– the insulation involved passes a dielectric strength test according to 8.8.3 using:
  - an a.c. test voltage whose r.m.s. value is equal to 1,06 times the PEAK WORKING VOLTAGE or
  - a d.c. test voltage equal to the peak value of the a.c. test voltage prescribed above;

  and

– the AIR CLEARANCE path is partly or entirely through air or along the surface of an insulating material of material group I.

If the AIR CLEARANCE path is also partly along the surface of a material that is not material group I, the dielectric strength test is conducted only across the part(s) of the path that are through air.

8.9.1.14 Minimum CREEPAGE DISTANCES for two MEANS OF OPERATOR PROTECTION

Minimum CREEPAGE DISTANCES for two MEANS OF OPERATOR PROTECTION are obtained by doubling the values shown in Table 16 for one MEANS OF OPERATOR PROTECTION.

8.9.1.15 * CREEPAGE DISTANCES and AIR CLEARANCES for DEFIBRILLATION-PROOF APPLIED PARTS

CREEPAGE DISTANCES and AIR CLEARANCES needed to satisfy 8.5.5.1 for DEFIBRILLATION-PROOF APPLIED PARTS shall not be less than 4 mm.

Table 11 – Not used

Table 12 – Minimum CREEPAGE DISTANCES and AIR CLEARANCES providing MEANS OF PATIENT PROTECTION

WORKING VOLTAGE V d.c. up to and including	WORKING VOLTAGE V r.m.s. up to and including	Spacing providing one MEANS OF PATIENT PROTECTION		Spacing providing two MEANS OF PATIENT PROTECTION	
		CREEPAGE DISTANCE mm	AIR CLEARANCE mm	CREEPAGE DISTANCE mm	AIR CLEARANCE mm
17	12	1,7	0,8	3,4	1,6
43	30	2	1	4	2
85	60	2,3	1,2	4,6	2,4
177	125	3	1,6	6	3,2
354	250	4	2,5	8	5
566	400	6	3,5	12	7
707	500	8	4,5	16	9
934	660	10,5	6	21	12
1 061	750	12	6,5	24	13
1 414	1 000	16	9	32	18
1 768	1 250	20	11,4	40	22,8
2 263	1 600	25	14,3	50	28,6
2 828	2 000	32	18,3	64	36,6
3 535	2 500	40	22,9	80	45,8
4 525	3 200	50	28,6	100	57,2
5 656	4 000	63	36,0	126	72,0
7 070	5 000	80	45,7	160	91,4
8 909	6 300	100	57,1	200	114,2
11 312	8 000	125	71,4	250	142,8
14 140	10 000	160	91,4	320	182,8

NOTE 1 For MOPP, the values of CREEPAGE DISTANCE and AIR CLEARANCE are based on values in the second edition of IEC 60601-1 [74] and are applied regardless of pollution degree, over-voltage category and material group.

NOTE 2 The CREEPAGE DISTANCE and AIR CLEARANCE in this table are both related to r.m.s. or d.c. WORKING VOLTAGES.

NOTE 3 It is recognised that the values in this table do not take into account waveforms with low r.m.s. and high PEAK WORKING VOLTAGES. For the specific case of switch mode power supply units employing MOPP, use the measured r.m.s. as the WORKING VOLTAGE.

NOTE 4 Barriers providing 2 MOOP according to Tables 13 to Table 15 (inclusive) or according to IEC 60950-1:2005, IEC 60950-1:2005/AMD1:2009 and IEC 60950-1:2005/AMD2:2013 meet the requirements for 1 MOPP according to this table for WORKING VOLTAGES up to and including 707 V d.c. / 500 V r.m.s. At higher WORKING VOLTAGES, 2 MOOP does not necessarily provide 1 MOPP.

Barriers providing REINFORCED INSULATION (2 MOOP) according to IEC 62368-1:2018 meet the requirements for 1 MOPP for WORKING VOLTAGES up to and including 354 V d.c. / 250 V r.m.s. according to this table. At higher WORKING VOLTAGES, REINFORCED INSULATION (2 MOOP) does not necessarily provide 1 MOPP.

Table 13 – Minimum AIR CLEARANCES providing MEANS OF OPERATOR PROTECTION from the MAINS PART

AIR CLEARANCE in mm

WORKING VOLTAGE up to and including		NOMINAL MAINS VOLTAGE ≤ 150 V (MAINS TRANSIENT VOLTAGE 1 500 V)				150 V < NOMINAL MAINS VOLTAGE ≤ 300 V (MAINS TRANSIENT VOLTAGE 2 500 V)		300 V < NOMINAL MAINS VOLTAGE ≤ 600 V (MAINS TRANSIENT VOLTAGE 4 000V)	
Voltage peak or d.c.	Voltage r.m.s (sinusoidal)	Pollution degrees 1 and 2		Pollution degree 3		Pollution degrees 1, 2 and 3		Pollution degrees 1, 2 and 3	
V	V	One MOOP	Two MOOP	One MOOP	Two MOOP	One MOOP	Two MOOP	One MOOP	Two MOOP
210	150	1,0	2,0	1,3	2,6	2,0	4,0	3,2	6,4
420	300	1 MOOP 2,0 2 MOOP 4,0						3,2	6,4
840	600	1 MOOP 3,2 2 MOOP 6,4							
1 400	1 000	1 MOOP 4,2 2 MOOP 6,4							
2 800	2 000	1 or 2 MOOP 8,4							
7 000	5 000	1 or 2 MOOP 17,5							
9 800	7 000	1 or 2 MOOP 25							
14 000	10 000	1 or 2 MOOP 37							
28 000	20 000	1 or 2 MOOP 80							
AIR CLEARANCES for WORKING VOLTAGES above 20 kV r.m.s. or 28 kV d.c. can be prescribed by particular standards if necessary.									
NOTE AIR CLEARANCES are a function of peak voltage in the circuit. The r.m.s. voltage column is provided for the special case where the voltage has a sinusoidal waveform.									

Table 14 – Additional AIR CLEARANCES for insulation in MAINS PARTS with PEAK WORKING VOLTAGES exceeding the peak value of the NOMINAL MAINS VOLTAGE [a]
(see 8.9.1.10)

NOMINAL MAINS VOLTAGE ≤ 150 V r.m.s. or 210 V d.c.		150 V r.m.s. or 210 V dc < NOMINAL MAINS VOLTAGE ≤ 300 V r.m.s. or 420 V d.c.	Additional AIR CLEARANCE mm	
Pollution degrees 1 and 2	Pollution degree 3	Pollution degrees 1, 2 and 3		
PEAK WORKING VOLTAGE V	PEAK WORKING VOLTAGE V	PEAK WORKING VOLTAGE V	One MOOP	Two MOOP
210	210	420	0	0
298	294	493	0,1	0,2
386	379	567	0,2	0,4
474	463	640	0,3	0,6
562	547	713	0,4	0,8
650	632	787	0,5	1,0
738	715	860	0,6	1,2
826	800	933	0,7	1,4
914		1 006	0,8	1,6
1 002		1 080	0,9	1,8
1 090		1 153	1,0	2,0
		1 226	1,1	2,2
		1 300	1,2	2,4

[a] When using this table, select the appropriate column for the RATED MAINS VOLTAGE and pollution degree and choose the row in that column which covers the actual PEAK WORKING VOLTAGE. Read the additional AIR CLEARANCE required from the relevant right hand column (for one or two MEANS OF OPERATOR PROTECTION and add this to the minimum AIR CLEARANCE from Table 13 to give the total minimum AIR CLEARANCE.

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

Table 15 – Minimum AIR CLEARANCES for MEANS OF OPERATOR PROTECTION in SECONDARY CIRCUITS
(see 8.9.1.12)

AIR CLEARANCES in mm

WORKING VOLTAGE up to and including		**Transient value for SECONDARY CIRCUIT ≤ 800 V (NOMINAL MAINS VOLTAGE ≤ 150 V)**				**Transient value for SECONDARY CIRCUIT ≤ 1 500 V (150 V < NOMINAL MAINS VOLTAGE ≤ 300 V)**				**Transient value for SECONDARY CIRCUIT ≤ 2 500 V (300 V < NOMINAL MAINS VOLTAGE ≤600 V)**		**Circuit not subject to transient overvoltages**	
Voltage V peak or V d.c.	**Voltage V r.m.s. (sinu-soidal)**	**Pollution degrees 1 and 2**		**Pollution degree 3**		**Pollution degrees 1 and 2**		**Pollution degree 3**		**Pollution degrees 1, 2 and 3**		**Pollution degrees 1 and 2 only**	
		One MOOP	Two MOOP	One MOOP	Two MOOP	One MOOP	Two MOOP	One MOOP	Two MOOP	One MOOP	Two MOOP	One MOOP	Two MOOP
71	50	0,7	1,4	1,3	2,6	1,0	2,0	1,3	2,6	2,0	4,0	0,4	0,8
140	100	0,7	1,4	1,3	2,6	1,0	2,0	1,3	2,6	2,0	4,0	0,7	1,4
210	150	0,9	1,8	1,3	2,6	1,0	2,0	1,3	2,6	2,0	4,0	0,7	1,4
280	200	One MOOP 1,4; two MOOP 2,8								2,0	4,0	1,1	2,2
420	300	One MOOP 1,9; two MOOP 3,8								2,0	4,0	1,4	2,8
700	500	One MOOP 2,5; two MOOP 5,0											
840	600	One MOOP 3,2; two MOOP 5,0											
1 400	1 000	One MOOP 4,2; two MOOP 5,0											
2 800	2 000	One or two MOOP 8,4, but see 8.9.1.13											
7 000	5 000	One or two MOOP 17,5, but see 8.9.1.13											
9 800	7 000	One or two MOOP 25, but see 8.9.1.13											
14 000	10 000	One or two MOOP 37, but see 8.9.1.13											
28 000	20 000	One or two MOOP 80, but see 8.9.1.13											
42 000	30 000	One or two MOOP 130, but see 8.9.1.13											

NOTE AIR CLEARNACES are a function of peak voltage in the circuit. The r.m.s voltage column is provided for the special case where the voltage has a sinusoidal waveform.

Table 16 – Minimum CREEPAGE DISTANCES providing MEANS OF OPERATOR PROTECTION [a]

CREEPAGE DISTANCE in mm

WORKING VOLTAGE V r.m.s or d.c.	Spacing for one MEANS OF OPERATOR PROTECTION						
	Pollution degree 1	Pollution degree 2			Pollution degree 3		
	Material group	Material group			Material group		
	I, II, IIIa, IIIb	I	II	IIIa or IIIb	I	II	IIIa or IIIb
25	Use the AIR CLEARANCE from the appropriate table	0,5	0.5	0,5	1,3	1,3	1,3
50		0,6	0,9	1,2	1,5	1,7	1,9
100		0,7	1,0	1,4	1,8	2,0	2,2
125		0,8	1,1	1,5	1,9	2,1	2,4
150		0,8	1,1	1,6	2,0	2,2	2,5
200		1,0	1,4	2,0	2,5	2,8	3,2
250		1,3	1,8	2,5	3,2	3,6	4,0
300		1,6	2,2	3,2	4,0	4,5	5,0
400		2,0	2,8	4,0	5,0	5,6	6,3
600		3,2	4,5	6,3	8,0	9,6	10,0
800		4.0	5,6	8,0	10,0	11,0	12,5
1 000		5,0	7,1	10,0	12,5	14,0	16,0

NOTE 1 Minimum CREEPAGE DISTANCES for two MEANS OF OPERATOR PROTECTION are obtained by doubling the values in this table.

NOTE 2 A CREEPAGE DISTANCE cannot be less than the required air clearance. See 8.9.1.4.

NOTE 3 For WORKING VOLTAGE values greater than 1 000 V, refer to Table A.2.

[a] CREEPAGE DISTANCES within this table apply to all situations.

8.9.1.16 Conductive surface coatings

When conductive coatings are applied to non-metallic surfaces, it shall be established that flaking or peeling does not result in the reduction of any AIR CLEARANCE or CREEPAGE DISTANCE.

Compliance is checked by examination of the construction and of the available data. If such data is not available, compliance is checked by application of an appropriate coating test standard.

NOTE Example of coating test standards include ISO 2409 [78], ISO 4624 [79] and UL 746C [82].

8.9.2 * Application

a) * For insulation in the MAINS PART between parts of opposite polarity, the minimum CREEPAGE DISTANCES and AIR CLEARANCES are not required if short circuiting of each single one of these CREEPAGE DISTANCES and AIR CLEARANCES in turn does not result in a HAZARDOUS SITUATION described in 13.1.

b) The contribution to the CREEPAGE DISTANCES of any groove or air gap less than the minimum spacing (X) shall be limited to its width (see Figure 23 to Figure 31 [inclusive]).

c) If AIR CLEARANCE provides a MEANS OF PROTECTION, the relative positioning shall be such that the relevant parts are rigid and located by moulding or the design shall be otherwise such that there is no reduction of a distance below the specified value by deformation or movement of the parts.

Where limited movement of one of the relevant parts is normal or likely, this shall be taken into account when computing the minimum AIR CLEARANCE.

8.9.3 * Spaces filled by insulating compound

8.9.3.1 General

Where distances between conductive parts are filled with insulating compound, including where insulation is reliably cemented together with insulating compound, so that AIR CLEARANCES and CREEPAGE DISTANCES do not exist, only the requirements for solid insulation apply.

NOTE Examples of such treatment include potting, encapsulation and vacuum impregnation, components or subassemblies that are treated with an insulating compound that fills voids; and internal insulation between adjacent tracks on one layer of a multi-layer printed board.

Compliance is checked by inspection, measurement and test of samples. Requirements for CREEPAGE DISTANCES and AIR CLEARANCES do not apply if samples pass the thermal cycling, humidity preconditioning and dielectric strength tests specified in either 8.9.3.2 and 8.9.3.4 or 8.9.3.3 and 8.9.3.4.

8.9.3.2 Insulating compound forming solid insulation between conductive parts

For situations where insulating compound forms solid insulation between conductive parts, a single finished sample is tested. The sample is subjected to the thermal cycling PROCEDURE as specified in 8.9.3.4, followed by humidity preconditioning according to 5.7 except for 48 hours only, followed by a dielectric strength test according to 8.8.3 except that the test voltage is multiplied by 1,6. The tests are followed by inspection, including sectioning, and measurement. Cracks or voids in the insulating compound such as would affect the homogeneity of the material constitute a failure.

8.9.3.3 Insulating compound forming a cemented joint with other insulating parts

For situations where insulating compound forms a cemented joint with other insulating parts, the reliability of the joint is checked by testing three samples. If a winding of solvent-based enamelled wire is used, it is replaced for the test by a metal foil or by a few turns of bare wire, placed close to the cemented joint. The three samples are then tested as follows.

– *One of the samples is subjected to the thermal cycling PROCEDURE as specified in 8.9.3.4. Immediately after the last period at highest temperature during thermal cycling it is subjected to a dielectric strength test according to 8.8.3 except that the test voltage is multiplied by 1,6*;

– *The other two samples are subjected to humidity preconditioning according to 5.7 except for 48 hours only, followed by a dielectric strength test according to 8.8.3 except that the test voltage is multiplied by 1,6.*

8.9.3.4 Thermal cycling

The sample is subjected 10 times to the following sequence of temperature cycles:

68 h	*at*	T_1	*± 2 °C;*
1 h	*at*	*25 °C*	*± 2 °C;*
2 h	*at*	*0 °C*	*± 2 °C;*
not less than 1 h	*at*	*25 °C*	*± 2 °C,*

where T_1 *is the higher of*

– *10 °C above the maximum temperature of the relevant part as determined according to 11.1.1; or*

– *85 °C.*

However, the 10 °C margin is not added if the temperature is measured by an embedded thermocouple.

The period of time taken for the transition from one temperature to another is not specified, but the transition is permitted to be gradual.

8.9.4 * Measurement of CREEPAGE DISTANCES AND AIR CLEARANCES

Compliance is checked by measurement taking into account the rules in Figure 22 to Figure 31 (inclusive). In each figure, the dashed line (— — —) represents AIR CLEARANCE *and the shaded bar ( )represents* CREEPAGE DISTANCE.

The minimum spacing (X) for grooves transverse to the CREEPAGE DISTANCE in Figure 23 to Figure 25 and Figure 27 to Figure 31 (inclusive) that are considered a MEANS OF OPERATOR PROTECTION may be adjusted based on pollution degree if the minimum AIR CLEARANCE is 3 mm or more. The minimum width of the groove is:

– *0,25 mm for pollution degree 1*
– *1,0 mm for pollution degree 2*
– *1,5 mm for pollution degree 3*

If the specified minimum AIR CLEARANCE is less than 3 mm, the minimum spacing (X) for grooves transverse to the CREEPAGE DISTANCE is the lesser of:

– *the relevant value specified in the previous paragraph, or*
– *one third of the specified minimum AIR CLEARANCE.*

The minimum spacing (X) for a groove transverse to a CREEPAGE DISTANCE that is considered a MEANS OF PATIENT PROTECTION is 1 mm for pollution degree 1 and pollution degree 2, and 1,5 mm for pollution degree 3.

Any corner with included angle less than 80° is assumed to be bridged with an insulating link of X mm moved into the least favourable position (see Figure 25).

Where the distance across the top of a groove is X mm or more, no CREEPAGE DISTANCE exists across the air space (see Figure 24).

CREEPAGE DISTANCES and AIR CLEARANCES between parts moving relative to each other are measured with the parts in their least favourable positions.

Computed CREEPAGE DISTANCE is never less than measured AIR CLEARANCE.

Coatings of varnish, enamel or oxide are ignored. Coverings of any insulating material, however, are considered as insulation, if the covering is equivalent to a sheet of insulating material of equal thickness with respect to its electrical, thermal and mechanical properties.

If CREEPAGE DISTANCES or AIR CLEARANCES for one or two MEANS OF PROTECTION are interrupted by one or more floating conductive parts, the minimum values specified in Table 12 to Table 16 (inclusive) apply to the sum of the sections, except that distances less than X mm are not taken into consideration.

If there are grooves transverse to the CREEPAGE DISTANCE, the wall of the groove is counted as CREEPAGE DISTANCE only if the width of the groove is more than X mm (see Figure 24). In all other cases the groove is neglected.

In the case of a barrier placed on the surface of insulation or held in a recess, the CREEPAGE DISTANCES are measured over the barrier only if the latter is so affixed that dust and moisture cannot penetrate into the joint or recess.

For ME EQUIPMENT provided with an APPLIANCE INLET, the measurements are made with an appropriate connector inserted. For other ME EQUIPMENT incorporating POWER SUPPLY CORDS, *they are made with supply conductors of the largest cross-sectional area specified by the MANUFACTURER and also without conductors.*

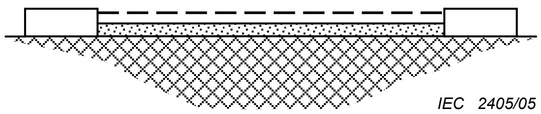
Movable parts are placed in the least favourable position; nuts and screws with non-circular heads are tightened in the least favourable position.

CREEPAGE DISTANCES and AIR CLEARANCES through slots or openings in external parts are measured to the standard test finger of Figure 6. If necessary, a force is applied to any point on bare conductors and to the outside of metal ENCLOSURES in an endeavour to reduce the CREEPAGE DISTANCES and AIR CLEARANCES while taking the measurements.

The force is applied by means of a standard test finger having a tip as shown in Figure 6 and has a value of:

2 N for bare conductors;
30 N for ENCLOSURES.

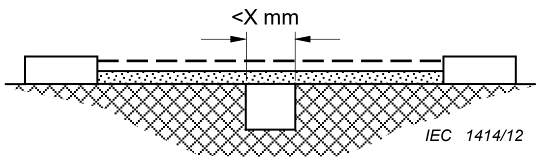
CREEPAGE DISTANCE and AIR CLEARANCES are measured after use of the test hook according to 5.9.2.2, if relevant.



Condition: Path under consideration is a flat surface.

Rule: CREEPAGE DISTANCE and AIR CLEARANCE are measured directly across the surface.

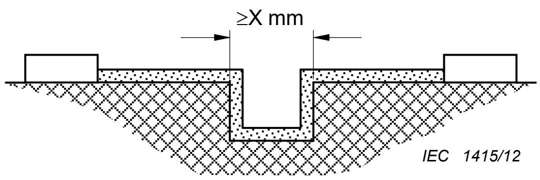
Figure 22 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 1



Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than X mm.

Rule: CREEPAGE DISTANCE and AIR CLEARANCE are measured directly across the groove as shown.

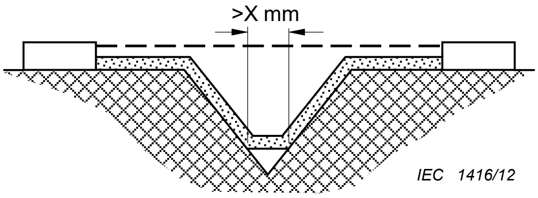
Figure 23 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 2



Condition: Path under consideration includes a parallel-sided groove of any depth and equal to or more than X mm.

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

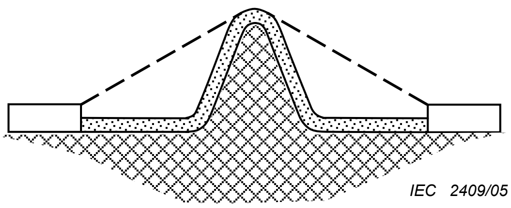
Figure 24 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 3



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

Rule: AIR CLEARANCE is the “line of sight” distance. CREEPAGE DISTANCE path follows the contour of the groove but “short circuits” the bottom of the groove by a X mm link.

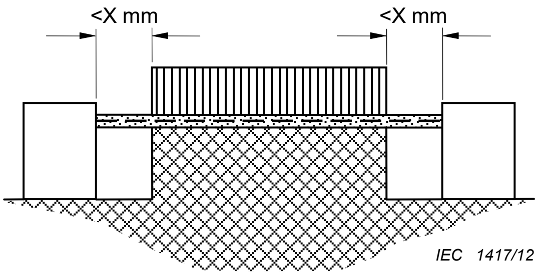
Figure 25 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 4



Condition: Path under consideration includes a rib.

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

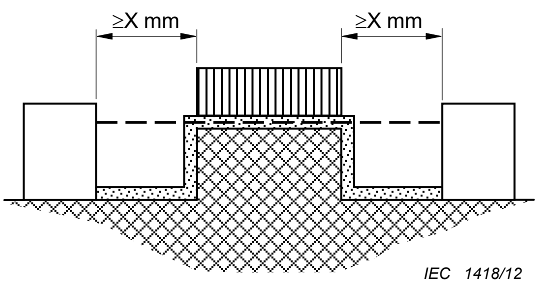
Figure 26 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 5



Condition: Path under consideration includes an uncemented joint (see 8.9.3) with grooves less than X mm wide on each side.

Rule: CREEPAGE DISTANCE and AIR CLEARANCE path are the “line of sight” distance shown.

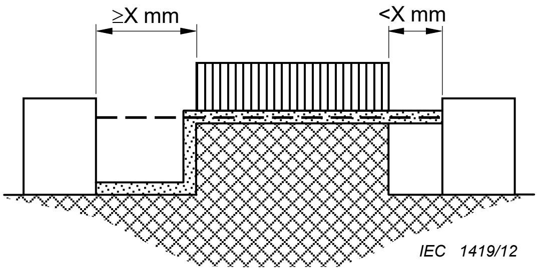
Figure 27 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 6



Condition: Path under consideration includes an uncemented joint (see 8.9.3) with grooves equal to or more that X mm wide on each side.

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

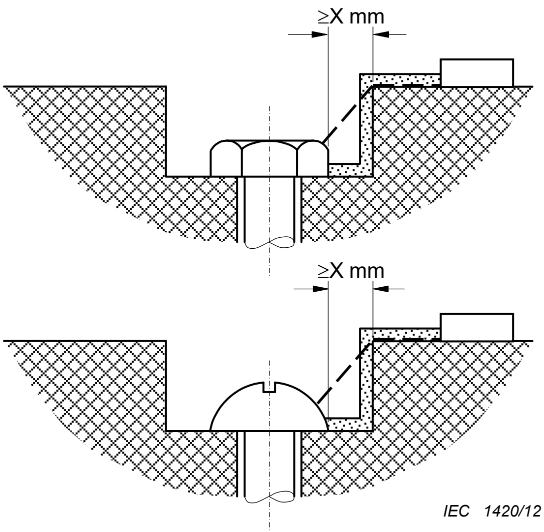
Figure 28 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 7



Condition: Path under consideration includes an uncemented joint (see 8.9.3) with a groove on one side less than X mm wide and the groove on the other side equal to or more than X mm wide.

Rule: AIR CLEARANCE and CREEPAGE DISTANCE are as shown.

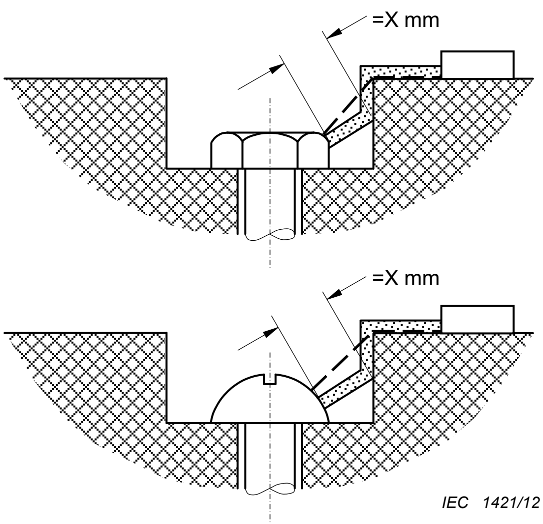
Figure 29 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 8



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

Rule: The AIR CLEARNACE is the shortest distance to any point on the head of the screw. CREEPAGE DISTANCE path follows the surface.

Figure 30 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 9



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

Rule: Measurement of CREEPAGE DISTANCE is from screw to wall at any point where the distance is equal to X mm. The AIR CLEARANCE is the shortest distance to any point on the head of the screw.

Figure 31 – CREEPAGE DISTANCE and AIR CLEARANCE – Example 10