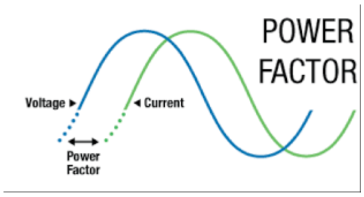
15 KW 3 phase compressor scenario   cable calculation process.

Simple design process.



0.8

a) **Determine Design Current I_b**

Design Current (Three phase)

$$I_b = \frac{P}{\sqrt{3}\ x\ VL\ x\ cos\emptyset}$$

$$I_b = \frac{15\ kW}{1.732\ x\ 400\ x\ 0.8} = \mathbf{27.063A} \quad \mathbf{I_b = 27.1\ Amps}$$

Can I apply diversity?

OSG Table A2 Pg 137

Type of premises		
Small shops, stores, offices and business premises	4 Motors (other than lift motors, which are subject to special consideration)	100 % f.l. of largest motor +80 % f.l. of second largest motor +60 % f.l. of remaining motors

For a business premises **100 % of full load (f.l.)** current. ✗

b) **Determine rating and type of overcurrent protective consider additional protection if required.**

Nominal Rating of Device **In**

$I_n \geq I_b \geq I_z$ (This gives compliance with **BS7671 (2022)** Regulation 433.1.1 **OVERLOAD PROTECTION**)

EATON EBM 81 3 phase consumer unit with 125 A Main Switch.

EATON 3 pole MCB available and compatible with existing consumer unit. ✓

Fault protection provided by the MCB **Type C**

(**Possible inrush current** to consider on initial startup)

OSG Table 7.2.7 (ii) Pg 90

Select a BS EN 60898-1 Type C 32A.

BS 7671 (2022) Table 41.3 Pg 68 / OSG Table B6 Pg 145

$I_n \geq I_b$ 32 ≥ 27.1 ✓

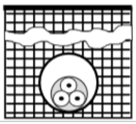
c) Determine Installation number or Reference Method

Multicore armoured cable in conduit or in cable ducting direct in the ground.

BS7671 (2022) Table 4A2 Pg 437

Reference Method **D (Installation number 70)** ✓

TABLE 4A2 *(continued)*

Installation Method			Reference Method to be used to determine current-carrying capacity
Number	Examples	Description	
70		Multicore armoured cable in conduit or in cable ducting in the ground	D For multicore armoured cable only

d) De-Rating Factors to consider.

Ambient Ground Temperature C_a

BS 7671 (2022) Appendix 4 Table 4B2 Pg 441

C_a = 0.84 (70°C thermoplastic cable in 30°C Ambient temp)

TABLE 4B2 – Rating factors (C_a) for ambient ground temperatures other than 20 °C

Ground temperature °C	Insulation	
	70 °C thermoplastic	90 °C thermosetting
10	1.10	1.07
15	1.05	1.04
20	1.00	1.00
25	0.95	0.96
30	0.89	0.93
35	0.84	0.89
40	0.77	0.85
45	0.71	0.80
50	0.63	0.76
55	0.55	0.71
60	0.45	0.65
65	–	0.60
70	–	0.53
75	–	0.46
80	–	0.38

For depth of burial C_d

BS 7671 (2022) Appendix 4 Table 4B4 Pg 442

C_d = 0.94 (Cable buried in a duct 1.75 metres below the ground)

C_i: N/A
C_f: N/A
C_c: N/A
C_g: N/A

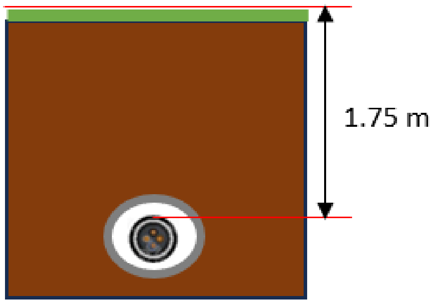


TABLE 4B4 – Rating factors (C_d) for depths of laying other than 0.7 m for direct buried cables and cables in buried ducts

Depth of laying, m	Buried direct	In buried ducts
0.5	1.03	1.02
0.7	1.00	1.00
1	0.97	0.98
1.25	0.95	0.96
1.5	0.94	0.95
1.75	0.93	0.94
2	0.92	0.93
2.5	0.90	0.92
3	0.89	0.91

e) **Determine CSA of cable required.**

BS 7671 (2022) Appendix 4 Pg 425

OSG Appendix F Pg 167

$I_z = \frac{In}{Ca \ x \ Cd}$

$I_z = \frac{32A}{0.84 \ x \ 094}$ = **41 A**

A cable needs to be selected that can carry at least **41 Amps**.

BS 7671 (2022) Appendix 4 Table 4D4A (column 7) Pg 454

10.0mm² conductor which has an **I_t = 50 A**

$I_t \geq I_z$ (This gives compliance with **BS7671 (2022) Regulation 433.1.1**)

$50 \geq 41$ ✓

15 KW 3 phase compressor scenario   cable calculation process.

TABLE 4D4A – Multicore armoured 70 °C thermoplastic insulated cables (COPPER CONDUCTORS)

Ambient temperature: 30 °C
Ground ambient temperature: 20 °C
Conductor operating temperature: 70 °C

CURRENT-CARRYING CAPACITY (amperes):

Conductor cross-sectional area	Reference Method C (clipped direct)		Reference Method E (in free air or on a perforated cable tray etc, horizontal or vertical)		Reference Method D (direct in ground or in ducting in ground, in or around buildings)	
	1 two-core cable, single-phase AC or DC	1 three- or four-core cable, three-phase AC	1 two-core cable, single-phase AC or DC	1 three- or four-core cable, three-phase AC	1 two-core cable, single-phase AC or DC	1 three- or four-core cable, three-phase AC
1	2	3	4	5	6	7
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)
1.5	21	18	22	19	22	18
2.5	28	25	31	26	29	24
4	38	33	41	35	37	30
6	49	42	53	45	46	38
10	67	58	72	62	60	50
16	89	77	97	83	78	64
25	118	102	128	110	99	82
35	145	125	157	135	119	98
50	175	151	190	163	140	116
70	222	192	241	207	173	143
95	269	231	291	251	204	169
120	310	267	336	290	231	192
150	356	306	386	332	261	217
185	405	348	439	378	292	243
240	476	409	516	445	336	280
300	547	469	592	510	379	316
400	621	540	683	590	-	-

Or have we overlooked something?

BS 7671 (2022) Appendix 4 Pg 425

Alternatively, I_t may be obtained from the following formulae, provided the circuits of the group are not liable to simultaneous overload. ✓

$$I_z = \frac{Ib}{Ca \times Cg}$$

$$I_z = \frac{27.1A}{0.84 \times 0.94} = \mathbf{34.32\ A}$$ ✓

We could now select a **6.0mm²** conductor as it has a current carrying capacity of 38 A.

Therefore

$I_t \geq I_z$ (This gives compliance with **BS7671 (2022) Regulation 433.1.1**)

38 ≥ 34 ✓

f) Calculate Volt Drop: (based on the selection of 10.0mm^2)

BS 7671 (2022) Appendix 4 (6) Pg 428 Table 4AB Pg 430

OSG Appendix F Pg 168

Volt drop = $\frac{mV/A/m \ x \ Ib \ x \ Length}{1000}$

mV/A/m = BS 7671 (2022) Table 4D4B (column 4) Pg 455 = **3.8 mV/A/m**

TABLE 4D4B

VOLTAGE DROP (per ampere per metre): Conductor operating temperature: 70 °C

Conductor cross-sectional area	Two-core cable, DC	Two-core cable, single-phase AC			Three- or four-core cable, three-phase AC		
1	2	3			4		
(mm²)	(mV/A/m)	(mV/A/m)			(mV/A/m)		
1.5	29	29			25		
2.5	18	18			15		
4	11	11			9.5		
6	7.3	7.3			6.4		
10	4.4	4.4			3.8		
16	2.8	2.8			2.4		
		r	x	z	r	x	z
25	1.75	1.75	0.170	1.75	1.50	0.145	1.50
35	1.25	1.25	0.165	1.25	1.10	0.145	1.10
50	0.93	0.93	0.165	0.94	0.80	0.140	0.81
70	0.63	0.63	0.160	0.65	0.55	0.140	0.57
95	0.46	0.47	0.155	0.50	0.41	0.135	0.43
120	0.36	0.38	0.155	0.41	0.33	0.135	0.35
150	0.29	0.30	0.155	0.34	0.26	0.130	0.29
185	0.23	0.25	0.150	0.29	0.21	0.130	0.25
240	0.180	0.190	0.150	0.24	0.165	0.130	0.21
300	0.145	0.155	0.145	0.21	0.135	0.130	0.185
400	0.105	0.115	0.145	0.185	0.100	0.125	0.160

Calculated volt drop = $\frac{3.8 \ x \ 27.1 \ x \ 43m}{1000}$ = **4.43 V** ✓

Max Volt drop is stated **BS 7671 (2022)** Table 4AB Pg 430.

For Power circuits **max volt drop** = 5% of U_o (230V) Max volt drop = $\frac{230 \ x \ 5}{100}$ = **11.5 V**

4.43V $\leq$ 11.5V ✓

Our calculated Volt drop is less than maximum allowed so is **acceptable.** ✓

6.4 Voltage drop in consumers' installations

The voltage drop between the origin of an installation and any load point should not be greater than the values in the table below expressed with respect to the value of the nominal voltage of the installation.

The calculated voltage drop should include any effects due to harmonic currents.

TABLE 4Ab – Voltage drop

	Lighting	Other uses
(i) Low voltage installations supplied directly from a public low voltage distribution system	3 %	5 %
(ii) Low voltage installation supplied from private LV supply (*)	6 %	8 %

(*) The voltage drop within each final circuit should not exceed the values given in (i).

Where the wiring systems of the installation are longer than 100 m, the voltage drops indicated above may be increased by 0.005 % per metre of the wiring system beyond 100 m, without this increase being greater than 0.5 %.

The voltage drop is determined from the demand of the current-using equipment, applying diversity factors where applicable, or from the value of the design current of the circuit.

NOTE 1: A greater voltage drop may be acceptable for a motor circuit during starting and for other equipment with a high inrush current, provided that in both cases the voltage variations remain within the limits specified in the relevant equipment standard.

NOTE 2: The following temporary conditions are excluded:

- voltage transients
- voltage variations due to abnormal operation.

g) Determine Max Disconnection time for this circuit. (Shock Protection)

ADS chosen protective measure from **Chapter 41 BS 7671 (2022)**

BS 7671 (2022) Pg 64 / 65

Regulation 411.3.2.3

Maximum disconnections time stated in Table 41.1 shall be applied to final circuits with a rated current not exceeding:

(i) 63 A with one or more socket-outlets
(ii) 32 A supplying fixed connected current-using equipment.

Therefore, with our fixed connected current-using equipment with a design current t of 27.1 Amps in a TN-S system, a **maximum disconnection time of 0.4s is required**. ✓

OSG Appendix B Pg 139

TABLE 41.1 –
Maximum disconnection times

System	50 V < U_0 ≤ 120 V (s)		120 V < U_0 ≤ 230 V (s)		230 V < U_0 ≤ 400 V (s)		U_0 > 400 V (s)	
	AC	DC	AC	DC	AC	DC	AC	DC
TN	0.8	NOTE 1	0.4	1	0.2	0.4	0.1	0.1
TT	0.3	NOTE 1	0.2	0.4	0.07	0.2	0.04	0.1

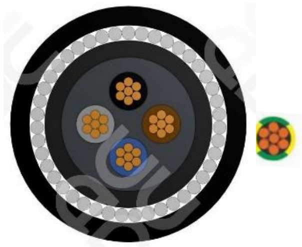
Where in TT systems the disconnection is achieved by an overcurrent protective device and the protective equipotential bonding is connected with all extraneous-conductive-parts within the installation in accordance with Regulation 411.3.1.2, the maximum disconnection times applicable to TN systems may be used.

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

Where compliance with this regulation is provided by an RCD, the disconnection times in accordance with Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD.

h) Determine maximum Earth fault loop impedance value (Zs) to achieve the 0.4 second **maximum** disconnection time.

BS 7671 (2022)



OSG Appendix I Pg 217

$Z_s = Z_e + (R_1 + R_2)$

Line conductor = 10.00 mm² 

Separate CPC conductor 2 sizes smaller = 4.00 mm² 

$R_1 + R_2 = \frac{m\Omega/m \ x \ Multiplier \ x \ Length}{1000}$

Values for mΩ/m: **OSG** Table I1 Pg 218 = 6.44 mΩ/m

10	4	6.44

Temperature multiplier values: **OSG** Table I3 Pg 220 = 1.20

Incorporated in a cable or bunched (NOTE 2)	1.20

(70°C Thermoplastic cable bunched with the live conductors)

$R_1 + R_2 = \frac{6.44 \ m\Omega/m \ x \ 1.2 \ x \ 43 \ m}{1000}$ = 0.3323 Ω   **$R_1 + R_2$ = 0.33 Ω**

Z_s = 0.24 Ω + 0.33 Ω = **0.57 Ω** ✓

i) Verify maximum earth fault loop impedance value as stated in **BS 7671 (2022)** to ensure 0.4 second disconnection time.

BS 7671 (2022) Table 41.3 Pg 68 max Zs for 32A Type C BS EN 60898-1 MCB = **0.68 Ω** ✓

Our **calculated Zs value** is **less than the maximum allowed** and therefore **acceptable**. ✓

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/($10I_n$)

j) **Determine the Fault current**. (I_f) Prospective Earth Fault Current. **(PEFC)**

OSG Appendix I Pg 217

$I_f = \frac{Uo}{Zs} = \frac{230V}{0.57\Omega}$ = **403.508 A** I_f = **404 Amps**

What about Prospective Short Circuit Current **(PSCC)**

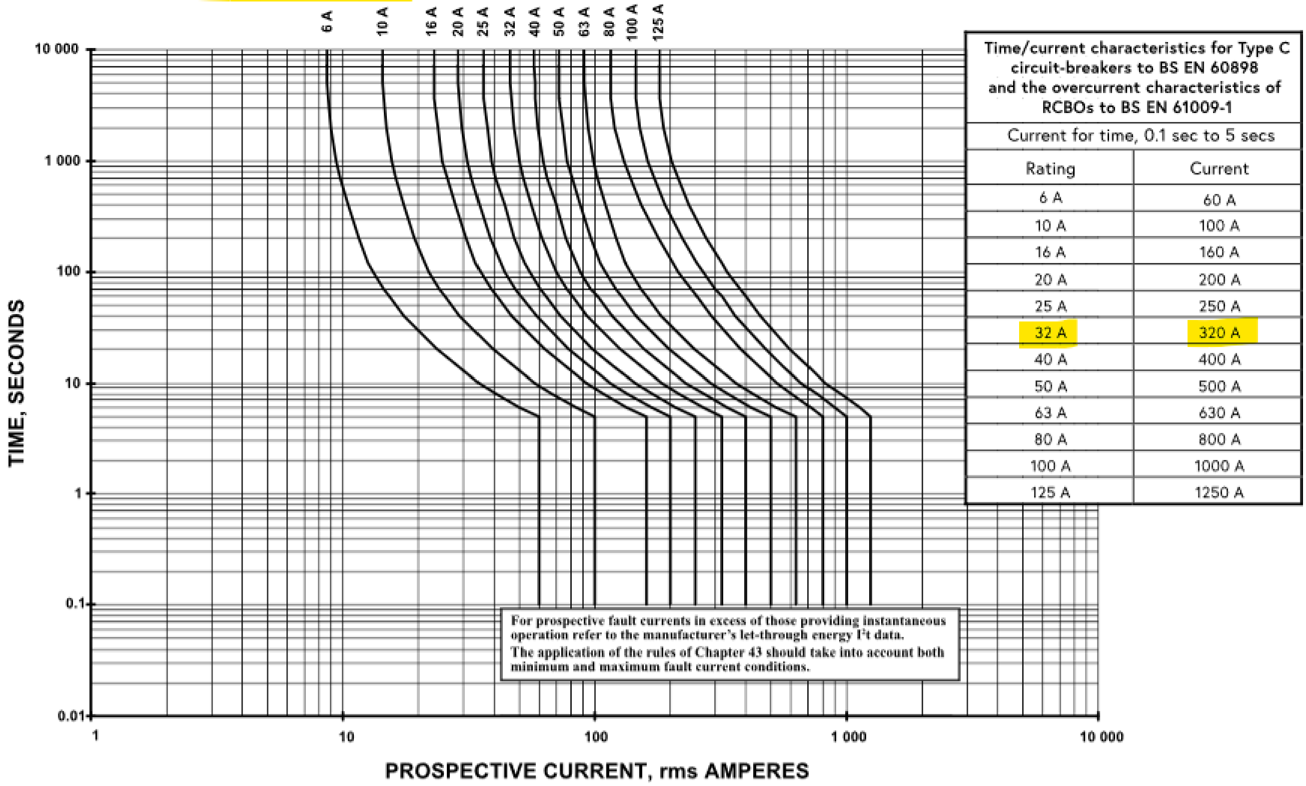
Do we need to consider this?

k) **Confirm the actual disconnection time of device selected.**

BS EN 60898-1 Type C BS EN 60898-1 MCB
BS 7671 (2022) Appendix 3 Fig 3A5 Pg 418

32 A	320 A

Fig 3A5 – Type C circuit-breakers to BS EN 60898 and RCBOs to BS EN 61009-1



A **minimum of 320 A** is required to disconnect the **32 A Type C MCB** between 0.1s to 5seconds.

Therefore, our **calculated fault current of 404 Amps** will achieve our maximum disconnection time of 0.4 seconds. **(0.1s actual)** ✓

l) Is the CSA of the sperate CPC selected acceptable within our design?

10.0mm^2 Line and Neutral conductors + 4.0mm^2 CPC →

BS 7671 (2022) Pg 199

Regulation 543.1.3 states to calculate minimum CSA of the CPC required:

$$S = \frac{\sqrt{I^2\, t}}{k}$$

I = **404 A**
t = Table 3A5 Appendix 3 **BS 7671 (2022)** Pg 418 = **0.1s**
k= Table 54.2 Pg 200 **BS 7671 (2022)** (70°C Thermoplastic Copper conductor) = **143**

TABLE 54.2 –
Values of k for insulated protective conductor not incorporated in a cable and not bunched with cables, or for seperate bare protective conductor in contact with cable covering but not bunched with cables, where the assumed initial temperature is 30 °C

Material of conductor	Insulation of protective conductor or cable covering		
	70 °C thermoplastic	90 °C thermoplastic	90 °C thermosetting
Copper	143/133*	143/133*	176
Aluminium	95/88*	95/88*	116
Steel	52	52	64
Assumed initial temperature	30 °C	30 °C	30 °C
Final temperature	160 °C/140 °C*	160 °C/140 °C*	250 °C

* Above 300 mm^2

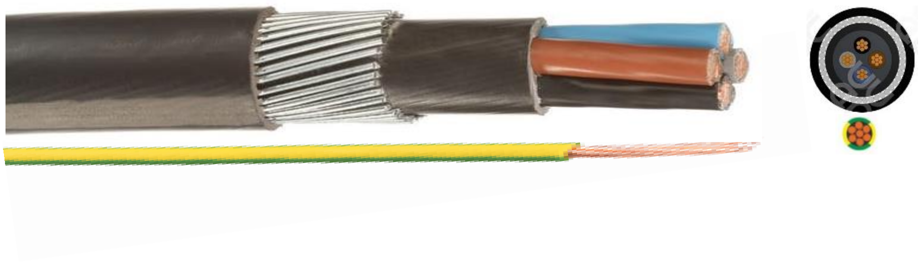
$$S = \frac{\sqrt{404A^2\ x\ 0.1s}}{143} = \mathbf{0.89\ mm^2}$$ ✓

The 4.0mm^2 separate CPC selected has a larger CSA than the minimum calculated of 0.89 mm^2 and therefore is an **acceptable CSA.** ✓

15 KW 3 phase compressor scenario   cable calculation process.

Summary

Our chosen cable CSA of 10.0mm^2 for the SWA and the 4.0mm^2 sperate CPC will comply fully with the relevant parts of BS 7671 (2022). ✓



Could this circuit be designed differently?

What CSA cable is recommended by software?