

Company Directive

STANDARD TECHNIQUE: SD5E/2

Design of Low Voltage Commercial and Industrial Connections

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Approved by



Policy Manager

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IMPLEMENTATION PLAN

Introduction

This document specifies the requirements for the design of low voltage (LV) Commercial and Industrial Connections to Western Power Distribution's (WPD's) Network.

Main Changes

This document has been updated as follows:

- References to ENA EREC G98 and ENA EREC G99 have been included, which shall take effect from 27th April 2019, but may be relevant to some connections prior to this date;
- Notes on further limitations for the use of 800A (Merlin Gerin NS800) circuit breakers have been included, due to the maximum number of cable connections available, along with the ratings for 4 x 630mm² copper cables, to account for this limitation;
- The dimensions of the draw pit in Figure 20, Typical circuit breaker Arrangement, have been revised, due to the physical size (width) of the circuit breakers that are currently used by WPD;
- LV transformer cabinets have been renamed, to reflect the current WPD Types;
- Type TMC 16/4/CB8 and TMC 16/4/CB12 have been added, to align with the current version of EE SPEC: 16;
- Type TMC 16/2/CB12 has been amended to reflect that 2 x fuse-ways are available, as well as the circuit breaker; and
- A small number of Sections have been re-referenced, to improve document flow.

Impact of Changes

Some of the changes included in the latest version of the document (ST:SD5E/2) will have an effect on the design of new and substantially modified commercial and industrial LV connections that utilise circuit breakers, due to a change in the cable entry draw pit size (width) for all circuit breakers and the 800A Merlin Gerin NS800 unit's cable connection limitations, although these limitations already exist in practice.

The remainder of the document changes will have little impact.

Implementation Actions

Managers responsible for staff involved with the design, installation, maintenance and replacement of LV commercial and industrial connections shall ensure these staff are familiar with and comply with the requirements of this document.

Implementation Timetable

This Standard Technique shall be implemented with immediate effect for new and substantially modified connections.

REVISION HISTORY

Document Revision & Review Table		
Date	Comments	Author
December 2018	<ul style="list-style-type: none"> References to ENA EREC G98 and ENA EREC G99 have been added to Sections 5.5 and 9.1 Note added to Section 8.1.1.1 to clarify that the use of WinDebut is allowed in place of Table 1 so long as the requirements of this document are satisfied Arrangement C has been re-referenced as Section 8.1.3 Notes have been added to Sections 8.1.2, 8.1.3 and Appendix D regarding the cable connection limitations of the 800A Merlin Gerin NS800 circuit breaker, currently used by WPD Figure 4 amended as Figures 4A and 4B, to allow the full range of available Arrangement B (Transformer MCCB and Metering MCCB) configurations available Section 8.1.2 (d), Figures 4, D1, D2 and D3 have been amended to align this ST:SD5E/2 with the latest version of EE SPEC: 16 The "Large LV Connection Assessment Tool" spreadsheet, used for Arrangements B and C, has been updated to include ratings for 4 x 630mm² copper cables and a note has been added, when an 800A circuit breaker is selected, regarding the Merlin Gerin NS800 circuit breaker's cable connection limitations. LV cabinet designations and available types have also been aligned with EE SPEC: 16 Draw pit dimensions have been revised in Figure 20 and associated Note 4 Ratings for 4 x 630mm² copper cables have been added to Appendix C Appendix C tables for Autumn and Winter ratings have been re-referenced as C3 and C4, respectively 4 x 630mm² copper cables have been added to the lists of available options in Appendix D 	Matt Pope/ Andy Hood
August 2017	<ul style="list-style-type: none"> Table 1 has been modified to clarify the requirements for pole-mounted 315kVA transformers Cosmetic changes made to Figure 8 to Figure 14 Minimum height requirement in Figure 20 has been corrected 	Andy Hood

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1.0 INTRODUCTION

- 1.1 This document specifies requirements for the design of low voltage (LV) commercial and industrial connections.
- 1.2 Western Power Distribution (WPD) staff and contractors use WinDebut software for carrying out LV load flow studies, where needed. Independent Connection Providers may either use WinDebut or other alternative systems as long as the criteria specified in this document are satisfied.
- 1.3 It should be noted that some of the standard arrangements described in this document (i.e. Arrangement B and C) do not require load flow studies to be carried out by the Planner.
- 1.4 The term “load” applies to electrical demand and also to generation. The term “demand” refers to load that consumes active power (kW). The term “generation” is a source of electrical energy produces active power (kW)

2.0 CUSTOMER INFORMATION

- 2.1 The first stage is to obtain relevant information on the connection requirements from the customer / developer. Guidance on the minimum information requirements is included in ST: NC1Y. For commercial and industrial the following information is required:
 - Customer name and address (correspondence address) and other contact details
 - Site address
 - Site plan at an appropriate scale to indicate the site boundary, layout of buildings and roads and proposed meter positions.
 - Letter of authority where the applicant is acting as an agent of the customer
 - Indicative date when the customer requires the connection(s) to be made
 - Total maximum import capacity and export capacity (kVA) required and any interim capacity / connection requirements for phased developments
 - The extent of any Contestable work to be carried out by the customer.
 - The maximum capacity required at each metering point
 - Details of any generation and electrical energy storage that is required to operate in parallel with the connection/s
 - Details of any export limitation schemes (ELs) that are used by the customer to restrict the site export
 - Details of any equipment that is likely to cause disturbance to the electricity supply stating as a minimum the number, type (e.g. motors, welders, heat pumps, high power lighting, kilns, large switched loads etc.)
 - Details of any street lighting or other un-metered connections to be installed within the development.

3.0 LOAD ESTIMATES

- 3.1 For commercial / industrial premises, the customer or their agent/developer is expected to estimate their maximum import and export capacity. The Planner should discuss and agree these requirements with the customer.
- 3.2 Diversity is not normally applied between different maximum demand (MD) metered commercial / industrial connections as there is a high probability that the installations will be operating at their MDs at the same time. If, however, there is a compelling reason for applying diversity between such connections, for example, due to the nature of the connected load, this may be applied at the discretion of the Planner.
- 3.3 For whole current metered commercial / industrial connections (i.e. Profile 3 and Profile 4 connections) diversity is applied to demand.
- 3.4 Diversity is not normally applied between generators, however, if there is a compelling reason for doing so e.g. due to operating restrictions or do to the nature of the generators this may be applied at the discretion of the Planner.

4.0 THERMAL REQUIREMENTS

- 4.1 WPDs plant and equipment must be adequately rated for the expected load. The meter operator and the customer must also ensure that their equipment is adequately rated.
- 4.2 When designing new or augmented networks for commercial and industrial connections summer sustained ratings are normally assumed for plant and equipment as the period of maximum demand or generation may occur at any time of year.
- 4.3 Cable and overhead line ratings in WinDebut are based on autumn cyclic conditions. Whilst this is acceptable for housing developments these ratings are not normally appropriate for commercial and industrial loads. When WinDebut is used the alternative ratings (i.e. summer sustained ratings) must be checked manually (see ST:SD8A and ST:SD8B part 1).
- 4.4 Transformers are assumed to have a summer sustained rating of 100% of their name plate rating (see ST: SD8D).
- 4.5 Alternative ratings (i.e. other than summer sustained ratings) may be used where there is compelling evidence to support this, however, it should be noted that Connection Agreements do not normally specify different import and export capacities for different seasons.

5.0 VOLTAGE REQUIREMENTS

- 5.1 The voltage on the LV network shall remain within statutory limits (i.e. 253V to 216.2V).

In order to achieve this requirement:

- The voltage drop across the distribution transformer and LV network (including the LV service) shall not exceed 8% of 230V (i.e. 18.4V).
- The voltage rise across the distribution transformer and LV network shall not exceed 1.5% of 230V (i.e. 3.45V)

Note:

- 1) WinDebut allocates a 2% voltage drop across the transformer (under maximum demand conditions) so the allowable voltage drop across the remaining LV network is 6% of 230V.
- 2) WinDebut uses a 240V base for its load flow studies and therefore it limits the voltage drop across the LV cables and lines to 5.76% of 240V and limits the maximum voltage rise across the transformer, cables and lines to 1.44% of 240V.

- 5.2 When assessing the voltage drop associated with 3 phase or split phase commercial and industrial connection a certain amount of unbalance shall be assumed. 3 phase demands are assumed to operate with 20% unbalance and split phase connections with an unbalance of 33%, where:

$$\% \text{ Unbalance} = 100 \times I_N / (I_{L1} + I_{L2} + I_{L3})$$

I_N = neutral current

I_{L1} = current in phase 1

I_{L2} = current in phase 2

I_{L3} = current in phase 3 (where applicable)

- 5.3 In practice, where an LV network is modelled in WinDebut (or equivalent) the poly-phase (i.e. 3 phase or split phase) connection that is expected to have the greatest impact on voltage drop shall be modelled with un-balance and all other poly-phase connections are modelled with balanced demand.

- For a 3 phase connection, model 2 phases at 100% of the maximum demand (per phase) and the third phase at 50% of the maximum demand (per phase)
- For a split phase connection model 1 phase at 100% of the maximum demand (per phase) and the other phase at 50% of the maximum demand (per phase)

For example, a three phase, profile 8 connection with a maximum demand of 300kVA is modelled in WinDebut as follows:

- Phase R and Phase Y are each modelled as 100kVA single phase demands
- Phase B modelled as a 50kVA single phase demand

The figure shows two side-by-side screenshots of the 'Network Editor' dialog box, specifically the 'Point Load' tab for 'ID: 1'. Both windows have the 'Settings For Consumer' dropdown set to '1' and '2' respectively. The 'Cores Available' is set to 'Three' in both. The 'Consumer Type' is 'EIGHT_100_0' in both. The 'Number of Consumers' is '2' in the left window and '1' in the right window. The 'Specified Distribution' section shows 'Red' and 'Yellow' phases with values of 100 and 100 in the left window, and 0 and 0 in the right window. The 'Unit Overrides (kW)' section shows 'Day' and 'Night' values of 100 and 0 in the left window, and 50 and 0 in the right window. The 'Consumer type details' at the bottom of both windows reads 'ELEXON 8 Non-Domestic, MD - Load Factor >40%'.

Figure 1 Modelling Unbalanced Maximum Demand Connections in WinDebut

5.4 For whole current connections unbalance is modelled as follows:

- For a 3 phase connection model 2 phases at a 1/3 of the estimated annual consumption (EAC) and the third phase at 1/6 of the EAC.
- For a split phase connection model 1 phase at 1/2 of the estimated annual consumption (EAC) demand and the other phase at 1/4 of the EAC

For example, a three phase, profile 3 connection with an estimated annual consumption of 40000 kWh would be modelled as follows:

- R and Y phases modelled as $40000/3 = 13333$ kWh single phase demands
- B phase modelled as a $40000/6 = 6667$ kWh single phase demand

The figure shows two side-by-side screenshots of the 'Network Editor' dialog box, specifically the 'Point Load' tab for 'ID: 1'. Both windows have the 'Settings For Consumer' dropdown set to '1' and '2' respectively. The 'Cores Available' is set to 'Three' in both. The 'Consumer Type' is 'THREE_20000_0' in both. The 'Number of Consumers' is '2' in the left window and '1' in the right window. The 'Specified Distribution' section shows 'Red' and 'Yellow' phases with values of 13333 and 13333 in the left window, and 6667 and 6667 in the right window. The 'Unit Overrides (kWh)' section shows 'Day' and 'Night' values of 13333 and 0 in the left window, and 6667 and 0 in the right window. The 'Consumer type details' at the bottom of both windows reads 'ELEXON 3 Unrestricted Non-Domestic'.

Figure 2 Modelling Unbalanced Whole Current Connections in WinDebut

5.5 When assessing voltage rise due to generation, the demand is still modelled with unbalance but generator output is normally assumed to be balanced. This is because G59 and G99 restrict maximum generation unbalance to 3.68kW.

6.0 POWER QUALITY REQUIREMENTS

- 6.1 Phase to neutral loop impedances shall satisfy the requirements of ST: SD5R.
- 6.2 Equipment rated up to 16A per phase is assumed to comply with the following standards and may be connected without further consideration:
- BS EN 61000-3-2: Limits for harmonic currents produced by equipment connected to public low-voltage systems with inputs current $\leq 16\text{A}$ per phase.
 - BS EN 61000-3-3: Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage systems, for equipment with rated current $\leq 16\text{A}$ per phase and not subject to conditional connection.
- 6.3 Equipment rated up to 75A per phase should comply with:
- BS EN 61000-3-11: Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage systems - equipment rated current $\leq 75\text{A}$ per phase and subject to conditional connection.
 - BS EN 61000-3-12: Limits for harmonic currents produced by equipment connected to public low-voltage systems with inputs current $>16\text{A}$ and $\leq 75\text{A}$ per phase.
- 6.3.1 BS EN 61000-3-11 and BS EN 61000-3-12 define requirements for the maximum system impedance and minimum fault level at the exit point which the equipment is connected to. These requirements shall be met when designing networks and when assessing whether reinforcement is needed (before such equipment may be connected).
- 6.4 Equipment that does not comply with the above standards shall be assessed in accordance with:
- ENA Engineering Recommendation G5: Planning levels for voltage distortion and connection of non-linear equipment to transmission systems and distribution systems in the UK
 - ENA Engineering Recommendation P28: Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the UK, and
 - ENA Engineering Recommendation P29: Planning limits for voltage unbalance in the UK.
- 6.5 Guidance on how to assess power quality requirements is included in ST: SD6F and ST: SD6J.

7.0 PROTECTION REQUIREMENTS

7.1 The following protection criteria shall be satisfied for new and substantially modified LV designs:

- Faults on LV circuits shall be capable of being cleared within 60s*
- Faults on mains cables and overhead lines shall be capable of being cleared within the short circuit rating of the cable or line, so far as is reasonably practicable*
- Faults at the terminals of WPD cut-outs and multi-service distribution and metering circuit breakers shall be capable of being cleared within 5s*
- Earth fault loop impedances shall satisfy the requirements of ST:SD5R
- LV fuses and LV circuit breakers settings shall, as far as possible, grade with HV protection.

** Note, these criteria assume that that there is zero resistance at the point of fault.*

7.2 The customer is responsible for ensuring their installation is adequately protected in accordance with BS7671 (IET Wiring Regulations).

7.3 WinDebut, where used, checks that WPDs cables and overhead lines are adequately protected, as long as the correct substations fuse is modelled. Cut-out fuse clearance times and earth fault loop impedances must be checked manually in accordance with ST: SD5R.

8.0 PHYSICAL DESIGN REQUIREMENTS

8.1 Standard Arrangements

Four standard arrangements are used for LV commercial and industrial connections:

Arrangement A: Fused arrangement via 100A cut-out, heavy duty cut-out or multi-service distribution board.

Arrangement B: LV metering circuit breaker fed from a substation LV cabinet.

Arrangement C: LV metering circuit breaker fed from a transformer cable box.

8.1.1 Arrangement A

In this case the LV connection is derived from a fused cut-out or multi-service distribution board connected to a conventional LV circuit as shown in Figure 3 below. The maximum load is limited by plant and equipment ratings (e.g. ratings of LV cables and transformers) and by voltage and protection restrictions.

The following requirements apply:

- (a) ST: SD5D specifies the requirements for cut-out arrangements, including typical draw pit requirements. Standard cut-out/CT metering panels are available in three ratings, 200A, 400A and 600A. Combined cut-out/CT metering panels are suitable for the following cable sizes:
 - 200A unit – 35mm² to 95mm² cable
 - 400A unit – 70mm² to 185mm² cable
 - 600A unit – 95mm² to 300mm² cable.
- (b) ST: SD5C specifies the requirements for multi-occupancy buildings and multi-service distribution boards.
- (c) WPD staff shall use WinDebut for modelling the LV network whereas ICPs may utilise other equivalent design tools, as long as the requirements of this document are satisfied. WinDebut uses autumn cyclic ratings for cables and autumn ratings for overhead lines and so the correct ratings (normally summer sustained) must be checked manually against the values in ST:SD8B part 1 and ST:SD8A.
- (d) LV protection requirements shall be checked and satisfied. Where WinDebut is used, LV fuses shall be manually set up at the first node on each circuit (see ST:SD5K for further guidance). Failure to model the fuses correctly could give rise to excessive fault clearance times or allow short circuit ratings of cables and/or overhead lines to be exceeded.
- (e) Phase to neutral and phase to earth loop impedances shall be checked manually to ensure the requirements of ST: SD5R are satisfied.
- (f) Whole current metering is typically used for connections rated up to 100A per phase. CT metering shall be used for 3 phase and split phase connections rated above 100A per phase.

- (g) The system earthing shall satisfy the requirements of ST:TP21D. Customer earthing shall be in accordance with ST:TP21E. Where the connection is made via a heavy duty cut-out, combined cut-out / CT metering panel or multi-service distribution board and PME or SNE derived from CNE network is provided, a PME earth shall be connected to the incoming side of the cut-out/MSDB.

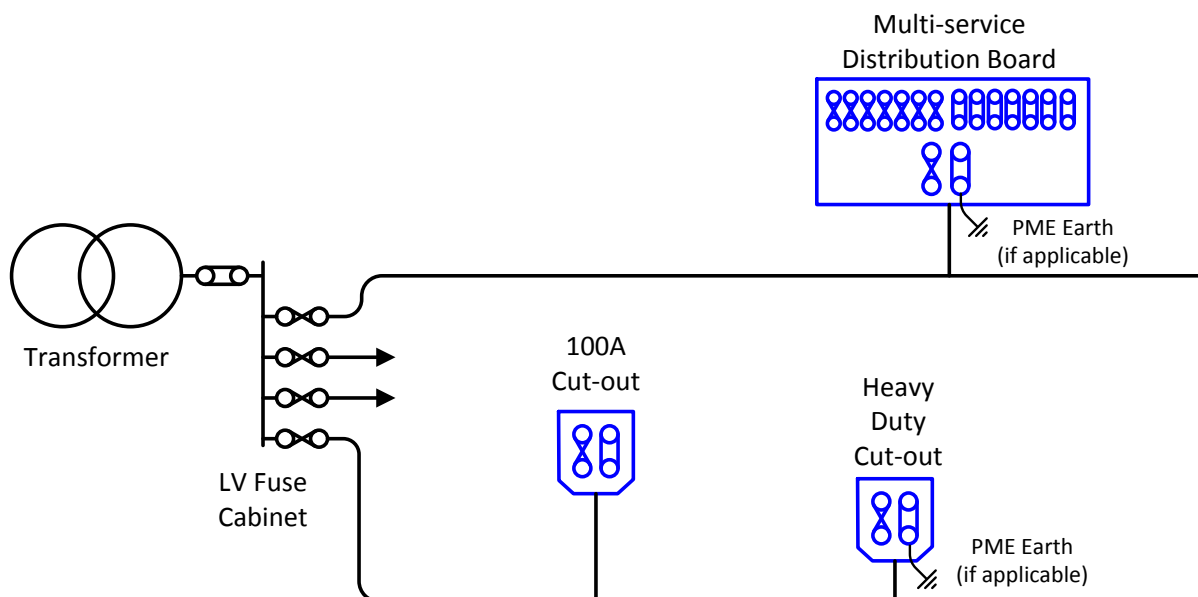


Figure 3 Options for Arrangement A

8.1.1.1 Dedicated LV Circuits

Where one 3 phase demand is dedicated to an LV circuit (i.e. no other connections are made to the circuit) Table 1 may be used to determine the fusing requirements and the maximum cable lengths that satisfy protection, earth fault loop impedance and voltage requirements.

The Planner must check that the power quality aspects are satisfied.

Table 1 may only be used where all of the following criteria are satisfied:

- The load is always imported, not exported. Table 1 must not be used where active power (kW) is exported.
- Summer sustained ratings are applicable.
- 95mm², 185mm² Wavecon or 300mm² mains cables are used for the whole circuit length.
- Only one customer is connected to the LV circuit.

For all other situations the network shall be modelled in WinDebut^[1].

Notes: [1] This statement does not suggest that WinDebut cannot also be used for situations where the above criteria are met. Staff involved with the design of this type of connection may use WinDebut for all of the above situations, as long as the requirements of this document and other relevant design criteria are satisfied.

T/F Rating	Maximum Demand	Substation Fuse	Cut-out Fuse	Maximum Cable Length ^[4]		
				95mm ² Wcon	185mm ² Wcon	300mm ² Wcon
315kVA ^[4]	160A (110kVA)	315A	160A	211m	411m	597m
	200A (138kVA)	315A ^[1]	200A ^[1]	172m	336m	489m
	250A (173kVA)	315A ^[1]	250A ^[1]	-	269m	391m
	315A (217kVA)	315A ^[1]	315A ^[1]	-	211m	306m
500kVA	160A (110kVA)	400A	160A	195m	390m	480m
	200A (138kVA)	400A	200A	172m	336m	480m
	250A (173kVA)	400A ^[1]	250A ^[1]	-	269m	391m
	315A (217kVA)	400A ^[1]	315A ^[1]	-	211m	306m
	355A (245kVA)	400A ^[1]	355A ^[1]	-	-	275m
	400A (276kVA)	400A ^[1]	400A ^[1]	-	-	244m
800kVA	160A (110kVA)	400A	160A	200m	400m	490m
	200A (138kVA)	400A	200A	172m	336m	489m
	250A (173kVA)	400A ^[1]	250A ^[1]	-	269m	370m
	315A (217kVA)	400A ^[1]	315A ^[1]	-	211m	306m
	355A (245kVA)	400A ^[1]	355A ^[1]	-	-	275m
	400A (276kVA)	400A ^[1]	400A ^[1]	-	-	244m
1000kVA	160A (110kVA)	400A	160A	200m	400m	495m
	200A (138kVA)	400A	200A	172m	336m	489m
	250A (173kVA)	500A	250A	-	269m	375m
	315A (217kVA)	500A ^[1]	315A ^[1]	-	211m	306m
	355A (245kVA)	500A ^[1]	355A ^[1]	-	-	275m
	400A (276kVA)	500A ^[1]	400A ^[1]	-	-	244m

Table 1 Arrangement A - Fuse requirements and maximum cable lengths where the LV circuit is dedicated to one 3 phase customer connection

Notes: [1] The substation LV fuses do not grade with the cut-out fuses.

[2] Cable options assume they are laid direct in ground.

[3] Combined cut-out / CT cabinets are suitable for terminating the following cable sizes:

- 200A unit – 35mm² to 95mm² cable
- 400A unit – 70mm² to 185mm² cable
- 600A unit – 95mm² to 300mm² cable

[4] Where a 315kVA pole mounted transformer is used the substation fuse may be increased to 400A and the maximum demand increased accordingly. Where this is the case the maximum LV circuit length shall be determined from WinDebut.

8.1.2 Arrangement B

Arrangement B is suitable for LV loads up to 1000kVA. In this case, the substation LV cabinet includes a LV circuit breaker which feeds a number of single core cables (600mm² soldals, 740mm² soldals or 630mm² copper cables). These cables are terminated in a LV metering circuit breaker at the customer's installation. The options are shown in Figures 4A and 4B.

In addition:

- (a) The cables must be laid in a touching trefoil arrangement (see also section 8.3) and solidly bonded, i.e. the armour must be bonded at both ends. The cable ratings are listed in Table 4.
- (b) Earthing options include Protection Multiple Earthing (PME / TN-C-S), Separate Neutral Earthing (SNE / TN-S), Direct Earthing (TT) and Protective Neutral Bonding (PNB). Further information is provided in Figure 8 to 12.
- (c) WPD's specification for metering circuit breaker panels is EE SPEC: 28. Requirements for the meter position, including space requirements and cable entry details are included in Section 8.4.
- (d) WPD's specification for LV cabinets is EE SPEC: 16 and include the following Moulded Case Circuit Breaker (MCCB) options:
 - Type TMC 16/2/CB8 cabinet; 1x 800A^[1] circuit breaker and 2x 630A fuse-ways
 - Type TMC 16/4/CB8 cabinet; 1x 800A^[1] circuit breaker and 4x 630A fuse-ways
 - Type TMC 16/2/CB12 cabinet; 1x 1250A circuit breaker and 2x 630A fuse-ways
 - Type TMC 16/4/CB12 cabinet; 1x 1250A circuit breaker and 4x 630A fuse-ways
 - Type TMC 16/-/CB16 cabinet; 1x 1600A circuit breaker only
 - Type TMC 16/-/2CB8^[2] cabinet; 2x 800A^[1] circuit breakers.
- (e) The following spreadsheet shall be used to determine the required cable type and the maximum acceptable cable length for specific circumstances.

[<Large LV Connection Assessment Tool>](#)

- Notes:
- [1] The present 800A (Merlin Gerin NS800) circuit breaker only allows for up to 4 x single core cable connections. This means that, when the cables are installed in ducting, the full 800A rating of the circuit breaker may not be achievable. Where 4 x single core cables are not sufficient for requirements (e.g. due to thermal ratings), 1250A (Merlin Gerin NS1250) circuit breakers may be installed, to allow for up to 8 x single core cable connections. Where the use of 1250A circuit breakers in place of 800A circuit breakers constitutes the minimum cost scheme, the associated increase in asset cost should normally be borne by the customer.
 - [2] Where the Type TMC 16/-/2CB8 cabinet is used, each circuit breaker shall supply a different connection. The circuits must not be operated in parallel.

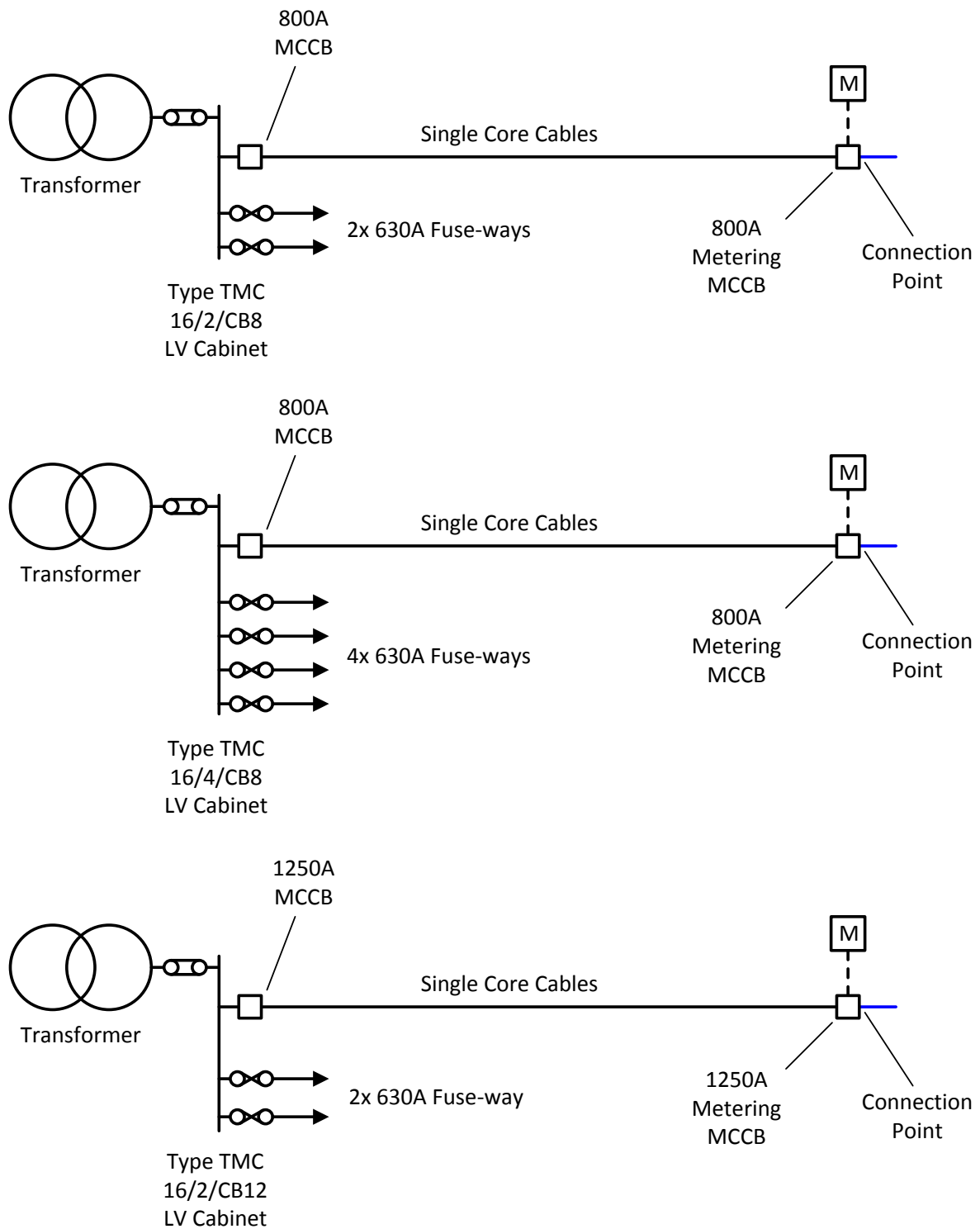


Figure 4A Arrangement B (Transformer MCCB and Metering MCCB)

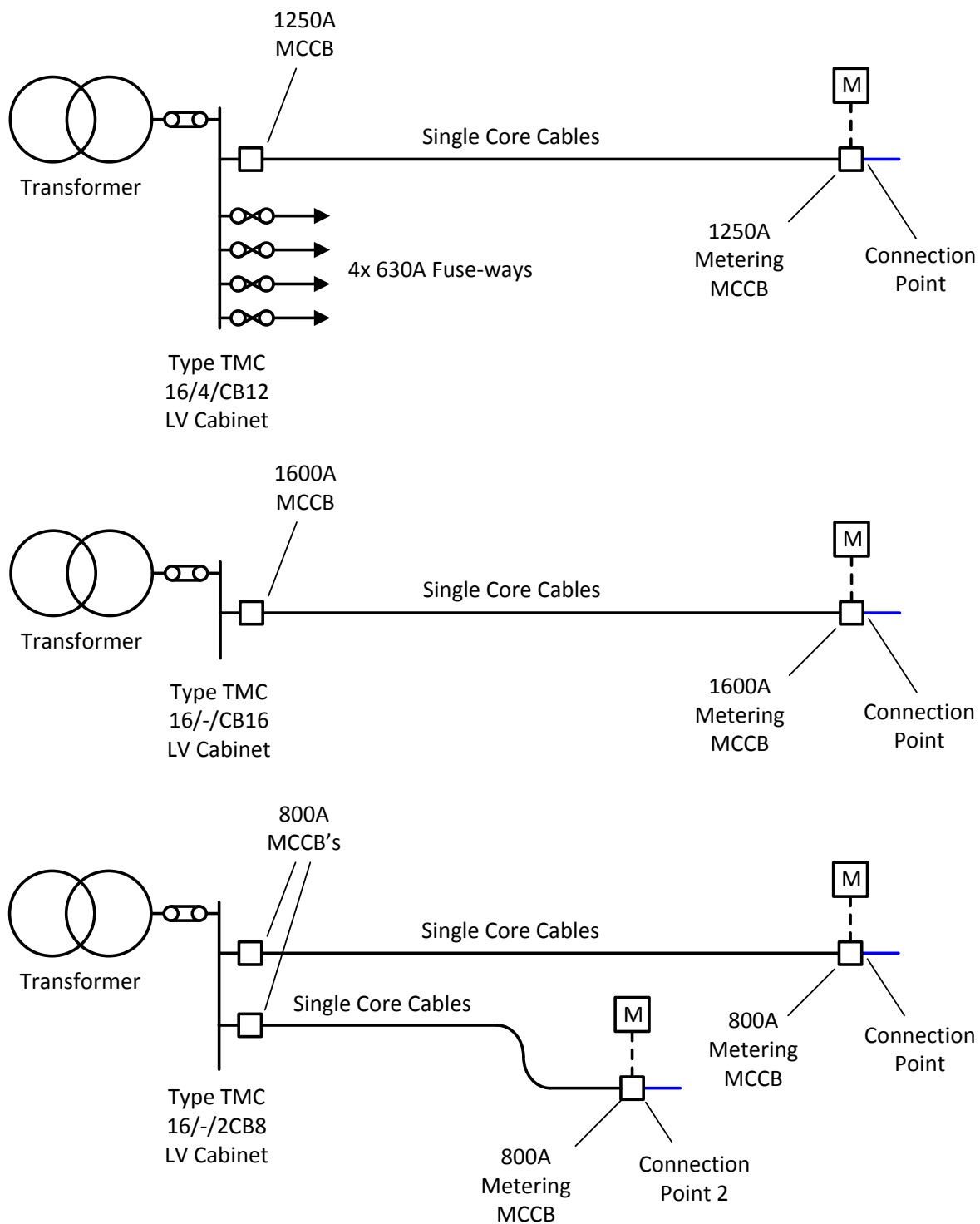


Figure 4B Arrangement B (Transformer MCCB and Metering MCCB) (Continued)

8.1.3 Arrangement C

In this case, the WPDs transformer is fitted with a cable box and a short length (up to 20m) of single core cables are installed between the transformer and a LV metering circuit breaker. The metering circuit breaker is located in the customer's building / enclosure. This arrangement is shown in Figure 5.

In addition:

- (a) The cables must be laid in a touching trefoil arrangement (see also section 8.3) and be solidly bonded, i.e. the armour must be bonded at both ends. The cable ratings are listed in Table 4.
- (b) PNB earthing shall be provided in accordance with Figure 13 and 14.
- (c) WPD's specification for metering circuit breaker panels is EE SPEC: 28. Requirements for the meter position, including space requirements and cable entry details are included in Section 8.4.
- (d) The transformer cable box specification is included in EE SPEC: 16^[1].
- (e) The following spreadsheet shall be used to determine the required cable type and the maximum acceptable cable length for specific circumstances.

[<Large LV Connection Assessment Tool>](#)

Notes: [1] The present 800A (Merlin Gerin NS800) circuit breaker only allows for up to 4 x single core cable connections. This means that, when the cables are installed in ducting, the full 800A rating of the circuit breaker may not be achievable. Where 4 x single core cables are not sufficient for requirements (e.g. due to thermal ratings), 1250A (Merlin Gerin NS1250) circuit breakers may be installed, to allow for up to 8 x single core cable connections. Where the use of 1250A circuit breakers in place of 800A circuit breakers constitutes the minimum cost scheme, the associated increase in asset cost should normally be borne by the customer.

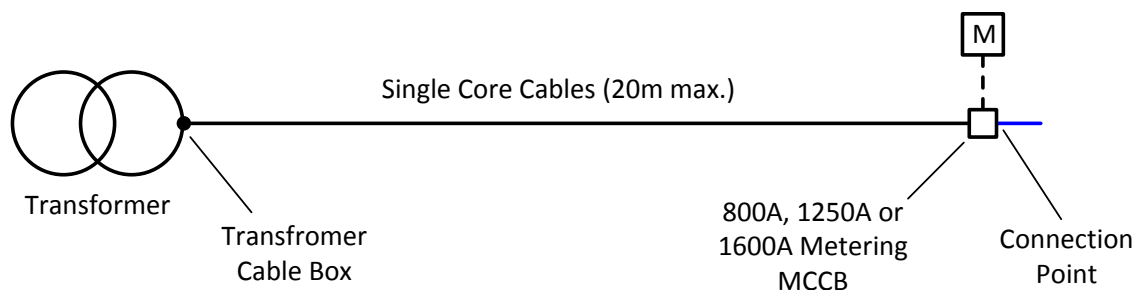


Figure 5 Arrangement C (Transformer MCCB only)

8.2 Substation Locations

8.2.1 The following criteria shall be considered when selecting the substation location:

- The substation should be close to the load centre in order to minimise the voltage drop / rise, losses and phase to neutral / earth loop impedances.
- Risk of accidental damage and vandalism shall be minimised.
- The substation shall be accessible at all times without delay (i.e. on a 24/7 basis). 24 hour access is required for personnel, equipment and plant (including the connection of mobile generation).
- The substation should be located at least 5m from the living areas and bedrooms of residential properties / hotels etc. to minimise the risk of noise complaints.
- The substation shall be located at least 9m from earthed LV metalwork (e.g. steel framed buildings) where the HV and LV earth electrodes need to be segregated. Further guidance on earthing requirements is provided in ST:TP21D.

8.2.2 WPD substations shall not be placed within:

- Customer buildings where HV and LV earthing systems need to be segregated.
- Rooms that have no external walls or that have no doors leading directly outside.
- Rooms with inadequate natural ventilation
- Rooms / locations without acceptable escape routes for personnel

8.2.3 Ground mounted substation plant shall be installed on anti-vibration pads and placed within an appropriate GRP enclosure or substation building. Requirements for substation foundations and enclosures are specified in ST: NC1V.

8.3 Cables and Cable Installation

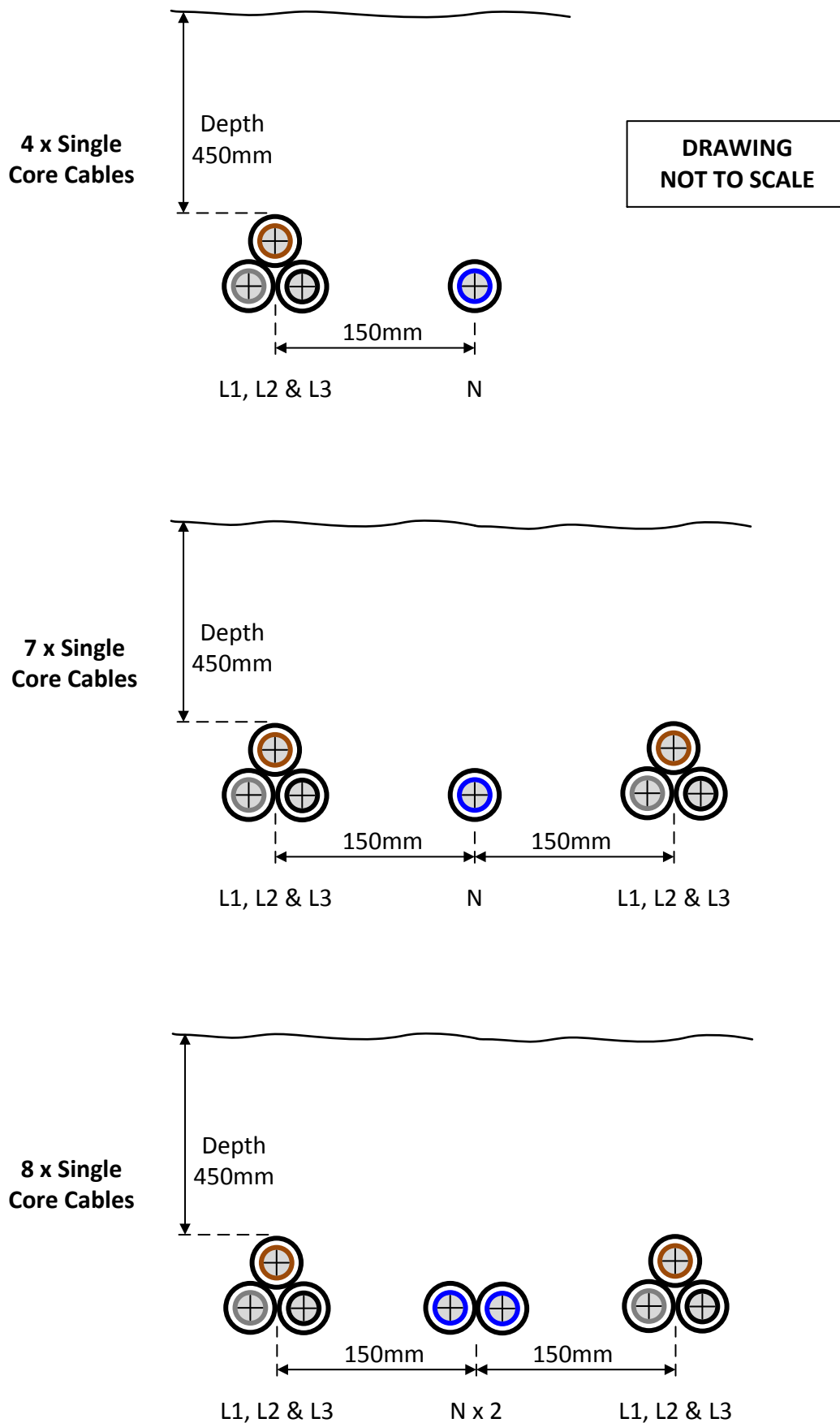
8.3.1 Detailed requirements for cables are specified in the CA series of WPD policy. Cable installation requirements are specified in ST: CA6A.

8.3.2 3 phase LV cables shall not be operated in parallel.

8.3.3 Single core cables (i.e. 600mm² and 740mm² solidal and 630mm² copper) shall be solidly bonded (i.e. the armour is bonded at both ends) and installed in a touching trefoil configuration as shown in Figure 6 and 7. It is essential that touching trefoil configuration is maintained over the entire cable run in order to prevent high levels of current being induced in the armouring (which would de-rate the cable). The only exception to this is the short length (1m or so) at each end of the cable run which must be separated to make the termination to the switchgear or transformer.

8.3.4 Service / cable entry requirements are specified in Section 8.4 and Figure 15 to 18.

8.3.5 Requirements for earthing / bonding single core cables are shown in Figure 8 to 14.



Note, the external diameter of each single core cable depends on its type and cross-sectional area, however, this is typically about 50mm.

Figure 6 Single Core Cable in Trefoil Configuration - Laid Direct in Ground

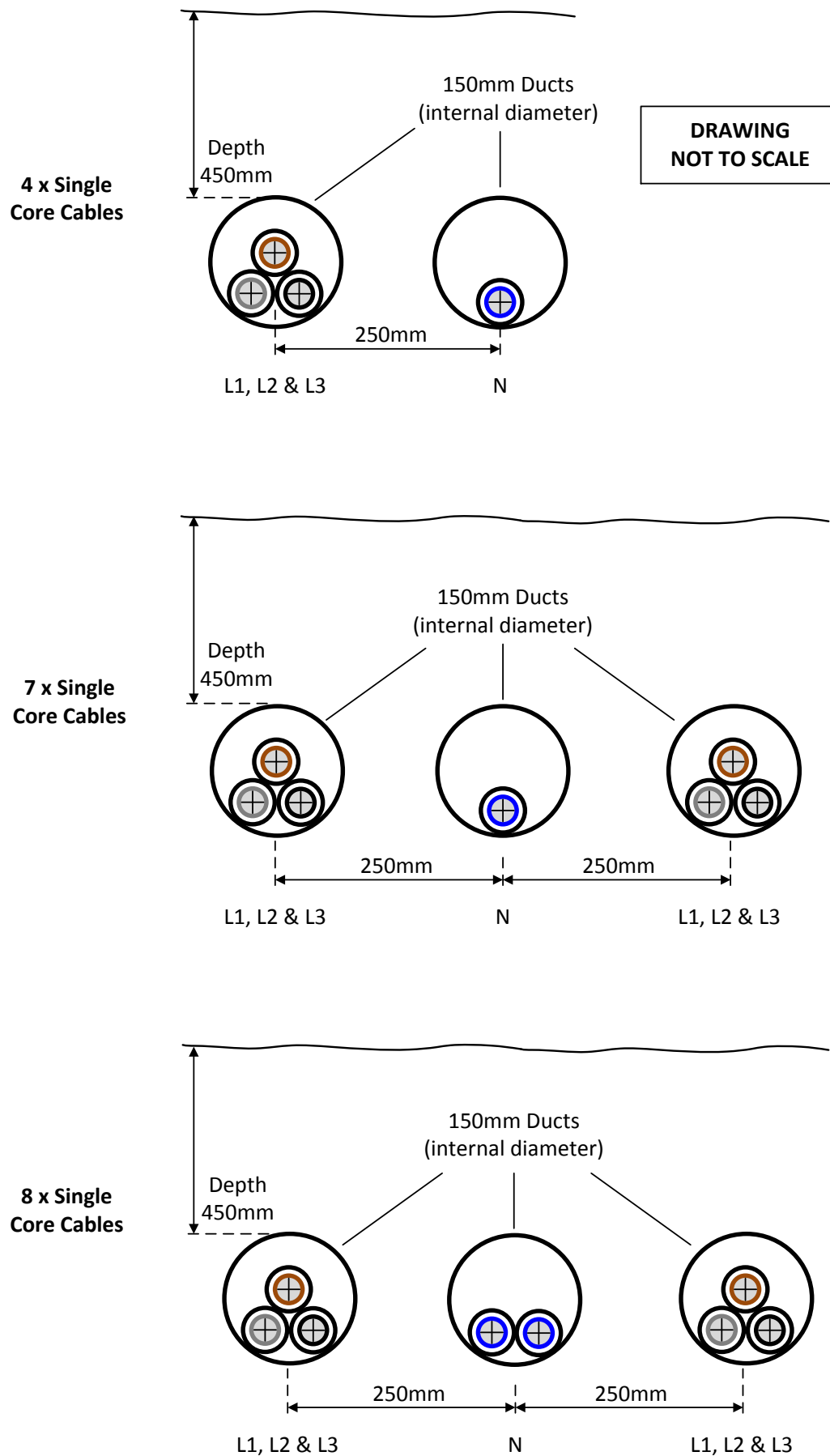


Figure 7 Single Core Cables in Trefoil Configuration – Installed in Ducts

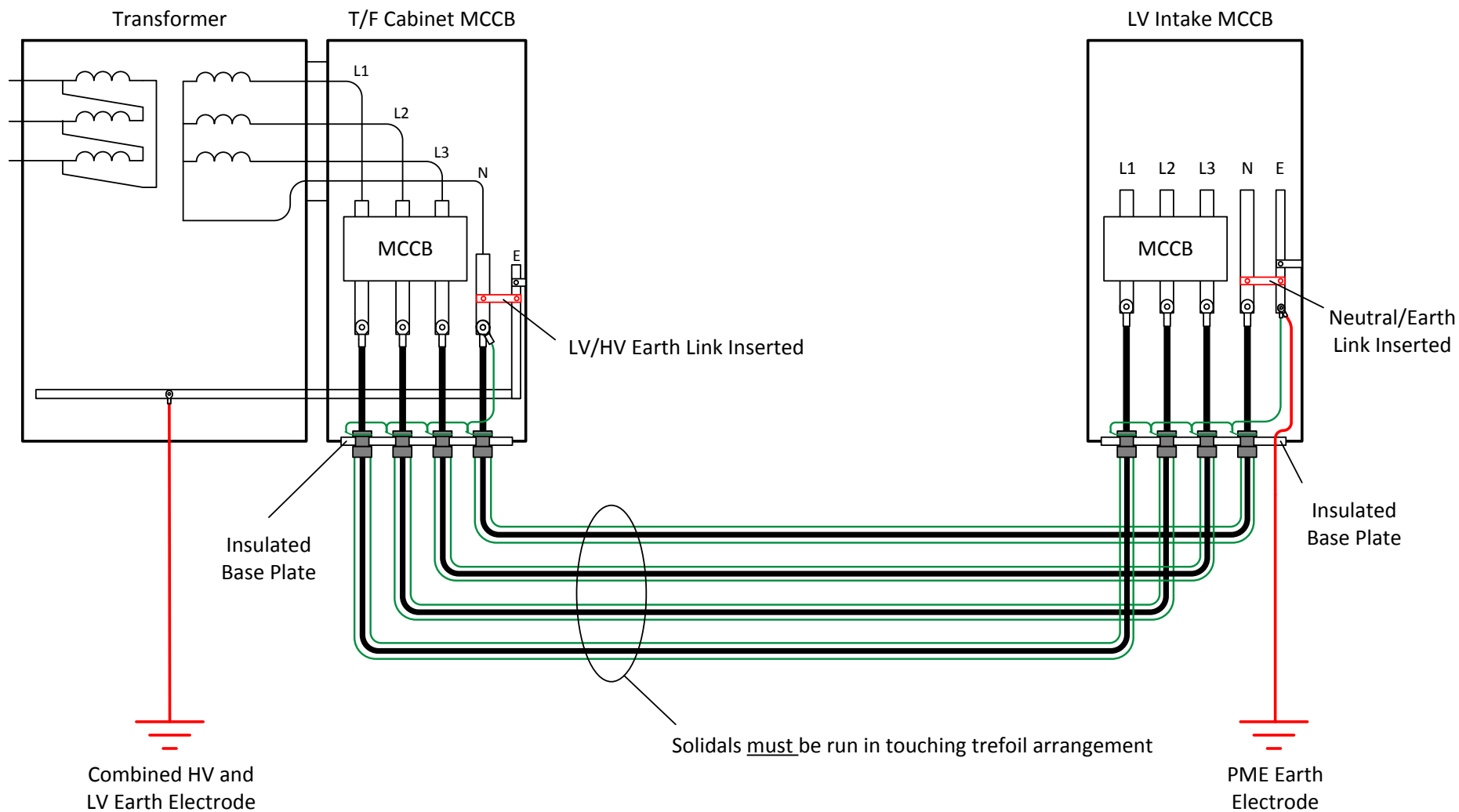


Figure 8 Single Core Cable Earthing / Bonding – Arrangement B, PME Connection with Combined HV and LV Earthing

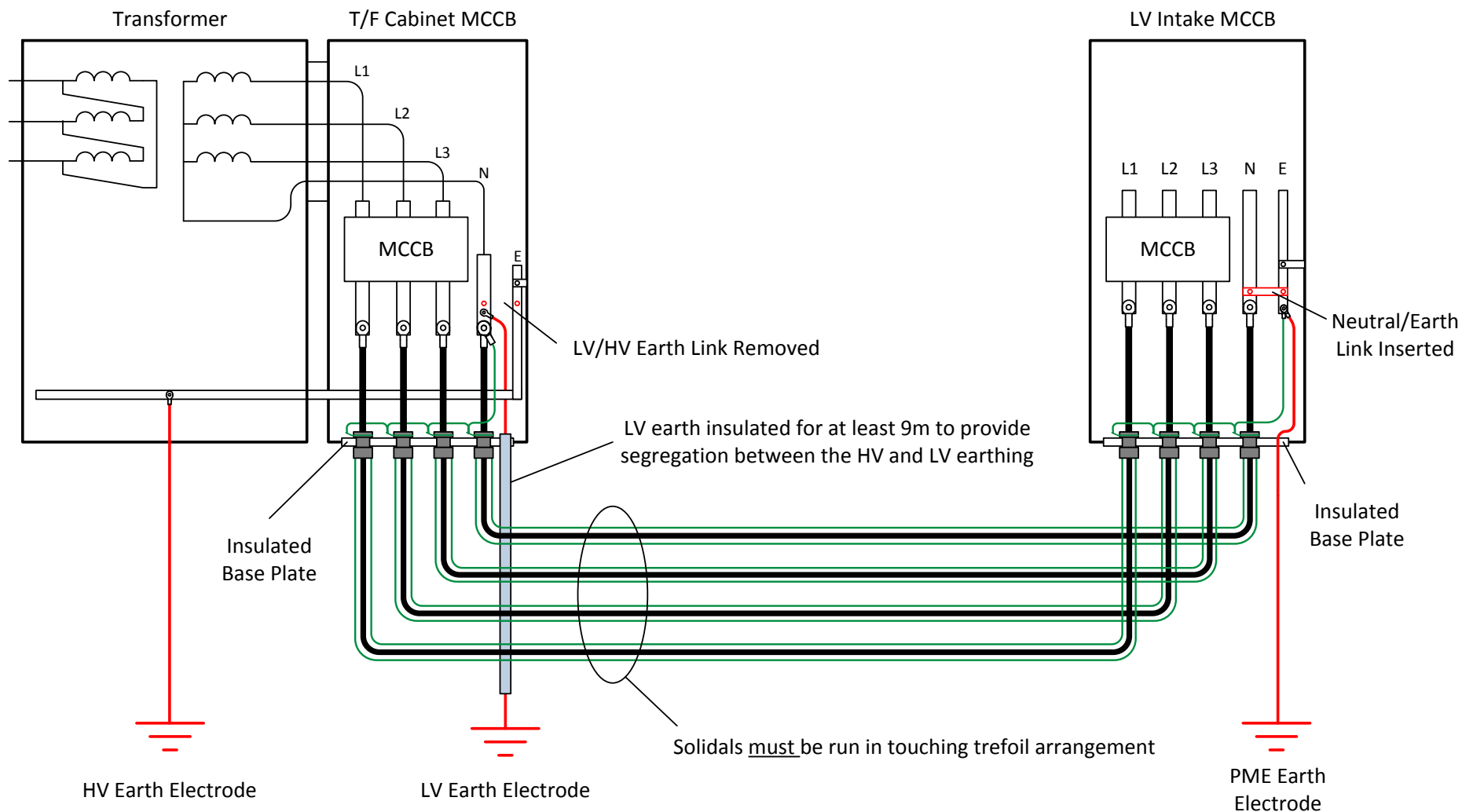
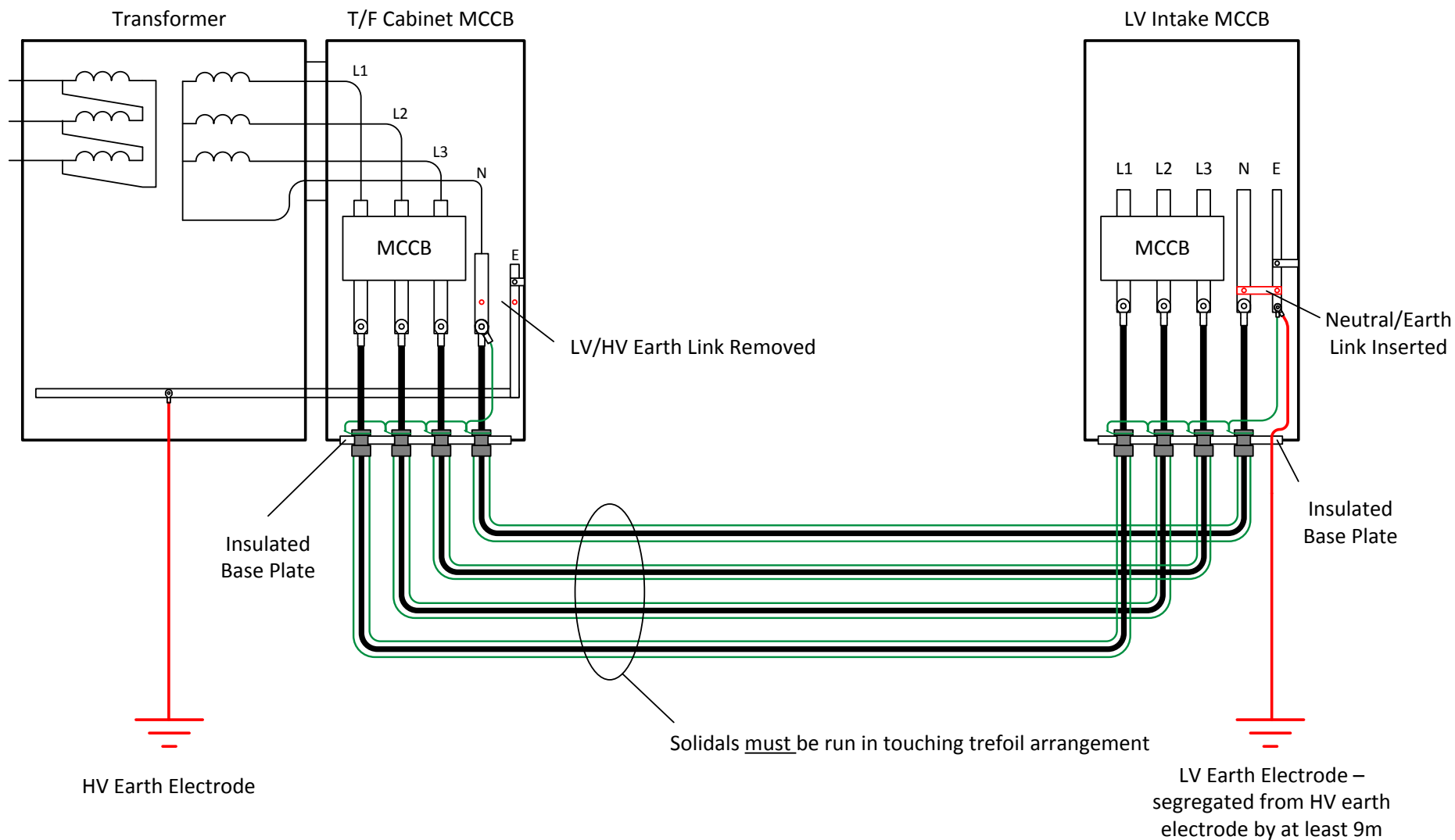


Figure 9 Single Core Cable Earthing / Bonding – Arrangement B, PME Connection with Segregated HV and LV Earthing



Note, this option is only acceptable where just one customer is connected to the substation

Figure 10 Single Core Cable Earthing / Bonding – Arrangement B, PNB Connection with Segregated HV and LV Earthing

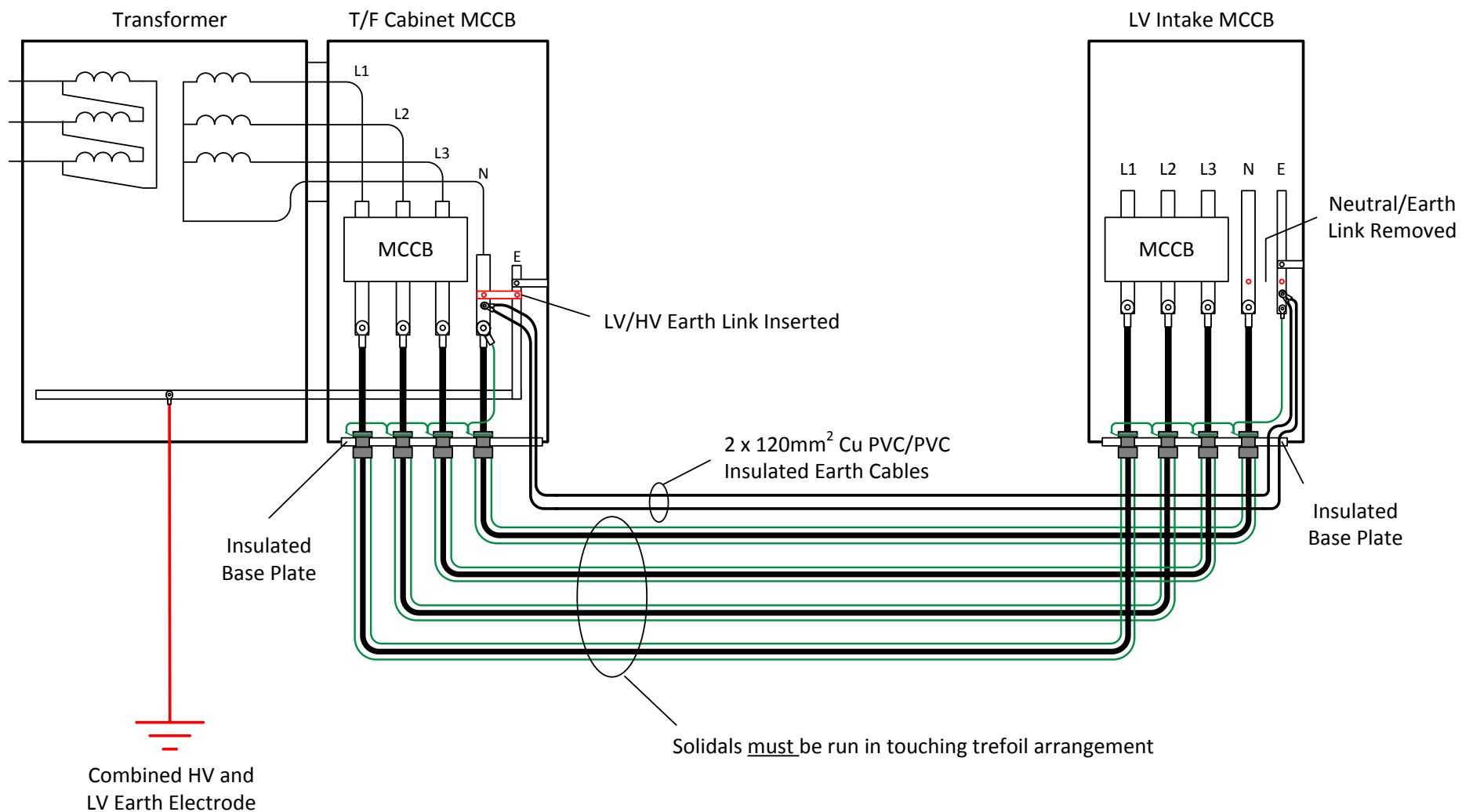


Figure 11 Single Core Cable Earthing / Bonding – Arrangement B, SNE Connection with Combined HV and LV Earthing

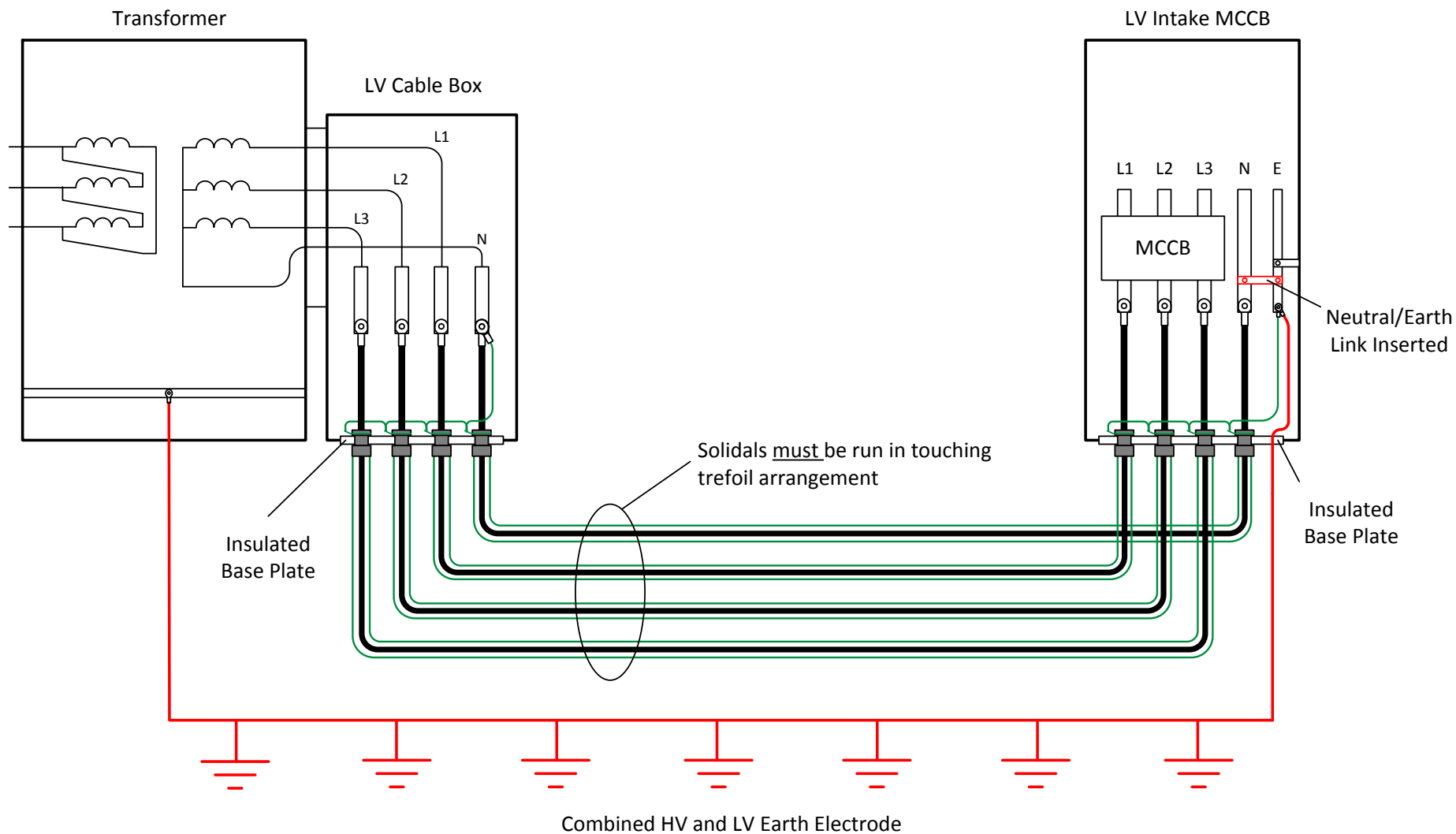


Figure 13 Single Core Cable Earthing / Bonding – Arrangement C, PNB Connection with Combined HV and LV Earthing

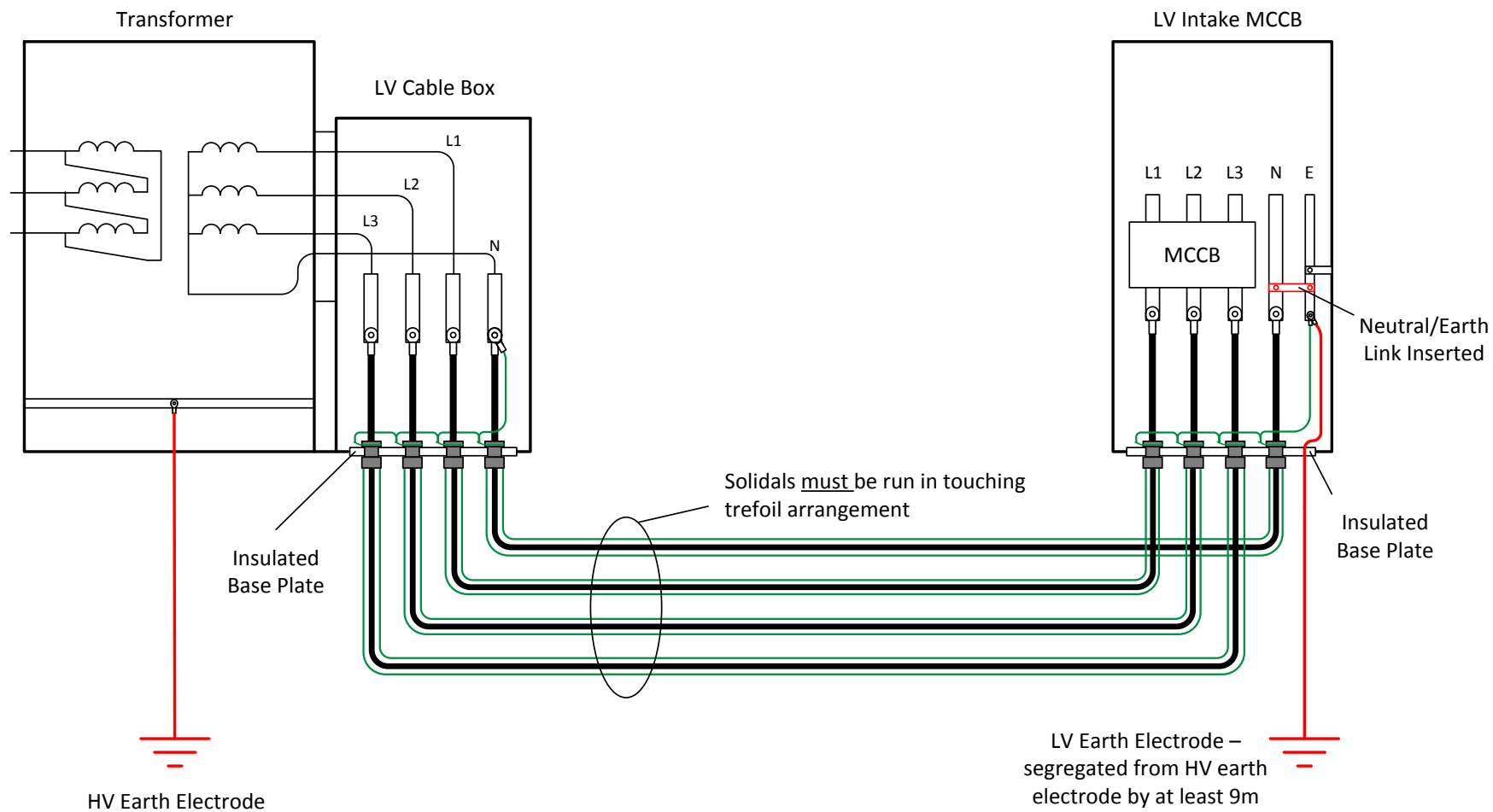


Figure 14 Single Core Cable Earthing / Bonding – Arrangement C, PNB Connection with Segregated HV and LV Earthing

8.4 Service / Meter Position

8.4.1 The requirements for the intake and metering positions shall be considered at an early stage of the building design and shall be agreed by WPD. Intake and metering positions shall:

- Include sufficient space to enable WPD's equipment and also any equipment owned by the Meter Operator and / or BNO to be installed, maintained and replaced. The precise space requirements depend on the type of equipment that is to be installed.
- Be easily accessible, kept free from obstructions and be well lit. It is not acceptable for the intake / meter positions to be located within a storage room;
- Not be a confined space, as defined in the Confined Spaces Regulations 1997. For completeness the definition of a confined space is also reproduced below:

"confined space" means any place, including any chamber, tank, vat, silo, pit, trench, pipe, sewer, well or similar space in which, by virtue of its enclosed nature, there arises a reasonably foreseeable specified risk".

"specified risk" means a risk of –

(a) serious injury to any person at work arising from a fire or explosion;

(b) without prejudice to paragraph (a)-

(i) the loss of consciousness of any person at work arising from an increase in body temperature;

(ii) the loss of consciousness or asphyxiation of any person at work arising from gas, fume vapour or lack of oxygen;

(c) the drowning of any person at work arising from an increase in the level of liquid; or

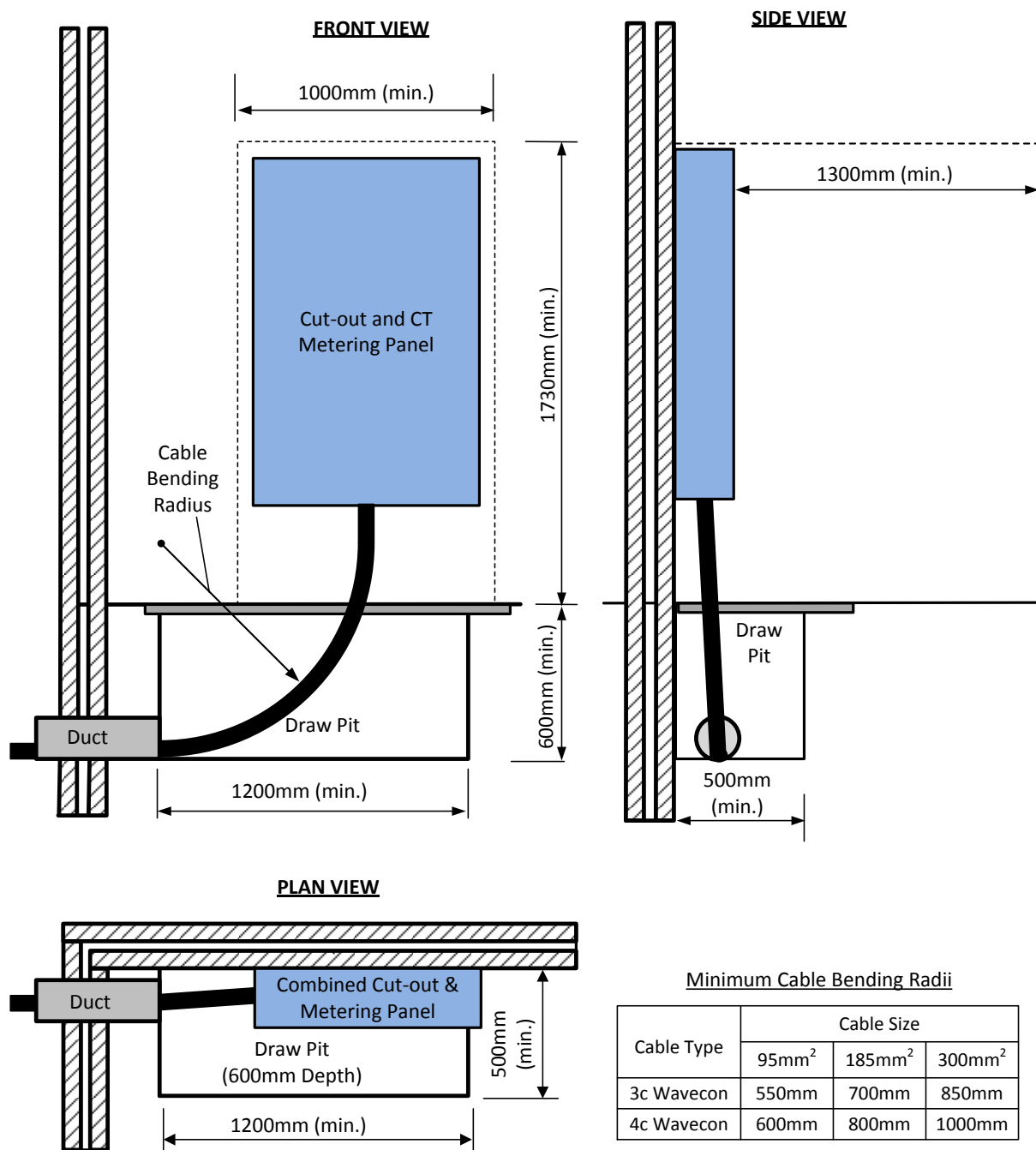
(d) the asphyxiation of any person at work arising from a free flowing solid or the inability to reach a respirable environment due to entrapment by a free flowing solid".

- Include an adequate means of escape;
- Be located inside a building or enclosure that is weatherproof, dry and naturally ventilated. It is not acceptable for intake positions or meter positions to be placed within kitchens, toilets, bathrooms saunas, steam rooms etc.;
- Have an ambient temperature normally between 5°C and 20°C and not exceeding 30°C. It is not acceptable for intake positions or meter positions to be located within a cupboard or small room with a significant heat source (e.g. boiler, emersion heater etc.);
- Comply with all relevant regulations including Buildings Regulations and Fire Safety Regulations.
- Not be placed where there is a significant risk of them being damaged or vandalised.

8.4.2 Electrical equipment shall be segregated from gas meters by at least 300mm and from gas pipes by at least 25mm.

8.4.3 Intake positions shall be located at ground level close to the point of entry of the incoming cable and consistent with maintaining an adequate bending radius for the cable.

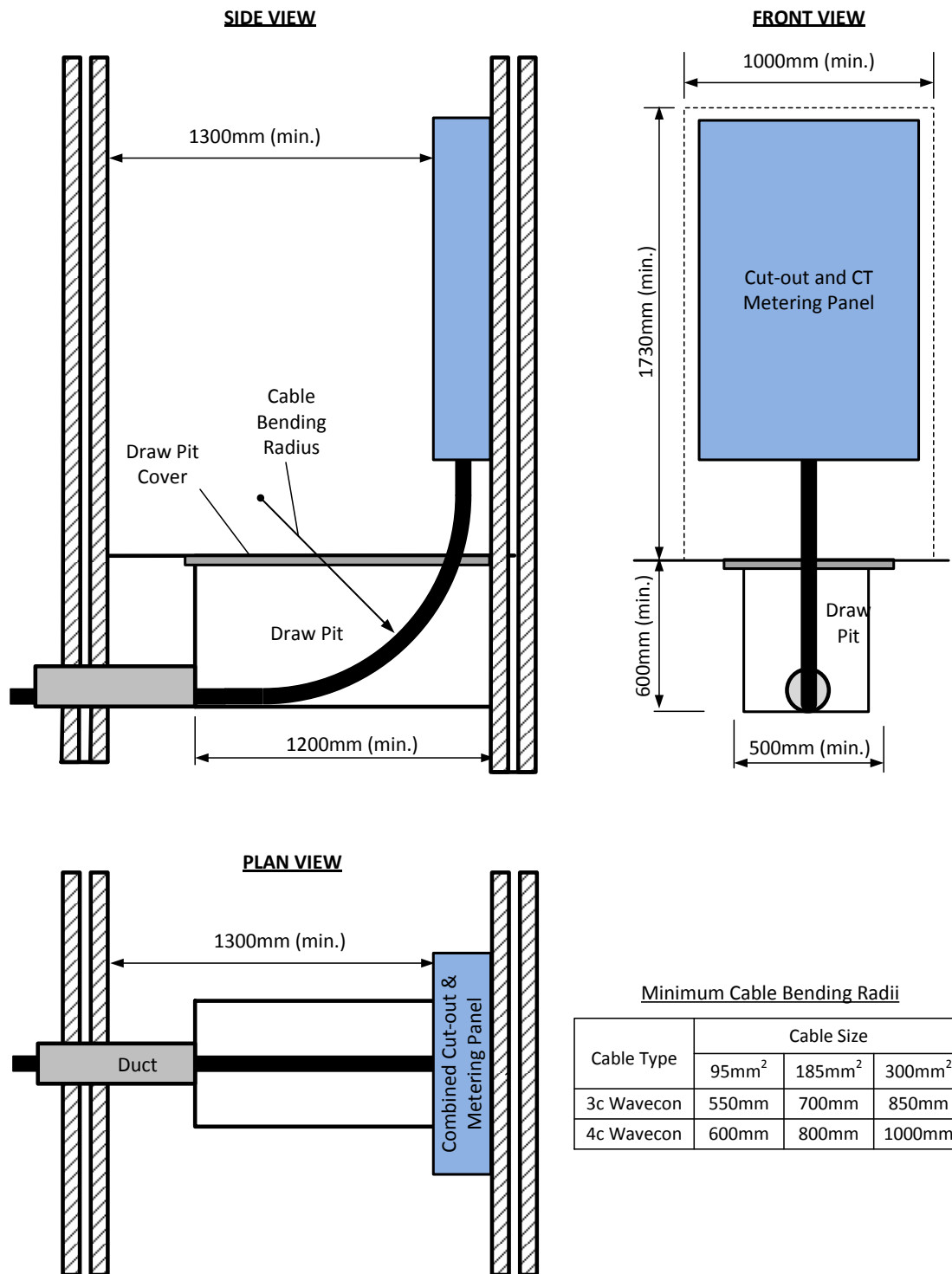
- 8.4.4 The metering must be installed between 0.5m and 1.8m above the finished floor level, in accordance with the Meter Operation Code of Practice Agreement (MOCOPA).
- 8.4.5 Settlement metering must be accessible to the customer. It is not acceptable for the metering for one connection to be located in part of a building that is owned (or is likely to be owned) by a different customer.
- 8.4.6 The wall on which Western Power Distribution's equipment and the meter operator's equipment is fixed shall be suitable for fixing and supporting the weight of this equipment. Where a metering circuit breaker, multi service distribution board or heavy duty cut-out and CT metering is to be installed the wall shall be constructed from solid masonry (i.e. brick or block construction) or from a substantial studwork faced with fire retardant plywood. Plywood, where used, must have a minimum thickness of 18mm and satisfy the requirements of EN 13501-1 Class B – s1 d0. Where whole current metering is to be installed the customer / developer shall securely fix suitable boarding (e.g. chipboard or plywood) to the back wall of the service / metering area so that meters and cut-outs can be easily screwed to this boarding.
- 8.4.7 Sufficient working space must be provided to allow cables to be pulled in and manipulated. Free space of at least 1.3m shall be provided in front of the metering equipment and WPD's cut-out / switchgear to allow for equipment (including cables) to be operated, inspected, maintained and, where necessary, replaced.
- 8.4.8 The minimum space requirement for whole current metering is 400mm high x 500mm wide, dedicated for WPD and metering equipment.
- 8.4.9 The minimum space requirements for heavy duty cut-out arrangements (e.g. combined heavy duty cut-outs and CT metering cabinets) are defined in Figure 15 to 19. These diagrams also define the maximum bending radii for cables and requirements for draw pits and ducts. Cable routes and ducts must be straight (with the exception of the slow bend duct shown in Figure 17 to 19). The maximum continuous length of duct used within a building is 10m. Whenever a cable runs in a duct within a building it should be easily withdrawable in order to allow the cable to be replaced in the future.
- 8.4.10 Space and draw pit requirements for free-standing MCCBs are defined in Figure 20. Cable routes and ducts must be straight. The maximum continuous length of duct within the building is 10m.
- 8.4.11 Where a metering MCCB is used (Arrangement B or C) the customer may connect to the MCCB via a direct busbar connection or via cables. The maximum length of cable, between WPD's MCCB and the customer's incoming switchgear is 10m.
- 8.4.12 Where an additional meter panel is to be installed, for example where a Metering MCCB is used (Arrangement B or C) or where, for some reason, the meters are not fitted to the heavy Duty Cut-out / CT metering panel (Arrangement A) additional wall space of 600mm high x 600mm wide shall be provided within 3m of the MCCB or Metering CT Cabinet. The panel has a depth of approximately 300mm and shall be positioned so that the metering is between 500mm and 1800mm above the finished floor level. In addition at least 1300mm of free space shall be provided in front of the panel to allow for the meters to be read and the panel to be maintained, installed / replaced.



Notes:

- 1) Arrangement is suitable for 95, 185 and 300 wavecon cable.
- 2) Depth of draw pit must be increased to 700mm where 300mm² 4c Wavcon cable is used due to the increased bending radius.
- 3) Duct shall have a minimum internal diameter of 100mm
- 4) 50mm x 25mm rebate shall be provided for draw pit cover
- 5) Where a separate meter panel is to be installed additional wall space shall be provided.

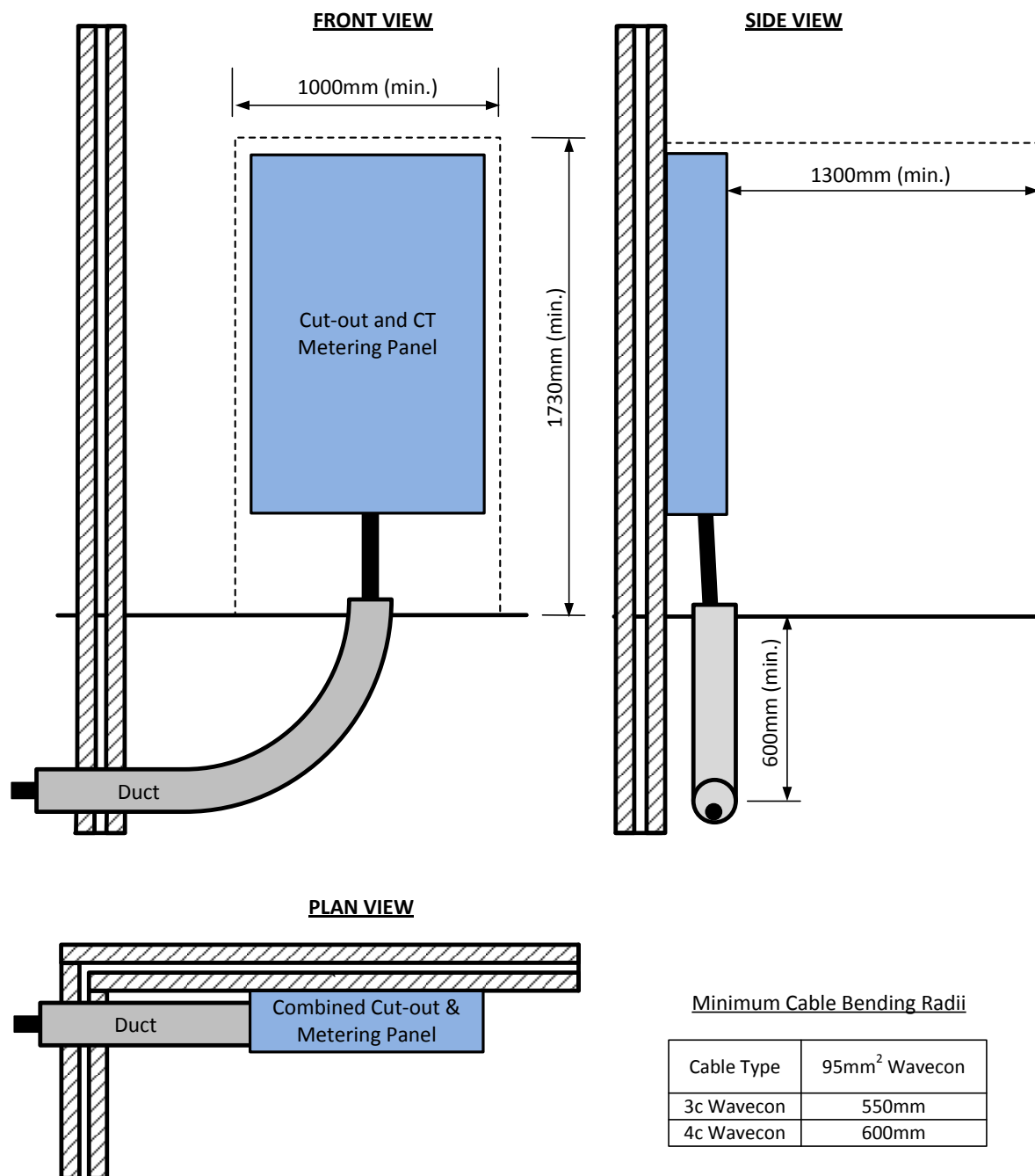
Figure 15 Combined Cut-out / CT Metering Arrangement; Draw Pit - Option 1



Notes:

- 1) Arrangement is suitable for 95, 185 and 300 Wavecon cable.
- 2) Depth of draw pit must be increased to 700mm where 300mm² 4c Wavcon cable is used due to the increased bending radius.
- 3) 50mm x 25mm rebate shall be provided for draw pit cover
- 4) Where a separate meter panel is to be installed additional wall space shall be provided.

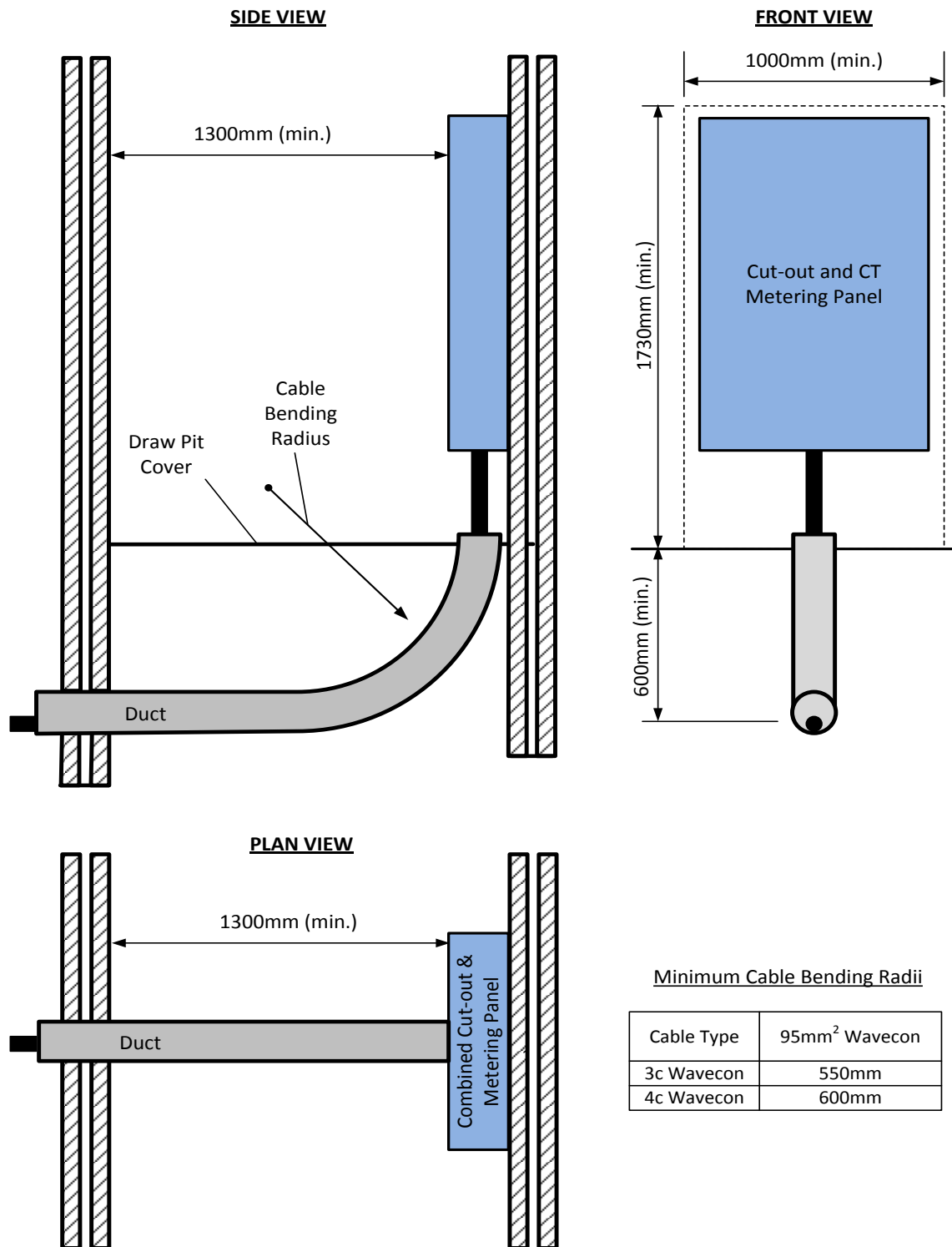
Figure 16 Combined Cut-out / CT Metering Arrangement; Draw Pit - Option 2



Notes:

- 1) Slow bend duct is only suitable for cables with a cross-sectional area of 95mm² or less (e.g. 95 wavecon).
- 2) Duct shall have a minimum internal diameter of 125mm and a bending radius of at least 600mm.
- 3) Where a separate meter panel is to be installed additional wall space shall be provided.

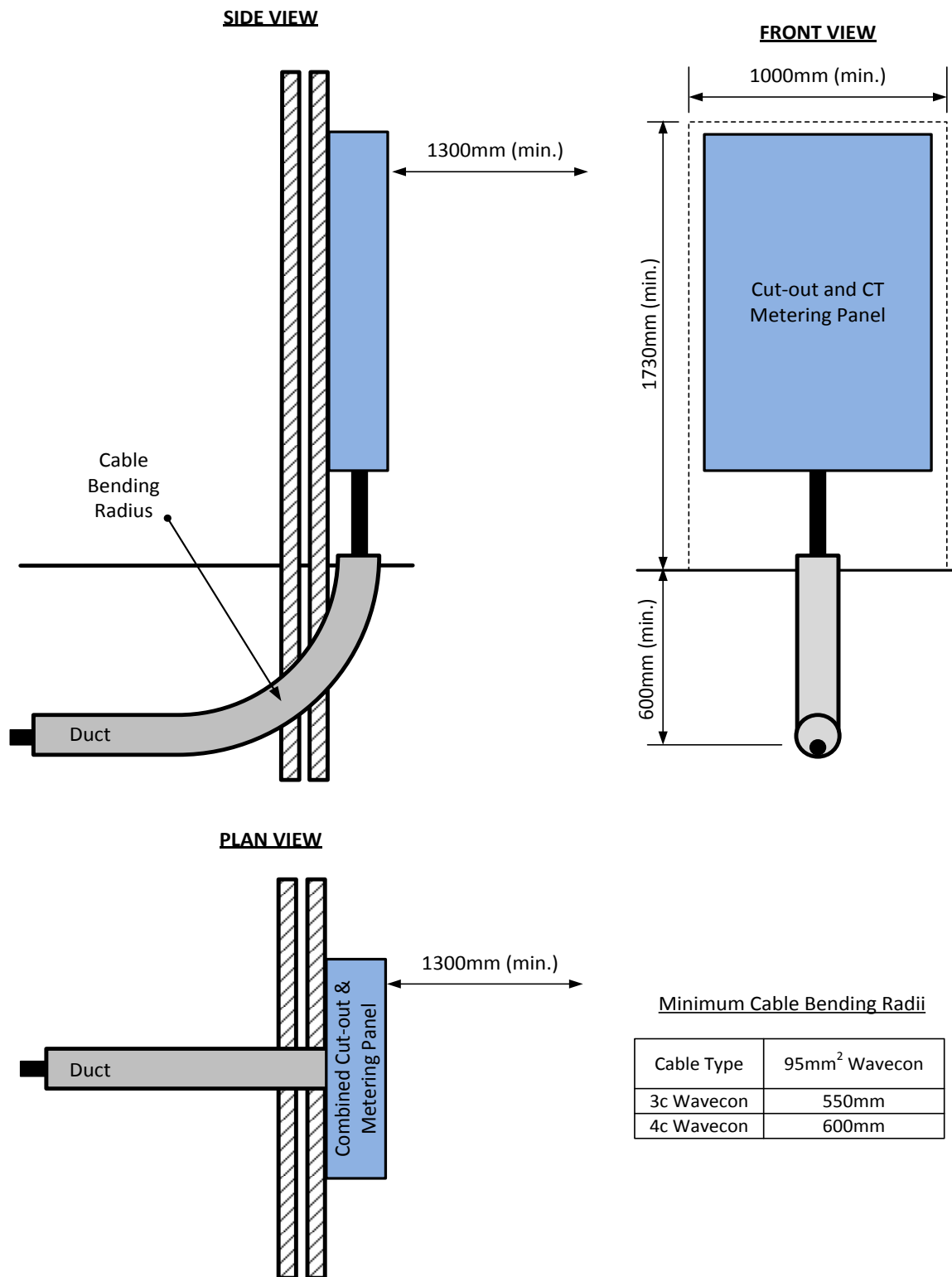
Figure 17 Combined Cut-out / CT Metering Arrangement; Slow Bend Duct - Option 1



Notes:

- 1) Slow bend duct is only suitable for cables with a cross-sectional area of 95mm² or less.
- 2) Duct shall have a minimum internal diameter of 125mm and a bending radius of at least 600mm.
- 3) Where a separate meter panel is to be installed additional wall space shall be provided.

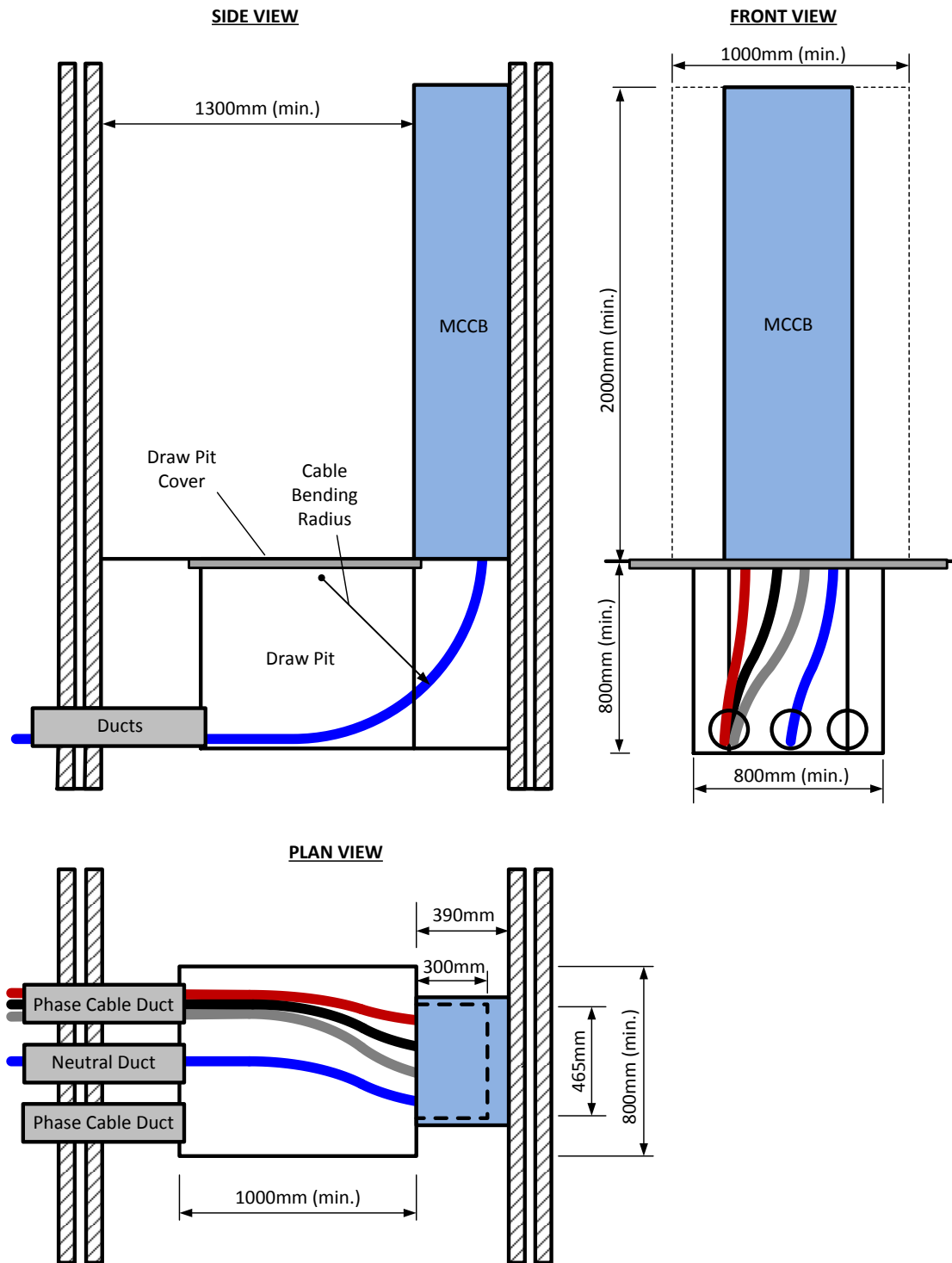
Figure 18 Combined Cut-out / CT Metering Arrangement; Slow Bend Duct – Option 2



Notes:

- 1) Slow bend duct is only suitable for cables with a cross-sectional area of 95mm² or less.
- 2) Duct shall have a minimum internal diameter of 125mm and a bending radius of at least 600mm.
- 3) Where a separate meter panel is to be installed additional wall space shall be provided.

Figure 19 Combined Cut-out / CT Metering Arrangement; Slow Bend Duct – Option 3



Notes:

- 1) Options for cable configurations shown in Figure 6 and 7.
- 2) Minimum cable bending radius for single core cables is 400mm.
- 3) 50mm x 25mm rebate provided for draw pit cover.
- 4) MCCB placed directly above 300mm x 465mm aperture in draw pit.
- 5) Additional wall space is required for the Meter Operator's metering panel.

Figure 20 Typical MCCB Arrangement

8.5 LV Circuit Breakers

- 8.5.1 Arrangement B and C require the use of one or more LV circuit breaker. LV circuit breakers installed within WPD's LV cabinets shall comply with the latest version of EE SPEC: 16 and metering circuit breakers shall comply with EE SPEC: 28.
- 8.5.2 LV metering circuit breakers that provide the interface between WPD's network and the customer shall be owned and maintained by Western Power Distribution (WPD).
- 8.5.3 At the time of issue of this document WPD's standard circuit breakers and tripping units are as follows. Appendix C and E provide further details of this equipment.
- Merlin Gerin NS800 MCCB with Micrologic 5.0 trip unit
 - Merlin Gerin NS1250 MCCB with Micrologic 5.0 trip unit
 - Merlin Gerin NS1600 MCCB with Micrologic 6.0A trip unit.
- 8.5.4 When circuit breakers are to be purchased and/or installed by the customer or the customers appointed contractor, under Competition in Connections rules, alternative makes/types of circuit breaker and tripping unit may be offered. Alternative equipment is acceptable as long as it satisfies the latest issue of WPD's specification EE SPEC: 28 or EE SPEC: 16, as applicable, and is approved for use by the Policy Section.
- 8.5.5 Protection settings for standard circuit breaker tripping units shall be obtained from the [Large LV Connection Assessment Tool](#). If non-standard circuit breakers and tripping units are used or if the customer has other specific requirements, advice shall be sought from Primary System Design.
- 8.5.6 Further information on MCCB trip units is provided in Appendix A and on Metering MCCBs is included in Appendix B.

8.6 Emergency / Remote Tripping

- 8.6.1 Metering MCCB panels complying with the latest version EE:SPEC 28 have a trip button positioned on the front of the panel to allow the circuit breaker to be manually tripped under emergency conditions.
- 8.6.2 The mechanism is designed so that the MCCB can only be reset and closed following the removal of a WPD system padlock and therefore this may only be carried out by personnel with an appropriate WPD operational authorisation.
- In some cases the customer may wish to trip WPD's metering MCCB remotely, either from a remote emergency trip button or from their protection systems. This may be achieved by arranging for either a 230Vac or a 24Vdc shunt trip coil to be fitted to the MCCB. Under voltage release coils shall not be fitted to WPD owned MCCBs.

Note, MCCBs complying with the current version of EE SPEC 28 may be specified with a shunt trip coil, as an option.

8.6.3 WPD may only make this remote trip facility available to the customer where:

- The number of MCCB operations will not be increased significantly (i.e. by no more than 1 additional operation per year)
- The customer's protection equipment etc. will be adequately rated and reliable.

WPD reserve the right to charge the customer for re-closing the circuit breaker where they trip it.

8.6.4 A typical arrangement is shown in Figure 21. It is important that links are installed on the MCCB panel to allow isolation of the customer's tripping supply. These links should be clearly labelled "Trip Receive from Customer".

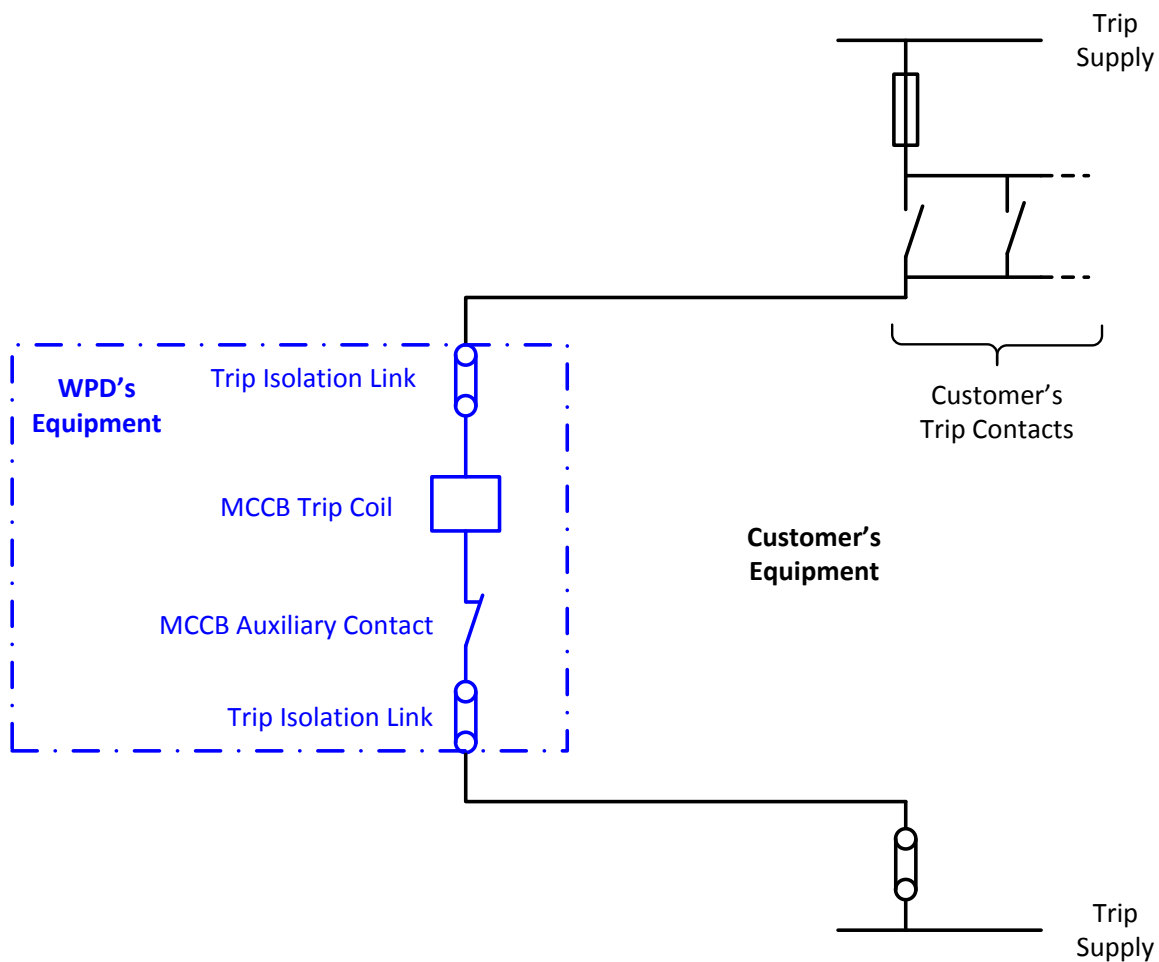


Figure 21 Emergency / Remote Tripping

8.7 Metering

- 8.7.1 Metering is the responsibility of the appointed Meter Operator. Where CT metering is used WPD's Distribution Business provides a combined cut-out / CT panel, a heavy duty cut-out and separate CT panel or a metering MCCB. These include the metering CTs, CT safe access terminal blocks and, where applicable, potential fuses/links.
- 8.7.2 Metering CT's shall be class 0.5S to BS EN 60044-1. The CT ratio shall be chosen to reflect the rating of the connection. The following standard CT ratios are available:
- 200/5, 400/5 and 600/5 (combined cut-out / metering panels)
 - 800/5, 1200/5, 1600/5 (metering MCCBs)

9.0 GENERATION CONNECTIONS

- 9.1 Customer connections that include generation (standby or parallel generation) shall satisfy the requirements of ENA EREC G59, G83, G98 and G99, as applicable.
- 9.2 Where the customer uses an Export Limitation Scheme (ELS) to prevent their Agreed Export Capacity from being exceeded this shall satisfy the requirements of ST: SD1E.

10.0 MULTIPLE CONNECTIONS TO A SINGLE CUSTOMER

- 10.1 The preferred arrangement is for each customer to have one connection per premises but in some cases, for example where the site is spread over a large area, additional connections may be required. Where this is the case the customer must take the following precautions to prevent confusion and to minimise hazards:
- Each connection shall be provided by the same Distribution Network Operator (DNO). It is not acceptable for connections from two separate DNOs (including Independent Distribution Network Operators) to be provided in one building / premises.
 - Each connection shall be clearly labelled. The labels shall state the presence of additional connections and describe their locations.
 - The cables / circuits associated with each incoming connection shall, as far as possible, be physically separated (i.e. installed in different parts of the premises) to prevent the incoming connections from being inadvertently paralleled.
 - Metalwork and equipment supplied from different connections shall, as far as possible, be separated by at least 2m from each other to prevent both items being touched by a single person at the same time, minimising the risk of hazardous touch potentials.
 - Where two or more separate connections are located in the same intake room the earth terminals of each of the incoming cut-outs, distribution boards and / or circuit breakers (as applicable) shall be connected together using insulated copper earthing cable. The cross-sectional area of this cable shall, as far as reasonably practicable, be equal to, or greater than, the copper equivalent cross-sectional area of the earth conductor within the largest incoming cable. Where it is not possible to achieve this requirement due to different sizes of cut-outs / switchgear the earth cable shall be reduced to the largest acceptable size for the smallest item of equipment.

- 10.2 It is not recommended that a second LV connection is used to back up the main supply (e.g. to provide improved security) as WPD cannot guarantee the reliability of back-up connections. The customer should install a standby generator for such purposes instead. Further guidance on firefighting supplies in multi-occupancy buildings is given ST:SD5C.
- 10.3 Where the customer insists on a second LV supply for security reasons this shall be achieved using a break before make changeover switch or by using mechanically interlocked switchgear. Changeover arrangements relying on electrical interlocking may only be accepted if the system cannot be defeated by manual / mechanical switching and the customer can demonstrate the system is fail-safe.

MICROLOGIC TRIPPING UNITS

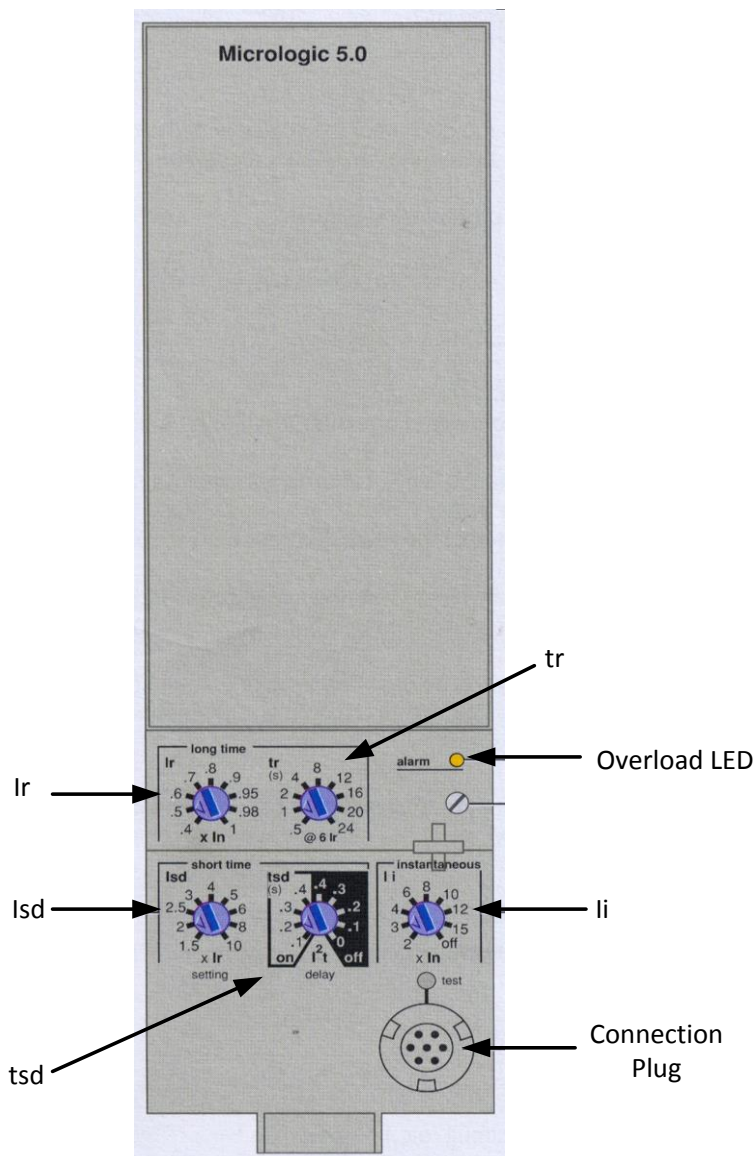
The standard trip unit (protection relays) used with the 800A and 1250A MCCB is the Merlin Gerin Micrologic 5.0. The 1600A MCCB is fitted with a Micrologic 6.0A as standard.

Both these devices provide overcurrent protection and include a load setting, adjustable I^2t characteristics and two stages of fast operating protection. The characteristics and settings are shown in the following diagrams.

The Micrologic 6.0A trip unit also includes an earth fault element that detects current in the neutral and earth.

Alternative trip units may be encountered on MCCBs, particularly those purchased prior to issue of this document or those provided by the customer under competition in connections. Where this is the case, protection settings shall be obtained from Primary Design. Further information is available from the [Micrologic](#) user guide.

Tripping Unit



Tripping Characteristic (using log-log axis)

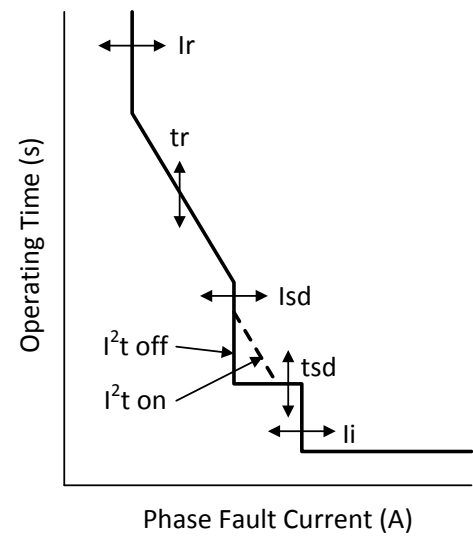


Figure A1 Micrologic 5.0 Trip Unit

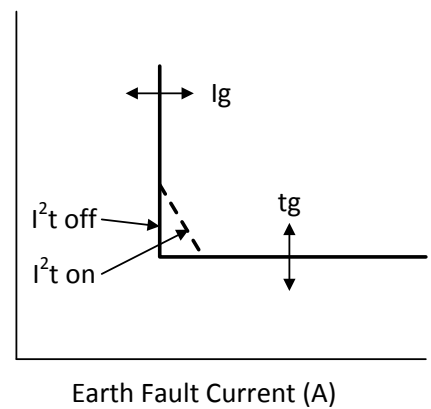
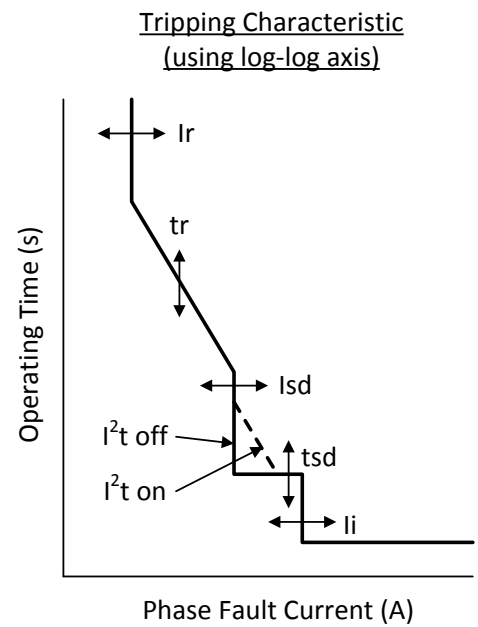
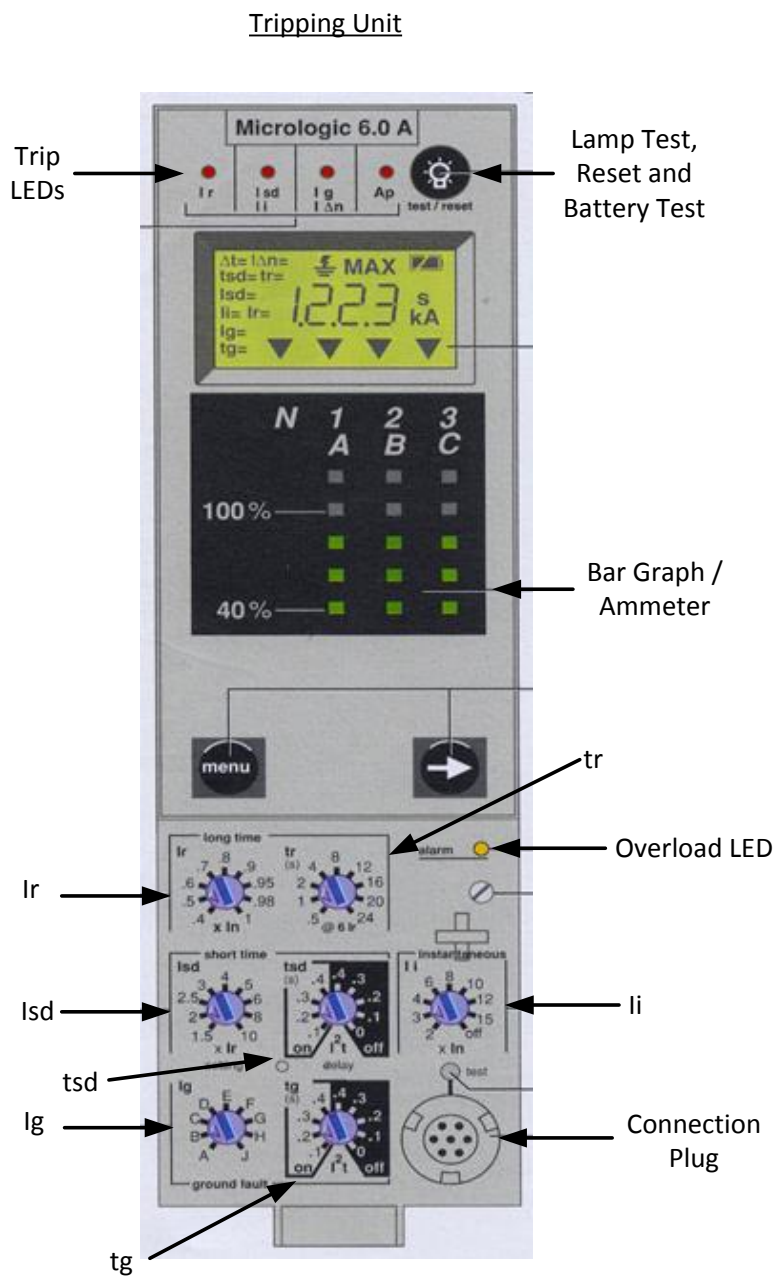


Figure A2 Micrologic 6.0A Trip Unit

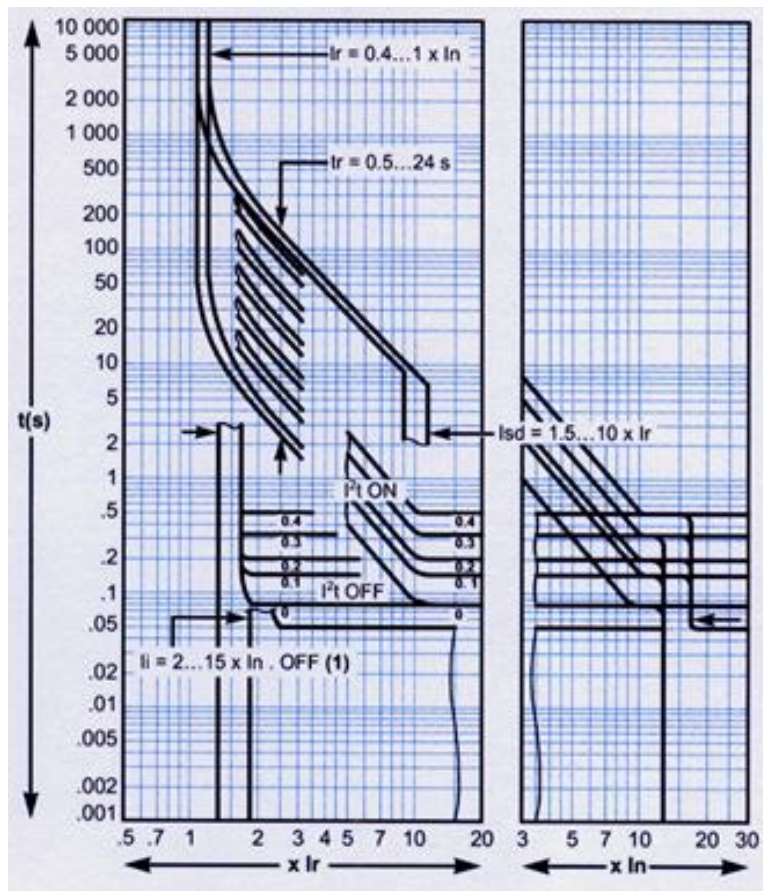
Long time											
Current setting (A)		$I_r = I_n \times$	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.98	1
Tripping between 1.05 and 1.20 x I_r											
Time delay (s)	Accur. 0 to −30%	t_r at 1.5 x I_r	12.5	25	50	100	200	300	400	500	600
	Accur. 0 to −20%	t_r at 6 x I_r	0.5	1	2	4	8	12	16	20	24
	Accur. 0 to −20%	t_r at 7.2 x I_r	0.34	0.69	1.38	2.7	5.5	8.3	11	13.8	16.6
Thermal memory			20 minutes before and after tripping								
Short time											
Pick-up (A)		$I_{sd} = I_r \times \dots$	1.5	2	2.5	3	4	5	6	8	10
Accuracy $\pm 10\%$											
Time delay (s)	Settings	I^2t Off	0	0.1	0.2	0.3	0.4				
		I^2t On		0.1	0.2	0.3	0.4				
	T_{sd} (Max resettable time)		20	80	140	230	350				
	T_{sd} (Max break time)		80	140	200	320	500				
Instantaneous											
Pick-up (A)		$I_i = I_n \times \dots$	2	3	4	6	8	10	12	15	off
Accuracy $\pm 10\%$											

Figure A3 Micrologic 5.0 Trip Unit Settings

Long time											
Current setting (A)		Ir = In x	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.98	1
Tripping between 1.05 and 1.20 x Ir											
Time delay (s)	Accur. 0 to −30%	tr at 1.5 x Ir	12.5	25	50	100	200	300	400	500	600
	Accur. 0 to −20%	tr at 6 x Ir	0.5	1	2	4	8	12	16	20	24
	Accur. 0 to −20%	tr at 7.2 x Ir	0.34	0.69	1.38	2.7	5.5	8.3	11	13.8	16.6
Thermal memory			20 minutes before and after tripping								
Short time											
Pick-up (A)		Isd = Ir x ...	1.5	2	2.5	3	4	5	6	8	10
Accuracy ± 10%											
Time delay (s)	Settings	I²t Off	0	0.1	0.2	0.3	0.4				
		I²t On		0.1	0.2	0.3	0.4				
	Tsd (Max resettable time)		20	80	140	230	350				
	Tsd (Max break time)		80	140	200	320	500				
Instantaneous											
Pick-up (A)		Ii = In x ...	2	3	4	6	8	10	12	15	off
Accuracy ± 10%											
Earth Fault											
Pick-up (A)	Ig = In x		A	B	C	D	E	F	G	H	J
	In =< 400A		0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	400A < In =< 1200A		0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	In > 1200A		500	640	720	800	880	960	1040	1120	1200
Time delay (ms) At In or 1200A	Settings	I²t Off	0	0.1	0.2	0.3	0.4				
		I²t On		0.1	0.2	0.3	0.4				
	Tg (Max resettable time)		20	80	140	230	350				
	Tg (Max break time)		80	140	200	320	500				

Figure A4 Micrologic 6.0A Trip Unit Settings

Micrologic 5.0 and 6.0A
Phase Current Characteristic



Micrologic 6.0A
Earth Fault Characteristic

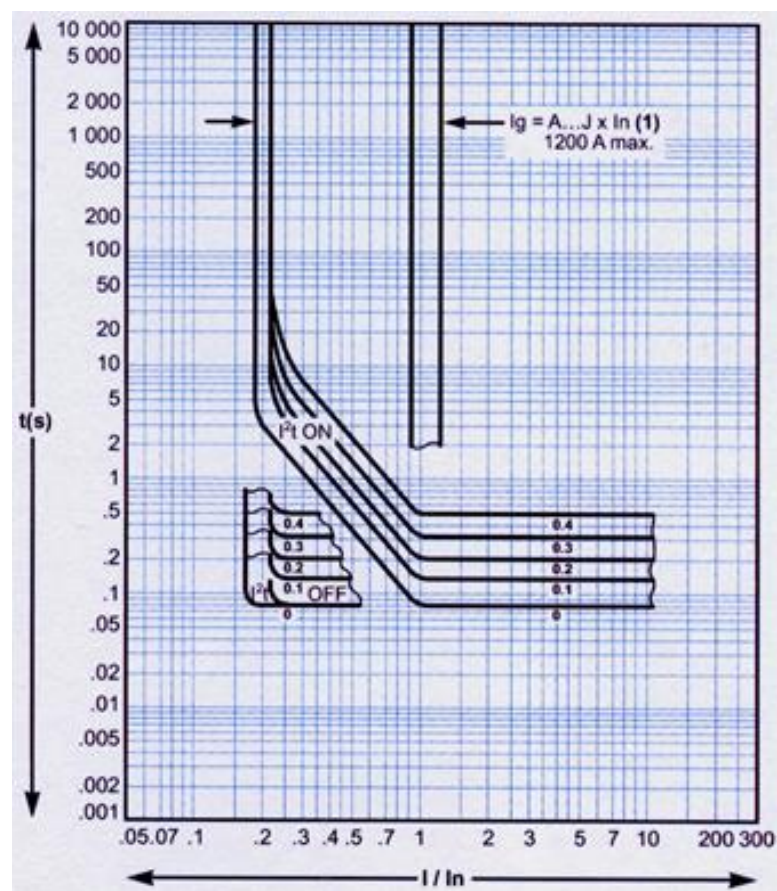


Figure A6 Micrologic Trip Unit Settings / Characteristics

METERING MCCBS

The following Links provide access to the latest MCCB Drawings:

- [800A Metering MCCB](#)
- [1250A Metering MCCB](#)
- [1600A Metering MCCB](#)

Figure B1 shows a photograph of the busbar chamber and Figure B2 a photograph of the circuit breaker locking arrangement, which allows the MCCB to be tripped by the customer but not re-closed.

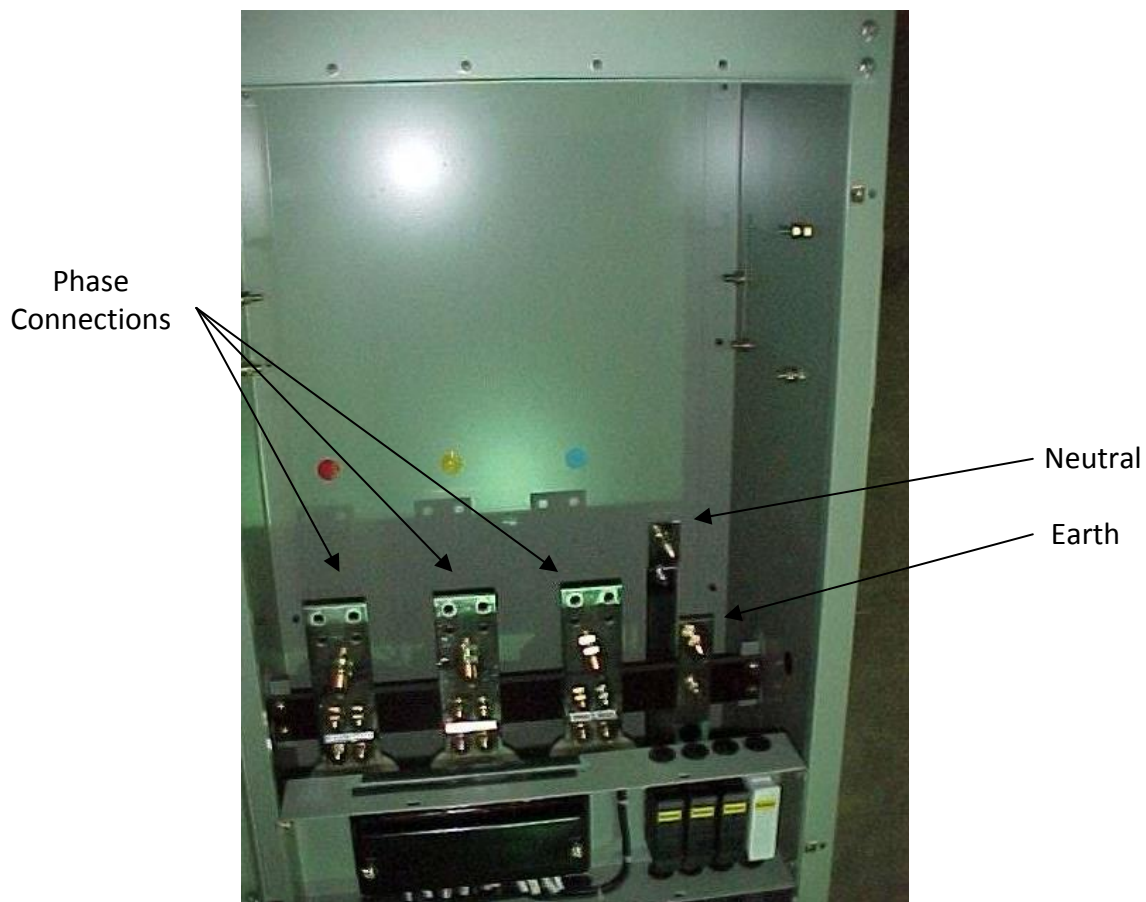


Figure B1 Metering MCCB Busbar Chamber



Figure B2 Metering MCCB Locking Arrangement

RATINGS OF SINGLE CORE LV CABLES IN TREFOIL CONFIGURATION

Cable Type & Number	Sustained Rating (A)				Cyclic Rating (A)			
	Direct in Ground	PVC Duct	Rigiduct	Air	Direct in Ground	PVC Duct	Rigiduct	Air
4 x 600mm ² Solidal	726	601	557	912	840	671	611	912
4 x 740mm ² Solidal	792	657	607	1021	922	738	669	1021
4 x 630mm ² Copper	909	753	695	1179	1060	846	766	1179
7 x 600mm ² Solidal	1288	1122	1052	1824	1544	1282	1178	1824
7 x 740mm ² Solidal	1394	1222	1144	2014	1684	1406	1286	2042
7 x 630mm ² Copper	1590	1396	1304	2358	1920	1608	1470	2358
8 x 600mm ² Solidal	1288	1122	1052	1824	1544	1282	1178	1824
8 x 740mm ² Solidal	1394	1222	1144	2014	1684	1406	1286	2042
8 x 630mm ² Copper	1590	1396	1304	2358	1920	1608	1470	2358

Table C1 Spring Ratings

Cable Type & Number	Sustained Rating (A)				Cyclic Rating (A)			
	Direct in Ground	PVC Duct	Rigiduct	Air	Direct in Ground	PVC Duct	Rigiduct	Air
4 x 600mm ² Solidal	673	572	533	838	784	646	590	838
4 x 740mm ² Solidal	733	625	580	938	860	710	646	939
4 x 630mm ² Copper	841	715	664	1084	988	814	739	1084
7 x 600mm ² Solidal	1190	1062	1034	1676	1438	1230	1134	1676
7 x 740mm ² Solidal	1288	1156	1084	1878	1568	1346	1236	1878
7 x 630mm ² Copper	1468	1320	1240	2168	1784	1538	1414	2168
8 x 600mm ² Solidal	1190	1062	1034	1676	1438	1230	1134	1676
8 x 740mm ² Solidal	1288	1156	1084	1878	1568	1346	1236	1878
8 x 630mm ² Copper	1468	1320	1240	2168	1784	1538	1414	2168

Table C2 Summer Ratings

RATINGS OF SINGLE CORE LV CABLES IBN TREFOIL CONFIGURATION (CONTINUED)

Cable Type & Number	Sustained Rating (A)				Cyclic Rating (A)			
	Direct in Ground	PVC Duct	Rigiduct	Air	Direct in Ground	PVC Duct	Rigiduct	Air
4 x 600mm ² Solidal	712	595	552	912	826	667	608	912
4 x 740mm ² Solidal	777	650	602	1021	906	733	665	1021
4 x 630mm ² Copper	909	753	695	1179	1060	846	766	1179
7 x 600mm ² Solidal	1234	1088	1020	1824	1488	1250	1148	1824
7 x 740mm ² Solidal	1338	1184	1108	2042	1624	1368	1254	2042
7 x 630mm ² Copper	1524	1352	1266	2385	1856	1566	1432	2358
8 x 600mm ² Solidal	1234	1088	1020	1824	1488	1250	1148	1824
8 x 740mm ² Solidal	1338	1184	1108	2042	1624	1368	1254	2042
8 x 630mm ² Copper	1524	1352	1266	2385	1856	1566	1432	2358

Table C3 Autumn Ratings

Cable Type & Number	Sustained Rating (A)				Cyclic Rating (A)			
	Direct in Ground	PVC Duct	Rigiduct	Air	Direct in Ground	PVC Duct	Rigiduct	Air
4 x 600mm ² Solidal	785	628	579	947	900	692	628	947
4 x 740mm ² Solidal	856	688	633	1060	988	763	689	1060
4 x 630mm ² Copper	984	789	724	1225	1138	875	789	1125
7 x 600mm ² Solidal	1396	1180	1098	1894	1662	1332	1216	1894
7 x 740mm ² Solidal	1512	1284	1196	2120	1814	1460	1330	2120
7 x 630mm ² Copper	1724	1470	1366	2450	2076	1668	1520	2450
8 x 600mm ² Solidal	1396	1180	1098	1894	1662	1332	1216	1894
8 x 740mm ² Solidal	1512	1284	1196	2120	1814	1460	1330	2120
8 x 630mm ² Copper	1724	1470	1366	2450	2076	1668	1520	2450

Table C4 Winter Ratings

CALCULATION SPREADSHEET INSTRUCTIONS

D1 A calculation spreadsheet has been developed for Arrangement B and C. Guidelines on using this spreadsheet is provided below:

Two worksheets are available, one for Arrangement B and another for Arrangement C.

D2 Arrangement B

Step 1 Select the Arrangement B Worksheet

Step 2 Select the proposed transformer rating, LV cabinet type and HV fault level.

The cabinet type options are shown in the diagram (to the right) and the references are in accordance with EE SPEC: 16.

The HV fault level can have an effect on the protection (e.g. the maximum length of cable and also the supply characteristics). A value of 50MVA is provided as a default.

ARRANGEMENT B

Transformer Rating: 500 kVA
 Cabinet Type: 16/2/CB8 800A MCCB & 2 additional fuseways
 HV Fault Level: 50 MVA

Load Type	Power (kVA)	Power Factor	Current (A)
Load connected to metering MCCB:			
Maximum Import	300	0.98 Lagging	435
Maximum Export	0	1.00 Leading	0
Total load connected to fuseways:			
Maximum Import	200	0.98 Lagging	290
Maximum Export	0	1.00 Leading	0
Total substation load:			
Maximum Import	500	0.98 Lagging	725
Maximum Export	0	1.00 Leading	0

Settings for T/F MCCB

Trip Unit: Micrologic 5.0
 ACB Rating, In: 800A
 Ir: 560A (i.e. 0.7xIn)
 tr: 8s
 Isd: 2240A (i.e. 4xIr)
 tsd: 0.1s, Ixtd on
 Ii: 6400A (i.e. 8xIn)
 Ig: N/A
 tg: N/A

Settings for Metering MCCB

Trip Unit: Micrologic 5.0
 ACB Rating, In: 800A
 Ir: 480A (i.e. 0.6xIn)
 tr: 8s
 Isd: 1440A (i.e. 3xIr)
 tsd: 0.1s, Ixtd on
 Ii: 4800A (i.e. 6xIn)
 Ig: N/A
 tg: N/A

MCCB CIRCUIT 1

Cable Type: 4 x 600 sqmm (SOLIDAL)
 NOTE: 800A MCCBs ONLY ALLOW 4 x CABLE CONNECTIONS
 Maximum Cable Length (m): 150
 Cable Length Limited by: Practical Considerations

Laid	Sustained Ratings (A)				Cyclic Ratings (A)			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
In Ground	726	673	712	785	840	784	826	900
In PVC Duct	601	572	595	628	671	646	667	692
In Rigiduct	557	533	552	579	611	590	608	628
In Air	912	838	912	947	912	838	912	947

Figure D1 Selecting Arrangement B, transformer rating and HV fault level

Step 3 Specify the maximum load associated with the first MCCB.

Power (kVA): Both maximum import capacity (i.e. demand) and the maximum export capacity (i.e. generation) must be specified. If no generation is present then select 0 kVA.

Power Factor

A power factor of 0.98 lagging is typical for imported power, however a lower lagging power factor should be considered where the connection includes a significant motor load or lighting load. For imported power, a lagging power factor normally increases the voltage drop.

For generator connection a specific power factor or power factor range may be specified as part of the connection agreement. For exported power a lagging power factor increases the voltage rise whereas a leading power factor reduces the voltage rise (or may even cause a voltage drop).

- Step 4 Specify the maximum total load associated with the remaining circuits (i.e. fuse-ways or additional MCCB).

The load associated with the remaining circuits (depending on the LV cabinet type) should be entered. This process is the same as Step 3.

ARRANGEMENT B

Transformer Rating: 500 kVA
Cabinet Type: 16/2/CB8 800A MCCB & 2 additional fuseways
HV Fault Level: 50 MVA

Load Type	Power (kVA)	Power Factor	Current (A)
Load connected to metering MCCB:			
Maximum Import	300	0.98 Lagging	435
Maximum Export	0	1.00 Leading	0
Total load connected to fuseways:			
Maximum Import	200	0.98 Lagging	290
Maximum Export	0	1.00 Leading	0
Total substation load:			
Maximum Import	500	0.98 Lagging	725
Maximum Export	0	1.00 Leading	0

Settings for T/F MCCB

Trip Unit: Micrologic 5.0
ACB Rating, In: 800A
Ir: 560A (i.e. 0.7xIn)
tr: 8s
Isd: 2240A (i.e. 4xIr)
tsd: 0.1s, lxlxt on
Ii: 6400A (i.e. 8xIn)
Ig: N/A
tg: N/A

Settings for Metering MCCB

Trip Unit: Micrologic 5.0
ACB Rating, In: 800A
Ir: 480A (i.e. 0.6xIn)
tr: 8s
Isd: 1440A (i.e. 3xIr)
tsd: 0.1s, lxlxt on
Ii: 4800A (i.e. 6xIn)
Ig: N/A
tg: N/A

MCCB CIRCUIT 1

Cable Type: 4 x 600 sqmm (SOLIDAL)
NOTE: 800A MCCBs ONLY ALLOW 4 x CABLE CONNECTIONS
Maximum Cable Length (m): 150
Cable Length Limited by: Practical Considerations

Laid	Sustained Ratings (A)				Cyclic Ratings (A)			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
In Ground	726	673	712	785	840	784	826	900
In PVC Duct	601	572	595	628	671	646	667	692
In Rigiduct	557	533	552	579	611	590	608	628
In Air	912	838	912	947	912	838	912	947

Figure D2 Selecting Load Requirements

Step 5 Enter proposed single core cable type and the number of cables to be used for each MCCB circuit.

The following options are available:

- 4 x 600mm² Solidals (i.e. one cable per phase and one for the neutral)
- 4 x 740mm² Solidals (i.e. one cable per phase and one for the neutral)
- 4 x 630mm² Copper (i.e. one cable per phase and one for the neutral)
- 7 x 600mm² Solidals (i.e. two cables per phase and one for the neutral)
- 7 x 740mm² Solidals (i.e. two cables per phase and one for the neutral)
- 7 x 630mm² Copper (i.e. two cables per phase and one for the neutral)
- 8 x 600mm² Solidals (i.e. two cables per phase and two for the neutral)
- 8 x 740mm² Solidals (i.e. two cables per phase and two for the neutral)
- 8 x 630mm² Copper (i.e. two cables per phase and two for the neutral)

It should be noted that the 800A (Merlin Gerin NS800) MCCB presently used by WPD only allows for up to 4 x cable connections.

The use of 8 x solidals instead of 7x makes little difference to the spreadsheet calculations but does provide a higher neutral rating which may be necessary where the 3rd, 6th, 9th etc. harmonics) are expected to be high.

The screenshot displays a spreadsheet with the following sections:

- Maximum Export:** A table with columns for Maximum Export, Maximum Import, and Maximum Export. Values include 0, 1.00, Lagging, 0, 200, 0.98, Lagging, 290, 0, 1.00, Lagging, 0.
- Total load connected to fuseways:** A table with columns for Maximum Import, Maximum Export, and Maximum Export. Values include 500, 0.98, Lagging, 725, 0, 1.00, Leading, 0.
- Settings for T/F MCCB:** Trip Unit: Micrologic 5.0, ACB Rating, In: 800A, Ir: 560A (i.e. 0.7xIn), tr: 8s, Isd: 2240A (i.e. 4xIr), tsd: 0.1s, Ix1st on, Ii: 6400A (i.e. 8xIn), Ig: N/A, tg: N/A.
- Settings for Metering MCCB:** Trip Unit: Micrologic 5.0, ACB Rating, In: 800A, Ir: 480A (i.e. 0.6xIn), tr: 8s, Isd: 1440A (i.e. 3xIr), tsd: 0.1s, Ix1st on, Ii: 4800A (i.e. 6xIn), Ig: N/A, tg: N/A.
- MCCB CIRCUIT 1:** Cable Type: 4 x 600 sqmm (SOLIDAL) (highlighted with a red circle). NOTE: 800A MCCBs ONLY ALLOW 4 x CABLE CONNECTIONS. Maximum Cable Length (m): 1.50. Cable Length Limited by: Practical Considerations. NOTE: SOLIDALS MUST BE LAID IN TREFOIL ARRANGEMENT.
- Sustained Ratings (A):** A table with columns for Laid, Spring, Summer, Autumn, Winter. Values include 726, 673, 712, 785, 840, 784, 826, 900.
- Cyclic Ratings (A):** A table with columns for Laid, Spring, Summer, Autumn, Winter. Values include 601, 572, 595, 628, 671, 646, 667, 692.
- MCCB Connection 1 - Characteristics:** A table with columns for Proposed Cable Length (m), Maximum Voltage Drop (% of 230V), Maximum Voltage Rise (% of 230V), Prospective 3 Phase Fault Current (A), Prospective Earth Fault Current (A), Maximum 3ph Fault Impedance (Ω), Maximum Earth Fault Loop Impedance (Ω). Values include 50, 3.823, 0.000, 9390, 8130, 0.027, 0.031.

Figure D3 Selecting Proposed Cable

Step 6 Check the following results:

- Transformer rating
- Cable ratings for each MCCB circuit
- MCCB Settings
- Maximum Cable Length for each MCCB circuit

Where equipment ratings are exceeded these will be shown in red and struck through, for example if the rating of a 500kVA transformer is exceeded its rating will be shown as follows: ~~500kVA~~

Additional warning messages (in red text) are provided where MCCB settings cannot be provided (e.g. due the rating of the MCCB being exceeded).

Supply characteristics are provided for each of the MCCB circuits. These details may be supplied to the customer and / or used for power quality assessments.

Step 7 Where necessary revise the input data (transformer rating, LV cabinet type etc. and repeat the checks until a satisfactory outcome is achieved.

D2 Arrangement C

Step 1 Select the Arrangement C Worksheet

Step 2 Select the proposed transformer rating and HV fault level.

The HV fault level can have an effect on the protection (e.g. the maximum length of cable and also the supply characteristics). A value of 50MVA is provided as a default.

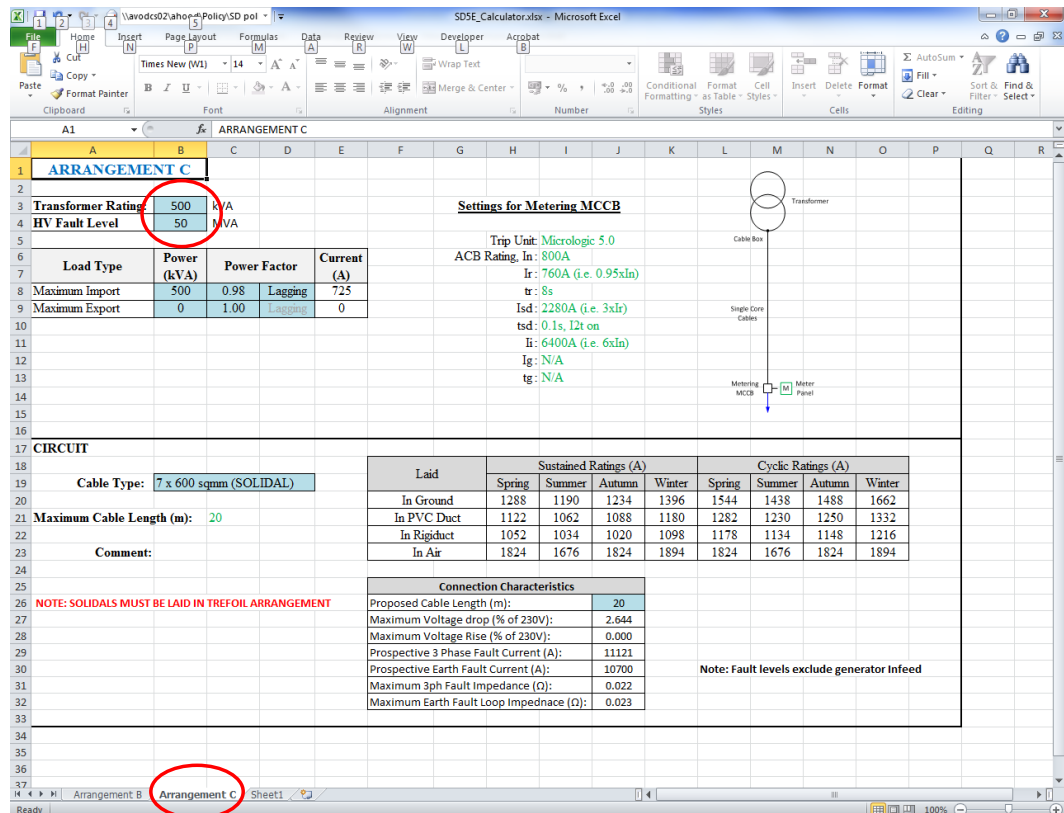


Figure D4 Selecting Arrangement B, transformer rating and HV fault level

Step 3 Specify the maximum load associated with the MCCB.

Power (kVA): Both maximum import capacity (i.e. demand) and the maximum export capacity (i.e. generation) must be specified. If no generation is present then select 0 kVA.

Power Factor

A power factor of 0.98 lagging is typical for imported power, however a lower lagging power factor should be considered where the connection includes a significant motor load or lighting load. For imported power, a lagging power factor normally increases the voltage drop.

For generator connection a specific power factor or power factor range may be specified as part of the connection agreement. For exported power a lagging power factor increases the voltage rise whereas a leading power factor reduces the voltage rise (or may even cause a voltage drop).

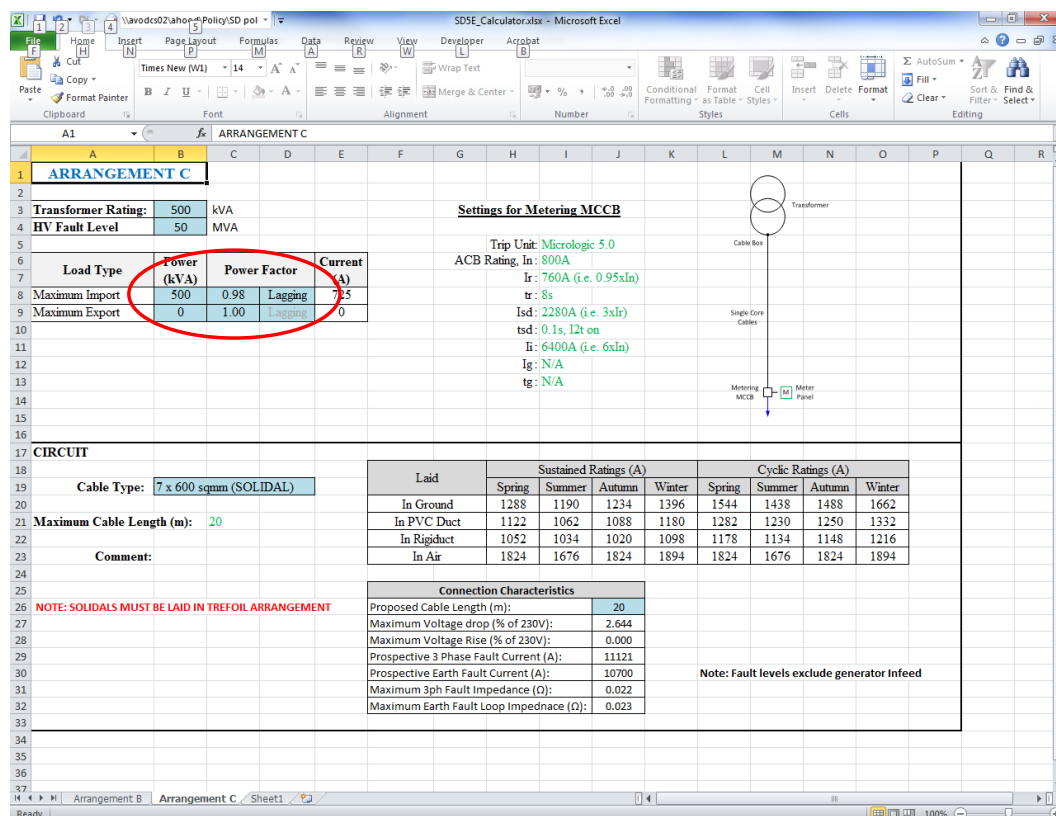


Figure D5 Selecting Load Requirements

Step 4 Enter the proposed single core cable type and the number of cables to be used

The following options are available:

- 4 x 600mm² Solidals (i.e. one cable per phase and one for the neutral)
- 4 x 740mm² Solidals (i.e. one cable per phase and one for the neutral)
- 4 x 630mm² Copper (i.e. one cable per phase and one for the neutral)
- 7 x 600mm² Solidals (i.e. two cables per phase and one for the neutral)
- 7 x 740mm² Solidals (i.e. two cables per phase and one for the neutral)
- 7 x 630mm² Copper (i.e. two cables per phase and one for the neutral)
- 8 x 600mm² Solidals (i.e. two cables per phase and two for the neutral)
- 8 x 740mm² Solidals (i.e. two cables per phase and two for the neutral)
- 8 x 630mm² Copper (i.e. two cables per phase and two for the neutral)

It should be noted that the 800A (Merlin Gerin NS800) MCCB presently used by WPD only allows for up to 4 x cable connections.

The use of 8 x solidals instead of 7x makes little difference to the spreadsheet calculations but does provide a higher neutral rating which may be necessary where the 3rd, 6th, 9th etc. harmonics) are expected to be high.

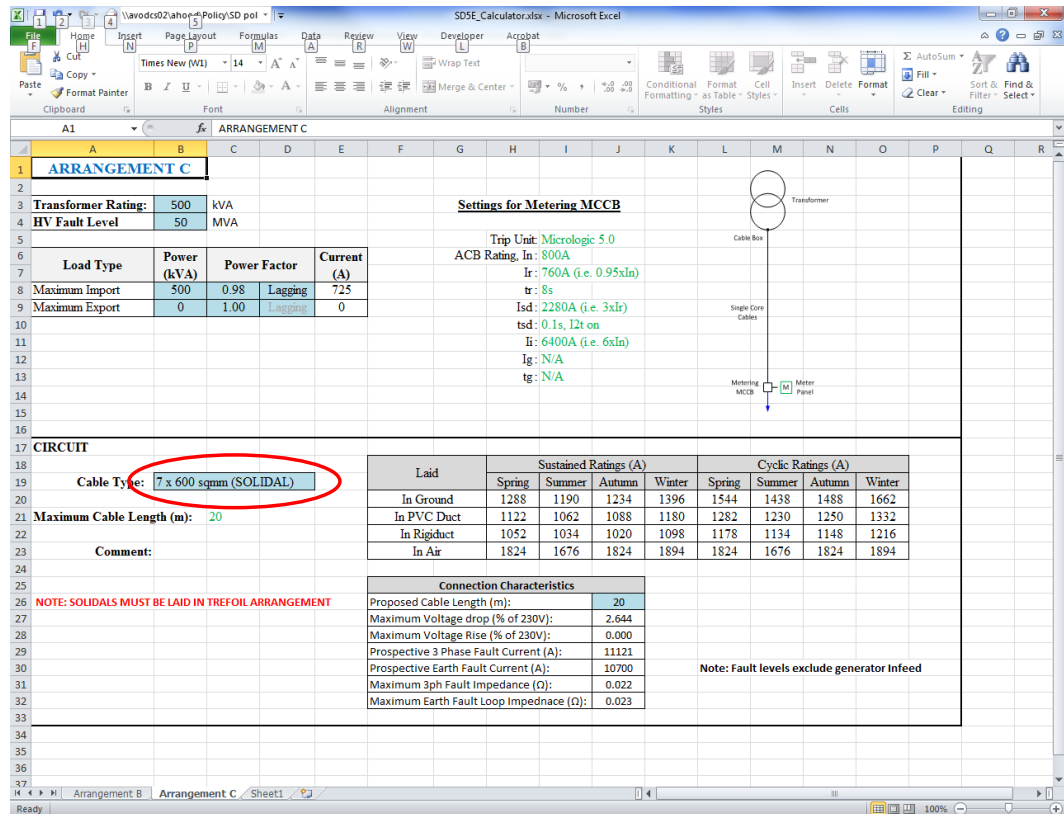


Figure D6 Selecting Proposed Cable

Step 5 Check the following results:

- Transformer rating
- Cable ratings
- MCCB Settings
- Maximum Cable Length

Where equipment ratings are exceeded these will be shown in red and struck through, for example if the rating of a 500kVA transformer is exceeded its rating will be shown as follows: ~~500kVA~~

In addition, warning messages are provided where MCCB settings cannot be provided (e.g. due the rating of the MCCB being exceeded).

Step 6 Where necessary revise the input data (transformer rating, LV cabinet type etc. and repeat the checks until a satisfactory outcome is achieved.

SUPERSEDED DOCUMENTATION

This document supersedes ST:SD5E/1 dated July 2017 which has now been withdrawn

ASSOCIATED DOCUMENTS

BS 7671, IEE Wiring Regulations Sixteenth Edition

EE SPEC: 16, LV Distribution Fuse Boards

EE SPEC: 28, LV Indoor Intake Metering Units

ST: CA6A, The Installation of Underground Cables

ST: SD5A, Design of Low Voltage Domestic Networks

ST: SD5C, Low Voltage Connections to Multi-occupancy Buildings

ST: SD5D, Arrangements for LV Cut-outs

ST: SD5K, Use of WinDebut Software

ST: SD5R, Earth Fault Loop Impedances and Phase to Neutral Loop Impedances

ST: SD8A, Overhead Line Ratings

ST: SD8B Part 1, LV Cable ratings

ST: SD8D, Distribution Transformer Ratings

ST: TP21D, 11kV, 6.6kV and LV System Earthing

ST: TP21E, Provision of WPD Earth Terminals to Customer LV Installations

ENA EREC G5, Limits for Harmonics in the United Kingdom Electricity Supply System

ENA EREC G59, Recommendations for the Connection of Generating Plant to the Distribution Systems of Licensed Distribution Network Operators

ENA EREC G83, Recommendations for the Connection of Type Tested Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with Low-Voltage Distribution Systems

ENA EREC G98, Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019

ENA EREC G99, Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019

ENA EREC P28, Planning Limits for Voltage Fluctuations Caused by Industrial, Commercial and Domestic Equipment in the United Kingdom

ENA EREC P29, Planning Limits for Voltage Unbalance in the United Kingdom

KEY WORDS

Design, construction, pole mounted, ground mounted, pad mounted, fuses, protection, MCCB, transformer, HV, LV, connection capacity.