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

ITU-T Recommendation K.21

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

Summary

This Recommendation specifies resistibility requirements and test procedures for telecommunication equipment which is installed in or on a customer premises building.

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 contacts between telecommunication lines and power lines and electrostatic discharges. The sources for overvoltages in internal lines are mainly inductive coupling caused by lightning currents being conducted in nearby lightning strokes or lightning currents being conducted in nearby conductors.

Major changes compared with the 2000 version of this Recommendation include:

- replacing the longitudinal test with a port to earth test;
- the introduction of an external port to port test;
- adding internal port requirements.

Source

ITU-T Recommendation K.21 was approved by ITU-T Study Group 5 (2001-2004) under the ITU-T Recommendation A.8 procedure on 29 July 2003.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation K.21

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

1 Scope

This Recommendation specifies resistibility requirements and test procedures for telecommunication equipment which is attached to or installed within a Customer premises building. The requirements of this Recommendation assume that earthing and bonding is in accordance with ITU-T Rec. K.31.

This Recommendation applies to both external and internal ports. Basic ITU-T Rec. K.44 (Test methods and test circuits) is an integral part of this Recommendation. It should be read in conjunction with ITU-T Recs K.11 and 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 Recommendation K.11 (1993), *Principles of protection against overvoltages and overcurrents*.
- ITU-T Recommendation K.31 (1993), *Bonding configurations and earthing of telecommunication installations inside a subscriber's building*.
- ITU-T Recommendation K.39 (1996), *Risk assessment of damages to telecommunication sites due to lightning discharges*.
- ITU-T Recommendation K.44 (2003), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*.
- IEC 61000-4-2:2001, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*.

3 Definitions and abbreviations

3.1 Definitions

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

4 Tests

A summary of the tests applicable to equipment installed in a Customer Premise building is given in Table 1. The numbers given in the "Port type" columns, e.g., 2.2.1.a, refer to the "Test No." of Tables 2 to 5. The words "Under study" mean that the 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 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/K.44.

Refer to 5.2/K.44 on selecting the enhanced resistibility requirement.

NOTE – The port to external port test, for the basic test level, does not apply when the equipment is designed to be always used with a connection to ground.

Table 1a/K.21 – Applicable tests for external ports

Test type	No. of ports simultaneously tested	Test connections	Primary protection	Port type			
				Symmetric port	Co-axial port	Dedicated power feed port	Mains power port
Lightning/ Voltage	Single	Transverse	No	2.1.1.a		4.1.1.a	5.1.1.a
		Port to earth	No	2.1.1.b		4.1.1.b	5.1.1.b
		Port to external port	No	2.1.1.c		4.1.1.c	5.1.1.c
		Transverse	Yes	2.1.2.a		4.1.2.a	5.1.2.a
		Port to earth	Yes	2.1.2.b		4.1.2.b	5.1.2.b
		Port to external port	Yes	2.1.2.c		4.1.2.c	5.1.2.c
	Multiple	Port to earth	No	2.1.3.a		n.a.	n.a.
		Port to external port	No	2.1.3.b		n.a.	n.a.
		Port to earth	Yes	2.1.4.a		n.a.	n.a.
		Port to external port	Yes	2.1.4.b		n.a.	n.a.
Lightning/ Current	Single	Port to earth	No	2.1.5.a		4.1.5.a	n.a.
		Port to external port	No	2.1.5.b		4.1.5.b	n.a.
	Multiple	Port to earth	No	2.1.6.a		n.a.	n.a.
		Port to external port	No	2.1.6.b		n.a.	n.a.

Table 1a/K.21 – Applicable tests for external ports

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

Table 1b/K.21 – Applicable tests for ports connected to internal cabling

Test type	Primary protection	Unshielded cable	Shielded cable	Floating d.c. power interface	Earthed d.c. power interface
Lightning	No	7.1	7.2	7.3	7.4

Table 2a/K.21 – Lightning test conditions for ports connected to external symmetric pair cables

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
2.1.1.a	Single port, lightning, inherent, transverse	A.3.1 and A.6.1-1 (a and b) 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	5 of each polarity	None	A	1) Test 2.1.1 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. 2) If the inherent protection of the port under test contains SPDs that are connected to earth, a $U_{c(max)}$ of 1.5 kV shall be used instead of 6 kV. 3) 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.
2.1.1.b	Single port, lightning, inherent, port to earth	A.3.1 and A.6.1-2 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV See comments $R = 25$ Ω	5 of each polarity	None	A	
2.1.1.c	Single port, lightning, inherent, port to external port	A.3.1 and A.6.1-3 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV See comments $R = 25$ Ω	5 of each polarity	None	A	

Table 2a/K.21 – Lightning test conditions for ports connected to external symmetric pair cables

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
2.1.2.a	Single port, lightning, coordination, transverse	A.3.1 and A.6.1-1 (a and b) 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV $R = 25$ Ω	5 of each polarity	Special test protector, see 8.4/K.44	A During the test the special test protector must operate at $U_c = U_{c(max)}$	When the equipment contains high current-carrying components which eliminate the need for primary protection, refer to 10.1.1/K.44.
2.1.2.b	Single port, lightning, coordination, port to earth	A.3.1 and A.6.1-2 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV $R = 25$ Ω	5 of each polarity			
2.1.2.c	Single port, lightning, coordination, port to external port	A.3.1 and A.6.1-3 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25$ Ω $U_{c(max)} = 4$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV $R = 25$ Ω	5 of each polarity			
2.1.3a	Multiple port, lightning, inherent, port to earth	A.3.1 and A.6.1-4 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	5 of each polarity	None	A	The multiple port test is simultaneously applied to 100% of the ports, limited to a maximum of 8 ports. This test does not apply when the equipment is designed to be always used with primary protection.
2.1.3b	Multiple port, lightning, inherent, port to external port	A.3.1 and A.6.1-5 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25$ Ω	$U_{c(max)} = 1.5$ kV $R = 25$ Ω				
2.1.4a	Multiple port, lightning, port to earth	A.3.1 and A.6.1-4 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV $R = 25$ Ω	5 of each polarity	Agreed primary protector	A	The multiple port test is simultaneously applied to 100% of the ports, limited to a maximum of 8 ports.
2.1.4b	Multiple port lightning, port to external port	A.3.1 and A.6.1-5 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25$ Ω	$U_{c(max)} = 6$ kV $R = 25$ Ω				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.

Table 2a/K.21 – Lightning test conditions for ports connected to external symmetric pair cables

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
2.1.5a	Single port, 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	5 of each polarity	None	A	This test only applies when the equipment contains high current-carrying components which eliminate the need for primary protection. Do not remove these components. The multiple port test is simultaneously applied to 100% of the ports, limited to a maximum of 8 ports.
2.1.5b	Single port, lightning current, port to external port	A.3.4 and A.6.1-3 8/20 μ s	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω				
2.1.6a	Multiple port, 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	5 of each polarity	None	A	
2.1.6b	Multiple port, lightning current, port to external port	A.3.4 and A.6.1-5 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				

Table 2b/K.21 – Power induction and earth potential rise test conditions for ports connected to external symmetric pair cables

Test No.	Test description	Test circuit (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
2.2.1.a	Power induction, inherent, transverse	A.3.6 and A.6.1-1 (a and b)	$W_{sp(max)} = 0.2 A^2s$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 V$	$W_{sp(max)} = 0.2 A^2s$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 V$	5	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees.
2.2.1.b	Power induction and earth potential rise, inherent, Port to earth	A.3.6 and A.6.1-2	$R = 600 \Omega$ $t = 0.2 s$	$R = 600 \Omega$ $t = 0.2 s$	5	None	A	
2.2.1.c	Power induction and earth potential rise, inherent, Port to external port	A.3.6 and A.6.1-3			5	None	A	
2.2.2.a	Power induction inherent/ coordination, transverse	A.3.6 and A.6.1-1 (a and b)	$W_{sp(max)} = 1 A^2s$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 600 V$	$W_{sp(max)} = 10 A^2s$ Frequency = 16 $\frac{2}{3}$, 50 or 60 Hz $U_{a.c.(max)} = 1500 V$	5	Special test protector, see 8.4/K.44	A	When the equipment contains high current-carrying components which eliminate the need for primary protection, refer to 10.1.3/K.44.
2.2.2.b	Power induction and earth potential rise, inherent/ coordination, Port to earth	A.3.6 and A.6.1-2	$R = 600 \Omega$ $t = 1.0 s$ (Note 1)	$R = 200 \Omega$ $t_{(max)} = 2 s$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (4-1) (Note 2)	5		A	
2.2.2.c	Power induction and earth potential rise, inherent/ coordination, Port to external earth	A.3.6 and A.6.1-3			5		A	

Table 2b/K.21 – Power induction and earth potential rise test conditions for ports connected to external symmetric pair cables

Test No.	Test description	Test circuit (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
2.3.1.a	Mains power contact, transverse	A.3.6 and A.6.1-1 (a and b)	U _{a.c.} = 230 V Frequency = 50 or 60 Hz t = 15 min for each test resistor	U _{a.c.} = 230 V Frequency = 50 or 60 Hz t = 15 min for each test resistor	1	None	For basic level: criterion B.	In some situations, the test may be performed with a reduced number of current limit resistors. Refer to item 11, clause 7.2 and I.1.4/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.
2.3.1.b	Mains power contact, Port to earth	A.3.6 and A.6.1-2	R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω.	R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω.	1	None	For enhanced level: criterion A for test resistors 160, 300 and 600 Ω, criterion B for the other resistor.	
2.3.1.b	Mains power contact, Port to external port	A.3.6 and A.6.1-3	See acceptance criteria column.	See acceptance criteria column.	1	None		

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

$U_{a.c.(max)} = 300 \text{ V} \dots 600 \text{ V}$, 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 4-2:

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

NOTE 2 – For test 2.2.2 (enhanced test level), the equipment shall comply with the specified criterion for all voltage/time combinations bounded (on and below) by the $10 \text{ A}^2\text{s}$ voltage/time curve in Figure 1. The curve in Figure 1 is defined by Equation 4-1 and the boundary conditions in Table 2b.

Table 3/K.21 – Test conditions for ports connected to external coaxial cables (Under study)

Table 4a/K.21 – Lightning test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
4.1.1.a	Single port, lightning, inherent, transverse	A.3.1 and A.6.1-1 (a and b) 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	$U_{c(max)} = 6$ kV $R = 25 \Omega$	5 of each polarity	None	A	1) 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. 2) If the inherent protection of the port under test contains SPDs that are connected to earth, a $U_{c(max)}$ of 1.5 kV shall be used instead of 6 kV. 3) 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.
4.1.1.b	Single port, lightning, inherent, port to earth	A.3.1 and A.6.1-2 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	5 of each polarity	None	A	
4.1.1.c	Single port, lightning, inherent, port to external port	A.3.1 and A.6.1-3 10/700 μ s	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	$U_{c(max)} = 1.5$ kV $R = 25 \Omega$	5 of each polarity	None	A	
4.1.2.a	Single port, lightning, coordination, transverse	A.3.1 and A.6.1-1 (a and b) 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 6$ kV $R = 25 \Omega$	5 of each polarity	Special test protector	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. 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.
4.1.2.b	Single port, lightning, coordination, port to earth	A.3.1 and A.6.1-2 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 6$ kV $R = 25 \Omega$	5 of each polarity	Special test protector	During the test, the special test protector must operate at $U_c = U_{c(max)}$	
4.1.2.c	Single port, lightning, coordination, port to external port	A.3.1 and A.6.1-3 10/700 μ s	$U_{c(max)} = 4$ kV $R = 25 \Omega$	$U_{c(max)} = 6$ kV $R = 25 \Omega$	5 of each polarity	Special test protector		

Table 4a/K.21 – Lightning test conditions for ports connected to external d.c. or a.c. dedicated power feeding cables

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
4.1.3	Multiple port, lightning, inherent, port to earth and port to external port		n.a.	n.a.				
4.1.4	Multiple port, lightning, port to earth and port to external port		n.a.	n.a.				
4.1.5a	Single port, 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	5 of each polarity	None	A	This test only applies when the equipment contains high current-carrying components which eliminate the need for primary protection. Do not remove these components.
4.1.5b	Single port, lightning current, port to external port	A.3.4 and A.6.1-3 8/20 μ s	I = 1 kA/wire R = 0 Ω	I = 5 kA/wire R = 0 Ω	5 of each polarity	None	A	
4.1.6	Multiple port, lightning current		n.a.	n.a.				
NOTE – As there is little knowledge of the agreed primary protector, it is not possible to give guidance. In the interim test conditions for symmetric pair ports have been provided.								

Table 4b/K.21 – 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 Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
4.2.1.a	Power induction, inherent, transverse	A.3.6 and A.6.1-1 (a and b)	$W_{sp(max)} = 0.2 A^2s$ Frequency = 16 2/3, 50 or 60 Hz $U_{a.c.(max)} = 600 V$	$W_{sp(max)} = 0.2 A^2s$ Frequency = 16 2/3, 50 or 60 Hz $U_{a.c.(max)} = 600 V$	5	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees.
4.2.1.b	Power induction and earth potential rise, inherent, Port to earth	A.3.6 and A.6.1-2	$R = 600 \Omega$ $t = 0.2 s$	$R = 600 \Omega$ $t = 0.2 s$	5	None	A	
4.2.1.c	Power induction and earth potential rise, inherent, Port to external port	A.3.6 and A.6.1-3			5	None	A	

Table 4b/K.21 – 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 Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
4.2.2.a	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 2/3, 50 or 60 Hz $U_{a.c.(max)} = 600 \text{ V}$ $R = 600 \text{ } \Omega$	$W_{sp(max)} = 10 \text{ A}^2\text{s}$ Frequency = 16 2/3, 50 or 60 Hz $U_{a.c.(max)} = 1500 \text{ V}$ $R = 200 \text{ } \Omega$	5	Special test protector	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.
4.2.2.b	Power induction and earth potential rise, inherent/coordination, port to earth	A.3.6 and A.6.1-2	$t = 1.0 \text{ s}$ (Note 1)	$t_{(max)} = 2 \text{ s}$ $t = \frac{W_{sp} \times R^2}{(U_{a.c.})^2}$ (4-1) (Note 2)	5	Special test protector	A	
4.2.2.c	Power induction and earth potential rise, inherent/coordination, port to external port.	A.3.6 and A.6.1-3			5	Special test protector	A	

Table 4b/K.21 – 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 Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
4.3.1.a	Mains power contact, transverse	A.3.6 and A.6.1-1 (a and b)	U _{a.c.} = 230 V Frequency = 50 or 60 Hz	U _{a.c.} = 230 V Frequency = 50 or 60 Hz	1	None	For basic level: criterion B. For enhanced level: criterion A for test resistors 160, 300 and 600 Ω, criterion B for the other resistor.	In some situations, the test may be performed with a reduced number of current limit resistors. Refer to item 11, clause 7.2 and I.1.4/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.
4.3.1.b	Mains power contact, Port to earth	A.3.6 and A.6.1-2	t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω See acceptance criteria column.	t = 15 min for each test resistor R = 10, 20, 40, 80, 160, 300, 600 and 1000 Ω See acceptance criteria column.	1	None		
4.3.1.b	Mains power contact, Port to external port	A.3.6 and A.6.1-3			1	None		

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

$U_{a.c.(max)} = 300 \text{ V} \dots 600 \text{ V}$, 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 (4-2):

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

NOTE 2 – For test 4.2.2 (enhanced test level), the equipment shall comply with the specified criterion for all voltage/time combinations bounded (on and below) by the $10 \text{ A}^2\text{s}$ voltage/time curve in Figure 1. The curve in Figure 1 is defined by Equation 4-1 and the boundary conditions in Table 4b.

Table 5/K.21 – Test conditions for mains power ports

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
5.1.1.a	Lightning, inherent, transverse	A.3-5 and A.6.4-1 combination wave	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	None	A	This test does not apply when the equipment is designed to be always used with primary protection and the operator agrees.
5.1.1.b	Lightning, inherent, port to earth	A.3-5 and A.6.4-2 combination wave	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	None	A	
5.1.1.c	Lightning, inherent, port to external port	A.3-5 and A.6.4-3 combination wave	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	None	A	
5.1.2.a	Lightning, inherent/coordination, transverse	A.3-5 and A.6.4-1 combination wave	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	Agreed primary protector (mains). (Note 2)	A	
5.1.2.b	Lightning, inherent/coordination, port to earth	A.3-5 and A.6.4-2 combination wave	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	Agreed primary protector (mains). (Note 2)	A	
5.1.2.c	Lightning, inherent/coordination, port to external port	A.3-5 for and A.6.4-3 combination wave	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \Omega$	5 of each polarity	Agreed primary protector (mains). (Note 2)	A	
5.2.1	Earth potential rise		Under study	Under study	5	None	A	

Table 5/K.21 – Test conditions for mains power ports

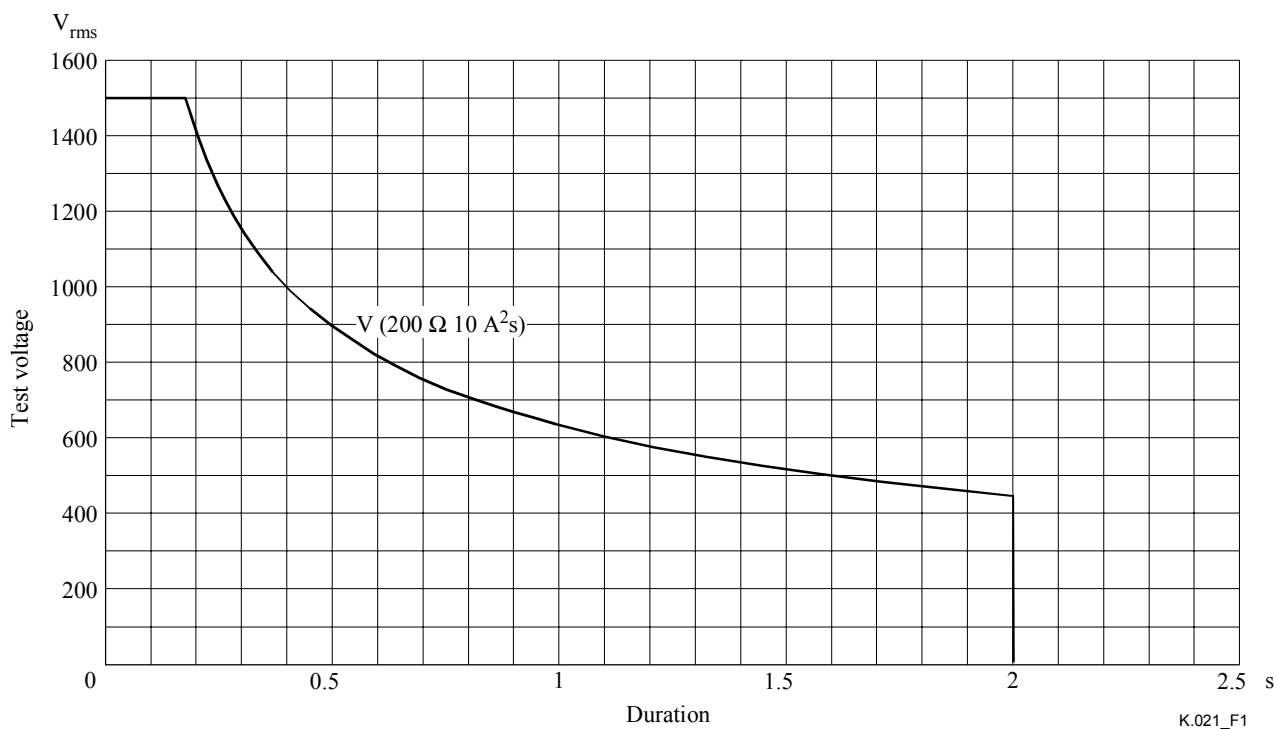
Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
5.2.2.a	Neutral potential rise, Port to earth	A.3.6 and A.6.4-1 a.c.	$U_{a.c.} = 600 \text{ V}$ Frequency = 50 or 60 Hz $t = 1 \text{ s}$ $R = 200 \text{ } \Omega$	$U_{a.c.} = 1500 \text{ V}$ Frequency = 50 or 60 Hz $t = 1 \text{ s}$ $R = 200 \text{ } \Omega$	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.
5.2.2.b	Neutral potential rise, Port to external port	A.3.6 and A.6.4-2 a.c.			5	None	A	
NOTE 1 – The tests in Table 5 apply to both mains powered equipment and the combination of plug pack and equipment for plug pack powered equipment.								
NOTE 2 – The total lead length used to connect the Agreed primary protector shall be 1 m.								

Table 6/K.21 – Test conditions for ESD applied to the enclosure

Test No.	Test description	Test circuit	Basic test level	Enhanced test level	Number of tests	Primary protection	Acceptance criteria
6.1.a	Air discharge	IEC 61000-4-2 1995	Level 3	Level 4	5	n.a.	A
6.1.b	Contact discharge	IEC 61000-4-2 1995	Level 3	Level 4	5	n.a.	A
NOTE – The test applies to the equipment enclosure.							

Table 7/K.21 – Lightning test conditions for ports connected to internal cables

Test No.	Test description	Test circuit and waveshape (See Annex A/K.44)	Basic test levels (Also see clause 7/K.44)	Enhanced test levels (Also see clauses 5 and 7/K.44)	Number of tests	Primary protection	Acceptance criteria	Comments
7.1	Unshielded cable	Figures A.3-5 and A.6-1 R = 10 Ω	$U_{c(max)} = 1000 \text{ V}$	$U_{c(max)} = 1500 \text{ V}$	5 of each polarity	None	A	
7.2	Shielded cable	Figures A.3-5 and A.6.5-1 R = 0 Ω	$U_{c(max)} = 1000 \text{ V}$	$U_{c(max)} = 1500 \text{ V}$	5 of each polarity	None	A	
7.3	Floating D.C. Power interface	Figures A.3-5 and A.6.3-1 R = 0 Ω Coupling element = 10 Ω + 9 μF in series	$U_{c(max)} = 1000 \text{ V}$	$U_{c(max)} = 1500 \text{ V}$	5 of each polarity	None	A	For D.C. Power supplies with both sides floating
7.4	Earthed D.C. Power interface	Figures A.3-5 and A.6.3-2a R = 0 Ω dpf1 coupling element = 10 Ω + 9 μF in series dpf2 connected to generator return	$U_{c(max)} = 1000 \text{ V}$	$U_{c(max)} = 1500 \text{ V}$	5 of each polarity	None	A	For D.C. Power supplies with one side grounded
NOTE – For equipment without an earth connection, wrap the equipment in foil and connect the foil to the generator return.								



Test voltage versus duration for a specific energy and source resistance.

Figure 1/K.21 – Test voltage versus duration to give $10 A^2s$ with 200Ω

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