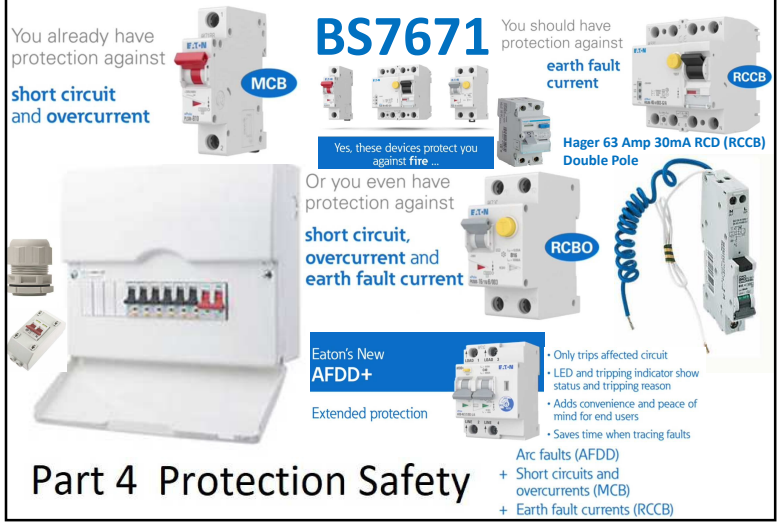
2018 18th Edition (BLUE BOOK)



Part 4 – Protection for Safety

Chapter 41 – Protection against Electric Shock

Chapter 42 – Protection against Thermal Effects

Chapter 43 – Protection against Overcurrent

Chapter 44 – Protection against Voltage variations

Part 4 – Protection for Safety

Chapter 41 – Protection against Electric Shock

411 – Automatic disconnection

412 – Class II Equipment

413 – Electrical Separation Part 1

414 – Separated Extra Voltage (SELV)

415 – Additional Protection (RCD, MCB)

416 – Barriers and Enclosures

417 – Obstacles and Placing Out Of Reach

418 – Non Conducting Location

Part 4 – Protection for Safety

Methods of reducing the likelihood of electric shock

1. Limit the **current flow to a person**
2. Limit the **current flow through a person**
3. Limit the **duration of the shock**

Part 4 – Protection for Safety

1. Limit the current flow to a person (Basic Protection)

- Insulation (416)
- Class II equipment (412)
- Barriers and enclosures (416.2)
- Non-conducting Location (418.1)

  restricted to trained personnel
- Obstacles and Placing Out Of Reach (417)
- Electrical Separation (413, 418.3)

Part 4 – Protection for Safety

2. Limit the current flow through a person

(Basic & Fault Protection)

- SELV (414)
- PELV (414)
- FELV (**411.7**)
- RLV (411.8)
- PROTECTIVE BONDING (415.2)
- EARTH FREE - PROTECTIVE 'EARTH' BONDING ZONE (418.2)

"…intended to prevent the appearance of a dangerous touch voltage"

Part 4 – Protection for Safety

3. Limit the **duration of the shock**

(Fault Protection)

- AUTOMATIC DISCONNECTION OF SUPPLY

  (RCD, OPD not shock protection) (411)
- RCD IN TT SYSTEMS (411.5)

Part 4 – Protection for Safety

Certain conditions apply for Automatic Protection (ADS) 411.4.4

1. Under fault conditions the supply must be disconnected from a circuit within the time stated - Table 41.1
2. Have an Earth Fault Loop Impedance below or equal to Uo/Ia - Tables 41.2 and 41.3
3. **This has changed to...Uo x Cmin /Ia**

Part 4 – Protection for Safety

From the BS7671 DPC 17th Edition Amendment 3

NOTE 1: The circuit loop impedances given in the table should not be exceeded when;
(i) the line conductors are at ~~their normal~~ the appropriate maximum permitted operating temperature, as given in Table 52.1, and
(ii) the circuit protective conductors are at the appropriate assumed initial temperature, as given in Tables 54.2 to 54.5.
If the conductors are at a different temperature when tested, the reading should be adjusted accordingly. See Appendix 14.

NOTE 2: The circuit loop impedances have been determined using a value for factor C_{min} of 0.95.

$$Z_s \leq \frac{U_0}{I_a} \longrightarrow Z_s \times I_a \leq U_0 \times C_{min}$$

Adjusts for a lower European supply voltage 230V-220V

Changes in supply voltages at sub-station transformers

411 - Shock Protection

Automatic disconnection under fault conditions
Instantaneous disconnection assumes 5 x In for a type 'B' MCB
Zs Maximum = Uo (218.5V) / 5 x In
Assumed touch voltage (right hand side of Table 41.3)

Type	Amd 2	Amd 3	Time(s)	Zs
B	46/In	43.7/In	0.1 - 5	Max
C	23/In	21.9/In	0.1 - 5	Max
D	11.5/In	10.9/In	0.1 - 3	Max
D	N/A	21.9/In	5	Max

Part 4 – Protection for Safety

The functioning of the symbols with regard to calculating Zs

411.4.4 The characteristics of the protective devices (see Regulation 411.4.5) and the circuit impedances shall fulfil the following requirement:

$Z_s \times I_a \leq U_0 \times C_{min}$

where:

Z_s is the impedance in ohms (Ω) of the fault loop comprising:
- the source
- the line conductor up to the point of the fault, and
- the protective conductor between the point of the fault and the source

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in Regulation 411.3.2.2, or Regulation 411.3.2.3. When an RCD is used this current is the residual operating current providing disconnection in the time specified in Regulation 411.3.2.2, or Regulation 411.3.2.3

U_0 nominal AC rms or ripple-free DC line voltage to Earth

C_{min} is the minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

NOTE: For a low voltage supply given in accordance with the Electricity Safety, Quality and Continuity Regulations , C_{min} is given the value 0.95.

Fault and Short Circuit Protection

Table 41.3 Maximum Zs for 0.1-5 Seconds disconnection

(a) Type B circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009

Rating (amperes)	3	6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)	14.57	7.28	4.37	2.73	2.19	1.75	1.37	1.09	0.87	0.69	0.55	0.44	0.35	$43.7/I_n$

(b) Type C circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009

Rating (amperes)	6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)	3.64	2.19	1.37	1.09	0.87	0.68	0.55	0.44	0.35	0.27	0.22	0.17	$21.9/I_n$

(c) Type D circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009

Rating (amperes)	6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms) 0.4 seconds	1.82	1.09	0.68	0.55	0.44	0.34	0.27	0.22	0.17	0.14	0.11	0.09	$10.9/I_n$
Z_s (ohms) 5 seconds	3.64	2.19	1.37	1.09	0.87	0.68	0.55	0.44	0.35	0.27	0.22	0.17	$21.9/I_n$

For the above devices :

Type B	Type C	Type D	Type D
$43.7/I_n$	$21.9/I_n$	$10.9/I_n$	$21.9/I_n$

Part 4 – Protection for Safety

TABLE 41.3 –
Maximum earth fault loop impedance (Z_s) for circuit-breakers with U_0 of 230 V, for operation giving compliance with the 0.4 s disconnection time of Regulation 411.3.2.2 and 5 s disconnection time of Regulation 411.3.2.3 (for RCBOs see also Regulation 411.4.204)

(a) Type B circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1														
Rating (amperes)	3	6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)	14.57	7.28	4.37	2.73	2.19	1.75	1.37	1.09	0.87	0.69	0.55	0.44	0.35	230 x 0.95/(5I_n)
(b) Type C circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1														
Rating (amperes)		6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)		3.64	2.19	1.37	1.09	0.87	0.68	0.55	0.44	0.35	0.27	0.22	0.17	230 x 0.95/(10I_n)
(c) Type D circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1														
Rating (amperes)		6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms) 0.4 sec		1.82	1.09	0.68	0.55	0.44	0.34	0.27	0.22	0.17	0.14	0.11	0.09	230 x 0.95/(20I_n)
Z_s (ohms) 5 secs		3.64	2.19	1.37	1.09	0.87	0.68	0.55	0.44	0.35	0.27	0.22	0.17	230 x 0.95/(10I_n)

NOTE 1: The circuit loop impedances have been determined using a value for factor C_{min} of 0.95.

Part 4 – Protection for Safety

Maximum Zs for Fuses to BS 88-2, BS 88-3, BS 3036 & BS 1362

TABLE 41.2 –
Maximum earth fault loop impedance (Z_s) for fuses, for 0.4 s disconnection time with U_0 of 230 V (see Regulation 411.4.201)

(a) General purpose (gG) and motor circuit application (gM) fuses to BS 88-2 – fuse systems E (boltcd) and G (clip-in)											
Rating (amperes)	2	4	6	10	16	20	25	32	40	50	63
Z_s (ohms)	33.1	15.6	7.80	4.65	2.43	1.68	1.29	0.99	0.75	0.57	0.44

(b) Fuses to BS 88-3 fuse system C						
Rating (amperes)	5	16	20	32	45	63
Z_s (ohms)	9.93	2.30	1.93	0.91	0.57	0.36

(c) Fuses to BS 3036						
Rating (amperes)	5	15	20	30	45	60
Z_s (ohms)	9.10	2.43	1.68	1.04	0.56	0.40

(d) Fuses to BS 1362		
Rating (amperes)	3	13
Z_s (ohms)	15.6	2.30

NOTE 1: The circuit loop impedances have been determined using a value for factor C_{min} of 0.95.

Part 4 – Protection for Safety

412. Protection by Double or Reinforced Insulation

412 PROTECTIVE MEASURE: DOUBLE OR REINFORCED INSULATION

412.2 Requirements for basic protection and fault protection

412.2.1.1 Electrical equipment shall be of the following types, type-tested and marked to the relevant standards:

(i) Electrical equipment having double or reinforced insulation (Class II equipment)

(ii) Electrical equipment declared in the relevant product standard as equivalent to Class II, such as assemblies of electrical equipment having total insulation (see BS EN 61439-1).

NOTE: This equipment is identified by the symbol ⧈ Refer to BS EN 60417: Class II equipment.

Part 4 – Protection for Safety

414 Protection through Extra Low Voltages

414 PROTECTIVE MEASURE: EXTRA-LOW VOLTAGE PROVIDED BY SELV OR PELV

414.2 Requirements for basic protection and fault protection

Both basic protection and fault protection ~~is~~ are deemed to be provided where:

(i) the nominal voltage cannot exceed the upper limit of voltage Band I, and

(ii) the supply is from one of the sources listed in Regulation 414.3, and

(iii) the conditions of Regulation 414.4 are fulfilled.

NOTE 1: If the system is …

Band 1 voltages: <50Vac, 120Vdc

Band 2 Voltages: >50Vac < 1000Vac, >120Vdc < 1500Vdc

Part 4 – Protection for Safety

Chapter 41 - Protection against Electric Shock

Part 4 – Protection for Safety

Chapter 41 - Protection against Electric Shock

Fault Protection
(Indirect Contact)

Part 4 – Protection for Safety

416 - 417 Basic Protection (Direct Contact)

Basic Insulation of Live Parts (416.1)

Barriers or Enclosures (416.2)

Obstacles(417.2),Placing out of Reach (417.3)

Class II Equipment (412)

Part 4 – Protection for Safety

418 Basic Protection where supervised by a skilled or instructed person

Non-conducting Location (418.1)
(no earth contact at sockets)

Earth Free Local Equipotential Bonding (418.2)
(Faraday's Cage)

Electrical separation from more than one item of electrical equipment (418.3)
e.g., common neutrals in IT systems