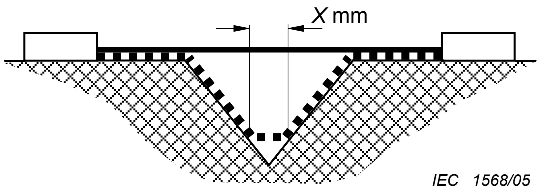
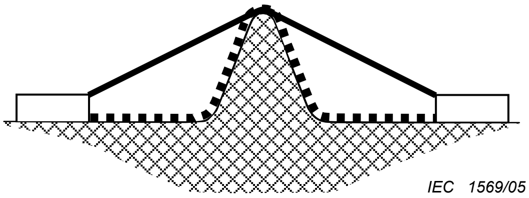


Condition: Path under consideration includes a V-shaped groove with internal angle of less than 80° and a width greater than *X* mm.

Rule: CLEARANCE is "line of sight" distance. CREEPAGE DISTANCE path follows the contour of the groove but "short-circuits" the bottom of the groove by a link *X* mm long.

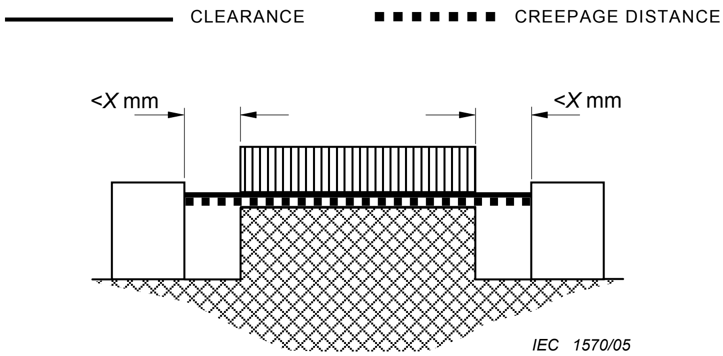
Figure F.3 – V-shaped groove



Condition: Path under consideration includes a rib.

Rule: CLEARANCE is the shortest direct air path over the top of the rib. CREEPAGE DISTANCE path follows the contour of the rib.

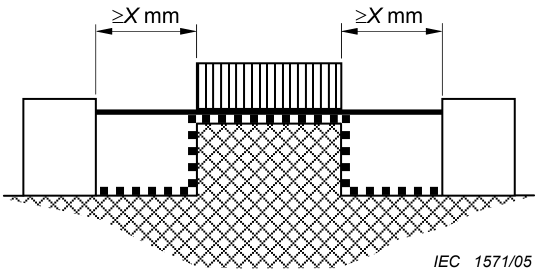
Figure F.4 – Rib



Condition: Path under consideration includes an uncemented joint with grooves less than *X* mm wide on either side.

Rule: CLEARANCE and CREEPAGE DISTANCE path is the "line of sight" distance shown.

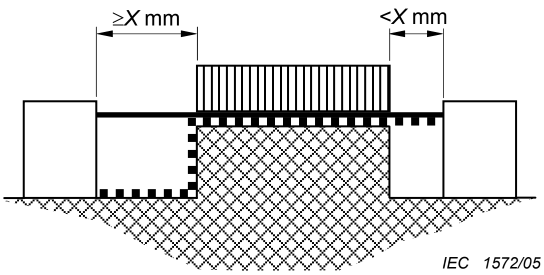
Figure F.5 – Uncemented joint with narrow groove



Condition: Path under consideration includes an uncemented joint with a groove equal to or more than *X* mm wide each side.

Rule: CLEARANCE is the "line of sight" distance. CREEPAGE DISTANCE path follows the contour of the groove.

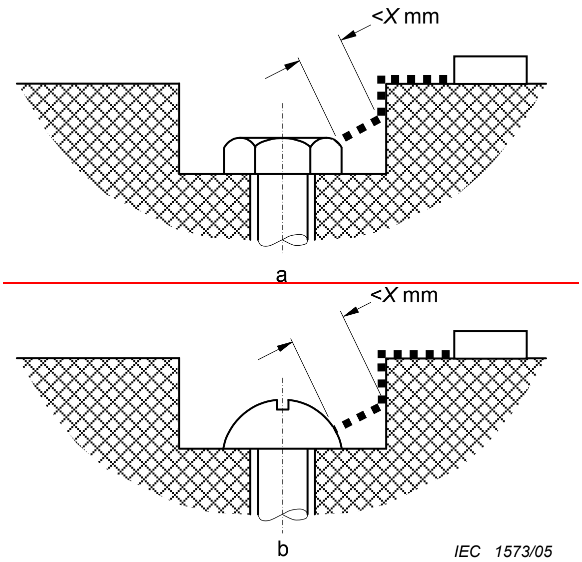
Figure F.6 – Uncemented joint with wide groove

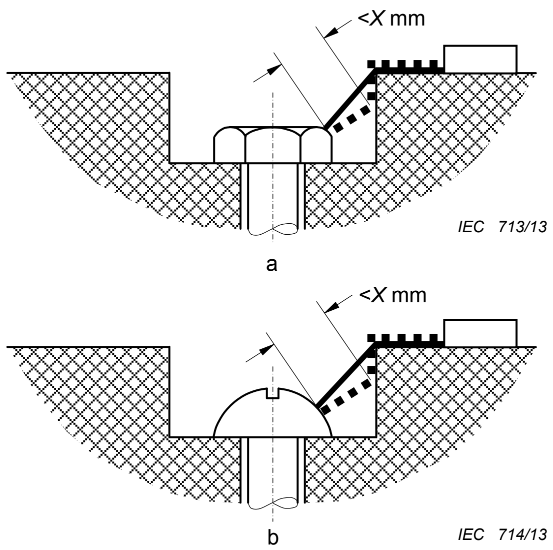


Condition: Path under consideration includes an uncemented joint with a groove on one side less than *X* mm wide and a groove on the other equal to or more than *X* mm wide.

Rule: CLEARANCE and CREEPAGE DISTANCE path are as shown.

Figure F.7 – Uncemented joint with narrow and wide grooves



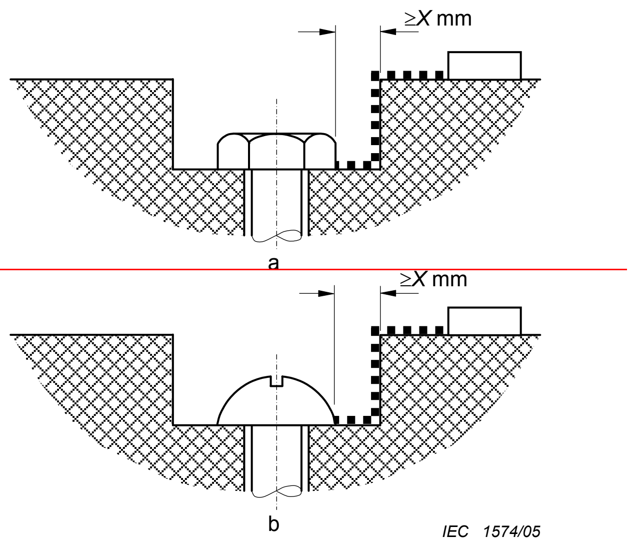


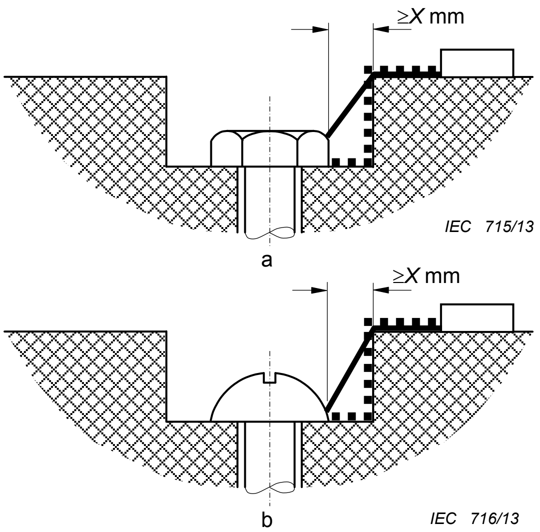
Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall where the distance is equal to *X* mm.

Figure F.8 – Narrow recess

CLEARANCE   CREEPAGE DISTANCE





Gap between head of screw and wall of recess wide enough to be taken into account.

Figure F.9 – Wide recess

──── CLEARANCE ■ ■ ■ ■ ■ ■ ■ CREEPAGE DISTANCE

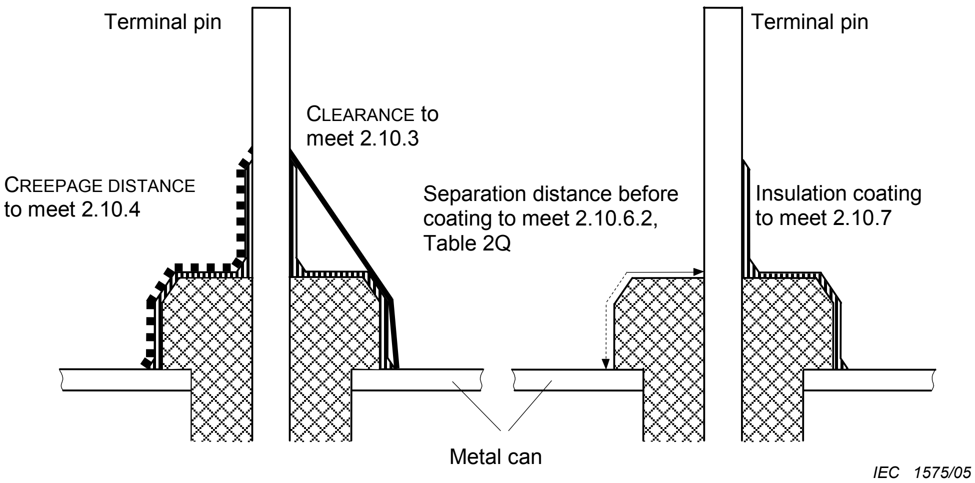


Figure F.10 – Coating around terminals

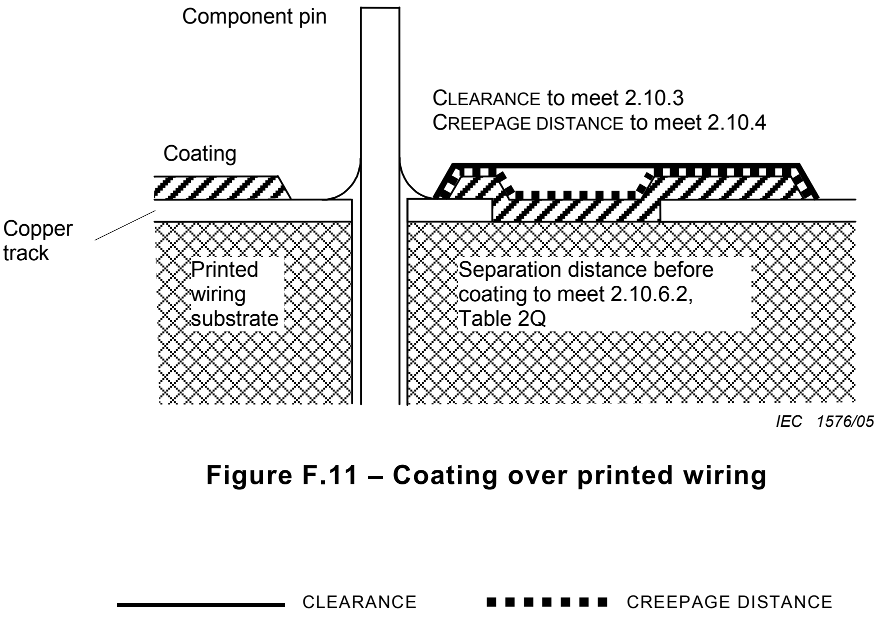
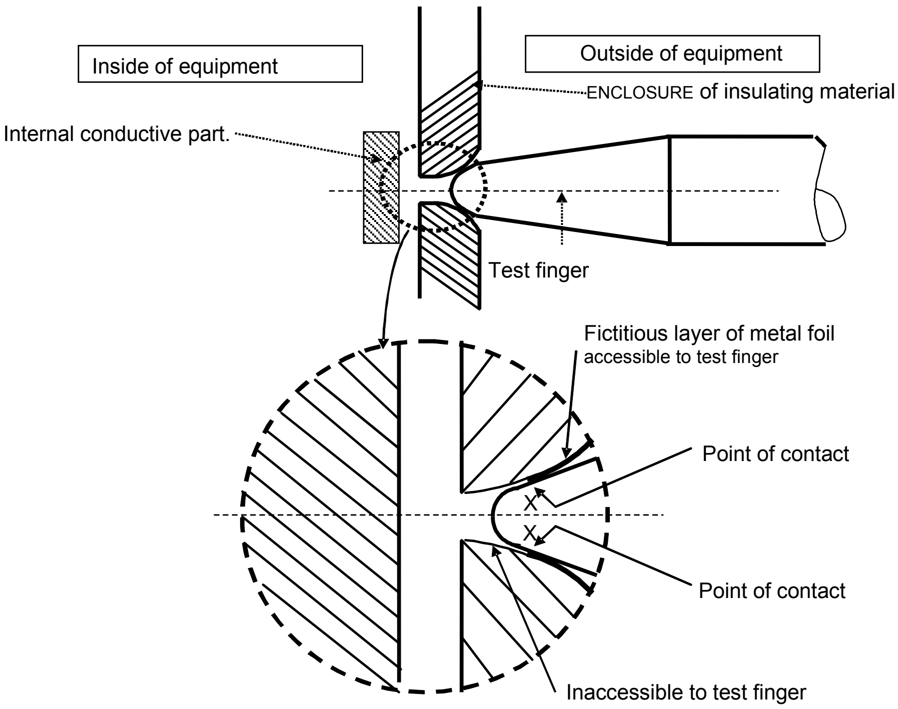


Figure F.11 – Coating over printed wiring



Point X is used for measurements of CLEARANCES and CREEPAGE DISTANCES from the BOUNDING SURFACE of an ENCLOSURE of insulating material to an internal conductive part (see 2.10.3.1 and 2.10.4)

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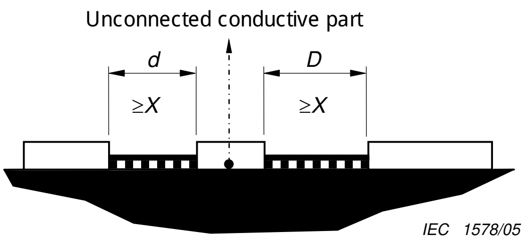
Figure F.12 – Measurements through openings in enclosures



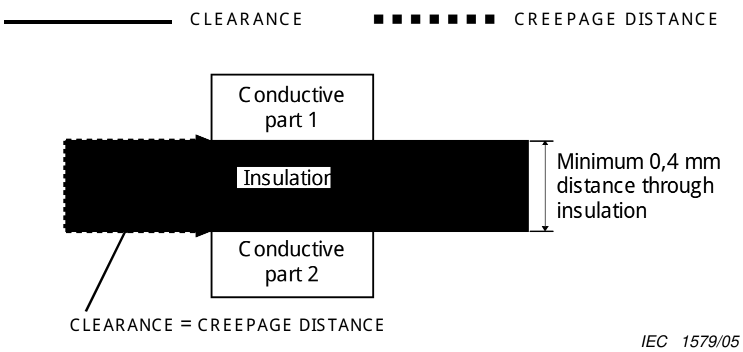
Condition: Insulation distance with intervening, unconnected conductive part.

Rule: CLEARANCE is the distance *d* + *D*.

CREEPAGE DISTANCE is also *d* + *D*.

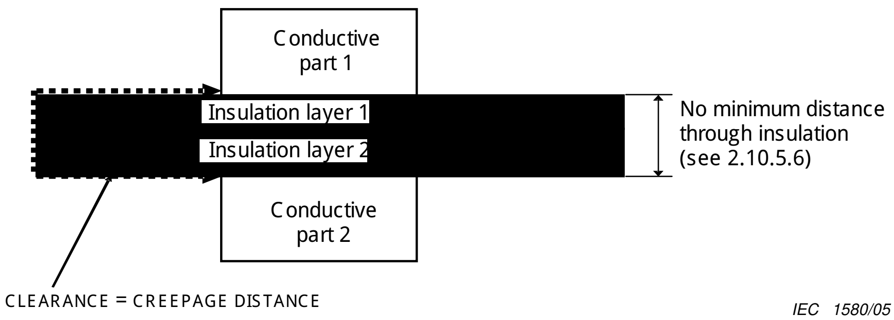
Where the value of *d* or *D* is smaller than *X*, it shall be considered as zero.

Figure F.13 – Intervening, unconnected conductive part



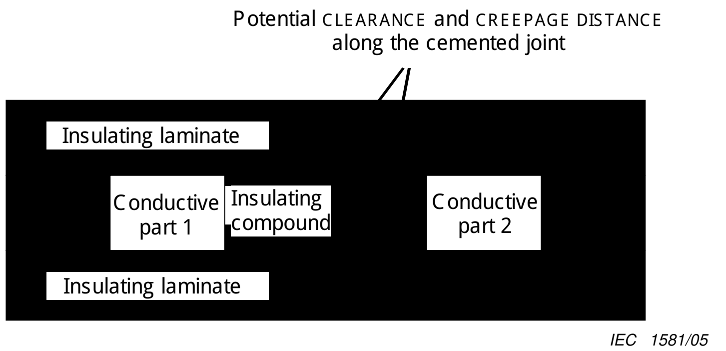
Thick sheet or solid insulating material as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.14 – Solid insulating material



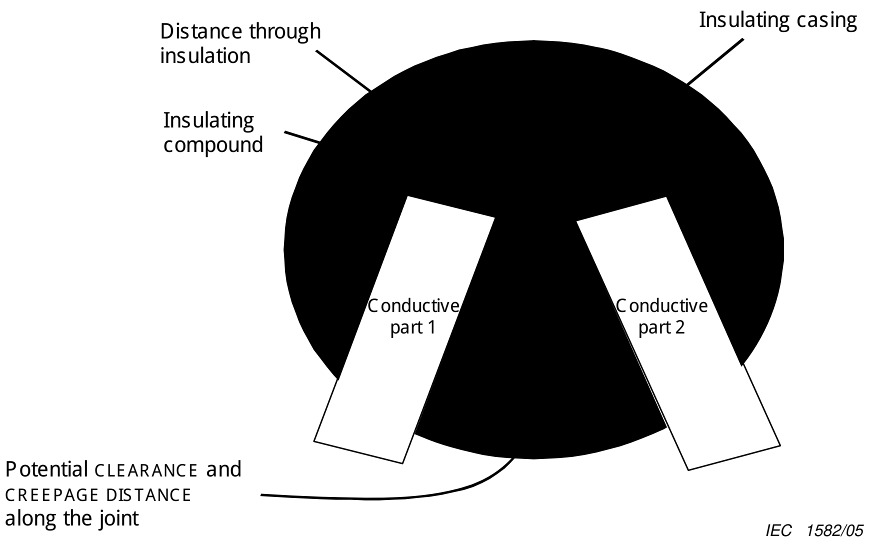
Two layers of thin sheet material as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.15 – Thin sheet insulating material



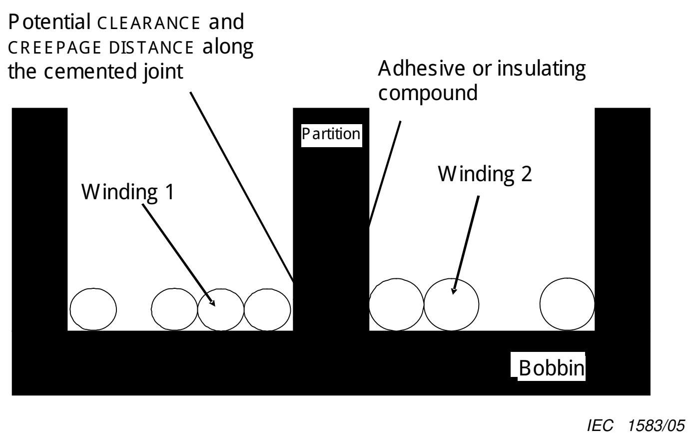
Insulating compound as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.16 – Cemented joints in multi-layer printed board



Insulating compound as SUPPLEMENTARY INSULATION or REINFORCED INSULATION inside a component

Figure F.17 – Component filled with insulating compound



Cemented joint as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.18 – Partitioned bobbin

Annex G
(normative)

Alternative method for determining minimum clearances

G.1 Clearances

G.1.1 General

CLEARANCES shall be so dimensioned that overvoltages, including transients, which may enter the equipment, and peak voltages that may be generated within the equipment, do not break down the CLEARANCE.

It is permitted to use either the requirements of 2.10.3 for Overvoltage Category I or Overvoltage Category II, using the PEAK WORKING VOLTAGE, or the requirements in Annex G for Overvoltage Category I, Overvoltage Category II, Overvoltage Category III or Overvoltage Category IV, using the REQUIRED WITHSTAND VOLTAGE, for a particular component or subassembly or for the whole equipment.

NOTE It is considered to be good practice to design SOLID INSULATION for higher transient overvoltages than the associated CLEARANCE.

G.1.2 Summary of the procedure for determining minimum clearances

NOTE 1 The minimum CLEARANCES for FUNCTIONAL INSULATION, BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, whether in a PRIMARY CIRCUIT or another circuit, depend on the REQUIRED WITHSTAND VOLTAGE. The REQUIRED WITHSTAND VOLTAGE depends in turn on the combined effect of the normal operating voltage (including repetitive peaks due to internal circuitry such as switch mode power supplies) and non-repetitive overvoltages due to external transients.

To determine the minimum value for each CLEARANCE, the following steps shall be used.

(1) Measure the PEAK WORKING VOLTAGE across the CLEARANCE in question.

(2) If the equipment is mains operated:

– determine the MAINS TRANSIENT VOLTAGE (Clause G.2); and

– for equipment to be connected to an AC MAINS SUPPLY, calculate the peak value of the nominal AC MAINS SUPPLY voltage.

(3) Use the rules in G.4.1 and the above voltage values to determine the ~~required withstand voltage~~ REQUIRED WITHSTAND VOLTAGE for mains transients and internal repetitive peaks. In the absence of transients coming from a ~~telecommunication network~~ TELECOMMUNICATION NETWORK, go to step 7.

(4) If the equipment is to be connected to a ~~telecommunication network~~ TELECOMMUNICATION NETWORK, determine the ~~telecommunication network transient voltage~~ TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE (Clause G.3).

(5) Use the ~~telecommunication network transient voltage~~ TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE and the rules in G.4.2 to determine the ~~required withstand voltage for telecommunication network transients~~ REQUIRED WITHSTAND VOLTAGE for TELECOMMUNICATION NETWORK TRANSIENTS. In the absence of mains and internal repetitive peaks, go to step 7.

(6) Use the rule in G.4.3 to determine the total ~~required withstand voltage~~ REQUIRED WITHSTAND VOLTAGE.

(7) Use the REQUIRED WITHSTAND VOLTAGE to determine the minimum CLEARANCE (Clause G.6).

NOTE 2 The effect of transients from a CABLE DISTRIBUTION SYSTEM is not taken into account (see G.4.4 and 7.4.1).

G.2 Determination of mains transient voltage

G.2.1 AC mains supply

For equipment to be supplied from the AC MAINS SUPPLY, the value of the MAINS TRANSIENT VOLTAGE depends on the overvoltage category and the AC MAINS SUPPLY voltage. In general, CLEARANCES in equipment intended to be connected to the AC MAINS SUPPLY shall be designed for Overvoltage Category II.

NOTE 1 See Annex Z for further guidance on the determination of overvoltage category.

Equipment that is likely, when installed, to be subjected to transient overvoltages that exceed those for its design Overvoltage Category II, will require additional protection to be provided external to the equipment. In this case, the installation instructions shall state the need for such external protection.

The applicable value of the MAINS TRANSIENT VOLTAGE shall be determined from the overvoltage category and the AC MAINS SUPPLY voltage, using Table G.1.

Table G.1 – AC mains transient voltages

AC MAINS SUPPLY voltage [a] V r.m.s.	MAINS TRANSIENT VOLTAGE [b] V peak			
	Overvoltage Category			
	I	II	III	IV
up to and including 50	330	500	800	1 500
over 50 up to and including 100	500	800	1 500	2 500
over 100 up to and including 150 [c]	800	1 500	2 500	4 000
over 150 up to and including 300 [d]	1 500	2 500	4 000	6 000
over 300 up to and including 600 [e]	2 500	4 000	6 000	8 000

[a] For equipment designed to be connected to a three-phase, three-wire supply, where there is no neutral conductor, the AC MAINS SUPPLY voltage is the line-to-line voltage. In all other cases, where there is a neutral conductor, it is the line-to-neutral voltage.

[b] The MAINS TRANSIENT VOLTAGE is always one of the values in the table. Interpolation is not permitted.

[c] Including 120/208 V and 120/240 V.

[d] Including 230/400 V and 277/480 V.

[e] Including 400/690 V.

NOTE 2 For Japan, the value of the MAINS TRANSIENT VOLTAGES for the nominal AC MAINS SUPPLY voltage of 100 V is determined from the row applicable to an AC MAINS SUPPLY voltage of 150 V.

G.2.2 Earthed d.c. mains supplies

If a DC MAINS SUPPLY is connected to protective earth and is entirely within a single building, the MAINS TRANSIENT VOLTAGE shall be assumed to be 71 V peak. If this connection is within the EUT, it shall be in accordance with 2.6.1 e).

NOTE The connection to protective earth can be at the source of the DC MAINS SUPPLY or at the equipment location, or both (see ITU-T Recommendation K.27).

G.2.3 Unearthed d.c. mains supplies

If a DC MAINS SUPPLY is not earthed and located as in G.2.2, the MAINS TRANSIENT VOLTAGE shall be assumed to be equal to the MAINS TRANSIENT VOLTAGE in the AC MAINS SUPPLY from which the DC MAINS SUPPLY is derived.

G.2.4 Battery operation

If equipment is supplied from a dedicated battery that has no provision for charging from an external MAINS SUPPLY, the MAINS TRANSIENT VOLTAGE shall be assumed to be 71 V peak.

G.3 Determination of telecommunication network transient voltage

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is known for the TELECOMMUNICATION NETWORK in question, it is permitted to use the known value in G.4.2.

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is not known, one of the following values shall be used:

– 1 500 V peak if the circuit connected to the TELECOMMUNICATION NETWORK is a TNV-1 CIRCUIT or a TNV-3 CIRCUIT; or

– 800 V peak if the circuit connected to the TELECOMMUNICATION NETWORK is an SELV CIRCUIT or a TNV-2 CIRCUIT.

The effect of a telephone ringing signal is not taken into account for this purpose.

G.4 Determination of required withstand voltage

G.4.1 Mains transients and internal repetitive peaks

In G.4.1, the effect of transients coming from a TELECOMMUNICATION NETWORK is ignored (see G.4.3).

The REQUIRED WITHSTAND VOLTAGE is determined according to Items a), b) or c).

NOTE Items a) and b) apply only for an AC MAINS SUPPLY. Item c) applies only for a DC MAINS SUPPLY.

The following abbreviations are used.

U_{pw}	the PEAK WORKING VOLTAGE of the CLEARANCE
$U_{a.c.\ mains\ peak}$	peak value of the AC MAINS SUPPLY voltage in the first column of Table G.1 corresponding to the RATED VOLTAGE or the upper limit of the RATED VOLTAGE RANGE.
$U_{mains\ transient}$	the MAINS TRANSIENT VOLTAGE determined in G.2.1 or G.2.2
$U_{measured}$	the maximum transient voltage from the mains, determined according to G.5 a)

a) **PRIMARY CIRCUITS**

It is permitted to use a1) or a2).

a1) The following Rules 1) and 2) shall be applied:

Rule 1) If $U_{pw} \leq U_{a.c.\ mains\ peak}$

$$U_{required\ withstand} = U_{mains\ transient}.$$

Rule 2) If $U_{pw} > U_{a.c.\ mains\ peak}$

$$U_{required\ withstand} = U_{mains\ transient} + U_{pw} - U_{a.c.\ mains\ peak}.$$

a2) The above Rules 1) and 2) shall be applied, but $U_{mains\ transient}$ shall be replaced by $U_{measured}$.

b) SECONDARY CIRCUITS whose PRIMARY CIRCUIT is supplied from an AC MAINS SUPPLY
It is permitted to use b1), b2) or b3).

b1) The following Rule 3) shall be applied:

Rule 3) $U_{required\ withstand} = U_{mains\ transient}$ or U_{pw}, whichever is the greater.

b2) The above Rule 3) shall be applied, but with $U_{mains\ transient}$ replaced by $U_{measured}$.

b3) The above Rule 3 shall be applied, but with $U_{mains\ transient}$ replaced by a voltage that is one step smaller in the following list from Table G.1:

330, 500, 800, 1 500, 2 500, 4 000, 6 000 and 8 000 V peak.

This is permitted in the following cases:

– a SECONDARY CIRCUIT, derived from an AC MAINS SUPPLY, that is connected to the main protective earthing terminal in accordance with 2.6.1 e);

– a SECONDARY CIRCUIT, derived from an AC MAINS SUPPLY and separated from the PRIMARY CIRCUIT by a metal screen that is connected to the main protective earthing terminal in accordance with 2.6.1 e).

c) SECONDARY CIRCUIT supplied from a DC MAINS SUPPLY

The above b1) or b3) shall be applied.

G.4.2 Transients from telecommunication networks

In G.4.2, the effect of transients coming from the mains and from internal circuitry is ignored (see G.4.3).

For transients from a TELECOMMUNICATION NETWORK, the REQUIRED WITHSTAND VOLTAGE is:

– the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE determined in Clause G.3;

– or the value measured in accordance with G.5 b);

whichever is less.

G.4.3 Combination of transients

If the transients described in G.4.1 and those described in G.4.2 affect the same CLEARANCE, the REQUIRED WITHSTAND VOLTAGE is the larger of the two voltages. The two values shall not be added together.

G.4.4 Transients from cable distribution systems

The effect of transients from a CABLE DISTRIBUTION SYSTEM is not taken into account when determining REQUIRED WITHSTAND VOLTAGE (however, see 7.4.1).