

## Electric field conditions

The insulation clearance is determined in Table 2 of IEC 60664-1, bearing in mind the following influencing factors:

- Rated impulse withstand voltage
- Electric field conditions
- Altitude: the values specified in Table 2 give sufficient impulse withstand capability for equipment for use at altitudes up to 2.000 m. For equipment for use at higher altitudes, the corrective factors specified in Table A2 of IEC 60664-1
- The micro-environment.

The shape and arrangement of the conductive parts influence the homogeneity of the electric field and consequently the clearance needed to withstand a given voltage. The clearances in Case A (inhomogeneous field) have the required impulse withstand voltage under all conditions: clearances not less than those specified in **Table 2 - Case A** can be used irrespective of the shape and arrangement of the conductive parts and without verification by an impulse withstand test.

### Determination of clearances

In accordance with standard IEC 60664-1, the following must be identified to determine it:

- The rated voltage of the power supply (usually 230/400V and therefore a conventional voltage line-to-neutral of **300V**), in star distribution networks with earthed neutral, or 400V for star networks without neutral, or with insulated neutral, or in networks with the distribution transformer's secondary winding delta connected, insulated or corner-earthed and, therefore, with conventional phase voltage of 600V);
- The overvoltage category (usually **III**);
- The rated impulse withstand voltage determined from Table 1 of IEC 60664-1 (usually **4 kV** or **6kV**);
- The type of electric field to which the parts through which the current flows shall be subjected (worse case = **inhomogeneous field**) and the degree of pollution (usually **3**).

Standard **EN 61984** specifies that the **through-air insulation distance** should be sized according to Table 2 of IEC 60664-1, but according to the rated impulse withstanding voltage obtained from **Table 5** of EN 61984. The rated impulse withstanding voltage must be selected according to the rated power supply voltage and to the overvoltage category. The assignment of connectors to a particular overvoltage category (usually **III**) is effected according to the rules of IEC 60664-1.

### Rated voltage

The voltage value assigned by the manufacturer to the connector and to which the operating and performance characteristics refer (IEC 60664-1, definition 1.3.9 modified).

NOTE – A connector may have more than one rated voltage value.

As concerns the choice of the type of electric field, the through-air insulation distances via windows and openings in the enclosures of insulating material, must comply with the values of case A in Table of IEC 60664-1. i.e. for non uniform field conditions.

**TABLE 5**

Rated impulse withstand voltage (EN 61984 Edition 1.0 - 2001-11)

Nominal voltage of the supply system ( $\leq$ rated insulation voltage of equipment)					Preferred values for the rated impulse withstand voltage in kV (1.2/50 $\mu$ s)			
					Overvoltage category *			
					I	II	III	IV
Voltage line-to-earth derived from the nominal voltage of the supply system to the a.c. voltage (r.m.s. value) or d.c. voltage	a.c. voltage (r.m.s. value)	a.c. voltage (r.m.s. value)	a.c. voltage (r.m.s. value) d.c. voltage	a.c. voltage (r.m.s. value) d.c. voltage	Special protected levels	Level for electrical equipment (household and similar)	Level for distribution supply systems	Input level
V	V	V	V	V	kV	kV	kV	kV
100	66/115	66	60	-	0.5	0.8	1.5	2.5
150	120/208; 127/220;	115; 120; 127	110; 120	220-110; 240-120;	0.8	1.5	2.5	4
300	220/380; 230/400; 240/415; 260/440; 277/480;	220; 230; 240; 260; 277;	220	440-220	1.5	2.5	4	6
600	347/600 380/660 400/690 415/720 480/830	347; 380; 400; 415; 440; 480 500; 577; 600;	480	960-480	2.5	4	6	8
1000		660; 690; 720; 830; 1000;	1000	-	4	6	8	12

\* Values for voltages  $\leq$  50V mentioned in IEC 60664-1, Encl. B

With the three values (b) (c) and (d) the minimum clearance is determined in Table 2 of IEC 60664-1

**TABLE 2\*)**

Minimum clearance for insulation co-ordination (IEC 60664-1 Edition 1.0 - 1992-10)

Required impulse withstand voltage	Minimum clearances in air in mm. up to 2.000 m. above sea level							
	Case A - inhomogenous field 1)				Case B - homogenous field 2)			
	degree of pollution				degree of pollution			
kV	1	2	3	4	1	2	3	4
0.33 <sup>3)</sup>	0.01	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.01	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
0.40	0.02	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.02	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
0.50 <sup>3)</sup>	0.04	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.04	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
0.60	0.06	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.06	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
0.80 <sup>3)</sup>	0.10	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.10	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
1.0	0.15	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.15	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
1.2	0.25	0.25	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>	0.2	0.2 <sup>4)5)</sup>	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
1.5 <sup>3)</sup>	0.5	0.5	<b>0.8 <sup>5)</sup></b>	1.6 <sup>5)</sup>	0.3	0.3	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
2.0	1.0	1.0	1.0	1.6 <sup>5)</sup>	0.45	0.45	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
2.5 <sup>3)</sup>	1.5	1.5	<b>1.5</b>	1.6 <sup>5)</sup>	0.6	0.6	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
3.0	2	2	2	2	0.8	0.8	0.8 <sup>5)</sup>	1.6 <sup>5)</sup>
4.0 <sup>3)</sup>	3	3	<b>3</b>	3	1.2	1.2	1.2	1.6 <sup>5)</sup>
5.0	4	4	4	4	1.5	1.5	1.5	1.6 <sup>5)</sup>
6.0 <sup>3)</sup>	5.5	5.5	<b>5.5</b>	5.5	2	2	2	2
8.0 <sup>3)</sup>	8	8	<b>8</b>	8	3	3	3	3
10.0	11	11	11	11	3.5	3.5	3.5	3.5
12.0 <sup>3)</sup>	14	14	14	14	4.5	4.5	4.5	4.5

1) Between pointed and flat electrode.

2) When the clearance is less than the value indicated for Case A an impulse withstand voltage test certificate is required

3) Preferential values specified in Table 1

4) For printed wiring material, the values of degree of pollution 1 apply except that the value shall not be less than 0.04 mm as specified in Table 4

5) These minimum clearances given for pollution degrees 2, 3 and 4 are based on experience rather than on fundamental data.

\*) Table 2 of IEC 60664-1 is modified in Variant 2. In particular, the columns referring to degree of pollution 4 have been eliminated. The definition of this degree is varied in 2.5.1 to: "permanent conductivity occurs, due to conductive dust, rain or other humid conditions". The through-air insulation distances for degree of pollution 4 area as specified for degree of pollution 3, with the exception that the minimum through-air distance is 1.6 mm.

In 2.5.2 it is specified that "in conductive pollution conditions, the dimensions for the surface insulation distances cannot be specified where permanent conductive pollution is present, e.g.: due to coal or metal dust. On the contrary, the insulation surface should be designed in order to prevent a seamless path of conductive pollution, e.g.: by means of ribs and cavities".

**The values written in bold are the most common multipole connectors for industrial purposes.**

If the component respects the minimum through-air insulation distance prescribed for live parts of opposing polarities, it is exempted from the impulsive voltage withstanding test. This test is run at sea level using increased voltage values in order to take into account rarefied air at high altitude (the prescribed values refer to 2000 m asl. However, if this distance is not respected, passing the test gives one the right to declare the relevant rated impulse withstanding voltage.

Declaration of the rated impulse withstanding voltage is optional for standard EN 61984: if the manufacturer declares the rated impulse withstanding voltage, the impulse withstanding voltage test is, in any event, necessary as dielectric verification. Alternatively, if the manufacturer does not declare this rated value, the voltage withstanding dielectric test at mains frequencies of 50/60 Hz for 60 s (test 4a of IEC 60512) is necessary, but at reduced values compared to the peak values of the impulsive test voltages of wave shape standardised at 1.2/50  $\mu$ s.

To this end, standard EN 61984 provides the following cross-reference table:

**TABLE 8**

Test voltages (EN 61984 Edition 1.0 - 2001-11)

Rated impulse withstand voltage kV	Test voltages		Withstand voltage (r.m.s. value) kV (50/60 Hz)
	Impulse withstand * voltage kV (1.2/50 $\mu$ s)	Test voltages at sea level	
0.33	0.33	0.35	0.23
0.5	0.5	0.55	0.37
0.8	0.8	0.91	0.50
1.5	1.5	1.75	0.84
2.5	2.5	2.95	1.39
4	4	4.8	2.21
6	6	7.3	3.31
8	8	9.8	4.26
12	12	14.8	6.6

\* If the test laboratory is situated between sea level and an altitude of 2000 m asl, interpolation of test impulsive voltage is allowed.

### Rated impulse withstand voltage

The rated impulse withstanding voltage assigned by the manufacturer to the connector, which refers to the withstanding capacity of its insulation with respect to transient overvoltages [IEC 60664-1, definition 1.3.9.2 modified].

### Impulse withstand voltage

The highest peak value of a voltage impulse of prescribed shape and polarity, which does not cause insulation faults under specified conditions.