Introduction

Fuse factor is how many times more than it’s rating will it trip.

TN system does not matter if it is TNS or TN-C-S

TT systems have to trip faster.

Fuse

The primary job of a fuse is overload protection.
Secondary job of a fuse is fault protection (**live** touches **Neutral**, **Live** touches **Earth**)

First Example

A kettle uses 2 kilowatts of electricity.

The current is 8.7.

The Fuse rating is 13 A.

I = P/V.

—----------

Second example

218.5 (Cmin)/30(B6 circuit breaker size) = 7.28

7.28 X 0.8 = 5.824 (0.8 accounts for heat loss if the cable is cold to begin with)

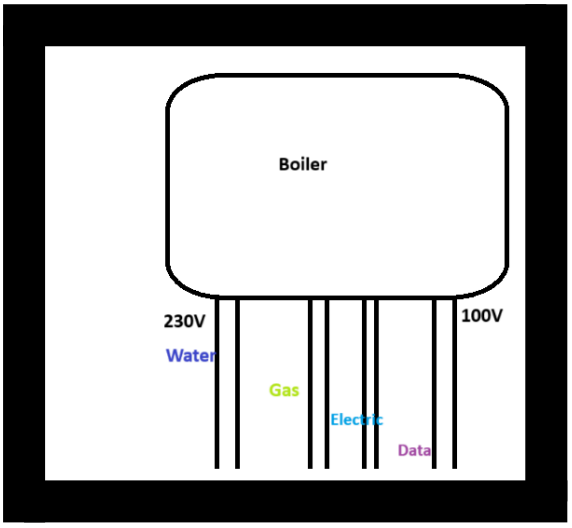
—----------

You do not need an RCD on every circuit. RCD provides additional protection and will trip at 30 milliamps to earth.

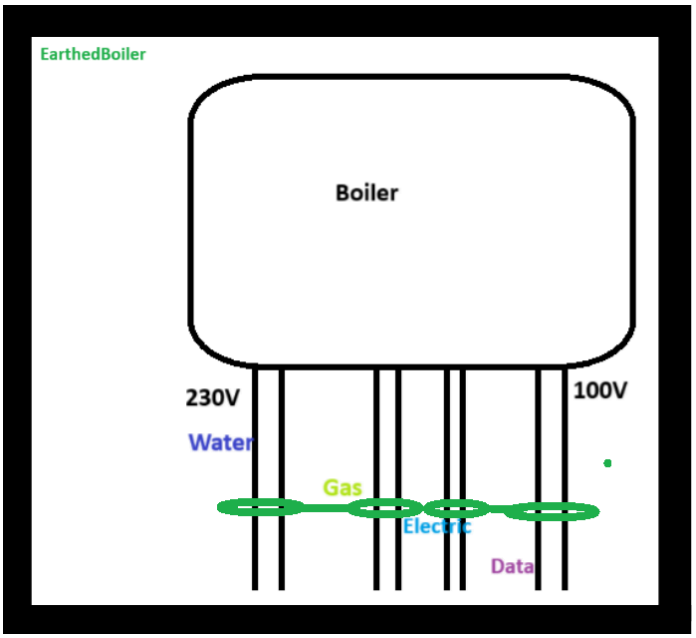
Equipotential

Electricity only flows when there is a difference in voltage.

In a shower room there is a risk that the user could touch a radiator and electric shower at the same time. Both of these devices have different voltages. This could lead to an electric shock. Therefore, to overcome this all the devices were **Earthed**. This meant that they would all have the same voltage and would mean that the user would not receive an electric shock.

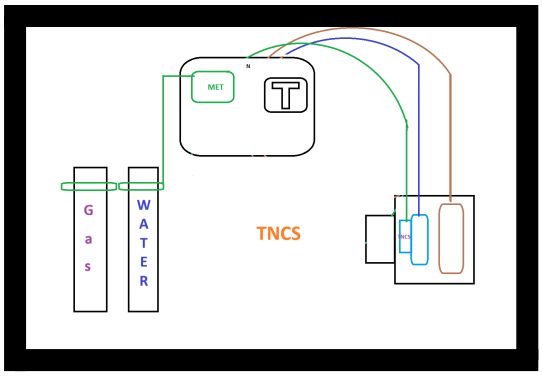


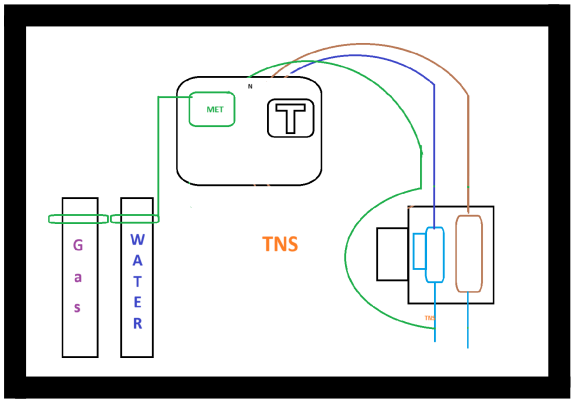
If someone touched the first and last pipe they would receive a shock of voltage of 130V. Because, that is the difference between the pipes. 230V - 100V = 130V



No potential difference - therefore no electrical shock.

Earthing Systems




MET
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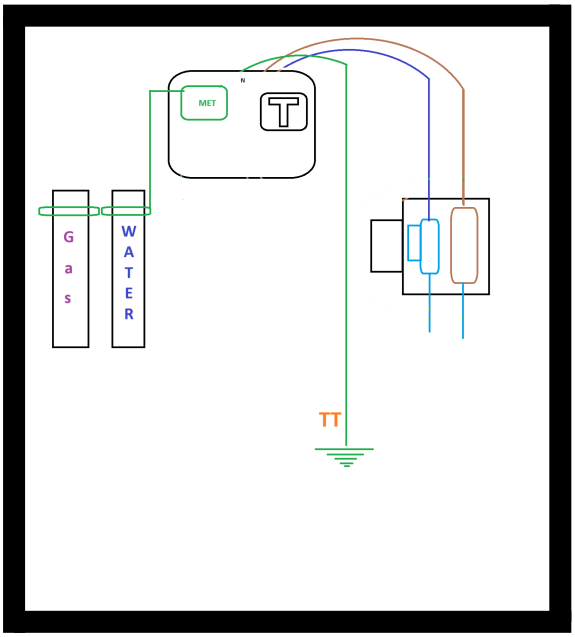
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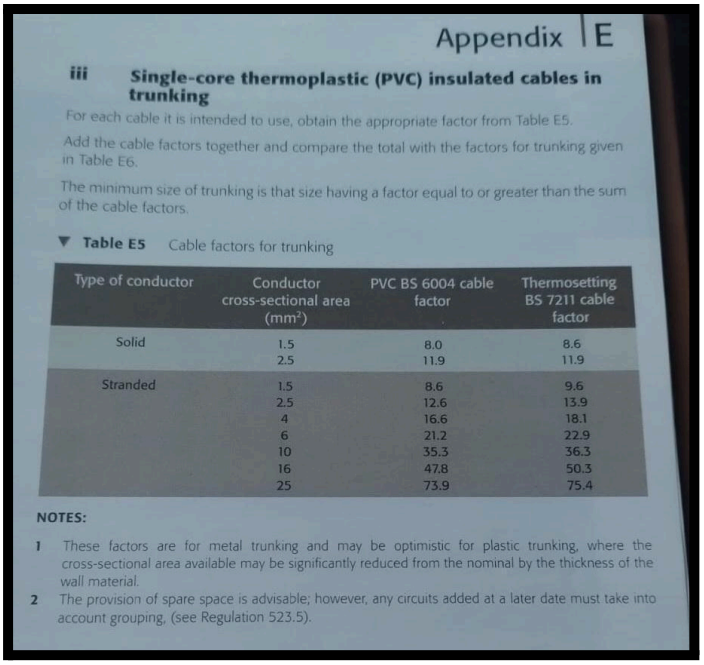
Example One: Trunking calculation

Using Table E5 we look-up the PVC BS 6004 cable factor based on the "Conductor cross-sectional area(mm²)"



Appendix E

iii Single-core thermoplastic (PVC) insulated cables in trunking

For each cable it is intended to use, obtain the appropriate factor from Table E5.

Add the cable factors together and compare the total with the factors for trunking given in Table E6.

The minimum size of trunking is that size having a factor equal to or greater than the sum of the cable factors.

▼ **Table E5** Cable factors for trunking

Type of conductor	Conductor cross-sectional area (mm^2)	PVC BS 6004 cable factor	Thermosetting BS 7211 cable factor
Solid	1.5	8.0	8.6
	2.5	11.9	11.9
Stranded	1.5	8.6	9.6
	2.5	12.6	13.9
	4	16.6	18.1
	6	21.2	22.9
	10	35.3	36.3
	16	47.8	50.3
	25	73.9	75.4

NOTES:

1 These factors are for metal trunking and may be optimistic for plastic trunking, where the cross-sectional area available may be significantly reduced from the nominal by the thickness of the wall material.

2 The provision of spare space is advisable; however, any circuits added at a later date must take into account grouping, (see Regulation 523.5).

Note down how many cables will be used in the trunking.

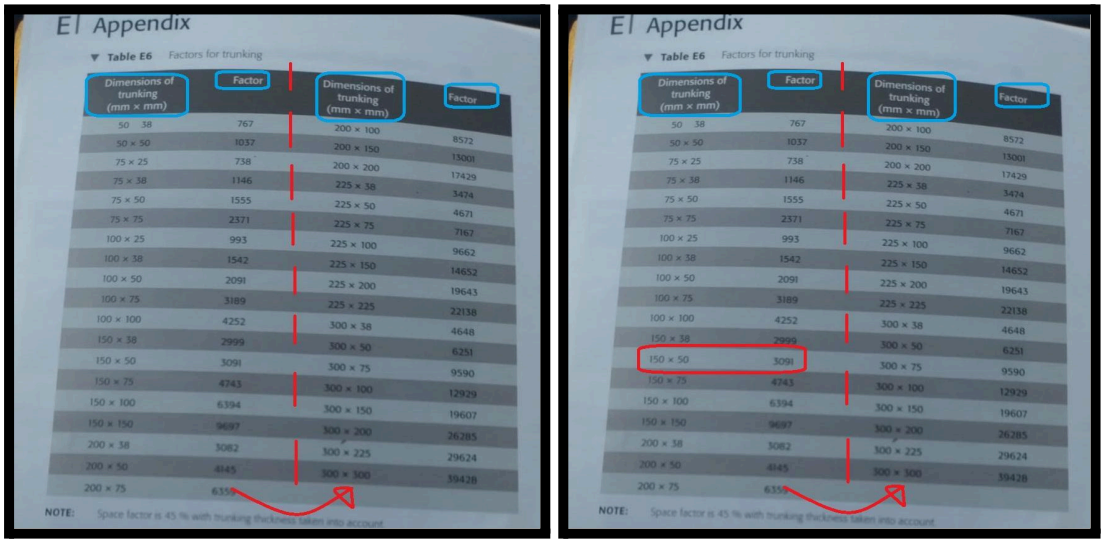
	Size of Cable (mm^2)	PVC BS 6004 cable factor	No. of wire	No. of circuits	Cable factor
Lighting circuit	1.5mm^2	8.6	3	4	103.2 (8.6x3x4)
Sockets	2.5mm^2	12.6	6	6	453.6 (12.6x6x6)
Waterheater	4mm^2	16.6	3	4	199.2(16.6x3x4)
Car Charger (3 phase circuit + Neutrel) 3 lines + N + E	6mm^2	21.2	5	1	106(21.2x5x1)
Ovens	16mm^2	47.8	3	2	286.8(47.8x3x2)
Shower	10mm^2	35.3	3	2	211.8(35.3x3x2)
				Sum of the cable factors	1360.6

What 1360.6 represents is the sum of the cable factors/total cable factor.

Next we go to page 166 Table E6. Because we want to determine the trunking factor. We perform a "look-up" of the trunking factor based on the total cable factor. There are multiple-right answers, however we use this criteria to decide what size trunking to use:

"The minimum size of trunking is that size having a factor equal to or greater than the sum of the cable factors."

Which in simple terms means the:
Trunking factor ≥ Sum of the cable factors.



Appendix

Table E6 Factors for trunking

Dimensions of trunking (mm × mm)	Factor	Dimensions of trunking (mm × mm)	Factor
50 38	767	200 × 100	8572
50 × 50	1037	200 × 150	13001
75 × 25	738	200 × 200	17429
75 × 38	1146	225 × 38	3474
75 × 50	1555	225 × 50	4671
75 × 75	2371	225 × 75	7167
100 × 25	993	225 × 100	9662
100 × 38	1542	225 × 150	14652
100 × 50	2091	225 × 200	19643
100 × 75	3189	225 × 225	22138
100 × 100	4252	300 × 38	4648
150 × 38	2999	300 × 50	6251
150 × 50	3091	300 × 75	9590
150 × 75	4743	300 × 100	12929
150 × 100	6394	300 × 150	19607
150 × 150	9697	300 × 200	26285
200 × 38	3082	300 × 225	29624
200 × 50	4145	300 × 300	39428
200 × 75	6359		

NOTE: Space factor is 45 % with trunking thickness taken into account

Appendix

Table E6 Factors for trunking

Dimensions of trunking (mm × mm)	Factor	Dimensions of trunking (mm × mm)	Factor
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100 × 50	2091	225 × 200	19643
100 × 75	3189	225 × 225	22138
100 × 100	4252	300 × 38	4648
150 × 38	2999	300 × 50	6251
150 × 50	3091	300 × 75	9590
150 × 75	4743	300 × 100	12929
150 × 100	6394	300 × 150	19607
150 × 150	9697	300 × 200	26285
200 × 38	3082	300 × 225	29624
200 × 50	4145	300 × 300	39428
200 × 75	6359		

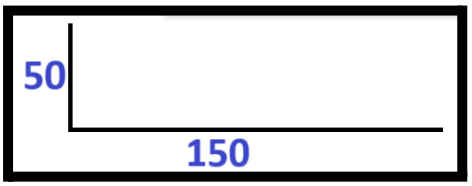
NOTE: Space factor is 45 % with trunking thickness taken into account

There are multiple right answers that satisfy our criteria.

As long as the trunking factor is >1360.6 (Sum of the cable factors) then the answer will be acceptable.

The answer we selected from Table E6 is the row with:

Dimensions of trunking (mm X mm)	Factor
150 X 50	3091



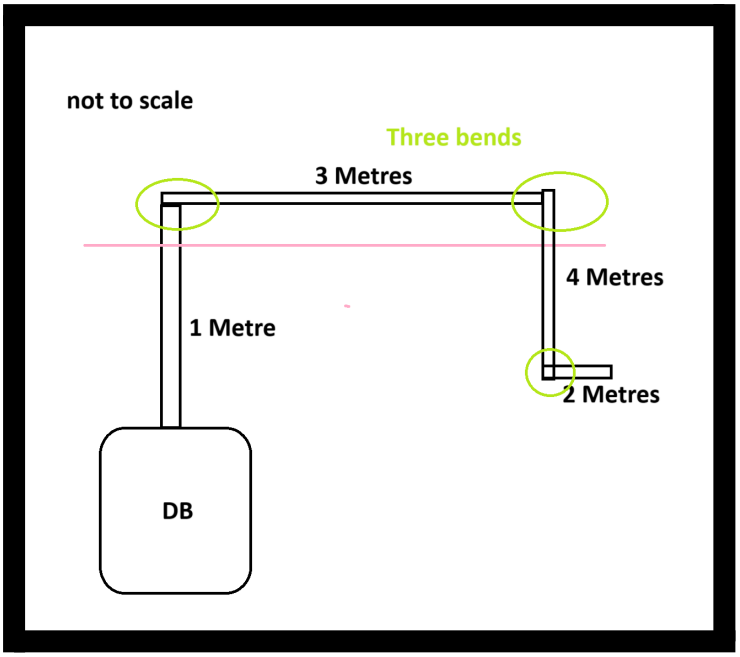
Example one: Conduit Calculations

Remember that we must calculate:

1) **cable factor**
2) Then we perform a “look-up” of the **conduit factor** based on the **cable factor**.

Side note:

- **Table E1 goes with Table E2**
- **Table E3 goes with Table E4**



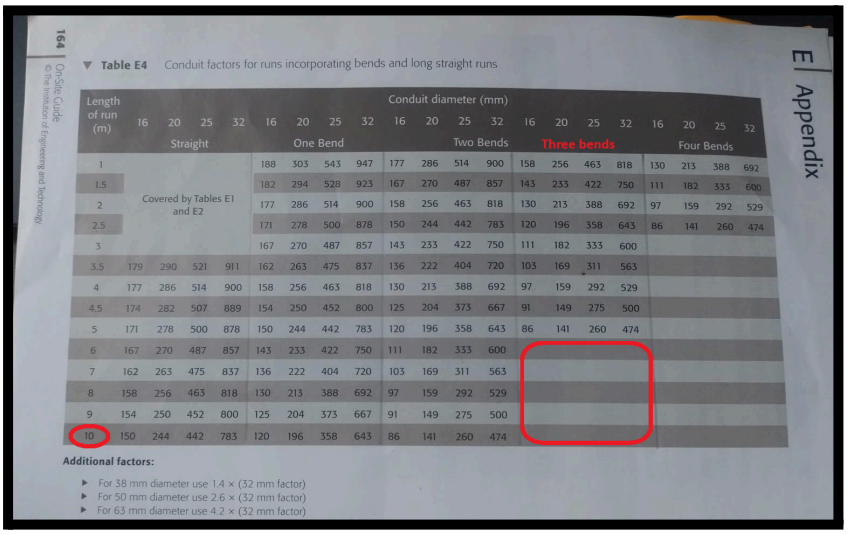
<u>Circuit Information</u>

We have a cable:

- **10 metres in length total => 1 + 3 + 4 + 2**
- **3 bends.**

For conduit calculations we look at Table E4.

Nothing in Table E4 corresponds to a circuit that is ten metres in length with three bends.



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E Appendix

Table E4 Conduit factors for runs incorporating bends and long straight runs

Length of run (m)	Conduit diameter (mm)																			
	Straight				One Bend				Two Bends				Three bends				Four Bends			
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
1	Covered by Tables E1 and E2				188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5					182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
2					177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
2.5					171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
3					167	270	487	857	143	233	422	750	111	182	333	600				
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563				
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529				
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500				
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474				
6	167	270	487	857	143	233	422	750	111	182	333	600								
7	162	263	475	837	136	222	404	720	103	169	311	563								
8	158	256	463	818	130	213	388	692	97	159	292	529								
9	154	250	452	800	125	204	373	667	91	149	275	500								
10	150	244	442	783	120	196	358	643	86	141	260	474								

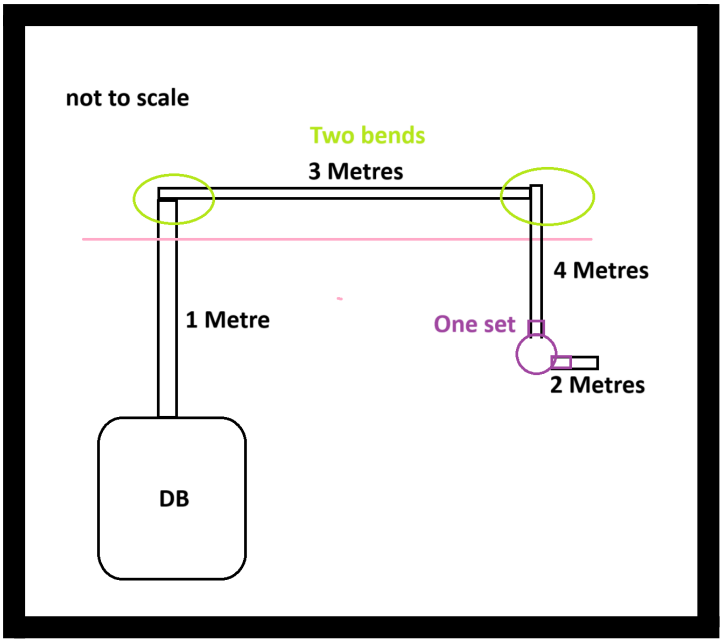
Additional factors:

- For 38 mm diameter use 1.4 × (32 mm factor)
- For 50 mm diameter use 2.6 × (32 mm factor)
- For 63 mm diameter use 4.2 × (32 mm factor)

However, if we adjust the circuit to:

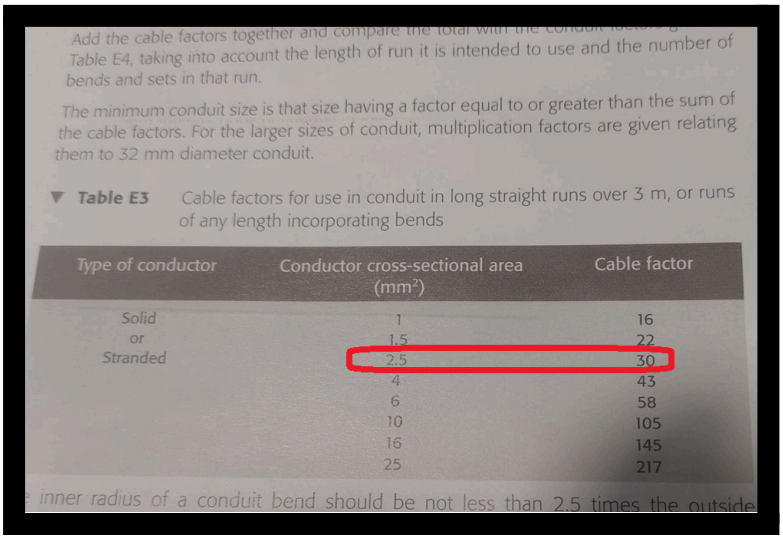
Amended circuit information:

- **three cables of size 2.5 (mm²) (size = conductor cross-sectional area (mm²));**
- **1 + 3 + 4 = 8 metres. An 8 meter long run.**
- **Then there is an angle box, followed by another 2 metres.**



Part A: Cable factor calculations

To answer this question first look at Table E3. But specifically, the column "Conductor cross-sectional area (mm²)".



Add the cable factors together and compare the total with the conduit factors in Table E4, taking into account the length of run it is intended to use and the number of bends and sets in that run.

The minimum conduit size is that size having a factor equal to or greater than the sum of the cable factors. For the larger sizes of conduit, multiplication factors are given relating them to 32 mm diameter conduit.

▼ **Table E3** Cable factors for use in conduit in long straight runs over 3 m, or runs of any length incorporating bends

Type of conductor	Conductor cross-sectional area (mm²)	Cable factor
Solid or Stranded	1	16
	1.5	22
	2.5	30
	4	43
	6	58
	10	105
	16	145
	25	217

inner radius of a conduit bend should be not less than 2.5 times the outside

Conductor cross-sectional area (mm²)	Cable factor (for a single cable)	No. of cables	Total Cable factor
2.5 mm²	30	3	90 (30 X 3)
		Sum of cable factor	90

cable factor which is 90.

Part B: conduit calculations

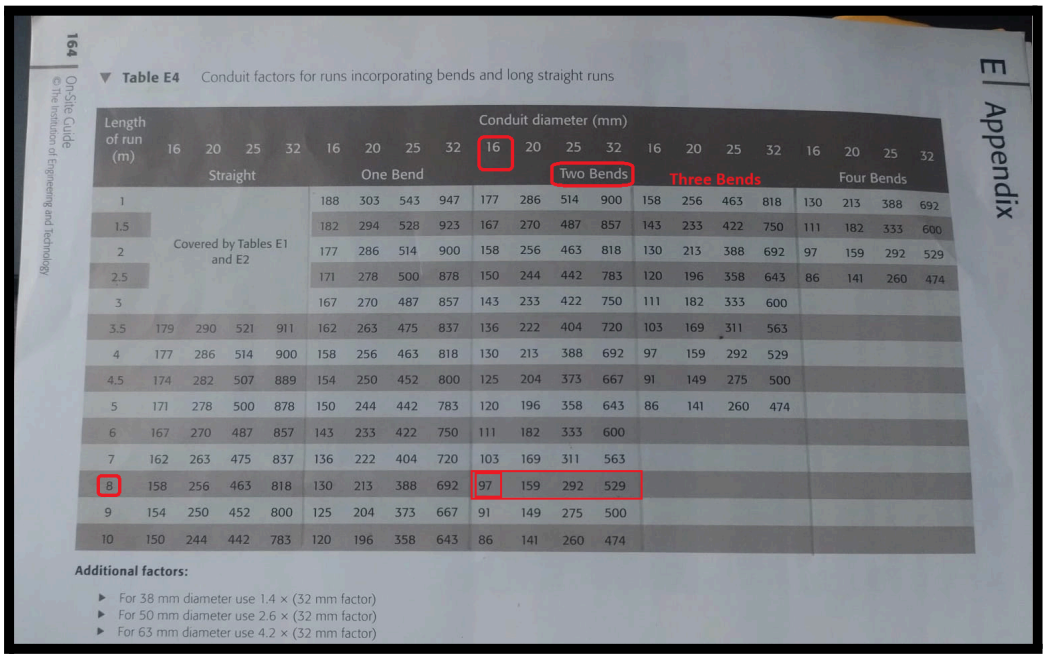
"The minimum conduit size is that size having a factor equal to or greater than the sum of cable factors"

Which in simple terms means:

Conduit factor ≥ sum of cable factor

This means our conduit factor has to be equal to or greater than the sum of cable factor which is 90.

We now refer to Table E4 (page 164) for conduit calculations.



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E Appendix

▼ **Table E4** Conduit factors for runs incorporating bends and long straight runs

Length of run (m)	Conduit diameter (mm)																			
	Straight				One Bend				Two Bends				Three Bends				Four Bends			
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
1	Covered by Tables E1 and E2				188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5					182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
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6	167	270	487	857	143	233	422	750	111	182	333	600								
7	162	263	475	837	136	222	404	720	103	169	311	563								
8	158	256	463	818	130	213	388	692	97	159	292	529								
9	154	250	452	800	125	204	373	667	91	149	275	500								
10	150	244	442	783	120	196	358	643	86	141	260	474								

Additional factors:

- For 38 mm diameter use 1.4 × (32 mm factor)
- For 50 mm diameter use 2.6 × (32 mm factor)
- For 63 mm diameter use 4.2 × (32 mm factor)

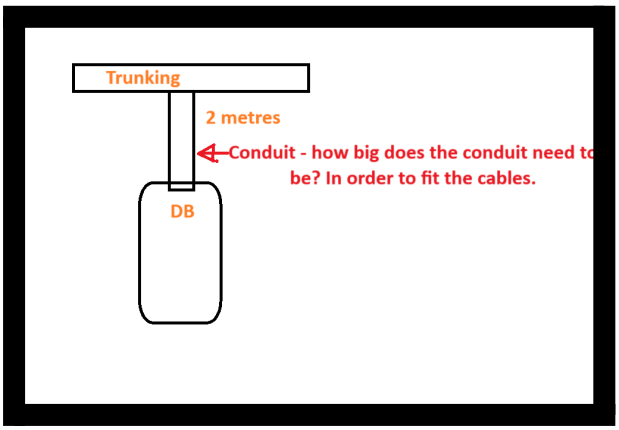
Look at the row which has the value 8 for the column "Length of run (m)" Remember we have two bends and one set.

The total cable factor is 90. We use the total cable factor to look-up the conduit factor. Which will be 97. because it is states:

"The minimum conduit size is that size having a factor equal to or greater than the sum of cable factors"

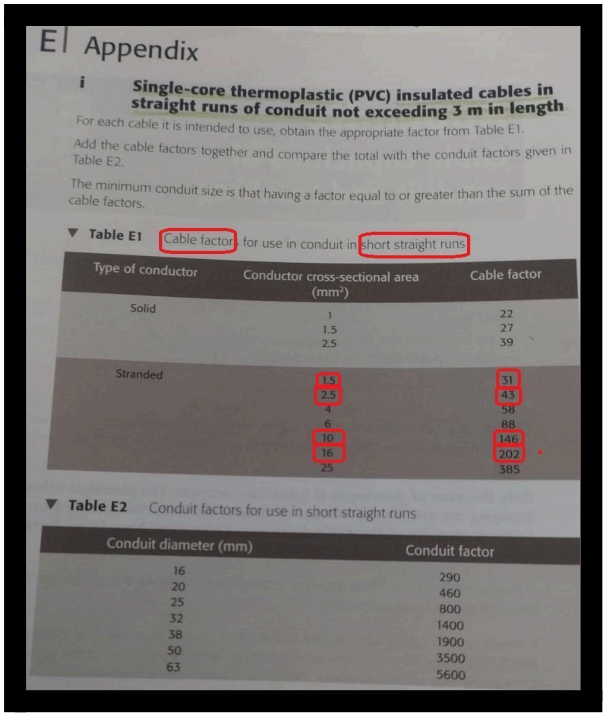
The reason we select 8 for the column "Length of run (m)" is because that is how long our circuit is before the set (stop & start). There is another 2 metres after the set. However, for those last two metres the conduit factor will be 16mm as well. Our calculation applies to the whole circuit. 16mm is large enough for 2 metres.

Final example Conduit calculation



Step one

We use Table E1 to get the cable factor based on the Conductor cross-sectioned area mm².



E1 Appendix

i **Single-core thermoplastic (PVC) insulated cables in straight runs of conduit not exceeding 3 m in length**

For each cable it is intended to use, obtain the appropriate factor from Table E1.

Add the cable factors together and compare the total with the conduit factors given in Table E2.

The minimum conduit size is that having a factor equal to or greater than the sum of the cable factors.

▼ **Table E1** Cable factors for use in conduit in short straight runs

Type of conductor	Conductor cross-sectional area (mm²)	Cable factor
Solid	1	22
	1.5	27
	2.5	39
Stranded	1.5	31
	2.5	43
	4	58
	6	88
	10	146
	16	202
	25	385

▼ **Table E2** Conduit factors for use in short straight runs

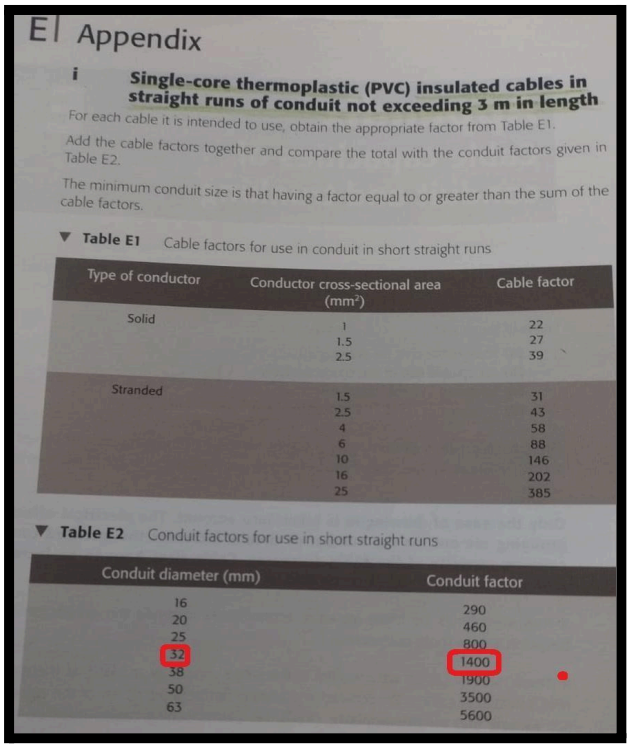
Conduit diameter (mm)	Conduit factor
16	290
20	460
25	800
32	1400
38	1900
50	3500
63	5600

Step two

Note down how many cables will be used in the conduit.

Conductor cross-sectional area (mm^2)	Cable factor	No. of cables	Total
16 mm^2	202	2	404 (202 X 2)
10mm^2	146	1	146 (146 X 1)
1.5mm^2	31	3 X 2	186 ((31 X 3) X 2)
2.5mm^2	43	3	129 (43 X 3)
		Total cable factor	865

When we add up all of the cable factors. We get the total cable factor.
We use the total cable factor to "look-up" the conduit factor on Table E2.



E Appendix

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	2.5	43
	4	58
	6	88
	10	146
	16	202
	25	385

▼ **Table E2** Conduit factors for use in short straight runs

Conduit diameter (mm)	Conduit factor
16	290
20	460
25	800
32	1400
38	1900
50	3500
63	5600

We have to round up to the nearest whole value so 865 goes to 1400.
The conduit diameter is hence 32 mm.

Extra step

Because there is an excess. By excess, I mean we calculated the total cable factor to be 865. However, because it is over the 800 conduit factor we had to place into the 1400 bracket. So we can use two tails on trunking.

First tail

404 + 146 = 550

25mm Conduit

Second tail

186 + 129 = 315

20mm Conduit

Why - because these cables are similar in sizes would be more likely to run these cables together.

This approach could be considered as more optimal than having all four cables in a 32 mm conduit.

Practical workshop write-up Section

Insulation resistance needs to be >200ohms.

We perform two insulation resistance tests. One on Live and neutral wires. The second test on Live and Earth wires. If either of the latter two cases happens this is classified as a fault within the circuit.

Remember a fuse will trip on two conditions:
- **there is a fault in the circuit**
- **or if there is an overload.**

A fault is classified as when Live touches Neutral. Or Live touches Earth.

>200ohms means that the wires are not touching each other inside the circuit. Because when we have high resistance there is no current. Hence, there is no current flowing between the wires.

Continuity test for a radial circuit test

Continuity checks that the circuit is complete.

(R1 + R2) means (Live + Earth)

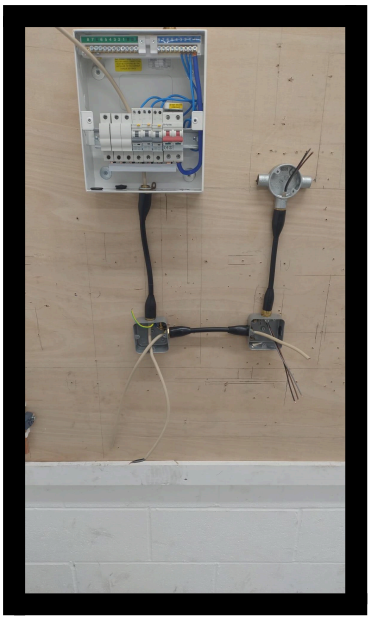
Which means we get the Live wire and add it to the Earth Wire. Which in a practical sense means we move the Brown live wire into the connector block inside the fuse box.

We need to test the furthest Current Using Device (CUD) from the fuse box. We attach one probe to the earth terminal of the furthest CUD. Attach the other to the Live terminal of the Furthest CUD.

On the electrical tester place the setting on Continuity and hit test.

Picture of the board

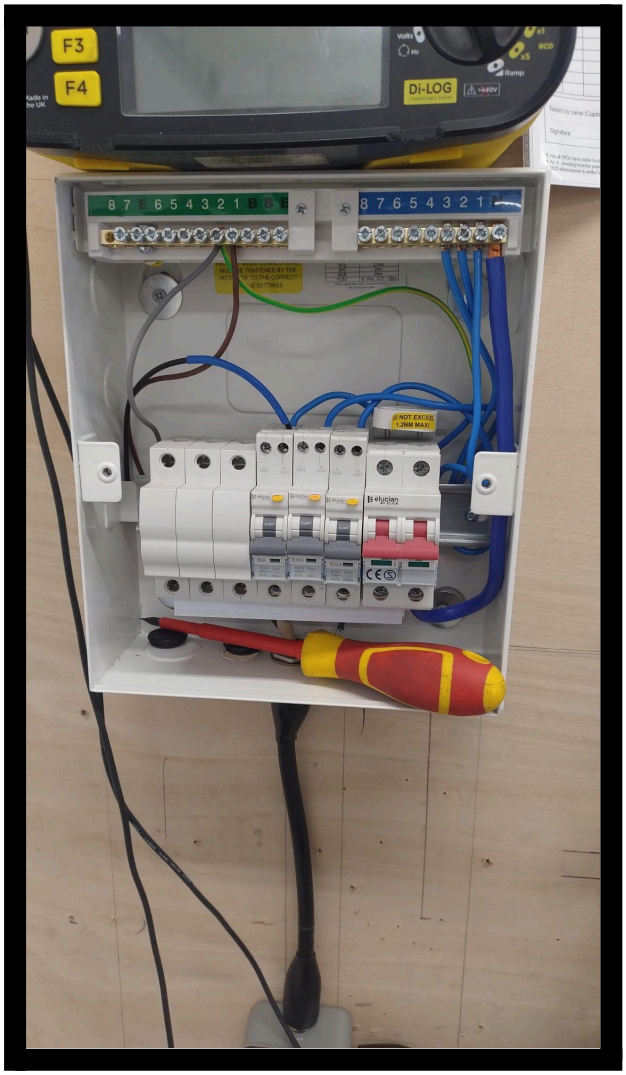
This was the board at the start of lesson 13.



Testing R1 + R2 - How does the Fuse board look?

The fuse box. Ignore the green and yellow. Because, in this board we used the brown live wire and the grey wire as earth.

The reason why we put the brown live wire and the grey wire into the connector block is because we are testing for (R1 + R2).


F3
F4
Di-LOG
8 7 6 5 4 3 2 1
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TEST
F1
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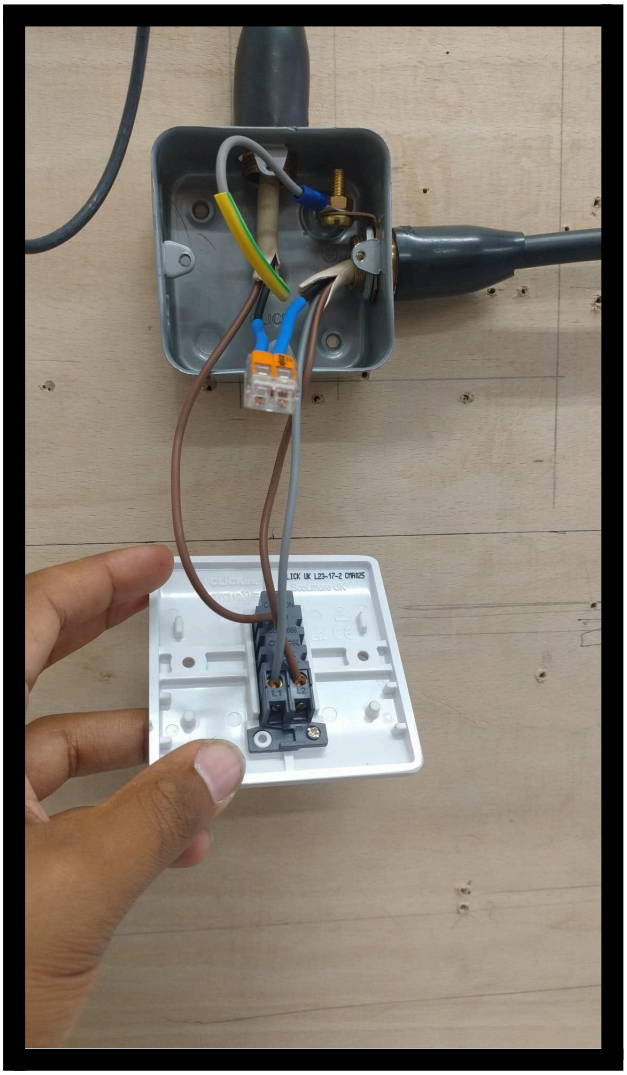

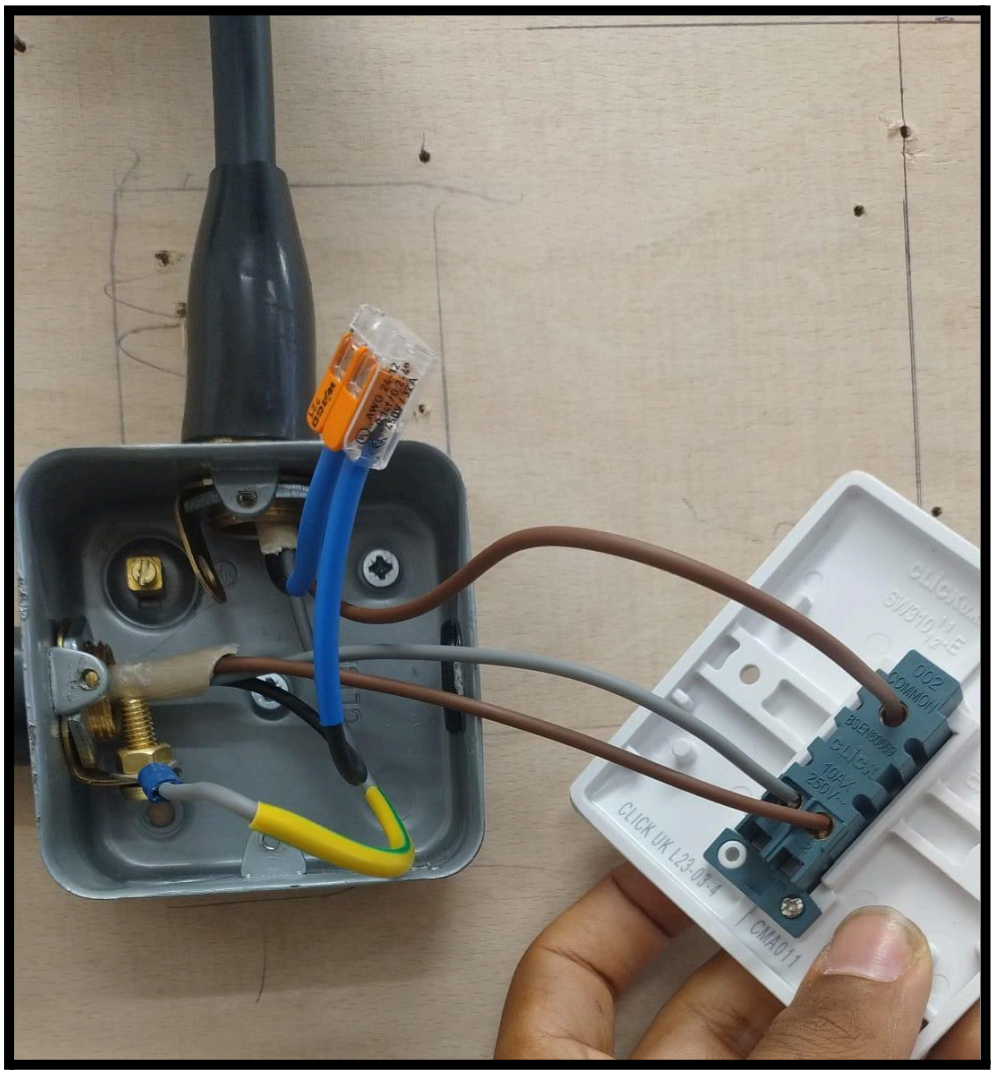
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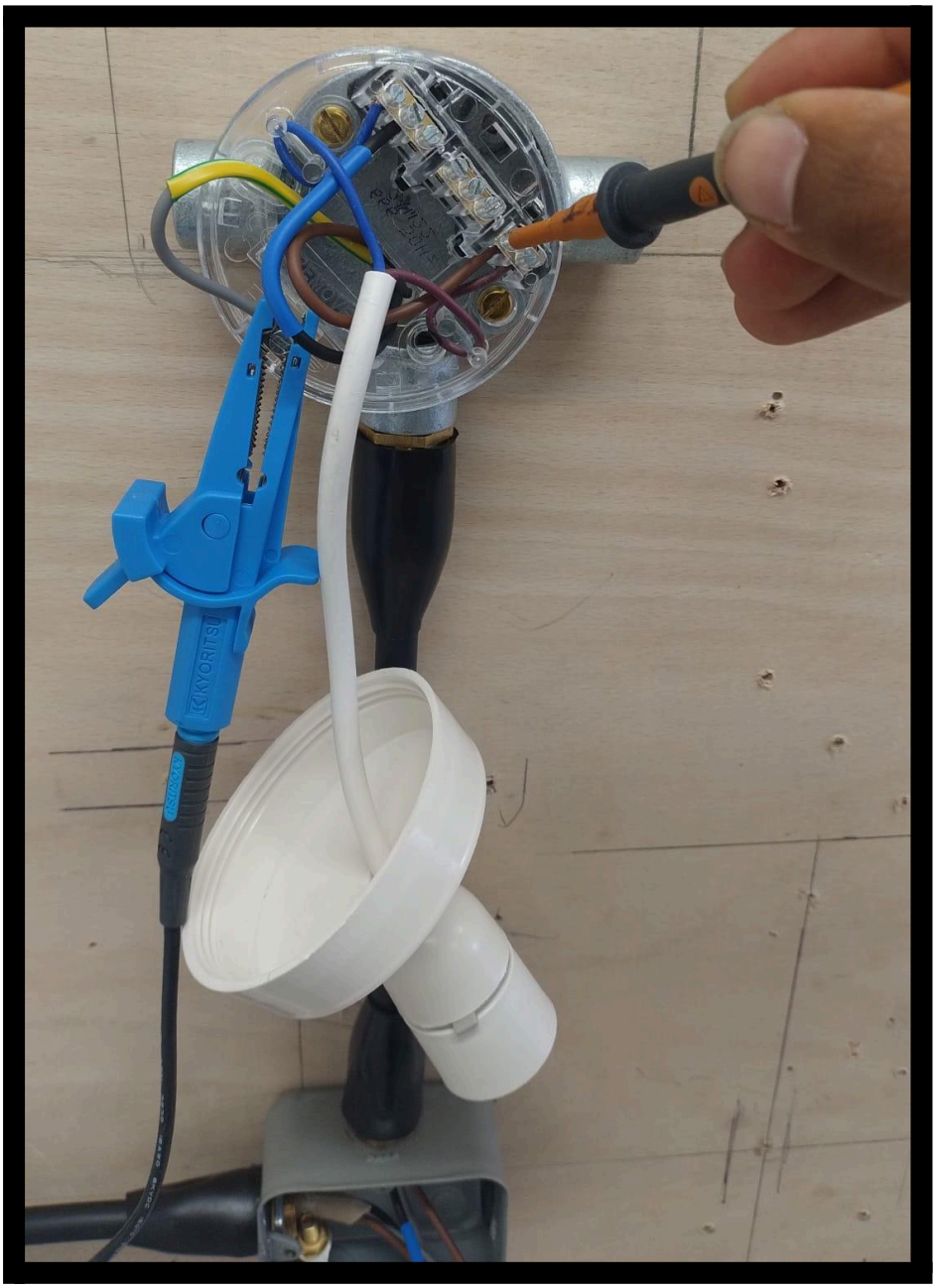
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