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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Live working – Minimum approach distances – Part 2: Method of determination of the electrical component distance for AC systems from 1,0 kV to 72,5 kV

Travaux sous tension – Distances minimales d'approche – Partie 2: Méthode de détermination de la distance du composant électrique pour les réseaux en courant alternatif de tension comprise entre 1,0 kV et 72,5 kV

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LIVE WORKING – MINIMUM APPROACH DISTANCES –

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International Standard IEC 61472-2 has been prepared by IEC technical committee technical committee 78: Live working.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
78/1319/FDIS	78/1326/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61472 series, published under the general title *Live working – Miminum approach distances*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

LIVE WORKING – MINIMUM APPROACH DISTANCES –

Part 2: Method of determination of the electrical component distance for AC systems from 1,0 kV to 72,5 kV

1 Scope

This part of IEC 61472 specifies a method for determining the electrical component of the minimum approach distances for live working, for AC systems 1 kV up to and including 72,5 kV. This document addresses system overvoltages and the working air distances between equipment and/or workers at different potentials.

The withstand voltage and minimum approach distances determined by the method described in this document can be used only if the following working conditions prevail:

– workers are trained for, and skilled in, working live lines or close to live conductors or equipment;
– the operating conditions are adjusted so that the statistical overvoltage does not exceed the value selected for the determination of the required withstand voltage;
– transient overvoltages are the determining overvoltages;
– tool insulation has no continuous film of moisture present on the surface;
– no lightning is observed within 10 km of the work site;
– allowance is made for the effect of the conducting components of tools.

NOTE In some countries, special procedures have been developed to permit live working with surface moisture on tools at distribution voltages (below 50 kV).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
highest voltage of a system
U_s
highest value of operating voltage (phase-to-phase voltage) which occurs under normal operating conditions at any time and any point in the system

Note 1 to entry: Transient overvoltages and permanent induction from adjacent lines are not taken into account in the calculation formula

[SOURCE: IEC 60050-601:1985, 601-01-23, modified – the symbol U_s and the words "(phase-to-phase voltage)" have been added, and Note 1 has been revised.]

3.2
transient overvoltage
short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60050-614:2016, 614-03-14]

3.3
nominal system voltage
suitable approximate value of voltage used to designate or identify a system

[SOURCE: IEC 60038:2009, 3.1]

3.4
per unit statistical overvoltage phase-to-earth
u_{e2}
phase-to-earth per unit overvoltage that has a 2 % probability of being exceeded

3.5
per unit statistical overvoltage phase-to-phase
u_{p2}
per unit overvoltage that has a 2 % probability of being exceeded

3.6
statistical overvoltage
U_2
overvoltage that has a 2 % probability of being exceeded

3.7
minimum approach distance
D_A
minimum electrical and ergonomic distance in air to be maintained between any part of the body of a worker, or any conductive tool being directly handled, and any live conductors or equipment at different potentials

3.8
electrical distance
D_U
electrical component of the minimum air distance between two electrodes which represent live and/or earthed conductors or equipment, required to prevent sparkover under the most severe electrical stress that will arise under the chosen conditions

3.9
ergonomic distance
D_E
distance in air added to the electrical distance, to take into account inadvertent movement and errors in judgement of distances while performing work

[SOURCE: IEC 60050-651:2014, 651-21-13, modified – the symbol D_E has been added.]

4 Minimum approach distance, D_A

The minimum approach distance, D_A, is determined by:

$$D_A = D_U + D_E \quad (1)$$

where

D_U is the required minimum electrical distance, and

D_E is the required ergonomic distance which is dependent on work procedures, level of training, skill of the workers, type of construction, and such contingencies as inadvertent movement and errors in appraising distances (see Annex B for details).

5 Factors influencing the minimum approach distance

5.1 Control of system overvoltages

The maximum amplitude of overvoltages in the work area can be reduced by the usual practice of making the circuit-breaker reclosing devices inoperative, or by using protective gaps or surge arresters.

5.2 Statistical overvoltage

The electrical stress at the work area shall be known. The electrical stress is described as the statistical overvoltage that can be present at the work area. In a three-phase AC power system the statistical overvoltage U_{e2} between phase and earth is:

$$U_{e2} = \left(\sqrt{2} / \sqrt{3}\right) U_s \, u_{e2} \quad (2)$$

where

U_s is the highest voltage of the system, and

u_{e2} is the statistical overvoltage phase-to-earth expressed in per unit.

Similarly:

$$U_{p2} = \left(\sqrt{2} / \sqrt{3}\right) U_s \, u_{p2} \quad (3)$$

where

u_{p2} is the statistical overvoltage phase-to-phase expressed in per unit.

If the per unit phase-to-phase data are not available, an approximate value can be derived from u_{e2} by the following formula:

$$u_{p2} = 1{,}35 \, u_{e2} + 0{,}45 \quad (4)$$

The transient overvoltages to be considered are those caused by system faults and switching operations, whether they occur on the lines being worked, or on adjacent lines or associated equipment.

The values of statistical overvoltages shall be those measured or determined by a transient network analyzer (TNA) or by digital computer studies. If such studies do not provide the statistical overvoltages (2 % values) but only the "truncated values", without the statistical distribution, the transformation of the truncated values into 2 % values can be made.

Application and typical values of statistical overvoltages are shown in Annex A, for use when no other values are available.

5.3 Conductive floating object

The conductive floating object(s) is(are) accounted for by the distance F which is the sum of all dimensions, in the direction of the gap axis of the conductive floating object(s) in the air gap. This distance is considered in the determination of the minimum approach distance, D_A:

$$D_A = D_U + D_E + F \quad (5)$$

5.4 Insulators

The influence of metallic caps and pins of suspension insulators is negligible and shall be ignored.

5.5 Determination of minimum electrical distance, D_U

The minimum electrical distance is determined from the impulse rod-to-rod withstand voltage of IEEE 516-2009, Table 1, and presented in Table 2 and Table 3. For systems using other per unit overvoltage factors the minimum electrical distance may be derived from Table 1 using linear interpolation.

6 Example calculation

Determine the minimum phase-to-earth electrical distance, D_U, for a 20 kV system. The highest system voltage for this example is chosen to be 1,05 times the nominal system voltage (see Clause A.3):

$$U_s = 21 \text{ kV}$$

Applying the per unit statistical overvoltage factor, u_{e2} = 3,5 to the highest system peak phase-to-earth voltage using Formula (2), the statistical overvoltage becomes

$$U_{e2} = 60 \text{ kV}$$

Interpolating from the data of Table 1:

66,3 kV − 58,6 kV = 7,7 kV

and correspondingly

6 cm − 5 cm = 1 cm or 10 mm.

Therefore the distance for 60 kV is found by:

10 mm / 7,7 kV = 1,3 mm/kV

66,3 kV – 60 kV = 6,3 kV

6,3 kV × 1,3 mm/kV = 8 mm

60 mm – 8 mm = 52 mm or 5,2 cm.

Table 1 – Distance for rod-to-rod gap from IEEE 516-2009

Impulse (TOV) rod-to-rod withstand (kV peak)	60 Hz rod-to-rod sparkover (kV peak)	Gap spacing from IEEE Std 4:1995 (cm)
27,6	25	2
39,8	36	3
50,8	46	4
58,6	53	5
66,3	60	6
77,4	70	8
87,3	79	10
95	86	12
105	95	14
115	104	16
123,8	112	18
132,6	120	20
158	143	25
184,5	167	30
212,2	192	35
240,9	218	40
268,5	243	45
298,4	270	50
355,8	322	60

Table 2 – Phase-to-earth electrical distance for system voltages from 1,0 kV up to and including 72,5 kV, u_{e2} = 3,5 a)

Highest system voltage U_s kV (RMS)	Statistical overvoltage U_{e2} kV (peak)	Electrical distance b) D_U mm
> 1,0	2,9	20 c)
12,5	36	27
17,5	50	40
24,0	69	64
26,4	75	76
36,0	103	136
40,5	116	162
52,0	149	232
72,5	207	341

a) Refer to A.4.2.

b) IEEE 516-2009, Table 2, impulse (TOV) rod-rod withstand (kV peak).

c) This distance is beyond the range of data from IEEE 516-2009, Table 2, and is considered acceptable for application.

Table 3 – Phase-to-phase electrical distances for system voltages from 1,0 kV up to and including 72,5 kV, u_{p2} = 5,2 [a)]

Highest system voltage U_s kV (RMS)	Statistical overvoltage U_{p2} kV (peak)	Electrical distance [b)] D_U mm
> 1,0	4,2	20 [c)]
12,5	53	43
17,5	74	74
24,0	101	133
26,4	112	153
36,0	152	238
40,5	171	275
52,0	220	363
72,5	306	514

a) u_{p2} = 1,35 u_{e2} + 0,45. Refer to A.4.2.

b) IEEE 516-2009, Table 2, impulse (TOV) rod-rod withstand (kV peak).

c) This distance is beyond the range of data from IEEE 516-2009, Table 2, and is considered acceptable for application.

Other distances may be used according to particular system requirements.