

CABLE SEPARATIONS GUIDE

MINIMUM SEPARATIONS BETWEEN BURIED POWER AND TELECOMMUNICATION CABLES

NZCCPTS

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The New Zealand Committee for the Co-ordination of Power and Telecommunication Systems Inc. (NZCCPTS)

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GUIDE

ON

MINIMUM SEPARATIONS

BETWEEN

BURIED POWER AND

TELECOMMUNICATION CABLES

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Foreword

This document provides industry guidelines on the minimum separations that should apply between buried power and telecommunication cables.

Comments for revision of this guide are welcomed. Any comments or information that may be useful should be forwarded to:

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1. Introduction

This document provides industry guidelines on the minimum separations that should apply between buried power and telecommunication cables. This supersedes the separations in the national "industry agreement" between Telecom and the Electricity Supply Association of NZ, that has applied for the last sixteen years.

The basic minimum separations are summarised in the following table. However it is important to also read the Application Rules associated with this table to understand how these separations should be applied, and what exceptions to these separations are permitted.

A discussion paper explaining the reasons behind these minimum separations is included in this document as Appendix A.

Specific requirements for burying power cables are contained in AS/NZS 3000 Wiring Rules, Section 3.11 Underground Wiring Systems. These include minimum depth, the need for a warning marker tape, bedding requirements and mechanical protection requirements.

2. Minimum Separations between Buried Power and Telecommunication Cables

Voltage and Cable Type	At Crossings		On Parallel Runs		
	With Protection	Without Protection	In Road Reserve (see Section 3 Rule (4))		Service Lead Into House
			Separation in Shared Trench (any direction) or Separation when Cables are Vertically Apart	Separation when Cables are Horizontally Apart (NOT in a Shared Trench)	
LV neutral screened or armoured	50mm	150mm	150mm	300mm	Same as "In Road Reserve" EXCEPT FOR residential urban undergrounding projects, where 0mm is permitted for neutral screened cables if the requirements of Section 3 Rule (3) are met.
LV <u>not</u> neutral screened or armoured	50mm	450mm	450mm	600mm	Same as "In Road Reserve"
HV	150mm	450mm	450mm (2.4km limit on length)	600mm	Same as "In Road Reserve"

3. Application Rules for the Above Minimum Separations

- (1) Unless otherwise specified, the above minimum separations can be applied horizontally, vertically, or in any other direction. However, future access to the power cable will be much more difficult if the telecommunications cable is laid directly above the power cable. For similar reasons, pad mounted power plant (e.g. distribution transformers, 11kV ring main units) should not be installed above telecommunications cables.

In the road reserve, where different horizontal and vertical separations apply, separations in directions other than horizontal or vertical should be a proportionate combination of the horizontal and vertical minimum separations (s_H and s_V respectively).

$$\text{i.e. } s_\theta = \left(\frac{\theta}{90}\right)s_H + \left(\frac{90-\theta}{90}\right)s_V$$

where θ = angle to vertical (in degrees) of direction of separation

- (2) The minimum separations between buried power and telecommunication cables on parallel runs apply regardless of whether protection (e.g. plastic slabs) is installed over the power cable.
- (3) For residential urban undergrounding projects, the 150mm/300mm separation from "LV neutral screened or armoured" cables on parallel runs can be reduced to a "nil" separation for **service leads into houses**, provided:
- (i) the power cable serves an urban residential property
 - (ii) the power cable is 230V single phase neutral screened cable
 - (iii) the power cable is protected by an HRC fuse (or similarly fast acting protection)
 - (iv) the telecommunication cable is in a continuous sub-duct (no joints), with a (sub-duct) insulation rating in excess of the highest voltage present in the power cable
 - (v) the length of parallel, at this reduced separation, is < 50m.

Note:

- This reduced separation does not apply to 230V single phase armoured, unscreened cables.
- The 150mm/300mm minimum separation is still required in the road reserve.

- (4) All the above are minimum separations between buried power and telecommunication cables. An extra allowance of 150mm has been included when using these separations on parallel runs in the horizontal, or mostly horizontal, plane (i.e. both the power and telecommunication cables are at approximately the same depth), to account for the fact cables can never be laid at exactly the specified offset, and hence guarantee maintaining the minimum separation (this will also facilitate future installation of joints in the power or telecommunications cables). This does not apply to shared trenches, where both cables can be clearly seen so that the minimum separation can be maintained at all times.
- (5) Protection must be such that spades, picks (and some diggers) will not "cut" through the protection slab above the power cable, without the operator realising he had "hit" something and stopping - before also hitting the power cable beneath the protection slab.

Protection must be installed as detailed in AS/NZS 3000 Wiring Rules, clause 3.11.3.3.

The installation of the telecommunication cable and/or power cable in a PVC pipe does not constitute "protection", unless the pipe has equivalent mechanical properties to a 'heavy duty' duct (PVC or PE) as defined in AS/NZS2053:1995.

The purpose of protection slabs is to protect the power cable from being "cut". As such, they should be installed in the horizontal plane immediately above (and within 75mm of) the power cable, and overlap each side of the power cable by at least 40mm. Whether it is between the power and telecommunication cables is irrelevant.

To ensure the protection slab does not "skew", the bedding material must first be placed alongside and above the power cable and "tamped down", to provide a firm flat horizontal base to lay the protection slab on.

- (6) All the above minimum separations can be reduced to 0mm separation to allow any type of power cable to be buried directly alongside a concrete telecommunication pit or manhole that is accessible (i.e. "visible") from above ground.
- (7) Where a power cable is installed directly under a telecommunication plastic pit and is covered by suitable mechanical protection (see (5) above), the minimum separations that apply between the power cable and the plastic pit are those minimum separations specified "At Crossings With Protection".
- (8) For HV and LV power cables which may carry sufficiently high load currents for them to get quite hot (e.g. those feeding industrial areas), larger separations than the minimum separations specified should be applied wherever possible, to provide extra protection from the heating effect of the power cable(s).
- (9) Where practical, greater separations than the above minimum separations specified for LV power cables (including neutral screened) may be advisable to limit future induction of harmonic noise currents and electrically fast transient voltages (e.g. switching transients). This applies to both street and service lead separations.
- (10) These specified separations apply only to power and telecommunication cables that are "vulnerable" to being damaged by a digger. If the power or telecommunication cable is situated so that it is "virtually impossible" for it to be damaged by a digger, then an appropriate minimum separation for that section should be negotiated between the cable owners on a case-by-case basis. Considerations should include:
 - heating from the power cable
 - access to the cables for later testing/augmentation/repair
 - possible noise induction (especially if long lengths of close parallel are involved).
 Normal protection slabs, as defined in (3) above, provide some protection, but do not prevent a cable being damaged by a digger. More substantial protection is required for these minimum separations to not apply. Examples of this include installing the power and/or telecommunication cable:
 - in a pipe set in concrete (e.g. part of a bridge approach),
 - in heavy duty non-metallic conduit (as defined in AS/NZS 2053), or
 - in medium or heavy duty galvanised steel pipe (as defined in AS 1074).
- (11) For optical fibre cables that are either:
 - (i) completely non-metallic, or
 - (ii) are non-metallic, except for a metallic strength member that is insulated at all joints and terminations,
 electrical hazard arising from a digger bridging between the power and telecommunication cables, is not an issue. However the normal maintenance requirement for accessing the optical fibre or power cable, without serious risk of damaging the other cable, still applies. Also, the issue of risk to the telecommunication worker when attempting to dig down to a telecommunication cable close to a hazardous power cable, still applies.

For these reasons, the minimum separations in the previous table should still apply in full to optical fibre cables.

APPENDIX A

ISSUES TAKEN INTO ACCOUNT IN DETERMINING MINIMUM SEPARATION VALUES

A1 Background

This Appendix was prepared by the NZCCPTS Shared Trenches and Underground Cable Clearances Working Party.

From previous studies into possible hazard from induction and EPR, it was concluded that the main issues requiring close consideration in any review of the agreed minimum separations between power and telecommunication cables, are the practical issues of avoiding power contact (diggers bridging between the power cable phase conductor(s) and the telecommunication cable conductors), and being able to dig up or install plant without damaging another utility's plant. Electrical noise induction can also be an issue in some situations. We have attempted to cover these issues in this document.

In the following sections we have:

- (1) reviewed the hazard presented by contact with various HV and LV power cable types,
- (2) detailed the practical issues affecting the desirable minimum separations in the service trench (i.e. from the street "boundary box" into the house) and the road reserve situations. These points arose mainly from a long discussion with the Telecom Manager for Outside Plant Maintenance in Canterbury, and have been subsequently endorsed by the other Telecom Outside Plant Maintenance Managers in the South Island and in Auckland, and representatives from Orion, Vector and Clear Communications Limited.

A1.1 Hazard from Contact With Power Cables

If a chain digger or bucket digger cuts through and simultaneously contacts the conductors of both the power and telecommunication cables, a substantial voltage will be impressed on the telecommunication cable conductors for the duration of the power fault.

The Christchurch local power utility, Orion, report that they have about one case per week of a digger on private property damaging the power service cable. So this is not an uncommon situation.

A1.2 Hazard from Contact with a Neutral Screened (or Armoured) LV Power Cable

In the case of a neutral screened (or armoured) LV power cable, if the phase conductor is in contact with the digger, the neutral screen will almost certainly also be in contact with it. So the total "fault circuit" will typically involve 230Vrms ($\pm 6\%$) "feeding" the fault, via the impedance of the phase conductor from the 11kV/400V distribution transformer to the point of "fault" (typically $< 0.1\Omega$), and returning to the transformer neutral connection (star point) via the following parallel paths:

- (i) via the neutral screen (normally a similar impedance to the phase conductor (i.e. typically $< 0.1\Omega$ path))
- (ii) through the earthing impedance of the digger contact with the local earth, then through the earth back to the transformer neutral connection point via the distribution transformer earth/MEN system earths (typically $> 10\Omega$ path)
- (iii) via the telecommunication cable pair(s) to the exchange, through the exchange line card and exchange earth, then through the earth, back to the transformer neutral connection point via the distribution transformer earth/MEN system earths (typically $> 100\Omega$ path).

The typical voltage expected to be impressed on the telecommunication cable conductors in this situation would be just under half the supply voltage (230Vrms $\pm 6\%$) - say a maximum of 120Vrms.

The typical duration of this "hard" fault would be $< 20\text{ms}$, if the power cable is protected by an HRC fuse (or similarly fast acting protection).

While this voltage is only slightly more than the normal Telecom ring voltage (typically $80\text{Vrms} \pm 10\%$), they cannot be directly compared, since the Telecom ringing circuit source impedance is typically between 100Ω and 800Ω , while the power "fault" source impedance is typically $< 1\Omega$.

The effect of applying this full "fault" voltage of 120Vrms to a human was evaluated for the "reasonable worst case" body current path of "left hand to feet", for a fault duration of 20ms , assuming 0Ω impedance due to clothing/footwear or local earthing impedance (i.e. worst case scenario). According to IEC 479-1 (1994), "Effects of Current Passing Through the Human Body", which is internationally accepted as the "bible" on this issue, this would result in "usually no harmful physiological effects." The probability of ventricular fibrillation (i.e. electrocution) resulting from this voltage is considered negligible.

A1.3 Hazard from Contact with an LV Power Cable that is not Neutral Screened or Armoured

If the power cable is not neutral screened (or armoured), there is a significant chance that the phase conductor but NOT the neutral conductor could end up in contact with the digger, impressing a voltage of up to $230\text{Vrms} (\pm 6\%)$ onto the telecommunication cable conductors. And the duration of this "exposure" could easily be "indefinite", since the impedance of the bucket/spade contact with the earth (plus the (MEN) earth impedance of the distribution transformer) is very unlikely to be less than the approximately 1Ω needed to blow the fuse at the distribution transformer.

Contact with a voltage of 230V rms for any duration longer than 1 second is potentially lethal. It is also likely to damage telecommunication cable and equipment.

A1.4 Hazard from Contact with an HV Power Cable

Clearly any HV contact with telecommunication conductors is extremely hazardous to humans, and is likely to cause substantial damage to telecommunication plant.

A2 Practical Issues

A2.1 Service Trench Separations

In Christchurch, Telecom experiences 50 to 60 faults in service leads per month. The vast majority involve direct buried cable (i.e. not in pipe), and are caused by nicks to the cable sheath (by a spade, fork, garden stake, wooden pegs, etc.). Most of these faults would not happen if the Telecom cable was in a pipe. For some time now, all new Telecom service leads have been installed in pipe. However there is still a substantial legacy of service leads that were not installed in pipe.

Usually the exact location of the fault is unknown. So Telecom staff have to dig up their cable (by spade) in the vicinity of the power cable. If this cable is neutral screened (and protected by an HRC fuse (or similarly fast acting protection), this is not particularly hazardous (see previous section). However there is a fair chance Telecom staff could nick the power cable's sheath if it is very close to their cable, and has no protection (e.g. plastic slabs) above it. Hence a 150mm minimum separation should be maintained between telecommunication **direct-buried** cable (i.e. not in pipe) and LV cable without protection.

If the telecommunication cable is in pipe, it is very unlikely to be damaged by anything other than a digger. In Christchurch Telecom experiences more than 1 case per month involving diggers hitting service leads. Once the damage is done, the digger driver will almost always leave the trench open. So Telecom staff can easily see exactly where the fault is, and usually also exactly where the power cable is. Hence there should normally be little likelihood of Telecom staff nicking the power cable when doing repairing the telecommunication cable, even if the cables have a "nil" separation.

It helps if the power cable has warning tape laid above it (AS/NZS 3000 requires an orange marker tape to be laid not more than 200mm above buried power cables, unless the power cables are enclosed in light orange duct, or protected by light orange polymeric cable cover strip). If the power cable is pulled in by a pneumatic thrust borer (e.g. grundomat), and is not in pipe, the warning tape should still be (loosely) installed with the power cable - even when wrapped around the power cable, it may still provide some pre-warning. It also helps to distinguish the power cable from the telecommunication cable, water pipes etc. - these can often be hard to tell apart. To comply with AS/NZS 3000, most types of power cable installed using trenchless techniques require additional mechanical protection which can be provided by first pulling a heavy duty rigid duct (as defined in AS/NZS2053) into the hole. Signal strip is difficult to install above the duct using thrust installation.

Also, any specific minimum separation(s) for **service** trenches are now virtually unenforceable. These trenches are often dug, and the power and telecommunication cables/pipes laid, by homeowners or contractors. Neither the Telecommunication Network Operator or the Power Utility have much real control over the minimum standards that actually result. The Telecommunication Network Operator or Power Utility can state what its minimum standards are, and even "demand" that these be adhered to, but in practice it can't rely on these actually being followed, since they are effectively "unenforceable". It would be far better to instead simply ensure that:

- (i) the power cable is neutral screened
- (ii) the power cable is protected by an HRC fuse (or similarly fast acting protection)
- (iii) the telecommunication cable is in a continuous sub-duct (no joints) with a (sub-duct) insulation rating in excess of the highest voltage present in the power cable
- (iv) the length of parallel, at < 150mm separation, is < 50m (this maximum parallel length requirement is desirable to limit possible "noise" induction).

A2.2 Road Reserve Separations

In the vast majority of cases, the minimum separations specified in the previous agreed minimum separations between power and telecommunication cables (see below) have been adhered to in the road reserve.

Table A1 Previous Agreed Minimum Separations between Buried Power and Telecommunication Cables

Voltage and Cable Type	At Crossings		On Parallel Runs	
	With Protection	Without Protection	With Protection	Without Protection
LV neutral-screened, or armoured	50mm	150mm	50mm	150mm
LV <u>not</u> neutral-screened, or armoured	50mm	450mm	450mm	450mm
HV	150mm	450mm	450mm (2.4km limit on length)	450mm (2.4km limit on length)

Note

These minimum separations are now superseded, and should no longer be used.

A2.3 LV Neutral Screened Power Cable

According to the previous agreed minimum separations, a telecommunication cable that is not in pipe can be installed directly over a protection slab which is directly over a LV neutral screened or armoured power cable (so long as there is 50mm minimum separation between the cables). In this situation there is a substantial danger that power staff attempting to access their cable will excessively "stretch" the telecommunication cable (causing immediate or future faults). Telecommunications staff have a good idea of how much a telecommunication cable can be safely "stretched" without causing problems. Power staff don't, and don't seem to be well motivated to be "gentle" with telecommunication plant when trying to access their plant (especially if this means having to dig up a greater trench length to expose sufficient of the telecommunication cable to enable it to be "gently" stretched out of the way). To overcome this "stretching" problem, **a minimum separation of 150mm should apply in the road reserve, regardless of whether protection (e.g. plastic slabs) is used.** A minimum separation of 150mm should also allow telecommunications staff to dig up and repair telecommunication cable(s), without significant risk of damaging an adjacent LV neutral screened power cable, even if the power cable has no "protection" over it.

Also, trenching within 300mm of the recorded offset of an existing telecommunication cable incurs a high risk of hitting the cable, since the actual position of the cable can easily be up to 150mm closer than the recorded offset. Hence the minimum separation in the street from LV neutral screened cable should be:

- (i) 150mm for the shared trench case (i.e. both cables/pipes laid at the same time - you can see exactly where the other cable/pipe is),
- or
- (ii) 300mm horizontal separation (or 150mm vertical separation) if trench sharing is not occurring (i.e. one party is already there (but out of sight), the second party is laying new plant).

The previous agreed minimum separations from LV neutral-screened or armoured power cables, both at crossings and on parallel runs, are 50mm with protection (e.g. plastic slabs) and 150mm without protection. So adopting the above revised minimum clearances on parallel runs in the street would mean there would be less incentive to use protection slabs (or similar protection) - smaller separations would only apply when protection is installed at crossings and under telecommunication plastic pits (see Application Rule (6) in Section 3).

This will not be a great loss for the following reasons:

- If a telecommunication cable was in a pipe directly over a protection slab which was directly over a LV neutral screened or armoured power cable, power staff would have great difficulty accessing their plant.
- There is also a problem with installing mechanical protection properly. Bedding material should be placed alongside and over the power cable and "tamped down", to provide a firm flat base to lay the protection slab on, before the protection slab is laid. If this is not done and an "air gap"/lightly tamped area is left under the protection slab, it may skew and the trench surface may "sink". This could result in two very similar looking telecommunication and power cables ending up virtually side by side.
- Mechanical protection installed in a trench must make the trench more difficult to ram properly.

A2.4 LV Power Cable that is not Neutral Screened or Armoured

This is much more dangerous (to telecommunications staff especially) than LV neutral screened cable since:

- (i) the "contact" voltage is 230Vrms ($\pm 6\%$) (c.f. up to 120V for neutral screened cable - see previous section on "Hazard from Contact with Power Cables")

- (ii) the duration of the "exposure" could easily be "indefinite" (c.f. say less than 20ms for neutral screened cable protected by an HRC fuse (or equivalent)), since the impedance of the bucket/chain/spade contact with the earth plus the (MEN) earth impedance of the distribution transformer, is very unlikely to be less than the say 1Ω needed to blow the fuse at the distribution transformer, when only one phase is cut/damaged/contacted by the bucket/chain/spade - this could easily happen with a cable that has no neutral screen (or armouring).

Mechanical protection should adequately protect a power cable from digging with spades, picks, etc. However it would not stop a backactor. Today, most construction digging in the road reserve is done with a backactor (especially in urban areas). So the presence of "protection" (e.g. plastic slabs) over a power cable in the road reserve would not greatly affect the risk of the power cable being damaged/contacted. The primary safeguard in this case must come from suitable minimum separations (and the use of neutral screened LV power cables).

The "depth" of dirt scraped up by each backactor scoop depends on the soil type. In hard ground, it could be less than 200mm/scoop. In sandy ground, it could be up to the bucket "height" (400mm?). So a minimum separation of 450mm should continue to apply to all "hazardous" power cables (i.e. all LV power cables that are not neutral screened or armoured, or any HV cable).

A2.5 HV Power Cable

Because of the extreme "hazard" presented by HV (typically 11kV or 33kV) cables, the minimum separation should be retained at 450mm regardless of whether the HV cable is armoured, has some form of neutral screen, or is installed with protection (e.g. plastic slabs). The reasons for this are as outlined in the above two paragraphs.

A2.6 Crossings

The previous agreed minimum separations at crossings have not caused any problems, so no change is proposed to these separations. The reduced separations permitted at crossings "with protection" are not a problem if mechanical protection is installed over the power cable, and the power cable is installed below the telecommunication cable.

A3 Electrical Noise Induction

Currently, noise induction from power cables to telecommunication copper cables is not a major problem. However, problems do exist, and the trends for the future are not promising.

Harmonic noise currents in power cables seem to be on the increase. At the same time there is a rapid growth in the use of ordinary copper pair telecommunication cable circuits for high bit-rate data uses (e.g. internet), making future telecommunication circuits increasingly susceptible to any induced electrical noise (particularly in the higher frequency range (i.e. > 10 kHz) such as those generated by switching transients).

For this reason, it is desirable to maximise the separation between power and telecommunication cables wherever this is possible, and only consider "reduced" separations in special circumstances, where the gains are believed to outweigh the future degradation of the quality of the copper based telecommunication services.

At present the only circumstance where this is felt warranted is where existing urban residential properties with aerial power service leads are being converted to underground power service leads, and in many of these cases, the underground power service lead needs to be installed by thrust-boring. In these cases, there is a strong convenience in having the power and telecommunication cables share the same thrust-bored hole into the residential property. To minimise the future noise induction impacts of this practice, it should only be applied if:

- the LV cable is neutral screened (Note: LV Armoured but not neutral-screened cables do not qualify)

- the LV power cable serves an urban residential property, and is single phase (230V) only - this tends to avoid the “noisier” industrial type loads (including those in residential properties)
- the length of parallel is less than 50m.

Noise induction is not an issue with fibre-optic cables that are totally non-metallic, or fibre optic cables whose only metal component is a steel strength member.