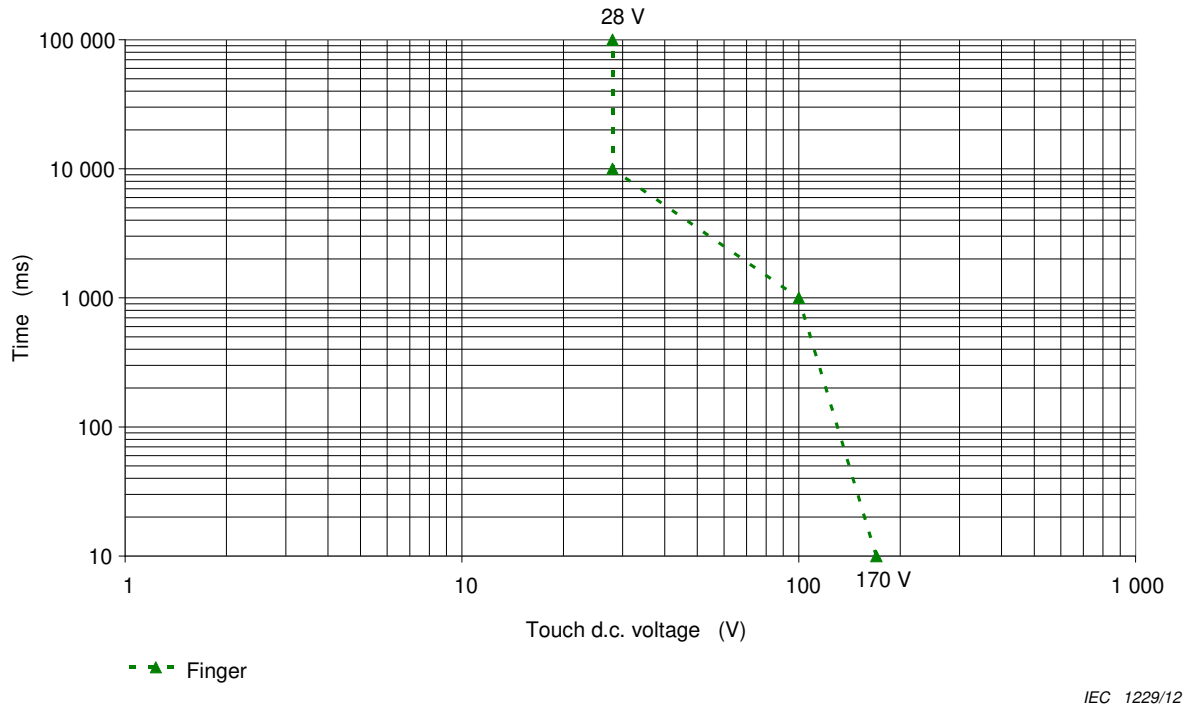


Figure A.10 – Touch time- d.c. voltage zones of dry skin condition

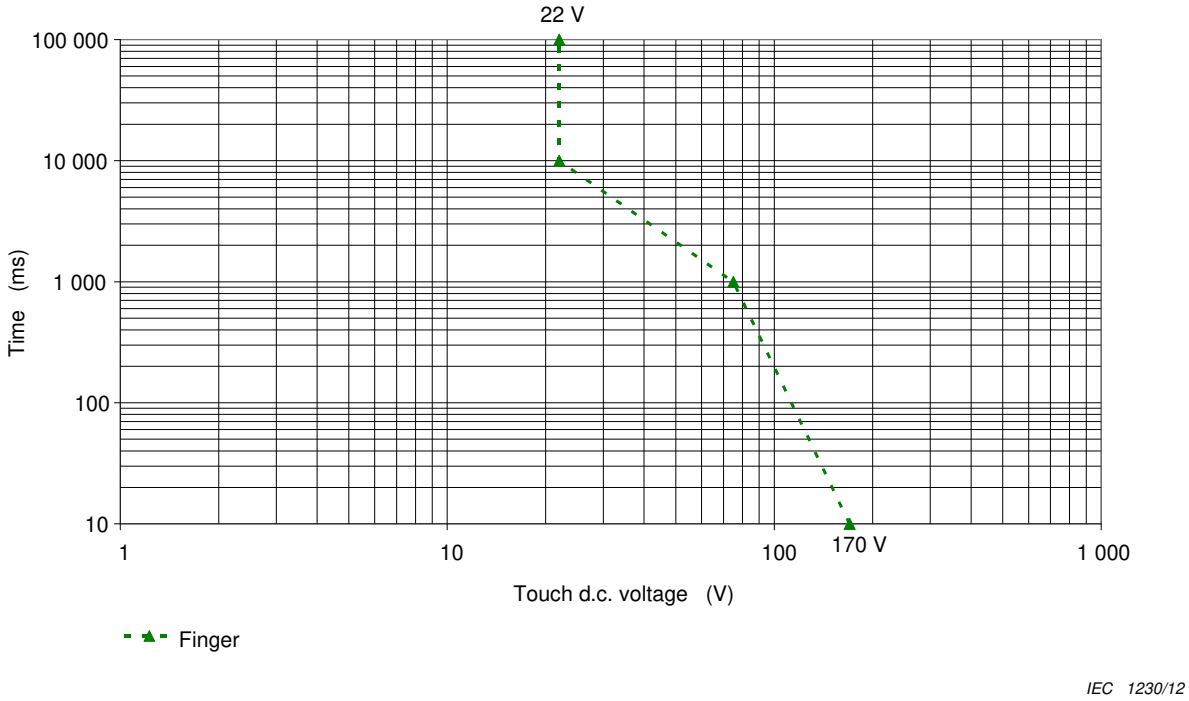


Figure A.11 – Touch time- d.c. voltage zones of water-wet skin condition

A.5.9 Touch time-a.c. voltage zones of *ventricular fibrillation*

Figures A.12, A.13 and A.14 provide information about the short term non-recurring a.c. touch voltage limits for protection against ventricular fibrilation.

The figures provide information for acceptable level for part of the body, hand and finger tip under dry, water-wet and salt water wet conditions.

For some combinations no information for time-voltage zone is given and *basic protection* against accessibility is required.

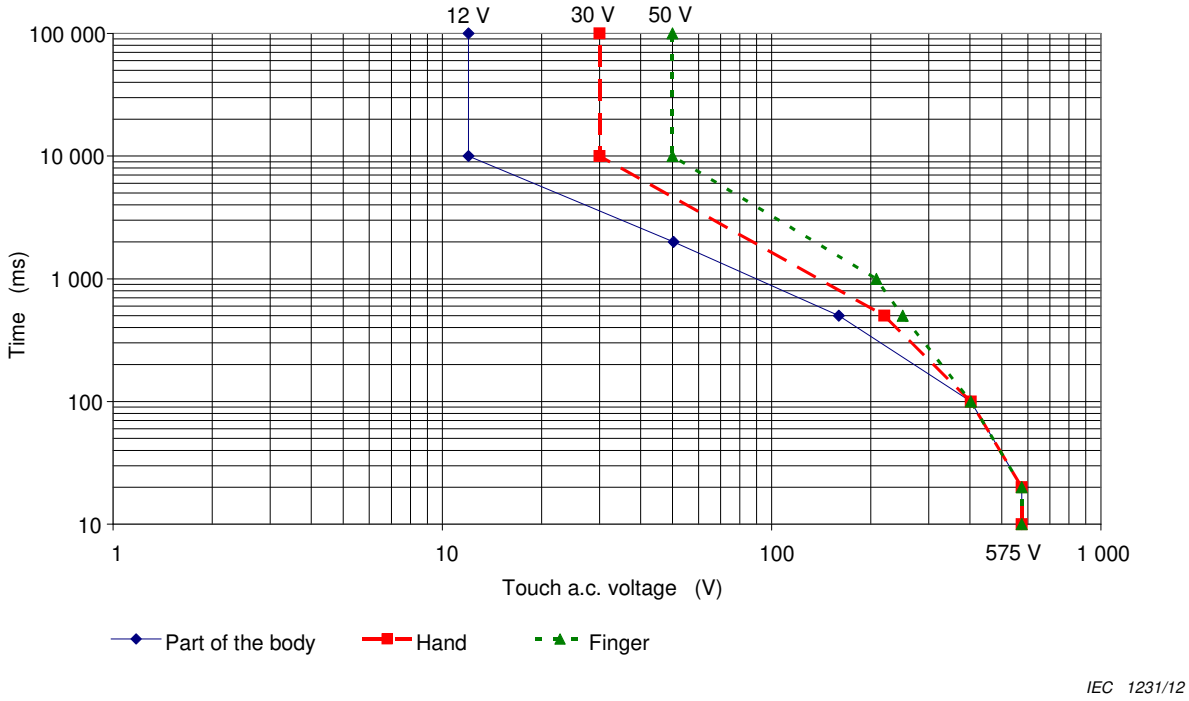


Figure A.12 – Touch time- a.c. voltage zones for dry skin condition

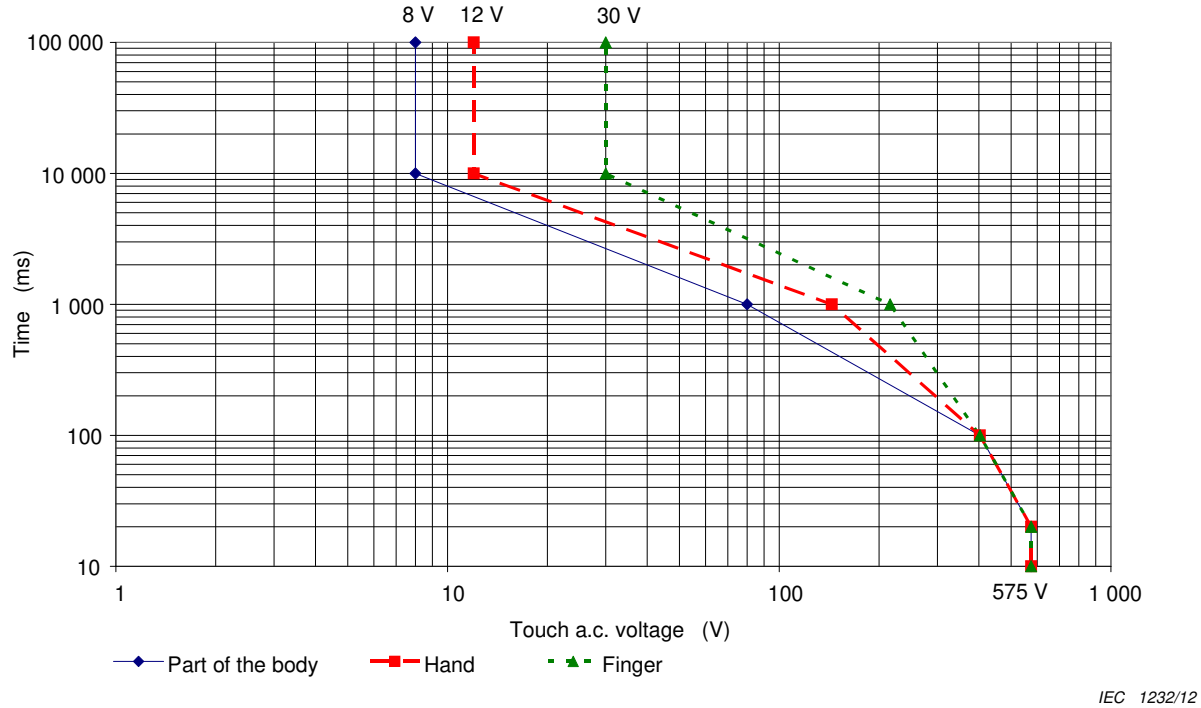


Figure A.13 – Touch time- a.c. voltage zones of water-wet skin condition

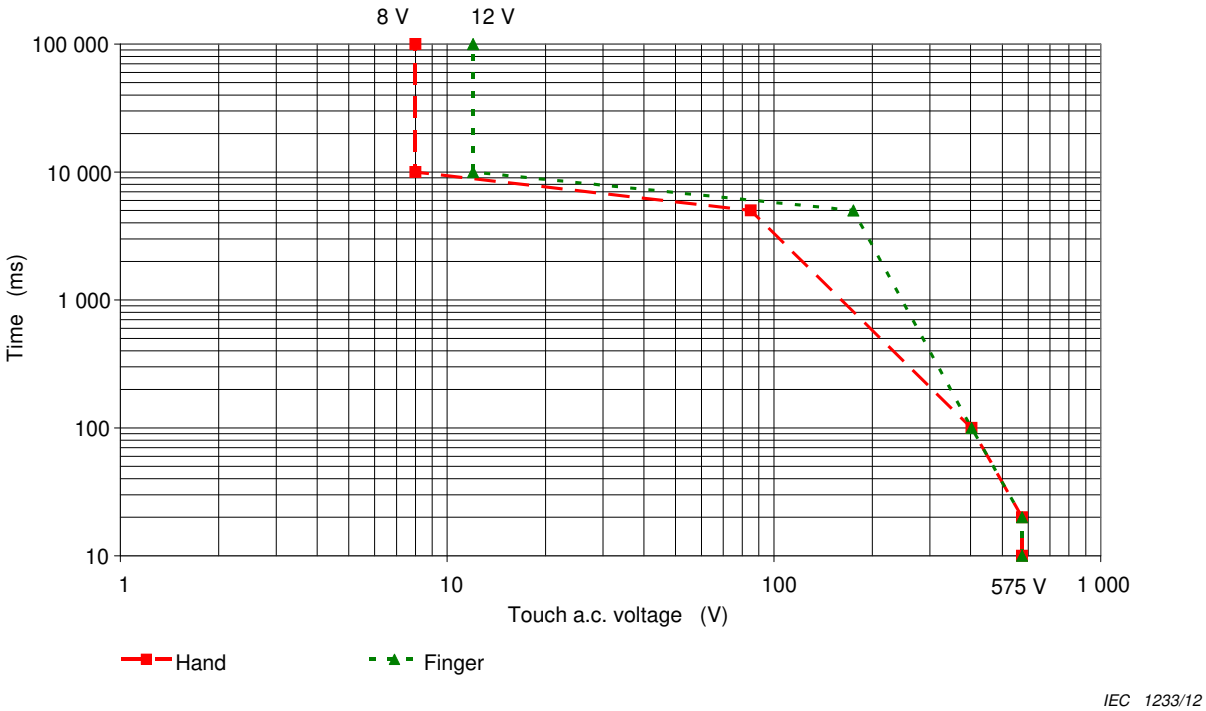


Figure A.14 – Touch time- a.c. voltage of saltwater-wet skin condition

A.5.10 Touch time- a.c. voltage zones of *muscular reaction (inability to let go reaction)*

Figures A.15, A.16 and A.17 provide information about the short term non-recurring a.c. touch voltage limits for protection against *muscular reaction*.

The figures provide information for acceptable level for part of the body, hand and finger tip under dry, water-wet and salt water wet conditions.

For some combinations no information for time-voltage zone is given and *basic protection* against accessibility is required.

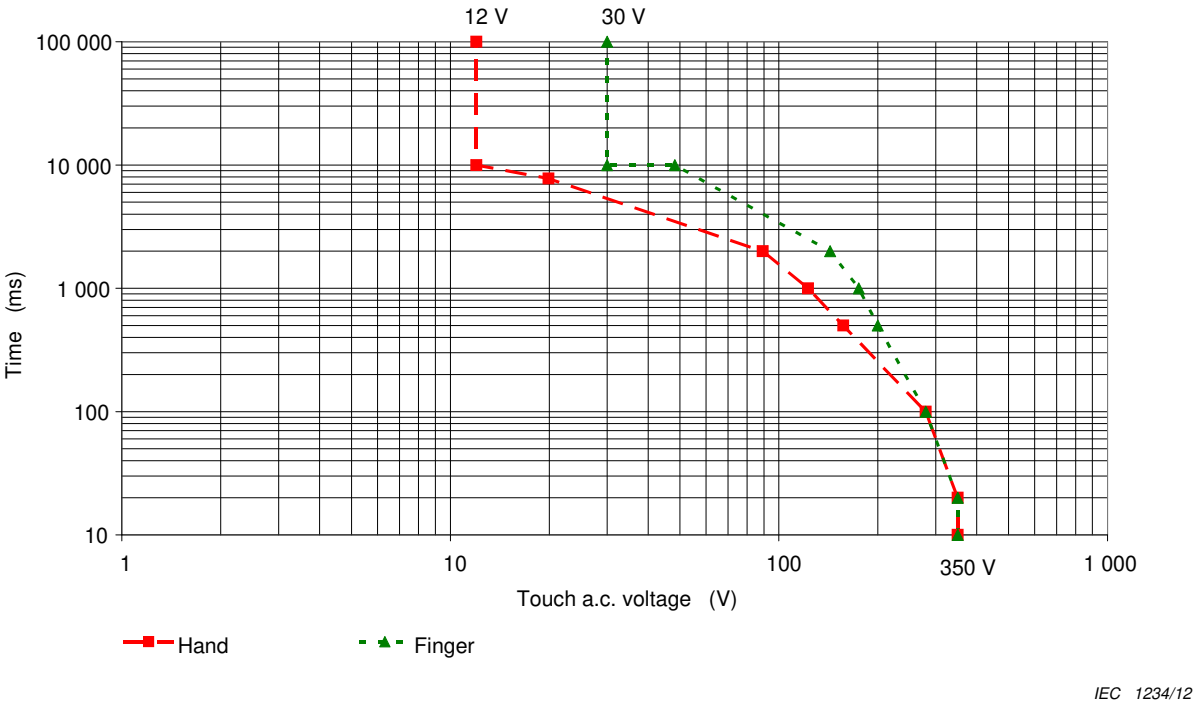


Figure A.15 – Touch time- a.c. voltage zones of dry skin condition

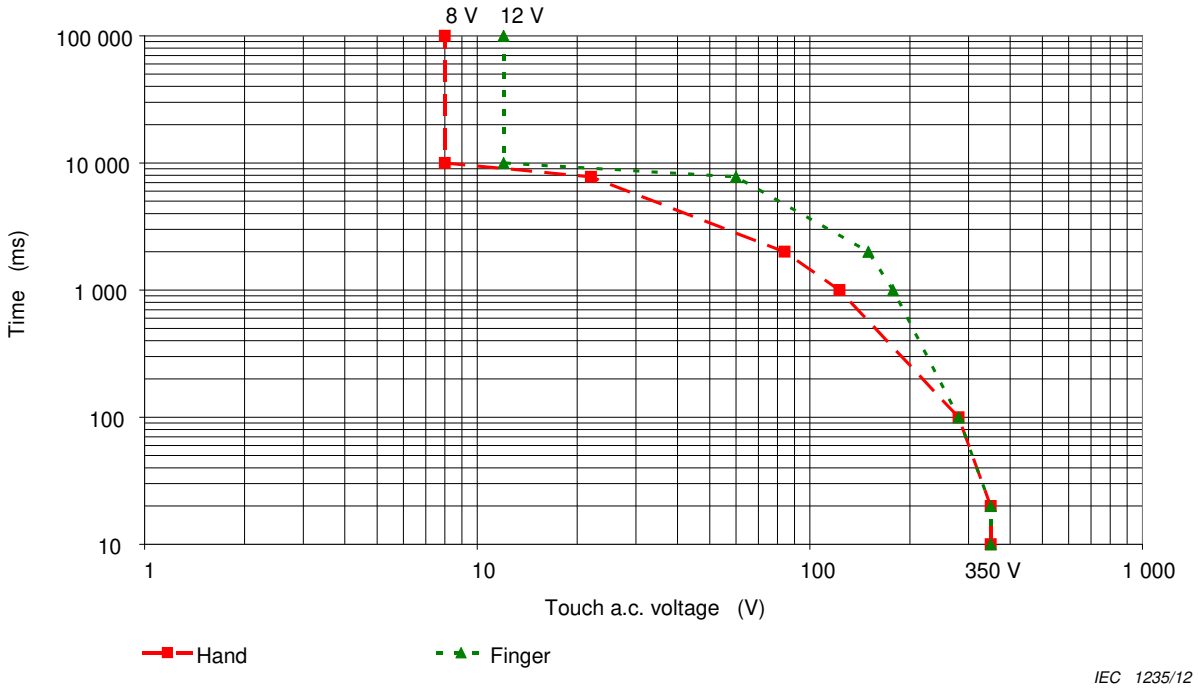


Figure A.16 – Touch time- a.c. voltage zones of water-wet skin condition

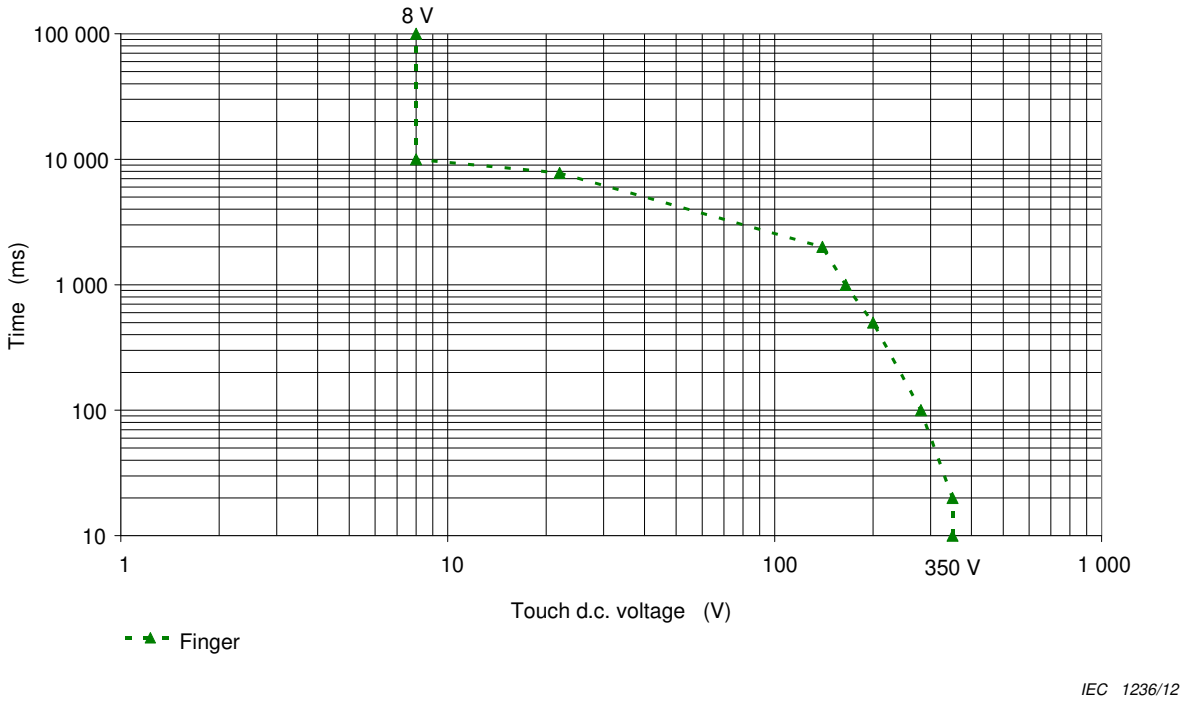


Figure A.17 – Touch time- a.c. voltage zones of saltwater-wet skin condition

A.5.11 Touch time- a.c.voltage zones for *startle reaction*

Figures A.18 and A.19 provide information about the short term non-recurring a.c. touch voltage limits for protection against *startle reaction*.

The figures provide information for acceptable level for part of the body, hand and finger tip under dry, water-wet and salt water wet conditions.

For some combinations no information for time-voltage zone is given and *basic protection* against accessibility is required.

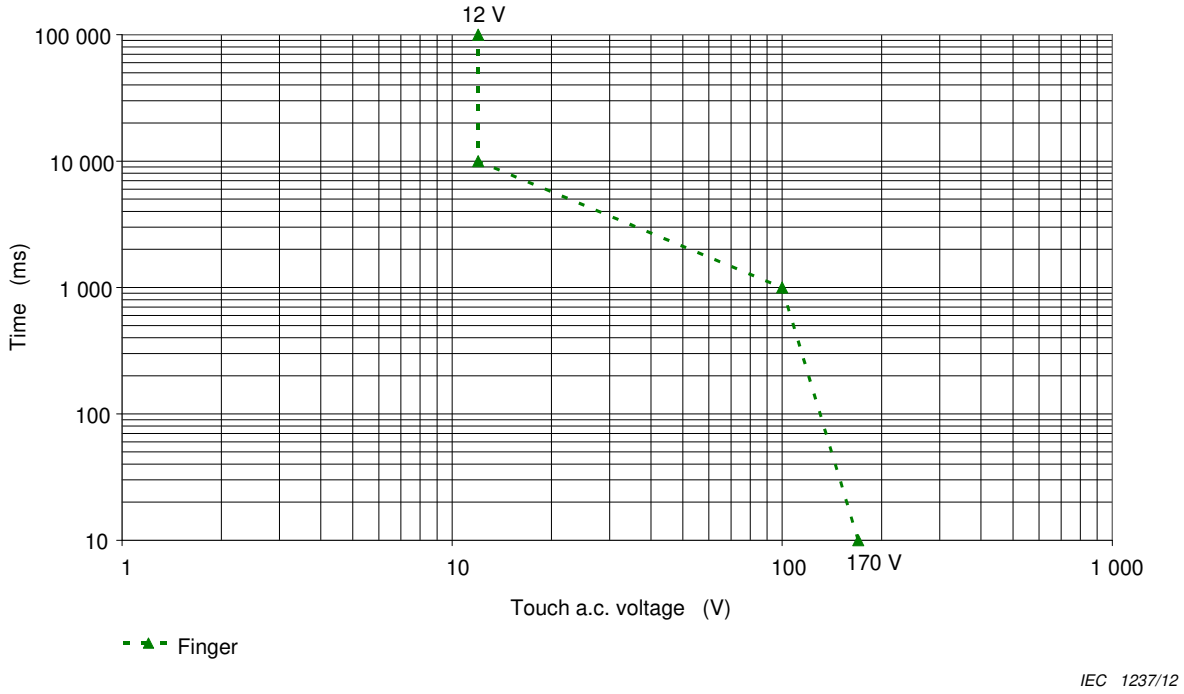


Figure A.18 – Touch time- a.c. voltage zones of dry skin condition

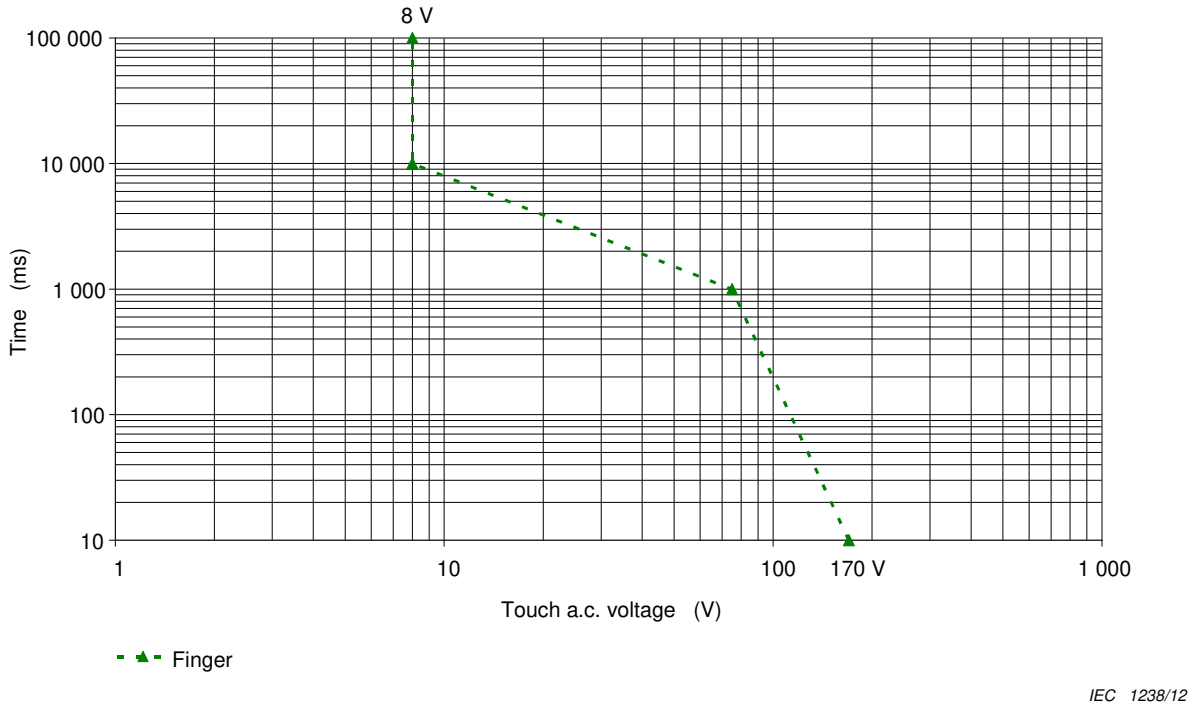


Figure A.19 – Touch time- a.c. voltage zones of water-wet skin condition

A.6 Evaluation of the *working voltage* of circuits

A.6.1 General

Determination of the *working voltage* for

- a.c. r.m.s. (U_{AC});
- a.c. recurring peak (U_{ACP}); and
- d.c. (average)

is done with the method set out below. Three cases of waveforms are considered as an example.

Figures A.20 to A.22 show typical waveforms for the evaluation of *working voltage*.

A.6.2 AC working voltage

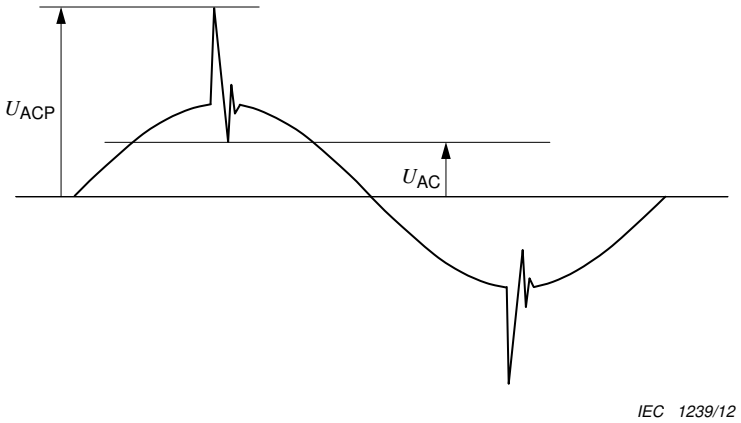


Figure A.20 – Typical waveform for a.c. *working voltage*

The *working voltage* has an r.m.s. value U_{AC} and a recurring peak value U_{ACP}.

The *DVC* is that of the lowest voltage row of Table 5 for which both of the following conditions are satisfied:

- $U_{AC} \leq U_{ACL}$
- $U_{ACP} \leq U_{ACPL}$

Example with values:

U_{AC} = 39 V --> is lower than U_{ACL} = 50 V --> *DVC B*
U_{ACP} = 91 V --> is higher than U_{ACPL} = 71 V --> *DVC C*

The rule for determination of *DVC* of the voltage is to select the highest *DVC*.

Result: --> this *working voltage* becomes *DVC C.*

A.6.3 DC *working voltage*

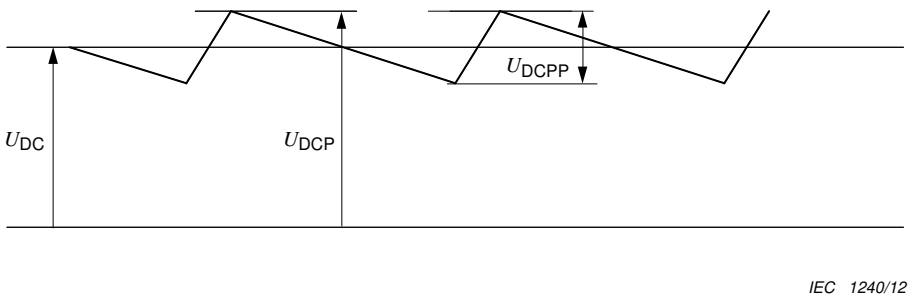


Figure A.21 – Typical waveform for d.c. *working voltage*

The *working voltage* has a mean value U_{DC} and a recurring peak value U_{DCP}, caused by a ripple voltage of r.m.s. value not greater than 10 % of U_{DC}.

The *DVC* is that of the lowest voltage row of Table 5 for which both of the following conditions are satisfied:

- $U_{DC} \leq U_{DCL}$

- $U_{DCP} \leq 1{,}17 \times U_{DCL}$

A.6.4 Pulsating *working voltage*

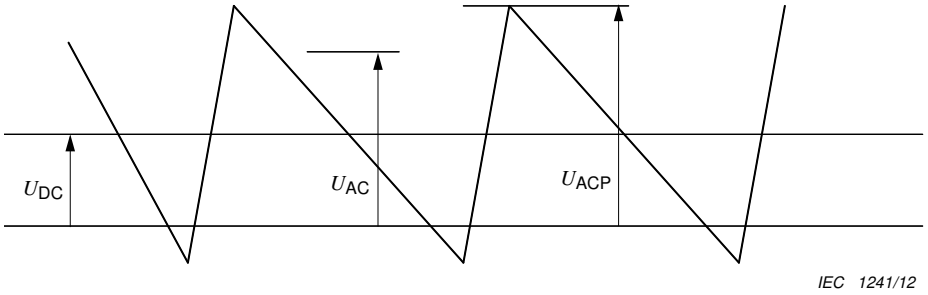


Figure A.22 – Typical waveform for pulsating *working voltage*

The *working voltage* has a mean value U_{DC} and a recurring peak value U_{ACP}, caused by a ripple voltage of r.m.s. value U_{AC} greater than 10 % of U_{DC}.

The *DVC* is that of the lowest voltage row of Table 5 for which both of the following conditions are satisfied:

$$\frac{U_{AC}}{U_{ACL}} + \frac{U_{DC}}{U_{DCL}} \leq 1$$

$$\frac{U_{ACP}}{U_{ACPL}} + \frac{U_{DC}}{1{,}17 \times U_{DCL}} \leq 1$$

A.7 Examples of the use of elements of protective measures

Protection against electric shock shall be achieved by means of:

- combination of *basic protection* according to 4.4.3 and *fault protection* according to 4.4.4; or
- *Enhanced protection* according to 4.4.5.

Table A.4 provides examples of typical combinations of those measures.

The grade of *insulation* depends on:

- the *DVC* of the *live parts* according *to* Table 5;
- the *insulation* requirement between *adjacent circuits* according to Table 6;
- the connection of accessible conductive parts to earth by *protective equipotential bonding* according to Table 6; and
- non conductive accessible parts.

As an alternative to solid *insulation*, a clearance according to 4.4.7.4, shown by L_1 and L_2 in Table A.4 may be provided.

In Table A.4, three cases are considered:

Case a):

Accessible parts are conductive and are connected to earth by *protective equipotential bonding*.

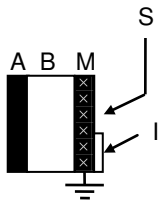
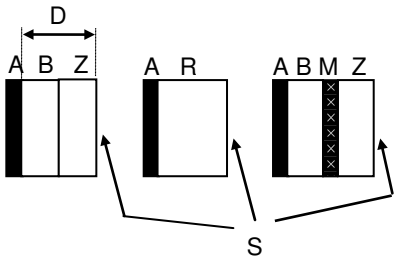
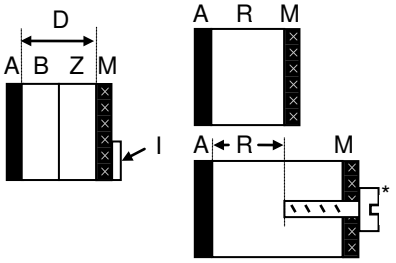
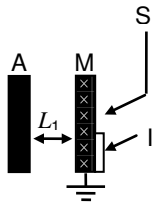
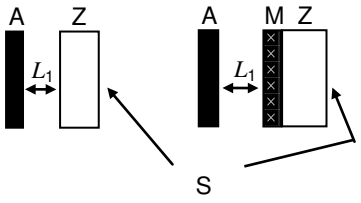
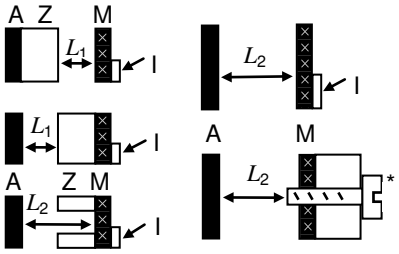
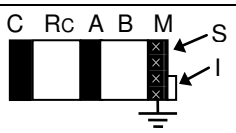
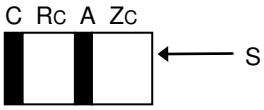
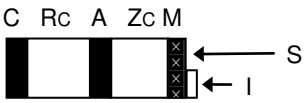
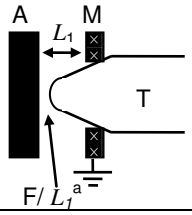
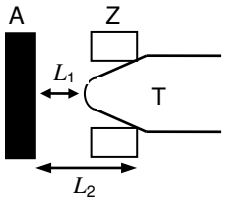
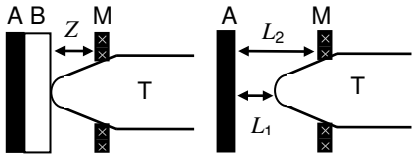
- *Basic insulation* is required between accessible parts and the *live parts*. The relevant voltage is that of the *live parts* (see Table A.4, cells 1a, 2a, 3a).

Cases b) and c):

Accessible parts are non-conductive (case b) or conductive but not connected to earth by *protective equipotential bonding* (case c). The required *insulation* is:

- Double or reinforced *insulation* between accessible parts and *live parts* of *DVC C*. The relevant voltage is that of the *live parts* (see Table A.4, cells 1b), 1c), 2b) and 2c)).
- Supplementary *insulation* between accessible parts and *live parts* of circuits of *DVC A* or B which are separated by *basic insulation* from *adjacent circuits* of *DVC C*. The relevant voltage is the highest voltage of the *adjacent circuits* (see Table A.4, upper cells 3b), 3c)).
- *Basic insulation* between accessible parts and *live parts* of circuits of *DVC B* which have protective *separation* from *adjacent circuits* of *DVC C*. The relevant voltage is that of the *live parts* (see Table A.4, lower cells 3b), 3c)).

Table A.4 – Examples for protection against electrical shock

Type of *insulation*	*Insulation* configuration		
	a Accessible conductive parts connected to earth by *protective equipotential bonding*	b Accessible parts not conductive	c Accessible parts conductive, but NOT connected to earth by *protective equipotential bonding*
1. Solid			
2. Totally or partially by air clearance			
3. *Insulation* for *adjacent circuits*: Circuit A: lower voltage circuit Circuit C: higher voltage circuit; *DVC C*			
4. Requirements for apertures in *enclosures*			

A	*live part*	L_1	clearance for *basic insulation*	T	test finger (Clause 12 of IEC 60529:1989)
B	*basic insulation* for circuit A	L_2	clearance for *reinforced insulation*	Z	*supplementary insulation* for circuit A
Bc	*basic insulation* for circuit C	M	conductive part	Zc	*supplementary insulation* for circuit C
C	*adjacent circuit*	R	*reinforced insulation* for circuit A	*	also applies to plastic screws
D	*double insulation* for circuit A	Rc	*reinforced insulation* for circuit C	F	*functional insulation* for circuit A
I	*insulation* less than B	S	surface of equipment		

NOTE 1 In column c) a plastic screw is treated like a metal screw because a user could replace it with a metal screw during the life of the equipment.

NOTE 2 In row 4, the insertion of the test finger is considered to represent the first fault.

[a] *Functional insulation* is sufficient if the opening is covered during normal operation. It shall not be possible to remove the cover without the use of a tool or key. If the opening is not covered during normal operation, *basic insulation* is required.