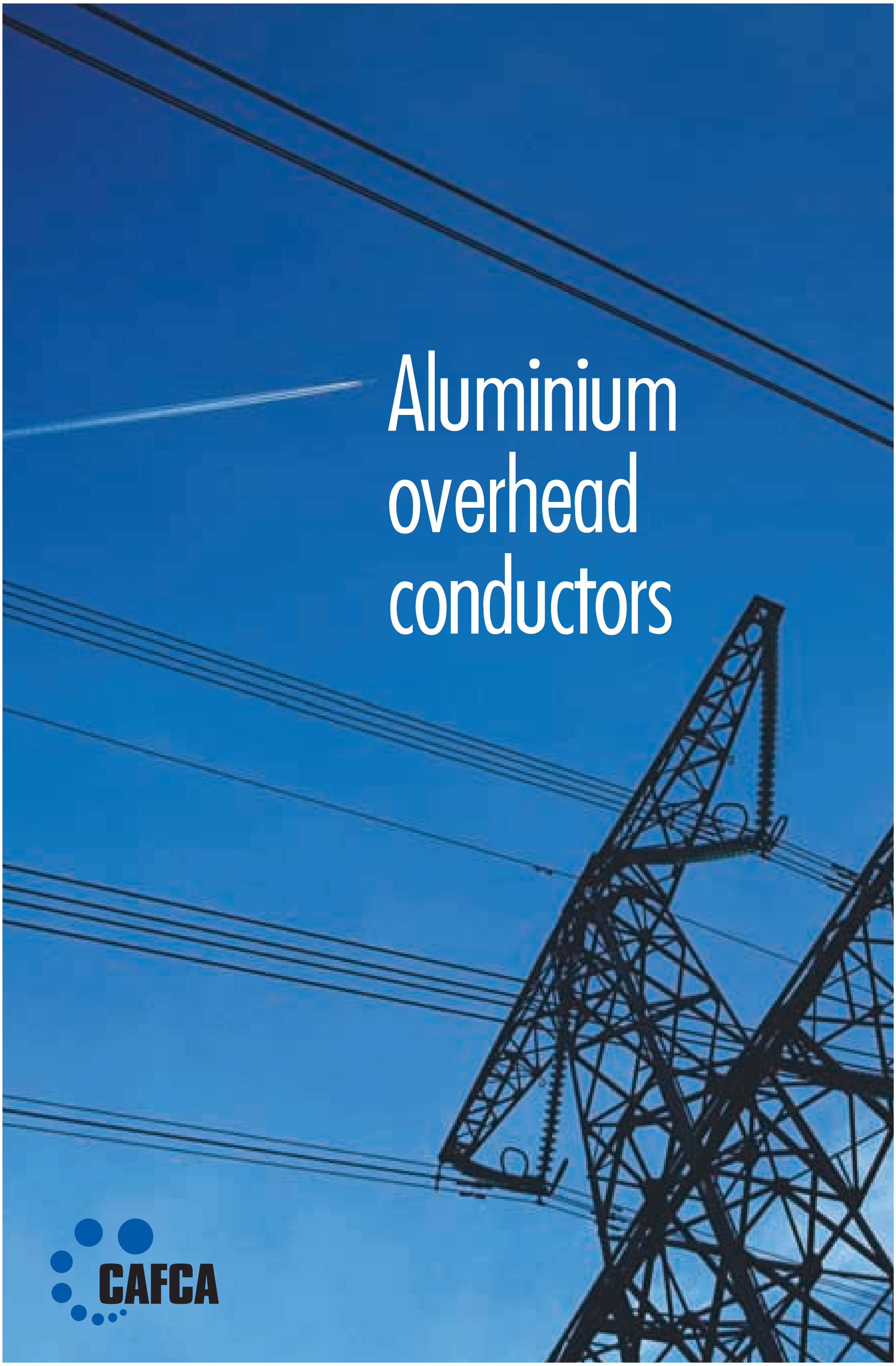
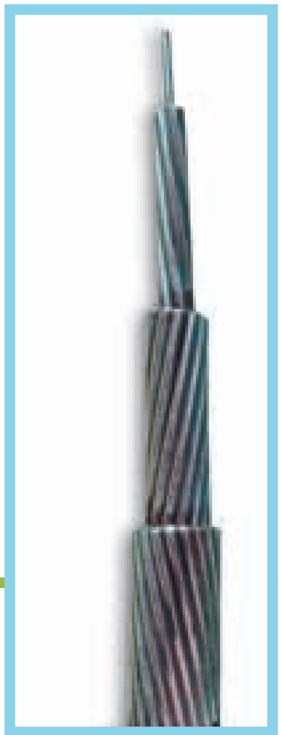
# Aluminium overhead conductors



CAFCA

## Contents





CAFCA manufactures overhead line conductors for all kinds of electrical transmission and distribution systems.

We supply conductors of all aluminium and aluminium conductor steel reinforced to British or other specifications. We also supply conductors with PVC insulation.

We manufacture these conductors in our aluminium factory where we closely co-ordinate wire drawing, stranding and corrosion prevention to ensure the highest product quality.

Aluminium stranding process

# CORPORATE

CAFCA is the only cable manufacturer in Zimbabwe. It was established in 1947 and is listed on the Zimbabwe, Johannesburg & London stock exchanges. CAFCA is part of CBI Electric African Cables (RSA), which in turn is owned by Reunert Limited (RSA).

## PRODUCTS & MARKETS

CAFCA manufactures and supplies cable and allied products for the transmission and distribution of electrical energy and information primarily in Southern and Central Africa. We manufacture over 900 cabling products including 11kV XLPE cables, all to British, South African and Zimbabwe quality standards.

CAFCA offers a toll manufacturing option to all its customers who can access key raw materials such as copper and aluminium, which are converted at the cost of value addition.

We also recover decommissioned cables for recycling that can be exchanged for other products within our manufacturing range.

# MANUFACTURING

## STANDARDS

**Standards Association of Zimbabwe (SAZ)**
SAZ 240-Electrical cables with extruded solid dielectric 300/500V, 1900/3300V
South African National Standards (SANS, formerly SABS)
SANS 1507-PVC distribution cable rated 300/500V and 1900/3300V
SANS 1418-2 aerial bundled conductor
SANS 1339-XLPE insulated cable rated 3.8/6.6kV and 19/33kV

**British Standards (BS)**
BS 215 Part 1:1970 – Specification for aluminium conductors

**International Electro-technical Commission (IEC)**
IEC 502-Extruded solid dielectric insulated power cables 1kV and 30kV

**South African Post Office (SAPO)**
BS 215 Part 1:1970 – Specification for aluminium conductors

**British Post Office (BPO)**
BPO CW 1127 – Aerial distribution telephone cable (self-supporting)
BPO CW 1128 – Jelly-filled cellular polyethylene telephone cable

**Post & Telecommunications (PTC)**
Underground cables and aerial distribution copper cables
We also make product to customer's own specification.

### QUALITY MANAGEMENT STANDARDS

Accredited to ISO 9001: 2008
(First company to gain accreditation in Zimbabwe: year 1999)

### ENVIRONMENT MANAGEMENT STANDARDS

Accredited to ISO 14001:2004
9Design and manufacture0
(First cable company in sub-Saharan Africa to achieve the international quality standard)

### OCCUPATIONAL HEALTH AND SAFETY STANDARD

Accredited to OHSAS 18,001:2007

# MILESTONES

CAFCA was the first company in Zimbabwe to achieve ISO 9002 accreditation, later upgraded to ISO 9001:2000, which enables us to design as well as produce cabling to international standards

In 1999 CAFCA became the first cable company in sub-Saharan Africa to be awarded the environmental standard, ISO 14,001:2004.

Zimbabwe Electricity Supply Authority annual supply contracts
- Low voltage armoured cables: 1985-98, 2000-03
- All aluminium conductor: 1988-99, 2001-03
- Aluminium conductor steel reinforced 1988-99, 2001-03

Anglo American Corporation annual supply contract 1985-2000

BHP annual supply contract 1996-1999

Botswana Power Corporation
- Split concentric annual supply contract 2000-2004

Botswana Ministry of Health
- Annual supply of low smoke and fume white stripe cables 2002-2004

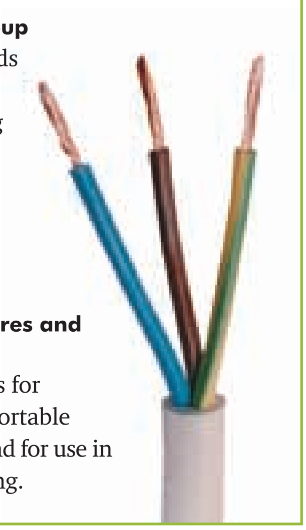
African Cables (South African)
- Monthly delivery of 600/1000V red stripe to SANS 1507 2003 to date

Confederation of Zimbabwe Industries (CZI)
- Industrial Exporter of the Year 1$^{st}$ Runner up 2005

**Product group**
Bare copper conductor, solid or stranded

**Salient features and applications**
Available as either hard drawn or annealed for equipment and circuit earthing or sold out to enamellers for motor and transformer and motor wire.

**Product group**
Flexible cords (cabtyre) and welding cables



**Salient features and applications**
Flexible cords for connecting portable equipment and for use in internal wiring.

**Product group**
Auto and instrument wire

**Salient features and applications**
Bunched fine wire conductors insulated for use as auto or instrument wire.

**Product group**
Indoor switchboard cable

**Salient features and applications**
Telephone cable for wiring distribution boards and switchboards.

**Product group**
Single cores

**Salient features and applications**
Colour coded and used in internal wiring of fixtures.

**Product group**
Armoured cables

**Salient features and applications**
Available from 1.5mm2 to 300mm2, 2 – 4 cores and in the 0.6/1kV and 3.3kV ranges. Other options available are flame retardant, low-tox or zerotox to meet various safety considerations in the case of a fire.

**Product group**
Jumper and blasting wire

**Salient features and applications**
Twisted pair or triple PVC insulated conductors for electronic panel wiring or for use as blasting wire.

**Product group**
Underground petroleum jelly-filled cables

**Salient features and applications**
Cross-linked polyethylene insulated communication cables with petroleum jelly as an agent against moisture ingress.

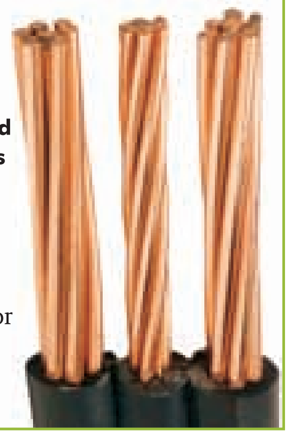
**Product group**
Aluminium conductors (with or without steel reinforcement) AAC and ACSR

**Salient features and applications**
Overhead conductor for HT and LV power transmission and distribution.

**Product group**
Coaxial cable

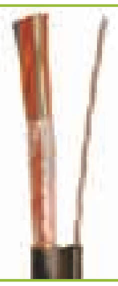
**Salient features and applications**
Radio frequency cables, available in the 50 and 75 ohm specifications

**Product group**
Aerial bundled conductor



**Salient features and applications**
Twisted and insulated overhead aluminium conductor for overhead distribution

**Product group**
Aerial distribution cable



**Salient features and applications**
Overhead conductor for HT and LV power transmission and distribution. Self-supporting overhead telephone service cable (polythene insulated)

**Product group**
Medium voltage XLPE cables

**Salient features and applications**
XLPE insulated cable rated up to 11kV for underground power distribution networks.

**Product group**
Multi-core cables

**Salient features and applications**
Cables for control, panel wiring and signalling.

**Product group**
14.4mm copper rod

**Salient features and applications**
For equipment earthing or further drawing down to smaller wire for various applications.

# OTHER PRODUCTS IN OUR RANGE

**Aerial distribution cable** – Self-supporting (with caternary wire) overhead service cable, polyethylene insulated
Coaxial cables – Radio frequency cables available in the 50 and 75 ohm specifications
Aerial bundled conductor – Twisted and insulated aluminium conductor for overhead power distribution
Copper rod – We convert copper cathode into 14 mm copper rod.

# ALUMINIUM OVERHEAD CONDUCTORS

The following notes are intended to describe the various factors that should be considered when selecting conductors and earth wires for particular duties.
As most of the subjects are quite complex, these notes are intended merely as an introduction and guide. For further information it is recommended that the line designer refers to the appropriate technical literature. For guidance in this respect we provide a bibliography, Appendix 1.

## Current rating

As this is the principal purpose of conductors (excluding the more recent communication aspect) the current rating is of primary importance. When a conductor carries an electric current its resistivity losses plus the radiation of the sun cause a temperature rise. This is balanced by radiation and convection from the conductor surface, which tend to lower the temperature. Under a given set of conditions an equilibrium or operating temperature will be achieved.
It is common practice and in some cases a statutory requirement, that 750 C is used as the maximum operating temperature, although this value can be exceeded under certain circumstances. It must be borne in mind that at increased temperature, a loss of physical strength, increased sags, loss of power and oxidation of conductor fittings can become more pronounced. Factors to be taken into account when choosing a conductor to carry a particular current are resistance, temperature coefficient of resistance, maximum operating temperature, ambient temperature, wind speed, diameter, emissivity of the surface, solar absorption and radiation. Some of these factors will vary in different parts of the world and care must be taken in adapting to local conditions.

## Resistance and reactance

DC resistance is a basic characteristic and is always quoted for conductors. It is dependent only upon temperature change. Individual wires are normally measured and used for quality control purposes. The DC resistance of the complete conductor can then be simply calculated from this figure.

AC resistance on all-aluminium or all-alloy conductors is caused by the skin effect on current density and can be calculated.
It depends upon frequency and increases above DC resistance from 0% on small conductors up to the order of 5% on large alloy conductors. On steel cored conductors it becomes more complex, being also dependent upon the magnetic properties of the core and upon the current carried.
Inductive and capacitive reactance are present in AC lines but depend upon many factors in addition to conductors.

Conductor diameter, spacing within bundles, phase spacing, height and length of line, frequency, current, etc, are involved. Reactance is therefore related to total line design and outside the conductor manufacturer's field of operation.
sed for sag and tension calculations.

## Corona

Corona occurs when the electric potential is high enough to exceed the dielectric strength of the air surrounding it, causing ionisation. If the potential gradient is high enough, the discharge will emit light energy and a halo will be seen around the conductors.

The effects of this condition are power losses from the line, noise and radio interference. It can also adversely affect adjacent carrier and signal circuits.
At higher voltages, generally above 132kV, corona begins to become a problem and measures have to be taken to contain it. These are normally concerned with conductors diameter and spacing. Surface finish of a conductor can also accentuate the occurrence of corona.

Weather conditions have a direct bearing on the degree of corona; as the air temperature increases the breakdown value of the air reduces. A reduction in breakdown value is also caused by a fall in air pressure. Poor weather conditions can have a very marked effect. Generally the problem comes with the jurisdiction of the line designer.

## Fault currents

These are generally caused by line to earth faults or lightning strikes. In the case of earth faults it is common practice to quote these as $I^2T$ values where I is the fault current usually in kA and T the time of the fault in seconds. $I^2T$ characteristic of conductors can be estimated by calculations but it is common practice to support these by tests where the importance of the project warrants them. Lightning faults are more complex and a function of the complete transmission line.

## Sags and tensions

Sag and tension calculations are an essential part of the preparation for the correct design and installation of an overhead line. The methods employed by line designers are well established and it is not proposed to describe them in this catalogue. The physical and mechanical characteristics required by the line designer are given in the appropriate tables.

## Modulus of elasticity

The modulus of elasticity for conductors can be calculated from the values given in Table 1 for aluminium, steel, etc. These values are known as the theoretical moduli. When the modulus of elasticity of a full conductor is obtained by test, the value arrived at is somewhat less than the theoretical and is called the practical value. It is this value which is used for sag and tension calculations.

# Vibration

Wind induced vibration and oscillation of overhead line conductors manifest themselves in three different modes as follows:

(a) **Galloping**
This is a low frequency, large amplitude oscillation generally caused by winds of 5 to 10 metres/sec. It can occur on very long spans such as river crossings and exposed mountainous terrain with a typical amplitude of 3 metres. It can be reduced significantly by making the conductor surface smooth by the use of segmental wires in the outer layer.

(b) **Sub-span oscillation**
This occurs between the spacers of bundled conductors. It is a function of conductor diameter, conductor spacing, wind angle and velocity. It is low frequency in the range of 0.15 to 3 Hz with amplitudes up to the conductor spacing.

(c) **Aeolian vibration**
This type of vibration occurs when a steady wind of fairly low velocity – 1 to 16 metres per second – flows across cylindrical objects. This causes vortices to be shed on the leeward side creating forces in alternating up and down directions. Vibration is therefore vertical having amplitudes up to the conductor diameter. The frequency of vibration is related to the natural frequency of the conductor and is in the region of 3 to 100Hz.

All these types of vibration fall within the province of the line designer who must be aware of the causes and prevention when designing a line.

### Coefficient of linear expansion

Like the modulus of elasticity the coefficient of linear expansion of a conductor can be calculated from the values of test samples and these figures are well established. Unlike the modulus figures these figures are more accurate and can be used for sag and tension calculations. It is, therefore, common practice to use the theoretical figures. For designs not listed, the coefficient can be calculated.

# Creep

Creep of an overhead conductor in service, also occasionally referred to as an inelastic elongation, is made up of three parts. Following the mechanical loading of a conductor there is a general settling down of the wires, a slight elongation caused by the indentation of the wires at the point of contact between the adjacent layers, and metallic creep in the wires. As a result of these strains there is an increase in length and hence of sag of the conductor over the years which has to be considered at the design stage.

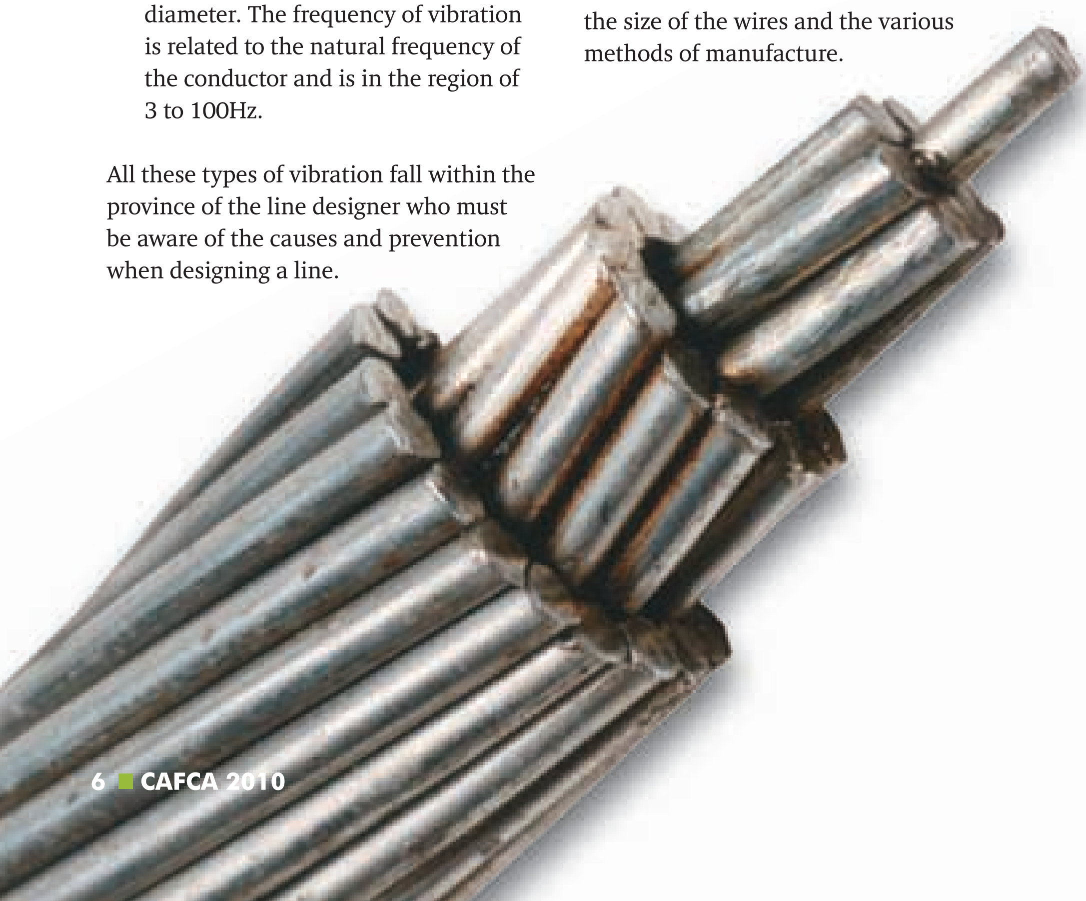
The rate of creep in a line depends upon many factors: the tensile stress, which is constantly changing due to loading and atmospheric conditions; the materials of the conductor and their combinations; the size of the wires and the various methods of manufacture.

# Corrosion

An overhead line conductor in service is exposed to the corrosive effects of the atmosphere causing a reduction in tensile strength and an increase in resistance. It is therefore essential for the security and longevity of the line that corrosion is minimised or prevented.

In a stranded conductor there are many crevices at interstrand positions where local screening from the air can lead to differential aeration. If moisture is introduced, crevice corrosion cells can be established and these can become progressively more active. In multi-metal conductors, galvanic cells may be formed between differing metals leading to the loss of zinc on steel and eventually loss of the steel itself with disastrous results.

Covering internal, or even all the layers with protective compounds is a very effective method of protection. The use of larger diameter wires is also recommended as is the use of homogenous conductors such as all-alloy. ■■■■■



## Table 1 - Characteristics of conductor materials

| | Annealed copper | Hard drawn copper | Cadmium copper | Hard drawn aluminium | Aluminium alloy (to BS 3242) | Galvanised steel |
|---|---|---|---|---|---|---|
| Conductivity, per cent | 100 | 97 (average) | 79.2 (min) | 61 (min) | 53.5 | |
| Volume resistivity at 20°C<br>ohm-mm²/m<br>microhm/inch³ | 0.01.724 †<br>(standard)<br>0.67879 | 0.01771 ‡<br>(average)<br>0.69712 | 0.021769<br>(maximum)<br>0.85705 | 0.028264<br>(maximum)<br>1.1128 | 0.0322<br>(standard)<br>1.2677 | -<br><br>- |
| Mass resistivity at 20°C<br>ohm-gramme/m<br>ohm-lb/mile | <br>0.15328<br>875.2 | <br>0.15741<br>898.83 | <br>0.19472<br>1111.9 | <br>0.076398<br>436.23 | <br>0.08694<br>496.42 | <br>-<br>- |
| Resistance at 20°C<br>ohm-mm²/km<br>ohm-inch²/1 000 yards | <br>17.241<br>0.24437 | <br>17.71<br>0.25096 | <br>21.769<br>0.030854 | <br>28.264<br>0.040059 | <br>32.2<br>0.045637 | <br>-<br>- |
| Density at 20°C<br>gramme/cm³ | <br>8.89 | <br>8.89 | <br>8.945 | <br>2.703 | <br>2.70 | <br>7.78 |
| Weight<br>kg/mm²/km<br>lb/inch²/1 000 yards | <br>8.89<br>11562 | <br>8.89<br>11562 | <br>8.945<br>11634 | <br>2.703<br>3516 | <br>2.703<br>3516 | <br>7.84<br>10197 |
| Temp. coefficient of resistance at 20°C (68°F) per °C | 0.00393 | 0.00381 | 0.0031 | 0.00403 | 0.0036 | |
| Coefficient of linear expansion at 20°C (68°F) per °C | $17x10^{-6}$ | $17x10^{-6}$ | $17x10^{-6}$ | $23x10^{-6}$ | $23x10^{-6}$ | $11.5x10^{-6}$ |
| per °F | $9.44x10^{-6}$ | $9.44x10^{-6}$ | $9.44x10^{-6}$ | $12.78x10^{-6}$ | $12.78x10^{-6}$ | $12.75x10^{-6}$ |
| Ultimate tensile stress (approx)<br>MN/m²<br>kgf/mm²<br>lbf/inch² | <br>255<br>25<br>36000 | <br>420<br>41<br>60000 | <br>635<br>62<br>90000 | <br>165<br>16<br>23500 | <br>300<br>29<br>44000 | <br>1350<br>132<br>190000 |
| Modulus of elasticity MN/m²<br>mg/mm²<br>lb/inch² | $9$ to $10.5x10^4$<br>$9$ to $10.5x10^3$<br>$13$ to $15x10^6$ | $12.5x10^4$<br>$12.5x10^3$<br>$18x10^6$ | $12.5x10^4$<br>$12.5x10^3$<br>$18x10^6$ | $7.0x10^4$<br>$7.0x10^3$<br>$9.9x10^6$ | $7.0x10^4$<br>$7.0x10^3$<br>$9.9x10^6$ | $20.0x10^4$<br>$20.0x10^3$<br>$28x10^6$ |

† For calculations, this figure has been extended to 0.017241379

‡ At assumed average ultimate tensile strength: 420 MN/m² (41 kgf/mm², 27 tons f/inch²)

## Table 2 - Comparative loading under maximum conditions

| Subject | | Hard drawn copper | Cadmium copper | Hard drawn aluminium | Steel cored aluminium | Aluminium alloy |
|---|---|---|---|---|---|---|
| Equivalent copper section | mm² | 65 | 65 | 65 | 65 | 65 |
| | inch² | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Stranding | mm | 7/3.34 | 7/3.71 | 7/4.39 | 7/4.39, 7/1.93 | 7/4.65 |
| | inch | 7/.136 | 7/.146 | 7/.173 | 7/.173, 7/.076 | 7/.183 |
| Overall diameter | mm | 10.4 | 11/1 | 13.2 | 14.6 | 13.9 |
| | inch | 0.408 | 0.438 | 0.519 | 0.574 | 0.549 |
| Ultimate tensile strength | kgf | 2660 | 4295 | 1680 | 4151 | 3488 |
| | lbf | 5870 | 9470 | 3700 | 9150 | 7690 |
| | N | 26111.1 | 42124.7 | 16458.8 | 40701.2 | 34206.8 |
| Weight | kg/m | 0.587 | 0.682 | 0.290 | 0.453 | 0.326 |
| | lb/ft | 0.395 | 0.458 | 0.195 | 0.304 | 0.218 |
| Assumed ice load: | | | | | | |
| 9.5mm (0.375 inch) | kg/m | 0.542 | 0.563 | - | 0.658 | 0.640 |
| radial thickness | lb/ft | 0.365 | 0.379 | 0.442 | - | 0.431 |
| 4.75mm (0.187 inch) | kg/m | 4.75 | 4.750.217 | 4.75 0.246 | 4.75- | 4.75 0.256 |
| radial thickness | lb/ft | 0.139 | 0.146 | 0.165 | - | 0.172 |
| Wind load on conductor base | kg/m | 0.404 | 0.434 | 0.515 | 0.570 | 0.544 |
| | lb/ft | 0.272 | 0.292 | 0.346 | 0.383 | 0.366 |
| with 9.5 mm (0.375 inch) | kg/m | 1.148 | 1.180 | - | 1.131 | 1.288 |
| | lb/ft | 0.772 | 0.792 | - | 0.760 | 0.866 |
| with 4.75 mm (0.187 inch) | kg/m | 0.776 | 0.807 | 0.887 | - | 0.916 |
| | lb/ft | 0.522 | 0.542 | 0.596 | - | 0.616 |
| Resultant load on conductor | kg/m | 0.721 | 0.808 | 0.591 | 0.724 | 0.633 |
| base | lb/ft | 0.484 | 0.543 | 0.397 | 0.487 | 0.426 |
| with 9.5 mm (0.375 inch) | kg/mm | 1.602 | 2.276 | - | 1.720 | 1.611 |
| | lb/ft | 1.086 | 1.529 | - | 1.158 | 1.082 |
| with 4.75 mm (0.187 inch) | kg/m | 1.115 | 1.210 | 1.037 | - | 1.082 |
| | lb/ft | 0.750 | 0.812 | 0.696 | - | 0.729 |

## Choice of conductor

Conductor selection is governed not only by electrical, mechanical and economic criteria but also by environmental factors such as radio interference and appearance. The conductor's electrical characteristics must be selected to ensure that voltage regulation, line stability, temperature rise and power losses are kept within acceptable limits.

Mechanically, the conductor's strength must be sufficient to support its own weight together with any superimposed loading due to ice and wind that may be relevant to the location. At the same time, the sag of the conductor, under the specified range of loadings, must be such that ground clearances are maintained. The conductor sag therefore has an influence on the height and spacing of the line structures and on the overall economics of the line.

On extra high voltage lines, radio interference or corona losses may be critical in the choice of minimum conductor diameter and also in the bundled arrangement of conductors per phase. The choice of numbers of conductors per bundle could be influenced by mechanical considerations and the environmental fact of their visual impact on the landscape.

The objective of this publication is to provide basic conductor data to assist line designers to make the optimum choice of conductor to achieve the best compromise between the often conflicting electrical, mechanical, environmental and economic factors and in the case of FIBRAL conductors, the communication factor.

# Current ratings

For thermal equilibrium in a conductor the following conductor surface heat balance condition must be satisfied:

heat generated ($I^2R$) + heat gained from solar radiation = heat lost by convection + heat lost by radiation

This condition is basis of the formula given by V.T. Morgan in Proc. IEE, Vol. 122, No.2.

Morgan's formula, which has been used for the current ratings given in this publication, is:

$$I^2KR_0[1+\alpha\ (\theta+t_\alpha)] = \pi d\{h\theta+E\sigma[(\theta+t_\alpha+273)^4 - (t_\alpha+273)^4]\}-\alpha_B I_S d$$

where $d$ = overall diameter of conductor, mm

| | | |
|---|---|---|
| $E$ | = | thermal emissivity of conductor surface |
| $h$ | = | heat transfer coefficient (being a function of wind velocity, angle and Reynold's Number) |
| $I_S$ | = | intensity of solar radiation, W/m$^2$ |
| $K$ | = | lay factor |
| $R_0$ | = | resistance at 0°C |
| $t_\alpha$ | = | air temperature, °C |
| $\alpha$ | = | temperature coefficient of resistance, per °C |
| $\alpha_S$ | = | thermal absorptivity of conductor surface |
| $\theta$ | = | temperature rise of conductor, °C |
| $\sigma$ | = | Stefan-Boftzmann constant = $5.7\times10^{-8}$W/m$^2$ |

The ratings are based on the following conditions:

| | Wind speed (cross wind) | Ambient temperature | Intensity of solar radiation | Temperature rise |
|---|---|---|---|---|
| Temperate | 0.447 m/s | 20°C | 850 W/m$^2$ | 30°C |
| Tropical | 0.447 m/s | 35°C | 1200 W/m$^2$ | 20°C |

## Sags and tensions

Although space prevents a full account of all aspects of line design being given, the following is an outline of the basic principles of sag and tension calculations.

### Basic

The starting point for all calculations is the sagging basis, or bases, laying down the minimum factor of safety at which the conductor is allowed to operate under certain conditions. For instance, in the United Kingdom a typical requirement is that at -6° C, with a cross-wind pressure of 383 N/m$^2$ and 12.7 mm radial thickness of ice, the tension in the conductor shall not exceed 50 per cent of its breaking load: that is, a safety factor of 2. This is known as the Maximum Working Tension (MWT) requirement.

Another probable requirement is that at 16° C, with no wind or ice, the tension shall not exceed 20 per cent of the conductor breaking load. This is the Everyday Stress (EDS) requirement.

Where more than one requirement is laid down, for example both an MWT and an EDS requirement one will be the critical basis; if this is complied with the other one will follow automatically. Usually, there is a particular span length above which the one basis is critical and below which the other is critical.

## Symbols

| Symbol | | | SI | Technical metric | Imperial |
|---|---|---|---|---|---|
| $E$ | = | modulus of elasticity of conductor | MN/m$^2$ | kgf/mm$^2$ | lb/in$^2$ |
| $A$ | = | total cross sectional area of conductor | mm$^2$ | mm$^2$ | in$^2$ |
| $\alpha$ | = | linear coefficient of expansion | /°C | /°C | /°F |
| $t_1$ | = | initial temperature | °C | °C | °F |
| $t_2$ | = | final temperature | °C | °C | °F |
| $W$ | = | weight (see footnote) | kg/m | kg/m | lb/ft |
| $W_1$ | = | initial weight (see footnote) | kg/m | kg/m | lb/ft |
| $W_2$ | = | final weight (see footnote) | kg/m | kg/m | lb/ft |
| $L$ | = | span length | m | m | ft |
| $T$ | = | tension | N | kgf | lb |
| $T_1$ | = | initial tension | N | kgf | lb |
| $T_2$ | = | final tension | N | kgf | lb |
| $D$ | = | gag of conductor | m | m | ft |
| $x$ | = | conductor diameter | mm | mm | in |
| $y$ | = | radial thickness of ice | mm | mm | in |
| $p$ | = | wind pressure | N/m$^2$ | kgf/m$^2$ | lb/ft$^2$ |
| $g$ | = | gravitational constant = 9.81 m/sec$^2$ in SI units | | | |
| 1 kgf | = | | 9.81 N in SI units | | |

Note: $W$, $W_1$ or $W_2$ may include wind and/or ice loading and in SI these values represent mass rather than weight.

## Formulae

The actual shape of the curve taken up by a conductor is a catenary whose equation involves hyperbolic functions. Calculations can be simplified by assuming that the curve is a parabola which, for high span to sag ratios, is very close to a catenary. Where the sag is less than 1.0 per cent of the span, the parabola is accurate enough for most purposes.

The formulae shown use the parabolic equations and also assume level spans, i.e. spans in which the anchor points at each end of the span are at the same height. For non-level spans and special cases, such as long river crossings, more sophisticated techniques are required.

On this basis, the formulae required are:

$$D = \frac{WL^2}{8T} \quad \text{------} \quad (1)$$

*For imperial and technical metric units*

$$EA\alpha(t_2 - t_1) + \frac{W_1^2 L^2 EA}{24T_1^2} - T_1 = \frac{W_2^2 L^2 EA}{24T_2^2} - T_2 \quad \text{------} \quad (2)$$

For imperial and technical metric units

$$D = \frac{WgL^2}{8T} \quad \text{------} \quad (1a)$$

For SI units

$$EA\alpha(t_2 - t_1) + \frac{W_1^2 g^2 L^2 EA}{24T_1^2} - T_1 = \frac{W_2^2 g^2 L^2 EA}{24T_2^2} - T_2 \quad \text{------} \quad (2a)$$

For SI units

Ice weight per unit length $= By(y=x)$ ------ (3)

where B=1.24 lb / ft in imperial units

and B= 2.87 x $10^{-3}$kg / m in technical metric and SI units

$$\text{Wind load} = \frac{p(2y+x)}{12} \text{ lb / ft} \quad \text{------} \quad (4a)$$

Imperial units

$$\text{Wind load} = \frac{p(2y+x)}{1000} \text{ N / m or kgf / m} \quad \text{------} \quad (4b)$$

For SI units and technical metric units

$$\text{Wind load} = \frac{p(2y+x)}{1000} \text{ N / m or kgf / m} \quad \text{------} \quad (4b)$$

For SI units and technical metric units

$$\text{Effective weight} = \sqrt{\left[(\text{weight of conductor + ice})^2 + (\text{wind load})^2\right]} \quad \text{---} \quad (5)$$

$$\text{Effective weight} = \sqrt{\left[(\text{weight of conductor + ice})^2 + \left(\frac{\text{wind load}}{g}\right)^2\right]} \quad \text{--} \quad (5a)$$

For SI units

If the MWT (or EDS) is the critical basis, the initial weight, temperature and tension will correspond with it. Final weight, temperature and tension will in that case correspond with the other specified parameters of the line – such as temperature, span and sag.

For instance, if the MWT is the critical basis, $W_1$ would be the effective weight defined in formula (5) or (5a). In these formulae ice load acts vertically downwards and wind load is assumed to act horizontally.

$W_2$ would be the weight of the conductor alone if the temperature were such that no ice could form, and no wind existed.

On the other hand, if ice and wind loads were stated then they would have to be taken into account by using formula (5) or (5a) to calculate $W_2$.

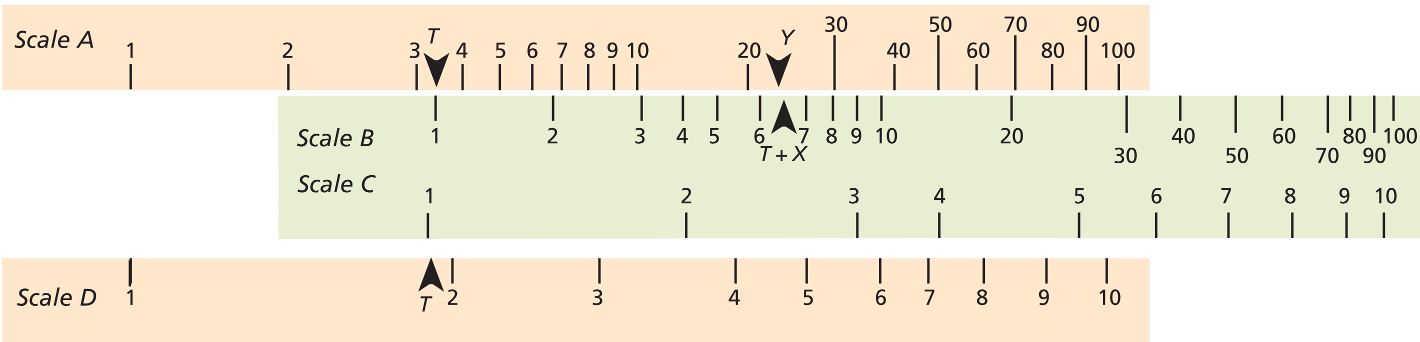
The final tension is calculated by substituting the appropriate values in formula (2) or (2a). It can then be used to determine the sag for these conditions, using formula (1) or (1a).

The final tension T2 may be calculated by trial and error using a slide rule. Formula (2) or (2a) may be rewritten in the form:

$$T_2^2 (T_2 + X) = Y \qquad (6)$$

where X and Y are known. This equation may be solved by the method illustrated in Figure 1. By subtracting the value $T_2$ from $(T_2 + X)$ the known value of X is obtained. When this occurs the value of T2 is the correct solution. ■■■■■

**Figure 1**




## A worked example

A conductor is to have an MWT of 65 951 N (or 6725 units kgf in technical metric units) at a temperature of 6° C with 12.7 mm of radial ice and a wind load of 383 N/m$^2$ (or 39 kgf/m$^2$ in technical metric units). The sag at 20° C in a span of 400 m is required.

The conductor data is:

| | | SI units | Technical metric units |
|---|---|---|---|
| *X* | = | 28.62 mm | 28.62 |
| *E* | = | 69 x 10$^3$ MN/m$^2$ | 7.036 x 103 kgf/mm$^2$ |
| *A* | = | 485.5 MM$^2$ | 485.5 mm$^2$ |
| *a* | = | 19.3 x 10$^{-6}$/ºC | 19.3 x 10$^{-6}$/ºC |
| *W2* | = | 1.621 kg/m | 1.621 kg/m = weight of conductor alone |

## Formulae

### The calculations required are

| Formula Number | Quantity | Units | Calculation | Value |
|---|---|---|---|---|
| (3) | Ice load | SI & technical metric | 2.87 x 103 x 12.7(12.7 + 28.62) | 1.505 kg/m |
| | Total vertical weight | SI & technical metric | 1.621 + 1.505 | 3.126 kg/m |
| (4b) | Wind load | SI<br>Technical metric | 0.383 (2 x 12.7 + 28.62)<br>0.039 (2 x 12.7 + 28.62) | 20.69 N/m<br>2.11 kg/m |
| (5a)<br><br><br>(5) | Effective conductor<br><br>Weight<br>$W_1$ | SI<br><br><br>Technical metric | $\sqrt{\left[3.126^2 + \left(\frac{20.69}{9.81}\right)^2\right]}$<br><br>$\sqrt{\left[3.126^2 + 2.11^2\right]}$ | 3.771 kg/m<br><br><br>3.771 kg/m |
| (2a)<br><br>(2) | Tension $T_2$ at 20°C<br><br>Tension $T_2$ at 20°C | SI<br><br>Technical metric | $T_2^2\left[T_2 + 16775 + 70123 - 65951\right] = 56.298 \times 10^{12}$<br><br>$T_2^2\left[T_2 + 1711 + 7146 - 6725\right] = 596.9 \times 10^8$ | 32479 N<br><br>3312 kgf solution by slide rule |
| (1a)<br>(1) | Sag D at 20°C | SI<br>Technical metric | $(1.621 \times 9.81 \times 400^2) / (8 \times 32479)$<br>$(1.621 \times 400^2) / (8 \times 3312)$ | 9.79 m<br>9.79 m |

## All-aluminium conductors (AAC)

All-aluminium conductors are the most favoured type for use on relatively short spans, particularly low and medium voltage distribution lines. Their popularity is principally due to their ability to carry a given current at the lowest capital cost.

This cost does not, however, take the total line into account, including poles and tower heights, spans, wind and ice loads, etc. When these factors are considered the low strength-to-weight ratio of all-aluminium conductor becomes a limiting factor.

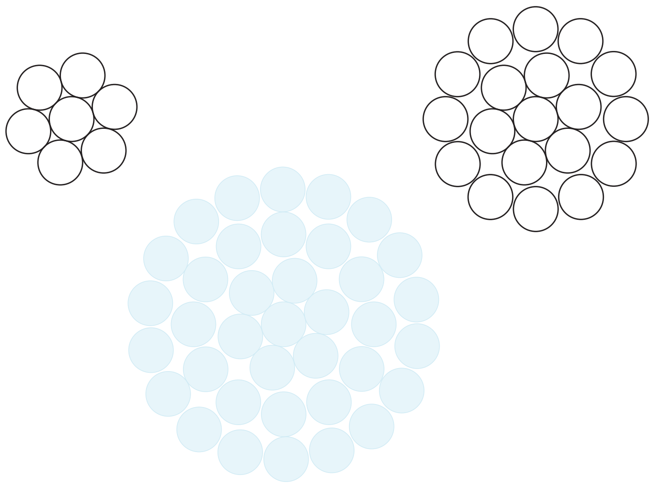
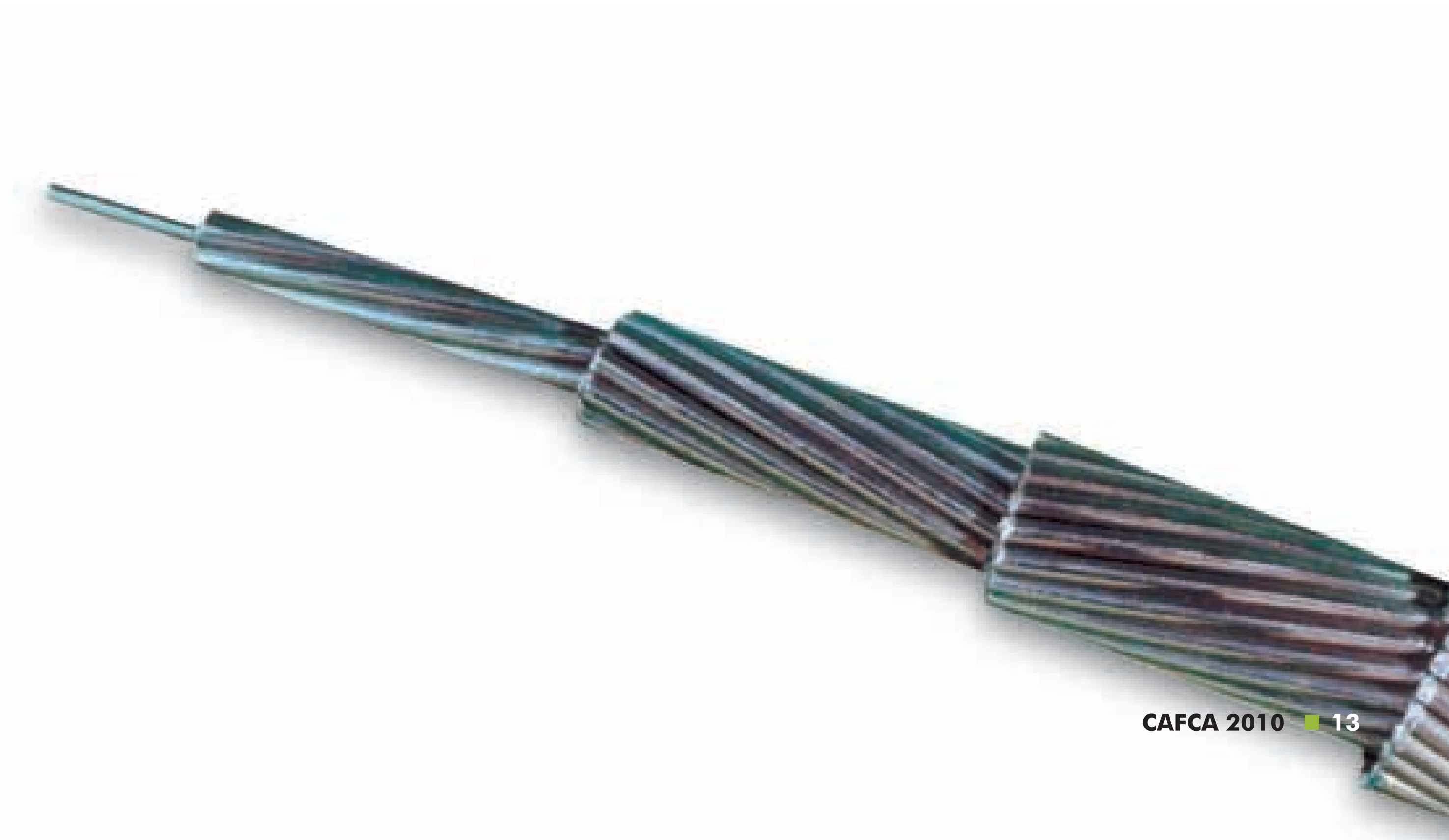


**Table 3**

| Stranding | Practical or final modulus of elasticity | | Coefficient of linear expansion at 20°C |
|---|---|---|---|
| | N/mm$^2$ | kg/mm$^2$ | x $10^{-6}$/°C |
| 3 | 62000 | 6322 | 23 |
| 7 | 58850 | 6000 | 23 |
| 19 | 55900 | 5700 | 23 |
| 37 | 55900 | 5700 | 23 |
| 61 | 53950 | 5500 | 23 |
| 91 | 53950 | 5500 | 23 |
| 127 | 50500 | 5150 | 23 |



## Aluminium conductors- British sizes BS 215 Part 1:1970

### Table 4

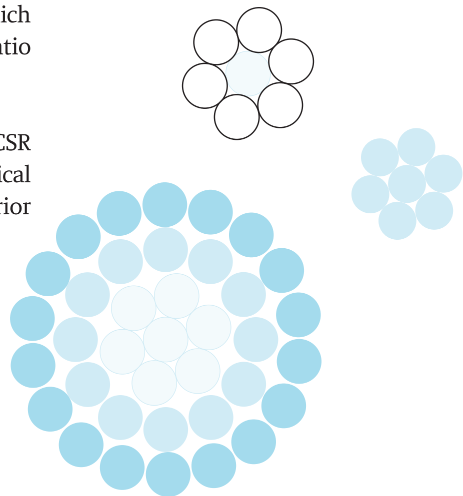
| Code name | Nominal aluminium area | Stranding and wire diameter | Actual area | Overall diameter | Weight | Calculated dc breaking load | | Calculated resistance at 20°C | Breaking length | Current rating tropical |
|---|---|---|---|---|---|---|---|---|---|---|
| | mm² | mm | mm² | mm | kg/km | kN | kgf | ohms/km | km | amp |
| Midge | 22 | 7/2.06 | 23.33 | 6.18 | 64 | 3.99 | 407 | 1.227 | 6.36 | 147 |
| Aphis | 25 | 3.3.35 | 26.44 | 7.22 | 73 | 4.12 | 420 | 1.083 | 5.68 | 163 |
| Gnat | 25 | 7/2.21 | 26.85 | 6.63 | 74 | 4.59 | 468 | 1.066 | 6.32 | 161 |
| Weevil | 30 | 3/3.66 | 31.56 | 7.89 | 87 | 4.86 | 495 | 0.9070 | 5.63 | 181 |
| Mosquito | 35 | 7/2.59 | 36.88 | 7.77 | 101 | 6.03 | 614 | 0.7763 | 6.08 | 195 |
| Ladybird | 40 | 7/2.79 | 42.80 | 8.37 | 117 | 6.87 | 701 | 0.6689 | 5.99 | 214 |
| Ant | 50 | 7/3.10 | 52.83 | 9.30 | 145 | 8.28 | 844 | 0.5419 | 5.82 | 244 |
| Fly | 60 | 7.3.40 | 63.55 | 10.20 | 174 | 9.90 | 1010 | 0.4505 | 5.80 | 273 |
| Bluebottle | 70 | 7/3.66 | 73.65 | 10.98 | 202 | 11.33 | 1156 | 0.3887 | 5.72 | 299 |
| Earwig | 75 | 7/3.78 | 78.55 | 11.34 | 215 | 11.94 | 1217 | 0.3645 | 5.66 | 311 |
| Grasshopper | 80 | 7/3.91 | 84.05 | 11.73 | 230 | 12.78 | 1303 | 0.3406 | 5.67 | 325 |
| Clegg | 90 | 7/4.17 | 95.60 | 12.51 | 262 | 14.53 | 1482 | 0.2995 | 5.66 | 351 |
| Wasp | 100 | 7/4.39 | 106.0 | 13.17 | 290 | 16.01 | 1633 | 0.2702 | 5.63 | 375 |
| Beetle | 100 | 19/2.67 | 106.4 | 13.35 | 293 | 17.39 | 1773 | 0.2704 | 6.05 | 376 |
| Bee | 125 | 7/4.90 | 132.0 | 14.70 | 361 | 19.94 | 2033 | 0.2169 | 5.63 | 429 |
| Cricket | 150 | 7/5.36 | 157.9 | 16.08 | 432 | 23.85 | 2432 | 0.1813 | 5.63 | 479 |
| Hornet | 150 | 19/3.25 | 157.6 | 16.25 | 434 | 24.70 | 2519 | 0.1825 | 5.80 | 579 |
| Caterpillar | 175 | 19/3.53 | 185.9 | 17.65 | 511 | 28.61 | 2917 | 0.1547 | 5.71 | 530 |
| Chafer | 200 | 19/3.78 | 213.2 | 18.90 | 587 | 32.41 | 3305 | 0.1349 | 5.63 | 577 |
| Spider | 225 | 19/3.99 | 237.6 | 19.95 | 654 | 36.12 | 3683 | 0.1211 | 5.63 | 617 |
| Cockroach | 250 | 19/4.22 | 265.7 | 21.10 | 731 | 40.39 | 4118 | 0.1083 | 5.63 | 661 |
| Butterfly | 300 | 19/4.65 | 322.7 | 23.25 | 888 | 48.74 | 4970 | 0.08916 | 5.60 | 746 |
| Moth | 350 | 19/5.00 | 373.1 | 25.00 | 1027 | 56.36 | 5746 | 0.07711 | 5.59 | 816 |
| Drone | 350 | 37/3.58 | 372.4 | 25.06 | 1027 | 57.31 | 4844 | 0.07742 | 5.69 | 815 |
| Locust | 400 | 19/5.36 | 428.7 | 26.80 | 1180 | 64.76 | 6603 | 0.06711 | 5.60 | 890 |
| Centipede | 400 | 37/3.78 | 415.2 | 26.46 | 1145 | 63.11 | 6435 | 0.06944 | 5.62 | 972 |
| Maybug | 450 | 37.4.09 | 486.1 | 28.63 | 1340 | 73.89 | 7535 | 0.05931 | 5.62 | 961 |
| Scorpion | 500 | 37/4.27 | 529.8 | 29.89 | 1461 | 80.03 | 8160 | 0.05442 | 5.59 | 1014 |
| Cicada | 600 | 37/4.65 | 628.3 | 32.55 | 1732 | 94.90 | 9678 | 0.04589 | 5.59 | 1127 |
| Tarantula | 750 | 37/5.23 | 794.9 | 36.61 | 2192 | 120.07 | 12244 | 0.03627 | 5.59 | 1305 |

## Aluminium conductors steel reinforced (AAC)

This type of conductor possesses a higher strength-to-weight ratio than AAC and because of this it can be used on longer spans and in more severe weather conditions. It also possesses a higher modulus of elasticity and lower coefficient of thermal expansion both of which enhance its mechanical characteristics. These properties can be varied by altering the aluminium to steel ratio in the stranding geometry.

Higher strength steel can also be used which gives an improved strength-to-weight ratio without affecting any other property.

For a given current rating the cost of ACSR will be greater than AAC but the mechanical advantages it possesses mean it is superior economically when the total line is considered. It is this fact which makes it currently the most commonly used type of conductor.



### Table 5

| Stranding | Practical or final modulus of elasticity | | Coefficient of linear expansion at 20°C |
|---|---|---|---|
| | N/mm2 | kg/mm2 | x $10^{-6}$/°C |
| 6/1 | 79400 | 8096 | 19.1 |
| 7/1 | 82870 | 8450 | 17.7 |
| 8/1 | 98000 | 9993 | 16.9 |
| 18/1 | 66000 | 6730 | 21.2 |
| 36/1 | 59820 | 6100 | 22.0 |
| 9/3 | 88300 | 9004 | 17.0 |
| 6/7 | 75500 | 7699 | 19.8 |
| 7/7 | 78460 | 8000 | 18.4 |
| 12/7 | 104950 | 10702 | 15.3 |
| 14/7 | 107900 | 11003 | 15.0 |
| 24/7 | 72570 | 7400 | 19.6 |
| 26/7 | 75510 | 7700 | 18.9 |
| 30/7 | 80240 | 8200 | 17.8 |
| 45/7 | 61000 | 6220 | 20.9 |
| 48/7 | 62000 | 6322 | 20.5 |
| 54/7 | 68650 | 7000 | 19.3 |
| 72/7 | 60000 | 6118 | 21.7 |
| 14/19 | 109840 | 11200 | 15.0 |
| 16/19 | 117700 | 12002 | 14.2 |
| 30/19 | 78460 | 8001 | 18.0 |
| 32/19 | 80420 | 8200 | 17.5 |
| 36/19 | 79040 | 8060 | 16.9 |
| 54/19 | 66690 | 6800 | 19.4 |
| 66/18 | 66500 | 6781 | 18.3 |
| 76/19 | 60800 | 6200 | 21.25 |
| 84/19 | 63750 | 6500 | 20.6 |
| 20+42/19 | 76500 | 7800 | 18.4 |
| 54+66/37 | 78460 | 8000 | 18.0 |

# Aluminium conductors

## Aluminium conductors steel reinforced - British sizes BS 215 Part 2:1970

### Table 6

| Code name | Nominal aluminum area | Standing and wire diameter | | Actual area | | | Overall diameter | Weight | | | Calculated breaking load | | Calculated dc resistance at 20oC | Breaking length | Current rating *Tropical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Aluminium | Steel | Aluminium | Steel | Total | | Aluminium | Steel | Total | | | | | |
| | mm2 | mm | mm | mm2 | mm2 | mm2 | mm | kg/km | kg/km | kg/km | kgf | kN | ohms/km | km | amp |
| Mole | 10 | 6/1.50 | 1/150 | 10.60 | 1.77 | 12.37 | 4.50 | 29 | 14 | 43 | 421 | 4.13 | 2.707 | 9.79 | 92 |
| Squirrel | 20 | 6/2.11 | 1/2.11 | 20.98 | 3.50 | 24.48 | 6.33 | 58 | 27 | 85 | 807 | 7.91 | 1.368 | 9.49 | 140 |
| Gopher | 25 | 6/2.36 | 1/2.36 | 26.25 | 4.37 | 30.62 | 7.08 | 72 | 34 | 106 | 979 | 9.60 | 1.093 | 9.24 | 161 |
| Weasel | 30 | 6/2.59 | 1/2.59 | 31.61 | 5.27 | 36.88 | 7.77 | 87 | 41 | 128 | 1167 | 11.44 | 0.9077 | 9.12 | 181 |
| Fox | 35 | 6/2.79 | 1/2.79 | 36.88 | 6.11 | 42.99 | 8.37 | 101 | 48 | 149 | 1342 | 13.16 | 0.7823 | 9.01 | 198 |
| Ferret | 40 | 6/3.00 | 1/3.00 | 42.41 | 7.07 | 49.48 | 9.00 | 116 | 55 | 171 | 1553 | 15.23 | 0.6766 | 9.08 | 217 |
| Rabbit | 50 | 6/3.35 | 1/3.35 | 52.88 | 8.81 | 61.69 | 10.05 | 145 | 69 | 214 | 1872 | 18.36 | 0.5426 | 8.75 | 248 |
| Mink | 50 | 6/3.66 | 1/3.66 | 63.13 | 10.52 | 73.65 | 10.98 | 173 | 82 | 255 | 2223 | 21.80 | 0.4545 | 8.72 | 277 |
| Skunk | 60 | 12/2.59 | 7/2.59 | 63.22 | 36.88 | 100.10 | 12.95 | 175 | 289 | 464 | 5396 | 52.92 | 0.4568 | 11.6 | 287 |
| Beaver | 70 | 6/3.99 | 1/3.99 | 75.02 | 12.50 | 87.52 | 11.97 | 205 | 98 | 303 | 2626 | 25.78 | 0.3825 | 8.67 | 308 |
| Horse | 70 | 12/2.79 | 7/2.79 | 73.36 | 42.80 | 116.16 | 13.95 | 203 | 335 | 538 | 6240 | 61.19 | 0.3936 | 11.6 | 315 |
| Raccoon | 75 | 6/4.10 | 1/4.10 | 79.22 | 13.20 | 92.42 | 12.30 | 217 | 103 | 320 | 2774 | 27.20 | 0.3622 | 8.67 | 318 |
| Otter | 80 | 6/4.22 | 1/4.22 | 83.92 | 13.99 | 97.91 | 12.66 | 230 | 109 | 339 | 2939 | 28.82 | 0.3419 | 8.67 | 330 |
| Cat | 90 | 6/4.50 | 1/4.50 | 95.43 | 15.90 | 111.33 | 13.50 | 262 | 124 | 386 | 3330 | 32.66 | 0.3007 | 8.63 | 357 |
| Hare | 100 | 6/4.72 | 1/4.72 | 105.00 | 17.50 | 122.50 | 14.16 | 288 | 137 | 425 | 3666 | 35.95 | 0.2733 | 8.63 | 379 |
| Dog | 100 | 6/4.72 | 7/1.57 | 105.00 | 13.55 | 118.55 | 14.15 | 288 | 106 | 394 | 3332 | 32.68 | 0.2733 | 8.46 | 375 |
| Hyena | 100 | 7/4.39 | 7/1.93 | 106.00 | 20.48 | 126.48 | 14.57 | 293 | 160 | 453 | 4183 | 41.02 | 0.2728 | 9.23 | 382 |
| Cougar | 125 | 18/3.05 | 1/3.05 | 131.50 | 7.31 | 138.81 | 15.25 | 362 | 57 | 419 | 3052 | 30.03 | 0.2190 | 7.31 | 431 |
| Leopard | 125 | 6/5.28 | 7/1.75 | 131.40 | 16.84 | 148.24 | 15.81 | 361 | 132 | 493 | 4156 | 40.76 | 0.2184 | 8.43 | 435 |
| Tiger | 125 | 30/2.36 | 7/2.36 | 131.20 | 30.62 | 161.82 | 16.52 | 363 | 240 | 603 | 5914 | 58.00 | 0.2203 | 9.81 | 438 |
| Dingo | 150 | 18/3.35 | 1/3.35 | 158.70 | 8.81 | 167.51 | 16.75 | 437 | 69 | 506 | 3642 | 35.72 | 0.1814 | 7.2 | 484 |
| Wolf | 150 | 30/2.59 | 7/2.59 | 158.10 | 36.88 | 194.98 | 18.13 | 437 | 389 | 726 | 7061 | 69.24 | 0.1828 | 9.73 | 444 |
| Caracal | 175 | 18/3.61 | 1/3.61 | 184.20 | 10.24 | 194.44 | 18.05 | 507 | 80 | 587 | 4191 | 41.10 | 0.1563 | 7.14 | 530 |
| Lynx | 175 | 30/2.79 | 7/2.79 | 183.40 | 42.80 | 226.20 | 10.53 | 507 | 335 | 842 | 8136 | 79.79 | 01576 | 9.66 | 538 |
| Jaguar | 200 | 18/3.86 | 1/3.86 | 210.60 | 11.70 | 222.30 | 19.30 | 580 | 91 | 671 | 4749 | 46.57 | 0.1367 | 7.08 | 576 |
| Panther | 200 | 30/3.00 | 7/3.00 | 212.10 | 49.48 | 261.58 | 21.00 | 586 | 388 | 974 | 9407 | 92.25 | 0.1362 | 9.66 | 589 |
| Lion | 225 | 20/3.18 | 7/3.18 | 238.30 | 55.60 | 293.90 | 22.26 | 659 | 436 | 1095 | 10248 | 100.50 | 0.1213 | 9.36 | 633 |
| Bear | 250 | 30/3.35 | 7/3.35 | 264.40 | 61.70 | 326.10 | 23.45 | 731 | 483 | 1214 | 11339 | 111.20 | 0.1093 | 9.34 | 675 |
| Goat | 300 | 30/3.71 | 7/3.71 | 324.30 | 75.67 | 399.97 | 25.97 | 896 | 593 | 1489 | 13848 | 135.80 | 0.08911 | 9.3 | 766 |
| Sheep | 350 | 30/3.99 | 7/3.99 | 375.10 | 87.53 | 462.63 | 27.93 | 1037 | 686 | 1723 | 15938 | 156.30 | 0.07704 | 9.25 | 838 |
| Antelope | 350 | 54/2.97 | 7/2.97 | 374.10 | 48.50 | 422.60 | 26.73 | 1034 | 380 | 1414 | 12084 | 118.50 | 0.07727 | 8.55 | 828 |
| Bison | 350 | 54/3.00 | 7/3.00 | 381.70 | 49.48 | 431.18 | 27.00 | 1055 | 388 | 1443 | 12328 | 120.90 | 0.07573 | 8.54 | 839 |
| Deer | 400 | 30/4.27 | 7/4.27 | 429.60 | 100.20 | 529.80 | 29.89 | 1187 | 785 | 1972 | 18202 | 178.50 | 0.06727 | 9.23 | 912 |
| Zebra | 400 | 54/3.18 | 7/3.18 | 428.90 | 55.60 | 484.50 | 28.62 | 1186 | 436 | 1622 | 13450 | 131.90 | 0.06740 | 8.29 | 902 |
| Elk | 450 | 30/4.50 | 7/4.50 | 477.10 | 111.30 | 588.40 | 31.50 | 1318 | 872 | 2190 | 20221 | 198.30 | 0.06057 | 9.23 | 973 |
| Camel | 450 | 54/3.35 | 7/3.35 | 476.00 | 61.70 | 537.70 | 30.15 | 1316 | 483 | 1799 | 14878 | 145.90 | 0.06073 | 8.27 | 962 |
| Moose | 500 | 54/3.35 | 7/3.53 | 528.50 | 68.51 | 597.01 | 31.77 | 1461 | 537 | 1998 | 16417 | 161.00 | 0.054470 | 8.22 | 1026 |

## Aluminium stranded conductors - ASTM B231/823m:2004

### Table 7

| Code name | Conductor size | | | Required construction | | | *Overall diameter | | Mass | | Rated strength at 20oC | | Maximum dc resistance | | Current rating Temperate | Current rating Tropical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AWG or MCM | $mm^2$ | Class | Number of wires | mm | inch | mm | inch | kg/km | lb/1000ft | kips | kN | ohm/km | ohm/1000 ft | amp | amp |
| Bluebonnet | 3500000 | 1773 | A | 127 | 4.22 | 0.1661 | 54.860 | 2.160 | 4977 | 3344 | 58.7 | 261 | 0.01612 | 0.00491 | 1425 | - |
| Trillium | 3000000 | 1520 | A | 127 | 3.9 | 0.1535 | 50.7 | 1.996 | 4226 | 2840 | 50.3 | 223 | 0.01887 | 0.00575 | 1308 | - |
| Bitterroot | 2750000 | 1393 | A | 91 | 4.42 | 0.1740 | 48.62 | 1.914 | 3872 | 2602 | 46.1 | 205 | 0.02050 | 0.00625 | 1242 | - |
| Lupine | 2500000 | 1297 | A | 91 | 4.21 | 0.1657 | 46.31 | 1.823 | 3519 | 2365 | 41.9 | 186 | 0.02260 | 0.00689 | 1178 | - |
| Sagebrush | 2250000 | 1140 | A | 91 | 3.99 | 0.1571 | 43.89 | 1.728 | 3166 | 2127 | 37.7 | 167 | 0.02516 | 0.00767 | 1108 | - |
| Cowslip | 2000000 | 1013 | A | 91 | 3.77 | 0.1484 | 41.47 | 1.633 | 2787 | 1873 | 34.2 | 153 | 0.02818 | 0.00859 | 1035 | - |
| Jessamine | 1750000 | 886.7 | AA | 61 | 4.3 | 0.1693 | 38.7 | 1.524 | 2442 | 1641 | 29.7 | 132 | 0.03232 | 0.00985 | 959 | - |
| Coreopsis | 1590000 | 805.7 | AA | 61 | 4.1 | 0.1614 | 36.9 | 1.453 | 2216 | 1489 | 27 | 120 | 0.03555 | 0.01084 | 907 | 48 |
| Gladiolus | 1510500 | 765.4 | AA, A | 61 | 4 | 0.1575 | 36 | 1.417 | 2108 | 1417 | 25.6 | 114 | 0.03735 | 0.01138 | 881 | 86 |
| Carnation | 1431000 | 725.1 | AA, A | 61 | 3.89 | 0.1531 | 35.01 | 1.378 | 1997 | 1342 | 24.3 | 108 | 0.03949 | 0.01204 | 854 | 117 |
| Columbine | 1351000 | 694.8 | AA, A | 61 | 3.78 | 0.1488 | 34.02 | 1.339 | 1884 | 1266 | 23.4 | 104 | 0.04182 | 0.01275 | 825 | 144 |
| Narcissus | 1272000 | 644.5 | AA, A | 61 | 3.67 | 0.1445 | 33.03 | 1.300 | 1774 | 1192 | 22 | 98.1 | 0.04437 | 0.01352 | 797 | 170 |
| Hawthorn | 1192000 | 604.2 | AA, A | 61 | 3.55 | 0.1398 | 31.95 | 1.258 | 1662 | 1117 | 21.1 | 93.5 | 0.04742 | 0.01445 | 767 | 184 |
| Marigold | 1113000 | 564 | AA, A | 61 | 3.43 | 0.1350 | 30.87 | 1.215 | 1553 | 1044 | 19.7 | 87.3 | 0.05079 | 0.01548 | 738 | 197 |
| Bluebell | 1033500 | 523.7 | AA | 37 | 4.25 | 0.1673 | 29.75 | 1.171 | 1441 | 968 | 17.7 | 78.8 | 0.05454 | 0.01662 | 706 | 207 |
| Larkspur | 1033500 | 523.7 | A | 61 | 3.31 | 0.1303 | 29.79 | 1.173 | 1442 | 969 | 18.3 | 81.3 | 0.05454 | 0.01662 | 707 | 207 |
| Hawkweed | 1000000 | 506.7 | AA | 37 | 4.18 | 0.1646 | 29.26 | 1.152 | 1395 | 937 | 17.2 | 76.2 | 0.05639 | 0.01719 | 693 | 210 |
| Camellia | 1000000 | 506.7 | A | 61 | 3.25 | 0.1280 | 29.25 | 1.152 | 1394 | 937 | 17.7 | 78.3 | 0.05657 | 0.01724 | 693 | 210 |
| Magnolia | 954000 | 483.4 | AA | 37 | 4.08 | 0.1606 | 28.56 | 1.124 | 1331 | 894 | 16.4 | 72.6 | 0.05918 | 0.01804 | 674 | 215 |
| Goldenrod | 954000 | 483.4 | A | 61 | 3.18 | 0.1252 | 28.62 | 1.127 | 1331 | 894 | 16.9 | 75 | 0.05909 | 0.01801 | 675 | 214 |
| Cockscomb | 900000 | 456 | AA | 37 | 3.96 | 0.1559 | 27.72 | 1.091 | 1256 | 844 | 16.4 | 68.4 | 0.06282 | 0.01915 | 651 | 219 |
| Snapdragon | 900000 | 456 | A | 61 | 3.09 | 0.1217 | 27.81 | 1.095 | 1256 | 844 | 15.9 | 70.8 | 0.06259 | 0.01908 | 653 | 219 |
| Arbutus | 795000 | 402.8 | AA | 37 | 3.72 | 0.1465 | 26.04 | 1.025 | 1109 | 745 | 13.9 | 61.8 | 0.07119 | 0.02170 | 605 | 222 |
| Lilac | 795000 | 402.8 | A | 61 | 2.9 | 0.1142 | 26.1 | 1.028 | 1110 | 746 | 14.3 | 63.8 | 0.07105 | 0.02166 | 607 | 222 |
| Petunia | 750000 | 380 | AA | 37 | 3.62 | 0.1425 | 25.34 | 0.998 | 1046 | 703 | 13.1 | 58.6 | 0.07518 | 0.02291 | 585 | 223 |
| Cattail | 750000 | 380 | A | 61 | 2.82 | 0.1110 | 25.38 | 0.999 | 1046 | 703 | 13.5 | 60.3 | 0.07514 | 0.02290 | 586 | 223 |
| Violet | 715000 | 362.6 | AA | 37 | 3.53 | 0.1390 | 24.71 | 0.973 | 998.5 | 671 | 12.8 | 56.7 | 0.07906 | 0.02410 | 570 | 222 |
| Nasturtium | 715000 | 362.6 | A | 61 | 2.75 | 0.1083 | 24.75 | 0.974 | 998.5 | 671 | 13.1 | 58.4 | 0.07902 | 0.02408 | 570 | 222 |
| Verbena | 700000 | 354.7 | AA | 37 | 3.49 | 0.1374 | 24.43 | 0.962 | 975.7 | 656 | 12.5 | 55.4 | 0.08088 | 0.02465 | 562 | 221 |
| Flag | 700000 | 354.7 | A | 61 | 2.72 | 0.1071 | 24.48 | 0.964 | 975.8 | 656 | 12.9 | 57.1 | 0.08077 | 0.02462 | 563 | 221 |
| Heuchera | 650000 | 329.4 | AA | 37 | 3.37 | 0.1327 | 23.59 | 0.929 | 907.4 | 610 | 11.6 | 51.7 | 0.08675 | 0.02644 | 538 | 220 |
| Orchid | 636000 | 322.3 | AA, A | 37 | 3.33 | 0.1311 | 23.31 | 0.918 | 886.9 | 596 | 11.4 | 50.4 | 0.08884 | 0.02708 | 531 | 220 |
| Meadowsweet | 600000 | 304 | AA, A | 37 | 3.23 | 0.1272 | 22.61 | 0.890 | 836.3 | 562 | 10.7 | 47.5 | 0.09443 | 0.02878 | 513 | 218 |
| Dahlia | 556500 | 282 | AA | 19 | 4.35 | 0.1713 | 21.75 | 0.856 | 775.8 | 521 | 9.75 | 43.3 | 0.10139 | 0.03090 | 489 | 214 |
| Mistletoe | 556500 | 282 | A | 37 | 3.12 | 0.1228 | 21.84 | 0.860 | 775.7 | 521 | 9.94 | 44.3 | 0.10121 | 0.03085 | 493 | 215 |
| Zinnia | 500000 | 253.3 | AA | 19 | 4.12 | 0.1622 | 20.6 | 0.811 | 697.1 | 468 | 8.76 | 38.9 | 0.11302 | 0.03445 | 459 | 210 |
| Hyacinth | 500000 | 253.3 | A | 37 | 2.95 | 0.1161 | 20.65 | 0.813 | 696.8 | 468 | 9.11 | 40.5 | 0.11321 | 0.03451 | 461 | 210 |
| Cosmos | 477000 | 241.7 | AA | 19 | 4.02 | 0.1583 | 20.1 | 0.791 | 664.8 | 447 | 8.36 | 37 | 0.11872 | 0.03618 | 447 | 207 |
| Syringa | 477000 | 241.7 | A | 37 | 2.88 | 0.1134 | 20.16 | 0.794 | 664.8 | 447 | 8.69 | 38.6 | 0.11878 | 0.03620 | 449 | 208 |
| Goldentuft | 450000 | 228 | AA | 19 | 3.91 | 0.1539 | 19.55 | 0.770 | 627.6 | 422 | 7.89 | 35 | 0.12549 | 0.03825 | 432 | 204 |
| Canna | 397500 | 201.4 | AA, A | 19 | 3.67 | 0.1445 | 18.35 | 0.722 | 554.9 | 373 | 7.11 | 31.6 | 0.14244 | 0.04342 | 401 | 196 |
| Daffodil | 350000 | 177.3 | A | 19 | 3.45 | 0.1358 | 17.25 | 0.679 | 487.9 | 328 | 6.39 | 28.4 | 0.16119 | 0.04913 | 373 | 188 |
| Tulip | 336400 | 170.5 | A | 19 | 3.38 | 0.1331 | 16.9 | 0.665 | 469.5 | 315 | 6.15 | 27.3 | 0.16793 | 0.05119 | 364 | 186 |
| Peony | 300000 | 152 | A | 19 | 3.19 | 0.1256 | 15.95 | 0.628 | 418.3 | 281 | 5.48 | 24.3 | 0.18853 | 0.05746 | 340 | 178 |
| Daisy | 266800 | 135.2 | AA | 7 | 4.96 | 0.1953 | 14.88 | 0.586 | 372.3 | 250 | 4.83 | 21.4 | 0.21167 | 0.06452 | 313 | 169 |
| Laurel | 266800 | 135.2 | A | 19 | 3.01 | 0.1185 | 15.05 | 0.593 | 372.2 | 250 | 4.97 | 22.1 | 0.21175 | 0.06454 | 317 | 170 |
| Sneezewort | 250000 | 126.7 | AA | 7 | 4.8 | 0.1890 | 14.4 | 0.567 | 348.8 | 234 | 4.52 | 20.1 | 0.22602 | 0.06889 | 300 | 164 |
| Valerian | 250000 | 126.7 | A | 19 | 2.91 | 0.1146 | 14.55 | 0.573 | 348.6 | 234 | 4.66 | 20.7 | 0.22656 | 0.06905 | 305 | 166 |
| Oxlip | 4/0 | 107.2 | AA, A | 7 | 4.42 | 0.1740 | 13.26 | 0.522 | 295.2 | 198 | 3.83 | 17 | 0.26655 | 0.08124 | 273 | 153 |
| Phlox | 3/0 | 85 | AA, A | 7 | 3.93 | 0.1547 | 11.79 | 0.464 | 233.9 | 157 | 3.04 | 13.5 | 0.33716 | 0.10277 | 237 | 138 |
| Aster | 2/0 | 67.4 | AA, A | 7 | 3.5 | 0.1378 | 10.5 | 0.413 | 185.7 | 125 | 2.51 | 11.1 | 0.42509 | 0.12957 | 207 | 124 |
| Poppy | 1/0 | 53.5 | AA, A | 7 | 3.12 | 0.1228 | 9.36 | 0.369 | 147.2 | 99 | 1.99 | 8.84 | 0.53495 | 0.16305 | 180 | 111 |
| Pansy | 1 | 42.4 | AA, A | 7 | 2.78 | 0.1094 | 8.34 | 0.328 | 116.6 | 78 | 1.64 | 7.3 | 0.67380 | 0.20537 | 157 | 99 |
| Iris | 2 | 33.6 | AA, A | 7 | 2.47 | 0.0972 | 7.41 | 0.292 | 92.6 | 62 | 1.35 | 5.99 | 0.85355 | 0.26016 | 136 | 88 |
| Rose | 4 | 21.1 | A | 7 | 1.96 | 0.0772 | 5.88 | 0.231 | 58.2 | 39 | 0.881 | 3.91 | 1.35553 | 0.41316 | 104 | 69 |
| Peachbell | 6 | 13.3 | A | 7 | 1.56 | 0.0614 | 4.68 | 0.184 | 36.6 | 25 | 0.563 | 2.53 | 2.13979 | 0.65221 | 72 | 50 |

* Calculated using stable strand construction dimensions

## Aluminium conductors

### Aluminium alloy conductors - BS EN 50183:2000

**Table 8**

| Code name | Nominal aluminium area | Equivalent copper area | Stranding and wire diameter | Actual area | Overall diameter | Weight | Calculated breaking load | | Calculated dc resistance at 20°C | Curent Rating *Tropical |
|---|---|---|---|---|---|---|---|---|---|---|
| | mm² | mm² | mm | mm² | kg/km | kg/km | N | kgf | ohms/km | amp |
| - | - | 6.45 | 7/1.47 | 11.7 | 4.41 | 32 | 3280 | 335 | 2.816 | 48 |
| Box | - | 9.68 | 7/1.85 | 18.8 | 5.55 | 51 | 5260 | 536 | 1.755 | 55 |
| Acacia | - | 12.9 | 7/2.08 | 23.9 | 6.24 | 66 | 6710 | 684 | 1.375 | 61 |
| Almond | 25 | 16.1 | 7/2.34 | 30.1 | 7.02 | 82 | 8450 | 862 | 1.094 | 85 |
| Cedar | 30 | 19.4 | 7/2.54 | 35.5 | 7.62 | 97 | 9950 | 1015 | 0.9281 | 85 |
| - | - | 22.6 | 7/2.77 | 42.2 | 8.31 | 115 | 11830 | 1206 | 0.7799 | 92 |
| Fir | 40 | 25.8 | 7/2.95 | 47.8 | 8.85 | 131 | 13400 | 1366 | 0.6880 | 99 |
| Hazel | 50 | 32.3 | 7/3.30 | 59.9 | 9.9 | 164 | 16800 | 1713 | 0.5498 | 113 |
| Pine | - | 38.7 | 7/3.61 | 71.7 | 10.83 | 196 | 20100 | 2050 | 0.4593 | 119 |
| - | - | 45.2 | 7/3.91 | 84.1 | 11.73 | 230 | 23570 | 2404 | 0.3916 | 126 |
| Willow | - | 48.4 | 7/4.04 | 89.8 | 12.12 | 246 | 25180 | 2568 | 0.3665 | 132 |
| - | - | 51.6 | 7/4.19 | 96.5 | 12.57 | 264 | 27060 | 2759 | 0.3410 | 138 |
| - | - | 58.1 | 7/4.45 | 108.8 | 13.35 | 298 | 30500 | 3110 | 0.3026 | 145 |
| Oak | 100 | 64.5 | 7/4.65 | 118.9 | 13.95 | 325 | 33300 | 3396 | 0.2769 | 150 |
| - | - | 64.5 | 19/2.82 | 118.8 | 14.1 | 326 | 33300 | 3396 | 0.2786 | 151 |
| Mulberry | - | 80.6 | 19/3.18 | 151.1 | 15.9 | 415 | 42360 | 4320 | 0.2190 | 166 |
| Ash | 150 | 96.8 | 19/3.48 | 180.7 | 17.4 | 497 | 50600 | 5160 | 0.1830 | 181 |
| Elm | 175 | 113 | 19/3.76 | 211 | 18.8 | 580 | 59100 | 6027 | 0.1568 | 188 |
| Poplar | - | 129 | 37/2.87 | 239 | 20.09 | 658 | 67000 | 6832 | 0.1387 | 196 |
| - | - | 145 | 37/3.05 | 270.8 | 21.35 | 746 | 75900 | 7740 | 0.1224 | 204 |
| Sycamore | - | 161 | 37/3.23 | 303 | 22.61 | 835 | 85000 | 8668 | 0.1094 | 205 |
| Upas | 300 | 194 | 37/3.53 | 362.1 | 24.71 | 997 | 101500 | 10350 | 0.09155 | 209 |
| - | - | 226 | 37/3.81 | 421.8 | 26.67 | 1162 | 118300 | 12063 | 0.0786 | 216 |
| Yew | - | 258 | 37/4.06 | 479.9 | 28.42 | 1322 | 134500 | 13715 | 0.06908 | 215 |

## Aluminium conductor steel reinforced - ASTM B232/B232M: 2001

### Table 9

| Code name | Size | | Class | Sranding Design Aluminum/ Steel | Sranding | | | | | | | | Nominal O.G. of Conductors | | Mass | | Rated Strength | | Maximum dc resistance at 20ºC | | Current Rating | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Aluminum Diameter | | | | Steel Diameter | | | | | | | | | | | | Temperate | Tropical |
| | AWG or MCM | mm2 | | | Number | mm | inch | Layers | Number | mm | inch | Layers | mm | inch | kg/km | lb/1000 ft | kips | kN | ohm/km | ohm/1000 ft | amp | amp |
| Chukar | - | 901.93 | AA | 84/19 | 84 | 3.70 | 0.1456 | 4 | 19 | 2.22 | 0.0874 | 2 | 40.69 | 1.602 | 3083 | 2072 | 48.9 | 218 | 0.03173 | 0.009671 | 975 | - |
| Falcon | - | 805.8 | AA | 54/19 | 54 | 4.36 | 0.1716 | 3 | 19 | 2.62 | 0.103 | 2 | 39.24 | 1.545 | 3039 | 2042 | 51.6 | 230 | 0.03553 | 0.010830 | 917 | - |
| Lapwig | - | 805.8 | AA | 45/7 | 45 | 4.78 | 0.188 | 3 | 7 | 3.18 | 0.1253 | 1 | 38.20 | 1.504 | 2664 | 1790 | 40.5 | 180 | 0.03552 | 0.010828 | 911 | - |
| Parrot | - | 765.16 | AA | 54/19 | 54 | 4.25 | 0.1672 | 3 | 19 | 2.55 | 0.1003 | 2 | 38.23 | 1.505 | 2884 | 1938 | 48.9 | 218 | 0.03743 | 0.011408 | 890 | - |
| Nuthatch | - | 765.16 | AA | 45/7 | 45 | 4.65 | 0.1832 | 3 | 7 | 3.10 | 0.1221 | 1 | 37.24 | 1.466 | 2530 | 1700 | 38.5 | 171 | 0.03741 | 0.011403 | 886 | 34 |
| Plover | - | 725.16 | AA | 54/19 | 54 | 4.14 | 0.1628 | 3 | 19 | 2.48 | 0.0977 | 2 | 37.21 | 1.465 | 2735 | 1838 | 46.4 | 206 | 0.03948 | 0.012033 | 862 | 34 |
| Bobolink | - | 725.16 | AA | 45/7 | 45 | 4.53 | 0.1783 | 3 | 7 | 3.02 | 0.1189 | 1 | 36.25 | 1.427 | 2397 | 1611 | 36.9 | 164 | 0.03949 | 0.012038 | 859 | 72 |
| Martin | - | 684.84 | AA | 54/19 | 54 | 4.02 | 0.1582 | 3 | 19 | 2.41 | 0.0949 | 2 | 36.17 | 1.424 | 2582 | 1735 | 43.8 | 195 | 0.04181 | 0.012743 | 835 | 73 |
| Dipper | - | 685.16 | AA | 45/7 | 45 | 4.40 | 0.1733 | 3 | 7 | 2.93 | 0.1155 | 1 | 35.20 | 1.386 | 2263 | 1521 | 34.8 | 155 | 0.04181 | 0.012743 | 831 | 109 |
| Pheasant | - | 644.51 | AA | 54/19 | 54 | 3.90 | 0.1535 | 3 | 19 | 2.34 | 0.0921 | 2 | 35.10 | 1.382 | 2432 | 1634 | 41.2 | 183 | 0.04441 | 0.013535 | 807 | 109 |
| Bittern | - | 644.51 | AA | 45/7 | 45 | 4.27 | 0.1681 | 3 | 7 | 2.85 | 0.1121 | 1 | 34.16 | 1.345 | 2131 | 1432 | 32.8 | 146 | 0.04443 | 0.013543 | 802 | 135 |
| Grackle | - | 604.26 | AA | 54/19 | 54 | 3.77 | 0.1486 | 3 | 19 | 2.27 | 0.0892 | 2 | 33.99 | 1.338 | 2278 | 1531 | 39.7 | 177 | 0.04738 | 0.014442 | 773 | 140 |
| Bunting | - | 604.26 | AA | 45/7 | 45 | 4.14 | 0.1628 | 3 | 7 | 2.76 | 0.1085 | 1 | 33.07 | 1.302 | 1997 | 1342 | 30.7 | 137 | 0.04737 | 0.014439 | 772 | 163 |
| Finch | - | 563.93 | AA | 54/19 | 54 | 3.65 | 0.1436 | 3 | 19 | 2.19 | 0.0862 | 2 | 32.84 | 1.293 | 2128 | 1430 | 37 | 165 | 0.05074 | 0.015465 | 746 | 162 |
| Bluejay | - | 563.93 | AA | 45/7 | 45 | 4.00 | 0.1573 | 3 | 7 | 2.66 | 0.1049 | 1 | 31.98 | 1.259 | 1866 | 1254 | 28.7 | 128 | 0.05074 | 0.015467 | 743 | 178 |
| Curlew | - | 523.68 | AA | 54/7 | 54 | 3.51 | 0.1383 | 3 | 7 | 3.51 | 0.1383 | 1 | 31.62 | 1.245 | 1978 | 1329 | 34.6 | 154 | 0.05470 | 0.016674 | 715 | 177 |
| Ortlan | - | 528.68 | AA | 45/7 | 45 | 3.85 | 0.1515 | 3 | 7 | 2.57 | 0.101 | 1 | 30.78 | 1.212 | 1731 | 1163 | 26.6 | 118 | 0.05470 | 0.016674 | 712 | 192 |
| Cardinal | - | 483.42 | AA | 54/7 | 54 | 3.38 | 0.1329 | 3 | 7 | 3.38 | 0.1329 | 1 | 30.38 | 1.196 | 1826 | 1227.1 | 32 | 142 | 0.05924 | 0.018056 | 681 | 191 |
| Rail | - | 483.42 | AA | 45/7 | 45 | 3.70 | 0.1456 | 3 | 7 | 2.47 | 0.0971 | 1 | 29.59 | 1.165 | 1598 | 1074 | 24.9 | 111 | 0.05923 | 0.018052 | 679 | 201 |
| Canary | - | 456.06 | AA | 54/7 | 54 | 3.28 | 0.1291 | 3 | 7 | 3.28 | 0.1291 | 1 | 29.51 | 1.162 | 1723 | 1158 | 30.2 | 134 | 0.06278 | 0.019135 | 660 | 196 |
| Ruddy | - | 455.81 | AA | 45/7 | 45 | 3.59 | 0.1414 | 3 | 7 | 2.40 | 0.0943 | 1 | 28.73 | 1.131 | 1508 | 1013 | 23.5 | 105 | 0.06280 | 0.019141 | 656 | 206 |
| Mallard | - | 402.84 | AA | 30/19 | 30 | 4.14 | 0.1628 | 2 | 19 | 2.48 | 0.0977 | 2 | 28.96 | 1.14 | 1836 | 1233.9 | 35.8 | 159 | 0.07106 | 0.021659 | 618 | 191 |
| Condor | - | 402.84 | AA | 54/7 | 54 | 3.08 | 0.1213 | 3 | 7 | 3.08 | 0.1213 | 1 | 27.74 | 1.092 | 1521 | 1022 | 26.6 | 118 | 0.07111 | 0.021675 | 614 | 206 |
| Tern | - | 402.84 | AA | 45/7 | 45 | 3.38 | 0.1329 | 3 | 7 | 2.25 | 0.0886 | 1 | 27.00 | 1.063 | 1332 | 895 | 21.2 | 94 | 0.07109 | 0.021667 | 610 | 213 |
| Drake | - | 402.84 | AA | 26/7 | 26 | 4.44 | 0.1749 | 2 | 7 | 3.45 | 0.136 | 1 | 28.14 | 1.108 | 1627 | 1093 | 29.6 | 132 | 0.07104 | 0.021653 | 614 | 201 |
| Cuckoo | - | 402.9 | AA | 24/7 | 24 | 4.62 | 0.182 | 2 | 7 | 3.08 | 0.1213 | 1 | 27.74 | 1.092 | 1522 | 1023 | 26.4 | 117 | 0.07107 | 0.021663 | 614 | 206 |
| Redwing | - | 362.58 | AA | 30/19 | 30 | 3.92 | 0.1544 | 2 | 19 | 2.35 | 0.0926 | 2 | 27.46 | 1.081 | 1651 | 1109.3 | 32.2 | 143 | 0.07900 | 0.024080 | 581 | 198 |
| Starling | - | 362.58 | AA | 26/7 | 26 | 4.21 | 0.1659 | 2 | 7 | 3.28 | 0.129 | 1 | 26.70 | 1.051 | 1464 | 983.7 | 26.6 | 118 | 0.07896 | 0.024066 | 578 | 205 |
| Stilt | - | 362.64 | AA | 24/7 | 24 | 4.39 | 0.1727 | 2 | 7 | 2.92 | 0.1151 | 1 | 26.31 | 1.036 | 1371 | 921 | 24.1 | 107 | 0.07893 | 0.024059 | 577 | 208 |
| Gannet | - | 337.81 | AA | 26/7 | 26 | 4.07 | 0.1601 | 2 | 7 | 3.16 | 0.1245 | 1 | 25.76 | 1.014 | 1363 | 916.2 | 24.8 | 110 | 0.08478 | 0.025841 | 618 | 200 |
| Flamingo | - | 337.74 | AA | 24/7 | 24 | 4.23 | 0.1667 | 2 | 7 | 2.82 | 0.1111 | 1 | 25.40 | 1.000 | 1277 | 857.9 | 22.4 | 100 | 0.08472 | 0.025822 | 552 | 210 |
| Egret | - | 322.26 | AA | 30/19 | 30 | 3.70 | 0.1456 | 2 | 19 | 2.22 | 0.0874 | 2 | 25.88 | 1.019 | 1469 | 987.2 | 29.4 | 131 | 0.08884 | 0.027078 | 542 | 200 |
| Scoter | - | 322.26 | AA | 30/7 | 30 | 3.70 | 0.1456 | 2 | 7 | 3.70 | 0.1456 | 1 | 25.88 | 1.019 | 1481 | 995.1 | 28.7 | 128 | 0.08884 | 0.027078 | 541 | 200 |
| Grosbeak | - | 322.26 | AA | 26/7 | 26 | 3.97 | 0.1564 | 2 | 7 | 3.09 | 0.1216 | 1 | 25.15 | 0.99 | 1301 | 874.2 | 23.6 | 105 | 0.08884 | 0.027078 | 538 | 206 |
| Rook | - | 322.26 | AA | 24/7 | 24 | 4.14 | 0.1628 | 2 | 7 | 2.76 | 0.1085 | 1 | 24.82 | 0.977 | 1218 | 818.2 | 21.4 | 95 | 0.08882 | 0.027074 | 537 | 208 |
| Kingbird | - | 322.39 | AA | 18/1 | 18 | 4.78 | 0.188 | 2 | 1 | 4.78 | 0.188 | 0 | 23.88 | 0.94 | 1027 | 689.9 | 15.3 | 68 | 0.08881 | 0.027069 | 530 | 215 |
| Teal | - | 306.58 | AA | 30/19 | 30 | 3.61 | 0.142 | 2 | 19 | 2.16 | 0.0852 | 2 | 25.25 | 0.994 | 1397 | 938.6 | 28 | 125 | 0.09340 | 0.028469 | 527 | 201 |
| Wood Duck | - | 306.58 | AA | 30/7 | 30 | 3.61 | 0.142 | 2 | 7 | 3.61 | 0.142 | 1 | 25.25 | 0.994 | 1409 | 946.5 | 27.3 | 121 | 0.09340 | 0.028469 | 523 | 200 |
| Squab | - | 306.58 | AA | 26/7 | 26 | 3.87 | 0.1525 | 2 | 7 | 3.01 | 0.1186 | 1 | 24.54 | 0.966 | 1237 | 831.3 | 22.8 | 101 | 0.09344 | 0.028481 | 523 | 205 |
| Peacock | - | 306.58 | AA | 24/7 | 24 | 4.03 | 0.1588 | 2 | 7 | 2.69 | 0.1059 | 1 | 24.21 | 0.953 | 1159 | 778.8 | 20.4 | 91 | 0.09336 | 0.028455 | 522 | 208 |
| Eagle | - | 282 | AA | 30/7 | 30 | 3.46 | 0.1362 | 2 | 7 | 3.46 | 0.1362 | 1 | 24.21 | 0.953 | 1296 | 870.7 | 25.8 | 115 | 0.10153 | 0.030945 | 500 | 199 |
| Dove | - | 282 | AA | 26/7 | 26 | 3.72 | 0.1463 | 2 | 7 | 2.89 | 0.1138 | 1 | 23.55 | 0.927 | 1139 | 765.2 | 21.2 | 94 | 0.10153 | 0.030946 | 499 | 204 |
| Parakeet | - | 282 | AA | 24/7 | 24 | 3.87 | 0.1523 | 2 | 7 | 2.58 | 0.1015 | 1 | 23.22 | 0.914 | 1066 | 716.1 | 18.7 | 83 | 0.10149 | 0.030935 | 492 | 206 |
| Osprey | - | 282 | AA | 18/1 | 18 | 4.47 | 0.1758 | 2 | 1 | 4.47 | 0.1758 | 0 | 22.33 | 0.879 | 898 | 603.3 | 13.4 | 60 | 0.10156 | 0.030957 | 492 | 211 |
| Hen | - | 241.68 | AA | 30/7 | 30 | 3.20 | 0.1261 | 2 | 7 | 3.20 | 0.1261 | 1 | 22.43 | 0.883 | 1111 | 746.4 | 22.1 | 98 | 0.11844 | 0.036101 | 457 | 195 |
| Hawk | - | 241.68 | AA | 26/7 | 26 | 3.44 | 0.1354 | 2 | 7 | 2.67 | 0.1053 | 1 | 21.79 | 0.858 | 975 | 655.3 | 18.4 | 82 | 0.11853 | 0.036129 | 455 | 199 |
| Flicker | - | 241.68 | AA | 24/7 | 24 | 3.58 | 0.141 | 2 | 7 | 2.39 | 0.094 | 1 | 21.49 | 0.846 | 914 | 613.9 | 16.2 | 72 | 0.11841 | 0.036092 | 454 | 200 |
| Pelican | - | 241.68 | AA | 18/1 | 18 | 4.14 | 0.1628 | 2 | 1 | 4.14 | 0.1628 | 0 | 20.68 | 0.814 | 770 | 517.3 | 11.5 | 51 | 0.11843 | 0.036098 | 449 | 204 |
| Lark | - | 201.42 | AA | 30/7 | 30 | 2.92 | 0.1151 | 2 | 7 | 2.92 | 0.1151 | 1 | 20.47 | 0.806 | 925 | 621.8 | 18.9 | 84 | 0.14216 | 0.043331 | 410 | 188 |
| Ibis | - | 201.42 | AA | 26/7 | 26 | 3.14 | 0.1236 | 2 | 7 | 2.44 | 0.0961 | 1 | 19.89 | 0.783 | 813 | 546 | 15.3 | 68 | 0.14225 | 0.043357 | 403 | 191 |
| Brant | - | 201.42 | AA | 24/7 | 24 | 3.27 | 0.1287 | 2 | 7 | 2.18 | 0.0858 | 1 | 19.61 | 0.772 | 761 | 511.4 | 13.9 | 62 | 0.14213 | 0.043321 | 405 | 192 |
| Chickadee | - | 201.42 | AA | 18/1 | 18 | 3.77 | 0.1486 | 2 | 1 | 3.77 | 0.1486 | 0 | 18.87 | 0.743 | 641 | 431 | 9.7 | 43 | 0.14215 | 0.043327 | 403 | 194 |
| Oriole | - | 170.45 | AA | 30/7 | 30 | 2.69 | 0.1059 | 2 | 7 | 2.69 | 0.1059 | 1 | 18.82 | 0.741 | 783 | 526.4 | 16.2 | 72 | 0.16793 | 0.051186 | 372 | 179 |
| Linnet | - | 170.45 | AA | 26/7 | 26 | 2.89 | 0.1137 | 2 | 7 | 2.25 | 0.0884 | 1 | 18.29 | 0.72 | 688 | 462 | 13.3 | 59 | 0.16810 | 0.051236 | 371 | 182 |
| Merlin | - | 170.45 | AA | 18/1 | 18 | 3.47 | 0.1367 | 2 | 1 | 3.47 | 0.1367 | 0 | 17.37 | 0.684 | 543 | 364.8 | 8.4 | 37 | 0.16797 | 0.051198 | 366 | 184 |
| Ostrich | - | 152 | AA | 26/7 | 26 | 2.73 | 0.1074 | 2 | 7 | 2.12 | 0.0835 | 1 | 17.27 | 0.68 | 613 | 412.2 | 12 | 53 | 0.18839 | 0.057423 | 346 | 175 |
| Partridge | - | 135.16 | AA | 26/7 | 26 | 2.57 | 0.1013 | 2 | 7 | 2.00 | 0.0788 | 1 | 16.31 | 0.642 | 546 | 366.9 | 10.6 | 47 | 0.21177 | 0.064547 | 323 | 168 |
| Waxwing | - | 135.16 | AA | 18/1 | 18 | 3.09 | 0.1217 | 2 | 1 | 3.09 | 0.1217 | 0 | 15.47 | 0.609 | 430 | 289.1 | 6.7 | 30 | 0.21193 | 0.064597 | 319 | 170 |
| Penguin | 0000 | 107.23 | AA, A | 6/1 | 6 | 4.77 | 0.1878 | 1 | 1 | 4.77 | 0.1878 | 0 | 14.30 | 0.563 | 433 | 290.8 | 7.95 | 35 | 0.26700 | 0.081381 | 276 | 151 |
| Pigeon | 000 | 85.03 | AA, A | 6/1 | 6 | 4.25 | 0.1672 | 1 | 1 | 4.25 | 0.1672 | 0 | 12.75 | 0.502 | 343 | 230.5 | 6.3 | 28 | 0.33684 | 0.102670 | 241 | 137 |
| Quail | 00 | 67.42 | AA, A | 6/1 | 6 | 3.78 | 0.1489 | 1 | 1 | 3.78 | 0.1489 | 0 | 11.35 | 0.447 | 272 | 182.8 | 5.05 | 22 | 0.42473 | 0.129457 | 210 | 123 |
| Raven | 0 | 53.48 | AA, A | 6/1 | 6 | 3.37 | 0.1327 | 1 | 1 | 3.37 | 0.1327 | 0 | 10.11 | 0.398 | 216 | 145.2 | 4.12 | 18 | 0.53476 | 0.162995 | 183 | 111 |
| Robin | 1 | 42.39 | AA, A | 6/1 | 6 | 3.00 | 0.1181 | 1 | 1 | 3.00 | 0.1181 | 0 | 8.99 | 0.354 | 171 | 115 | 3.34 | 15 | 0.67515 | 0.205786 | 160 | 100 |
| Sparate | 2 | 33.61 | AA, A | 7/1 | 7 | 2.47 | 0.0974 | 1 | 1 | 3.30 | 0.1299 | 0 | 8.26 | 0.325 | 159 | 106.63 | 3.39 | 15 | 0.85082 | 0.259329 | 138 | 88 |
| Sparrow | 2 | 33.61 | AA, A | 6/1 | 6 | 2.67 | 0.1052 | 1 | 1 | 2.67 | 0.1052 | 0 | 8.03 | 0.316 | 136 | 91.2 | 2.68 | 12 | 0.85088 | 0.259348 | 139 | 88 |
| Swanate | 4 | 21.16 | AA, A | 7/1 | 7 | 1.96 | 0.0772 | 1 | 1 | 2.61 | 0.1029 | 0 | 6.53 | 0.257 | 100 | 66.95 | 2.2 | 10 | 1.35431 | 0.412794 | 104 | 69 |
| Swan | 4 | 21.16 | AA, A | 6/1 | 6 | 2.12 | 0.0834 | 1 | 1 | 2.12 | 0.0834 | 0 | 6.35 | 0.25 | 85 | 57.35 | 1.76 | 8 | 1.35384 | 0.412651 | 105 | 69 |
| Thrush | 5 | 16.77 | A | 6/1 | 6 | 1.89 | 0.0743 | 1 | 1 | 1.89 | 0.0743 | 0 | 5.66 | 0.223 | 68 | 45.51 | 1.41 | 6 | 1.70578 | 0.519921 | 91 | 61 |
| Turkey | 6 | 13.29 | AA, A | 6/1 | 6 | 1.68 | 0.0661 | 1 | 1 | 1.68 | 0.0661 | 0 | 5.03 | 0.198 | 54 | 36.02 | 1.12 | 5 | 2.15525 | 0.656919 | 78 | 53 |

## Aluminium-Alloy 6201 Conductors - ASTM B399

### Table 10

| Conductor size | | Requires construction | | | | Mass | | Rated strength | | Nominal dc resistance at 20°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dameter of wires | | | | | | | | |
| AWG or MCM | mm2 | Number of wires | inch | mm2 | Class | lb/1000 ft | kg/km | kips | kN | ohm/1000 ft | ohm/km |
| - | 886 | 61 | 0.1694 | 4.30 | AA | 1632 | 2431 | 56.9 | 251 | 0.01151 | 0.03781 |
| - | 759 | 61 | 0.1568 | 3.98 | AA | 1399 | 2082 | 48.8 | 215 | 0.01344 | 0.04414 |
| - | 631 | 61 | 0.1431 | 3.63 | AA | 1165 | 1732 | 40.6 | 179 | 0.01613 | 0.05306 |
| - | 508 | 37 | 0.1644 | 4.18 | AA | 932.5 | 1393 | 32.9 | 146 | 0.02015 | 0.06597 |
| - | 456 | 37 | 0.1560 | 3.96 | AA | 839.7 | 1250 | 29.6 | 131 | 0.02238 | 0.07351 |
| - | 404 | 37 | 0.1470 | 3.73 | AA | 745.6 | 1109 | 26.3 | 116 | 0.02520 | 0.08285 |
| - | 381 | 37 | 0.1424 | 3.62 | AA | 699.6 | 1045 | 24.7 | 109 | 0.02686 | 0.08796 |
| - | 354 | 37 | 0.1375 | 3.49 | AA | 652.3 | 971.2 | 23.0 | 101 | 0.02881 | 0.09464 |
| - | 330 | 37 | 0.1325 | 3.37 | AA | 605.7 | 905.5 | 21.4 | 94.9 | 0.03102 | 0.10150 |
| - | 303 | 37 | 0.1273 | 3.23 | AA, A | 559.1 | 831.9 | 20.6 | 91.0 | 0.03361 | 0.11049 |
| - | 279 | 37 | 0.1219 | 3.10 | AA, A | 512.7 | 766.2 | 18.9 | 83.9 | 0.03665 | 0.11995 |
| - | 253 | 19 | 0.1622 | 4.12 | AA | 466.1 | 695.0 | 16.8 | 74.2 | 0.04031 | 0.13224 |
| - | 228 | 19 | 0.1539 | 3.91 | AA | 419.6 | 626.0 | 15.1 | 66.8 | 0.04478 | 0.14683 |
| - | 203 | 19 | 0.1451 | 3.69 | AA, A | 373.0 | 557.5 | 13.4 | 59.5 | 0.05037 | 0.16486 |
| - | 178 | 19 | 0.1357 | 3.45 | A | 326.3 | 487.3 | 11.8 | 52.0 | 0.05759 | 0.18860 |
| - | 152 | 19 | 0.1257 | 3.19 | A | 280.0 | 416.7 | 10.5 | 46.6 | 0.06712 | 0.22059 |
| - | 126 | 19 | 0.1147 | 2.91 | A | 233.1 | 346.7 | 8.76 | 38.8 | 0.08061 | 0.26509 |
| 0000 | 107 | 7 | 0.1739 | 4.42 | AA, A | 197.4 | 294.7 | 7.34 | 32.5 | 0.09519 | 0.31188 |
| 000 | 84.9 | 7 | 0.1548 | 3.93 | AA, A | 156.4 | 233.0 | 5.82 | 25.7 | 0.12013 | 0.39450 |
| 00 | 67.3 | 7 | 0.1379 | 3.50 | AA, A | 124.1 | 184.8 | 4.62 | 20.4 | 0.15137 | 0.49738 |
| 0 | 53.5 | 7 | 0.1228 | 3.12 | AA, A | 98.43 | 146.8 | 3.82 | 17.0 | 0.19089 | 0.62592 |
| 2 | 33.5 | 7 | 0.0974 | 2.47 | AA, A | 61.92 | 92.00 | 2.40 | 10.6 | 0.30343 | 0.99870 |
| 4 | 21.1 | 7 | 0.0772 | 1.96 | A | 38.90 | 57.90 | 1.51 | 6.69 | 0.48300 | 1.5860 |
| 6 | 13.2 | 7 | 0.0612 | 1.55 | A | 24.49 | 36.20 | 0.949 | 4.18 | 0.76856 | 2.5361 |

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