7.3.7.8.3.4 Compliance

Compliance is checked by the tests described in 7.5.1 to 7.5.3 applied according to 7.3.7.8.2.

When a component or sub-assembly makes use of thin sheet insulating materials, it is permitted to perform the tests on the component rather than on the material.

7.3.7.8.4 Printed wiring boards (PWBs)

7.3.7.8.4.1 General

Insulation between conductor layers in double-sided single-layer PWBs, multi-layer PWBs and metal core PWBs, shall meet the requirements for solid insulation in 7.3.7.8.

For the inner layers of multi-layer PWBs, the insulation between adjacent tracks on the same layer shall be treated as either:

- a creepage distance for pollution degree 1 and a clearance as in air (see Annex A, figure A.13); or

- as solid insulation, in which case it shall meet the requirements of 7.3.7.8.

7.3.7.8.4.2 Use of coating materials

A coating material used to provide a microenvironment or to provide functional, basic, supplementary and reinforced insulation shall meet the requirement as specified below.

Type 1 protection (as defined in IEC 60664-3) improves the microenvironment (Pollution Degree) of the parts under protection. The clearance and creepage distance of Table 13 and Table 14 for pollution degree 1 apply under the protection. Between two conductive parts, it is a requirement that one or both conductive parts, together with all the spacing between them, are covered by the protection.

Type 2 protection is considered to be similar to solid insulation. Under the protection, the requirements for solid insulation specified in 7.3.7.8 are applicable and spacings shall not be less than those specified in Table 1 of IEC 60664-3. The requirements for clearance and creepage in Table 13 and Table 14 do not apply. Between two conductive parts, it is a requirement that both conductive parts, together with the spacing between them, are covered by the protection so that no airgap exists between the protective material, the conductive parts and the printed wiring boards.

The coating material used to provide Type 1 and Type 2 protection shall be designed to withstand the stresses anticipated to occur during the expected lifetime of the PCE.

Compliance is checked by a type test on representative PWB's, conducted according to IEC 60664-3 Clause 5. For the Cold test (5.7.1), a temperature of –25 °C shall be used, and for the rapid change of temperature test (5.7.3): –25 °C to +125 °C, except that if the temperature rating of the PCE is lower than –25 °C, the low temperature limit for the test is reduced to the rating of the PCE.

7.3.7.8.5 Wound components

Varnish or enamel insulation of wires shall not be used for basic, supplementary, double or reinforced insulation.

Wound components shall meet the requirements of 7.3.7.8.1 and 7.3.7.8.2.

The component itself shall pass the requirements given in 7.3.7.8.1 and 7.3.7.8.2. If the component has reinforced or double insulation, the voltage test in 7.5.2 shall be performed as a routine test.

7.3.7.8.6 Potting materials

A potting material may be used to provide solid insulation or to act as a coating to protect against pollution. If used as solid insulation, it shall comply with the requirements of 7.3.7.8.1 and 7.3.7.8.2. If used to protect against pollution, the requirements for Type 1 protection in 7.3.7.8.4.2 apply.

7.3.7.9 Insulation requirements above 30 kHz

Where voltages across insulation have fundamental frequencies greater than 30 kHz, further considerations apply. Requirements for this are provided in IEC 60664-4, and the more severe of these and the requirements of 7.3.7.1 to 7.3.7.8 shall be applied.

Annex G contains flow-charts for the determination of clearance and creepage distances under these circumstances. For convenience, Tables 1 and 2 of IEC 60664-4 are also included in Annex G.

7.3.8 Residual Current Detection (RCD) or Monitoring (RCM) device compatibility

RCD and RCM devices are used to provide protection against insulation faults in a.c. supply circuits in some domestic and industrial installations, in addition to any protection provided by the installed equipment.

An insulation fault or direct contact with certain types of PCE circuits can cause residual current with a d.c. component to flow and thus reduce the ability of an RCD or RCM of type A or AC to provide this protection for other equipment in the installation (see IEC 60755 and IEC 62020).

Pluggable type A PCE shall be designed so that, under normal and single-fault conditions, any resulting d.c. component in the residual current does not exceed the d.c. current withstand requirements in IEC 60755 and IEC 62020 for RCD and RCM of type A.

PCE that is pluggable type B or fixed equipment, may have a d.c. residual current component present in excess of the d.c. current withstand requirements in IEC 60755 and IEC 62020 for RCD and RCM of type A, if the information required by 5.3.2 item l) is provided in the installation instructions.

Compliance is checked by inspection if the installation instructions, and by the following measurements, to be performed under normal conditions, and during any fault conditions which may result in risk of a d.c. residual current component in the AC current. Faults are selected by analysis of the schematic.

The residual current in the AC input and/or output circuit is measured using a meter or power analyzer or other instrument that can detect only the d.c. component of the residual current. The resulting d.c. residual current component is compared to the limits in IEC 60755 or IEC 62020 as appropriate.

NOTE 1 RCDs of type A according to IEC 61008-1 and IEC 61009-1 are able to tolerate 6 mA smooth d.c. current while keeping their protective functionality, however depending on the design RCD manufacturers may declare much higher values for their products.

NOTE 2 This requirement may be met by protective means in the PCE, for example by incorporating means to disconnect the PCE from the mains in case of excessive d.c. current component.

NOTE 3 Annex E gives guidelines to assist with the selection of the RCD or RCM type.

NOTE 4 For design and construction of electrical installations, care should be taken with RCD of Type B. All the RCD upstream from an RCD of Type B up to the supply transformer should be of Type B.

7.3.8DV DR *Modification:*

In the fourth paragraph, replace ″item l with ″item n.″

7.3.9 Protection against shock hazard due to stored energy

7.3.9.1 Operator access area

Equipment shall be so designed that there is no risk of electric shock in operator access areas from stored charge after disconnection of the PCE.

In the case of plugs, connectors, or similar devices that can be disconnected without the use of a tool, the withdrawal of which results in the exposure of conductors (e.g. pins), the discharge time to reduce the voltage to DVC A (see 7.3.2.2) or, for capacitors, to a stored charge level below the limits specified in 7.3.5.3.2, shall not exceed 1 s.

Compliance is checked by inspection of the equipment and relevant circuit diagrams, taking into account the possibility of disconnection with any switch in either position, and if necessary by measuring the voltage with respect to time after disconnection of the source. For a.c. sources, disconnection at the peak of the a.c. voltage waveform is required.

7.3.9.2 Service access areas

Capacitors and other energy storage devices located behind panels that are removable for servicing, installation, or disconnection shall present no risk of electric shock or energy hazard from stored charge after disconnection of the PCE.

Capacitors within a PCE shall be discharged to a voltage less than DVC A (see 7.3.2.2), or an energy level below the limits specified in 7.3.5.3.2, within 10 s after the removal of power from the PCE. If this requirement is not achievable for functional or other reasons, the warning symbol 21 of Annex C and an indication of the discharge time shall be placed in a clearly visible position on the enclosure, the capacitor protective barrier, or at a point close to the capacitor(s) concerned (depending on the construction) (see 5.2.2.4).

For energy storage devices (such as batteries or ultracapacitors) the intended function of which is to maintain charge even with the PCE off and disconnected from external sources, a barrier or insulation shall be provided so that unintentional contact with hazardous live parts is prevented. The warning symbol 21 of Annex C shall be placed in a clearly visible position on or adjacent to the barrier or insulation, where it will be seen before removal of the barrier or insulation.

Compliance is checked by inspection of the equipment and relevant circuit diagrams, taking into account the possibility of disconnection with any switch in either position and non-operation of periodic power consuming devices or components within the PCE. If the discharge time cannot be accurately calculated, the discharge time shall be measured.

7.4 Protection against energy hazards

7.4.1 Determination of hazardous energy level

A hazardous energy level is considered to exist if:

a) the voltage is 2 V or more, and power available after 60 s exceeds 240 VA.

Compliance is checked by calculations or by the following test:

With the equipment operating under normal operating conditions, a variable resistive load is connected to the parts under consideration and adjusted to obtain a level of 240 VA. Further adjustment is made, if necessary, to maintain 240 VA for a period of 60 s. If the voltage is 2 V or more, the output power is at a hazardous energy level, unless an overcurrent protective device opens during the above test, or for any other reason the power cannot be maintained at 240 VA for 60 s;

Or

b) the stored energy in a capacitor is at a voltage, U of 2 V or more, and the stored energy, E, calculated from the following equation, exceeds 20 J:

$$E = 0{,}5\ CU^2$$

where

E is the energy, in joules (J);

C is the capacitance, in farads (F);

U is the measured voltage on the capacitor, in volts (V).

7.4.2 Operator access areas

Equipment shall be so designed that there is no risk of energy hazard in operator access areas from accessible circuits.

A risk of injury due to an energy hazard exists if it is likely that two or more bare parts (one of which may be earthed) between which a hazardous energy level exists will be bridged by a metallic object.

The likelihood of bridging the parts under consideration shall be determined. Compliance is shown by means of the test finger of Figure D.1, in a straight position. If it is possible to bridge the parts with this test finger, a hazardous energy level shall not exist.

Barriers, guards, and similar means preventing unintentional contact may be provided as an alternative to limiting the energy.

7.4.3 Service access areas

Energy storage devices located behind panels that are removable for servicing, installation, or disconnection shall present no risk of electric energy hazard from charge stored after disconnection of the PCE.

Energy storage devices within a PCE shall be discharged to an energy level less than 20 J, as in 7.4.1, within 10 s after the removal of power from the PCE. If this requirement is not achievable for functional or other reasons, the warning symbol 21 of Annex C and an indication of the discharge time shall be placed in a clearly visible position on the enclosure, the protective barrier, or at a point close to the energy storage device(s) concerned (depending on the construction).

For energy storage devices (such as batteries or ultracapacitors) the intended function of which is to maintain charge even with the PCE off and disconnected from external sources, a barrier or insulation shall be provided so that unintentional contact with parts at a hazardous energy level is prevented. The warning symbol 21 of Annex C shall be placed in a clearly visible position on or adjacent to the barrier or insulation, where it will be seen before removal of the barrier or insulation.

Compliance is checked by inspection of the equipment and relevant circuit diagrams, taking into account the possibility of disconnection with any switch in either position and nonoperation of periodic power consuming devices or components within the PCE. If the discharge time cannot be accurately calculated, the discharge time shall be measured.

7.5 Electrical tests related to shock hazard

7.5.1 Impulse voltage test (type test)

The impulse voltage test is performed with a voltage having a 1,2/50 µs waveform (see Figure 6 of IEC 60060-1) and is intended to simulate overvoltages induced by lightning or due to switching of equipment. See Table 15 for conditions of the impulse voltage test.

Tests on clearances smaller than required by Table 13 (as allowed by 7.3.7.4.2) and on solid insulation are performed as type tests using appropriate voltages from Table 16.

Tests on components and devices for protective separation are performed as a type test before they are assembled into the PCE, unless the test can be performed on the completed PCE without reducing the stress applied to the protective separation. Testing is performed using the impulse withstand voltages listed in column 3 or column 5 of Table 16.

Where transient limiting means is used to reduce impulse voltage levels as in paragraph g) of 7.3.7.1.2, the reduction provided is verified by a type test. The values of column 2 or column 4 in Table 16 are applied to the PCE, and measurements are made in the circuit after the transient limiting means, to determine the level to which transients have been reduced.

If it is necessary to test a clearance that has been designed for altitudes between 2 000 m and 20 000 m (using Table A.2 of IEC 60664-1), the appropriate test voltage may be determined from the clearance distance, using Table 13 in reverse.

Table 15 – Impulse voltage test

Subject	Test conditions	
Test reference	Clause 19, 20.1.1 and Figure 6 of IEC 60060-1; 6.1.2.2.1 of IEC 60664-1	
Requirement reference	According to 7.3.4.3, 7.3.5.3 and 7.3.7	
Preconditioning	*Live parts* belonging to the same circuit shall be connected together. Protective impedances shall be disconnected unless required to be tested. Impulse voltage to be applied 1) between circuit under test and the surroundings and 2) between circuits to be tested. Power is not applied to circuits under test.	
Initial measurement	According to specification of PCE, component, or device	
Test equipment	Impulse generator 1,2/50 µs with an effective internal impedance not higher than 2 Ω for testing clearances and 500 Ω for testing solid insulation and components.	
Measurement and verification	a)	b)
	Clearances smaller than required by Table 7	Solid reinforced insulation
	Clearances reduced by overvoltage limiting means or by circuit characteristics	Clearances, components and devices for protective separation
	Solid basic or supplementary insulation	
Test voltage	Three pulses 1,2/50 µs of each polarity in ≥ 1 s interval, peak voltage (± 5 %) according to:	
	column 2 or column 4 of Table 16	column 3 or column 5 of Table 16
	When the test is carried out on a clearance at an altitude less than 2 000 m, the test voltage shall be increased according to Table F.5 of IEC 60664-1, which is reproduced as Table F.2 of this international standard.	

Compliance is checked via application of the impulse voltage test and is successfully passed if no puncture, flashover, or sparkover occurs.

Table 16 – Impulse test voltage

Column 1	2	3	4	5
System voltage (see 7.3.7.2.1)	Impulse withstand voltage for insulation between circuits not connected directly to the mains and their surroundings according to overvoltage category II		Impulse withstand voltage for insulation between circuits connected directly to the mains and their surroundings according to overvoltage category III	
	Basic or supplementary	Reinforced	Basic or supplementary	Reinforced
V r.m.s.	V	V	V	V
≤50	500	800	800	1 500
100	800	1 500	1 500	2 500
150	1 500	2 500	2 500	4 000
300	2 500	4 000	4 000	6 000
600	4 000	6 000	6 000	8 000
1 000	6 000	8 000	8 000	12 000
–	Interpolation is permitted		Interpolation is not permitted	
	NOTE Test voltages for overvoltage categories I and III can be derived in a similar way from Table 12.		NOTE Test voltages for overvoltage categories II and IV can be derived in a similar way from Table 12.	

Table 16DV DR *Modification of Table 16 by replacing it with the following:*

Table 16DV – Impulse test voltage

Column 1	2	3	4	5
System voltage (see 7.3.7.2.1)	Impulse withstand voltage for insulation between circuits not connected directly to the mains and their surroundings according to overvoltage category II		Impulse withstand voltage for insulation between circuits connected directly to the mains and their surroundings according to overvoltage category III	
	Basic or supplementary	Reinforced	Basic or supplementary	Reinforced
V	V	V	V	V
50 V rms or 71 V dc	500	800	800	1 500
100 V rms or 141 V dc	800	1 500	1 500	2 500
150 V rms or 213 V dc	1 500	2 500	2 500	4 000
300 V rms or 424 V dc	2 500	4 000	4 000	6 000
600 V rms or 849 V dc	4 000	6 000	6 000	8 000
1 000 V rms or 1 500 V dc	6 000	8 000	8 000	12 000
2 000 V dc	8 000	12 000	12 000	16 000
–	Interpolation is permitted		Interpolation is not permitted	
	NOTE Test voltages for overvoltage categories I and III can be derived in a similar way from Table 12.		NOTE Test voltages for overvoltage categories II and IV can be derived in a similar way from Table 12.	

7.5.2 Voltage test (dielectric strength test) (type test and routine test)

7.5.2.1 Purpose of test

The test is used to verify that the clearances and solid insulation of components and of assembled PCE has adequate dielectric strength to resist overvoltage conditions. Routine tests are performed to verify that clearances and solid insulation have not been omitted, reduced, or damaged during the manufacturing operations.

7.5.2.2 Value and type of test voltage

The values of the test voltage are determined from column 2 or 3 of Table 17 or Table 18 depending upon whether the circuit under test is mains connected or not mains connected.

The test voltage from column 2 is used for testing circuits with basic insulation.

Between circuits with protective separation (double or reinforced insulation), the test voltage of column 3 shall be applied for type tests. For routine tests between circuits with protective separation the values from column 2 shall be applied, to prevent damage to the solid insulation due to causing partial discharge within the solid insulation.

The values of column 3 shall apply to circuits with protective separation, and between circuits and accessible surfaces of PCE, which are non-conductive or conductive but not connected to the protective earthing conductor.

The voltage test shall be performed with a sinusoidal voltage at 50 Hz or 60 Hz. If the circuit contains capacitors the test may be performed with a d.c. voltage of a value equal to the peak value of the specified a.c. voltage.

7.5.2.2DV D1 ***Modification by adding the following:***

Add the following to the end of the first paragraph ″For PCE circuits that are not separated from the mains by at least simple separation, the considered circuit is tested at the same time as the mains circuit, using a value determined from Table 17 based on the mains system voltage.″

Table 18 is applicable for circuits isolated from mains with at least basic insulation. See also Annex I.

Table 17 – AC or DC test voltage for circuits connected directly to the mains

Column 1 System voltage (see 7.3.7.2.1)	2[b] Voltage for type testing circuits with basic insulation, and for all routine testing		3[b] Voltage for type testing circuits with protective separation, and between circuits and accessible surfaces (non-conductive or conductive but not connected to protective earth, protective class II according to 7.3.6.4)	
	a.c. r.m.s. [a]	d.c.	a.c. r.m.s.	d.c.
V	V	V	V	V
≤ 50	1 250	1 770	2 500	3 540
100	1 300	1 840	2 600	3 680
150	1 350	1 910	2 700	3 820
300	1 500	2 120	3 000	4 240
600	1 800	2 545	3 600	5 090
1 000	2 200	3 110	4 400	6 220
NOTE Interpolation is permitted.				
[a] Corresponding to 1 200 V + system voltage. [b] A voltage source with a short-circuit current of at least 0,1 A according to 5.2.2.2 of IEC 61180-1 is used for this test.				

Table 18 – a.c. or d.c. test voltage for circuits not connected directly to the mains

Column 1	2[a]		3[a]	
Working voltage (recurring peak) (see 7.3.7.2.3)	Voltage for type testing circuits with basic insulation, and for all routine testing		Voltage for type testing circuits with protective separation, and between circuits and accessible surfaces (non-conductive or conductive but not connected to protective earth, protective class II according to 7.3.6.4)	
	a.c. r.m.s.	d.c.	a.c. r.m.s.	d.c.
V	V	V	V	V
≤ 71	80	110	160	220
141	160	225	320	450
212	240	340	480	680
330	380	530	760	1 100
440	500	700	1 000	1 400
600	680	960	1 400	1 900
1 000	1 100	1 600	2 200	3 200
1 600	1 800	2 600	2 900	4 200
NOTE 1 Interpolation is permitted. NOTE 2 Test voltages in this table are based upon 80 % of the withstand voltage for the corresponding clearance of Table 12 as provided by Table A.1 of IEC 60664-1.				
[a] A voltage source with a short-circuit current of at least 0,1 A according to 5.2.2.2 of IEC 61180-1 is used for this test.				

Table 18DV DR *Modification of Table 18 by adding two new rows in accordance with the following:*

2 300 3 000	2 600 3 400	3 700 4 800	4 200 5 400	5 900 7 700

7.5.2.3 Humidity pre-conditioning

For type tests on PCE for which wet locations requirements apply, according to 6.1, the humidity pre-conditioning of 4.5 shall be performed immediately prior to the voltage test.

7.5.2.4 Performing the voltage test

The test shall be applied as follows, according to Figure 13:

a) Test (1) between accessible conductive part (connected to earth) and each circuit sequentially (except DVC A circuits). Test voltage according to Table 17 and Table 18, column 2, corresponding to voltage of considered circuit under test.

Test (2) between accessible surface (non conductive or conductive but not connected to earth) and each circuit sequentially (except DVC A circuits). Test voltage according to Table 17 and Table 18, column 3 (for type test) or column 2 (for routine test), corresponding to voltage of considered circuit under test.

b) Test between each considered circuit sequentially and the other adjacent circuits connected together. Test voltage according to Table 17 and Table 18, column 2, corresponding to voltage of considered circuit under test.

c) Test between DVC A circuit and each adjacent circuit sequentially. Test voltage according to Table 17 and Table 18 column 3 (for type test) or column 2 (for routine test), corresponding to the circuit with the higher voltage. Either the adjacent circuit or the DVC A circuit may be earthed for this test. If basic insulation is required between adjacent DVC A circuits, the basic insulation is required to be tested. Where functional insulation is permitted between adjacent DVC A circuits, that functional insulation is not required to be tested.

It may not be possible to perform type tests of protective insulation at voltages according to column 3 of Table 17 and Table 18 without overstressing Basic insulation between the circuits under test and the chassis. In these cases the type test of insulation used for protective separation shall be performed at voltages according to column 2 of the appropriate Table, or it may be necessary to disassemble the PCE.

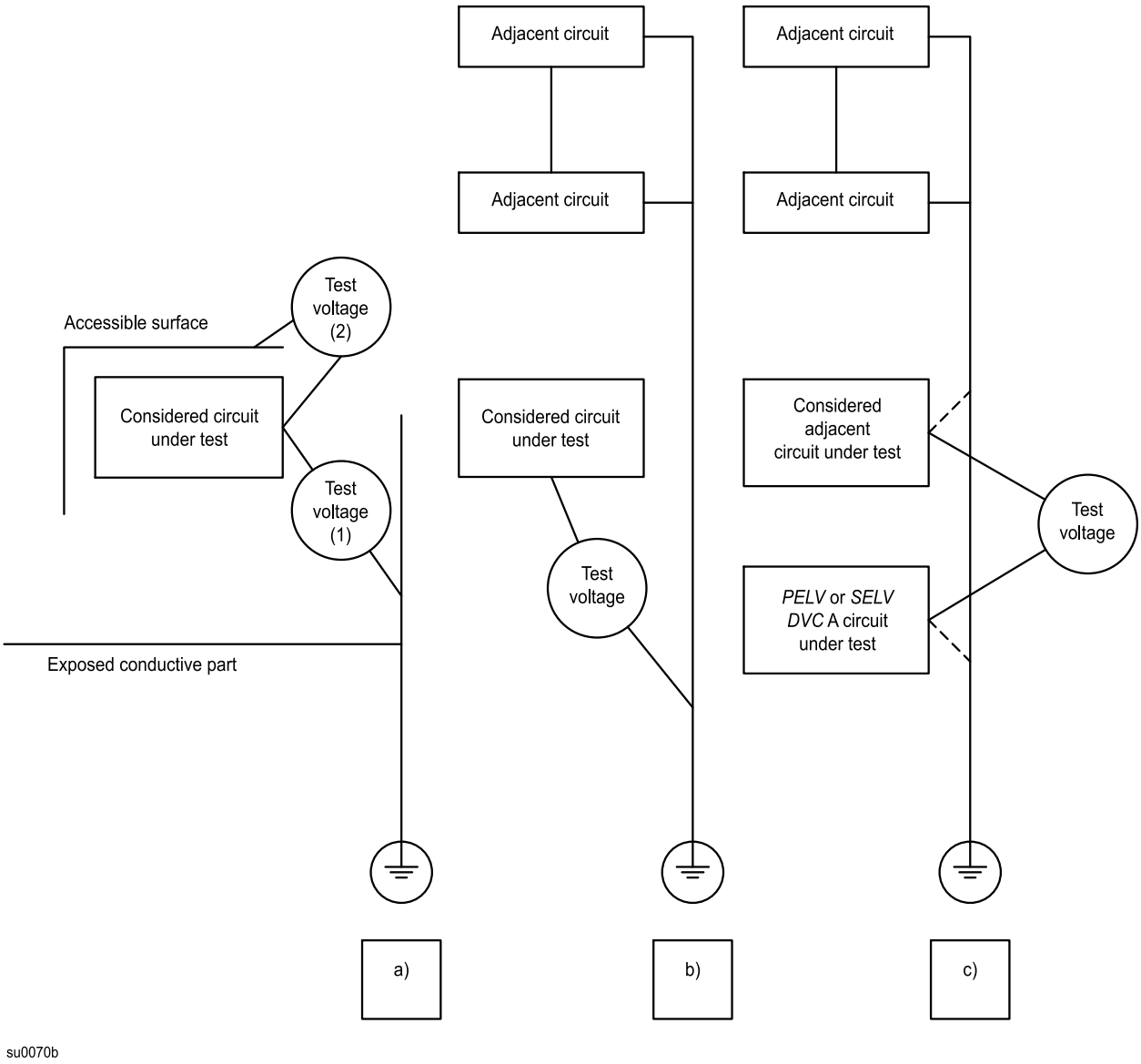

Figure 13 – Voltage test procedures