Clearance Distance Data as per UL-60950/IEC-60950

1.2.8 Circuits and circuit characteristics

1.2.8.1
AC MAINS SUPPLY:
a.c. power distribution system external to the equipment for supplying power to a.c. powered equipment
These power sources include public or private utilities and, unless otherwise specified in the standard (for example, 1.4.5), equivalent sources such as motor-driven generators and uninterruptible power supplies.

NOTE : See Annex V for typical examples of a.c. power distribution systems.

1.2.8.2
DC MAINS SUPPLY :
d.c. power distribution system, with or without batteries, external to the equipment, for supplying power to d.c. powered equipment, excluding the following:

– a d.c. supply providing power over TELECOMMUNICATION NETWORK wiring to remote equipment;
– a limited power source (see 2.5) whose open circuit voltage is less than or equal to 42,4 V d.c.;
– a d.c. supply whose open circuit voltage is greater than 42,4 V d.c. and less than or equal to 60 V d.c., and whose available power output is less than 240 VA

Circuitry connected to a DC MAINS SUPPLY is considered to be a SECONDARY CIRCUIT (for example, an SELV CIRCUIT, a TNV CIRCUIT or a HAZARDOUS VOLTAGE SECONDARY CIRCUIT) in the meaning of this standard.

NOTE : See ITU-T Recommendation K.27 for bonding configurations and earthing inside a telecommunication building.

1.2.8.3
MAINS SUPPLY :
power distribution system that is either an AC MAINS SUPPLY or a DC MAINS SUPPLY

1.2.8.4
PRIMARY CIRCUIT :
circuit that is directly connected to the AC MAINS SUPPLY
It includes, for example, the means for connection to the AC MAINS SUPPLY, the primary windings of transformers, motors and other loading devices.

NOTE : Conductive parts of an INTERCONNECTING CABLE may be part of a PRIMARY CIRCUIT as stated in 1.2.11.6.

1.2.8.5
SECONDARY CIRCUIT :
circuit that has no direct connection to a PRIMARY CIRCUIT and derives its power from a transformer, converter or equivalent isolation device, or from a battery

NOTE : Conductive parts of an INTERCONNECTING CABLE may be part of a SECONDARY CIRCUIT as stated in

1.2.8.6
HAZARDOUS VOLTAGE
voltage exceeding 42,4 V peak, or 60 V d.c., existing in a circuit that does not meet the requirements for either a LIMITED CURRENT CIRCUIT or a TNV CIRCUIT

1.2.8.7

ELV CIRCUIT :

SECONDARY CIRCUIT with voltages between any two conductors of the circuit, and between any one such conductor and earth (see 1.4.9), not exceeding 42,4 V peak, or 60 V d.c., under normal operating conditions, which is separated from HAZARDOUS VOLTAGE by BASIC INSULATION, and which neither meets all of the requirements for an SELV CIRCUIT nor meets all of the requirements for a LIMITED CURRENT CIRCUIT

1.2.8.8

SELV CIRCUIT :

SECONDARY CIRCUIT that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value

NOTE 1 : The limit values of voltages under normal operating conditions and single fault conditions (see 1.4.14) are specified in 2.2. See also Table 1A.

1.2.8.9

LIMITED CURRENT CIRCUIT :

circuit that is so designed and protected that, under both normal operating conditions and single fault conditions, the current that can be drawn is not hazardous

NOTE : The limit values of currents under normal operating conditions and single fault conditions (see 1.4.14) are specified in 2.4.

1.2.8.10

HAZARDOUS ENERGY LEVEL :

available power level of 240 VA or more, having a duration of 60 s or more, or a stored energy level of 20 J or more (for example, from one or more capacitors), at a potential of 2 V or more

1.2.8.11

TNV CIRCUIT :

circuit that is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions (see 1.4.14), the voltages do not exceed specified limit values

A TNV CIRCUIT is considered to be a SECONDARY CIRCUIT in the meaning of this standard.

NOTE 1 :The specified limit values of voltages under normal operating conditions and single fault conditions (see 1.4.14) are given in 2.3.1. Requirements regarding accessibility of TNV CIRCUITS are given in 2.1.1.1.

NOTE 2 : Conductive parts of an INTERCONNECTING CABLE may be part of a TNV CIRCUIT as stated in 1.2.11.6.
TNV CIRCUITS are classified as TNV-1 CIRCUITS, TNV-2 CIRCUITS and TNV-3 CIRCUITS as defined in 1.2.8.12, 1.2.8.13 and 1.2.8.14.

NOTE 3 : The voltage relationships between SELV and TNV CIRCUITS are shown in Table 1A.

Table 1A – Voltage ranges of SELV and TNV circuits

		Normal operating voltages	
Overvoltages from TELECOMMUNICATION NETWORKS possible?	Overvoltages from CABLE DISTRIBUTION SYSTEMS possible ?	Within SELV CIRCUIT limits	Exceeding SELV CIRCUIT limits but within TNV CIRCUIT limits
Yes	Yes	TNV-1 CIRCUIT	TNV-3 CIRCUIT
No	Not applicable	SELV CIRCUIT	TNV-2 CIRCUIT

1.2.8.12
TNV-1 CIRCUIT :

TNV CIRCUIT :
– whose normal operating voltages do not exceed the limits for an SELV CIRCUIT under normal operating conditions and

– on which overvoltages from TELECOMMUNICATION NETWORKS and CABLE DISTRIBUTION SYSTEMS are possible

1.2.8.13
TNV-2 CIRCUIT :

TNV CIRCUIT
– whose normal operating voltages exceed the limits for an SELV CIRCUIT under normal operating conditions and

– which is not subject to overvoltages from TELECOMMUNICATION NETWORKS

1.2.8.14
TNV-3 CIRCUIT :

TNV CIRCUIT
– whose normal operating voltages exceed the limits for an SELV CIRCUIT under normal operating conditions and

– on which overvoltages from TELECOMMUNICATION NETWORKS and CABLE DISTRIBUTION SYSTEMS are possible

1.2.9 Insulation Types:

1.2.9.1
FUNCTIONAL INSULATION :
insulation that is necessary only for the correct functioning of the equipment

NOTE FUNCTIONAL INSULATION by definition does not protect against electric shock. It may, however, reduce the likelihood of ignition and fire.

1.2.9.2
BASIC INSULATION :
insulation to provide basic protection against electric shock

1.2.9.3

SUPPLEMENTARY INSULATION :

independent insulation applied in addition to BASIC INSULATION in order to reduce the risk of electric shock in the event of a failure of the BASIC INSULATION

1.2.9.4

DOUBLE INSULATION :

insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

1.2.9.5

REINFORCED INSULATION :

single insulation system that provides a degree of protection against electric shock equivalent to DOUBLE INSULATION under the conditions specified in this standard

NOTE : The term "insulation system" does not imply that the insulation has to be in one homogeneous piece. It may comprise several layers that cannot be tested as BASIC INSULATION and SUPPLEMENTARY INSULATION.

1.2.9.6

WORKING VOLTAGE :

highest voltage to which the insulation or the component under consideration is, or can be, subjected when the equipment is operating under conditions of normal use

Overvoltages that originate outside the equipment are not taken into account.

1.2.9.7

RMS WORKING VOLTAGE :

r.m.s. value of a WORKING VOLTAGE, including any d.c. component

NOTE : For the purpose of determining RMS WORKING VOLTAGES, the rules of 2.10.2.2 apply, and where relevant those of 1.4.8.

1.2.9.8

PEAK WORKING VOLTAGE :

peak value of a WORKING VOLTAGE, including any d.c. component and any repetitive peak impulses generated in the equipment

Where peak-to-peak ripple exceeds 10 % of the average value, the requirements related to peak or a.c. voltages are applicable.

NOTE For the purpose of determining PEAK WORKING VOLTAGES, the rules of 2.10.2.3 apply, and where relevant those of 1.4.8.

1.2.9.9

REQUIRED WITHSTAND VOLTAGE :

peak voltage that the insulation under consideration is required to withstand

1.2.9.10

MAINS TRANSIENT VOLTAGE :

highest peak voltage expected at the power input to the equipment, arising from external transients on the MAINS SUPPLY

1.2.9.11

TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE :

highest peak voltage expected at the TELECOMMUNICATION NETWORK connection point of the equipment, arising from external transients on the network

NOTE The effect of transients from CABLE DISTRIBUTION SYSTEMS is not taken into account.

Defination for Clearance distances

2.10.3.2 Mains transient voltages

a) AC MAINS SUPPLY:

For equipment to be supplied from an 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 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 2J.

Table 2J – AC mains transient voltages

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

[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.

b) Earthed DC 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 2.6.1d).

c) Unearthed DC MAINS SUPPLIES :
If a DC MAINS SUPPLY is not earthed and located as in b) above, 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.

d) 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.

2.10.3.3 Clearances in primary circuits

For insulation in PRIMARY CIRCUITS, between PRIMARY CIRCUITS and earth and between PRIMARY CIRCUITS and SECONDARY CIRCUITS, the following rules apply.

For an AC MAINS SUPPLY not exceeding 300 V r.m.s. (420 V peak):
a) if the PEAK WORKING VOLTAGE does not exceed the peak value of the AC MAINS SUPPLY voltage, minimum CLEARANCES are determined from Table 2K;

b) if the PEAK WORKING VOLTAGE exceeds the peak value of the AC MAINS SUPPLY voltage, the minimum CLEARANCE is the sum of the following two values:
• the minimum CLEARANCE from Table 2K; and
• the appropriate additional CLEARANCE from Table 2L.

For an AC MAINS SUPPLY exceeding 300 V r.m.s. (420 V peak), minimum CLEARANCES are determined from Table 2K.

Table 2K – Minimum clearances for insulation in primary circuits and between primary and secondary circuits

CLEARANCES in mm

PEAK WORKING VOLTAGE [a] up to and including	MAINS TRANSIENT VOLTAGE														
	1 500 V [c]						2 500 V [c]						4 000 V [c]		
	Pollution degree														
	1 and 2 [b]			3			1 and 2 [b]			3			1, 2 [b] and 3		
V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	0,4	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,0	2,0 (1,5)	4,0 (3,0)	1,3	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
210	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,4	2,0 (1,5)	4,0 (3,0)	1,5	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
420	F 1,5 B/S 2,0 (1,5) R 4,0 (3,0)												2,5	3,2 (3,0)	6,4 (6,0)
840	F 3,0 B/S 3,2 (3,0) R 6,4 (6,0)														
1 400	F/B/S 4,2 R 6,4														
2 800	F/B/S/R 8,4														
7 000	F/B/S/R 17,5														
9 800	F/B/S/R 25														
14 000	F/B/S/R 37														
28 000	F/B/S/R 80														
42 000	F/B/S/R 130														

The values in the table are applicable to FUNCTIONAL INSULATION (F) if required by 5.3.4 a) (see 2.10.1.3), BASIC INSULATION (B), SUPPLEMENTARY INSULATION (S) and REINFORCED INSULATION (R).

The values in parentheses apply to BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION only if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in Clause R.2. DOUBLE INSULATION and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

If the PEAK WORKING VOLTAGE exceeds the peak value of the AC MAINS SUPPLY voltage, linear interpolation is permitted between the nearest two points, the calculated minimum CLEARANCE being rounded up to the next higher 0,1 mm increment.

[a] If the PEAK WORKING VOLTAGE exceeds the peak value of the AC MAINS SUPPLY voltage, see 2.10.3.3 b) regarding additional CLEARANCES.

[b] It is not required to pass the tests of 2.10.10 for Pollution Degree 1.

[c] The relationship between MAINS TRANSIENT VOLTAGE and AC MAINS SUPPLY voltage is given in Table 2J.

Table 2L – Additional clearances in primary circuits

CLEARANCES in mm

MAINS TRANSIENT VOLTAGE						
1 500 V [c]				2 500 V [c]		
Pollution Degrees 1 and 2 [b]	Pollution Degree 3	FUNCTIONAL [a] BASIC or SUPPLEMENTARY INSULATION	REINFORCED INSULATION	Pollution Degrees 1, 2 and 3 [b]	FUNCTIONAL [a] BASIC or SUPPLEMENTARY INSULATION	REINFORCED INSULATION
PEAK WORKING VOLTAGE up to and including V				PEAK WORKING VOLTAGE up to and including V		
210 (210)	210 (210)	0,0	0,0	420 (420)	0,0	0,0
298 (288)	294 (293)	0,1	0,2	493 (497)	0,1	0,2
386 (366)	379 (376)	0,2	0,4	567 (575)	0,2	0,4
474 (444)	463 (459)	0,3	0,6	640 (652)	0,3	0,6
562 (522)	547 (541)	0,4	0,8	713 (729)	0,4	0,8
650 (600)	632 (624)	0,5	1,0	787 (807)	0,5	1,0
738 (678)	715 (707)	0,6	1,2	860 (884)	0,6	1,2
826 (756)	800 (790)	0,7	1,4	933 (961)	0,7	1,4
914 (839)		0,8	1,6	1 006 (1 039)	0,8	1,6
1 002 (912)		0,9	1,8	1 080 (1 116)	0,9	1,8
1 090 (990)		1,0	2,0	1 153 (1 193)	1,0	2,0
		1,1	2,2	1 226 (1 271)	1,1	2,2
		1,2	2,4	1 300 (1 348)	1,2	2,4
		1,3	2,6	(1 425)	1,3	2,6

The additional CLEARANCES in the table apply if required by 2.10.3.3 b).

The values in parentheses shall be used:

- if the values in parentheses in Table 2K are used; and
- for FUNCTIONAL INSULATION if required by 5.3.4 a).

For voltage values above the PEAK WORKING VOLTAGE values given in the table, linear extrapolation is permitted.

[a] There is no minimum CLEARANCE for FUNCTIONAL INSULATION unless it is required by 5.3.4 a). See 2.10.1.3.

[b] It is not required to pass the tests of 2.10.10 for Pollution Degree 1.

[c] The relationship between MAINS TRANSIENT VOLTAGE and AC MAINS SUPPLY voltage is given in Table 2J.

2.10.3.4 Clearances in secondary circuits

Minimum CLEARANCES in SECONDARY CIRCUITS are determined from Table 2M.

The PEAK WORKING VOLTAGE for use in Table 2M is:

– the peak value of a sinusoidal voltage;

– the measured peak value of a non-sinusoidal voltage.

The highest transient overvoltage for use in Table 2M is either

– the highest transient from the MAINS SUPPLY, determined in accordance with 2.10.3.6 or 2.10.3.7; or

– the highest transient from a TELECOMMUNICATION NETWORK, determined in accordance with 2.10.3.8,

whichever is the higher value.

Table 2M – Minimum clearances in secondary circuits

CLEARANCES in mm

PEAK WORKING VOLTAGE up to and including	Highest transient overvoltage in the SECONDARY CIRCUIT (V peak)																	
	Up to and including 71 V			Over 71 V up to and including 800 V			Up to and including 800 V			Over 800 V up to and including 1 500 V						Over 1 500 V up to and including 2 500 V [a]		
	Pollution Degree																	
	1 and 2 [b]						3			1 and 2 [b]			3			1, 2 [b] and 3		
V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	0,2	0,4 (0,2)	0,8 (0,4)	0,2	0,7 (0,2)	1,4 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
140	0,2	0,7 (0,2)	1,4 (0,4)	0,2	0,7 (0,2)	1,4 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
210	0,2	0,7 (0,2)	1,4 (0,4)	0,2	0,9 (0,2)	1,8 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
280	0,2	1,1 (0,2)	2,2 (0,4)	F 0,8 B/S 1,4 (0,8) R 2,8 (1,6)												1,5	2,0 (1,5)	4,0 (3,0)
420	0,2	1,4 (0,2)	2,8 (0,4)	F 1,0 B/S 1,9 (1,0) R 3,8 (2,0)												1,5	2,0 (1,5)	4,0 (3,0)
700	F/B/S 2,5 R 5,0																	
840	F/B/S 3,2 R 5,0																	
1 400	F/B/S 4,2 R 5,0																	
2 800	F/B/S/R 8,4 See [c]																	
7 000	F/B/S/R 7,5 See [c]																	
9 800	F/B/S/R 25 See [c]																	
14 000	F/B/S/R 37 See [c]																	
28 000	F/B/S/R 80 See [c]																	
42 000	F/B/S/R 130 See [c]																	

The values in the table apply to FUNCTIONAL INSULATION (F) if required by 5.3.4 a) (see 2.10.1.3), BASIC INSULATION (B), SUPPLEMENTARY INSULATION (S) and REINFORCED INSULATION (R).

Linear interpolation is permitted between the nearest two points, the calculated minimum CLEARANCE being rounded up to the next higher 0,1 mm increment.

If the CLEARANCE path is partly along the surface of insulation that is not Material Group I, the test voltage is applied across the air gap and Material Group I only. The part of the path along the surface of any other insulating material is bypassed.

The values in parentheses apply to BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in Clause R.2 of Annex R. DOUBLE INSULATION and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

[a] For transient overvoltages higher than 2 500 V peak, either Table 2K shall be used or the minimum CLEARANCE shall be determined using Annex G.

[b] It is not required to pass the tests of 2.10.10 for Pollution Degree 1.

[c] In a SECONDARY CIRCUIT, for PEAK WORKING VOLTAGES above 1 400 V, the minimum CLEARANCE is 5 mm provided that the CLEARANCE path passes an electric strength test according to 5.2.2 using:

- an a.c. test voltage whose r.m.s. value is 106 % of the PEAK WORKING VOLTAGE (peak value is 150 % of the PEAK WORKING VOLTAGE), or
- a d.c. test voltage equal to 150 % of the PEAK WORKING VOLTAGE.

2.10.3.6 Transients from an a.c. mains supply

Except as permitted below, the highest transient in a SECONDARY CIRCUIT due to transients on the AC MAINS SUPPLY is the value measured in accordance with 2.10.3.9 a).

Alternatively, for certain SECONDARY CIRCUITS it is permitted to assume that the highest transient is either of the following:
– the value measured in accordance with 2.10.3.9 a); or
– one step lower in the following list than the MAINS TRANSIENT VOLTAGE from Table 2J in the PRIMARY CIRCUIT:
330, 500, 800, 1 500, 2 500 and 4 000 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;
– 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.

2.10.3.7 Transients from a d.c. mains supply

NOTE 1 : A circuit connected to a DC MAINS SUPPLY is considered to be a SECONDARY CIRCUIT(see 1.2.8.2).

The highest transient in a SECONDARY CIRCUIT due to transients on a DC MAINS SUPPLY is
– the MAINS TRANSIENT VOLTAGE, if the SECONDARY CIRCUIT is directly connected to the DC MAINS SUPPLY; or
– the value measured in accordance with 2.10.3.9 a) in other cases except as given in 2.10.3.2 b) and 2.10.3.2 c).

NOTE 2 : Both of the above options depend on the value of the MAINS TRANSIENT VOLTAGE. In some cases, this value is assumed to be 71 V peak [see 2.10.3.2 b) or d)]. The appropriate column of Table 2K is used and no measurement is necessary.