external port to external port test, also add an STP/primary protector to the untested port.		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. (lower voltage level testing also required for each test – see clause 7.3 of [ITU-T K.44])

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
2.1.5a	Single pair, lightning current, port to earth	A.3-4 and A.6.1-2 8/20 μ s	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω	alternating ± 5 surges (60 seconds between successive surges)	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 pair 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 μ s	n.a.	n.a.				
2.1.6a	Multiple pair, lightning current, port to earth	A.3-4 and A.6.1-4 8/20 μ s	I = 1 kA/wire Limited to 6 kA total R = 0 Ω	I = 5 kA/wire Limited to 30 kA total R = 0 Ω	alternating ± 5 surges (60 seconds between successive surges)	None	A	
2.1.6b	Multiple pair, lightning current, port to external port	A.3-4 and A.6.1-5 8/20 μ s	n.a.	n.a.				
2.1.7	UTP Ethernet transverse	Figure A.6.7-5 (1.2/50-8/20 combination wave generator (CWG)) R=10 Ω	$U_{c(max)} = 600$ V	$U_{c(max)} = 1500$ V	alternating ± 5 surges (60 seconds between successive surges)	None	A	(lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
2.1.8	STP Ethernet simultaneous port to earth test	Figure A.6.7-4 (1.2/50-8/20 CWG) R=10 Ω	$U_{c(max)} = 2500 \text{ V}$	$U_{c(max)} = 6000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	(lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])
2.1.9	UTP Ethernet port rated impulse voltage test	Figure A.6.7-3a (1.2/50-8/20 CWG) R=5 Ω	$U_{c(max)} = 2500 \text{ V}$ surge	$U_{c(max)} = 6000 \text{ V}$	2 of each polarity for surge/ single application for dc	None (Note 1)	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.
2.1.10	PoE Mode A & Mode B transverse testing	Figure A.6.7-2 (1.2/50-8/20 CWG) R= 10 Ω	$U_{c(max)} = 600 \text{ V}$	$U_{c(max)} = 1500 \text{ V}$	Alternating ±5 surges (60 seconds between surges)	None	A	(lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])
2.1.11	STP Ethernet shield bond test	Figure A.6.7-6 (1.2/50-8/20 CWG) R=10 Ω	$U_{c(max)} = 1500 \text{ V}$	$U_{c(max)} = 6000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	(lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])

NOTE 1 – When the cabling is fitted with SPDs, the equipment user and manufacturer may use different test conditions upon mutual agreement; this topic is currently under study.

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

Test no.	Test description	Test circuit (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
2.2.1a	Power induction, inherent, transverse	A.3-6 and A.6.1-1 (a and b)	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ Frequency = 16 $\frac{2}{3}$, 50 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.
2.2.1b	Power induction, inherent and earth potential rise, port to earth	A.3-6 and A.6.1-2						
2.2.1c	Power induction, inherent and earth potential rise, port to external port	A.3-6 and A.6.1-3						
2.2.2a	Power induction, inherent/coordination, transverse	A.3-6 and A.6.1-1 (a and b)	$W_{sp(max)} = 1 \text{ A}^2\text{s}$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 1.0 \text{ s}$ (Note 1)	$W_{sp(max)} = 10 \text{ A}^2\text{s}$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 1500 \text{ V}$ $R = 200 \Omega$ $t_{(max)} = 2 \text{ s}$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2} \text{ (6-1)}$ (Note 2)	5	Special test protector; see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary	A	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						

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
2.2.2c	Power induction and earth potential rise, inherent/ coordination, port to external port	A.3-6 and A.6.1-3	n.a.	n.a.		protector to the untested port.		
2.3.1a	Mains power contact, inherent, transverse	A.3-6 and A.6.1-1 (a and b)	$U_{a.c.} = 230 \text{ V}$ 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.	$U_{a.c.} = 230 \text{ V}$ 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, 600, and 1000 Ω ; criterion B for the other resistor values.	In some situations, the test may be performed with a reduced number of current limit resistors. Refer to item 11, clause 7.2 of [ITU-T K.44] and clause I.1.4 of [ITU-T K.44] for guidance on selecting the necessary size of resistors. When the equipment is designed to be always used with primary protection, and the operator agrees, perform this test with the special test protector installed.
2.3.1b	Mains power contact, inherent, port to earth	A.3-6 and A.6.1-2						
2.3.1c	Mains power contact, inherent, port to external port	A.3-6 and A.6.1-3						

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

NOTE 1 – The test conditions for the Test 2.2.2 (basic test level) may be adapted to the local conditions by variation of the test parameters within the following limits, so that $I^2t = 1 \text{ A}^2\text{s}$ is fulfilled:

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

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

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

$$R = U_{a.c.(m)} \sqrt{\frac{t}{1 \text{ A}^2\text{s}}} \quad (6-2)$$

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 $10 \text{ A}^2\text{s}$ voltage/time curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 and the boundary conditions in this table.

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

Table 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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
3.1.1	Lightning, inherent, differential	A.3-5 and A.6.2-1 1.2/50 μ s – 8/20 μ s CWG	$U_{c(max)} = 1.0$ kV $R = 0$ Ω	$U_{c(max)} = 1.5$ kV $R = 0$ Ω	alternating ± 5 surges (60 seconds between successive surges)	None	A	This test does not apply when the equipment is designed to be always used with primary protection. (lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])
3.1.2	Lightning, coordination, differential	A.3.5 and A.6.2-1 1.2/50 μ s – 8/20 μ s CWG	$U_{c(max)} = 4$ kV $R = 0$ Ω	$U_{c(max)} = 6$ kV $R = 0$ Ω	alternating ± 5 surges (60 seconds between successive surges)	Special test protector; see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port.	A When the test is performed with $U_c = U_{c(max)}$, the special test protector must operate. Of course it may also operate with a voltage of $U_c < U_{c(max)}$.	When the equipment contains high current-carrying components, which eliminate the need for primary protection, refer to clause 10.2 of [ITU-T K.44]. (lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])
3.1.3	Lightning current, differential	A.3.4 and A.6.2-1 8/20 μ s	$I = 1$ kA	$I = 5$ kA	alternating ± 5 surges (60 seconds between successive surges)	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])	Number of tests	Primary protection [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
3.1.4	Lightning shield test, port to earth	A.3.4 and A.6.2-2 8/20 μ s	I = 4 kA (Note 1) I = 2 kA (Note 2)	I = 20 kA (Note 1) I = 5 kA (Note 2)	alternating ± 5 surges (60 seconds between successive surges)	Special test protector; see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port.	A	Only applies to earthed equipment and equipment without isolation capacitors in the coaxial cable path.
3.1.5	Lightning shield test, port to external port	A.3.4 and A.6.2-3 8/20 μ s	n.a.	n.a.				

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

NOTE 2 – Applicable equipment not covered by Note 1.

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

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

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

Test no.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
4.1.1a	Single pair, lightning, inherent, transverse	A.3-1 and A.6.3-1 (a and b) 10/700 μ s	$U_{c(max)} = 1.0$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	alternating ± 5 surges (60 seconds 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. If this test is not performed, the appropriate test from Table 7 applies. 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 μ s	$U_{c(max)} = 1.0$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ 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 μ s	n.a.	n.a.				
4.1.2a	Single pair, lightning, coordination, transverse	A.3-1 and A.6.3-1 (a and b) 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 4$ kV $R = 25 \Omega$	alternating ± 5 surges (60 seconds between successive surges)	Special test protector; 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 $U_c < U_{c(max)}$.	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 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 4$ 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 μ s	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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
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.				
4.1.5a	Single pair, lightning current, port to earth	A.3-4 and A.6.3-2 8/20 μ s	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω	alternating \pm 5 surges (60 seconds between successive surges)	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.
4.1.5b	Single pair, lightning current, port to external port	A.3-4 and A.6.3-3 8/20 μ s	n.a.	n.a.				
4.1.6	Multiple pair, lightning current		n.a.	n.a.				
NOTE 1 – As there is little knowledge of the agreed primary protector, it is not possible to give guidance. In the interim, test conditions for symmetric pair ports have been provided.								

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

Test no.	Test description	Test circuit (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
4.2.1.a	Power induction, inherent, transverse	A.3-6 and A.6.3-1 (a and b)	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ Frequency = $16 \frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \Omega$ $t = 0.2 \text{ s}$	$W_{sp(max)} = 0.2 \text{ A}^2\text{s}$ Frequency = $16 \frac{2}{3}$, 50 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. 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						

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
4.2.2a	Power induction, inherent/coordination, transverse	A.3-6 and A.6.3-1 (a and b)	$W_{sp(max)} = 1 \text{ A}^2\text{s}$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \text{ } \Omega$ $t = 1.0 \text{ s}$ (Note 1)	$W_{sp(max)} = 10 \text{ A}^2\text{s}$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 1500 \text{ V}$ $R = 200 \text{ } \Omega$ $t_{(max)} = 2 \text{ s}$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2} \text{ (6-1)}$ (Note 2)	5	Special test protector; see clause 8.4 of [ITU-T K.44]. When performing the external port to external port test, also add an STP/primary protector to the untested port.	A	When the equipment contains high current-carrying components 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.6.3-2						

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 [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	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	U _{a.c.} = 230 V Frequency = 50 Hz t = 15 min for each test resistor	1	None	For basic level: criterion B. For enhanced level: criterion A for test resistors 160, 300, 600 and 1000 Ω; criterion B for the other resistor values.	In some situations, the test may be performed with a reduced number of current limit resistors. Refer to item 11, clauses 7.2 and I.1.4 of [ITU-T K.44] for guidance on selecting the necessary size of resistors. When the equipment is designed to be always used with primary protection, and the operator agrees, perform this test with the special test protector installed.
4.3.1b	Mains power contact, inherent, port to earth	A.3-6 and A.6.3-2	R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω See acceptance criteria column.	R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω See acceptance criteria column.				
4.3.1c	Mains power contact, inherent, port to external port	A.3-6 and A.6.3-3	n.a.	n.a.				

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

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

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

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

$$R = U_{a.c.(m)} \sqrt{\frac{t}{1 \text{ A}^2 \text{ s}}} \quad (6-2)$$

NOTE 2 – For Test 4.2.2 (enhanced test level), the equipment shall comply with the specified criterion for all voltage/time combinations bounded (on and below) by the $10 \text{ A}^2\text{s}$ voltage/time curve in Figure 1. The curve in Figure 1 is defined by Equation 6-1 and the boundary conditions in this table.

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

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])	Number of tests	Primary protection [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	Comments
5.1.1a	Lightning, inherent, transverse	A.3-5 and A.6.4-1 1.2/50-8/20 CWG	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	alternating ± 5 surges (60 seconds 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.
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	A.3-5 and A.6.4-1 1.2/50-8/20 CWG	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$	alternating ± 5 surges (60 seconds between successive surges)	Agreed primary protector (mains). When performing the external port to external port test, also add an STP/primary protector to the untested port.	A	
5.1.2b	Lightning, inherent/coordination, port to earth	A.3-5 and A.6.4-2 1.2/50-8/20 CWG	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$				
5.1.2c	Lightning, inherent/coordination, port to external port	A.3-5 and A.6.4-3 1.2/50-8/20 CWG	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$				

Table 5 – Test conditions for mains power ports

Test no.	Test description	Test circuit and waveform (see figures in Annex A of [ITU-T K.44])	Basic test levels (also see clause 7 of [ITU-T K.44])	Enhanced test levels (also see clauses 5 and 7 of [ITU-T K.44])	Number of tests	Primary protection [ITU-T K.44], clause 8)	Acceptance criteria [ITU-T K.44], clause 9)	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, port to external 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.								

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 [ITU-T K.44], clause 9)
6.1a	Air discharge	[IEC 61000-4-2] (2008)	Level 3	Level 4	5	n.a.	A
6.1b	Contact discharge	[IEC 61000-4-2] (2008)	Level 3	Level 4	5	n.a.	A

NOTE 1 – The test applies to the equipment enclosure.

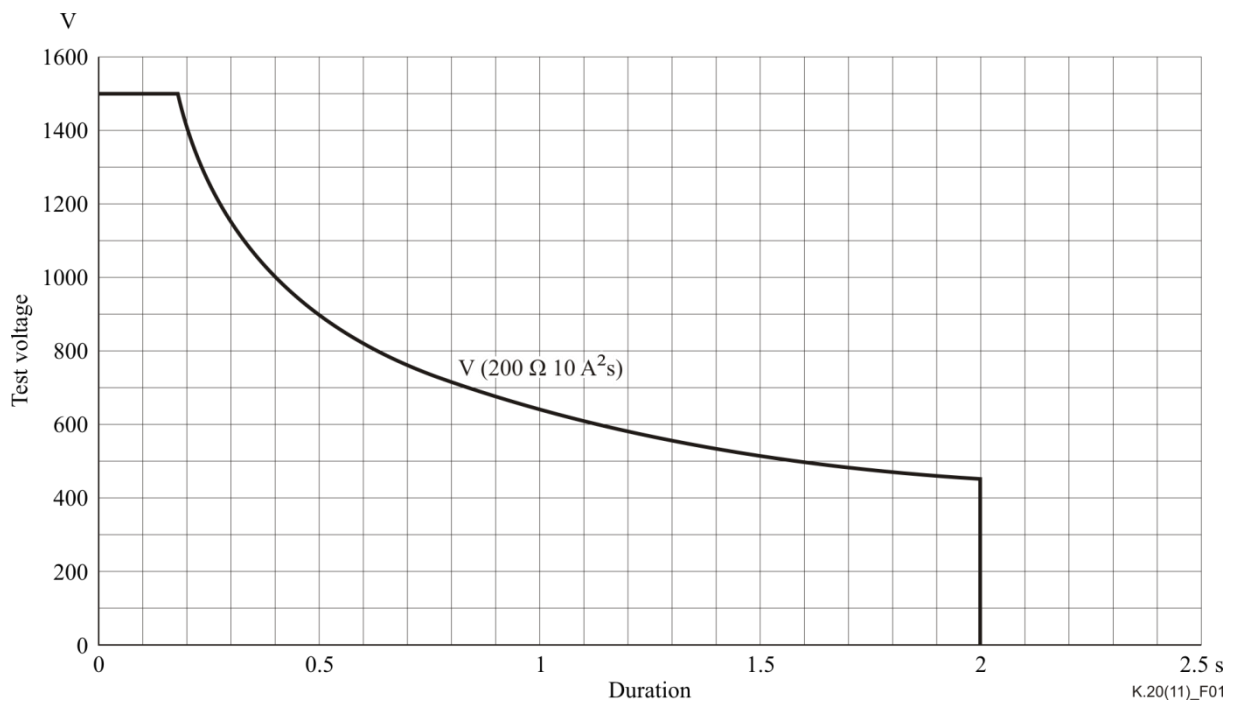


Figure 1 – Test voltage versus duration to give 10 A²s with 200 Ω

Table 7 – Lightning test conditions for ports connected to internal 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 [ITU-T K.44], clause 8	Acceptance criteria [ITU-T K.44], clause 9	Comments
7.1	Unshielded cable with symmetric pairs	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.5-1 R = 10 Ω The value of R is independent of the number of conductors.	$U_{c(max)} = 500 \text{ V}$	$U_{c(max)} = 1000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	The test is applied simultaneously to all symmetric cable pairs connected to the equipment port under test.
7.2	Shielded cable to earth	Figures A.3-5 The value of R is independent of the number of conductors. and A.6.5-2 R = 0 Ω	$U_{c(max)} = 500 \text{ V}$	$U_{c(max)} = 1000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	
7.3	USB shielded cable to earth	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.5-2 R = 0 Ω	$U_{c(max)} = 100 \text{ V}$	$U_{c(max)} = 150 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	Test is performed with the supplied cable (not the 20 m cable specified in Figure A.6.5-2). (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

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 [ITU-T K.44], clause 8	Acceptance criteria [ITU-T K.44], clause 9	Comments
7.4	STP Ethernet simultaneous port to earth	Figure A.6.7-4 (1.2/50-8/20 CWG) R = 0 Ω	$U_{c(max)} = 1000 \text{ V}$	$U_{c(max)} = 1500 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	(lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])
7.5	PoE Mode A & Mode B transverse testing	Figure A.6.7-2 (1.2/50-8/20 CWG) R = 10 Ω	$U_{c(max)} = 600 \text{ V}$	$U_{c(max)} = 1000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	(lower voltage level testing also required – see clause 7.3 of [ITU-T K.44])
7.6	UTP Ethernet port rated impulse voltage test	Figure A.6.7-3a (1.2/50-8/20-CWG) R = 5 Ω	$U_{c(max)} = 2500 \text{ V}$ surge	$U_{c(max)} = 6000 \text{ V}$ surge	2 of each polarity/ single application of dc	None (Note 1)	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.
7.7	Floating d.c. power interface	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.6-2 R = 0 Ω Coupling element = 10 Ω + 9 μF in series	$U_{c(max)} = 500 \text{ V}$	$U_{c(max)} = 1000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	For d.c. power supplies with both sides floating.
7.8	Earthed d.c. power interface	Figures A.3-5 (1.2/50-8/20 CWG) and A.6.6-1a R = 0 Ω dpf1 coupling element = 10 Ω + 9 μF in series dpf2 connected to generator return	$U_{c(max)} = 500 \text{ V}$	$U_{c(max)} = 1000 \text{ V}$	alternating ±5 surges (60 seconds between successive surges)	None	A	For d.c. power supplies with one side earthed.

Table 7 – Lightning test conditions for ports connected to internal 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 [ITU-T K.44], clause 8	Acceptance criteria [ITU-T K.44], clause 9	Comments
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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.

Appendix I

Floating transverse power induction and earth potential rise test for ports connected to external symmetric pair cables

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction

A network operator replaced older concentrators with new types of access nodes in 1999-2000. Although the line cards of the new nodes passed all of the tests of this Recommendation, including the enhanced level tests, a large number of the line cards were damaged in the field in 2000-2002. The damaged components were generally the subscriber line integrated circuit (SLIC). After three years of intensive study and testing, similar damage could be reproduced in laboratory conditions. The protection on the line cards were amended to allow the line cards to pass this new test. After applying the new protection to line cards in the field, the number of damaged SLICs were reduced by more than 95 per cent in 2003 and 2004.

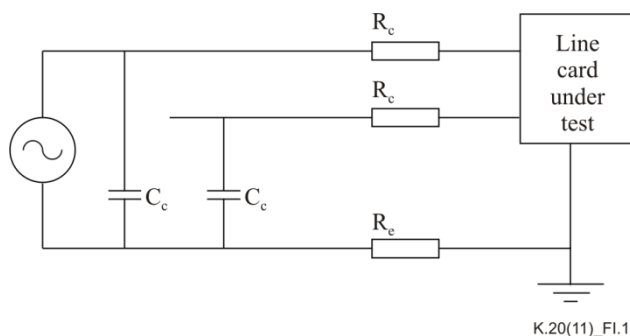
This appendix provides some background information and specifies a simple test method additional to those specified in Table 2b. In the case described above, this test repeatedly caused damage in the ports with the original protection.

Because the reason for this type of coupling is not completely understood, the test method is not included in the main text of this Recommendation. Manufacturers and operators can apply this test using their discretion.

I.2 Discussion on the reason for the damages

As described in clause I.3 below, a power frequency test voltage is applied transversally between a and b when both are floating. This differs from the transverse test of Table 2b where either a or b is connected to the earth(ed frame of the equipment under test). The transverse test of Table 2b simulates the situation where one of the primary protectors in front of the equipment under test operates and the other does not operate.

Theoretically, a power frequency voltage of 100 to 200 V should not appear in a subscriber loop as a result of induction. Such a relatively high voltage between a and b would be an indication of the presence of a connection to earth somewhere in the loop. This connection could be an operation of a gas discharge tube at the subscriber end of the line as a result of power frequency earth potential rise. An attempt to simulate such a case was done by testing the line card in the set-up shown in Figure I.1.



Coupling resistors, R_c , represent the line resistances; capacitances, C_c , represent the line capacitances to earth and R_e represents the earthing resistance of the overvoltage protectors at the subscriber end of the line.

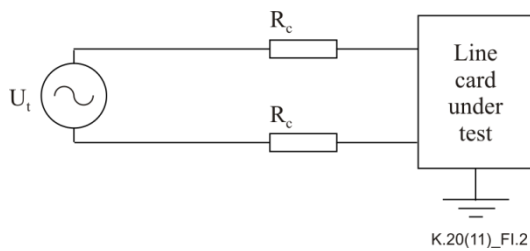
Figure I.1 – Test set-up for a line card in a telecom centre to simulate earth potential rise at the subscriber end

The damage could be reproduced with certain values of the coupling components of Figure I.1, but not with $R_c = 0$. This strengthens the understanding that the damages have something to do with phenomena along the line.

The simplest way to reveal a port's sensitivity to being damaged for this reason is the floating test described below.

I.3 Test set-up and test voltages

The floating transverse test set-up is shown in Figure I.2. This is easily realized, for example, with an isolation transformer if the test generator is originally earthed. The duration of the test voltage may be, for example, 300 ms, and the coupling resistors may be approximately 100 to 200 Ω . The test voltage is gradually increased over the operation threshold of the secondary protection. In the case described in clause I.1 the port was repeatedly damaged, e.g., at 145 V test voltage with $R_c = 140 \Omega$.



Special test protectors may be used in front of the line card under test if the test is extended to higher voltages.

Figure I.2 – Test set-up for floating power induction and earth potential rise

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