The following or similar wording is regarded as suitable:

"CAUTION

DOUBLE POLE/NEUTRAL FUSING"

As an alternative to the above wording, the use of the following combination of representative symbols is permitted:

- the electric shock hazard symbol IEC 60417-6042:2010-11 or ISO 7010-W012:2011-05;
- the fuse symbol IEC 60417-5016:2002-10;
- an indication that the fuse is in the neutral N (see Annex C).

However, in this case, the statement shall also be provided in the documentation.

Annex A
(normative)

Additional information for protection against electric shock

A.1 General

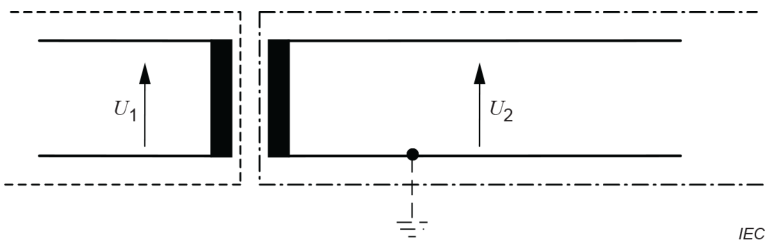
Figure A.1 to Figure A.3 show examples of the means used for protection against electric shock in *class III equipment* and *DVC As* circuits (see 4.4.6.4).

The following key applies to Figure A.1 to Figure A.3.

- - - - - - - - - - - - - - - - - - -	*Basic protection*
—·—·—·—·—·—·—·—·—	*Enhanced protection* to *adjacent circuits* according to Table 3

A.2 Protection by means of *DVC As*

(see 4.4.2.2)



Key

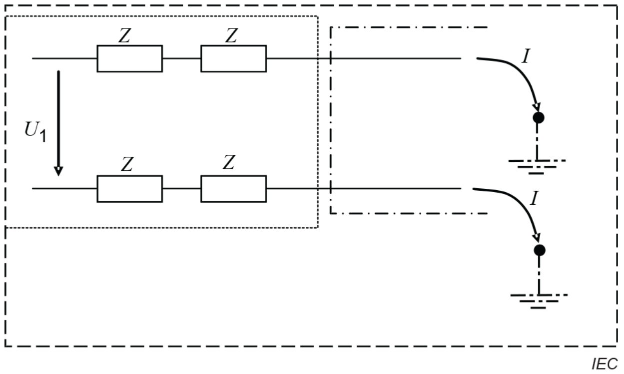
U_1 hazardous voltage, earthed or unearthed

U_2 ≤ *DVC As* from Table 2

Figure A.1 – Protection by *DVC As* with *enhanced protection*

A.3 Protection by means of *protective impedance*

(see 4.4.5.5)



Key

Z resistor

U_1 hazardous voltage, unearthed

I ≤ limits in Table 5

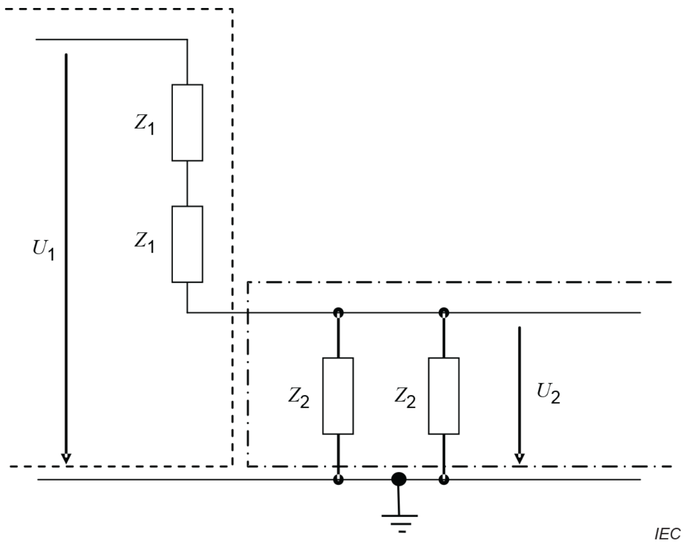
Figure A.2 – Protection by means of *protective impedance*

NOTE A similar approach can be made for earthed systems.

To provide protection in *single fault conditions*, use the following formula: $I = \frac{U_1}{Z}$.

A.4 Protection by using limited voltages

(see 4.4.2.2)



Key

Z resistor

U_1 hazardous voltage, earthed

U_2 ≤ *DVC As* from Table 2

Figure A.3 – Protection by using limited voltages

To provide protection in *single fault conditions*, use the following formulae:

$$U_2 = \frac{U_1 Z_2}{2Z_1 + Z_2} \quad \text{or} \quad U_2 = \frac{U_1 Z_2}{2(Z_1 + Z_2/2)}$$

A.5 Evaluation of the *working voltage* of circuits

A.5.1 General

The decisive voltage of each circuit of the *PECS* in respect of the protective means to be employed against electric shock is the highest voltage which occurs between any two arbitrary *live parts* within this circuit during rated worst operating conditions when used as intended.

If connection of the circuit to *PE* is provided, then the decisive voltage is the highest voltage which occurs between any arbitrary *live part* of this circuit and earth (for example circuits connected to an earthed three-phase supply).

A portion of a *DVC As* circuit may exceed the voltage limits of Table 2 when this portion is protected against direct contact according to 4.4.3.3 and the *accessible* portion of the *DVC As circuit* complies with the voltage limits of Table 2 under *single fault conditions* according to 4.2. However, the voltages in this higher voltage portion of the circuit shall still be used in the determination of *clearances* for the circuit under consideration to its surroundings in 4.4.7.4 and 4.4.7.5.

A.5.2 Classification of the *working voltage*

The limits of Table 2 are valid for nearly sinusoidal *AC* and nearly ripple free *DC*. However, electronic power conversion circuits present voltage waveforms which are neither nearly sinusoidal AC nor ripple free DC.

In A.5.2, methods and rules are provided to classify any voltage shape into one of the *DVC* in Table 2.

In the first step, the mean value of the voltage under investigation is determined.

If the mean value is zero, this voltage is considered *AC working voltage* and the rules are given in A.5.3.

NOTE The meaning of "zero" is a negligible mean value.

If the mean value is unequal to zero, in the second step the *RMS* value of the superposed ripple voltage is determined as follows:

- if this *RMS* value of the ripple does not exceed 10 % of the mean value of the *DC*, this voltage is considered *DC working voltage* and the rules are given in A.5.4;
- if this *RMS* value of the ripple exceeds 10 % of the mean value of the *DC*, this voltage is considered pulsating *working voltage* and the rules are given in A.5.5.

In the third step, determination of the applicable values for the *DVC* is done considering the:

- *AC RMS* (U_{AC}),
- *AC* recurring peak (U_{ACP}),
- *DC* mean (U_{DC}), and
- *DC* recurring peak (U_{DCP}),

as specified in 4.4.2.6.

Three cases of waveforms are considered: Figure A.4, Figure A.5 and Figure A.6 shows typical waveforms for the evaluation of *working voltage*.

A.5.3 AC *working voltage*

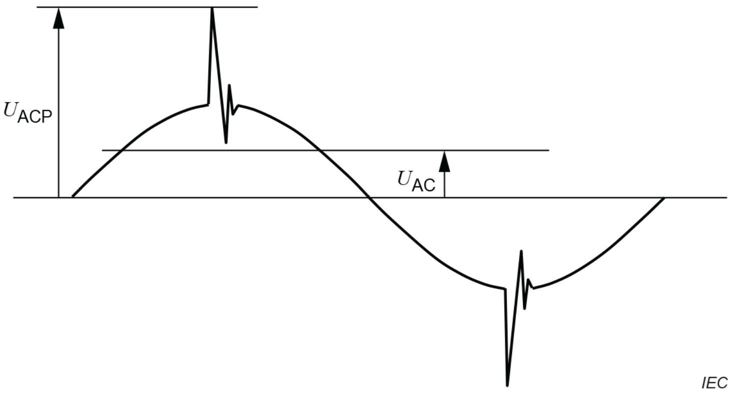


Figure A.4 – Typical waveform for *AC working voltage*

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

The *DVC* is that of the lowest voltage row of Table 2 starting with *DVC As* for which both of the following conditions are satisfied for the same row:

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

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 determining the *DVC* of the voltage is to select the highest *DVC*.

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

A.5.4 DC *working voltage*

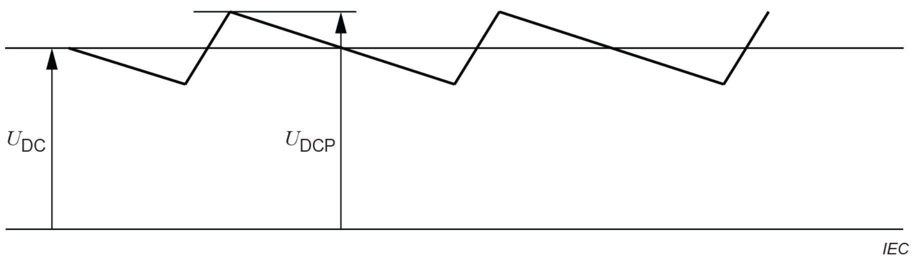


Figure A.5 – Typical waveform for *DC working voltage*

The *working voltage* has a mean value U_{DC} and a recurring peak value U_{DCP}.

The *DVC* is that of the *DVC* row of Table 2 starting with *DVC As* for which both of the following conditions are satisfied for the same row:

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

NOTE The value of 1,17 results from a superimposed ripple voltage on a triangle waveform with 10 % RMS value.

Example with values:

- U_{DC} = 39 V --> is lower than U_{DCL} = 60 V --> *DVC As* dry
- U_{DCP} = 69 V --> is lower than 1,17 × U_{DCPL} = 70,2 V --> *DVC As* dry

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

Result: --> this *working voltage* is *DVC As* dry.

A.5.5 Pulsating *working voltage*

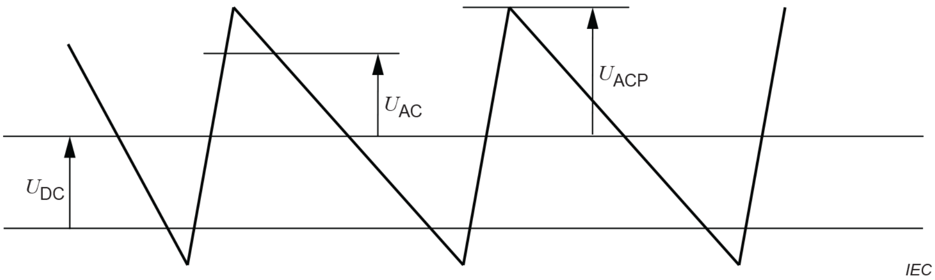


Figure A.6 – Typical waveform for pulsating *working voltage*

The *working voltage* has a mean value U_{DC}, an *AC* value U_{AC} and a recurring peak value U_{ACP}.

The *DVC* is that of the *DVC* row of Table 2 starting with *DVC As* for which both of the following conditions are satisfied for the same row:

$$\frac{U_{AC}}{U_{ACL}} + \frac{U_{DC}}{U_{DCL}} \leq 1 \quad \text{and} \quad \frac{U_{ACP}}{U_{ACPL}} + \frac{U_{DC}}{1{,}17 \times U_{DCL}} \leq 1$$

Example with values:

- U_{DC} = 39 V;
- U_{AC} = 49 V;
- U_{ACP} = 91 V.

First calculation with the limits of *DVC B*:

$$\frac{49}{50} + \frac{39}{120} = 0{,}980 + 0{,}325 = 1{,}305$$

the result is exceeding 1 --> *DVC C*

and

$$\frac{91}{71} + \frac{39}{1{,}17 \times 120} = 1{,}282 + 0{,}278 = 1{,}560$$

the result is exceeding 1 --> *DVC C*

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

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

A.6 The concept of protective means according to 4.4

A.6.1 General

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
- means for *enhanced protection* according to 4.4.5.

A.6.2 Examples of the use of elements of protective means

Table A.1 provides examples of typical combinations of means for protection against electric shock.

The required grade of protection depends on

- the *DVC* of the *live parts* according *to* Table 2,
- the *insulation* requirement between *adjacent circuits* according to 4.4.7.2.1,
- the connection of conductive *accessible part*s to earth by *protective equipotential bonding* according to 4.4.4.2, and
- non conductive *accessible part*s.

As an alternative to *solid insulation*, a *clearance* according to Table 8, shown by L_1 and L_2 in Table A.1 may be provided.

In Table A.1, three cases are considered:

- Case a) – *Accessible part*s are conductive and are connected to earth by *protective equipotential bonding*

  Basic insulation is required between *accessible part*s and the *hazardous live parts*. The relevant voltage is that of the *hazardous live parts* (see Table A.1, cells 1a, 2a, 3a).
- Cases b) and c) – *Accessible part*s are non-conductive (case b) or conductive but not connected to earth by *protective equipotential bonding* (case c)

  The required *insulation* is as follows.

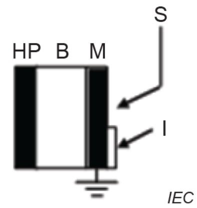
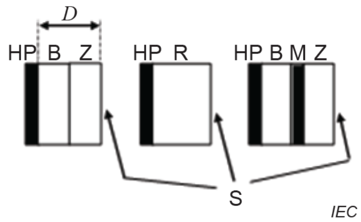
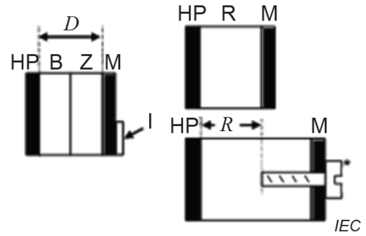
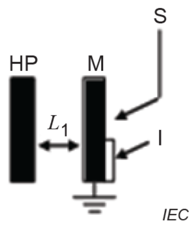
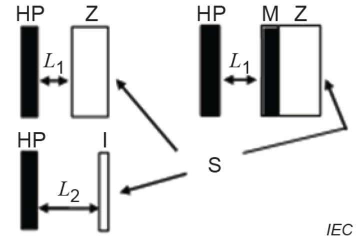
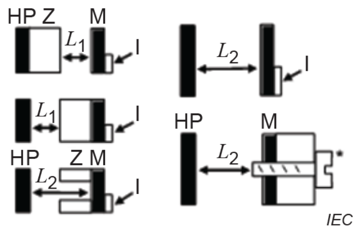
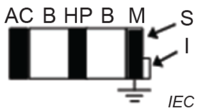
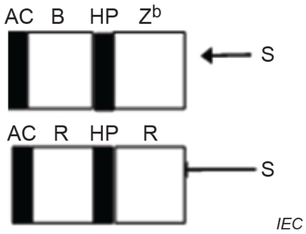
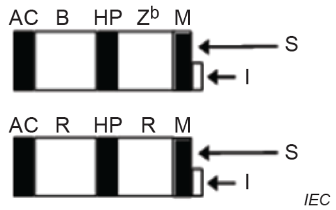
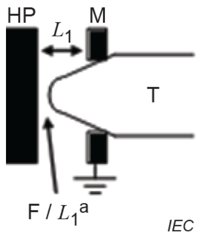
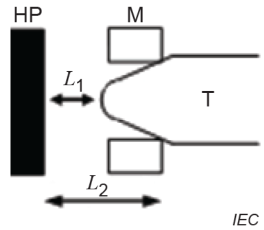
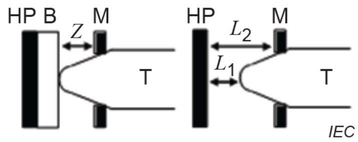
  – *Double insulation* or *reinforced insulation* between *accessible part*s and *hazardous live parts* of *DVC C*. The relevant voltage is that of the *live parts* (see Table A.1, cells 1b, 1c, 2b and 2c).

  – *Supplementary insulation* between *accessible part*s and *hazardous live parts* of circuits of *DVC C* which are separated by *basic insulation* from another *adjacent circuits* of *DVC C*. The relevant voltage is the highest voltage of the *adjacent circuits* (see Table A.1, upper cells 3b, 3c).

  NOTE 1 See also Table A.1, footnote b.

NOTE 2 Table A.1 does not show any *insulation* requirement for *DVC As* and *DVC B.*

Table A.1 – Examples for protection against electric shock

<table>
<tr><th>Type of protection</th><th colspan="3">Configuration</th></tr>
<tr><td></td><td>a
Conductive accessible parts connected to earth by protective equipotential bonding</td><td>b
Accessible parts not conductive</td><td>c
Accessible parts conductive, but <u>NOT</u> connected to earth by protective equipotential bonding</td></tr>
<tr><td>1. Solid insulation</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>2. Insulation totally or partially by air clearance</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>3. Insulation for adjacent circuits:
Circuit HP: lower voltage circuit; DVC C
Circuit AC: higher voltage circuit; DVC C</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>4. Requirements for openings in enclosures</td><td>
</td><td>
</td><td>
</td></tr>
</table>

HP	*Hazardous live part*	L_1	*clearance* for *basic insulation*	T	test finger according to Figure M.2
B	*basic insulation* for circuit	L_2	*clearance* for *reinforced insulation*	Z	*supplementary insulation* for circuit
AC	*adjacent circuit*	M	conductive part	*	also applies to plastic screws
D	*double insulation* for circuit	R	*reinforced insulation* for circuit	F	*functional insulation* for circuit
I	optional insulation less than B for other purposes than protection against electric shock.			S	surface of *PECS*

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 *PECS*.

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

NOTE 3 This table shows examples only, and does not cover every situation.

[a] *Functional insulation* is sufficient if the opening is covered during normal operation conditions. 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 operating conditions, *basic insulation* is required.

[b] When considering the insulation requirement Z from the *adjacent circuit* AC in row 3a, 3b and 3c, the insulation requirement from circuit HP from row 1 and row 2 shall be considered as well. The protection requirement shall be the higher of the requirement for HP (*reinforced insulation* from HP) from row 1 or 2 and the requirement for AC (*supplementary insulation* from AC) in row 3.

Annex B
(informative)

Considerations for the reduction of the *pollution degree*

B.1 General

The objective of Annex B is to give an overview of what factors should be considered to reduce the *pollution degree* for electrical equipment in order to allow for a reduction of the *clearance* and *creepage distance*s. As the means to be taken depend heavily on the nature of pollution, no comprehensive guidance can be given on how to achieve the goal of a lower *pollution degree* for the equipment.

B.2 Factors influencing the *pollution degree*

The following factors influence the *pollution degree*.

- Pollution
  - no pollution;
  - dry non-conductive pollution;
  - dry non-conductive pollution that can become conductive, when moist;
  - conductive pollution.

  NOTE Pollution can be external or can be internally generated or present internally at the conclusion of manufacturing.
- Moisture
  - no or low moisture without condensation;
  - temporary condensation;
  - permanent moisture;
  - rain or snow.

B.3 Reduction of influencing factors

Following are some means that may be applied to reduce the influencing factors. The described means to meet the requirements are only illustrative. There may be other possibilities.

- Coating (see 4.4.7.6).
- IP5X (dust test according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013).
- IPX4 to IPX8 depending on the environment.

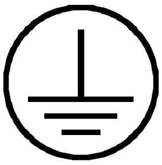
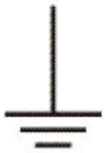
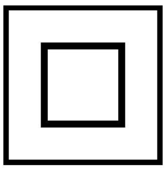
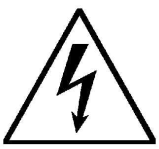
When hermetically sealing an electrical equipment, it should be ensured that the moisture level will be at the required low level when resealing the equipment after opening the *enclosure* (e.g. for service).

Annex C
(informative)

Symbols referred to in this document

C.1 Symbols used

Table C.1 – Symbols used

Symbol	Standard reference	Description	Subclauses
	IEC 60417-5019: 2006-08	*PE conductor* terminal	4.4.4.3.2, 6.3.9.2.2
	IEC 60417-5017: 2006-08	*PE conductor* terminal	4.4.4.3.2, 6.3.9.2.2
	IEC 60417-5018: 2011-07	Functional earthing terminal	4.4.6.3, 6.3.9.2.3
 	ISO 7010-W001: 2011-05 or ISO 7000-0434: 2006-12	Caution, refer to documentation	4.4.4.3.3, 4.4.8, 6.3.9.4, 6.3.9.5
	IEC 60417-5172: 2003-02	*Class II equipment* (double insulated)	4.4.6.3, 6.3.9.2.3
	IEC 60417-5180: 2003-02	*Class III equipment*	4.4.6.4, 6.3.9.2.4
 	IEC 60417-6042: 2010-11 or ISO 7010-W012: 2011-05	Caution, risk of electric shock	4.4.9, 6.5.2