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1 Purpose

This DSEI describes the requirements for any DEK machine design to ensure that earth connections are achieved via the methods described herein and to ensure that they comply with all the required standards.

All designs must comply with the continuity of earth connections described in this document, but the exact nature of stud assemblies can vary.

2 Glossary, Abbreviations

Term	Description
DSP	DEK Standard Part
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
PE	Protective Earth

3 References

BS7671:2018	IET Wiring Regs, 18 th Edition.
BS EN 61010-1:2010+A1:2019	Safety requirements for electrical equipment for measurement, control, and laboratory use. General requirements
BS EN 60950-1-2006+A2:2013	Information technology equipment. Safety. General requirements
BS EN 61010-2-201:2018	Safety requirements for electrical equipment for measurement, control, and laboratory use. Particular requirements for control equipment
BS EN 60204-31:2013	Safety of machinery. Electrical equipment of machines. Particular safety and EMC requirements for sewing machines, units and systems
IEC 60417-5019 (DB:2002-10)	Graphical Symbols for Use on Equipment

4 Requirements for Earth Connections

4.1 General

- Earth connection components must be plated or made of corrosion resistant material (either by material selection or treatment).
- Earth connection components welded or pressed into the metal chassis will make an electrical connection through the weld or metal deformation.
- Earth connection components screwed or fixed to a metal chassis will make an electrical connection with the metal chassis surface by contacting an area cleared of paint, anodising or any other non-conducting material.
- Connection with a metal chassis surface can be achieved by fitting a steel 'shake-proof' washer between the metal surface and a plain nut. This will enhance the electrical connection and prevent loosening.

- e) A 'shake-proof' washer and plain nut must be fitted first to earth studs in order to establish a flat conductive surface for electrical ring terminals.
- f) Plain washers must be fitted either side of electrical ring terminals.
- g) All earth wire conductors must be green-and-yellow coloured, or the wire must be identified by green-and-yellow sleeves.
- h) For an earthing braid, the insulation shall be either green-and-yellow or transparent.
- i) Tri-rated 2.5mm² conductor (Part No 88160383-01) is normally used for Protective Bonding conductors.
- j) Tri-rated 4.0mm² conductor (Part No 88155778-01) is normally used for Super Flexible Protective Bonding conductors.
- k) Other sizes of Protective Bonding conductors are acceptable as long they comply with Table 3B in section 10.
- l) Earth wire conductors must be terminated with a crimped ring terminal or clamped directly into a suitable terminal block.
- m) Chassis mounted terminal block groups must have one conductor connected to a nearby Protective Bonding earth point.

4.2 Stud Welded to Chassis

The stud must be welded to the metal chassis.

Electrical connection will be made by the weld and by contact with the thread.

4.3 Stud or Thread Pressed into Chassis (DSP 1.1.6)

The earth connection component must be pressed into the chassis and held by deformation of the metal.

Electrical connection will be made by the deformed chassis metal and by contact with the thread.

4.4 Stud Fitted to Chassis Threaded Hole or Nut Insert (DSP 1.1.5)

The stud must be screwed into a threaded hole in the metal chassis and prevented from loosening by fitting a steel 'shake-proof' washer followed by a plain nut.

Electrical connection will be made by the steel 'shake-proof' washer to an area of the chassis that is cleared of paint, anodising or any other non-conductive material and by contact with the thread.

4.5 Bolt Fitted to Chassis Threaded Hole or Nut Insert (DSP 1.1.5)

The bolt must be screwed into a threaded hole in the metal chassis and prevented from loosening by fitting a steel 'shake-proof' washer next to the head.

Electrical connection will be made by another steel 'shake-proof' washer to an area of the chassis that is cleared of paint, anodising or other non-conductive materials and by contact with the thread.

4.6 Plain Chassis or Component Hole

The earth connection component must be fixed by plain nuts with steel 'shake-proof' washers against the metal chassis on either side of the hole.

Electrical connection will be made by the steel 'shake-proof' washers to an area of the chassis that is cleared of paint, anodising or any other non-conductive material and by contact with the thread.

4.7 Protective Earth (PE) Connection

The Protective Earth (PE) conductor from the machine multicore mains supply cable must be connected directly to a dedicated PE stud on the machine chassis using a ring terminal connector.

An M6 thread is preferred for the chassis earth stud and it should be labelled by a standard earth symbol within a circle.

4.8 Protective Bonding Connections

Protective bonding conductors are used to ensure that all accessible metal covers are safely earthed in the event of a fault involving a dangerous voltage. This is achieved by connecting directly to a bonding stud or earth terminal block on the machine chassis. For example, the M37 power crate earth wire is passed straight back through the output gland of the mains isolator with sufficient stripped back length to reach a Protective Bonding stud on the machine chassis. The chassis studs can be optionally labelled by a standard earth symbol without an encompassing circle.

The conductor must be terminated with a ring terminal as described above; an M5 stud size is preferred so that the conductor cannot be fitted to the M6 protective earth stud. Other terminal sizes are admissible as long as they comply with Table 3E in section 10.

4.9 Functional Bonding Connections

Functional bonding conductors are used to ensure that metal covers and components are maintained at the earth potential for EMC, ESD purposes and screening for proper functioning of electronics components. This is achieved by connecting directly to a functional bonding stud or earth terminal block on the machine chassis.

The conductor must be terminated with a ring terminal as described above; an M5 stud size is preferred so that the conductor cannot be fitted to the M6 protective earth stud. Other terminal sizes are admissible as long as they comply with Table 3E in section 10.

5 Continuity of Earth Connections

The resistance between the PE terminal and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source. Earthed PELV supplies can produce misleading results in this test and therefore shall not be used. NOTE Larger currents used for the continuity test increases the accuracy of the test result, especially with low resistance values, i.e., larger cross-sectional areas and/or lower conductor lengths¹

The impedance between the PROTECTIVE CONDUCTOR TERMINAL and each ACCESSIBLE part for which PROTECTIVE BONDING is specified shall not exceed 0,1R. ²

Continuity must be tested between each protective stud and the Protective Earth conductor.

6 Chassis Paint or Plating Masking

When using a threaded earth stud, the threaded hole and a 9mm to 13mm diameter area under the washer must be free from any paint or plating. This can be achieved by removing the finish after painting/plating or masking the area prior to finishing.

Silicone plugs are available which are suitable for masking (eg. Essentra part 35-UWPP-500).

¹ BS EN 60204-1:2018, 18.2.2

² BS EN 61010-1:2010+A1:2019, 6.5.2.4

7 Earth Fixings

7.1 Plain Nuts

Plain brass, Stainless Steel or Plated nuts are used to provide electrical connectivity with the chassis and are used to 'lock' the final nut. A minimum of one thread should protrude beyond the last nut. Ideal thread engagement is 1.5 x the thread diameter in Steel and 2 x in Aluminium.

(Brass, M5 Part No. 88700526-01, M6 Part No. 88700549-01)

7.2 Washers Plain

Plain brass, Stainless Steel or Plated washers are used to protect electrical ring terminal connections.

(Brass, M5 Part No. 880G5120-01, M6 Part No. 88700686-01)

7.3 Washers Shake-proof / serrated

Steel shake-proof washers are used to prevent nuts from loosening and to electrically connect metal surfaces.

(Steel, M5 Part No. 88701513-01, M6 Part No. 88701514-01)



7.4 Wire Terminals

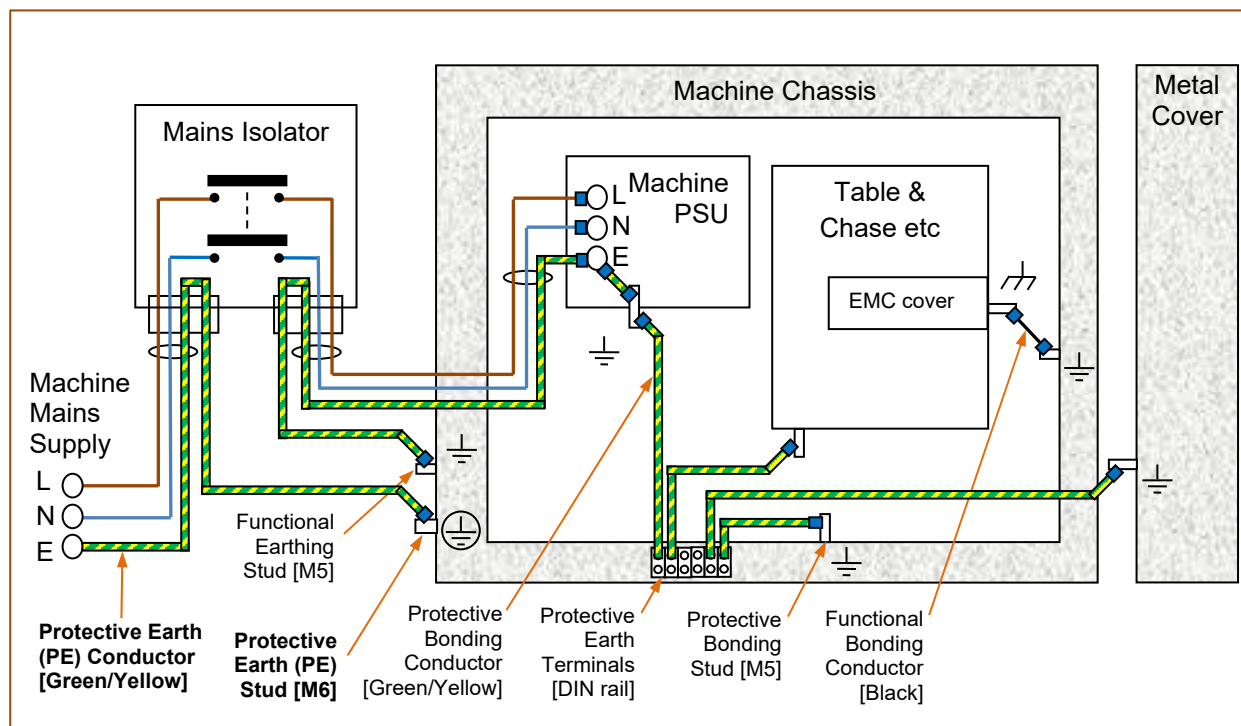
Ring terminals are used to terminate fixed earth wires.

(M5 Part No. 880E0479-01, M6 Part No. 88500311-01)

Female 6.35mm shrouded receptacles can be used to terminate metal cover earth wires.

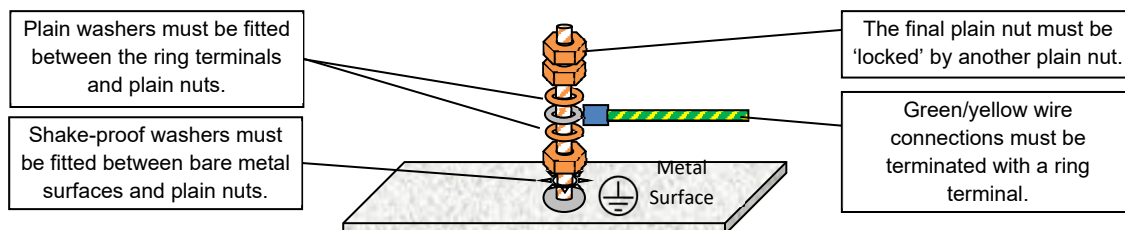
(Part No. 880E0478-01)

8 Schematic of Machine's Earth Connections

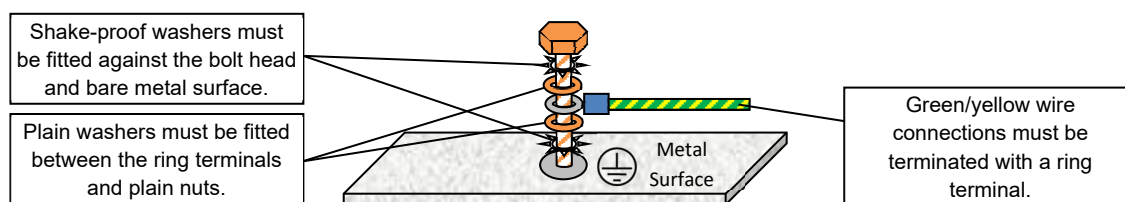


9 Earth Connection Assembly Examples

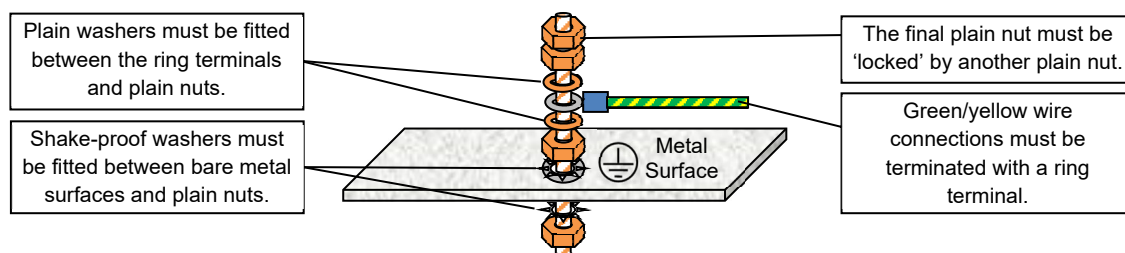
9.1 Stud Screwed into a Threaded Chassis Hole or Nut



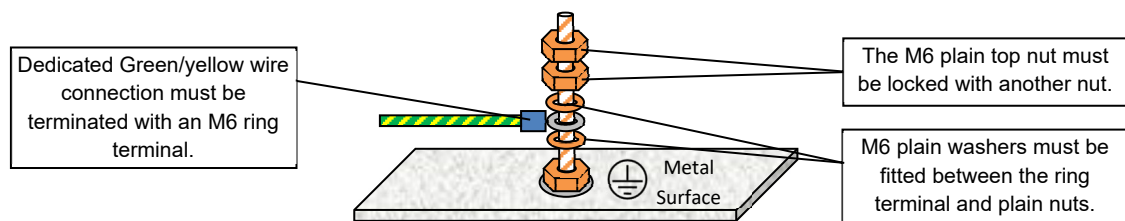
9.2 Earth Bolt Screwed into a Threaded Chassis Hole



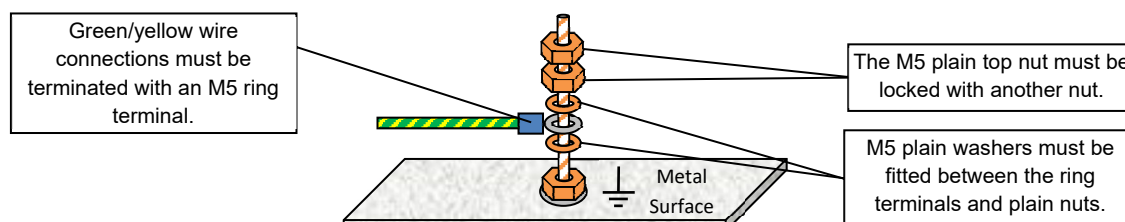
9.3 Stud Fixed into a Plain Chassis or Component Hole



9.4 M6 Protective Earthing (PE) Stud



9.5 M5 Protective Bonding Studs



10 Extracts from Standards

10.1 Minimum Size of Protective Bonding Conductors ³

Table 3B – Sizes of conductors

RATED CURRENT of equipment A	Minimum conductor sizes	
	Nominal cross-sectional area mm ²	AWG or kcmil [cross-sectional area in mm ²] see Note 2
[C] Up to and including 6	0,75 ^a	18 [0,8]
Over 6 up to and including 10	(0,75) ^b 1,0	16 [1,3]
Over 10 up to and including 16	(1,0) ^c 1,5	16 [1,3] [C]
Over 16 up to and including 25	2,5	12 [3]
Over 25 up to and including 32	4	10 [5]
Over 32 up to and including 40	6	8 [8]
Over 40 up to and including 63	10	6 [13]
Over 63 up to and including 80	16	4 [21]
Over 80 up to and including 100	25	2 [33]
Over 100 up to and including 125	35	1 [42]
Over 125 up to and including 160	50	0 [53]
Over 160 up to and including 190	70	000 [85]
Over 190 up to and including 230	95	0000 [107]
Over 230 up to and including 260	120	250 kcmil [126]
Over 260 up to and including 300	150	300 kcmil [152]
Over 300 up to and including 340	185	400 kcmil [202]
Over 340 up to and including 400	240	500 kcmil [253]
Over 400 up to and including 460	300	600 kcmil [304]
NOTE 1 IEC 60320 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by Footnotes a, b and c above. [C] Text deleted [C] NOTE 2 AWG and kcmil sizes are provided for information only. The associated cross-sectional areas, in square brackets, have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where 1 cmil is the area of a circle having a diameter of 1 mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America. ^a For RATED CURRENT up to 3 A, a nominal cross-sectional area of 0,5 mm² is permitted [C] Text deleted [C] provided that the length of the cord does not exceed 2 m. ^b The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 10 A in accordance with IEC 60320 (types C13, C15, C15A and C17) provided that the length of the cord does not exceed 2 m. ^c The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 16 A in accordance with IEC 60320 (types C19, C21 and C23) provided that the length of the cord does not exceed 2 m.		

³ BS EN 60950-1-2006+A2:2013, 3.2.5.1

10.2 Protective Earthing and Bonding Terminals

Equipment required to have protective earthing shall have a main protective earthing terminal.

...

Terminals shall be designed to resist accidental loosening of the conductor.

...

All pillar, stud or screw type protective earthing and protective bonding terminals shall comply with the minimum size requirements of Table 3E. ⁴

10.3 Sizes of Protective Earthing and Bonding Terminals ⁵

**Table 3E – Sizes of terminals for mains supply conductors
and protective earthing conductors ^a**

RATED CURRENT A up to and including	Conductor size mm ²	Minimum nominal thread diameter mm		Area of cross section mm ²	
		Pillar type or stud type	Screw type ^b	Pillar type or stud type	Screw type ^b
10	1	3,0	3,5	7	9,6
16	1,5	3,5	4,0	9,6	12,6
25	2,5	4,0	5,0	12,6	19,6
32	4	4,0	5,0	12,6	19,6
40	6	5,0	5,0	19,6	19,6
63	10 °	6,0	6,0	28	28
80	16 °	7,9	7,9	49	49

^a This table is also used for the sizes of terminals for PROTECTIVE BONDING CONDUCTORS if specified in 2.6.4.2.

^b "Screw type" refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.

^c As an alternative to the requirements of this table, the protective earthing conductor may be attached to special connectors, or suitable clamping means (for example, an upturned spade or closed loop pressure type; clamping unit type; saddle clamping unit type; mantle clamping unit type; etc.) that is secured by a screw and nut mechanism to the metal chassis of the equipment. The sum of the cross-sectional areas of the screw and the nut shall not be less than three times the cross-sectional area of the conductor size in Table 2D or Table 3B as applicable. The terminals shall comply with IEC 60998-1 and IEC 60999-1 or IEC 60999-2.

10.4 Connection of Accessible Parts

The following parts of equipment shall be reliably connected to the main protective earthing terminal of the equipment.

- Accessible conductive parts that might assume a HAZARDOUS VOLTAGE in the event of a single fault. ⁶

The accessible parts of Class I equipment (for example, chassis, frame and fixed metal parts of metal enclosures) other than those which cannot become hazardous shall be electrically interconnected and connected to a protective earth terminal for connection to an external protective conductor. This requirement can be met by structural parts providing adequate electrical continuity and applies whether the equipment is used on its own or incorporated in an assembly. ⁷

⁴ BS EN 60950-1-2006+A2:2013, 2.6.4.2

⁵ BS EN 60950-1-2006+A2:2013, 3.3.5

⁶ BS EN 60950-1-2006+A2:2013, 2.6.1

⁷ BS EN 61010-2-201:2018, 6.5.2.102

- The PROTECTIVE EARTH TERMINAL shall be of screw, stud or pressure type and shall be made of a suitable corrosion resistant material.
- The clamping means of PROTECTIVE EARTH TERMINALS shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a TOOL.
- The PROTECTIVE EARTH TERMINAL shall have no other function.

10.5 Protective Earthing

(Where the incoming mains earth is grounded to the machine chassis)

At each incoming supply point, the terminal for connection of the external protective earthing system or the external protective conductor shall be marked or labelled with the letters PE (see IEC 60445). ⁸

A wiring terminal intended for connection of a PROTECTIVE EARTHING CONDUCTOR shall be indicated by the symbol ⁹  ¹⁰

or with the letters PE, the graphical symbol being preferred,
or by use of the bicolour combination or GREEN-AND-YELLOW,
or by any combination of these.

These symbols shall not be located on screws or other parts that might be removed when conductors are being connected. ¹¹

The label is generally added to the sticker sheet for the machine in design. E.g., 03229561-01 for the TQ lower frame.

The following parts of equipment shall be reliably connected to the main protective earthing terminal of the equipment.

- Accessible conductive parts that might assume a HAZARDOUS VOLTAGE in the event of a single fault (see 1.4.14). ¹²

Separate wiring terminals shall be provided for the PROTECTIVE EARTHING CONDUCTOR, or one for each PROTECTIVE EARTHING CONDUCTOR if more than one is provided, and one or more for PROTECTIVE BONDING CONDUCTORS. ¹³

However, it is permitted to provide a single wiring terminal of the stud or screw type ... provided that the wiring termination of the PROTECTIVE EARTHING CONDUCTOR is separated by a nut from that of the PROTECTIVE BONDING CONDUCTORS.

10.6 Disconnection of Protective Earth

Protective earthing connections shall be such that disconnection of a protective earth at one point in a unit or a system does not break the protective earthing connection to other parts or units in a system, unless the relevant hazard is removed at the same time. ¹⁴

10.7 Protective Bonding Circuit

Equipotential bonding is for protection against electric shock. ¹⁵

(For instance, where machine panels are grounded to the machine chassis)

⁸ BS EN 60204-31:2013, 5.2

⁹ BS EN 60204-31:2013, 8.2.6

¹⁰ IEC 60417-5019 (DB:2002-10)

¹¹ BS EN 60950-1-2006+A2:2013, 1.7.7.1

¹² BS EN 60950-1-2006+A2:2013, 2.6.1

¹³ BS EN 60950-1-2006+A2:2013, 2.6.4.3

¹⁴ BS EN 60950-1-2006+A2:2013, 2.6.5.3

¹⁵ BS EN 60204-31:2013, definition

The protective bonding circuit consists of: ¹⁶

- PE terminal(s).
- The protective conductors in the equipment of the machine including sliding contacts where they are part of the circuit.
- The exposed conductor parts and conductive structural parts of the electrical equipment.
- Those extraneous conductive parts which form the structure of the machine.
- All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in that part of the protective bonding circuit.

Where a part is removed for any reason (for example routine maintenance), the protective bonding circuit for the remaining parts shall not be interrupted. ¹⁷

A continuity test shall be made. The resistance between the PE terminal and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source. Earthed PELV supplies can produce misleading results in this test and therefore shall not be used. NOTE Larger currents used for the continuity test increases the accuracy of the test result, especially with low resistance values, i.e., larger cross-sectional areas and/or lower conductor lengths¹⁸

Earthing conductors and their terminations shall not have excessive resistance.

...

- For equipment powered from a MAINS SUPPLY, if the PROTECTIVE CURRENT RATING of the circuit under test (see 2.6.3.3) is 16 A or less, the test current is 200 % of the PROTECTIVE CURRENT RATING applied for 120 s.

The resistance of the PROTECTIVE BONDING CONDUCTOR, calculated from the voltage drop, shall not exceed 0,1 Ω . After the test, the PROTECTIVE BONDING CONDUCTOR shall not be damaged. ¹⁹

The impedance between the PROTECTIVE CONDUCTOR TERMINAL and each ACCESSIBLE part for which PROTECTIVE BONDING is specified shall not exceed 0,1R. ²⁰

10.8 Screws for Protective Bonding

Self-tapping (thread-cutting and thread-forming) and spaced thread (sheet metal) screws are permitted to provide protective bonding but it shall not be necessary to disturb the connection during servicing.

In any case, the thickness of the metal part at the point where a screw is threaded into it shall not be less than twice the pitch of the screw thread. It is permitted to use local extrusion of a metal part to increase the effective thickness.

At least two screws shall be used for each connection. However, it is permitted to use a single screw provided that the thickness of the metal part at the point where the screw is threaded into it is a minimum of 0,9 mm for a screw of the thread-forming type and 1,6 mm for a screw of the thread-cutting type. ²¹

10.9 Functional Bonding/Earthing

Equipotential bonding necessary for proper functioning of electrical equipment. ²²

¹⁶ BS EN 60204-31:2013, 8.2.1

¹⁷ BS EN 60204-31:2013, 8.2.3

¹⁸ BS EN 60204-1:2018, 18.2.2

¹⁹ BS EN 60950-1:2006+A2:2013, 2.6.3.4

²⁰ BS EN 61010-1:2010+A1:2019, 6.5.2.4

²¹ BS EN 60950-1:2006+A2:2013, 2.6.5.7

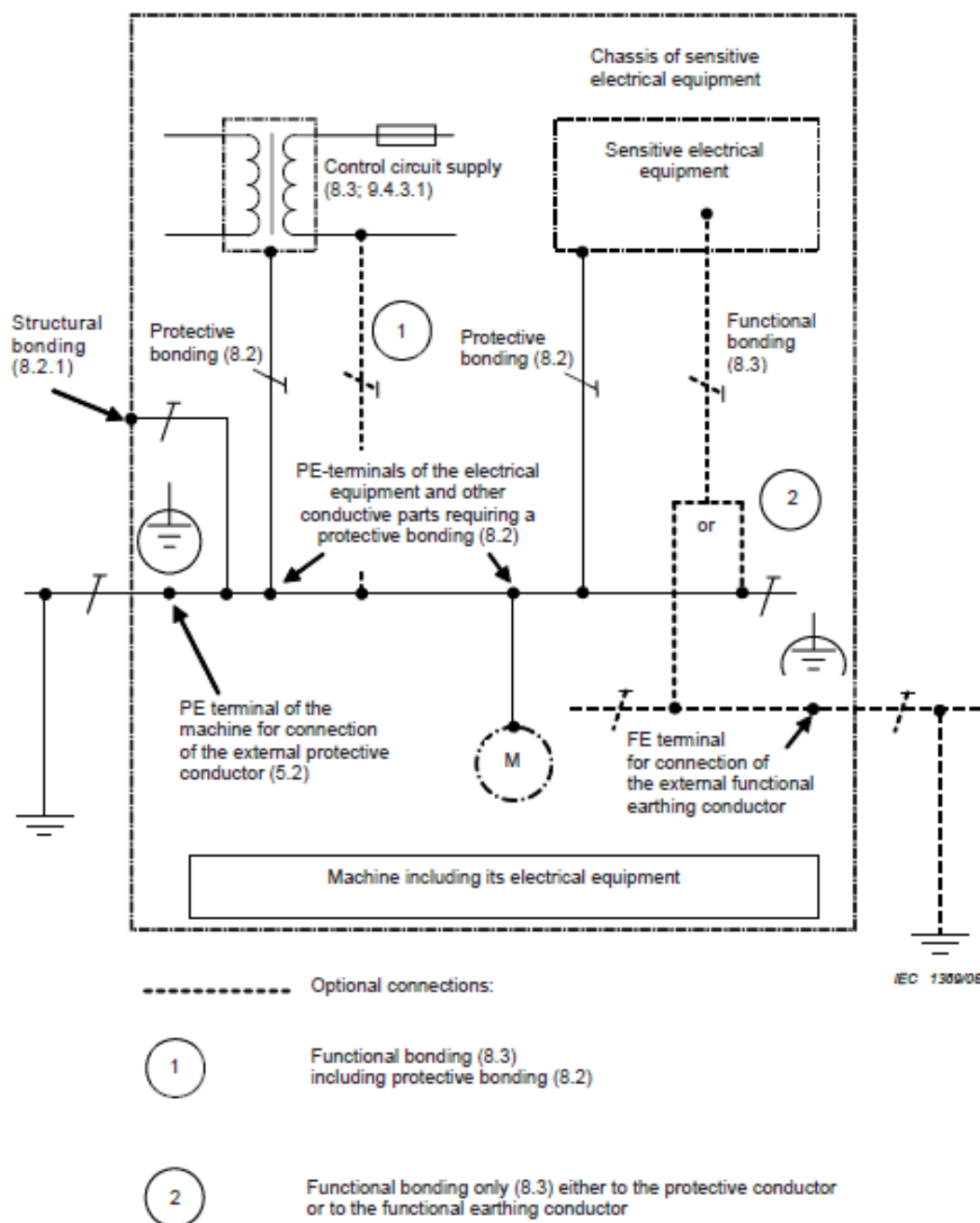
Earthing of a point in equipment or in a system, which is necessary for a purpose other than safety. ²³

(For instance, where cover panels are grounded for EMC or other reasons)

²² BS EN 60204-31:2013, definition

²³ BS EN 60950-1-2006+A2:2013, 1.2.13.9

10.10 Example of Equipotential Bonding for Machine Electrical Equipment ²⁴



NOTE The functional earthing conductor was previously referred to as 'noiseless earth conductor' and the 'FE' terminal was previously designated 'TE' (see IEC 60445).

²⁴ BS EN 60950-1-2006+A2:2013, 8.1