**Document No: MDI 0011**

**Amendment No: 6**

**Mains Design Instruction**

# Underground distribution cables – continuous current rating

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# MDI 0011 UNDERGROUND DISTRIBUTION CABLES – CONTINUOUS CURRENT RATING

## CONTENTS



## 1.0 PURPOSE

To specify the continuous current ratings of underground distribution cables that are installed on Endeavour Energy's underground distribution cable network.

## 2.0 SCOPE

The continuous current ratings covered by this instruction are considered to be conservative and will be adequate for all normal operating conditions.

## 3.0 REFERENCES

**Internal**

- Company Policy 9.2.10 – Network asset ratings
- Annexure 1: Rating factors – Winter temperature
- Annexure 2: Rating factors – Soil thermal resistivity
- Annexure 3: Rating factors – Cable depth
- Annexure 4: Rating factors – Cable formation
- Annexure 5: Rating factors – Proximity to other multicore cables
- Annexure 6: Examples applying multiple rating factors

**External**

- ENA National Electricity Network Safety Code (Doc 01-2008)
- AS/NZS 3008.1.1:2009 - Electrical installations - Selection of cables
- AS/NZS 4026:2001 - Electric cables for underground residential distribution
- IEC 60287-3-1:1995 - Electric cables - Calculation of the current ratings

## 4.0 DEFINITIONS AND ABBREVIATIONS

| | |
|---|---|
| **ASP** | Accredited Service Provider |
| **ETS** | Equipment Technical Specification |
| **HDPE** | High Density Polyethylene Cable |
| **HV** | High Voltage – a voltage exceeding 1,000 volts alternating current |
| **LV** | Low Voltage – a voltage normally exceeding 50 volts alternating current (AC), but not normally exceeding 1,000 volts AC. |
| **TR-XLPE** | Tree-Retardant Cross Linked Polyethylene |
| **XLPE** | Cross Linked Polyethylene - the primary insulation of the cable. For the purposes of this document, cables with XLPE insulation also refer to cables with TR-XLPE and X-90 insulation. |

## 5.0 ACTIONS

The electrical loadings applied to distribution underground cables must be in accordance with this instruction.

### 5.1 Current ratings

The tables listed in Section 5.3 give continuous current ratings for the most common installation conditions, as outlined in Section 5.2. These ratings should be used unless more specific information is available on the installation. If the installation conditions vary from those outlined in Section 5.2, the rating factors in the annexures must be applied to cater for changes to;

- Winter soil temperatures (Annexure 1);
- Soil thermal resistivity (Annexure 2);
- Cable depth (Annexure 3);

- Cable formation (Annexure 4); and/or
- Proximity to other cable installations (Annexure 5).

The rating for the single core cables assumes only one cable is being used per phase and is installed in trefoil.

If cables of different voltages are installed in the trench, the most conservative rating factor should be applied to all of the cables in the trench. An example is provided in Annexure 6, Example 4. A less conservative rating factor may only be applied if a cable rating study is conducted.

The cable rating must be limited by the section in the cable route that has the most significant impact on the cable rating. Even short distances where the cable enters thermally unfavourable conditions, such as a short cable section of increased depth, must be considered and cannot be ignored unless a rating study has proven there to be minimal impact on the cable rating.

Where a cable is proposed to cross over or under another cable circuit, the operating temperature of the cables can reduce the rating of both circuits. In addition, the installation scenarios and rating factors given in this standard may not be adequate to cover complex cable arrangements, such as within zone substations. A cable rating study should be conducted to calculate the applicable cable rating based on the installation conditions.

Where a rating study is required for an internal project, Transmission Mains Development is responsible for calculating a suitable cable rating. Where a rating study is required for a contestable (external) project, the Level 3 ASP Designer is responsible for calculating a suitable cable rating and must be checked by Transmission Mains Development.

For emergency ratings of the cables, contact the Network Mains Manager.

For short circuit and earth fault ratings of the new cables, refer to respective ETS.

## 5.2 Installation conditions

**Table 1: Installation conditions for a LV and HV cable (direct buried or in a conduits).**

| Voltage | Laying depth (m) | Cable insulation/ construction | Maximum continuous conductor temperature (˚C) | Soil Thermal resistivity (˚Cm/W) | Soil temperature (˚C) |
|---|---|---|---|---|---|
| LV | 0.6 | XLPE | 90 | 1.2 | 25 |
| | | Paper | 80 | | |
| HV | 0.8 | XLPE, screened | 90 | | |
| | | Paper, belted | 65 | | |
| | | Paper, screened | 70 | | |

The soil thermal resistivity and soil temperatures are in accordance with Company Policy 9.2.10.

## 5.3 Continuous current rating tables

The continuous current ratings given in the tables below are the maximum ratings to be applied.

### *5.3.1 Low voltage cables*

**Table 2: XLPE insulated low voltage cables**

| Conductor material | Number of cores | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|---|
| | | | ***Buried in duct*** | ***Buried direct*** |
| Copper | 1 | 16 $mm^2$ | 105 | 140 |
| | | 25 $mm^2$ | 135 | 180 |
| | 2 | 16 $mm^2$ | 100 | 130 |
| | 4 | 16 $mm^2$ | 80 | 110 |
| | | 25 $mm^2$ | 110 | 145 |
| | | 50 $mm^2$ | 160 | 205 |
| Aluminium | | 150 $mm^2$ | 240 | 330 |
| | | 185 $mm^2$ | 280 | 340 |
| | | 240 $mm^2$ | 330 | 395 |

**Table 3: Paper insulated low voltage cables**

| Conductor material | Number of cores | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|---|
| | | | ***Buried in duct*** | ***Buried direct*** |
| Copper | 3.5 | 0.1 $inch^2$ | 175 | 215 |
| | | 0.15 $inch^2$ | 215 | 255 |
| | | 0.2 $inch^2$ | 255 | 310 |
| | | 0.3 $inch^2$ | 325 | 400 |
| | | 0.4 $inch^2$ | 385 | 465 |
| Aluminium | 3.5 | 0.1 $inch^2$ | 135 | 165 |
| | | 0.2 $inch^2$ | 200 | 245 |
| | | 0.4 $inch^2$ | 300 | 370 |
| | | 240 $mm^2$ | 295 | 350 |

**Table 4: Consac low voltage cables**

| Conductor material | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|
| | | ***Buried in duct*** | ***Buried direct*** |
| Aluminium | 0.06 $inch^2$ | 100 | 120 |
| | 0.1 $inch^2$ | 140 | 170 |
| | 0.15 $inch^2$ | 170 | 205 |

| Conductor material | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|
| | | *Buried in duct* | *Buried direct* |
| | 0.2 inch$^2$ | 205 | 245 |
| | 0.25 inch$^2$ | 235 | 270 |
| | 0.3 inch$^2$ | 265 | 320 |
| | 0.4 inch$^2$ | 310 | 370 |
| | 95 mm$^2$ | 170 | 205 |
| | 185 mm$^2$ | 250 | 300 |
| | 240 mm$^2$ | 295 | 355 |

### *5.3.2 High voltage cables*

**Table 5: 11kV XLPE insulated cables**

| Number of cores | Conductor material | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|---|
| | | | *Buried in duct* | *Buried direct* |
| 1 | Copper | 25 mm$^2$ | 122 | 145 |
| | | 70 mm$^2$ | 220 | 249 |
| | | 150 mm$^2$ | 325 | 370 |
| | | 185 mm$^2$ | 360 | 415 |
| | | 240 mm$^2$ | 410 | 480 |
| | | 500 mm$^2$ | 550 | 660 |
| | Aluminium | 50 mm$^2$ | 155 | 160 |
| | | 150 mm$^2$ | 260 | 290 |
| | | 185 mm$^2$ | 290 | 330 |
| | | 240 mm$^2$ | 335 | 380 |
| | | 500 mm$^2$ | 470 | 550 |
| 3 | Copper | 185 mm$^2$ | 360 | 425 |
| | | 240 mm$^2$ | 420 | 500 |
| | | 300 mm$^2$ | 475 | 560 |
| | | 500 mm$^2$ | 587 | 678 |
| | Aluminium | 35 mm$^2$ | 105 | 125 |
| | | 95 mm$^2$ | 190 | 220 |
| | | 185 mm$^2$ | 275 | 320 |
| | | 240 mm$^2$ | 320 | 370 |
| | | 300 mm$^2$ | 365 | 429 |

**Table 6: 11kV paper insulated cables**

| Cable construction (number of cores) | Conductor material | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|---|
| | | | *Buried in duct* | *Buried direct* |
| Lead sheath, armoured, screened (3 core) | Copper | 150 $mm^2$ | 255 | 305 |
| | | 185 $mm^2$ | 295 | 340 |
| | | 300 $mm^2$ | 380 | 435 |
| | | 0.1 $inch^2$ | 170 | 195 |
| | | 0.25 $inch^2$ | 275 | 320 |
| | | 0.3 $inch^2$ | 305 | 355 |
| | | 0.5 $inch^2$ | 400 | 455 |
| | Aluminium | 120 $mm^2$ | 175 | 205 |
| | | 150 $mm^2$ | 205 | 240 |
| | | 240 $mm^2$ | 265 | 310 |
| | | 300 $mm^2$ | 300 | 350 |
| | | 0.15 $inch^2$ | 160 | 195 |
| | | 0.3 $inch^2$ | 240 | 280 |
| | | 0.5 $inch^2$ | 315 | 355 |
| | | 0.75 $inch^2$ | 370 | 430 |
| Lead sheath, HDPE served, screened (3 core) | Aluminium | 240 $mm^2$ | 265 | 310 |
| | | 300 $mm^2$ | 300 | 350 |
| Lead sheath, PVC served, screened (1 core) | Copper | 185 $mm^2$ | 300 | 345 |
| | | 0.5 $inch^2$ | 400 | 460 |
| | | 0.75 $inch^2$ | 480 | 570 |
| Lead sheath, armoured, belted (3 core) | Copper | 50 $mm^2$ | 125 | 145 |
| | | 185 $mm^2$ | 265 | 315 |
| | | 240 $mm^2$ | 315 | 365 |
| | | 300 $mm^2$ | 350 | 410 |
| | | 0.04 $inch^2$ | 85 | 100 |
| | | 0.06 $inch^2$ | 110 | 130 |
| | | 0.1 $inch^2$ | 155 | 180 |
| | | 0.15 $inch^2$ | 190 | 225 |
| | | 0.2 $inch^2$ | 225 | 260 |
| | | 0.3 $inch^2$ | 295 | 335 |
| | | 0.5 $inch^2$ | 375 | 430 |
| | Aluminium | 95 $mm^2$ | 140 | 170 |
| | | 150 $mm^2$ | 185 | 220 |
| | | 185 $mm^2$ | 210 | 250 |
| | | 240 $mm^2$ | 250 | 290 |
| | | 300 $mm^2$ | 280 | 325 |

| Cable construction (number of cores) | Conductor material | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|---|
| | | | *Buried in duct* | *Buried direct* |
| | | 0.15 inch$^2$ | 150 | 175 |
| | | 0.2 inch$^2$ | 175 | 205 |
| | | 0.3 inch$^2$ | 235 | 265 |
| | | 0.4 inch$^2$ | 270 | 310 |
| | | 0.5 inch$^2$ | 300 | 340 |

**Table 7: 22kV XLPE insulated cables**

| Number of cores | Conductor material | Cable core cross sectional area | Continuous summer rating (Amps) | |
|---|---|---|---|---|
| | | | *Buried in duct* | *Buried direct* |
| 1 | Copper | 70 mm$^2$ | 221 | 248 |
| 3 | Copper | 240 mm$^2$ | 425 | 500 |
| | Aluminium | 150 mm$^2$ | 250 | 295 |
| | | 240 mm$^2$ | 320 | 365 |
| | | 300 mm$^2$ | 375 | 435 |

## 6.0 AUTHORITIES AND RESPONSIBILITIES

**General Manager Asset Management** has the authority and responsibility for approving this instruction.

**Manager Asset Standards & Design** has the authority and responsibility for:

- reviewing and updating this instruction in accordance with Company Policy and Procedures; and
- endorsing and recommending changes and revision to this instruction.

**Network Mains Manager** has the authority and responsibility for:

- determining the emergency/short circuit current ratings of all underground cables used on the Endeavour Energy electrical network;
- endorsing and recommending changes and revisions to this instruction; and
- endorsing variations from the requirements of this instruction.

**Transmission Mains Development Manager** has the authority and responsibility for:

- determining the continuous current ratings (rating study) of underground cables installed within a zone substation;
- determining the continuous current ratings (rating study) of underground cables for internal projects that do not satisfy the assumptions or requirements of this standard; and
- checking the continuous current rating calculations (rating study) of underground cables by Level 3 ASP Designers for external projects that do not satisfy the assumptions or requirements of this standard.

**Manager System Control** has the authority and responsibility for overseeing System Operations employees comply with the requirements of this instruction.

**Regional Managers** have the authority and responsibility for overseeing that all designs carried out by Regional employees conform to the requirements of this instruction.

**Manager Network Connections** has the authority and responsibility for overseeing that all designs submitted by Level 3 ASP Designers conform to the requirements of this instruction.

**Level 3 ASP Designers** have the responsibility for calculating the continuous current rating calculations (rating study) of underground cables that do not satisfy the assumptions or requirements of this standard.

## 7.0 DOCUMENT CONTROL

**Documentation Content Coordinator** : Network Mains Manager

**Documentation Distribution Coordinator** : Branch Process Coordinator

## Annexure 1: Rating factors – Winter temperature

### A1.1 Rating factor for variation of soil temperature from 25°C

**Table 8: Rating factors for winter ambient soil temperature**

| Cable insulation/construction | Maximum Conductor temperature for continuous (˚C) | Soil ambient temperature (˚C) | |
|---|---|---|---|
| | | 25°C (Summer) | 18°C (Winter) |
| HV or LV XLPE | 90 | 1.00 | 1.06 |
| LV paper insulated | 80 | 1.00 | 1.07 |
| HV paper insulated, screened | 70 | 1.00 | 1.09 |
| HV paper insulated, belted | 65 | 1.00 | 1.10 |

## Annexure 2: Rating factors – Soil thermal resistivity

### A2.1. Rating factor for variation of soil thermal resistivity from 1.2°Cm/W

**Table 9: Rating factors for multicore cables direct buried**

| Conductor size ($mm^2$) | Soil thermal resistivity (°Cm/W) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.8 | 0.9 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
| Up to 16 | 1.09 | 1.06 | 1.04 | 0.95 | 0.86 | 0.79 | 0.74 |
| From 25 to 150 | 1.14 | 1.10 | 1.07 | 0.92 | 0.82 | 0.74 | 0.68 |
| From 185 to 400 | 1.16 | 1.11 | 1.07 | 0.92 | 0.82 | 0.74 | 0.68 |

**Table 10: Rating factors for multicore cables laid in duct/s**

| Conductor size ($mm^2$) | Soil thermal resistivity (°Cm/W) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.8 | 0.9 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
| Up to 16 | 1.05 | 1.04 | 1.03 | 0.97 | 0.92 | 0.87 | 0.83 |
| From 25 to 150 | 1.07 | 1.05 | 1.03 | 0.96 | 0.90 | 0.85 | 0.78 |
| From 185 to 400 | 1.09 | 1.06 | 1.04 | 0.95 | 0.87 | 0.82 | 0.76 |

## Annexure 3: Rating factors – Cable depth

### A3.1. Rating factor for depth of laying

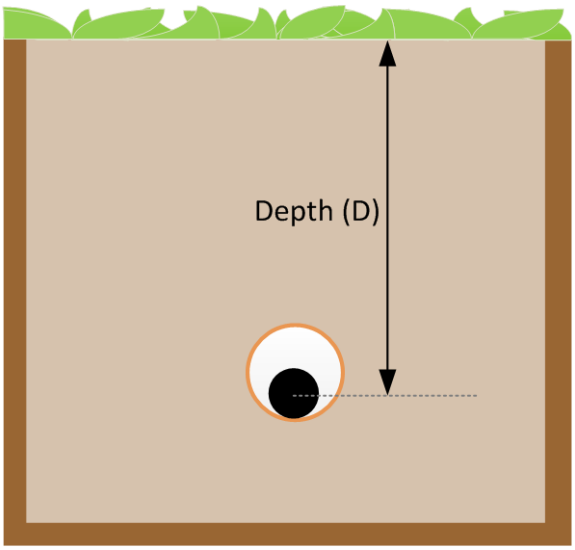



**Figure 1: Illustration of the depth D which is to be taken from the ground surface to the centre of the cable.**

**Table 11: Rating factors for multicore cables direct buried**

| Depth of laying D (m) | LV multicore cables | | | HV multicore cables | |
|---|---|---|---|---|---|
| | Up to 50mm$^2$ | 70mm$^2$ to 300mm$^2$ | Above 300mm$^2$ | Up to 300mm$^2$ | Above 300mm$^2$ |
| 0.6 | 1.00 | 1.00 | 1.00 | - | - |
| 0.8 | 0.98 | 0.98 | 0.97 | 1.00 | 1.00 |
| 1.00 | 0.96 | 0.96 | 0.95 | 0.98 | 0.97 |
| 1.25 | 0.95 | 0.94 | 0.93 | 0.96 | 0.95 |
| 1.50 | 0.94 | 0.93 | 0.92 | 0.95 | 0.94 |
| 1.75 | 0.93 | 0.91 | 0.90 | 0.94 | 0.92 |
| 2.00 | 0.92 | 0.90 | 0.89 | 0.92 | 0.90 |
| 2.50 | 0.91 | 0.89 | 0.88 | 0.91 | 0.89 |
| 3.0 or more | 0.90 | 0.88 | 0.86 | 0.90 | 0.88 |

**Table 12: Rating factors for cables laid in duct/s**

| Depth of laying D (m) | LV cables | | HV cables | |
|---|---|---|---|---|
| | Single core | Multicore | Single core | Multicore |
| 0.6 | 1.00 | 1.00 | - | - |
| 0.8 | 0.97 | 0.98 | 1.00 | 1.00 |
| 1.00 | 0.95 | 0.97 | 0.98 | 0.99 |
| 1.25 | 0.92 | 0.96 | 0.95 | 0.97 |
| 1.50 | 0.91 | 0.95 | 0.93 | 0.96 |
| 1.75 | 0.90 | 0.95 | 0.92 | 0.95 |
| 2.00 | 0.89 | 0.94 | 0.90 | 0.94 |
| 2.50 | 0.88 | 0.94 | 0.89 | 0.93 |
| 3.0 or more | 0.87 | 0.93 | 0.88 | 0.92 |

## Annexure 4: Rating factors – Cable formation

### A4.1. Rating factor for groups of multicore cables in horizontal formation

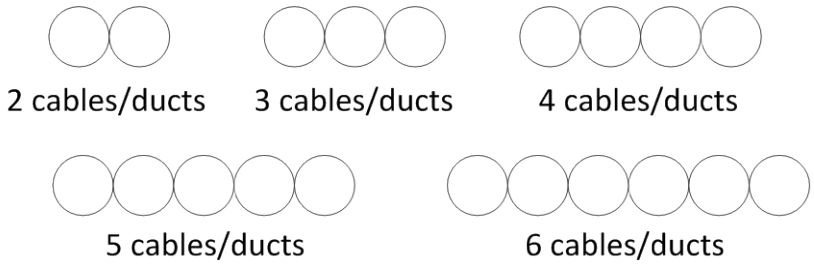



**Figure 2: Illustration of ducts laid in horizontal formation.**

**Table 13: Rating factors for multicore cables direct buried**

| Cable voltage kV | Number of cables in group | Proximity rating factors |
|---|---|---|
| | | Cables Touching |
| 0.6/1kV | 2 | 0.81 |
| | 3 | 0.70 |
| | 4 | 0.63 |
| | 5 | 0.59 |
| | 6 | 0.55 |
| 11kV<br>22kV | 2 | 0.80 |
| | 3 | 0.69 |
| | 4 | 0.63 |
| | 5 | 0.57 |
| | 6 | 0.55 |

**Table 14: Rating factors for multicore laid in ducts**

| Cable voltage kV | Number of cables in group | Proximity rating factors |
|---|---|---|
| | | Ducts touching |
| 0.6/1kV | 2 | 0.90 |
| | 3 | 0.82 |
| | 4 | 0.78 |
| | 5 | 0.75 |
| | 6 | 0.72 |
| 11kV and 22kV | 2 | 0.88 |
| | 3 | 0.80 |
| | 4 | 0.75 |
| | 5 | 0.71 |
| | 6 | 0.69 |

## A4.2. Rating factor for multicore cables laid in duct in tier formation

The following can be used for XLPE, TR-XLPE and paper insulated cables.

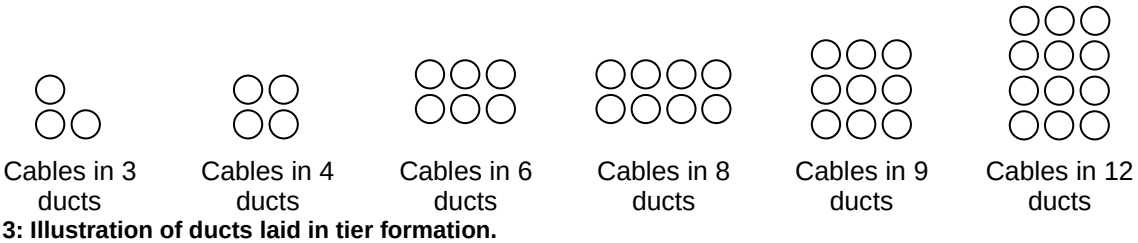



**Figure 3: Illustration of ducts laid in tier formation.**

**Table 15: Rating factors for LV insulated multi-core cables**

| Spacing (mm) | Proximity rating factors | | | | | |
|---|---|---|---|---|---|---|
| | 3 ducts | 4 ducts | 6 ducts | 8 ducts | 9 ducts | 12 ducts* |
| 0 (touching) | 0.82 | 0.77 | 0.68 | 0.62 | 0.59 | 0.54 |
| 50 | 0.83 | 0.78 | 0.69 | 0.63 | 0.60 | 0.55 |

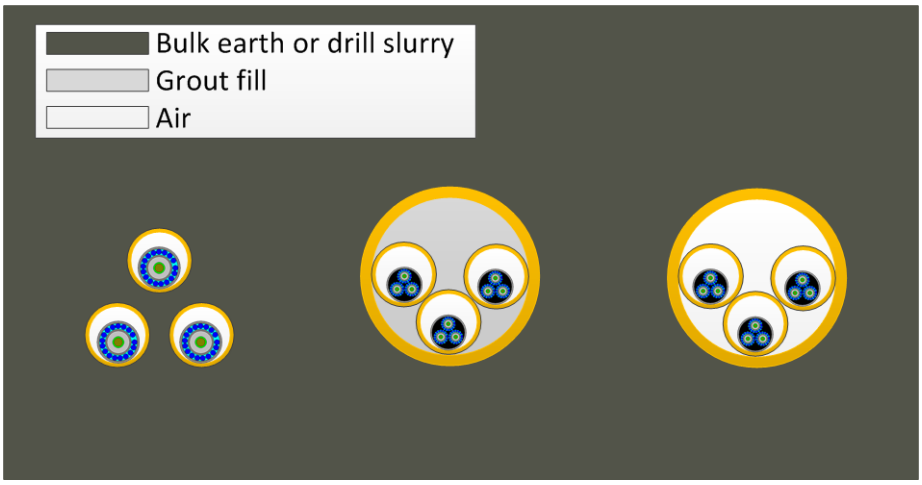
**Table 16: Rating factors for HV insulated multi-core cables**

| Spacing (mm) | Proximity rating factors | | | | | |
|---|---|---|---|---|---|---|
| | 3 ducts | 4 ducts | 6 ducts | 8 ducts | 9 ducts | 12 ducts* |
| 0 (touching) | 0.8 | 0.74 | 0.65 | 0.59 | 0.56 | 0.51 |
| 50 | 0.81 | 0.75 | 0.66 | 0.60 | 0.57 | 0.52 |

* This applies for both *4 x 3* and *3 x 4* arrangements.

## A4.3. Rating factor for installation by underbore or horizontal directional drilling

**Table 17: Rating factors for cables in underbores.**

| Cable Type | Underbore installation type | | |
|---|---|---|---|
| | Un-sleeved | Sleeved and grouted* borehole | Sleeved and un-grouted borehole |
| (example) |   | | |
| Single core | 1.00 | 1.00 | 0.93 |
| Multi-core | 1.00 | 1.00 | 0.96 |

* Grout refers to any thermally rated duct fill material, recognised as having thermal resistivity less than or equal to 1.2°Cm/W.

## Annexure 5: Rating factors – Proximity to other multicore cables

### A5.1. Proximity rating factor for the separation of two banks of ducts

This section should be used with Annexure 4: Rating factors – Cable formation to obtain the applicable cable rating.

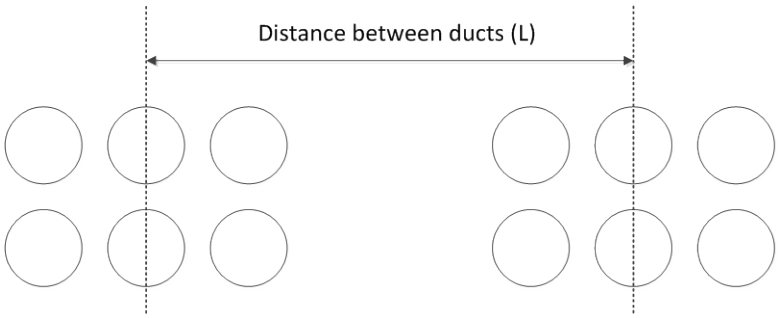



**Figure 4: Illustration of distance L between 2 banks of ducts.**

**Table 18: Rating factors for distance between 2 banks with various ducts in each.**

| Distance L (m) | Proximity rating factors | | | | |
|---|---|---|---|---|---|
| | 2 ducts | 3 ducts | 4 ducts | 5 ducts | 6 ducts |
| 1 | 0.89 | 0.88 | 0.85 | 0.83 | 0.83 |
| 2 | 0.93 | 0.93 | 0.91 | 0.91 | 0.91 |
| 3 | 0.95 | 0.94 | 0.93 | 0.93 | 0.93 |
| 4 | 0.97 | 0.96 | 0.95 | 0.95 | 0.95 |
| 5 | 0.98 | 0.97 | 0.96 | 0.96 | 0.96 |
| 6 | 0.99 | 0.97 | 0.97 | 0.97 | 0.97 |
| 7 | 0.99 | 0.97 | 0.97 | 0.97 | 0.97 |
| 8 | 0.99 | 0.98 | 0.97 | 0.97 | 0.97 |
| 10 | 1 | 0.99 | 0.98 | 0.98 | 0.98 |
| 12 | 1 | 0.99 | 0.98 | 0.98 | 0.98 |
| ≥ 15 | 1 | 1 | 1 | 1 | 1 |

If the two duct banks have a different number of ducts in each, the average rating should be used, e.g. if the number of ducts in each bank was 3 and 6, the rating should be taken as the average between two banks with 3 ducts in each and two banks with 6 ducts in each. An example is provided in Annexure 6, Example 3.

### A5.2. Proximity rating factor for the separation of single ducts

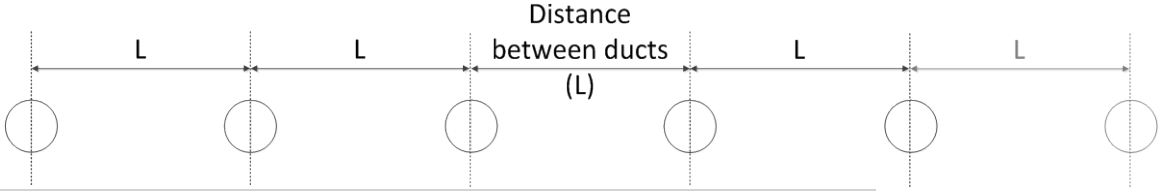



**Figure 5: Illustration of distance L between single ducts (shown with 5 or 6 ducts).**

**Table 19: Rating factors for distance between 5 or 6 banks with 1 duct in each.**

| Distance L (m) | Proximity rating factor | |
|---|---|---|
| | 5 ducts | 6 ducts |
| 0.5 | 0.79 | 0.77 |
| 0.75 | 0.84 | 0.83 |
| 1 | 0.88 | 0.87 |
| 1.25 | 0.9 | 0.9 |
| 1.5 | 0.93 | 0.92 |
| 3 | 0.98 | 0.97 |
| 4 | 0.99 | 0.98 |
| 6 | 0.99 | 0.99 |
| ≥ 8 | 1 | 1 |

## Annexure 6: Examples applying multiple rating factors

### Example 1: Cables installed in a bank of 6 ducts

A bank of 6 ducts has been installed. It has been forecasted that 4 x 3C 240mm² copper 11kV XLPE are required and is proposed to be installed as shown in Figure 6. The soil thermal resistivity is 1.2°Cm/W.

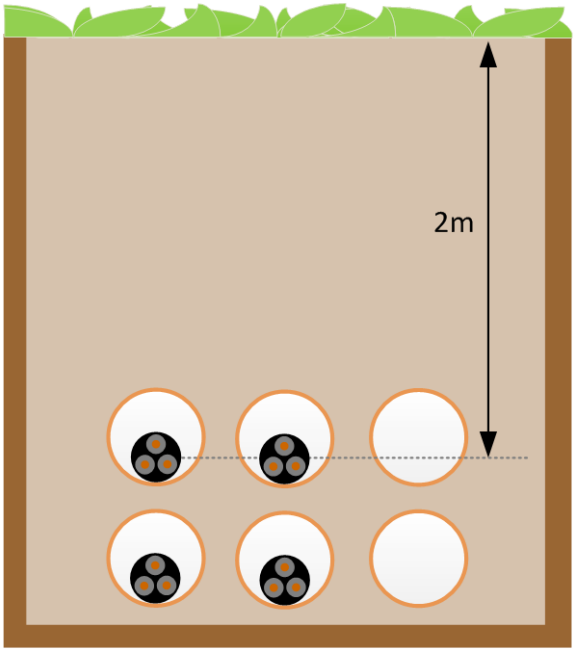



**Figure 6: 4 x 3C 240mm² copper 11kV XLPE cables installed in ducts. Two of the ducts are not being used in foreseeable future.**

The rating for a 3C 240mm² copper 11kV XLPE cable installed in a duct is listed in Table 5 as 420A. This rating must be adjusted using the rating factors applicable to the installation details.

As only 4 cables are required in the foreseeable future, the cable rating can assume the conduit bank is in a 2 x 2 arrangement, i.e. the spare conduits can be ignored. If the spare conduits are used in the future, the cable ratings will need to be adjusted to include the 2 additional cables.

| Installation conditions | Reference | Rating Factor |
|---|---|---|
| Summer rating | Annexure 1 Table 8 | 1 |
| 1.2°Cm/W thermal resistivity | Annexure 2 Table 10 | 1 |
| 2m HV multicore cable depth | Annexure 3 Table 12 | 0.94 |
| 2 x 2 HV cable duct formation with 50mm separation | Annexure 4 Table 16 | 0.75 |
| Not installed near other cable installations | Annexure 5 | 1 |

A summary of the rating factors are listed above and can be used to calculate the overall rating factor;

$$Overall\ rating\ factor = 1 \times 1 \times 0.94 \times 0.75 \times 1$$
$$= 0.705$$

This can now be used with the cable rating to find the feeder rating under the installation conditions;

$$Feeder\ ratings = 420A \times 0.705$$
$$= \mathbf{296A}$$

## Example 2: Cables installed in 2 banks of 2 ducts

2 banks of 2 ducts have been installed with a 3C 300mm² aluminium 22kV XLPE cable in each duct, as shown in Figure 7. The soil thermal resistivity is 1.2°Cm/W.

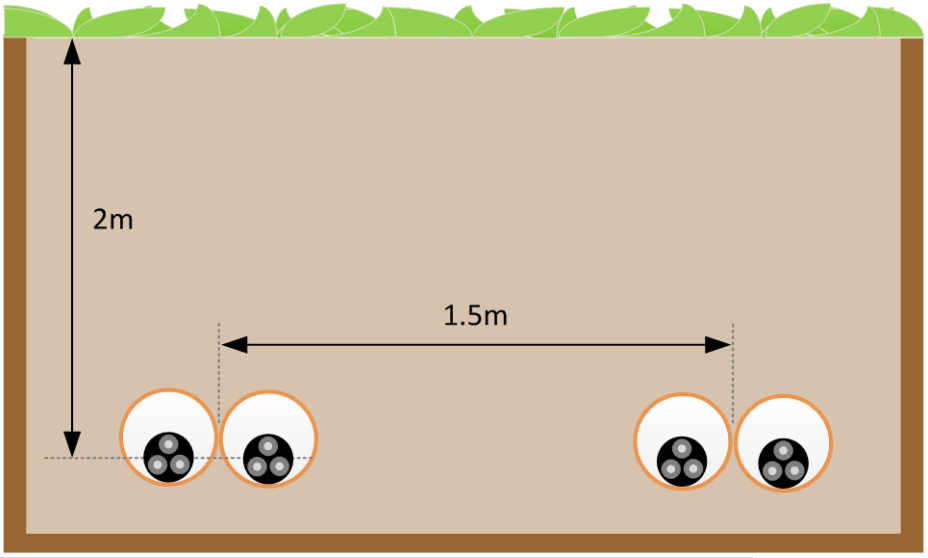



**Figure 7: 3C 300mm² aluminium 22kV XLPE cables installed in 2 banks of 2 ducts.**

The rating for a 3C 300mm² aluminium 22kV XLPE cable installed in a duct is listed in Table 7 as 375A. This rating must be adjusted using the rating factors applicable to the installation details.

| Installation conditions | Reference | Rating Factor |
|---|---|---|
| Summer rating | Annexure 1 Table 8 | 1 |
| 1.2°Cm/W thermal resistivity | Annexure 2 Table 10 | 1 |
| 2m HV multicore cable depth | Annexure 3 Table 12 | 0.94 |
| 2 HV cable duct formation with ducts touching | Annexure 4 Table 14 | 0.88 |
| 1.5m separation between banks of 2 ducts. | Annexure 5 Table 18 | 1m separation=0.89<br>2m separation=0.93 |

A summary of the rating factors are listed above and can be used to calculate the overall rating factor. However, Annexure 5 Table 18 does not provide a rating factor for 2 banks of conduits with a 1.5m separation. Instead, an average of the rating factors for 1m and 2m separation can be used;

$$Rating\ factor\ for\ 2\ banks\ with\ 1.5m\ seperation = \frac{0.89 + 0.93}{2}$$
$$= 0.91$$

Therefore;

$$Overall\ rating\ factor = 1 \times 1 \times 0.94 \times 0.88 \times 0.91$$
$$= 0.753$$

This can now be used with the cable rating to find the feeder rating under the installation conditions;

$$Feeder\ ratings = 375A \times 0.753$$
$$= \mathbf{282A}$$

### Example 3: Cables installed in 2 banks with 4 and 2 ducts

2 banks with 4 and 2 ducts have been installed with a 3C 300mm² aluminium 22kV XLPE cable in each duct, as shown in Figure 8. The soil thermal resistivity is 1.2°Cm/W.

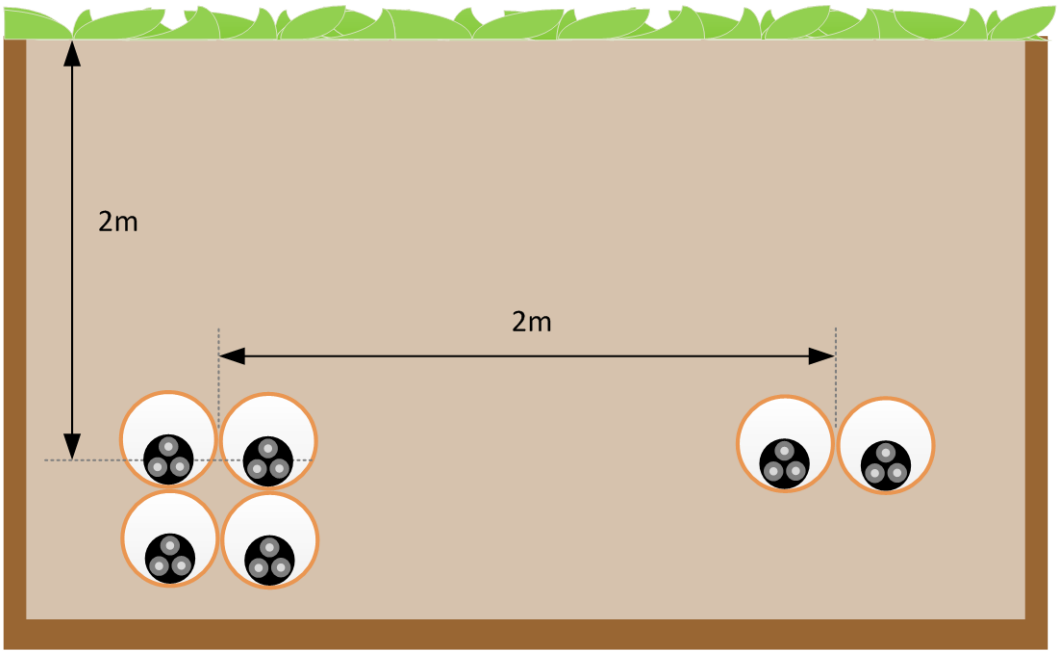



**Figure 8: 3C 300mm² aluminium 22kV XLPE cables installed in 2 banks with 4 and 2 ducts.**

The rating for a 3C 300mm² aluminium 22kV XLPE cable installed in a duct is listed in Table 7 as 375A. This rating must be adjusted using the rating factors applicable to the installation details.

The sections in Annexure 5 do not list the rating factors for installations where there the banks have a different number of ducts installed. As the cables are the same in all ducts, an average of the rating factors can be calculated and used.

Firstly, assume both banks contain only 2 ducts in each. The subsequent rating factors are outlined below.

| Installation conditions | Reference | Rating Factor |
|---|---|---|
| Summer rating | Annexure 1 Table 8 | 1 |
| 1.2°Cm/W thermal resistivity | Annexure 2 Table 10 | 1 |
| 2m HV multicore cable depth | Annexure 3 Table 12 | 0.94 |
| 2 HV cable duct formation with ducts touching | Annexure 4 Table 14 | 0.88 |
| 2m separation between banks of 2 ducts. | Annexure 5 Table 18 | 0.93 |

$$Rating\ factor\ for\ 2\ banks\ of\ 2\ ducts = 1 \times 1 \times 0.94 \times 0.88 \times 0.93 = 0.769$$

Secondly, assume both banks contain 4 ducts in each. The subsequent rating factors are outlined below.

| Installation conditions | Reference | Rating Factor |
|---|---|---|
| Summer rating | Annexure 1 Table 8 | 1 |
| 1.2°Cm/W thermal resistivity | Annexure 2 Table 10 | 1 |
| 2m HV multicore cable depth | Annexure 3 Table 12 | 0.94 |
| 4 HV cable duct formation with ducts touching | Annexure 4 Table 14 | 0.74 |
| 2m separation between banks of 4 ducts. | Annexure 5 Table 18 | 0.91 |

$$Rating\ factor\ for\ 2\ banks\ of\ 4\ ducts = 1 \times 1 \times 0.94 \times 0.74 \times 0.91$$
$$= 0.633$$

Therefore;

$$Overall\ rating\ factor = \frac{0.769 + 0.633}{2}$$
$$= 0.701$$

This can now be used with the cable rating to find the feeder rating under the installation conditions;

$$Feeder\ ratings = 375A \times 0.701$$
$$= \mathbf{262A}$$

**Example 4: LV and HV cables in the same cable trench**

6 ducts have been installed with a 3C 240mm² copper 11kV XLPE cable in 3 ducts and a 4C 240mm² aluminium 1kV XLPE cable in the other 3 ducts, as shown in Figure 9. The soil thermal resistivity is 1.2°Cm/W.

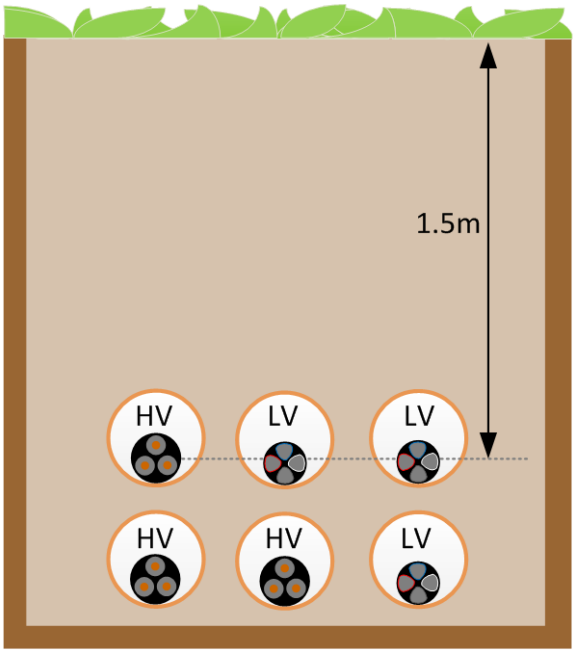



**Figure 9: 3C 240mm² copper 11kV XLPE cable in 3 ducts and a 4C 240mm² aluminium 1kV XLPE cable in the other 3 ducts.**

The rating for a 3C 240mm² copper 11kV XLPE cable installed in a duct is listed in 4 as 320A. The rating for a 4C 240mm² aluminium 1kV XLPE cable installed in a duct is listed in 1 as 330A. These ratings must be adjusted using the rating factors applicable to the installation details.

Since there are cables of different voltages in the same trench, the worst case rating factor must be applied to all cables in the trench. To do so, first assume all of the ducts are installed with LV cables. The rating factors have been summarised below.

| Installation conditions | Reference | Rating Factor |
|---|---|---|
| Summer rating | Annexure 1 Table 8 | 1 |
| 1.2°Cm/W thermal resistivity | Annexure 2 Table 10 | 1 |
| 1.5m LV multicore cable depth | Annexure 3 Table 12 | 0.95 |
| 3 x 2 LV cable duct formation with 50mm separation | Annexure 4 Table 15 | 0.69 |
| Not installed near other cable installations | Annexure 5 | 1 |

$$Rating\ factor\ for\ 6\ LV\ cables = 1 \times 1 \times 0.95 \times 0.69 \times 1 = 0.656$$

Now assume all of the ducts are installed with HV cables. The rating factors have been summarised below.

| Installation conditions | Reference | Rating Factor |
|---|---|---|
| Summer rating | Annexure 1 Table 8 | 1 |
| 1.2°Cm/W thermal resistivity | Annexure 2 Table 10 | 1 |
| 1.5m HV multicore cable depth | Annexure 3 Table 12 | 0.96 |
| 3 x 2 HV cable duct formation with 50mm separation | Annexure 4 Table 16 | 0.66 |
| Not installed near other cable installations | Annexure 5 | 1 |

$$Rating\ factor\ for\ 6\ HV\ cables = 1 \times 1 \times 0.96 \times 0.66 \times 1 = 0.634$$

The most conservative rating factor is for 6 HV cables being installed and should therefore also be applied to the LV cables;

$$HV\ feeder\ ratings = 320A \times 0.634 = \mathbf{202A}$$

$$LV\ feeder\ ratings = 330A \times 0.634 = \mathbf{209A}$$