

This article looks at 543.7 *Earthing requirements for the installation of equipment having high protective conductor currents* - a new group of regulations included in BS 7671:2008 Requirements for Electrical Installations, The IEE Wiring Regulations 17th Edition.

543.7 is a new group of regulations which replaces the now deleted Section 607 *Earthing requirements for the installation of equipment having high protective conductor currents*. Section 607 was previously a Special Location in Part 6 of BS 7671 but, as this type of installation is commonplace, the requirements are now included within the main body of the Regulations as it is no longer considered to be a special location or installation.

Overview

Some items of electrical equipment are designed to have a current flowing in the protective conductor when in use; these currents are often created by switch-mode power-supplies.

Commonly, IT (Information Technology) or computer-processing equipment use switch-mode power-supplies in applications where a particular voltage is required for operation.

Other items, such as electronic ballasts in high-frequency fluorescent luminaires or variable speed drives



Courtesy of Reddilight Limited

are also known to create currents in protective conductors. Faulty and interconnected equipment can also create protective conductor currents.

In reality, considering that many modern "intelligent" electrical items such as washing machines, refrigerators, A/V equipment, etc., have embedded computer-processing, protective conductor currents are very common and not just a problem for industrial or commercial applications.

Essentially, the requirements of 543.7 are related to the levels of protective conductor current :

■ Individual items

Individual items of electrical equipment having a protective conductor current exceeding 3.5 mA but not exceeding 10 mA shall be either permanently connected to the fixed wiring of the installation or connected by means of a plug and socket-outlet complying with BS EN 60309-2, and

■ Accumulative current in the circuit

Where the accumulative protective conductor current in a final or distribution circuit is likely to exceed 10 mA, a high integrity connection shall be provided.

Levels of protective conductor current

The levels of expected protective conductor current will vary depending on the type of electrical equipment. *BS EN 60335-1 Household and similar electrical appliances - Safety - Part 1: General requirements* states the fundamental conditions to which items of electrical equipment are manufactured and, hence, should perform when used under normal operating conditions.

Clause 13.2 of BS EN 60335 states that after the appliance has been operated for a duration corresponding to the most unfavourable conditions of normal use, the leakage current (protective conductor current) shall

not exceed the values shown in figure 1.

For terminology purposes, the term "high" protective conductor current is used when values of current exceed 3.5 mA flowing in the protective conductor.

The dangers

Where a current flows in a protective conductor, a voltage will present along the length of the conductor and Ohm's law dictates the size of the potential difference. If the connection to the means of earthing is lost then the metallic chassis of the electrical equipment will rise in potential in respect to Earth. Should a person or livestock make contact with the metallic chassis then current is likely to flow resulting in an electric shock.

The requirements of 543.7

Regulation 543.7.1.1 requires that individual items of electrical equipment having a protective conductor current above 3.5 mA but not exceeding 10 mA should be either permanently connected to the fixed wiring, see figure 2, of the installation or connected by means of a plug and socket-outlet, see figure 3, complying with BS EN 60309-2.

An earth monitoring system to BS 4444

An earth monitoring system to BS 4444 (see figure 4) installed which, in the event of a continuity fault occurring in the protective conductor, automatically disconnects the supply to the equipment.

The connection of equipment

The table shown in figure 5 (overleaf), shows the level of protective conductor current with the requirements of BS 7671:2008 for equipment.

Final and distribution circuits

The table overleaf in figure 6 shows the requirements of BS 7671:2008 for every final circuit and distribution

Class of equipment			Protective conductor
All	Portable, handheld, movable, etc. equipment	Stationary equipment	current (mA)
II			0.25
0			0.5
0I			0.5
III			0.5
	I		0.75
		I motor-operated appliances	3.5
		I heating appliances	0.75 mA, or 0.75 mA per kW rated power input of the appliance with a maximum of 5 mA, whichever is higher

Figure 1: Leakage currents as stated in Clause 13.2 of BS EN 60335



Figure 2: Example of a method of permanent connection to fixed wiring - a fused connection unit Courtesy of MK



Figure 3: Example of connection using socket-outlet to BS EN 60309-2 Courtesy of MK

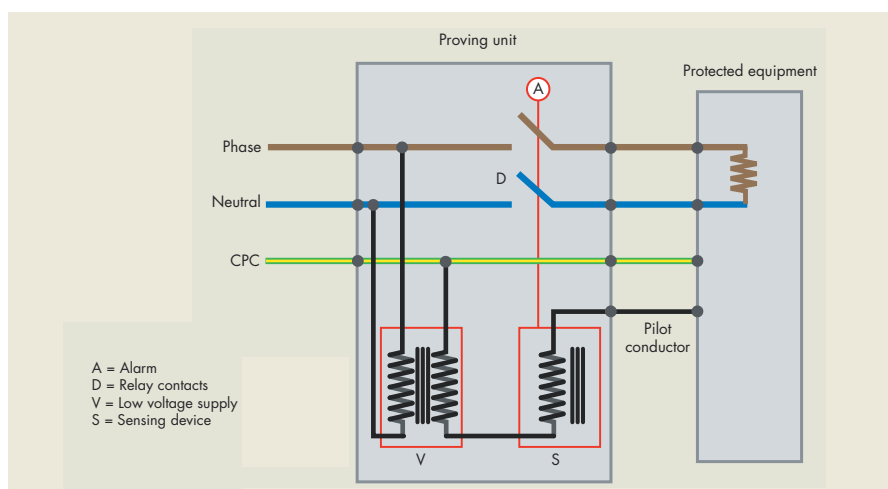


Figure 4: Simplified circuit for an earth proving unit

Regulation number BS 7671:2008	Current (mA)	The requirements of BS 7671:2008			
Common rules Chapter 51	0 ↓	No further requirements			
543.7.1.1	3.5 ↓	Equipment shall be	→ permanently connected to the installation or → by means of a plug and socket-outlet to BS EN 60309-2		
543.7.1.2	10 ↓	Equipment shall be	→ permanently connected to the installation, the distribution and final circuits shall be	→ a single CPC 10 mm ² minimum or → or a single copper conductor, 4 mm ² minimum with mechanical protection or	
			→	two individual CPCs or	Where CPCs are part of a multicore cable, the sum of all conductors shall not be less than 10 mm ²
			→	monitored by an earth monitoring device to BS 4444	In the event of CPC continuity failure, the supply is automatically disconnected
		→	connected by a flexible cable with a plug and socket-outlet to BS EN 60309-2	→ the CPC of the flexible cable not less than:	2.5 mm ² for 16 A plugs 4 mm ² for plugs 32 A and above
			→	the CPC of the flexible cable not less than the line conductor	
		→	a protective conductor complying with Section 543 generally and monitored by an earth monitoring device to BS 4444 (see figure 4)	→ In the event of CPC continuity failure, the supply is automatically disconnected	

Figure 5: Table showing the requirements of BS 7671 in relation to protective conductor current of equipment

circuit intended to supply one or more items of equipment, such that the total protective conductor current is likely to exceed 10 mA:

Residual Current Devices

Regulation 411.3.3 requires that socket outlets, not exceeding 20 A, that are for use by ordinary persons intended for general use, are protected by an RCD rated at 30 mA or less, with an operating time not exceeding 40 ms at a residual current of 5 I_{Δn}; an exception is permitted if the socket-outlets are under the supervision of skilled or instructed persons.

When designing such circuits, the

designer must be aware of the type of equipment likely to be supplied.

Accumulative high protective conductor currents, in addition to starting surges when many items are energised simultaneously, can cause the RCD to operate.

As there is no testing requirement between 0.5 I_{Δn} and I_{Δn}, it is fair to assume that a 30 mA RCD could operate at any level of residual current greater than 15 mA. Therefore, it would be pertinent to design high protective conductor currents for any circuit protected by an RCD rated at 30 mA at a level no greater than 15 mA. See Guidance Note 3 for

more information on the testing of RCDs.

Labelling at distribution boards

Circuits at distribution boards with high protective conductor currents are to be labelled accordingly so that persons working on the distribution boards can maintain the protective precautions taken. The labelling information is to be in accordance with Regulation 543.7.1.5.

Where a circuit has or is likely to have a high protective conductor current, the protective conductor connection arrangements at the distribution board will be affected by,

Regulation number BS 7671:2008	Current (mA)	The requirements of BS 7671:2008	
543.7.1.3	>10	→	a single CPC 10 mm ² minimum
	The wiring of every final circuit and distribution circuit intended to supply one or more items of equipment, such that the total protective conductor current is likely to exceed 10 mA, shall have a high integrity protective connection complying with one or more of the following:	→	a single copper conductor, 4 mm ² minimum with mechanical protection
		→	two individual CPCs
		→	Where CPCs are part of a multicore cable, the sum of all conductors shall not be less than 10 mm ²
		→	monitored by an earth monitoring device to BS 4444 (see figure 4)
		→	In the event of CPC continuity failure, the supply is automatically disconnected

Figure 6: Table showing the requirements of BS 7671 in relation to the protective conductor current of circuits

for example, the sequence of connections.

Regulation 543.7.1.4 requires that where two protective conductors are utilised they are to be terminated independently of each other at all connection points, including accessories. This may pose a problem at the earth bar of the distribution board, i.e. there may not be an adequate number of spare ways to terminate conductors separately. Some large distribution boards may be provided with many spare terminals on the earth bar, whilst some manufacturers may supply an accessory kit to add extra ways. Where this is not an option, the following solution is one method of meeting the requirements:

The example is that the electrical installation has a six-way distribution/consumer unit and consists of six circuits:

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DB 1

- 1 Ring final circuit with high protective conductor current
- 2 Radial circuit with high protective conductor current
- 3 Ring final circuit
- 4 Radial circuit
- 5 Radial circuit
- 6 Radial circuit

Regulation 543.7.1.4 requires that where two protective conductors are used on circuits with high protective conductor currents, they are to be terminated into separate ways on the earth bar.

By installing circuits 1 and 2 across two-ways of the earth bar, in addition to marking each conductor with the correct circuit-identification ferrule, there is no ambiguity as to the function of each conductor (see figure 7).

Regulation 543.7.1.5 requires that information is provided at the distribution board indicating those circuits having a high protective conductor current (see figure 8).

Further information

- Guidance Note 1
- Guidance Note 3
- Guidance Note 5

Thanks to MK (mk.technical@honeywell.com) and Reddilight Limited (info@reddilight.co.uk) for the images used. ■

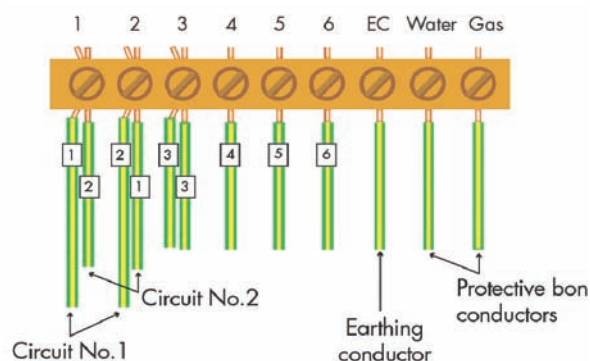


Figure 7: Termination of circuits with high protective conductor currents at the earth bar

DB1

The following circuits have high protective conductor current:

- 1 Ring final circuit with high protective conductor currents
- 2 Radial circuit with high protective conductor currents

Figure 8: Information in accordance with Regulation 543.7.1.5 indicating those circuits with high protective conductor current