IET Wiring Regulations

BS 7671: 2008

(Incorporating amendment no 3: 2015 and the ‘On Site Guide’)

Overview and application

Work book to be used in the course (20.5.16)

These notes and questions are written with a more practical flavour so that as practicing electricians we can discuss how to apply the sometimes difficult language of the regulations in a more day to day on-site situation.
We may not use all the questions, but feel free to address them in your own time if you want.

Practical applications of BS 7671 2008.

Part 1.

1. BS 7671 includes requirements for:

a) lift installation covered by BS 5655
b) equipment of fixed offshore installations
c) equipment for aircraft
d) fairgrounds

2. Which one of the following electrical installations is **NOT** covered by BS 7671?

a) public premises
b) construction sites
c) prefabricated buildings
d) lightning protection of buildings to BS EN 62305

3. Which of the following electrical installations needs to comply with BS 7671 and be supplemented by the requirements of other British standards or similar?

a) construction sites
b) exhibitions and fairgrounds
c) aircraft
d) emergency lighting

4. The IET Regulations are non-statutory but, if they are adhered to compliance with which one of the following statutory regulations is most likely?

a) Electricity Safety, Quality and Continuity Regulations 2002
b) Electricity at Work Regulations 1989
c) Cinematograph Regulations 1955
d) The Health and Safety at Work Act 1974

Part 2.

12. An overcurrent occurring in a circuit that is electrically sound is defined as:

a) leakage current
b) overload current
c) protective conductor current
d) short circuit current

13. Which one of the following is an exposed conductive part?

a) a water pipe
b) the casing of Class II equipment
c) a metal central heating radiator
d) the casing of a central heating pump

14. A d.c. voltage of 80V between conductors is classified as being:

a) extra low voltage
b) low voltage
c) separated extra low voltage
d) functional extra low voltage

15. Class II equipment:

a) must be earthed
b) is supplied by a separated safety source
c) must not be earthed
d) must be RCD protected

16. Protective conductor current is a current that:

a) is the same value as the design current
b) only flows when there is an earth fault
c) flows due to leakage or earth fault
d) always operates an RCD

17. SELV stands for:

a) safety extra low voltage
b) separated extra low voltage
c) safety extended low voltage
d) separated enabled voltage

18. The limit of ‘Arms reach’ below and under an occupied surface extends;
    a) 2.5m
    b) 1.25m
    c) 0.75m
    d) 0.25m

19. Where would you find an ‘earthing conductor’?
    a) Earthing any class I equipment
    b) Between the MET and the earthing facility
    c) Earthing all extraneous conductive parts
    d) Between pipe work in a bathroom

20. Which of the following is an ‘extraneous conductive part’
    a) The metallic body of a class I light fitting
    b) The metallic body of a class II light fitting
    c) The metal work of an electric radiator
    d) The metal steel work of a factory structure embedded in the ground

21. Is a neutral a live part?

22. A ‘system’ that utilises the supply neutral <u>as</u> the cpc is;
    a) TN-S
    b) TN-C-S
    c) TT
    d) IT

23. Which of the following provides correct ‘discrimination’ of fuses;
    a) Appliance – 3A, circuit - 60A, distribution board – 50A
    b) Distribution board – 60A, circuit – 20A, appliance – 13A
    c) Circuit – 13A, distribution board – 10, appliance – 13A
    d) Appliance – 5A, circuit – 32A, distribution board – 32A

24. Which of the following is the correct terminology;
    a) Live, neutral, earth
    b) Live, neutral, cpc
    c) Line, neutral, earth
    d) Line, neutral, cpc

25. 'A function intended to cut off for reasons of safety the supply from every source of energy' is defined as;
    a) An isolator
    b) Functional switch
    c) Switch-disconnector
    d) Isolation

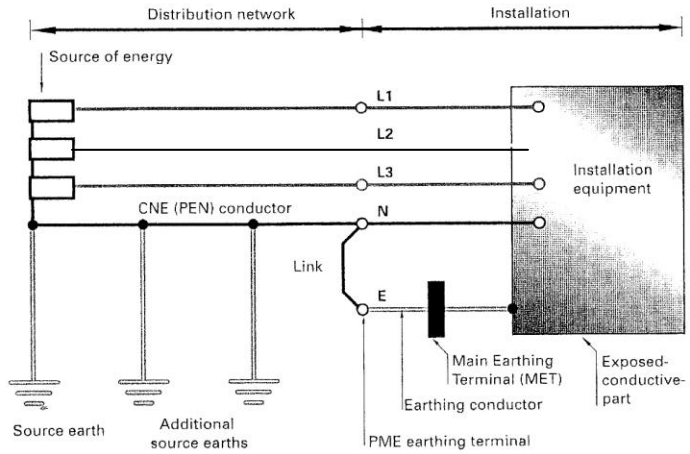
26. In a medical location which of the following would be found in a group 2 area
    a) Surgical operations
    b) External examinations
    c) Physiotherapy
    d) Consultations

27. A protective conductor does NOT connect to which of the following;
    a) Earth electrode
    b) Exposed-conductive-parts
    c) D.c negative
    d) Extraneous-conductive-parts

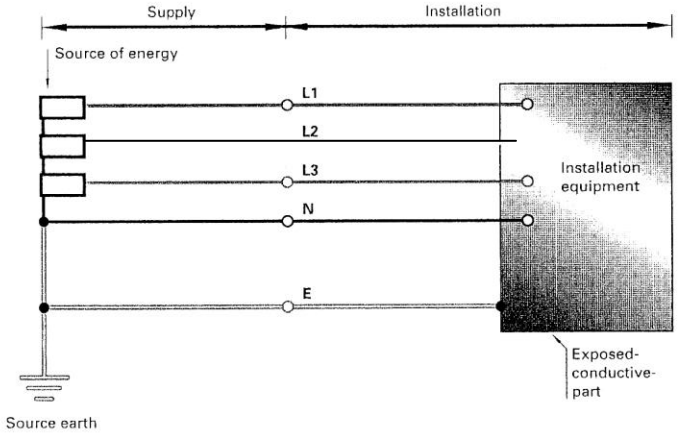
28. Which earthing system utilises a separate dedicated protective conductor for the connection to the source earth in the supply cable;
    a) TT
    b) TN-S
    c) TN-C-S
    d) IT

29. In a TN-C-S system;
    a) A separate independent earth electrode is used at the installation
    b) A combined earthed neutral is used as the supply cable
    c) There is no direct connection to earth
    d) A combined neutral and protective conductor is used throughout the system

Simple line diagram of a TN-C-S system with PME applied



TN-S system



TT system

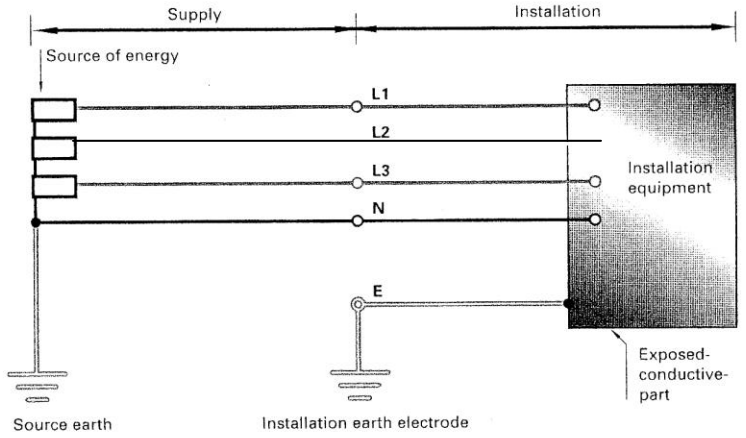


Fig 4

Part 3 and the 'On-site-guide'

1. What does 'diversity' allow for?

2. What current demand do we allow for a discharge light fitting?

3. What would be the maximum demand of a household distribution board feeding;
    a. lighting cct 1 with 10 fittings
    b. lighting cct 2 with 12 fittings
    c. 32A ring final circuit
    d. 20A radial socket circuit
    e. 3KW thermostatic water heater

Cct no	Description	Full load (amps)	Diversity allowance %	Revised full load

Max demand Total =

4. What would be the maximum demand of an office distribution board feeding;
    a. Lighting cct 1 with 15 x 35W modular fittings
    b. Lighting cct 2 with 18 x 35W modular fittings
    c. 32A ring main 1
    d. 32A ring main 2
    e. 20A radial sockets 1
    f. 20A radial sockets 2
    g. 3KW thermostatic water heater
    h. Cooker, comprising 4 x 1.5KW hob elements, 2kW main oven, 2kW grill, without socket outlet.

Cct no	Description	Full load (amps)	Diversity allowance %	Revised full load

Max demand Total =

5. Refer to the TTE workshop shop drawing, determine the maximum demand of the distribution board to feed all the machines and circuits required.

Cct no	Description	Full load (amps)	Estimated diversity %	Revised full load
1 L1				
2 L2				
3 L3				
4 L1				
5 L2				
6 L3				
7 L1				
8 L2				
9 L3				
10 L1				
11 L2				
12 L3				
13 L1				
14 L2				
15 L3				
16 L1				
17 L2				
18 L3				
19 L1				
20 L2				
21 L3				
22 L1				
23 L2				
24 L3				
25 L1				
26 L2				
27 L3				
28 L1				
29 L2				
30 L3				
31 L1				
32 L2				
33 L3				
34 L1				
35 L2				
36 L3				

Max demand Total =

Appendix 15 of BS 7671

6. Illustrate the three wiring options available for supplying socket outlets?

7. What is the recommended maximum area to be served by a 32A ring main? (see appendix 15)

8. How many sockets can be connected to an un-fused spur?

9. How many sockets can be connected to a fused spur (FCU)?

10. Should you feed a space heater or an immersion heater off a ring main?

11. Should you connect a cooker into a ring?

12. What is the minimum csa of the cable to be used to feed a socket outlet off a fused connection unit?

13. Can you spur off a 4.00mm^2 32A radial to a socket, with a 2.5mm^2 cable with-out a fused spur?

14. Referring to the plans of a proposed building attached, mark out a suggested number and position of lights, sockets and accessories, and 'a way' of best dividing up the following installation into circuits.

    A single story office building with;

I. 1 lobby with 4 sockets, 10 2D fluorescent lights 36W each
II. 4 rooms each with 10 PCs (2 doubles per PC recommended), and 400W of modular lighting 50W each.
III. 1 kitchen with 1x 32A cooker, kettle, microwave and dish washer (10A load each), and 100W of fluorescent strip lighting 50W each
IV. 1 board room with PC and projector, 20 recessed spot lights 50 W each
V. 2 washrooms with hand dryer, 4 x 2D fluorescent light 36W each
VI. 1 server plugged into a dedicated 13A socket (10A load)
VII. 1 phone system plugged into a dedicated 13A socket (8A load)
VIII. 1 heating boiler fused switch spur (5A load)
IX. Car park lighting (6 x 70W SON discharge light fittings)
X. Fire alarm dedicated supply (3A load)
XI. Door entry system (5A load)
XII. Intruder alarm (3A load)

Consideration should be given to

a) Number of lighting circuits, and areas to be covered
b) Number of socket outlet circuits, and areas to be covered
c) The need for dedicated circuits to specific items of equipment ie the server, phone system, fire alarm etc.
d) Inconvenience and disruption if one socket outlet circuit in an area goes faulty

Then calculate the maximum demand allowing for diversity, use the back blank table sheet to form a circuit table.

Part 4

Chapter 41.

Disconnection times

1. What is the disconnection time required for a 230Va.c, 6A lighting circuit in a TN system?

2. What is the disconnection time required for a 230Va.c, 32A distribution circuit in a TN system?

3. What is the disconnection time required for a 400V (line to earth Uo) a.c, 20A final circuit in a TT system?

4. What is the disconnection time required for a 230Va.c, 63A distribution circuit in a TT system?

5. Find the disconnection time of a 110Va.c 16A circuit feeding a pump control system in a TN system?

6. Additional protection for a socket outlet shall be provided by what?

7. What is the formula for calculating maximum permitted Earth Loop Impedance?

8. What is the formula for calculating 'actual' Earth loop impedance of a circuit?

Time / fault current characteristics of devices

9. What fault current will cause a BS 88-2 32A fuse to blow in 0.4 seconds?

10. How fast will a type C 80A mcb (BS 60898) trip if a fault current of 150A flows through it?

11. What is the minimum amount of current required to trip a 6A type B circuit breaker?

12. Given a fault current of 900Amps, what is the approximate disconnection time of a 60A BS 3036 fuse?

13. What amount of fault current will cause a 25A Type C RCBO to BS EN 61009-1 to trip in 600 seconds?

14. How fast will a Type B 10A circuit breaker trip given a fault current of 1000Amps?

Maximum earth loop impedance tables (TN systems)

15. What is the max earth fault loop impedance for a 15A BS 3036 fused circuit feeding a socket outlet in a TN system?

16. Find the maximum permitted earth fault loop impedance for a 125A distribution circuit protected by a BS 88-2 fuse in a TN system?

17. What is the max permitted earth fault loop impedance for a 32 A ring main protected by a BS 88-2 fuse in a TN system?

18. What is the max permitted earth fault loop impedance for a 3 ph machine, protected by a triple pole BS 60898 type D 50 amp mcb in a TN system?

19. A 16Amp BS 88-2 fuse protects a water heater for shock protection, what is the maximum permitted earth fault loop impedance?

20. What is the Max Zs permitted for a 32A Type B RCBO feeding a ring main?

On-site-guide

Determining the earth fault loop impedance of a circuit at the design stage (see Appendix I tables 11, 12, 13)

21. What would the R1 + R2 be for a 2.5mm²/1.5mm² twin & earth cable if the length of the run is 25m?

22. Referring to the above circuit, what would be the expected Zs if the ‘external loop impedance = 0.23Ω?

23. If the circuit above feeds a socket outlet, and is protected by a 20A type B circuit breaker, does it comply with the maximum Zs values permitted by the regulations for a TN system?

24. What would the R1 + R2 be for a 35.00mm² SWA 4 core cable (cpc is one of the cores), if the length of run is 48m?

25. Referring to the above circuit, if the Zs of the distribution board to feed the circuit is 0.35Ω, what would be the expected Zs at the end of the circuit?

26. Referring to the above circuit, does the circuit above comply with maximum Zs values assuming it is a TN system, and is protected with an 80A BS 88-2 fuse?

TT systems earth fault protection

27. An RCD is used as earth fault protection in a 230V TT system what disconnection time is required, if the circuit feeds a distribution board?

28. What is the maximum voltage permitted to exist between the equipment and earth during a fault

29. What maximum earth fault loop impedance is required if the RCD is rated at 100mA?

30. Where in doubt about the seasonal drying out of the earth, what maximum earth fault loop impedance is required to ensure 'stability'?

31. Why is it unlikely that an overcurrent protective device could be used as earth fault protection in a TT system?

Chapter 43

1. The definition ‘overcurrent’ covers both …..……...……..and……(430.1)

2. Which of the following circuits could NOT overload:
an immersion heater, lighting circuit, 20A radial feeding sockets, shower, large extraction fan motor, distribution circuit?

3. A single phase distribution circuit has a design current of 18A (Ib) after diversity, what rating mcb (In) and minimum cable rating (Iz) is required? (433.1.1)

4. Referring to question 3 above, if the cable is 70°C single-core thermoplastic, clipped direct, what size cables are required? (Table 4D1A)

5. A three phase motor has a full load current of 58A (Ib), what rating fuse and cable is required?

6. If the cable is ‘multicore armoured 90°C thermosetting insulated copper cable’, mounted on tray, what size will it be?

7. Correct co-ordination between conductors and overload protection device is achieved when:

   a) In is not less than the design current Ib
   b) In exceeds the lowest current carrying capacity Iz
   c) the current causing effective operation (I_2) exceeds 1.45 x Iz
   d) Ib is greater than Iz

8. The requirements for overload current protection are fulfilled when:

   a) Ib = 15A, In = 20A, Iz = 18A
   b) Ib = 20A, In = 15A, Iz = 15A
   c) Ib = 10A, In = 15A, Iz = 18A
   d) Ib = 2.5A, In = 10A, Iz = 8A

Appendix 4

1. What is the formula for finding the minimum rating cable for a situation? (appendix 4)

2. What air ambient temperature is assumed for the cable tables 4D1A onwards?

3. What is the rating factor for air ambient temperature 45°C for a 70° C thermoplastic cable.

4. Calculate 'It' for a 90°C thermosetting cable that is protected by a 40A mcb, and runs through a boiler room of air ambient temperature of 40°C.

5. What is the rating factor for a cable buried in the ground if the ground temperature is 10°C, the cable is 90°C thermosetting.

6. The rating factor for grouping 12 cables touching each other on a ladder system is?

   The group rating factors assume that all the cables are.....

7. A 63Amp fused cable grouped together touching seven <u>others</u> in a single layer on a perforated metal cable tray, all continually and fully loaded, what is the tabulated current-carrying capacity of the cable?

8. If the cable above is a 4 core 90°C multicore armoured thermosetting cable (XLPE), what size cable is required?

9. Calculate the current carrying capacity (It) of the cable which will feed the new Machine workshop assuming it will be fused at 63A, in an area of air ambient temperature of 25°C, and clipped direct.

10. If the cable above is a 4 core 90°C multicore armoured thermosetting cable (XLPE), what size cable is required?

Voltage drop

11. What is the formula for calculating volt drop?

12. What is the voltage drop over a cable run of 45m, with a three phase full load current of 68A to a machine, for a 16mm^2 multicore armoured 70° C thermoplastic cable?

13. What is the total volt drop over the entire new workshop installation if the following cables are installed, (all cables are multicore armoured 90°C thermosetting insulated copper);

    1st sub main – 35mm², 3 phase, Ib = 125A, length = 38m (use z column).
    2nd sub main – 16mm², 3 phase, Ib = 60A, length = 25m (use z column).
    Final circuit – 2.5mm², 1 phase, Ib = 20A, length = 10m.

Complete cable calculations

14. You are to install a new circuit to a 32Amp, 4 pin three phase socket outlet, the cable is 'multicore armoured 90°C thermosetting copper' the length of run is 55m and you will share a cable tray with six other cables touching each other, what rating BS 60898 type C mcb will you choose and what csa cable will you use?

***Step 1**; Minimum Cable rating = fuse/mcb rating = Design current =*

(Iz ≥ In ≥ Ib)

***Step 2**; Check cable rating It from app 4 equations*

$$It \text{ (for overload)} = \frac{In \text{ (fuse size)}}{Cg \times Ca \times Cs \times Cd \times Ci \times Cf \times Cc}$$

$$It \text{ (fault current)} = \frac{Ib \text{ (design)}}{Cg \times Ca \times Cs \times Cd \times Ci \times Cc}$$

***Step 3**; Select cable csa from cable tables*

***Step 4**; Check volt drop*

$$\text{Volt drop} = \frac{(\text{mV/A/m}) \times \text{Ib} \times \text{length}}{1000}$$

***Step 5**; Check expected fully loaded Zs (earth loop impedance) assuming the cpc is one of the cores and Ze =0.13Ω.*

Refer to the TTE work shop project exercise on page 8; determine the minimum current carrying capacity of the cable supplying the new distribution board.

If the distribution cable is to be mounted on tray with five other cables touching each other, all fully loaded, and the length of the run is 25metres, what csa of cable is to be used?

***Step 1**; Minimum Cable rating = fuse/mcb rating = Design current =*

(Iz ≥ In ≥ Ib)

***Step 2**; Check cable rating It from app 4 equations*

$$\text{It (for overload)} = \frac{\text{In (fuse size)}}{\text{Cg x Ca x Cs x Cd x Ci x Cf x Cc}} \qquad \text{It (fault current)} = \frac{\text{Ib (design)}}{\text{Cg x Ca x Cs x Cd x Ci x Cc}}$$

***Step 3**; Select cable csa from cable tables*

***Step 4**; Check volt drop*

$$\text{Volt drop} = \frac{(\text{mV/A/m}) \times \text{Ib} \times \text{length}}{1000}$$

***Step 5**; Check shock protection Zs (you will need to obtain the actual Zs of the DB)*

On-Site-Guide: General good practice

Cable bending radii

1. What is the bending radius of 2.5mm² Twin and Earth cable?

2. What is the bending radius of 25mm² 4 core thermoplastic SWA?

3. What is the bending radius of 95mm² 4core thermosetting SWA

Cables under floors

1. If you are to install cables in drill holes under a floor what is the minimum distance the hole must be from the surface?

2. What other options do have to run cables under floors?

Cables in walls

1. When is it permitted to run cables diagonally when concealed in walls?

Circuit breaker types

1. When would you use a type D circuit breaker?

2. When would you use a type B circuit breaker?

Conduit capacities

1. What size conduit is required if there are 6 x 4.00mm² in a straight run of 3 meters?

2. What size conduit is required for the same 6 x 4.00mm² this time the run includes one bend and 8 metres in length?

3. What size trunking is required if it contains;
   I. 6 x 1.5mm² stranded cores
   II. 6 x 2.5mm² stranded cores
   III. 15 x 6.00mm² cores

4. Referring to the TTE workshop project, if all the final circuits leaving the new DB will be singles installed in trunking, what sized trunking will be required?

Height of accessories (new on-site-guide only)

1. What is the building regulation that requires specific heights of accessories?

2. What is the recommended height of accessories in dwellings?

Supporting cables

1. A 1.5mm² twin and earth cable is to be clipped on a wall, what is the recommended minimum distance between clips horizontally and vertically?

2. A 50mm² 4 core SWA cable is to secured on to a tray system, what is the minimum distance between tie wraps?

3. What is the minimum distance between 25mm metal conduit saddles?

4. A 100mm x 100mm horizontal trunking run requires installing, what is the minimum distance between fixing screws?

Summary of cable calculations

Iz. - Cable size selection, to find tabulated current carrying capacity – It.

$$\text{It (for overload)} = \frac{\text{In (fuse size)}}{Cg \times Ca \times Cs \times Cd \times Ci \times Cf \times Cc} \qquad \text{It (fault current)} = \frac{\text{Ib (design)}}{Cg \times Ca \times Cs \times Cd \times Ci \times Cc}$$

(Cf rewirable fuse = 0.725) (Cc buried cable = 0.9)

$$\textbf{Volt drop} = \frac{(\text{mV/A/m}) \times Ib \times \text{length}}{1000} \qquad \text{in terms of length of cable} = \frac{\textit{Lights}\ \ \textit{other ccts}}{\text{6900 or 11500}} \Big/ (\text{mV/A/m}) \times Ib$$

ref 525 & app 4

Fault protection on TN systems (shock constraint)

Disconnection times *table 41.1 and reg 411.3.2.3 & .4*

Actual earth fault loop impedance - Zs = Ze + R1 + R2, **Max earth fault loop impedances** - *Tables 41.2, 3, 4*

Remember the adjustment 0.8 x values in tables 41.2, 3, 4 if a cables are cold when measuring (appendix 14)

Fault protection on TT systems where an RCD is used - *table 41.5*

Touch Voltage - $R_A \times I_{\Delta n} \leq 50$ Volts (max of 50 volts permitted)

Where $I_{\Delta n}$ = RCD rated trip current *ref 411.5.3*

Cpc size (Thermal constraint) $S = \frac{\sqrt{I^2 t}}{k}$

Where I = fault current = $\frac{V}{Zs}$ (earth loop impedance of that cct)

Where t = protective device operating time in fault current above.
(from graphs in app 3)

Where k = factor taken from tables 54.2 – 54.6

Co-ordination between conductors and protective device

Overload protection

Cable fuse design $I_2 \leq 1.45 \times Iz$ *ref 433.1.1*

$Iz \geq In \geq Ib$

Fault protection $t = \frac{k^2 S^2}{I^2}$ or $S = \frac{I\sqrt{t}}{K}$ *ref 543.1.3*

Summary of IP (Index of Protection) code

Solid foreign bodies		Water	
0	Not protected	0	Not protected
1	Protected against objects of ***50mm*** diameter or greater	1	Protected against vertically falling water drops
2	Objects of ***12.5mm*** diameter or greater	2	Vertically falling drops with the item tilted 15 degrees
3	Objects of ***2.5mm*** diameter or greater	3	Spraying water
4	Objects of ***1.00mm*** diameter or greater	4	Splashing water
5	Dust protected	5	Water jets
6	Dust tight	6	Powerful water jets
		7	Temporary immersion
		8	Continuous immersion

Additional letters

XXA	Protected against access with the back of the hand	The access probe, a sphere of ***50mm*** diameter, is required to have clearance from hazardous parts
XXB	Protected against access with a finger	The jointed test finger of ***12mm*** diameter and ***80mm*** length, is required to have clearance from hazardous parts
XXC	Protected against access with a tool	The access probe of ***2.5mm*** diameter and ***100mm*** length is required to have adequate clearance from hazardous parts
XXD	Protected against access with a wire	The access probe of ***1mm*** diameter and ***100mm*** length is required to have adequate clearance from hazardous parts

Circuit plan for small office

Cct no	description	Cable csa	Mcb rating	load	Diversity allowance %	Max demand
1 L1						
2 L2						
3 L3						
4 L1						
5 L2						
6 L3						
7 L1						
8 L2						
9 L3						
10 L1						
11 L2						
12 L3						
13 L1						
14 L2						
15 L3						
16 L1						
17 L2						
18 L3						
19 L1						
20 L2						

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38 L2						
39 L3						