

## Electrical data

### Conductor Resistance

Resistance formula:

$$R = \rho \frac{L}{A}$$

R = resistance in ohm per phase

$$\rho = \text{specific resistance} \frac{\text{Ohm} \cdot \text{mm}^2}{\text{m}}$$

A = conductor area mm<sup>2</sup>, L = conductor length, m

Resistance as a function of temperature:

$$R = R_0 (1 + \alpha (t - 20 \text{ °C}))$$

R = Resistance at t=20°C, t = conductor temperature °C,  $\alpha = 0,00393$  for copper

### Conductor resistance tinned annealed copper 250V, 0,6/1kV, 1,8/3(3,6)kV.

In accordance with IEC 60228, class 2. Tinned stranded annealed copper conductors for single core and multi-core cables 250V, 0,6/1kV and 1,8/3kV

| Nominal conductor area | No. of wires and diameter of wires | Approx. diam. | Max. resistance pr km |          |
|------------------------|------------------------------------|---------------|-----------------------|----------|
|                        |                                    |               | 20°C ohm              | 90°C ohm |
| mm <sup>2</sup>        | mm                                 | mmØ           |                       |          |
| 0,5                    | 7x 0,30                            | 0,9           | 36,7                  | 46,8     |
| 0,75                   | 7x 0,37                            | 1,1           | 24,8                  | 31,6     |
| 1                      | 7x 0,43                            | 1,3           | 18,2                  | 23,2     |
| 1,5                    | 7x 0,53                            | 1,6           | 12,2                  | 15,6     |
| 2,5                    | 7x 0,67                            | 2,0           | 7,56                  | 9,64     |
| 4                      | 7x 0,85                            | 2,6           | 4,70                  | 5,99     |
| 6                      | 7x 1,05                            | 3,2           | 3,11                  | 3,97     |
| 10                     | 7x 1,35                            | 4,1           | 1,84                  | 2,35     |
| 16                     | 7x 1,71                            | 5,2           | 1,16                  | 1,48     |
| 25                     | 7 x 2,13                           | 6,6           | 0,734                 | 0,936    |
| 35                     | 19x 1,53                           | 7,7           | 0,529                 | 0,675    |
| 50                     | 19x 1,80                           | 9,1           | 0,391                 | 0,499    |
| 70                     | 19x 2,17                           | 10,9          | 0,270                 | 0,344    |
| 95                     | 37x 1,80                           | 12,6          | 0,195                 | 0,249    |
| 120                    | 37x 2,03                           | 14,2          | 0,154                 | 0,196    |
| 150                    | 37x 2,27                           | 15,9          | 0,126                 | 0,161    |
| 185                    | 37x 2,52                           | 17,7          | 0,100                 | 0,128    |
| 240                    | 61x 2,24                           | 20,2          | 0,0762                | 0,0972   |
| 300                    | 61x 2,52                           | 22,6          | 0,0607                | 0,0774   |
| 400                    | 91x 2,36                           | 26,0          | 0,04475               | 0,0596   |
| 500                    | 91x 2,64                           | 29,0          | 0,0369                | 0,0463   |
| 630                    | 127x 2,52                          | 32,8          | 0,0286                | 0,0359   |

**Conductor resistance, tinned annealed copper conductor  
3,6/6(7,2)kV, 6/10(12)kV, 8,7/15(17,5)kV, 12/20(24)kV and 18/30(36)kV.**

In accordance with IEC 60228, class 2. Compressed tinned stranded annealed copper conductors for single core and multicore cables 3,6/6kV, 6/10kV, 8,7/15kV, 12/20(24)kV and 18/30(36)kV.

| Nominal conductor area<br>mm <sup>2</sup> | No. of wires and diameter of wires *)<br>mm | Approx. diam.<br>mmØ | Max. resistance pr km |             |
|-------------------------------------------|---------------------------------------------|----------------------|-----------------------|-------------|
|                                           |                                             |                      | 20°C<br>ohm           | 90°C<br>ohm |
| 16                                        | 7x 1,71                                     | 5,2                  | 1,16                  | 1,48        |
| 25                                        | 7 x 2,14                                    | 6,5                  | 0,734                 | 0,936       |
| 35                                        | 19x 1,53                                    | 7,4                  | 0,529                 | 0,675       |
| 50                                        | 19x 1,80                                    | 8,8                  | 0,391                 | 0,499       |
| 70                                        | 19x 2,17                                    | 10,3                 | 0,270                 | 0,344       |
| 95                                        | 37x 1,80                                    | 12,1                 | 0,195                 | 0,249       |
| 120                                       | 37x 2,03                                    | 13,6                 | 0,154                 | 0,196       |
| 150                                       | 37x 2,27                                    | 15,1                 | 0,126                 | 0,161       |
| 185                                       | 37x 2,52                                    | 16,8                 | 0,100                 | 0,128       |
| 240                                       | 61x 2,24                                    | 19,1                 | 0,0762                | 0,0972      |
| 300                                       | 61x 2,52                                    | 21,5                 | 0,0607                | 0,0774      |

\*) Diameter of wires before compressing

**Wire gauge conversion table**

**US Standard cross-section to square millimetres**

| U.S. Standard | Equivalent cross-section<br>mm <sup>2</sup> | Nearest available cross-section<br>mm <sup>2</sup> |
|---------------|---------------------------------------------|----------------------------------------------------|
| 20 AWG        | 0.519                                       | 0.5 – 0.75                                         |
| 18            | 0.823                                       | 1.0                                                |
| 16            | 1.31                                        | 1.5                                                |
| 14            | 2.08                                        | 2.5                                                |
| 12            | 3.31                                        | 4                                                  |
| 10            | 5.26                                        | 6                                                  |
| 8             | 8.37                                        | 10                                                 |
| 6             | 13.30                                       | 16                                                 |
| 4             | 21.15                                       | 25                                                 |
| 2             | 33.62                                       | 35                                                 |
| 1             | 42.41                                       | 50                                                 |
| 1/0           | 53.49                                       | 70                                                 |
| 2/0           | 67.23                                       | 70                                                 |
| 3/0           | 85.01                                       | 95                                                 |
| 4/0           | 107.2                                       | 120                                                |
| 250 MCM       | 126.7                                       | 120 - 150                                          |
| 300           | 152.0                                       | 150                                                |
| 350           | 177.3                                       | 185                                                |
| 400           | 202.7                                       | 185                                                |
| 450           | 228.0                                       | 185-240                                            |
| 500           | 253.4                                       | 240                                                |

| U.S. Standard | Equivalent cross-section mm <sup>2</sup> | Nearest available cross-section mm <sup>2</sup> |
|---------------|------------------------------------------|-------------------------------------------------|
| 550           | 278.7                                    | 240 – 300                                       |
| 600           | 304.0                                    | 300                                             |
| 650           | 329.4                                    | 300                                             |
| 700           | 354.7                                    | 300 – 400                                       |
| 750           | 380.0                                    | 400                                             |
| 800           | 405.4                                    | 400                                             |
| 850           | 430.7                                    | 400                                             |
| 900           | 456.0                                    | 400                                             |
| 950           | 481.4                                    | 400                                             |
| 1000          | 506.7                                    | 400 – 630                                       |
| 1250          | 633.4                                    | 630                                             |
| 1500          | 760.0                                    | 800                                             |
| 1750          | 886.7                                    | 800 – 1000                                      |
| 2000          | 1013.4                                   | 1000                                            |

### Current ratings for 250V and 0,6/1kV cables in fixed installations.

Current carrying capacities in continuous service at maximum rated temperature of 90°C.  
In accordance with IEC 60092-352 (2005) Annex B, Table B.4.

| Conductor area mm <sup>2</sup> | 1-core Amp | 2-core Amp | 3-4 core Amp |
|--------------------------------|------------|------------|--------------|
| 1                              | 18         | 15         | 13           |
| 1,5                            | 23         | 20         | 16           |
| 2,5                            | 30         | 26         | 21           |
| 4                              | 40         | 34         | 28           |
| 6                              | 52         | 44         | 36           |
| 10                             | 72         | 61         | 50           |
| 16                             | 96         | 82         | 67           |
| 25                             | 127        | 108        | 89           |
| 35                             | 157        | 133        | 110          |
| 50                             | 196        | 167        | 137          |
| 70                             | 242        | 206        | 169          |
| 95                             | 293        | 249        | 205          |
| 120                            | 339        | 288        | 237          |
| 150                            | 389        | 331        | 273          |
| 185                            | 444        | 377        | 311          |
| 240                            | 522        | 444        | 366          |
| 300                            | 601        | 511        | 420          |
| 400                            | 719        | 611        | 503          |
| 500                            | 827        | 703        | 579          |
| 630                            | 955        | 812        | 669          |

For cables with more than 4 cores, the current ratings are given by the following formula:

$$I = \frac{I_1}{\sqrt[3]{N}}$$

$I_1$  = current rating for single core

$N$  = number of cores

| No. of cores | 1,5 mm <sup>2</sup><br>Amp | 2,5 mm <sup>2</sup><br>Amp |
|--------------|----------------------------|----------------------------|
| 5            | 13                         | 18                         |
| 7            | 12                         | 16                         |
| 12           | 10                         | 13                         |
| 19           | 9                          | 11                         |
| 24           | 8                          | 10                         |
| 37           | 7                          | 9                          |

**Current rating for 1,8/3(3,6)kV, 3,6/6(7,2)kV, 6/10(12)kV, 8,7/15(17,5)kV, 12/20(24)kV and 18/30(36)kV cables in fixed installations.**

Current carrying capacities in continuous service at maximum rated temperature of 90°C. In accordance with IEC 60092-352 (2005) Annex B, Table B.4.

| Conductor area<br>mm <sup>2</sup> | 1-core<br>Amp | 2-core<br>Amp | 3-4 core<br>Amp |
|-----------------------------------|---------------|---------------|-----------------|
| 16                                | 96            | 82            | 67              |
| 25                                | 127           | 108           | 89              |
| 35                                | 157           | 133           | 110             |
| 50                                | 196           | 167           | 137             |
| 70                                | 242           | 206           | 169             |
| 95                                | 293           | 249           | 205             |
| 120                               | 339           | 288           | 237             |
| 150                               | 389           | 331           | 273             |
| 185                               | 444           | 377           | 311             |
| 240                               | 522           | 444           | 366             |
| 300                               | 601           | 511           | 420             |
| 400                               | 719           | -             | -               |
| 500                               | 827           | -             | -               |
| 630                               | 955           | -             | -               |

The tabled current ratings must be adjusted for ambient air temperatures other than 45°C.

Appropriate rating factors are:

| Ambient air temp. °C | 35   | 40   | 45   | 50   | 55   | 60   | 65   | 70   | 75   | 80   |
|----------------------|------|------|------|------|------|------|------|------|------|------|
| Rating factors       | 1,10 | 1,05 | 1,00 | 0,94 | 0,88 | 0,82 | 0,74 | 0,67 | 0,58 | 0,47 |

## Short circuit ratings

The following short circuit currents are for cables normally operating at a maximum conductor temperature of 85°C.

The theoretical temperature that arises in the conductor during a short circuit, which is used as a basis of the calculation, is 250°C.

EPR and XLPE insulation are capable of withstanding short term temperatures up to 250°C. The short circuit currents for copper conductors given in the table are values for one second, for other durations the current may be calculated from the following formula:

$$I_t = \frac{I}{\sqrt{t}}$$

$I_t$  = short circuit current for t sec. (Amp),  
 $I$  = short circuit current for one sec. (Amp),  
 $t$  = short circuit duration (sec.)

The duration of the short circuit based on these assumptions should be between 0,2 sec. and 5 sec.

| Conductor area<br>mm <sup>2</sup> | Current<br>1 second amperes | Conductor<br>area<br>mm <sup>2</sup> | Current<br>1 second amperes |
|-----------------------------------|-----------------------------|--------------------------------------|-----------------------------|
| 1,0                               | 140                         | 70                                   | 9800                        |
| 1,5                               | 210                         | 95                                   | 13300                       |
| 2,5                               | 350                         | 120                                  | 16800                       |
| 4                                 | 560                         | 150                                  | 21000                       |
| 6                                 | 840                         | 185                                  | 25900                       |
| 10                                | 1400                        | 240                                  | 33600                       |
| 16                                | 2240                        | 300                                  | 42000                       |
| 25                                | 3500                        | 400                                  | 56000                       |
| 35                                | 4900                        | 500                                  | 70000                       |
| 50                                | 7000                        | 630                                  | 88200                       |

## Reactance

The reactance of a cable operating in an AC system depends on many factors, including, in particular, the axial spacing between conductors and the proximity and magnetic properties of adjacent steelwork. The former is known for multicore cable, but may vary for single core cables depending upon the spacing between them and their disposition when installed. Reactance of cables in certain disposition when installed. Reactance of cables in certain dispositions remote from steelwork are calculable and are shown. The tabulated values are for cables with circular conductors. The value for a sector-shaped conductor should be taken as 90% of the calculated value.

Induction for 2-, 3- and 4- conductor cables is given by the formula:

$$L = 0,2 * \left( \ln \left( \frac{2a}{d} \right) + 0,25 \right) * 10^{-6}$$

$L$  = Induction in H/m and phase,  $a$  = Axial space between conductors in mm.  
 $d$  = conductor diameter in mm.

Reactance for 2-, 3- and 4-conductor cables is given by the formula:

$$X = 2 * \pi * f * L * I$$

X = Reactance in ohm pr. Phase, f = frequency in Hz, L = Induction in H/m and phase  
 l = Conductor length in meter.

## Reactance Values for Cables

### Power and control cables. RFOU 0,6/1 kV

| Cross-section<br>mm <sup>2</sup> | 2-, 3- and 4 cores<br>ohm/km |       | 1- core*<br>ohm/km |       |
|----------------------------------|------------------------------|-------|--------------------|-------|
|                                  | 60 Hz                        | 50 Hz | 60 Hz              | 50 Hz |
| 1,5                              | 0,132                        | 0,110 |                    |       |
| 2,5                              | 0,123                        | 0,103 |                    |       |
| 4                                | 0,115                        | 0,096 |                    |       |
| 6                                | 0,108                        | 0,090 |                    |       |
| 10                               | 0,101                        | 0,084 |                    |       |
| 16                               | 0,096                        | 0,080 | 0,139              | 0,116 |
| 25                               | 0,095                        | 0,079 | 0,134              | 0,112 |
| 35                               | 0,092                        | 0,076 | 0,127              | 0,106 |
| 50                               | 0,092                        | 0,076 | 0,123              | 0,103 |
| 70                               | 0,091                        | 0,075 | 0,120              | 0,100 |
| 95                               | 0,088                        | 0,073 | 0,116              | 0,097 |
| 120                              | 0,086                        | 0,072 | 0,113              | 0,094 |
| 150                              | 0,087                        | 0,072 | 0,110              | 0,092 |
| 185                              | 0,086                        | 0,072 | 0,109              | 0,091 |
| 240                              | 0,086                        | 0,072 | 0,109              | 0,090 |
| 300                              | 0,086                        | 0,071 | 0,107              | 0,089 |

\*) Reactance for 1-conductor cables given at Three- foil formation

### Power and control cables, BFOU 0,6/1 kV.

| Cross-section<br>mm <sup>2</sup> | 2-, 3- and 4 core<br>ohm/km |       | 1- core* ohm/km |       |
|----------------------------------|-----------------------------|-------|-----------------|-------|
|                                  | 60 Hz                       | 50 Hz | 60 Hz           | 50 Hz |
| 1,5                              | 0,138                       | 0,115 |                 |       |
| 2,5                              | 0,129                       | 0,107 |                 |       |
| 4                                | 0,120                       | 0,100 |                 |       |
| 6                                | 0,112                       | 0,094 |                 |       |
| 10                               | 0,105                       | 0,088 |                 |       |
| 16                               | 0,099                       | 0,082 | 0,144           | 0,120 |
| 25                               | 0,098                       | 0,081 | 0,135           | 0,113 |
| 35                               | 0,094                       | 0,078 | 0,129           | 0,107 |
| 50                               | 0,093                       | 0,078 | 0,125           | 0,104 |
| 70                               | 0,092                       | 0,077 | 0,121           | 0,101 |
| 95                               | 0,090                       | 0,075 | 0,117           | 0,098 |
| 120                              | 0,088                       | 0,073 | 0,112           | 0,094 |
| 150                              | 0,088                       | 0,073 | 0,112           | 0,094 |
| 185                              | 0,088                       | 0,073 | 0,109           | 0,091 |
| 240                              | 0,087                       | 0,072 | 0,109           | 0,091 |
| 300                              | 0,086                       | 0,072 | 0,108           | 0,090 |

\*) Reactance for 1-conductor cables given at Three- foil formation

**Medium Voltage Power cables. RFOU 6/10 kV**

| Cross-section<br>mm <sup>2</sup> | 3 core<br>ohm/km |       | 1- core*<br>ohm/km |       |
|----------------------------------|------------------|-------|--------------------|-------|
|                                  | 50 Hz            | 60 Hz | 50 Hz              | 60 Hz |
| 16                               | 0.119            | 0.143 | 0.154              | 0.185 |
| 25                               | 0.119            | 0.143 | 0.144              | 0.173 |
| 35                               | 0.114            | 0.137 | 0.138              | 0.166 |
| 50                               | 0.108            | 0.130 | 0.132              | 0.158 |
| 70                               | 0.103            | 0.124 | 0.125              | 0.150 |
| 95                               | 0.098            | 0.118 | 0.119              | 0.142 |
| 120                              | 0.095            | 0.114 | 0.116              | 0.139 |
| 150                              | 0.092            | 0.111 | 0.111              | 0.133 |
| 185                              | 0.092            | 0.111 | 0.108              | 0.130 |
| 240                              | 0.087            | 0.104 | 0.104              | 0.125 |
| 300                              | 0.084            | 0.101 | 0.104              | 0.124 |
| 400                              | -                | -     | 0.090              | 0.118 |
| 500                              | -                | -     | 0.097              | 0.117 |
| 630                              | -                | -     | 0.092              | 0.110 |

\*) Reactance for 1-conductor cables given at Three- foil formation

**Medium Voltage Power cables. RFOU 12/20(24)kV.**

| Cross-section<br>mm <sup>2</sup> | 3 core<br>ohm/km |       | 1-core*<br>ohm/km |       |
|----------------------------------|------------------|-------|-------------------|-------|
|                                  | 50 Hz            | 60 Hz | 50 Hz             | 60 Hz |
| 35                               | 0.128            | 0.153 | 0.149             | 0.178 |
| 50                               | 0.121            | 0.145 | 0.140             | 0.169 |
| 70                               | 0.115            | 0.135 | 0.133             | 0.160 |
| 95                               | 0.109            | 0.131 | 0.127             | 0.152 |
| 120                              | 0.105            | 0.126 | 0.124             | 0.149 |
| 150                              | 0.102            | 0.122 | 0.119             | 0.142 |
| 185                              | 0.099            | 0.118 | 0.116             | 0.139 |
| 240                              | 0.095            | 0.114 | 0.112             | 0.134 |
| 300                              | -                | -     | 0.108             | 0.130 |

\*) Reactance for 1-conductor cables given at Three- foil formation

**Impedance**

Induction for 2-, 3- and 4- conductor cables is given by the formula:

$$Z = \sqrt{(R^2 + X^2)}$$

Z = Impedance in ohm pr. phase

R = Resistance at operating temperature in ohm pr. phase.

X = Reactance in ohm pr. phase.

**Electrical characteristics for instrumentation and telecommunication cables  
such as 250 V cables: RFOU and BFOU according to IEC 60092-376**

**Cables with collective screen**

| Type                                      | Capacitance,<br>approx. (nF/km) | Inductance,<br>approx, (mH/km) | Resistance at<br>20°C, max.<br>(Ohm/km) | L/R ratio,<br>(microH/Ohm) |
|-------------------------------------------|---------------------------------|--------------------------------|-----------------------------------------|----------------------------|
| Unshielded pair 0,75 mm <sup>2</sup>      | 100                             | 0,67                           | 24,8                                    | 14,3                       |
| Unshielded triple 0,75<br>mm <sup>2</sup> | 100                             | 0,67                           | 24,8                                    | 14,3                       |
| Unshielded pair 1,5 mm <sup>2</sup>       | 110                             | 0,63                           | 12,2                                    | 26,6                       |
| Unshielded triple 1,5 mm <sup>2</sup>     | 110                             | 0,63                           | 12,2                                    | 26,6                       |
| Unshielded pair 2,5 mm <sup>2</sup>       | 125                             | 0,59                           | 7,56                                    | 39,0                       |
| Unshielded triple 2,5 mm <sup>2</sup>     | 125                             | 0,59                           | 7,56                                    | 39,0                       |

**Cables with individually screened pair/triples**

| Type                                    | Capacitance,<br>approx. (nF/km) | Inductance,<br>approx, (mH/km) | Resistance at 20°C,<br>max. (Ohm/km) | L/R ratio,<br>(microH/Ohm) |
|-----------------------------------------|---------------------------------|--------------------------------|--------------------------------------|----------------------------|
| Shielded pair 0,75 mm <sup>2</sup>      | 110                             | 0,67                           | 24,8                                 | 14,3                       |
| Shielded triple 0,75<br>mm <sup>2</sup> | 110                             | 0,67                           | 24,8                                 | 14,3                       |
| Shielded pair 1,5 mm <sup>2</sup>       | 125                             | 0,63                           | 12,2                                 | 26,6                       |
| Shielded triple 1,5 mm <sup>2</sup>     | 125                             | 0,63                           | 12,2                                 | 26,6                       |
| Shielded pair 2,5 mm <sup>2</sup>       | 145                             | 0,59                           | 7,56                                 | 39,0                       |
| Shielded triple 2,5 mm <sup>2</sup>     | 145                             | 0,59                           | 7,56                                 | 39,0                       |